Economics of Shared Infrastructure Access

Final Report

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Executive Summary

This report assesses the potential for shared access to infrastructure to support sustainable competition in next-generation access (NGA) networks. Specifically, the report considers fibre to the premises (FTTP) networks, and the potential for CP access to Openreach ducts to be an effective regulatory remedy in the wholesale local access market.

The economics of FTTP network deployment is characterised by high fixed costs of which the dominant component is the civil works: digging the roads and laying duct. Shared access to infrastructure would allow Communication Providers (CP) to avoid the high upfront cost of duct construction by enabling them to use existing Openreach duct. The access charges for using Openreach duct would be considerably less than the cost of new build infrastructure.

To assess the potential for shared access as a remedy in the UK market, Ofcom commissioned CSMG to conduct a three phase study.

In the first phase, CSMG researched international examples of shared infrastructure access and developed five case studies of countries in which regulated or commercial offers were present. The countries profiled are Australia, Canada, France, Portugal and the USA.

The case studies demonstrate that under the appropriate conditions, shared access to infrastructure can be a popular means for CPs to develop their networks. Key success factors include:

1. **Availability of infrastructure**
   In Paris the success of infrastructure access in the sewer system is in part due to the excellent condition and, easy accessibility of the infrastructure, and the amount of capacity available.

2. **Quality and availability of records**
   According to Portugal Telecom (PT), identifying available capacity was one of its major operational issues, as was the limited support from information systems.

3. **Planning restrictions**
   In Paris, use of the sewer network has been encouraged by the difficulty in obtaining permission for street works.

4. **Regulatory regime**
   All the markets surveyed had some form of regulatory requirement for duct sharing. Success has been achieved both in markets with reference offers (e.g. Portugal) and those based on commercial negotiation (e.g. USA).

5. **Supply-side economics**
   The relative pricing of infrastructure access versus alternative entry options is a

critical determinant of success. In Paris, the reduction in the cost of access to the sewer network led to an upsurge in demand.

6. **Demand-side economics**

   The available revenues in a particular geography will also influence choice of entry option. Particularly in the case of fibre deployments, far higher revenues are achievable in the business market. In the residential market, the revenue premium available through fibre is lower and hence CPs may choose lower-cost DSL alternatives in the short term.

The second phase of the project analysed the economics of shared duct access from two perspectives: first, in terms of the static cost of competition that would be created through infrastructure competition based on duct access; and second, comparing the economics of duct access versus alternative entry options for a CP contemplating market entry.

The cost of competition analysis shows that considerable cost can be avoided through duct access versus competitive new build network deployment. However, whilst competition under duct access avoids the cost of multiple duct networks, CPs continue to duplicate investment in the fibre and active elements of their networks. This duplicative investment drives up the cost of competition. The analysis shows that in a market with four competing CPs, the cost of competition would actually exceed the cost of a connection in a market with a single infrastructure. That is, having four competing FTTP networks instead of one will result in the cost per end user more than doubling.

From the perspective of a CP, duct access offers significant cost savings versus new build. If a CP were committed to infrastructure-based entry, then duct access would be an attractive option. However, a third entry option was also analysed – wholesale access using Openreach GEA (Generic Ethernet Access). GEA has far lower upfront fixed costs and may therefore be a more attractive to a CP in the face of uncertain demand. At current pricing levels, GEA becomes more expensive than shared access at scale, but a CP would have to connect 24% of homes in an area to breakeven. Further, if demand for NGA services is this high then it would be possible to reduce the GEA price. Therefore, in areas where GEA is available it is likely to be a more attractive option overall.

In the third phase of the study, CSMG researched the cost of new build network construction through a series of interviews with network operators and construction contractors. The research investigated the cost of different construction methods under a range of conditions. The cost estimates provided by the research participants showed considerable variation which reflects the high variability of construction cost in the real world. Construction in city centres was found to have the highest cost, driven by factors such as traffic management, lane closures and the possible need to work during the night. Where individual respondents provided cost ranges the high-end figures were typically 30% above the low end.

Slot trenching was found to be significantly cheaper than traditional trenching. The average response of £58/m in urban areas is 57% lower than aggregated responses for traditional trenching. It is therefore likely to become an important technology in future NGA deployments.

Direct burying in soft ground offered savings of around 24% versus traditional trenching. The lower construction costs however must be balanced against higher maintenance costs and a shorter life expectancy. The same is true for aerial fibre in pole deployments, poles being the lowest cost method surveyed at c.£17/m.

The interview findings were used to model the costs of a new-build FTTP network in two representative scenarios: a GPON network in an urban geotype and a Point-to-Point network in a suburban network. Traditional trenching was compared with a mix of traditional and slot trenching, realising savings in the two network scenarios of between 10% and 23%.

The report concludes that shared access to infrastructure would considerably reduce the cost of competition compared with multiple new build network deployments. However the duplicative investment in fibre and active components means there is still a significant cost to this type of competition. Competition on multiple networks may deliver dynamic benefits through competition and innovation, however an assessment of these benefits is outside the scope of this report.

Whilst shared access offers significant savings compared with new build the analysis indicates that network deployment based on shared access has significantly higher upfront cost which make it more expensive that GEA except at high volumes. This suggests that unless CPs place a high value on the strategic benefits of infrastructure ownership, they may find such a wholesale access service a more attractive and less risky option in the face of uncertain demand.

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1 INTRODUCTION

1.1 Context

BT has significantly extended its near-term FTTP deployment plans

In October 2009, BT announced a significant extension to its deployment plans for next-generation access (NGA)[1].

In its original plans communicated in July 2008, BT stated a target of one million homes and businesses for fibre-to-the-premises (FTTP) access, within its overall plan to reach c.10 million homes with next-generation access by 2012.

BT's revised plans have extended the FTTP target to around 2.5 million premises by 2012, equivalent to c.10% of UK households. Using the new access infrastructure, BT plans to deliver speeds of up to 100Mbps initially with the potential to reach 1Gbps in future.

Duct re-use is an important factor in BT's revised plans

In revising its target, BT noted that it was "making good progress with all aspects of its fibre programme and is commercially ahead of target. This has allowed the expansion of FTTP availability to be contained within its overall investment of £1.5 billion."

BT also stated that it "will now deploy FTTP in some areas where copper services are already available. This represents a broadening of BT's strategy as initially FTTP was to be deployed in new build sites only."

It is notable that BT has increased the extent of its FTTP programme within its original budget and timeline, whilst broadening the scope to include 'brownfield' deployment. Earlier comments from George Williamson, director of strategic network design at Openreach shed light on the revised plans: "What we have been doing is trying to assess how to re-use existing physical infrastructure. We are trying to improve our records on ducts. The result may be a doubling of the ratio of FTTP to FTTC."[2]

The potential for BT to re-use existing ducts is further supported by the initial findings of Ofcom's duct survey. The survey revealed an average of 17% empty duct-ends on routes sampled between the local exchange and the final street cabinet. On the same routes, unoccupied space averaged 30% per duct-end.

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[1] "BT to expand footprint for UK's fastest broadband", BT press release, 9 October 2009

[2] "Openreach assesses FTTP economics", Total Telecom, 9 September 2009

BT's FTTP network presents risks to ongoing innovation and competition

Whilst the acceleration of NGA deployment in Britain is likely to be applauded from several quarters, it presents a major challenge to the competitive structure of the fixed broadband sector.

Specifically for BT's FTTP network, passive access in the form of local fibre unbundling is not practical given BT's technology choice of GPON. To satisfy prospective regulatory requirements for wholesale access, BT has instead proposed an active product, Generic Ethernet Access (GEA).

In its 2008 consultation on super-fast broadband, Ofcom noted that whilst active and passive products both have different strengths, and a mix of both are likely to be necessary, Ofcom considers that "passive products offer the most desirable means to promote of competition where economically sustainable."[3]

As demonstrated through LLU, passive access – where sustainable – can create dynamic efficiencies by enabling innovation by competitive network investment. Conversely, active access risks a loss of service differentiation and innovation, unless it provides deep control into the underlying network.

Duct access may enable sustainable infrastructure-based competition in NGA

In the absence of fibre unbundling, shared access to infrastructure ("duct access") presents a potential alternative passive remedy. As a passive remedy, duct access provides the freedom for CPs to innovate in their network whilst avoiding the high civil costs associated with new build. In this context, duct access can be viewed as an intermediate rung on the 'ladder of investment' in the access network.

As outlined above, BT's recent announcements suggest it is re-using its existing civil infrastructure in its FTTP deployment. Should this be the case, the cost to BT of deploying NGA will be significantly lower than that of a competitor that needed to construct an alternative infrastructure.

The business case for NGA deployments involving civil works is characterised by very high fixed costs, with return on investment largely driven by the adoption rate of NGA within the homes passed. Given these characteristics, it is possible that many areas will only be served by a single NGA network. Whilst the initial investment to deploy NGA in a given area would be contestable, any first-mover could secure an effective monopoly going forwards.

[3] "Delivering super-fast broadband in the UK", Ofcom, 23 September 2008

Taking this argument to its conclusion, BT may enjoy a competitive advantage when contesting the initial investment, with the possibility of effectively foreclosing future competition in access network infrastructure where it deploys NGA.

Duct access provides a possible remedy to address this issue on two fronts. Firstly, shared access would level the playing field for CPs in the initial investment decision. Secondly, the availability of duct access may lower the investment hurdle sufficiently to permit sustainable infrastructure-based competition in the access network.

Ofcom is undertaking a market review of Wholesale Local Access

Ofcom is currently undertaking a market review of Wholesale Local Access (WLA), EC market 4, which it plans to consult on in early 2010. As part of this review, Ofcom is considering a wide range of possible remedies that could be applied to address any findings of significant market power (SMP).

Duct access is one such remedy, and has received political interest both in the UK and internationally. At a European level, in its draft recommendations on regulated access to NGNs, the EC strongly recommends duct access as a potential remedy where SMP is found in market 4.[4]

In its March 2009 statement Ofcom noted that, “some players have indicated, for the first time, that they would be interested in using a duct access product.”[5]

Ofcom concluded in its statement that “the increase in interest in duct access and indications of unoccupied capacity found in our survey of BT’s ducts suggests that this option is worthy of further investigation. Duct access has the potential to form an important input for those considering new access infrastructure build. Experience from our duct survey and international duct access product offers will inform the next phase of our work to consider how the practical and operational issues can be overcome.”

1.2 Scope

This report assesses the potential for shared access to infrastructure to enable sustainable competition in next-generation access networks. The report documents the findings of research and analysis conducted by CSMG on behalf of Ofcom during the period November 2009 to January 2010.

The objective of the project was to investigate:

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[4] “Regulated access to NGA Networks”, EC Draft Recommendation, 12 June 2009

[5] “Delivering super-fast broadband in the UK”, Ofcom Statement, 3 March 2009

- The cost drivers for duct access;
- Differences in cost and benefits between FTTP networks based on duct access and other means of promoting competition;
- The cost savings achievable through duct access versus the cost of installing new, separate duct.

The results and conclusions of the study are provided as input into Ofcom's ongoing WLA market review.

1.3 Report Outline

The report opens with five international case studies of shared access to infrastructure in Section 2. The case studies were developed using a combination of desk-research and selective interviews. The countries selected provide a mix or regulated and commercial offers of both duct and pole access. The case studies include a discussion of the historical context; a summary of relevant regulation; details of current prices and the basis of pricing; operational matters; current issues; and, an indication of level of take-up.

Following the case study research, CSMG developed a bottom-up cost model to analyse the cost drivers of shared infrastructure access and compare the costs with those of alternative entry options.

Section 3 of the report analyses the cost of competition for shared infrastructure access. In this section, costs are viewed at an industry level and the variation in cost with respect to the number of entrants is analysed.

The costs from the perspective of a CP contemplating market entry are analysed in Section 4. The comparative economics of duct access versus new build and wholesale are assessed under a range of input conditions.

Section 5 documents primary research conducted by CSMG into the cost of new build network construction. This section analyses the costs of different construction methods under different conditions. Using the research findings, the cost of building an NGA network in an exchange area is also calculated.

The conclusions of the study are presented in Section 6.

2 INTERNATIONAL CASE STUDIES

2.1 Australia

2.1.1 Overview

Following the deregulation of the telecoms sector in 1991, the Australian government began to create laws to facilitate competition by mandating carrier infrastructure sharing. In 1999, the Facilities Access Code came into effect, specifying a set of processes and procedures that carriers must adopt in situations where they are unable to reach commercial agreement for access. The overall regime can be characterised as one in which commercial negotiation is the preferred route, with safeguards in place to resolve any disputes that arise.

All licensed carriers have an obligation to provide shared access. Some utility firms also do so on a commercial basis.

2.1.2 Historical Perspective

Regulated infrastructure access began in Australia in the late 1990s, although commercial arrangements between Telstra and Optus had been in place since 1991.

The Australian government adopted a policy of co-locating or sharing facilities to assist the entry of new carriers and simultaneously address the problem of environmental detriment from excessive duplication of telecommunications facilities.

The passage of the Telecommunications Act of 1997 provided for regulated access to telecom infrastructure and empowered the Australian Competition and Consumer Commission (ACCC) to define the conditions under which access was to be provided. In drafting the conditions, the ACCC drew on the existing commercial agreements.

2.1.3 Current Regulatory Framework

The Telecommunications Act of 1997 provides for regulated access to telecom infrastructure (i.e. transmission towers, tower sites, and underground facilities), subject to a limited right to refuse access on the grounds that it would not be technically feasible and providing, that the requesting carrier has provided reasonable notice, and that is seeking access for a *bona fide* telecommunications purpose.[6] The facilities access regime also provides that the terms and conditions of access must be agreed between the parties or, failing agreement, determined by an arbitrator appointed by the parties, with the Australian Competition and Consumer Commission (ACCC) acting as arbitrator of last resort.

[6] Part 5, Schedule 1 of the Telecommunications Act of 1997

The Act applies to all licensed telecommunications carriers. Whilst Telstra owns the largest access network in Australia, there are several other carriers with competitive access infrastructure, such as Optus' HFC network, which passes 1.4 million premises.

Pursuant to the Act, the ACCC published the Facilities Access Code in 1999.[7] The Code defines a set of processes and procedures that carriers must follow in the absence of commercially agreed terms and conditions. It exists as a safety net for circumstances where parties cannot agree terms, and acts as a template that can be used in preparing commercial contracts.

The Code is specified to apply on a non-discriminatory basis. Furthermore, carriers are required to take all reasonable steps to ensure that, as far as practicable, carrier customers receive timely provision of access that is equivalent to that which the carrier provides to itself.

The ACCC arbitrates disputes between carriers that are related to infrastructure access. The hearings are generally held in private, and the ACCC does not comment on disputes except to initially announce the parties and a brief description. There is currently one dispute related to access being heard by the ACCC: Pipe Networks, Ltd vs. Telstra Corporation.[8] Details on the dispute are unavailable.

2.1.4 Operational Model

Telstra offers sub-duct access as standard. Sub-ducts must have a 32mm outer diameter (28mm internal diameter) and are installed in vacant or partly occupied Telstra duct (usually 100mm diameter).

Following submission of plans to Telstra and approval of the work, the wholesale customer is responsible for construction, which may include laying sub-ducts, cables, and any other necessary facilities within Telstra's infrastructure. Contractors undertaking the work must be Telstra approved. (A list of approved contractors is available online and includes, e.g. Optus.)

Once complete, Telstra personnel jointly inspect the works with the carrier's personnel.

2.1.5 Capacity Management

In cases where granting access to facilities prevents the infrastructure owner from using the facility to meet currently forecasted needs, the ACCC will consider the cost to the infrastructure owner of foregoing or delaying its current plans. In determining the access

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[7] A Code of Access to Telecommunications Transmission Towers, Sites of Towers and Underground Facilities. ACCC, October 1999.

[8] http://www.accc.gov.au/content/index.phtml/itemId/635059#h3_110

charges in such cases, the opportunity cost to the infrastructure owner can be added to any modification costs to extend the original access to meet the forecasted needs.

2.1.6 Pricing and Rate Setting

Terms and conditions are negotiated commercially between carriers. Where the parties cannot reach an agreement the ACCC will arbitrate. In disputes over the price of access, the ACCC seeks to determine the price that would occur if the provider of access faced effective competition, i.e. cost-oriented pricing. Such pricing will be influenced by factors including asset age, location, investment risk and available capacity. Price determinations may be achieved through benchmarking or efficient-cost modelling.

Telstra's published fees for duct access comprise one-time charges associated with the provisioning process and recurring charges for occupying the facilities. Recurring charges include distance-based duct charges and additional fees for equipment housed within the duct infrastructure. In 2007 and 2008, Telstra's recurring charges included the following rates:

- AU$6.95 / metre / year (minimum AU$695 for first 100 meters)
- AU$556 / year for each joint or splice (assuming a volume of less than 0.032 cubic metres – this being the norm)
- AU$556 / year for each loop of cable or fibre (up to 40m in length) to be installed in pit or manhole

The recurring charges are adjusted annually based on the Consumer Price Index.

In its 2002 SEC filing, Telstra noted: "Access to these facilities and information is on commercially negotiated or arbitrated terms and conditions... The Communications Minister can determine pricing principles for access to customer cabling and equipment, network infrastructure and information relating to the operation of a network, but has not done so to date."[9]

2.1.7 Additional Charges

Telstra's one-time charges for duct access include:

- performing the desk and field studies;
- approving the design and construction proposal;
- inspecting the installed sub-ducts;
- updating relevant Telstra databases;

[9] http://www.secinfo.com/dvtJ1.2z.htm

- other administrative costs.

2.1.8 Access to Utility Infrastructure

Australia's energy utility companies have also provided wholesale access to their duct infrastructure. This access, however, is currently not regulated nor mandated by the government or the ACCC. An example of utility pole sharing is Project Vista, initiated by the Queensland government in 2008, in which Ergon Energy agreed to construct optical fibre links along new high voltage power lines[10].

Going forward, the Australian government intends to amend the Telecommunications Act to enable the National Broadband Network (NBN – see below) to access utility infrastructure where necessary.

2.1.9 Current / Outstanding Issues

In December 2007, the Australian government launched an initiative to subsidize the construction of the NBN which would provide FTTH access to 90% of Australian homes and businesses.[11] The network would take the form of a public-private partnership and receive a government subsidy of AU$4.7 billion.

The government subsequently issued an RFP in April 2008 for the construction of the NBN, but did not receive any acceptable proposals. In particular, Telstra's proposal was rejected for technical reasons. The government is progressing the NBN plans and has drafted legislation for new build developments.[12]

Access to Telstra's duct infrastructure is a live issue for this initiative, although much of the eventual deployment may be aerial.

In September 2009, the government announced a proposal to structurally separate Telstra into wholesale and retail arms. This issue is currently being deliberated and highlights the significance and value of existing infrastructure for building out next-generation networks.

2.1.10 Qualitative Impact Assessment

Anecdotal evidence indicates that duct access in Australia is popular for certain last mile applications, although no official statistics are published. Australia had less than 1% penetration with FTTx access technologies in 2008. LLU is more commonly used for residential customers. However, metropolitan fibre operators have made use of duct access

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[10] http://www.dip.qld.gov.au/projects/telecommunications/project-vista.html

[11] http://www.minister.dbcde.gov.au/media/media_releases/2009/022

[12] http://www.minister.dbcde.gov.au/media/media_releases/2009/119

in serving customers in the central business districts. Duct access is rarely used for long-haul, inter-city routes.

Some provincial governments have encouraged deployments of next-generation fibre networks in new housing developments. The Victorian government, for example, launched the Aurora project in 2006, with the goal of providing FTTH to approximately 8000 residents in Melbourne's northern suburbs through a public-private partnership with housing developers.[13] The Tasmanian government launched the TasCOLT project and successfully deployed a pilot FTTH network covering 1250 premises, which included homes and businesses.[14] The project involved a consortium of developers, utilities, and technology partners.

2.2 Canada

2.2.1 Overview

Infrastructure sharing in Canada began in the 1950s, when cable operators first began deploying cable television networks. The current regulatory environment combines regulated access to telecoms infrastructure at a national level, with access to municipal utility infrastructure regulated by local governments.

All incumbent local exchange carriers must provide shared access. At least some of the utilities in Canada also do so.

2.2.2 Historical Perspective

Infrastructure sharing has a long history in Canada, dating back to the early cable TV deployments which first began in the Quebec and Ontario provinces in the 1950s and 1960s. As early as 1966, the incumbent local exchange carrier (ILEC) in these provinces, Bell Canada (BC), was providing access to its infrastructure through the "partial system agreement".

Under the partial system arrangement, Bell Canada provided coaxial cable distribution networks for the cable operators with the cable operators owning the head-end equipment, amplifiers and final drops to their customers. The cable operators had to pay Bell Canada to install the coaxial cable and were then charged a rental fee for occupying BC's infrastructure. Bell Canada prohibited certain types of traffic on the infrastructure, denying the cable operators the potential to develop interactive services, pay TV or communications services. The cable industry was far from happy with this arrangement.

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[13] Communications Infrastructure and Service Availability in Australia (2008)

[14] TasCOLT Review-Report (2008)

In 1976, due to pressure from the cable industry, Bell Canada created a shared-access policy, allowing operators to use their own cables with BC's infrastructure. The new telecom regulator, the Canadian Radio-television and Telecommunications Commission (CRTC), approved the new agreement, referred to as the Support Structure Offering.

In 1999, Bell Canada began a withdrawal from the partial systems agreement, with cable tenants offered the option to purchase leased plant.

2.2.3 Current Regulatory Framework

The Telecommunications Act (1993) conferred the CRTC with the power to grant cable companies and telecommunication carriers access to the support structures of other carriers. Infrastructure sharing is recognised as providing competitive and environmental benefits.

The CRTC's jurisdiction does not extend to utility infrastructure. In 1999, the CRTC tried to regulate the attachment rates to municipal power utilities[15]. However, the Municipal Electric Association (MEA) appealed this decision to the Federal Court of Appeal in Canada, which overturned the CRTC's decision in 2003[16].

2.2.4 Operating Model

In its 1995 Decision, the CRTC directed ILECs to permit cable operators and telecommunications carriers to "construct, maintain and operate their own plant and equipment on or in telephone company support structures using their own labour force or contractor."

This does not remove the right of support structure owners to set and enforce construction standards, providing these are based on safety and technical requirements.

2.2.5 Capacity Management

ILECs are allowed to reserve capacity for future needs. Disputes may arise, however, between operators seeking access and ILECs denying access based on reserved capacity requirements. In these cases, the operator seeking access to infrastructure may petition the CRTC, who in turn will require the ILEC to justify current and anticipated capacity requirements. The decision ultimately lies with the CRTC in these cases.

2.2.6 Pricing and Rate Setting

The CRTC has the authority to review and approve telecom infrastructure access rates. Canadian ILECs submit tariff proposals to the CRTC, along with supporting materials such as

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[15] CRTC Telecom Decision No. 99-13

[16] Barrie Public Utilities v. Canadian Cable Television Association, [2003], 1 SCC 28 (16 May 2003).

cost studies, to get approval for standard rates they may charge companies accessing their infrastructure.

The CRTC policy on rates is that they should be sufficient to cover causally attributable costs and provide a contribution towards common costs. In a 1986 decision, the CRTC determined that a ceiling should be determined for the common cost contribution using a formulaic approach to minimize subjectivity[17]. However, in the 1995 decision, the CRTC accepted that the application of the formulaic approach had become unduly complex and had not achieved the desired level of objectivity[18]. The CRTC concluded that application of the formulae was no longer appropriate although the principal of cost recovery, for direct costs and an adequate contribution to common costs should continue.

ILEC rates were set in 1995 and prices are still capped at the same levels. ILEC rates are currently:

- CAN$9.60 / pole / year
- CAN$2.40 / 30m of strand / year[19]
- CAN$27.00 / 30m of conduit / year

In 2009, the CRTC initiated a proceeding to examine the infrastructure access rates of the largest ILECs (i.e. TELUS, Bell Aliant, Bell Canada, and MTS Allstream)[20].

2.2.7 Additional Charges

The regulatory regime that the CRTC has established for ILECs allows for additional charges. Additional charges include engineering search fees, repair and maintenance fees, and costs associated with modifications to infrastructure to allow for attachments.

2.2.8 Access to Utility Infrastructure

Access to the infrastructure of other utilities is not regulated by the CRTC, as noted above, but generally by local governments or public utilities commissions (PUCs). The rates set by utilities are generally much higher than the regulated rates offered by the ILECs. For example, the Ontario Energy Board approved a rate of CAN$22.35 / pole / year for attachments to electric distribution poles[21].

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[17] Telecom Decision CRTC 86-16

[18] Telecom Decision CRTC 95-13

[19] A strand is a steel cable that supports telecoms cables between poles

[20] Telecom Notice of Consultation CRTC 2009-432

[21] Telecom Notice of Consultation CRTC 2009-432

In Montreal, the Commission des Services Electriques de Montreal (CSEM) has the mandate to manage the city's underground utility and telecom infrastructure and encourage burying overhead wires[22]. The CSEM standardizes the construction of duct infrastructure in Montreal, with the cooperation of telecom operators, utilities, and developers. The CSEM also manages the rental of duct capacity.

2.2.9 Current / Outstanding Issues

Several provincial regulators have exercised jurisdiction over access to utility infrastructure, including the rates and terms of access, although not all provincial regulators have assumed this authority. This asymmetry in regulation leads to cases where network deployments are stalled or not possible. One example of regulatory failure involved a municipal-owned electrical utility that denied access to its poles by the local cable company. The utility had plans to lay its own fibre network and provide competitive services.

The Telecom Policy Review Panel was appointed in 2005 to recommend ways of modernizing Canada's telecom policy framework. In 2006, they recommended that regulatory oversight of infrastructure access to both utilities and telecom operators be given to a single regulatory body:

> The CRTC should be empowered to resolve disputes over the terms and conditions of access between telecommunications service providers or broadcasting distribution undertakings and third-party owners of support structures, including, but not limited to, support structures owned by electricity utilities, municipalities or other parties. Under this new regime, parties should be required to attempt to reach agreement on access, failing which the CRTC should be empowered to resolve any disputes and order access on terms and conditions, including rates that are binding on both parties[23].

There have been no recent policy decisions to rectify this situation so far.

2.2.10 Qualitative Impact Assessment

Infrastructure access in Canada began as a way to encourage investment in a nascent cable television industry. By enforcing access regulations and standardizing pricing, the government has been able to encourage industry growth.

Cable operators have been successful at deploying networks nationally, and are a major competitor to incumbent telecom operators. Cable operators captured 55% of high speed

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[22] Stratégies d'avenir: Commission des services electriques de Montreal (2005)

[23] Telecom Policy Review Panel - Final Report (2006)

internet subscribers in 2008.[24] Overall, cable operators and utilities with telecom services accounted for 20% of wireline telecom revenue in 2008, a revenue share which continues to trend upwards.[25]

2.3 France

2.3.1 Overview

In France, access to existing civil infrastructure in Paris has stimulated competitive investment in NGA. The French government and the national regulatory authority, ARCEP, have identified access to France Telecom's ducts as critical to the deployment of next-generation, fibre access networks on a broader scale.

Shared infrastructure access in France is offered by France Telecom and several municipalities.

2.3.2 Historical Perspective

Following the introduction of local loop unbundling, the French broadband market witnessed strong growth with France Telecom facing aggressive competition from new entrants such as Free (Iliad). Having built successful businesses on copper-based infrastructures, these operators then turned to fibre-based access to enable higher speeds.

Between 2006 and 2007, France Telecom, Free and Neuf all announced plans to deploy FTTX networks. The business case for deployment was made possible through re-use of existing infrastructure, which significantly lowered costs; France Telecom would re-use the ducts of its copper local loop network, whilst, Free and Neuf planned to install their fibre in the Paris sewer network[26].

In late 2007, ARCEP initiated a market review of Markets 4 and 5 (respectively the markets for: wholesale physical network infrastructure access; and, wholesale broadband access). The review found, *inter alia*, that France Telecom held significant market power in the national market for wholesale physical network infrastructure access. As a result of this determination, ARCEP imposed obligations, including local loop unbundling and access to the physical (civil) infrastructure, on France Telecom[27].

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[24] Communications Monitoring Report 2009

[25] See above

[26] ARCEP, "The FTTx stakes", July 2008

[27] ARCEP, Decision 2008-0835, 24 July 2008

2.3.3 Current Regulatory Framework

Regulated access to telecom infrastructure is overseen by ARCEP, the national telecom regulator. In addition, the Competition Authority hears cases that may involve France Telecom's abuse of its monopoly on telecom infrastructure in France.

Following the market review (July 2008), ARCEP imposed a number of obligations in regard to France Telecom's physical infrastructure, including the requirements:

- to grant reasonable requests for access;
- to make capacity available where constraints exist ("*desaturation*"); and,
- to provide planning information.

Access to infrastructure is to be provided on a non-discriminatory basis, with France Telecom further required to formalize internal transfer pricing and processes for self-supply to its own operations.

The decision also requires France Telecom to publish a reference offer for access to its infrastructure containing both technical and commercial details. Tariffs are to be cost-oriented (based on occupancy) and respect the principals of efficiency.

In response, France Telecom published the first version of its reference offer in September 2008. The most recent version was published in April 2009 following an operator pilot [28].

2.3.4 Operating Model

To obtain access to France Telecom duct work, a communications provider (CP) must submit a planning application. Once the necessary preliminary studies have been completed, France Telecom grants access permits for the facilities on the route.

CPs undertake their own installation work, subject to contractual conditions specified by France Telecom. The conditions include obtaining necessary authorizations and compliance with health and safety requirements. FT personnel must supervise work in secure chambers, i.e. chambers locked for reasons of health and safety or having particular strategic importance.

Subject to planning rules, CPs may install their cables in ducts or sub-ducts. Where a CP installs cables directly into a duct, that duct cannot be shared with other operators. The reference offer specifies further rules with respect to the size of cables, the percentage space cables and sub-ducts may occupy, and the order in which available space should be utilized.

[28] France Telecom, "Offre d'Accès aux Installations de Genie Civil de France Télécom pour les Reseaux FTTx", 29 April 2009

2.3.5 Capacity Management

As noted above, France Telecom is obliged to make capacity available for duct access. To manage capacity, the current reference offer contains details of a principle of *non-saturation*. Under this rule, CPs must leave one resource (e.g. sub-duct) available that is equivalent to that which they use for their own needs. The reference offer notes that this rule may change later in 2009.

In the case of capacity not being available on a specific route, the reference offer lists a number of potential solutions including the removal of redundant cables.

2.3.6 Pricing and Rate Setting

The pricing is calculated in relation to the amount of duct area that is occupied by the cable. The effective area is calculated by multiplying the cross-sectional area of the cable by 1.6^2.

The draft price for duct access is €1.20 / meter / cm^2.

2.3.7 Additional Charges

There are a number of additional charges listed in France Telecom's reference offer such as the provision of preliminary information including plans for the duct infrastructure (€89 per sheet) and desk-based feasibility studies (€278 per study). An order processing fee of €20 per chamber is also applied.

Where France Telecom personnel are required on-site, hourly rates range from €79.40 to €238.20 depending on the time of day (out of hours support is charged at double time) and the urgency of the request.

2.3.8 Access to Utility Infrastructure

The most notable example of utility infrastructure being used to carry telecommunication cables in France is the Parisian sewer network. The City of Paris leases space in the sewers for telecoms and other services, largely avoiding the need for expensive and disruptive street works. CPs serving the business market have been using the sewers for fibre deployment since the 1990s. However, it wasn't until 2006, when price cuts were introduced[29], that consumer-focussed CPs embarked on large-scale residential network builds.

[29] Wall Street Journal Europe (2006)

Beyond Paris, other municipalities have also made infrastructure access available for telecoms networks. For example, the city of Montpellier entered into a contract with Free under which the CP will build an open network using municipal infrastructure[30].

Some cable networks may also be counted as municipal ducts. Cable networks were typically rolled out under contracts with local governments for establishing and operating cable networks in their area. Some of these contracts are classified as "delegated public service contracts" and are essentially public-private partnerships. Recent law applies a principle of shared use of public civil engineering infrastructure for cable[31]. Due to the legal status of these public service contracts, many cable operators today are required to open access on the ducts that they operate in French towns. If cable operators do not comply with reasonable demands for access, municipal authorities may seize their ducts, albeit whilst providing them reasonable compensation.

2.3.9 Current / Outstanding Issues

None found specific to duct access.

2.3.10 Qualitative Impact Assessment

The large-scale competitive fibre deployments in Paris demonstrate the success that can be achieved through providing shared access to existing infrastructure. Key success factors include a large quantity of available space and a shared interest (between the operators and the city officials) in avoiding street works.

The latest report from ARCEP states that 700km of France Telecom's ducts are now shared.[32] Adoption of France Telecom's regulated offer has been quite slow to date as piloting the operational processes took longer than expected. There has, however, been a high amount of industry engagement in this activity, indicating a degree of latent demand.

2.4 Portugal

2.4.1 Overview

Access to Portugal Telecom's (PT) communications ducts was established by law in 2004. ANACOM, the national telecom regulator, actively monitors PT's offer and settles disputes

30 Association des Villes et Collectivités pour les Communications électroniques et l'Audiovisuel (2007)

31 Law no. 2008-776, "Modernizing the Economy"

32 ARCEP, "Scorecard for wholesale fixed broadband and ultra-fast broadband offers - 3rd Quarter 2009". 11 January 2010

with accessing operators. The duct access offer has generated increasing levels of interest and has already made a positive contribution to competitive FTTH deployment.

Beyond PT, it is unclear how many other infrastructure owners in Portugal provide shared access.

2.4.2 Historical Perspective

Portugal Telecom, the national incumbent telecom carrier, has provided shared access to its ducts and poles for cable operators since the 1990s. However, as a condition of PT's privatization in 2001, the company is required to allow other communications companies access to its infrastructure.

2.4.3 Current Regulatory Framework

Regulatory access to PT's ducts was established in the 2004 Law of Electronic Communications, which gave ANACOM the power to establish the rules regarding regulatory access to PT ducts, masts and other infrastructure[33].

In 2004,, PT Communications, by the direction of ANACOM, created the Reference Conduit Access Offer (ORAC). The reference offer sets the terms, costs, and obligations that an accessing operator must comply with before gaining access to PT's ducts[34]. Fees are determined on a cost-oriented basis.

In January 2009, a "Protocol on NGNs" was signed between the government of Portugal and four major operators (Sonaecom, PT, ZON Multimedia, and Oni Communications). In essence, the agreement confirms the government's commitment to the development of next-gen networks through enabling duct sharing, maintaining a centralized information system, and providing a minimum line of credit of €800 million. At the time of writing, Vodafone Portugal is the only major Portuguese operator which has not yet signed the agreement; it is still coordinating with other operators on the issues of infrastructure access.

2.4.4 Operating Model

To obtain access to PT infrastructure, operators must seek and receive authorisation from PT. Operators may use the Extranet, a PT maintained database of its duct infrastructure, to identify the ducts that they wish to occupy. The operator then requests PT to conduct a feasibility study and, if this is successful, receives authorisation.

[33] ANACOM, Law of Electronic Communications, Law 5/2004

[34] PT Wholesale, ORAC version 2.9, 27 August 2008

Access to ducts to deploy or repair infrastructure is allowed by the operator or by contractors/agents approved by the operator, in accordance with standard operational procedures.

PT can supervise the works and examine the cables, to ensure they meet all the required technical specifications. Standard charges are applied for time spent by PT personnel monitoring or supervising such activities, including:

- Access to points of entry;
- Installation of cables in ducts and associated infrastructure;
- Intervention in cables installed in ducts;
- Removal of cables installed in ducts.

The CP is also responsible for removing its cables from PT ducts once they are no longer required. Failure to remove cables within an allotted time period results in PT charging for the removal of cables by its own personnel.

2.4.5 Capacity Management

PT is required to reserve 20% of duct space for competitors. PT may reserve duct space for its own purposes for up to a year; such cases must be justified to ANACOM.

2.4.6 Pricing and Rate Setting

The ORAC reference offer specifies charges for occupying ducts and related infrastructure. Prices have to be cost-oriented. Duct access is calculated in terms of distance and cross-sectional area, with a higher charge applied in Lisbon and Porto versus other municipalities.

Monthly charge for occupying sub-conduit (30mm or 42mm):

- Lisbon/Porto: €10.60 / month / km / cm^2
- Other municipalities: €8.30 / month / km / cm^2

Monthly charge for occupying a main conduit:

- Lisbon/Porto: €9.80 / month / km / cm^2
- Other municipalities: €7.50 / month / km / cm^2

Occupancy fees for associated infrastructure:

- Entry point in a footway box / manhole: €1.80 / month
- Joint in a footway box / manhole: €3.90 / month
- Spare cable in a footway box / manhole: €2.70 / month

2.4.7 Additional Charges

PT maintains Extranet, an electronic database of its existing duct infrastructure, which enables operators to plan network builds based on PT infrastructure availability. Access to the database is through annual subscription with fees determined by the geographic regions for which an operator wishes to access records. There are 20 regions in total, with annual fees ranging from €1,390 to €18,842 per region.

PT also levies charges for certain administrative tasks such as new construction notifications and delivery of detailed construction documents.

2.4.8 Access to Utility Infrastructure

In addition to regulating access to PT infrastructure, Portuguese law also provides for access to ducts and poles installed on state-owned property to be offered on a non-discriminatory basis. This access is administered by local or state governments.

Furthermore, the Law of Electronic Communications empowers ANACOM to consult and make determinations regarding access to non-telecommunications infrastructure in specific cases where there are no viable alternatives. Grounds for such determinations can include environmental concerns, security and preservation of landscapes and heritage.

2.4.9 Current / Outstanding Issues

In a 2008 presentation, PT noted that the main problems with duct access related to:

- controlling access to operators;
- identifying levels of duct occupation;
- meeting the SLA; and,
- dealing with the volume of orders with limited support from information systems[35].

2.4.10 Qualitative Impact Assessment

ANACOM does not publish ongoing statistics on duct access deployment; however, PT confirmed that, as of October 2008, more than 12,000km of duct was being shared with operators.[36]

ANACOM does monitor and publish the number of information requests, the first stage in the process of obtaining access to PT ducts. ANACOM's latest figures show that interest in duct

[35] PT Communications, "ORAC Duct Sharing Offer.", 9 October 2008

[36] See above

access grew significantly in 2008, with 1,325 requests for information on duct infrastructure processed by PT in the final quarter of that year.

Further evidence pointing to the success of duct access in Portugal can be found in the FTTx deployment plans of Sonaecom, PT's primary competitor in the Portuguese market. Sonaecom has announced it intends to invest €240 million in a next generation access network passing one million homes.[37] Sonaecom has explicitly stated that it is avoiding civil works through duct access, which would account for the low cost per home passed (€240).

2.5 United States

2.5.1 Overview

In the US, national infrastructure access mandates began as a way to help the cable television industry grow in its early stages in the late 1970s. Policies were then expanded to encourage competition among telecom service providers in the late 1990s. The current environment is characterized by inter-modal competition between cable and telecom service providers.

Incumbent local exchange carriers and local electricity companies are required to provide shared infrastructure access.

2.5.2 Historical Perspective

Cable television started becoming available nationally in the late 1950-60s. Infrastructure sharing agreements existed during this time period, but it was not until 1978 that the FCC was given the authority to regulate prices for infrastructure access.[38] Support for this type of regulation grew out of the need to encourage investment in the cable television industry, by bringing down the costs of new builds. The regulated entities[39] included any company whose poles, ducts, and rights-of-way were involved at all in wire communication services. The law established that rates should not be higher than the cost of providing access to the infrastructure plus a portion of the operating expenses for maintaining the infrastructure.

Until 1996, infrastructure access regulation was used to encourage cable television investments by reducing the cost barriers for new builds. The Telecommunications Act of 1996 encouraged the creation of competitive local exchange carriers (CLECs), to generate competition in the voice and data services market. Infrastructure access regulation was

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[37] Sonaecom presentation at the Mid Cap Event Paris, 29 September 2008

[38] Public Law 95-234, February 21, 1978, "Communications Act Amendment of 1978"

[39] Utility is defined as any entity whose rates are regulated by Federal or State governments, and owns infrastructure used for the delivery of wire communication service. It does not include railroads, cooperatives, or Federal/State-owned entities.

extended to benefit CLECs, in addition to cable operators. At the time, cable operators had begun to expand beyond the traditional video offering to voice and data services.

The 1996 law had two important implications for infrastructure access pricing: (1) infrastructure access had to be provided on a non-discriminatory basis[40] and (2) the FCC was given two years to establish an official formula for determining reasonable rates.

In 1998 the FCC established maximum rate guidelines to be used for settling rate disputes between infrastructure owners and tenants. The rate formulae were changed slightly between 1998 and 2001.

From 2001 onwards, cable providers of video service have been subject to lower maximum rates than telecom service providers. At the time the FCC initially created its policies, cable and Telco companies were not significantly competitive with one another. Today, however, cable and Telcos are increasingly offering competitive services (e.g., voice, data, and video) and the FCC is considering a single-rate policy for pole rentals.

2.5.3 Current Regulatory Framework

Current regulation requires ILECs and utilities to provide shared infrastructure access to cable operators and CLECs. Infrastructure includes poles, ducts and rights of way. The FCC has established maximum rate guidelines using a cost-based approach. The maximum rate guidelines, do not apply to ILECs purchasing access because they have significant ownership stakes in existing infrastructure and generally have the power to negotiate favourable joint-use agreements.

Current legislation allows state-level regulators the jurisdiction to pre-empt FCC regulation and create their own infrastructure access rules. As of 2009, twenty states have established their own regulatory regimes.[41] State regulators are also responsible for regulating access to municipal-owned and cooperative utilities' infrastructure, as legislation exempts these entities from FCC regulation.

2.5.4 Operating Model

Verizon and AT&T both publish their offers for infrastructure access online.[42, 43] The operating models for both firms are similar.

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[40] Utilities that provided access to any cable operators or CLECs are required to provide access to all CLECs and cable providers at the same rates, terms, and conditions.

[41] As of November 2009: Alaska, California, Connecticut, Delaware, District of Columbia, Idaho, Illinois, Kentucky, Louisiana, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Oregon, Utah, Vermont, Washington

[42] http://www22.verizon.com/wholesale/business/poleconduit/home/

The first step in the process is a field survey to establish the availability and condition of the infrastructure. The infrastructure owner has primary responsibility for conducting the survey; the party seeking access may also attend and, depending on local operating procedures and labour restrictions, may be permitted to undertake some preparatory work.

Following the survey, the infrastructure owner is responsible for undertaking any Make Ready Work (MRW) deemed necessary. Again, subject to local conditions, some of this work may be assigned to the party seeking access.

Once the MRW is complete, the infrastructure owner issues an occupancy permit allowing the party seeking access to install its own cables in the specified facilities.

The infrastructure owner reserves the right to inspect the installation once complete, and periodically thereafter.

2.5.5 Capacity Management

Infrastructure owners are allowed to reserve capacity on their facilities for future expansion of their core product or service (e.g. electricity distribution for an electric utility or telecom service for an ILEC). They are, however, required to let others attach equipment to infrastructure even when it is reserved for future use. When the reserved capacity is required, the infrastructure owner can give notice to entities leasing space and require them to pay for modifications needed to expand capacity.

2.5.6 Pricing and Rate Setting

The FCC’s approach to rate setting allows individual companies to negotiate terms and conditions on commercial terms, subject to published maximum rate guidelines and formulae.[44] Should parties be unable to agree terms, the FCC recommends attempting to resolve the dispute through mediation. Failing that, a formal complaint can be lodged with the FCC.

The maximum rates are intended to allow the infrastructure owner to recover no less than its incremental costs of providing space for attachments to poles or ducts, but not more than the fully-allocated cost of owning and maintaining the pole.

The formulae that the FCC uses to determine reasonable costs are complex, with different factors being applied depending on the services being carried, and on whether the infrastructure owner is a Telco or a utility. Costs in the formulae are based on regulatory accounting data.

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[43] https://clec.att.com/clec/hb/shell.cfm?section=1714#_Toc392986872

[44] FCC, Docket 01-170 “Consolidated Partial Order On Reconsideration”, 25 May 2001.

For cable television systems that do not also provide telecommunications services, the maximum permissible annual pole attachment rate is determined based on the proportion of space occupied:

$$Maximum\ Rate = Space\ Factor\ \times Net\ Cost\ of\ a\ Bare\ Pole\ \times Carrying\ Charge\ Rate$$

Where:

$$Space\ Factor = \frac{Space\ Occupied\ by\ Attachment}{Total\ Usable\ Space}$$

Whereas for pole attachments that provide telecommunications services, the number of attaching entities is also considered in the Space Factor term:

$$Space\ Factor = \frac{Space\ Occupied + \left(\frac{2}{3} \times \frac{Unusable\ Space}{No.of\ Attaching\ Entities}\right)}{Pole\ Height}$$

Application of these formulae gives the following illustrative rates for a vertical foot of occupied space:

- Cable Rate: $5-7/pole/year
- CLEC Rate: $10-17/pole/year
- ILEC Rate: $13-20/pole/year

For duct access, the maximum linear rate is based on percentage occupancy as follows:

$$\text{Maximum Rate} = \text{Percentage of Conduit Capacity Occupied} \times \text{Net Linear Cost of Conduit} \times \text{Carrying Charge Rate}$$

Under this formula, duct pricing maxima range from $0.50 to $5.00 per metre.

2.5.7 Additional Charges

Allowable costs include pre-construction survey, engineering, make-ready work, and change-out costs incurred to prepare for cable attachments.

The FCC formulae do not cover costs associated with modifying poles or ducts to accommodate existing or future attachments. The terms and conditions covering the costs or fees associated with these services are negotiated between infrastructure owners and renters. Disputes are generally settled by the FCC.

2.5.8 Access to Utility Infrastructure

As outlined above, the FCC regulates access to the poles and ducts of electricity utilities.

2.5.9 Current / Outstanding Issues

Exemptions: ILEC and Municipal/Cooperative Utilities

ILECs do not currently benefit from FCC mandated rates for access to utility infrastructure. Typically, ILECs own infrastructure and are able to negotiate joint-use agreements with other utilities. Problems arise, however, in the case of rural utilities and ILECs. For example, rural ILEC, CenturyTel, claims to pay up to 50% more than CLECs for access to infrastructure. The problem occurs because rural ILECs may want to expand their networks in areas where they do not own any infrastructure. Negotiations can last years and still result in rates substantially above the CLEC rate for pole attachment.

Municipal and cooperative utilities are exempt from FCC regulation because they are typically governed by local authorities. These utilities might provide electricity or water, but may sometimes use their infrastructure to deploy fibre for telecom services. In these cases, they have an incentive to overcharge for access to keep out competition.

Cable VoIP

Cable companies that provide voice service to subscribers via VoIP claim they do not need to pay the higher telecom rate for pole attachments. They claim the VoIP service is technically data, which does not require them to pay the telecom rate. This issue will be resolved if the FCC establishes a single rate for pole attachments.

2.5.10 Qualitative Impact Assessment

Infrastructure sharing was nationally mandated in the US to encourage the growth of the cable industry in the 1970s. In the 1990s, infrastructure sharing expanded to telecom to encourage competition with the incumbent carriers. A high-level assessment of cable industry shows that the growth of cable may have been helped by mandated infrastructure sharing: in 1980, 22% of TV households were cable subscribers; by 1989 52% of TV households were cable subscribers.[45]

[45] SNL Kagan 2009

2.6 Summary

Country	Regulated / Unregulated	Date introduced	Pricing Summary	Examples of Additional Charges	Level of Adoption
Australia	• Regulatory requirement • Commercially negotiated with regulatory fallback	• Commercially since 1990s • Facilities Access Code introduced in 1999	• AU$6.95 / metre / year	• Feasibility study • Inspection of installation	• Popular, but little in last mile
Canada	• Regulatory requirement • Pricing set by NRA	• Since 1950s	• Duct: CAN$27.00 / 30m / year • Pole: CAN$9.60 / yr	• Surveys • Make ready work	• Cable operator use high
France	• Regulated offer • Pricing set by NRA	• Paris sewers since 1990s or earlier • FT reference offer introduced 2008	• €1.20 / meter / cm^2	• €278 per study • Supervision from €79 / hour	• 700km of FT at Sept. 09
Portugal	• Regulated offer • Pricing set by NRA	• Since 1990s • PT reference offer introduced 2006	• €7.50 - €10.60 / month / km / cm2	• Database access • Admin tasks	• 12,000km of PT duct at Oct. 2008
USA	• Regulatory requirement • Commercially negotiated with regulatory fallback	• FCC regulation since 1978	• Duct: $0.50-$5.00 / metre / year • Pole: $5-20 / year	• Surveys • Make ready work	• Believed to be high

Table 1: Summary of Case Study findings

3 COST OF COMPETITION UNDER DUCT ACCESS

3.1 Introduction

The static cost of competition is the additional cost caused by duplicative investment in infrastructure. To assess the cost of competition in duct access, CSMG developed a bottom-cost model that calculates the variation in the total cost to industry as the number of CPs increases.

The model considers a GPON network deployment in a single cabinet district, i.e. the geographic area served by a single PCP cabinet. Where cost items serve a greater area than a cabinet district, these are allocated on a *pro rata* basis, for example: fixed costs at the exchange.

The reference architecture for the network is presented below.

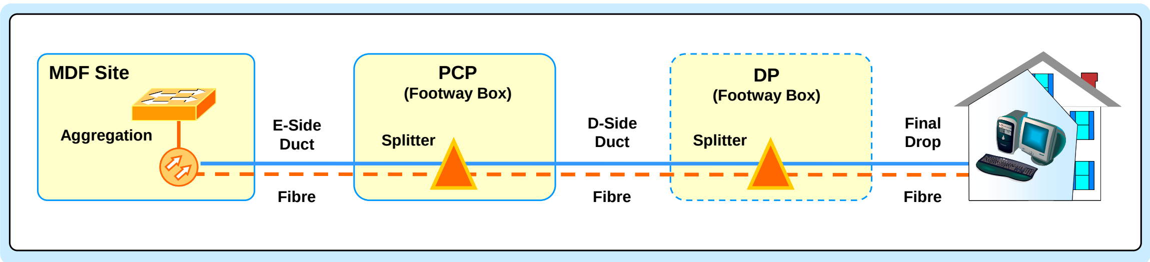

Figure 1: Reference Access Network Architecture

In calculating the total cost to industry, the costs incurred by Openreach and the CPs in building out their respective networks and connecting end customers are summed. Inter-operator costs (i.e. payments from CPs to Openreach) are excluded. The cost to industry as a whole provides an indication of the revenues that the industry would need to obtain to secure a return on its investment.

The model provides a static view of costs and is not time-series based. An annualized cost view is obtained through amortizing capital expenditure over the asset lifetime on a straight-line basis.

3.2 Key Assumptions

3.2.1 Scenario Definition

The Cost of Competition model considers three principal competitive scenarios. The characteristics of the scenarios are as follows:

One Overlay Network Openreach builds a FTTP GPON network re-using its existing duct network where possible, constructing new duct where required. Openreach owns the ducts, fibre, splitters, customer premises ONTs and the OLT located in the MDF. CPs serve customers using the Openreach GEA product.

Two Overlay Networks In addition to the network deployed by Openreach in the "One Overlay Network" scenario, a CP builds a second FTTP GPON network. The CP lays its fibre in Openreach ducts. Both the CP and Openreach own their own end-to-end networks in terms of fibre, splitters, customer premises ONTs and the OLT located in the MDF.

New Build A CP builds an FTTP GPON network using new ducts throughout. The CP owns the ducts, fibre, splitters, customer premises ONTs and the OLT located in the MDF. The new build scenario does not include the cost of Openreach deploying a parallel network.

In addition to these principal competitive scenarios, the economic analysis is subsequently extended to consider scenarios in which there are three and four overlay networks. In these scenarios, as with the Two Overlay Network scenario, the CPs and Openreach each deploy their own FTTP GPON networks using Openreach ducts.

3.2.2 Geotypes

Two geotypes were selected for the model – a dense urban exchange area, and a suburban exchange area with long loop lengths. The characteristics of the geotypes are based on those defined in the BSG report on NGA deployment produced by Analysys Mason[46].

Whilst these geotypes provide a good point of reference, it should be noted that the cabinet (PCP) sizes given are higher than the UK average which is closer to 300 lines per PCP. The majority of premises in the UK are served by cabinets smaller than those in the model.

Quantity	BSG Geotype	Lines per PCP	DPs per PCP	Lines per DP
Urban	>500k pop	500	63	8
Suburban	>20k lines (b)	400	50	8

Table 2: Network hierarchy assumptions by geotype

[46] AMG "The costs of deploying fibre-based next-generation broadband infrastructure", Sept 2008

The assumed duct lengths allow for a proportion of duct route common to multiple destinations as shown in the figure below.

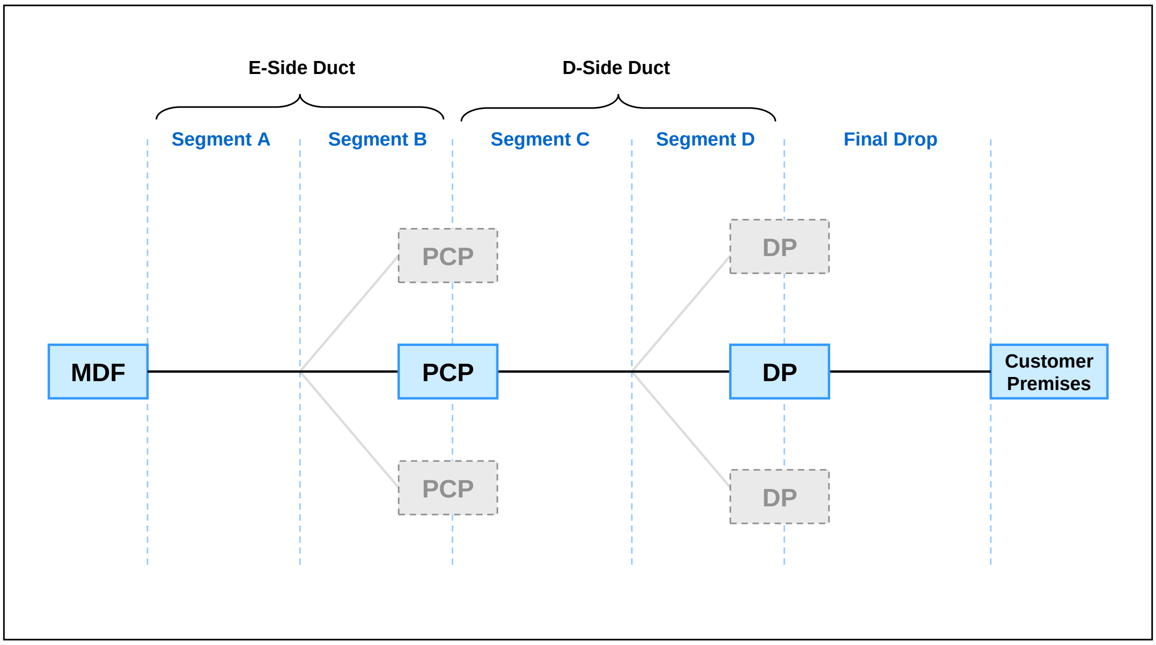

Figure 2:   Duct topology showing common duct segments

The duct lengths of each segment are also sourced from the BSG report.

Distance [m]	Segment A	Segment B	Segment C	Segment D	Final Drop
Urban	359	1,076	280	49	15
Suburban	778	2,335	579	102	33

Table 3: Route distance assumptions by geotype

3.2.3 Infrastructure Reuse

The ability to reuse some existing duct infrastructure was factored in to the model. The assumed amount of duct reuse is shown in the table below. In practice, the degree to which existing infrastructure can be reused is likely to vary by geography. This is particularly true of the final drop which may be based on duct, micro-duct, pole or direct-buried cable. To account for this, alternative reuse assumptions were tested in the sensitivity analysis at the end of this section.

Component	Proportion of existing infrastructure reused	Source
E-Side duct	50%	Ofcom
D-Side duct	80%	Ofcom
Final Drop	50%	Ofcom
PCP footway box	100%	CSMG industry research
DP footway box	40%	CSMG industry research

Table 4: Infrastructure reuse assumptions

3.2.4 Cost Assumptions

Costs in the model are based on industry sources and benchmarks.

Civil Works	Cost	Source
E-Side and D-Side ducts	£90 / m	CSMG industry research
New footway box	£1,750	Openreach price list

Table 5: Civil Works cost assumptions

Passive Network	Cost	Source
E-Side Fibre	£2.22 / metre	CSMG industry research
D-Side Fibre	£0.76 / metre	CSMG industry research
E-Side Fibre installation	£1.02 / metre	CSMG industry research
D-Side Fibre installation	£1.17 / metre	CSMG industry research
GPON splitter	£70	Analysys for BSG

Table 6: Passive Network cost assumptions

Active Network	Cost	Source
GPON OLT (32-port)	£57,600	Analysys for BSG
GPON ONT (CPE)	£90	CSMG industry research
Rack and power supply	£6,305	Openreach price list

Table 7: Active Network cost assumptions

Final Drop and CPE	Cost	Source
Duct	£35 / metre	CSMG industry research
Fibre	£1.30 / metre	CSMG industry research
Fibre installation	£200 / home	CSMG industry research
CPE (ONT)	£90	CSMG industry research

Table 8: Final Drop and CPE cost assumptions

The scope of the model is a single cabinet district. Where equipment located at the MDF is oversized for the needs of a single cabinet district (e.g. the OLT), an allocation of costs is taken based on the share of capacity used.

3.2.5 Asset Lifetimes

The model uses costs amortized by asset lifetime to provide an annualised cost view. The lifetimes of the various asset categories are presented in the table below.

Asset Category	Asset Lifetime
Civil Works	20 years
Passive Network	10 years
Active Network	5 years
CPE	3 years

Table 9: Asset lifetime assumptions

3.3 Model Outputs

3.3.1 Cost Categories

In the outputs charts, costs are grouped as follows:

Cost Category	Cost Line Items	Cost Category	Cost Line Items
Civils	E-side duct D-side duct New footway boxes	Final Drop	Final drop duct Final drop fibre Customer installation
Passive	Fibre optic cables GPON splitters	CPE	CPE
Active	GPON OLT Exchange rack and power supply	Network Opex	Maintenance costs

Table 10: Cost category definitions

3.3.2 Base case assumptions

The analysis in sections 3.3.3 through 3.3.7 adopts the following core base case set of assumptions

- The ability to reuse duct infrastructure is independent of the number of NGA networks seeking access
- CPs install their splitters in Openreach footway boxes with Openreach building new boxes where reuse of existing infrastructure is not possible
- CPs deploy their own fibre in the final drop. In scenarios with multiple CPs, the average number of drops per connected premises is assumed to be 1 plus 0.5 drops per CP (e.g. 1.5 drops per premises in the Two Overlay Network scenario)

The analysis in sections 3.3.8 and 3.3.9 tests alternatives to these base case assumptions. In section 3.3.8, the economic impact of duct reuse being dependent on the number of CPs is tested. Section 3.3.9 considers the impact of footway box duplication, i.e. CPs deploying their own footway boxes to house their splitters.

3.3.3 Upfront Fixed Costs

This analysis considers the fixed set-up costs to industry of building out a GPON network to pass all premises in the cabinet district under the three modelled scenarios. This view of costs excludes all subscriber variable costs such as the final drop and CPE. Only capital costs are included; recurring network operational costs (maintenance) are excluded.

The fixed costs for the urban and suburban geotypes are shown in the charts below.

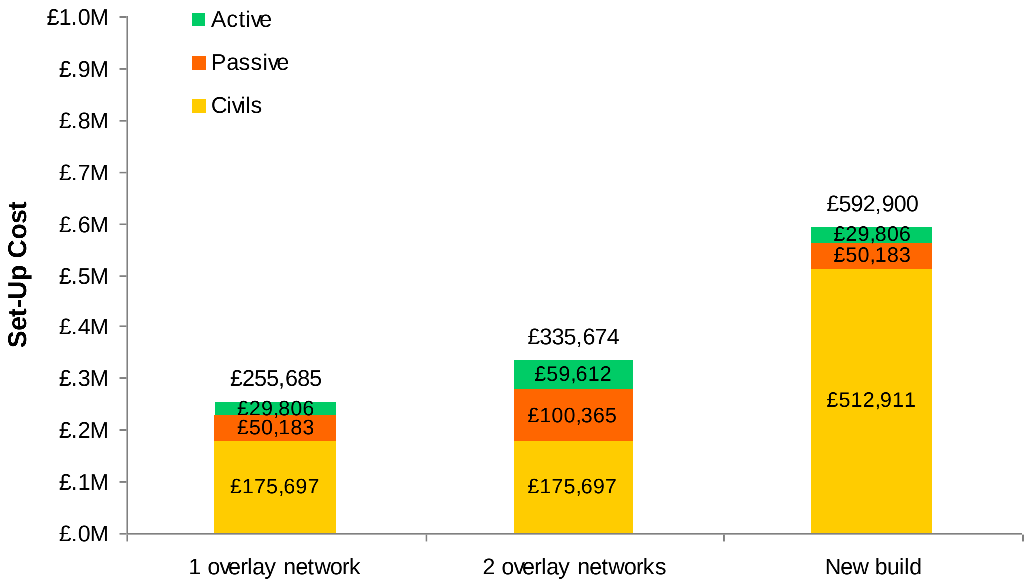

Figure 3: Fixed Cost to Industry - urban geotype

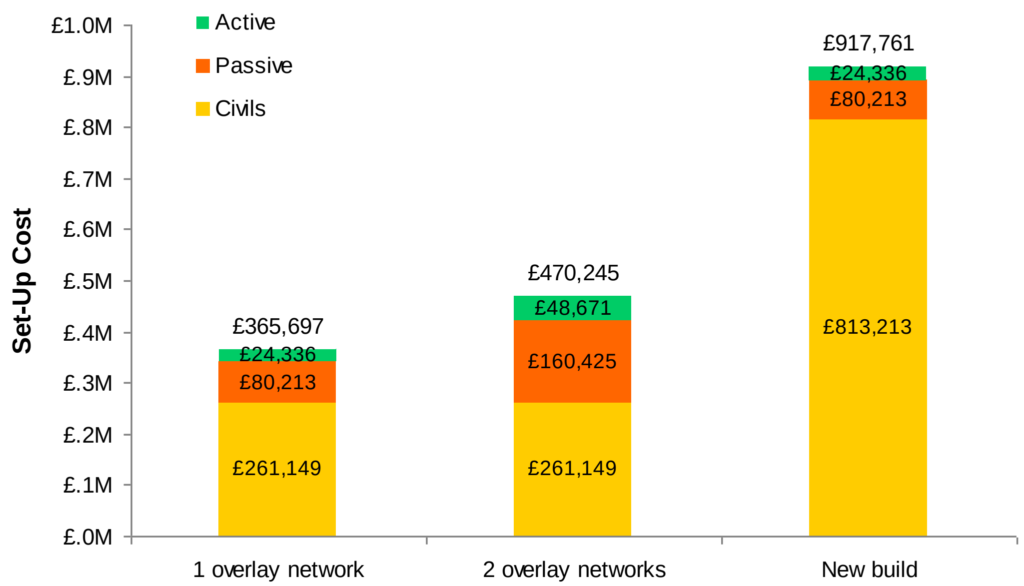

Figure 4: Fixed Cost to Industry - suburban geotype

The results for the One Overlay Network scenario show that under the given assumptions, the cost for Openreach to build out a network to pass all the premises in the urban geotype is £255,685. This includes the cost of building new ducts (where reuse is not possible), laying fibre, the GPON OLT and splitters.

The Two Overlay Network scenario adds the costs of a second GPON network and assumes that no additional new ducts are required (compared with the One Overlay Network scenario). Hence the Civils costs are the same across these scenarios whilst the Active and Passive network cost categories are duplicated.

The Civils costs in the New Build scenario are considerably higher than in the Overlay Network scenarios as this scenario assumes new ducts throughout. The difference between the cost totals for the New Build and One Overlay Network scenarios represents the cost that Openreach avoids in the latter case through reuse of existing infrastructure – £337,000 and £552,000 in the urban and suburban geotypes respectively.

The suburban geotype, despite having fewer premises than the urban, requires significantly higher expenditure on Civils due to the greater distances between the exchange, PCP and customer premises.

3.3.4 Annualized Fixed Costs

Viewing the fixed costs on an annualised basis provides a proxy for the level of returns a CP would require to cover the cost of its network investment. In the following charts, the line item costs are amortized by year according to their asset life. The annual costs of network maintenance are also included here under the Network Opex category[47].

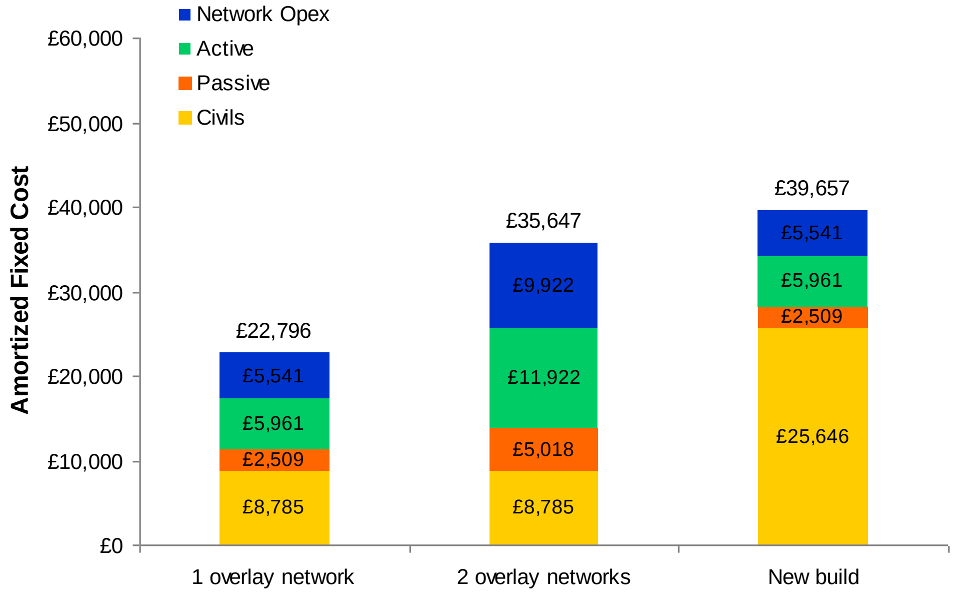

Figure 5: Annualised Fixed Cost to Industry - urban geotype

[47] Note that the analysis excludes the maintenance cost of reused existing duct.

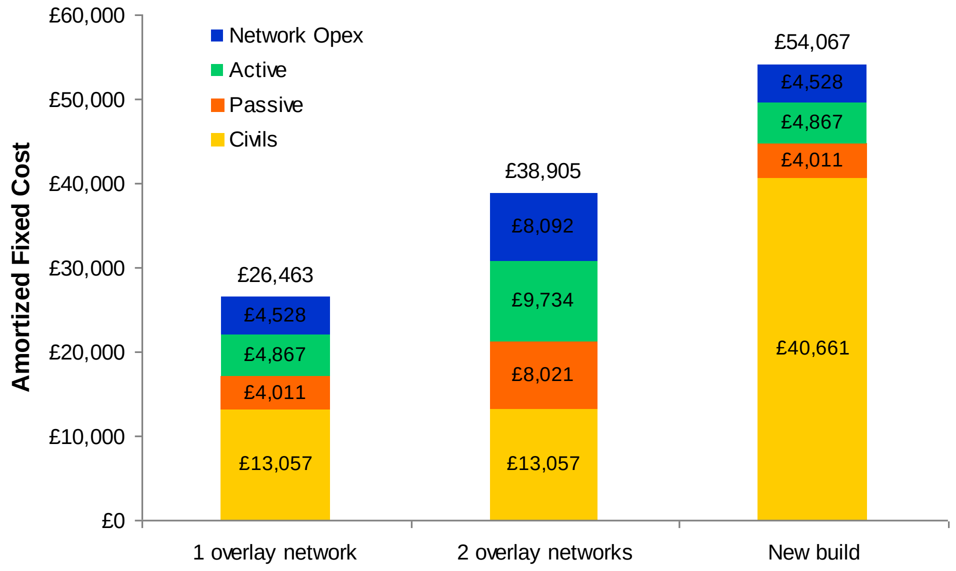

Figure 6: Annualised Fixed Cost to Industry - suburban geotype

In the annualised view of costs, the Civils category is less dominant due to the longer asset lives assumed for assets in this class.

On an annualised basis, the cost of New Build is approximately double that of the One Overlay Network scenario. This implies that if Openreach were to achieve the assumed levels of duct reuse, the contribution from revenues required to cover fixed costs (exclusive of existing duct maintenance) could be roughly halved versus new build.

3.3.5 Subscriber Variable Costs

Adding the subscriber variable costs to the fixed costs in the preceding sections provides a total view of network costs to industry. Throughout the report we assume 31% penetration to align with the value used in the BSG NGA report.

The cost stacks below show the total expenditure required to serve 31% of the premises in the cabinet district. The additional cost comprises the following line items:

- Construction of new duct in final drop where reuse not possible;
- Laying final drop fibre from the DP to the end-user premises;
- Customer Premises Equipment (a GPON ONT).

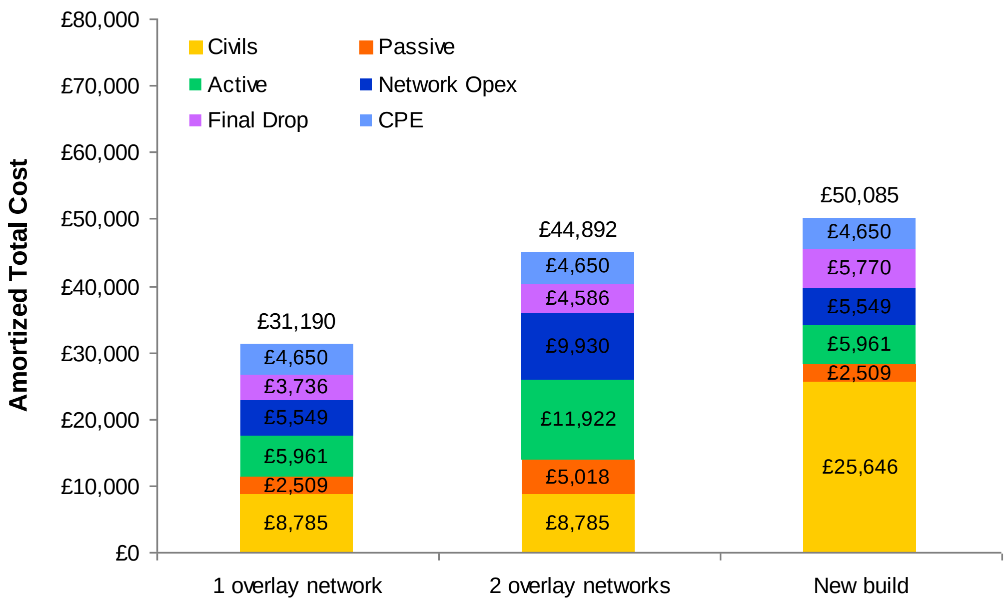

Figure 7: Annualised Cost to Industry at 31% penetration – urban geotype

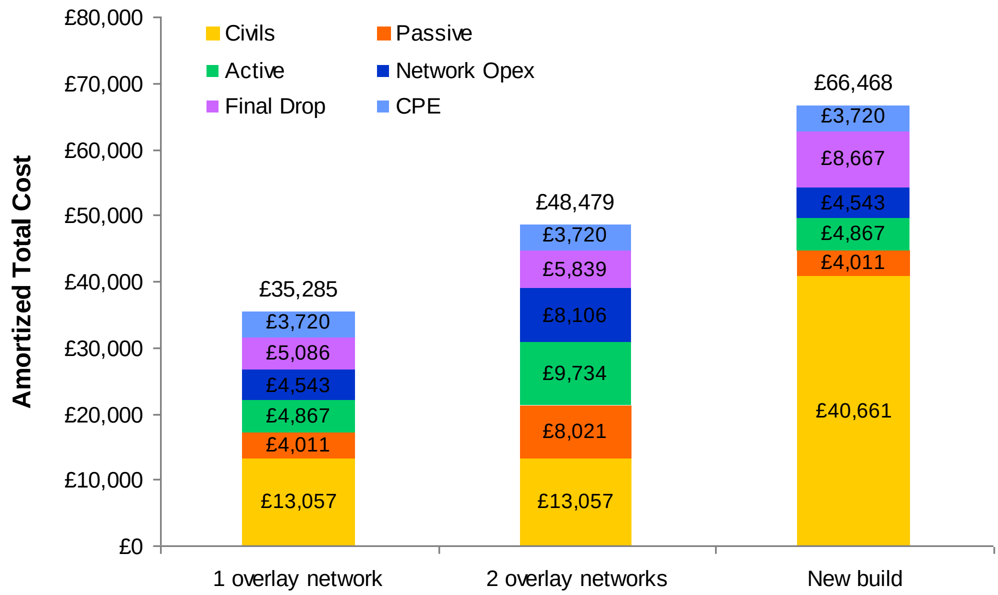

Figure 8: Annualised Cost to Industry at 31% penetration – suburban geotype

The increase in the costs of the final drop between the one and two overlay network scenarios is caused by the additional fibre and installation charges arising from premises served by both networks. The higher figure for the New Build scenario is due to the need to install all final drop ducts as new.

Note also that there is a small increase in the Network Opex across all scenarios versus the fixed cost stacks shown in Section 3.3.4 due to the cost of maintaining the final drop infrastructure.

As would be expected, the CPE cost is independent of scenario.

3.3.6 Cost per Premises

To compare the scenarios on a cost per premises basis, the costs in the above charts are divided by the number of premises served. Set-up costs are divided by the total number of premises in the cabinet district to determine the cost per home passed. To calculate the cost per home connected, the total costs (inclusive of Network Opex) are divided by only the number of premises connected. For reference, the incremental capex cost per connection is also provided. All costs are presented on an annualised basis.

In the following tables the scenarios are extended to show the costs with three and four overlay networks. The model assumes an additional 0.5 final drops per premises for each additional CP. The New Build scenario is also shown for comparison purposes.

Annualised Cost [£]		One Overlay Network	Two Overlay Networks	Three Overlay Networks	Four Overlay Networks	New Build
Urban Geotype	Set-up cost per premises passed [500 premises]	35	51	68	85	68
	Total cost per premises connected [at 31% penetration]	201	290	378	466	323
	Incremental cost to connect a premises	54	60	65	71	67
Suburban Geotype	Set-up cost per premises passed [400 premises]	55	77	99	121	124
	Total cost per premises connected [at 31% penetration]	285	391	497	604	536
	Incremental cost to connect a premises	71	77	83	89	100

Table 11: Annualised cost per premises

The following chart illustrates graphically the components of the incremental connection cost between the two cells highlighted in the table above, i.e. in going from one network to two.

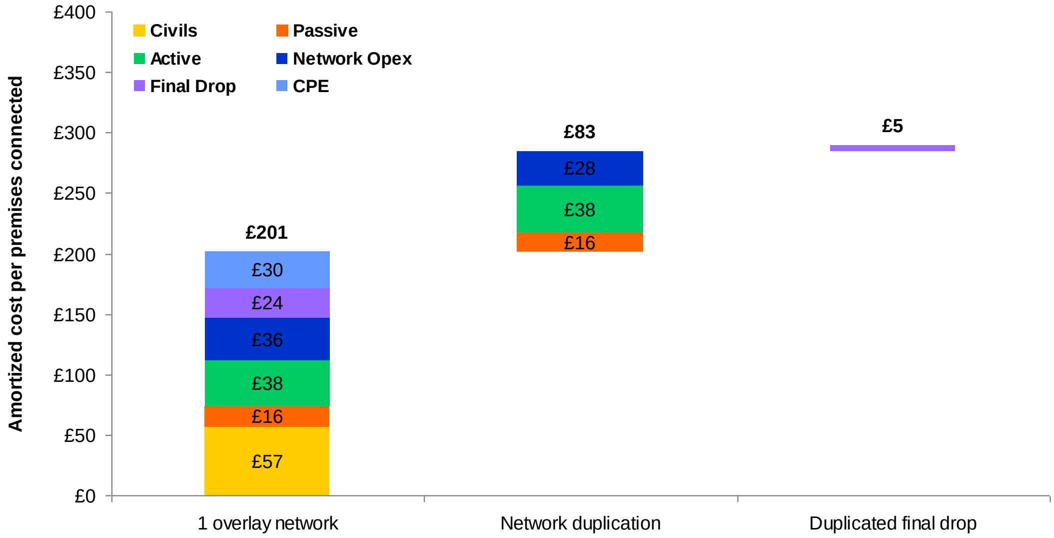

Figure 9: ***Contribution of second network to cost per connection – urban geotype***

The preceding chart and table consider the cost per connection at a fixed penetration of 31%. The chart below illustrates how the cost per connection varies with penetration.

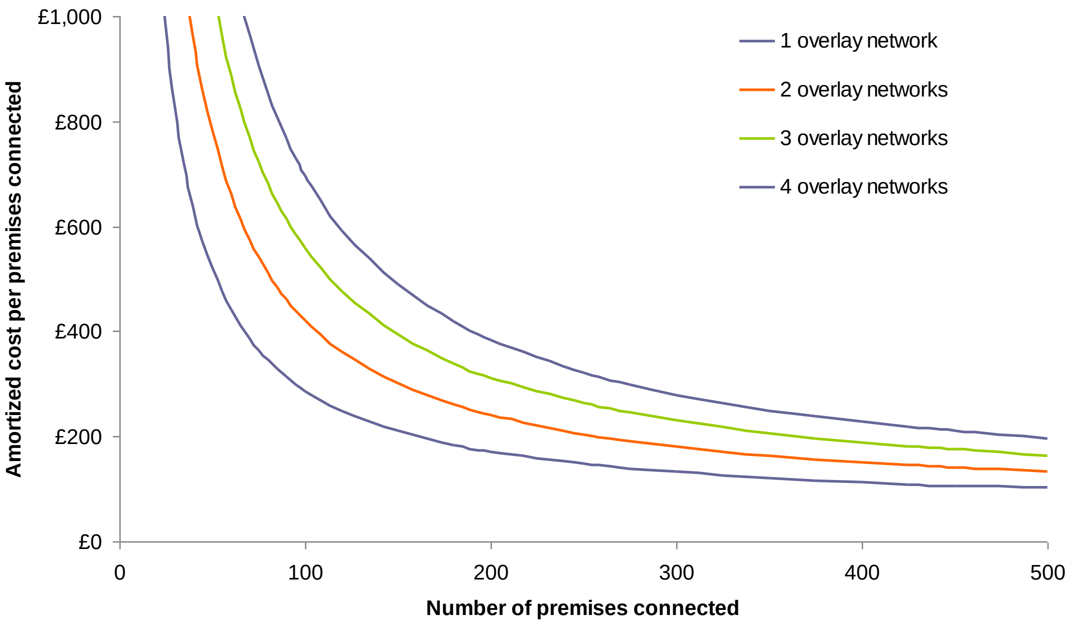

Figure 10: ***Annualized Cost per Connection to Industry - urban geotype***

The chart above shows how at increased scale, the fixed costs are amortized over more premises and the curves trend towards the variable cost. However the shallow curve of the lines in the chart shows that a significant share of the total premises in the cabinet district must be connected to achieve efficient scale. For the single network scenario in the urban geotype, the cost curve has substantially flattened out by 200 lines representing 40% penetration. With infrastructure competition, the number of premises required to achieve efficient scale is higher still.

3.3.7 Cost of Competition under Duct Access

The static cost of competition is the incremental cost at an industry level resulting from duplicative investment.

The cost of competition is calculated as the increase in the per-connection cost compared with the One Overlay Network scenario as shown in the following table. Assessing this on a per premises basis provides insight into the additional subscriber revenue that would need to be raised by industry to achieve the same level of returns.

Annualised Cost [£]		One Overlay Network	Two Overlay Networks	Three Overlay Networks	Four Overlay Networks
Urban Geotype	Total cost per premises connected [at 31% penetration]	201	290	378	466
	Cost of competition per connection	n/a	**88**	**177**	**265**
Suburban Geotype	Total cost per premises connected [at 31% penetration]	285	391	497	604
	Cost of competition per connection	n/a	**106**	**213**	**319**

Table 12: Static cost of competition

The table shows that each additional network adds £88 to the annualised cost of a connection in the urban geotype and £106 to a connection in the suburban geotype, assuming 31% penetration in both. In the most competitive scenario, with four competing infrastructures, this equates to £265 and £319 additional cost per premises respectively.

3.3.8 Impact of FTTP NGA deployment on duct reuse

The base case in the model assumes that the ability to reuse duct infrastructure is independent of the number of FTTP networks deployed in the existing ducts. However, in practice it is likely that the available space in some ducts will be insufficient to accommodate multiple networks.

To show the impact of this effect on the cost of competition, we have repeated the analysis with impaired duct reuse factors as shown in the table below.

Competitive Scenario	One Overlay Network [base case]	Two Overlay Networks	Three Overlay Networks	Four Overlay Networks
E-Side	50%	45%	40%	35%
D-Side	80%	75%	70%	65%
Final Drop	50%	45%	40%	35%

Table 13: Impaired duct reuse factors to allow for NGA congestion

The results of this analysis are shown in the following table.

Annualised Cost [£]		One Overlay Network	Two Overlay Networks	Three Overlay Networks	Four Overlay Networks
Urban Geotype	Set-up cost per premises passed [500 premises]	35	53	72	91
	Total cost per premises connected [at 31% penetration]	201	297	394	490
	Cost of competition per connection	n/a	**96**	**192**	**289**
Suburban Geotype	Set-up cost per premises passed [400 premises]	55	82	108	135
	Total cost per premises connected [at 31% penetration]	285	408	535	656
	Cost of competition per connection	n/a	**124**	**248**	**372**

Table 14: Cost of competition allowing for NGA congestion in shared ducts

Comparing the results in the table above with the base case in Table 11 shows that the cost of competition per network would increase from £88 to £96 in the urban geotype, and from £106 to £124 in the suburban geotype. The increase in the cost of competition is equal to the amortized per-subscriber cost of the additional ducts that must be replaced.

3.3.9 Impact of Footway Box Duplication

The base case assumes that under duct access, CPs install their splitters in Openreach footway boxes with Openreach building new boxes where reuse of existing infrastructure is not possible. An alternative implementation model would be for each CP to install its own footway boxes and interconnect these with the Openreach duct network.

The following table shows the impact on the cost of competition if each CP were to deploy its own footway boxes. The cost of passing and connecting premises is also shown.

Annualised Cost [£]		One Overlay Network	Two Overlay Networks	Three Overlay Networks	Four Overlay Networks
Urban Geotype	Set-up cost per premises passed [500 premises]	35	63	91	119
	Total cost per premises connected [at 31% penetration]	201	326	450	575
	Cost of competition per connection	n/a	**125**	**249**	**374**
Suburban Geotype	Set-up cost per premises passed [400 premises]	55	88	122	155
	Total cost per premises connected [at 31% penetration]	285	427	569	712
	Cost of competition per connection	n/a	**142**	**285**	**427**

Table 15: Cost of competition with Footway Box duplication

Comparing the results in the table above with the base case in Table 11 shows that the cost of competition per network would increase from £88 to £125 in the urban geotype, and from £106 to £142 in the suburban geotype. The increase in the cost of competition is equal to the amortized per-subscriber cost of the additional footway boxes.

3.3.10 Sensitivity Analysis by Cost Category

The sensitivity of the set-up costs and cost per connection to variations in the input costs was tested. The following table shows the impact on the cost of the One Overlay Network case with a 10% variation in the input costs. Sensitivity outputs are shown for both the upfront cost of coverage (set-up costs) and the annualised view of total costs at 31% penetration.

Variation in Cost	Upfront Set-Up Costs		Annualised Total Costs [at 31% penetration]	
Geotype	**Urban**	**Suburban**	**Urban**	**Suburban**
Civil Works	6.9%	7.1%	2.8%	3.7%
Passive Network	2.0%	2.2%	0.8%	1.1%
Active Network	1.2%	0.7%	1.9%	1.4%
Final Drop	-	-	1.2%	1.3%
CPE	-	-	1.5%	1.4%
Network Opex	-	-	1.8%	1.1%

Table 16: Sensitivity of One Overlay Network outputs to input cost variation

The results show that the fixed set-up costs are most sensitive to the cost of the civil works. This is not surprising given the dominance of civils costs in the upfront cost stack. The active network is the least significant cost component, particularly in the suburban geotype due to the higher volumes of duct and fibre required.

Civil costs are again the most sensitive input category in the annualised view of total costs. This is despite the higher lifetime (20 years) of this asset class.

3.3.11 Sensitivity to Duct Construction Costs

Duct construction costs are dependent on multiple factors including type of terrain, construction method, wayleave costs, traffic management costs and the presence of other underground services. The actual cost per metre in a given location could be higher or lower than the base cost (£90/m) used in the model. The sensitivity of the model to this specific input was therefore tested against a “high” and “low” case shown in the table below.

Note that in some circumstances construction costs may be even higher (e.g. central London) or lower (e.g. bare earth) than these inputs.

Cost [£]	Duct construction
Base case	£90/m
High case	£140/m
Low case	£60/m

Table 17: Alternative duct construction costs for sensitivity analysis

The following charts show the impact of the alternative construction costs on the upfront fixed costs in the two geotypes.

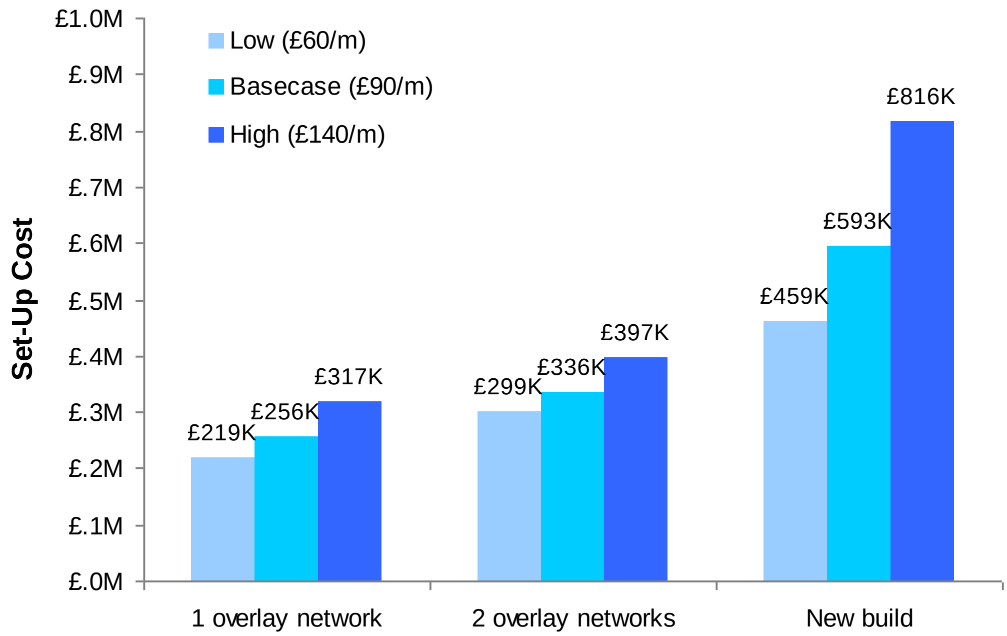

Figure 11: Fixed costs in urban geotype with alternative duct construction costs

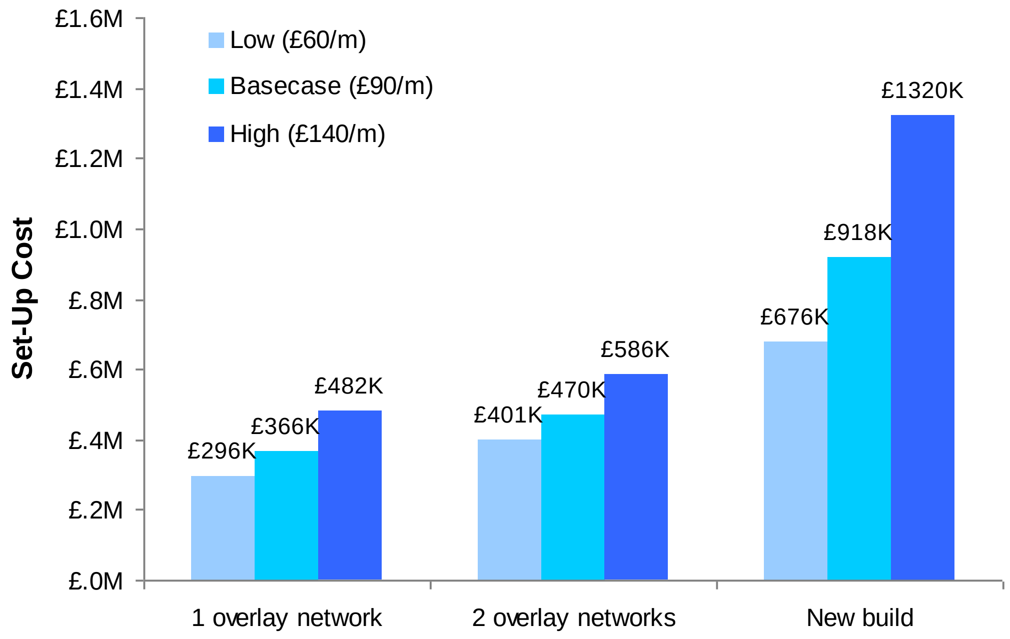

Figure 12: Setup costs in suburban geotype with alternative duct construction costs

The impact of the sensitivity adjusted construction costs on the cost per home passed is shown in the following table.

Annualised cost [£]		One Overlay Network	Two Overlay Networks	New Build
Urban Geotype	Low case (£60/m)	31	48	55
	Base case (£90/m)	35	51	68
	High case (£140/m)	41	58	91
Suburban Geotype	Low case (£60/m)	46	68	94
	Base case (£90/m)	55	77	124
	High case (£140/m)	69	92	174

Table 18: Cost per home passed under alternative duct construction costs

The range of duct construction costs tested has a significant impact on the cost per home passed. The impact is most pronounced in the New Build scenario as there is no reuse of existing infrastructure. In the urban geotype, the high case is 65% higher than the low case. In the suburban geotype this difference is 85% due to the greater distances involved.

Although significant in terms of cost to industry, the duct construction cost does not affect the absolute cost of competition within the duct access scenarios as there is only ever a single duct irrespective of number of CPs. In fact, in percentage terms the cost of competition will fall as the absolute costs increase.

3.3.12 Sensitivity to Infrastructure Reuse in the Final Drop

The opportunity to reuse duct in the final drop is dependent on many factors. In some areas, pole distribution is the norm for Openreach; in others direct buried cable has been employed. Where ducts are available, the bore varies by area and some ducts may be too small to support NGA overlay.

Given the wide variability in the opportunity to reuse ducts in the final drop, the sensitivity of the total costs at 31% penetration to this input was tested against a "high" and "low" case shown in the table below.

Reuse	Final drop duct
Base case	50%
High case	80%
Low case	30%

Table 19: Alternative duct reuse factors for sensitivity analysis

The following charts show the impact of the alternative duct reuse factors in the One and Two Network Overlay scenarios. New Build is not included as there is no duct reuse in this scenario.

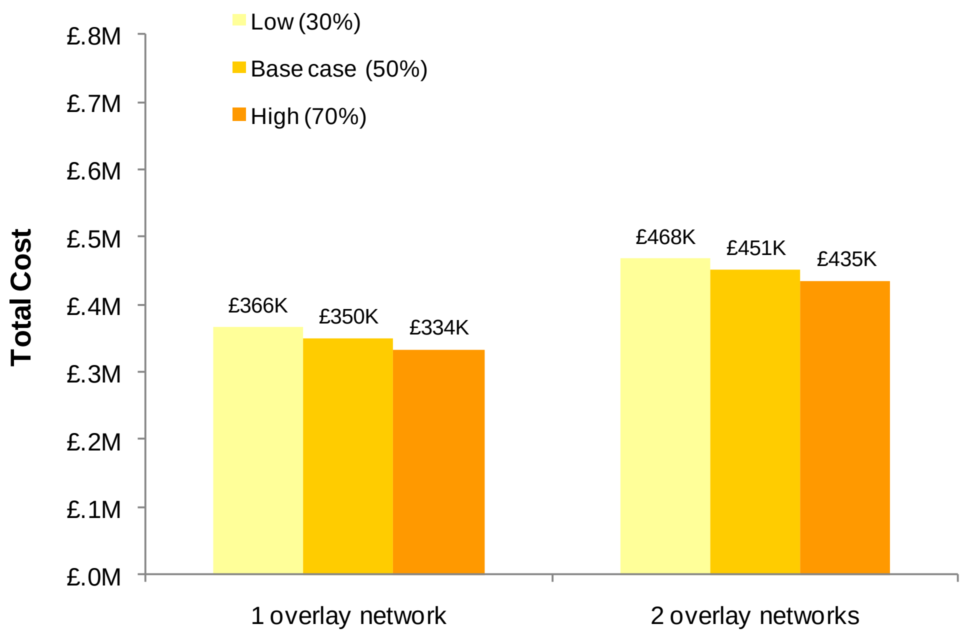

Figure 13: ***Total costs in urban geotype at 31% penetration with alternative assumptions for final drop duct reuse***

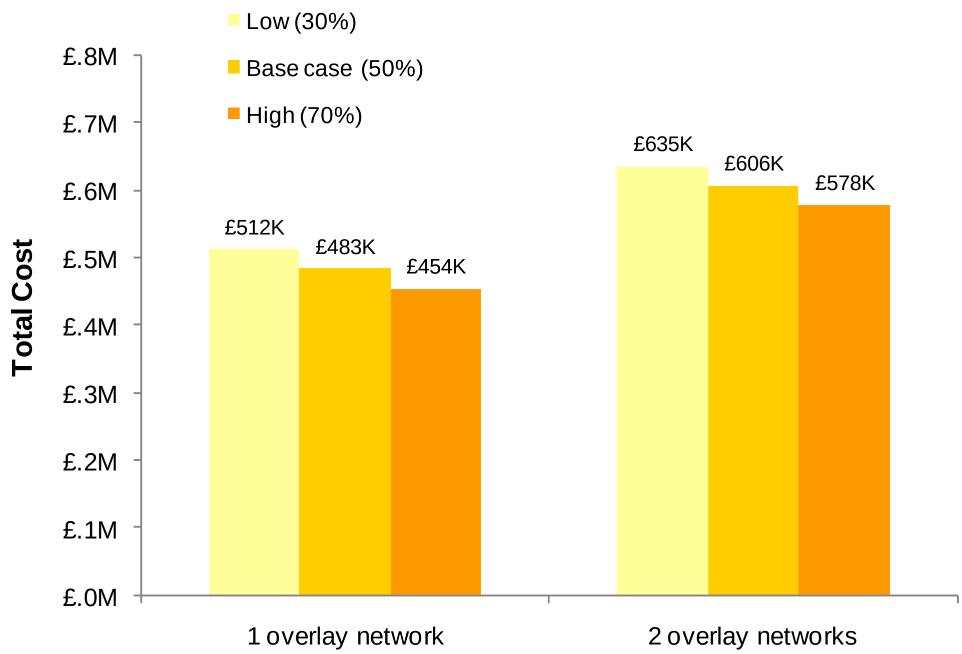

Figure 14: ***Total costs in suburban geotype at 31% penetration with alternative assumptions for final drop duct reuse***

The impact of the final drop duct reuse assumption on the cost per home connected is shown in the following table.

Annualised cost at 31% penetration [£]		One Overlay Network	Two Overlay Networks
Urban Geotype	Low case (30%)	206	295
	Base case (50%)	201	290
	High case (70%)	196	284
Suburban Geotype	Low case (30%)	296	403
	Base case (50%)	285	391
	High case (70%)	273	379

Table 20: Cost per home connected under alternative duct construction costs

In terms of the cost per home connected, the extent to which the final drop can be reused has a relatively small impact on the overall cost. This is due to a combination of two factors: firstly the final drop only accounts for less than 15% of the total amortized cost stack; secondly, even where existing duct can be reused the labour and materials costs of installing fibre in the duct are still incurred.

The impact in the suburban geotype is approximately twice that of the urban geotype due to the higher final drop duct length in the former.

As with the construction cost sensitivity above, reuse of final drop duct does not affect the absolute cost of competition within the duct access scenarios as there is only ever a single duct in the final drop irrespective of number of CPs.

3.4 Summary

The results of the Cost of Competition analysis are summarised in this section. We start with an assessment of the industry costs overall before drilling down into the cost of competition.

In section 3.3.3 the upfront set-up cost to industry to cover a cabinet district was analysed. Figures 3 and 4 highlight the high proportion of costs in the New Build scenario that are due to Civil Works – 87% and 89% in the urban and suburban geotypes respectively. Duct sharing therefore presents a significant opportunity to reduce industry-level costs versus duplicative new build construction.

Reuse of existing ducts where possible would further reduce industry costs. Comparing the costs of the One Overlay Network and New Build scenarios in the same figures shows the cost that could be avoided through infrastructure reuse. In the urban geotype the cost saving would be £337k (57% of set-up costs) and in the suburban geotype £552k (60% of set-up costs).

Viewing the costs on an annualised basis in Table 11, the cost saving through duct reuse equates to £33 per home passed (48% of New Build) in the urban geotype and £69 (55% of New Build) in suburban.

The cost per home connected is also shown in Table 11. Under base case conditions the cost per connection for New Build is £323 in the urban geotype and £536 in the suburban geotype. For the One Overlay Network scenario the cost per connection is lower at £201 in the urban geotype and £285 in the suburban geotype. (38% and 47% lower respectively).

Whilst duct sharing does present an opportunity to avoid duplication of substantial costs in Civil Works, it does not avoid the cost arising from each CP deploying its own GPON electronics and passive fibre network. This duplicative investment is the static cost of competition.

The results of the Cost of Competition analyses in Sections 3.3.7, 3.3.8 and 3.3.9 are summarised in the following table.

Annualised cost per connection at 31% penetration [£]		Two Overlay Networks	Three Overlay Networks	Four Overlay Networks
Urban Geotype	Base Case	88	177	265
	NGA congestion	96	192	289
	Footway box duplication	125	249	374
	Both of the above	133	264	398
Suburban Geotype	Base Case	106	213	319
	NGA congestion	124	248	372
	Footway box duplication	142	285	427
	Both of the above	160	320	480

Table 21: Summary of Cost of Competition under Duct Access

Under the base case (most favourable) conditions in Section 3.3.7, the additional cost per connection is £88 p.a. per additional network in the urban geotype and £106 in the suburban geotype. In a market with four infrastructure competitors, the additional cost of competition would be £265 and £319 respectively, representing increases of 132% and 112% over the cost per connection with a single FTTP network (£201 and £285).

The cost of competition increases when the impact on duct reuse (Section 3.3.8) and footway box duplication (Section 3.3.9) are factored in. Applying both of these raises the cost of competition per network to £133 in the urban geotype and £160 in the suburban geotype. In a market with four infrastructure competitors, the additional cost of competition would be £398 and £480 respectively, representing increases of 198% and 168% over the cost per connection with a single FTTP network.

4 ENTRY OPTION ANALYSIS

4.1 Introduction

For the entry option analysis, costs that a CP would face in serving a cabinet district under a range of entry options are compared. This analysis provides insight into the likely investment choices a CP would make for market entry.

The entry option analysis was conducted using the same core set of assumptions as that used in the cost of competition analysis in Section 3.

To recap, this model considers a GPON network deployment in a single cabinet district, i.e. the geographic area served by a single PCP cabinet. Where cost items serve a greater area than a cabinet district, these are allocated on a *pro rata* basis, for example: fixed costs at the exchange. The model provides a static view of costs and is not time-series based. An annualized cost view is obtained through amortizing capital expenditure over the asset lifetimes on a straight-line basis.

Depending on the entry option selected, the costs to the CP will be a combination of equipment, materials and labour costs, and prices for wholesale inputs.

The prices of the wholesale inputs are based on Openreach pricing where available (co-location and GEA), and industry benchmarks where there is no existing Openreach service (Duct Access). As these inputs are based on price, rather than real cost, the following analysis is subject to future wholesale pricing decisions that may be made.

4.2 Key Assumptions

4.2.1 Scenario Definition

The model considers three CP entry options; the CP is assumed to use only one entry option in the cabinet district. The characteristics of the options are as follows:

GEA	The CP enters the market using the Openreach GEA wholesale bitstream product. The CP co-locates an Ethernet switch in the exchange to interconnect with Openreach. The CP pays Openreach for access network connectivity.
Duct Access	The CP deploys its own GPON network using Openreach ducts. The CP owns the active and passive network elements and CPE. The CP pays Openreach access charges to use the ducts.

New Build The CP deploys its own GPON network using its own ducts. The CP owns the ducts, the active and passive network elements, and CPE. The CP ducts are built new.

For comparability, all scenarios assume that the CP co-locates its exchange equipment in an Openreach exchange.

4.2.2 Common Assumptions

Many of the assumptions are common to both the Entry Option Analysis and the preceding Cost of Competition section. Specifically, the following categories of assumptions are the same:

- Geotypes
  - Network Hierarchy
  - Duct Lengths
- Cost Assumptions
  - Civil Works
  - Passive Network
  - Active Network
  - Final Drop
  - CPE
- Asset Lifetime

4.2.3 Assumptions specific to the GEA Scenario

In the GEA scenario, the CP consumes the GEA product from Openreach. The CP also purchases an Ethernet switch which is co-located at the MDF site to interconnect with the Openreach network.

Active Network	Cost	Source
Gigabit Ethernet Switch	£2,010 / port	CSMG industry research

Table 22: CP Active Network cost assumptions

The GEA entry option assumes the CP uses the MCU1 co-location product to house its network equipment to interconnect with Openreach.

MDF Co-location	Cost to CP	Source
MCU1 set-up fee	£3,825	Openreach price list
MCU1 annual rental	£270	Openreach price list

Table 23: GEA co-location price assumptions

The GEA prices are taken from the Openreach price list. The end-user annual rental assumes a 50/50 mix of the 10Mbps and 30Mbps FTTP GEA products.

GEA	Cost to CP	Source
Interconnect set-up	£2,000 / port	Openreach price list
End-user connection	£130	Openreach price list
End-user annual rental	£222	Openreach price list

Table 24: GEA price assumptions

4.2.4 Assumptions specific to the Duct Access Scenario

The BBUSS3 co-location product is taken as a proxy for the co-location costs of the GPON network equipment.

MDF Co-location	Cost to CP	Source
BBUSS3 set-up	£6,305	Openreach price list
BBUSS3 annual rental	£650	Openreach price list

Table 25: Co-location price assumptions

Openreach does not offer a Duct Access product. The Duct Access prices in the model are therefore based on international benchmarks. These prices are illustrative and do not reflect any expectation of potential price levels should duct access emerge in the UK.

Duct Access	One-off cost	Annual Rental
International benchmarks from Section 2		
Australia	-	£3.88 / metre
Canada	-	-
France	£250 / duct	£1.08 / metre
Portugal	-	£0.85 / metre
USA	-	£1.67 / metre
Openreach price list		
SLU survey fee	£300 / survey	-
Values used in model		
E-side and D-side ducts	£300 / duct	£1.87 / metre
Final drop ducts	£50 / premises	£1.87 / metre

Table 26: Duct Access price assumptions

4.2.5 Assumptions specific to the New Build Scenario

The Openreach BBUSS3 co-location product (Table 25) is used as a proxy for the co-location / housing costs of the CP GPON equipment.

The model assumes that existing duct is not available to a CP building its own network. CP ducts and footway boxes are installed as new.

The extent to which Openreach is able to reuse its own infrastructure is not relevant to the Entry Option Analysis as these costs are not directly passed on to the CP in any of the scenarios.

4.3 Model Outputs

4.3.1 Year 1 Fixed Costs

Comparing the fixed costs for a CP illustrates the different scale of investment that would be required to enable a cabinet district under each entry option. In addition to the capital cost items (the scope of the fixed cost comparison at an industry level in Section 3.3.2), the comparisons in this section include operational expenses as ongoing access charges are a significant fixed cost component in two of the options considered. As this is an analysis of fixed costs, no subscriber variable costs are included.

The charts below show the capital and first year operational costs incurred to pass the all homes in the cabinet district. In the case of GEA, this amounts to a single interconnection with Openreach's access network. For duct access and new build, the CP must deploy the active and passive elements of its GPON network. The duct cost for the CP in the duct access scenario comprises one-off and recurring access charges. In the new build scenario the CP pays for ducts to be laid throughout the cabinet district.

Where cost items have capacity to serve more than a single cabinet district, a *pro rata* allocation of cost is taken. This applies to the OLT (16 of 32 ports used) and the co-location space (assumed to be sufficient to serve 10 cabinet districts). In the GEA scenario, we assume the full capacity of the 1Gbps interconnect is consumed by the cabinet district and thus allocate the full interconnect cost (£2,000) to the cost stack.

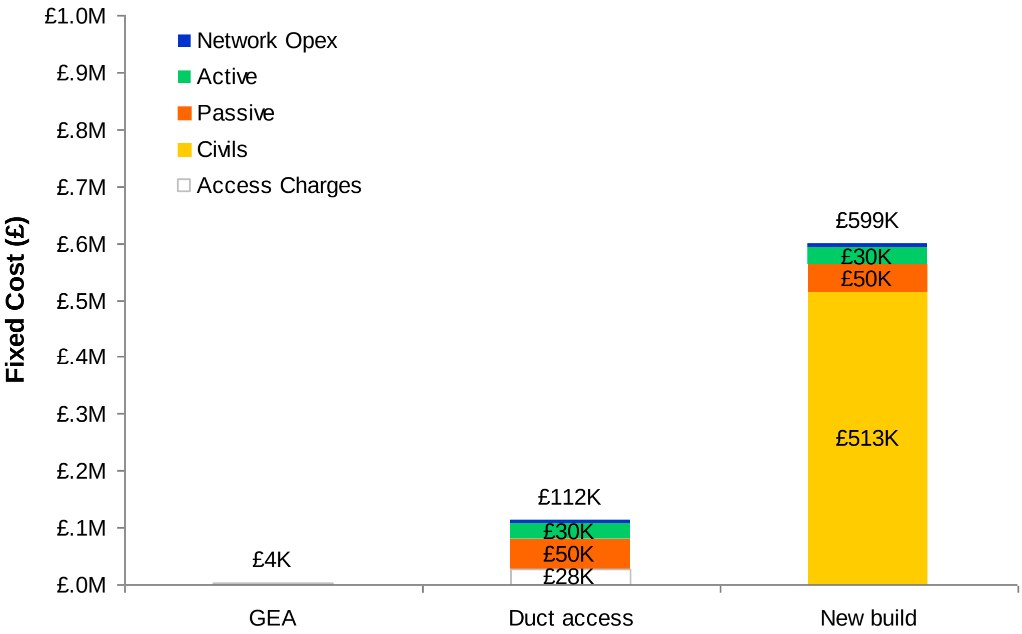

Figure 15: CP Year 1 Fixed Costs – urban geotype

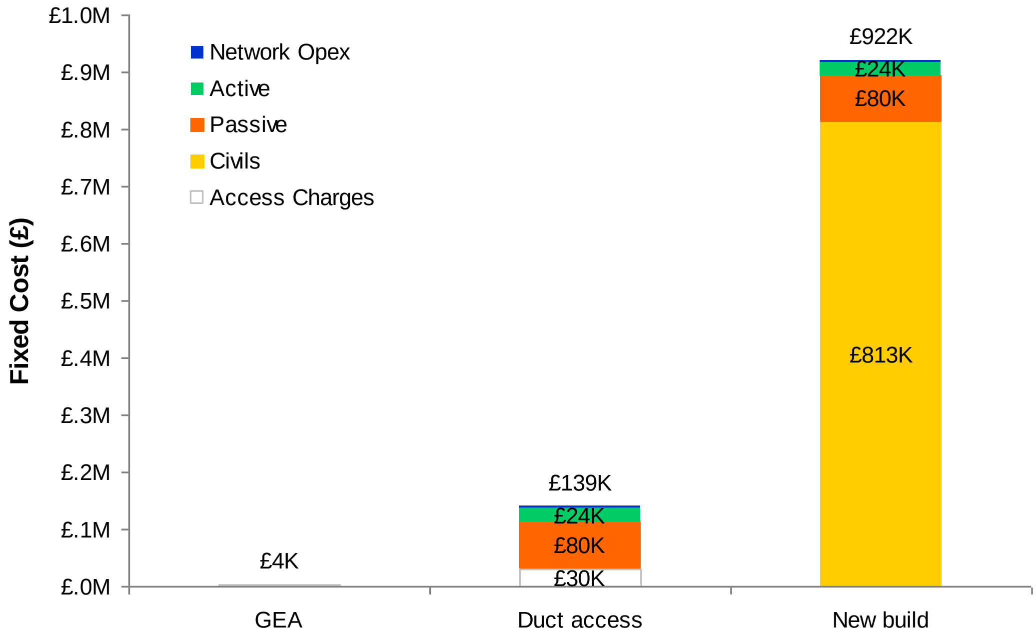

Figure 16: CP Year 1 Fixed Costs – suburban geotype

The charts show that the fixed costs of GEA are a fraction of the other entry options. Duct Access is also considerably less expensive upfront than New Build due to the avoidance of the Civil Works costs.

4.3.2 Annualized Fixed Costs

Viewing the fixed costs on an annualised basis provides an indication of the annual contribution a CP would require to cover its fixed investment. The following charts display the cost stacks from the preceding section with capital costs amortized by asset lifespan; operational costs are included in full.

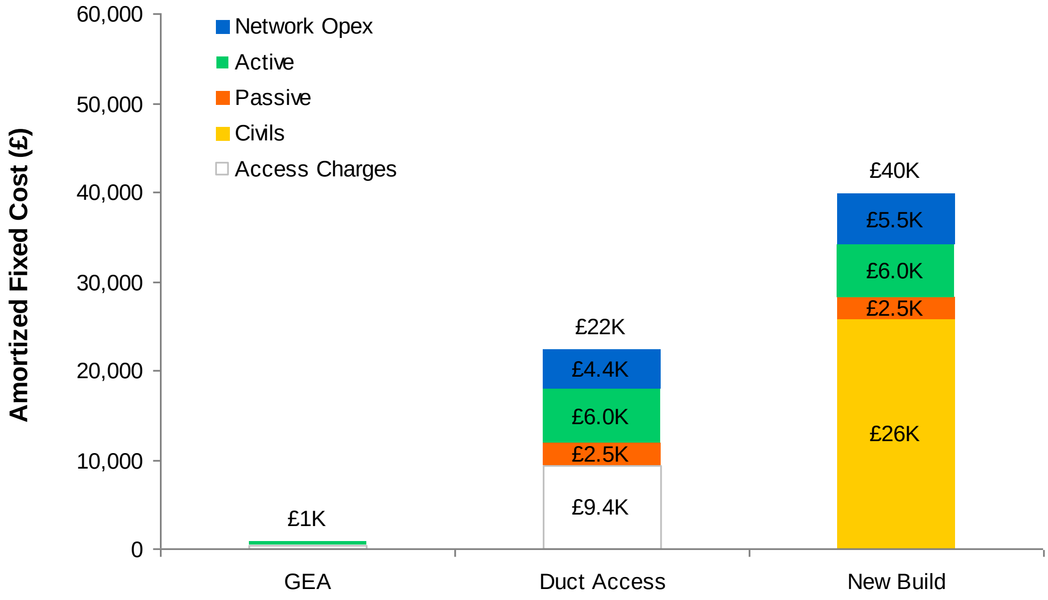

Figure 17: CP Amortized Fixed Costs – urban geotype

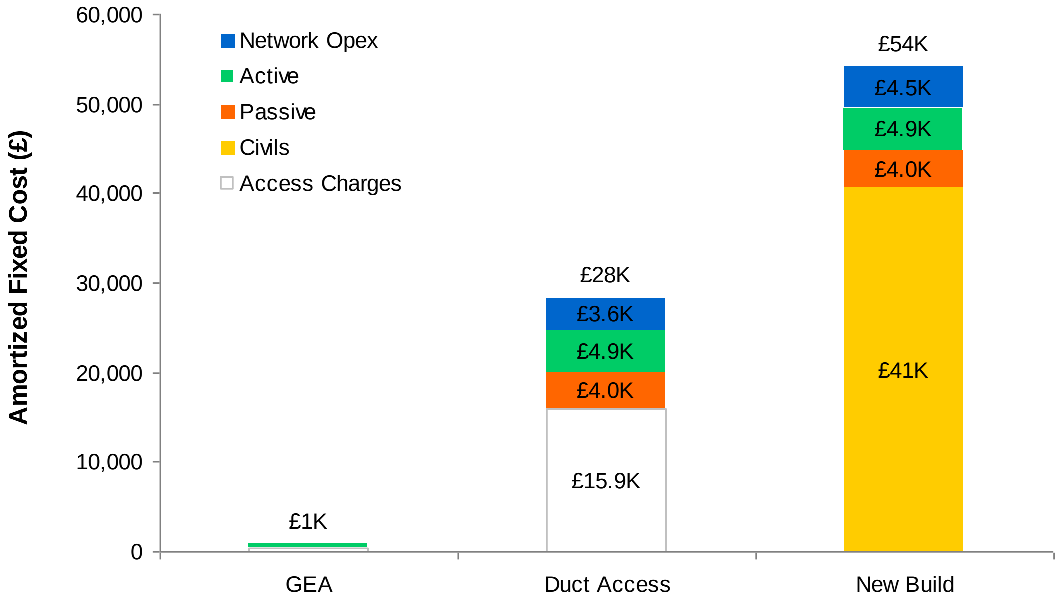

Figure 18: CP Amortized Fixed Costs – suburban geotype

On an annualised basis, the fixed costs of GEA are still significantly lower than the other entry options. The difference between the Duct Access and New Build options is less pronounced due to the long (20 year) asset lifetime over which the New Build civil works are amortized compared with the ongoing access charges that apply to duct access.

4.3.3 Subscriber Variable Costs

Adding the subscriber variable costs to the fixed costs from the preceding sections provides a total view of network costs to the CP. To align with the assumptions used in the Cost of Competition analysis, we assume 31% penetration throughout.

The cost stacks below show the total expenditure required to serve 31% of the premises in the cabinet district. The additional cost comprises the following line items:

- Subscriber access charges in the GEA scenario;
- Final drop fibre, installation and CPE in the duct access scenario;
- Construction of new duct in final drop, plus fibre, installation and CPE in the New Build scenario.

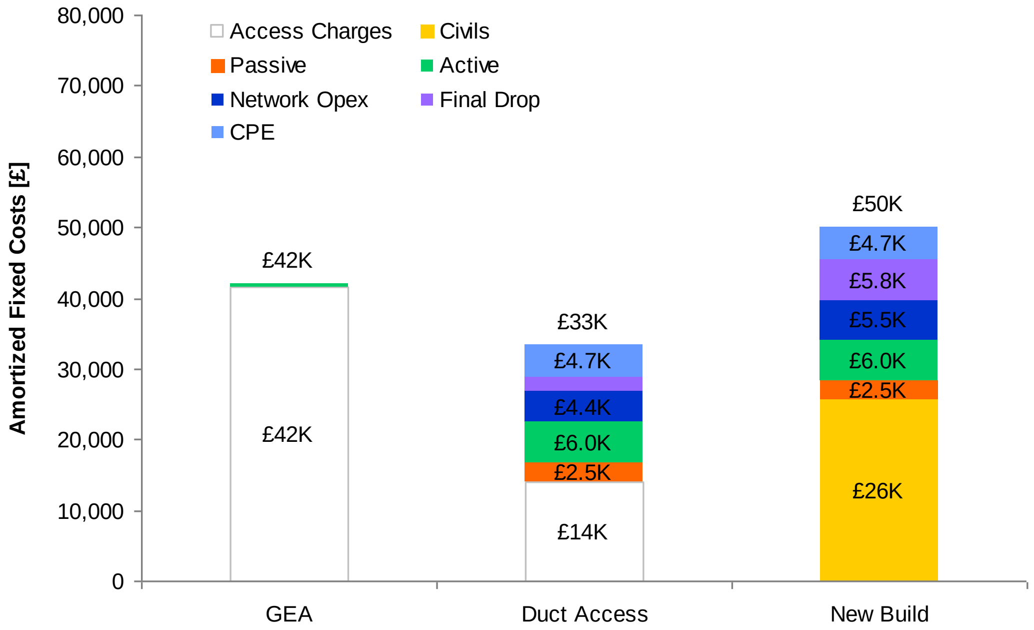

Figure 19: CP Annualised Cost at 31% Penetration – urban geotype

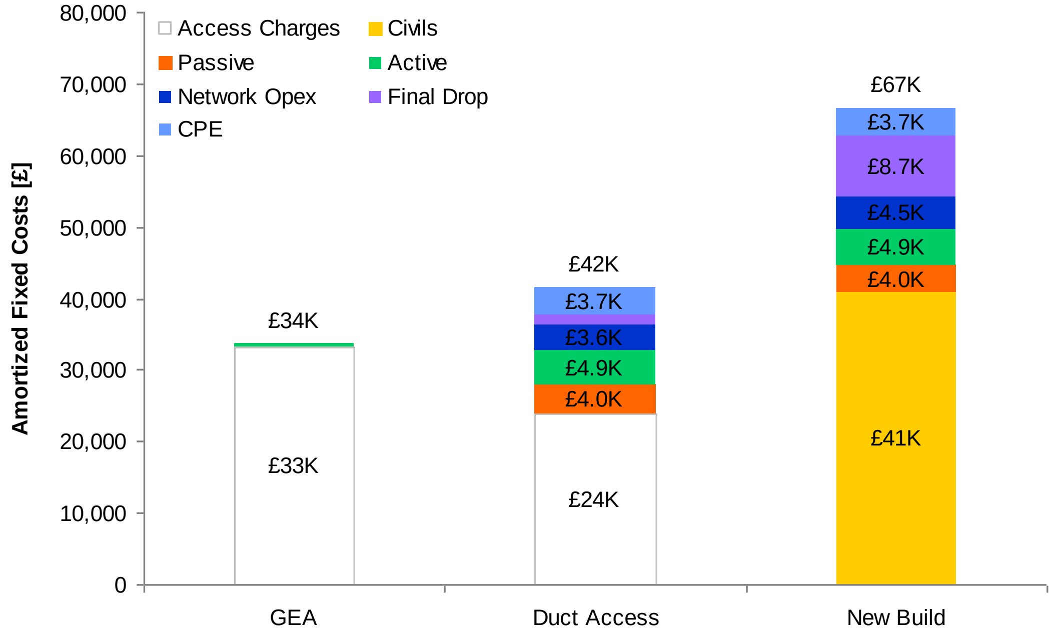

Figure 20: CP Annualised Cost at 31% Penetration – suburban geotype

Adding the subscriber variable costs to the fixed costs of the preceding section starts to bring the three cost stacks closer in line. Notably in the urban geotype, the total costs for GEA at 31% penetration are higher than those of Duct Access. New Build remains the most expensive option.

4.3.4 Cost per Premises

To compare the scenarios on a cost per premises basis, the costs in the above charts are divided by the number of premises served. Fixed costs are divided by the total number of premises in the cabinet district to determine the cost per home passed. To calculate the cost per home connected, the total costs are divided by only the number of premises connected. As the two rows have different denominators it is not possible to simply determine the difference; for clarity, the incremental cost of connection is therefore also provided.

Annualised Cost [£]		GEA	Duct Access	New Build
Urban Geotype	Fixed Year 1 cost per premises passed [500 premises]	2	44	79
	Total cost per premises connected [at 31% penetration]	271	215	324
	Incremental cost to connect a premises	266	72	67
Suburban Geotype	Set-up cost per premises passed [400 premises]	2	71	135
	Total cost per premises connected [at 31% penetration]	272	335	537
	Incremental cost to connect a premises	265	106	100

Table 27: Annualised cost per premises

The table shows that GEA provides by far the lowest fixed cost of coverage, i.e. the cost per premises passed. The cost per premises is significantly higher in duct access due to the investment the CP must make in the active and passive network elements, and the fixed access charges it must pay for the ducts. Unsurprisingly, New Build has the highest cost per premises passed of the three entry options due to the investment the CP must make in new ducts to pass the premises in the cabinet district.

Comparing the results for the urban and suburban geotypes, there is very little difference in the amortized costs for GEA as it has little fixed cost and the per-subscriber costs are independent of geotype. The difference in the fixed costs is most significant in the Duct Access scenario due to the greater distances increasing the duct construction cost. The higher cost to connect premises in the suburban geotype is due to the greater length of the final drop (33m versus 15m).

The preceding chart and table consider the cost per connection at a fixed penetration of 31%. The chart below illustrates how the cost per connection varies with penetration.

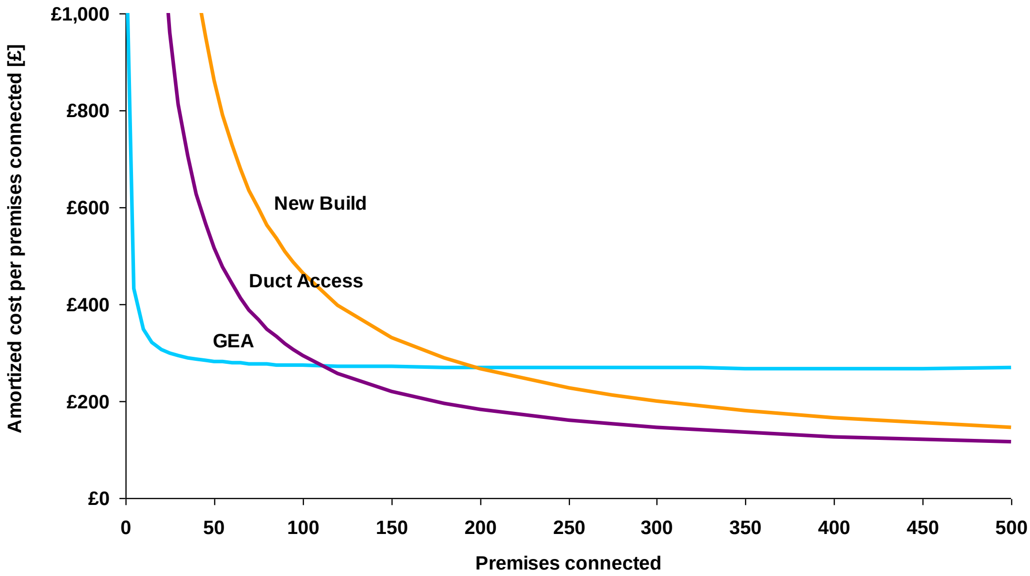

Figure 21: Annualized Cost per Connection to Industry - urban geotype

The cost curves in the chart highlight the difference in the cost profiles of the entry options. GEA carries very little fixed cost and therefore the GEA curve descends steeply and quickly flattens out as it trends towards the per-subscriber variable cost. The curves for Duct Access and New Build are much shallower due to the high fixed costs in these entry options. These two curves intersect the GEA cost curve at 120 and 200 lines respectively. These options would therefore be more cost effective for a CP that was confident of securing this scale (24% and 40% of the 500-premises urban cabinet district respectively).

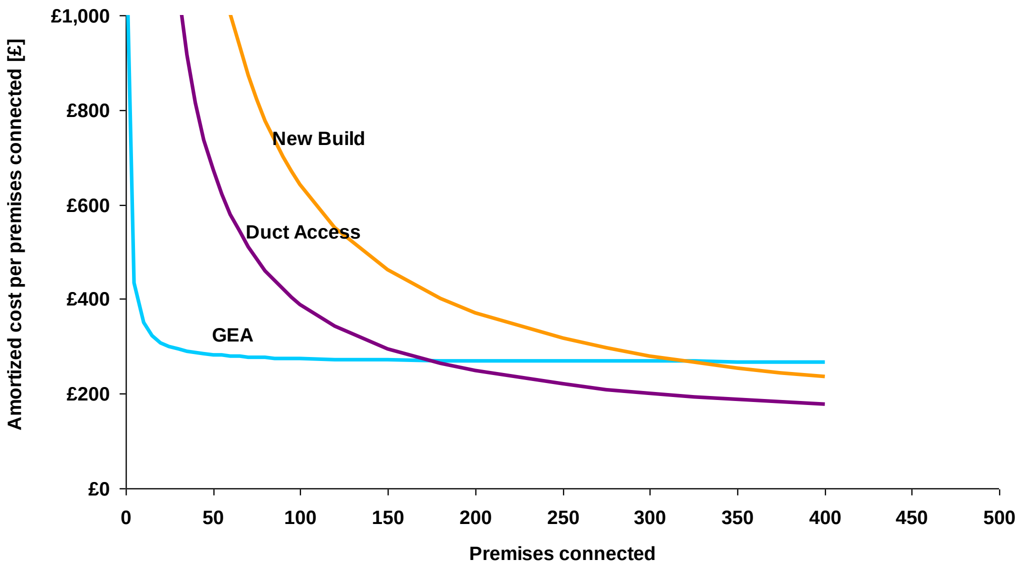

Figure 22: Annualized Cost per Home Connected to CP

The cost curves in the suburban geotype are similar to those of the urban with the curves truncated at 400 lines. The Duct Access and New Build curves are slightly shallower than in the urban case and now intersect the GEA curve at 180 (45%) and 325 lines (81%) respectively.

4.3.5 Impact of Footway Box Duplication in Duct Access

As explained in the Section 3.3.9 above, shared access to ducts may still require individual CPs to install their own footway boxes to terminate fibre cables at GPON splitters. The impact on the CP cost per premises is shown in the following table.

Annualised Cost [£]		Duct Access (Base Case)	Duct Access (Duplicated Boxes)
Urban Geotype	Set-up cost per premises passed [500 premises]	44	56
	Total cost per premises connected [at 31% penetration]	215	251
Suburban Geotype	Set-up cost per premises passed [400 premises]	71	82
	Total cost per premises connected [at 31% penetration]	335	371

Table 28: CP Amortized Cost per Premises with Footway Box duplication

Adding footway boxes to the CP cost stack in duct access results in an increase of 17% in the cost per connection in the urban geotype, and 10% in the suburban.

4.3.6 Sensitivity Analysis by Cost Category

The sensitivity of the CP's overall costs to variations in individual cost categories was tested. The following table shows the impact on the CP annualised cost per connection in the urban geotype with a 10% variation in the input costs. Cost per connection assumes 31% penetration.

Variation in cost	GEA	Duct Access	New Build
Access Charges	9.9%	4.2%	-
Civil Works	-	-	5.1%
Passive Network	-	0.8%	0.5%
Active Network	0.1%	1.8%	1.2%
Final Drop	-	0.5%	1.2%
CPE	-	1.4%	0.9%
Network Opex	-	1.3%	1.1%

Table 29: Sensitivity of CP cost per connection to input cost variation – urban geotype

The results show that the GEA and Duct Access costs are most sensitive to changes in the access charges. The most sensitive input for New Build is the cost of Civil Works.

As the Access Charges for GEA and Duct Access are price inputs there is flexibility in the level at which these are set. Given the high sensitivity of the entry options to these inputs, any changes in the wholesale prices could have a dramatic affect on their relative economics.

4.3.7 Sensitivity to Duct Construction Costs

As outlined in Section 3.3.11, duct construction costs are dependent on many local factors. The sensitivity of the CP costs was therefore also tested against the “high” and “low” case given in Table 17 above.

The impact of the alternative construction costs on the cost per home passed is shown in the following table. For reference the base case costs for GEA and Duct Access are also shown.

Annualised cost [£]		New Build	GEA [Base Case]	Duct Access [Base Case]
Urban Geotype	Low case (£60/m)	280	271	215
	Base case (£90/m)	324		
	High case (£140/m)	396		
Suburban Geotype	Low case (£60/m)	439	272	335
	Base case (£90/m)	537		
	High case (£140/m)	699		

Table 30: Cost per home passed under alternative duct construction costs

In terms of the relative attraction of New Build versus other entry options under these assumptions, the table below shows the point at which the cost curve for New Build intersects that of GEA, i.e. the number of connections a CP would need to achieve a lower annualised cost in New Build than GEA.

New Build vs. GEA		Connections
Urban Geotype	Low case (£60/m)	180
	Base case (£90/m)	200
	High case (£140/m)	275
Suburban Geotype	Low case (£60/m)	250
	Base case (£90/m)	325
	High case (£140/m)	-

Table 30: Number of Connections at which the annualised cost of New Build becomes cheaper than GEA

The results show that in the urban geotype an increase in the cost of construction to £140/m would push the breakeven point to 275 connections (55% of premises). This high-case cost is likely to be representative of at least some urban cabinet districts.

In the suburban geotype, with the high-case costs New Build is always more expensive than GEA.

Across all cost cases and geotypes, New Build was always more expensive per connection than Duct Access.

4.4 Summary

From the perspective of a CP, the cost analysis shows Duct Access to be favourable versus New Build but in many circumstances GEA is more economic than both.

In the comparison of fixed costs in Section 4.3.1, of the three entry options GEA has by far the lowest upfront entry cost at £4,100 for the cabinet district versus £112,000 and £599,000 in the urban geotype for Duct Access and New Build respectively. GEA therefore represents an attractive option for a CP that was cash constrained or wanted to limit its exposure to uncertain demand.

The high variable costs of GEA make it a more expensive option at scale. Under the base case assumptions, the analysis of total costs on an annualised basis in Section 4.3.4 shows Duct Access is more expensive for a CP with 120 connections in the urban geotype (24% of premises) and 180 connections (45%) for suburban. However it is worth noting again that the cabinet sizes used in this analysis are at the higher end of the scale, the average UK cabinet serving c. 290 premises.

At the base case penetration of 31%, Duct Access would cost the CP an annualised £215 per connection in the urban geotype and £335 in the suburban. The CP costs would be higher if CPs had to pay for the installation of their own footway boxes. The results in Section 4.3.5 show CP footway boxes would add 10% and 17% respectively to the annualised per connection costs, raising these to £251 (urban) and £371 (suburban).

Uncertainty around duct construction costs will be a significant factor for a CP's entry option decision. Given the local variation in costs, one would expect Duct Access to be more favourable in some areas than others. Testing alternative cost inputs in Section 4.3.7 caused a wide variation in the annualised cost per connection (a range in excess of £100 in the urban geotype; and in excess of £250 in suburban). Under the high cost case, the number of connections required for a CP to breakeven versus Duct Access rose to 275 (55%) in the urban scenario. The suburban scenario failed to breakeven.

The sensitivity analysis in Section 4.3.6 revealed the major cost driver under both GEA and Duct Access to be the pricing of the wholesale inputs. In our hypothetical model, both services are supplied by Openreach. In the absence of regulatory control, Openreach would have scope to adjust the relative pricing and influence the economic attractiveness of the two entry options. For a CP with a favourable business case for Duct Access, the risk of future price changes may deter an infrastructure based entry.

5 NETWORK CONSTRUCTION COSTS

5.1 Introduction

The civil works cost of network deployment are the most significant in new build network construction. These costs also vary significantly between areas due to differences in geology and ground cover.

This section benchmarks constructions costs within the telecoms industry. The benchmarks are then used to estimate the cost of building a next-generation network in an exchange district under a range of input assumptions.

5.2 Approach

Benchmark data for network construction costs were obtained through primary research, interviewing a range of organisations with first-hand experience of the civil works aspect of network construction.

Research participants were selected to provide a representative sample and included three UK Network Operators, one non-UK Network Operator, four Construction Contractors and one Water Utility. The interviews were conducted in December 2009 and January 2010.

Selected research participants are profiled in Appendix A.

5.3 Construction Methods

5.3.1 Traditional Trench Excavation

The traditional method of network construction is to excavate a trench along the route of the network to the desired depth, lay duct in the trench, and then refill and reinstate the original surface. The depth of telecoms ducts varies and is typically 300 – 600mm below the surface. A trench 300mm wide would be sufficient to accommodate most ducts.

Mini excavators are commonly used for digging such trenches. In areas where there is a high risk of damaging other underground services alternative methods such as manual digging may be necessary.

5.3.2 Vacuum Excavation

Vacuum excavation provides an alternative to traditional trench excavation. In vacuum excavation, compressed air or high pressure water is used to loosen the earth in the trench. A vacuum hose is then used to suck the debris from the trench into a tank.

In straightforward digs, vacuum extraction will generally be more costly than mechanical excavation, however it may be more cost effective under certain circumstances.

As no mechanical tools are employed, the solution is safe for use in areas with existing underground services. In comparison with manual digging, vacuum extraction improves productivity and avoids the risks to personnel associated with physical labour. John Mee Construction Ltd. estimates that in a 6-hour day a large vacuum excavator can remove 10 cubic metres of heavy soil in the presence of buried cables and pipes versus 1.5 cubic meters for manual excavation.

As debris is collected in an integrated tank, the need for traditional ‘muck away’ wagons can be avoided hence operations can be cleaner and occupy less space.

On carriageways, vacuum excavation may be used in conjunction with a mini excavator, the latter being used to remove the road surface before the vacuum excavator is employed.

5.3.3 Slot Trenching

Slot trenching (a.k.a. micro trenching) provides a low cost alternative to traditional trench excavation where limited duct space is required. A slot trenching machine uses a circular saw to cut a slot 25 – 30mm wide with typical depths up to 300mm. Small diameter ducts (16 – 20mm) may then be laid in the slot; alternatively, fibre may be buried directly. Where additional duct space is required, multiple ducts may be stacked vertically. The trench is then refilled and the surface reinstated. On carriageways a watertight compound is used to seal the surface.

This construction method is suitable on firm ground that can support the trench walls until the trench is backfilled, e.g. bedrock and the foundations of carriageways. To avoid damage to other services, the trench requires uncongested space and accurate records. Road authority approval is required if the cable is buried into the structure of a road. On carriageways and footways, slot trenching has the additional benefit of avoiding the safety risks associated with wider excavations.

Whilst this method is capable of accommodating many fibres (e.g. six 144-fibre cables), the relatively shallow depth does increase the risk of accidental cable cuts. As such, network operators may choose to avoid this method on strategically important segments of their network.

5.3.4 Moles (a.k.a. Directional Drilling)

Directional drilling provides a high accuracy in scenarios where digging is not possible or undesirable. It may be employed when crossing under railways, waterways and motorways. It also allows for steering around underground obstacles such as other services. Using this method it is possible to go to depths of 50m or more and distances of 100s of meters.

5.3.5 Impact Moles

Impact moles provide a low cost alternative to directional drilling over short distances where high accuracy is not required. They may be used for crossing under a street or in the final drop to minimise disturbance to the end-user’s property. The solution requires two pits to be dug – one at the entry point to the duct and the other at the exit. The rig is inserted into the entry pit and the mole (a boring tool) is aimed towards the exit pit. The mole is then rammed through the earth, typically using a compressor.

As the mole is not steered the technique lacks accuracy it can only be used where there is little risk of hitting other services. An ideal application would be the final drop across a residential garden. In this situation a small-bore duct (25mm) could be laid for less than £350.

5.4 Benchmarking Construction Costs

5.4.1 Introduction

Construction costs vary significantly between jobs due to the surface/terrain conditions, size and depth of duct, and the construction method employed. Other local factors that drive variation in cost between jobs included permits, traffic management and wayleave costs.

Because of the cost variations, the project sought budgetary figures for the average cost per metre in a number of pre-defined geotype/surface scenarios. The scenarios are as follows:

- City Carriageway
- Suburban Carriageway
- Footway
- Soft ground (bare earth)

The research participants were asked to provide average costs for construction in each scenario using the following construction methods:

- Traditional Trenching
- Slot Trenching
- Direct Burying
- Moles (Directional Drilling)
- Poles

5.4.2 Research Findings

Research participants provided data on combinations of construction method and scenario that they were familiar with. Several participants were unable to provide a full set of data.

Responses from some participants were provided by geotype (e.g. urban, suburban and rural) rather than by the predefined surface types. In Figure 1, these responses have been assigned to the closest matching surface type (e.g. urban to urban carriageway); the geotype/surface type for each response is labelled on the x-axis of the chart.

In addition to the results of the interviews, regulatory cost data from OFWAT for the water utilities is also included[48]. Care should be taken when comparing this with the results of the telecoms operators and contractors due to the difference in depth and materials employed.

<u>Traditional Trenching</u>

The responses for traditional trenching are shown in the chart below. Where cost ranges were provided, these are shown on the chart.

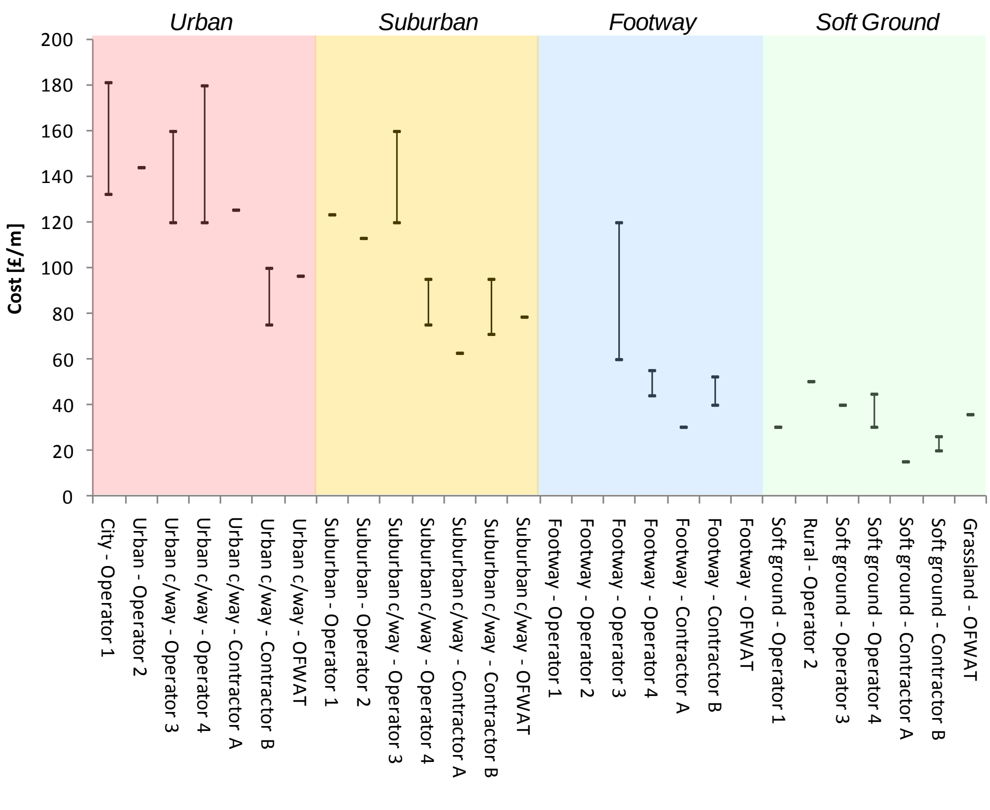

Figure 23: Traditional trenching cost by respondent and surface type

[48] OFWAT PR09 cost base report. 100mm duct, 900mm deep; inc. ancillary works and reinstatement.

The traditional trenching cost data is summarised in the table below. This analysis includes all responses, grouped by the four shaded geotypes in the chart above. The central range, excluding outliers, and mean values are shaded.

Cost [£/m]	Lowest	Lower Quartile	Mean	Upper Quartile	Highest
Urban	75	120	134	156	181
Suburban	63	76	98	118	160
Footway	30	42	57	58	120
Soft Ground	15	27	33	40	50

Table 31: Traditional trenching cost by geotype

The chart data and tabulated summary show considerable variation in the cost estimates.

Several respondents provided cost ranges, reflecting the variability in cost between jobs. Respondents identified a number of cost variables:

- Material being dug
- Surface type (e.g. block paving has higher reinstatement costs)
- Wayleave costs
- Construction permits (including lane closures, parking bay suspensions, etc.)
- Restrictions on the time of works (higher labour rate for night work)
- Traffic management
- Contract size (construction firms offer volume discounts)

Operators noted that the cost of network construction in central London was particularly high, primarily driven by the cost of permits, reinstatement and out-of-hours labour rates.

Most respondents included all of the above in their cost estimates. Operator 3 however, explicitly excluded permits, wayleaves and traffic management from its estimates. Despite this, the estimates from this organisation are still amongst the highest.

For each geotype, the lowest cost estimates were provided by one or other of the construction firms. Whilst it is not possible to be certain of the reason for this without a full cost breakdown, we believe it is at least partly due to operators carrying additional overheads, which they have added to the contractor rates.

Alternative Trenching Methods

Alternative construction methods offer the potential for cost reduction versus traditional trenching.

The chart below compares the cost of traditional trenching with slot trenching (in the urban and suburban geotypes) and direct burial (in soft ground) by respondent. Where traditional trenching costs were provided as ranges (see above), the lower end of the range has been used. Where ranges were supplied for the alternative methods, the mean value has been used.

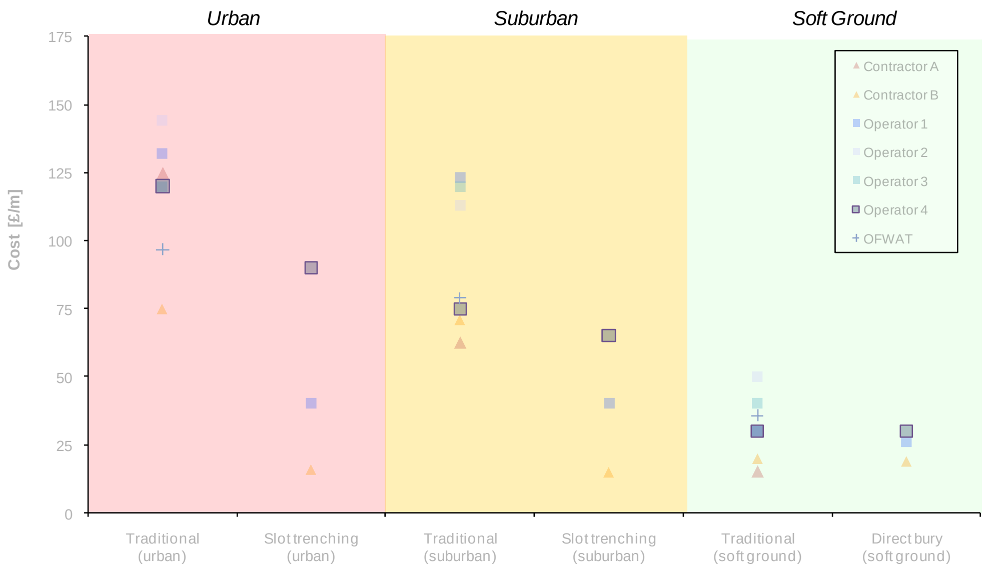

Figure 24: Construction cost by method (and scenario)

Cost estimates for traditional trenching, slot trenching and direct burial were provided by one contractor and two operators. Comparing these individual responses, two (Contractor B and Operator 1) estimated savings from slot trenching to be c.75% versus the cost of traditional trenching. The other respondent (Operator 4) estimated that savings would be lower at c.15 – 20%.

Likewise for direct burial, the first two of these respondents estimated savings of 5 and 15% respectively versus traditional trenching. However the data provided by Operator 4 showed little or no savings.

The slot trenching costs from the UK respondents are further analysed in Table 32.

Cost [£/m]	Lowest	Lower Quartile	Mean	Upper Quartile	Highest
Urban	16	34	58	84	95
Suburban	15	34	46	60	75
Footway	15	25	35	45	55

Table 32: Slot trenching cost by geotype

In addition to the cost estimates for slot trenching received from UK-based respondents analysed above, UNET (a network operator based in the Netherlands) provided its perspective of costs.

On the continent, estimates from UNET were as low as €20/m for large scale projects on highways. UNET also believe that the cost of slot trenching is likely to fall further as the technology becomes more popular. One other international data point was found through desk research – a contributor to the Cook Report put slot trenching in the US at around $26/m in 2008[49].

Moles and Poles

Moles and poles provide the highest and lowest cost per metre of network deployment respectively.

Estimates for mole boring (directional drilling) ranged from c.£120/m to £250/m. Respondents commented that the costs vary considerably depending of the length of a particular job due to the high fixed cost of mobilizing the team and rig (c.£2,000 - £5,000). Moles therefore do not offer a solution for cost saving in general, but could be cost effective under certain conditions.

At £15 - 18/m, poles represent the lowest cost construction method considered[50]. These cost estimates were provided by a single respondent (Contractor B) and are close to Openreach pricing for new poles (£14/m). Poles therefore offer a significant opportunity for cost reduction versus traditional trenching. However, this cost saving must be balanced against the high maintenance costs associated with aerial cable versus buried.

[49] Cook Report, "The Economics of Micro-trenching for Laying Fiber". June 2008

[50] The costs for pole deployment assume a pole spacing of 40m.

5.5 Summary of Construction Cost Benchmarking

The industry research showed a wide variation in the cost estimates provided by network operators and construction firms. The most likely source of this variation is differences in the detailed assumptions behind the figures provided. Local conditions can vary significantly between jobs, with cost drivers including:

- Material being dug
- Surface type (drives reinstatement costs)
- Wayleave costs
- Construction permits (including lane closures, parking bay suspensions, etc.)
- Restrictions on the time of works (higher labour rate for night work)
- Traffic management
- Contract size (construction firms offer volume discounts)

The wide variation in construction costs is demonstrated in the cost ranges that some respondents provided. The high end of the cost ranges shown in Figure 1 were typically 30% to 33% higher than the low end.

Despite the variations between responses for individual data points, the relative cost position of construction methods and scenarios were broadly consistent as shown in Figures 1 and 2. A summary of responses is provided in the following table, showing the mean values for each method.

Mean Cost [£/m]	Urban	Suburban	Footway	Soft ground
Traditional Trenching	134	98	57	33
Slot Trenching	58	46	35	-
Direct Burial	-	-	-	25
Mole	172	172	155	155
Pole	18	17	15	15

Table 33: Mean cost estimates by method (and scenario)

The table shows that on average, the urban geotype is the most expensive, followed by suburban, footway and, least expensive, construction on soft ground. The table also shows that on average, savings in construction costs are possible using alternatives to traditional trenching.

Slot trenching in particular has considerably lower cost than traditional trenching (39% to 57% lower mean depending on geotype); international estimates are even lower. This method would therefore be an attractive alternative in scenarios where the requirements and conditions are suitable.

The construction cost of direct burying is more cost effective than traditional trenching in soft ground (24% lower mean). However this saving must be weighed up against the lower life expectancy and higher maintenance costs of direct buried cable.

Of the construction methods surveyed, poles have the lowest deployment cost. Aerial cable does however have higher maintenance costs than buried.

Moles were the most expensive construction method. The average cost of mole boring was comparable with the upper estimates of traditional trenching in urban areas.

5.6 Cost Illustration for a Representative Network

5.6.1 Overview

This section considers the cost of network deployment in two representative scenarios:

- GPON in a dense urban area
- Point-to-point in suburban area

For each scenario, cost inputs from the research data in Section 5.4 are used with a mix of surface types appropriate to the locale.

5.6.2 Input Assumptions

<u>Geotypes</u>

Geotype distances and network hierarchy are aligned with the analyses in Section 3. The topology of the (point-to-point) copper distribution network is assumed to be efficient for both GPON and point-to-point fibre. The assumptions are repeated here for clarity:

Quantity	BSG Geotype	Lines per PCP	DPs per PCP	Lines per DP
Dense Urban	>500k pop	500	63	8
Suburban	>20k lines (b)	400	50	8

Table 34: Network hierarchy assumptions by geotype

Distance [m]	Segment A	Segment B	Segment C	Segment D	Final Drop
Dense Urban	359	1,076	280	49	15
Suburban	778	2,335	579	102	33

Table 35: Route distance assumptions by geotype

Surface Types

The assumed mix of surface-type by geotype for the E-side and D-side ducts is shown in the following table.

Network Duct Surface Type	City Carriageway	Suburban Carriageway	Footway	Soft ground
Dense Urban	60%	-	40%	-
Suburban	-	40%	50%	10%

Table 36: Surface mix assumptions by geotype

Construction Method

Two construction scenarios are evaluated:

1. Traditional trenching
2. A 50/50 mix of traditional and slot trenching in the E-side and D-side with slot trenching in the final drop[51]

Construction Costs

[51] Under perfect conditions an entire network could be constructed using slot trenching. In practice its application will be limited by ground conditions and operators seeking to minimize the chance of a cable cut on strategically important routes, e.g. the E-side duct.

The base case for the construction costs is the average of the UK telecoms operator and contractor responses in the research interviews (see Tables 31 and 32). In addition a high and low case is tested against the upper and lower quartiles.

5.6.3 Results for GPON Network in Dense Urban Geotype

The construction cost of a new-build GPON network connecting all homes in a cabinet district in the dense urban geotype are shown in the chart below. The costs include civil works and fibre costs; other passive and active network elements (including CPE) are excluded.

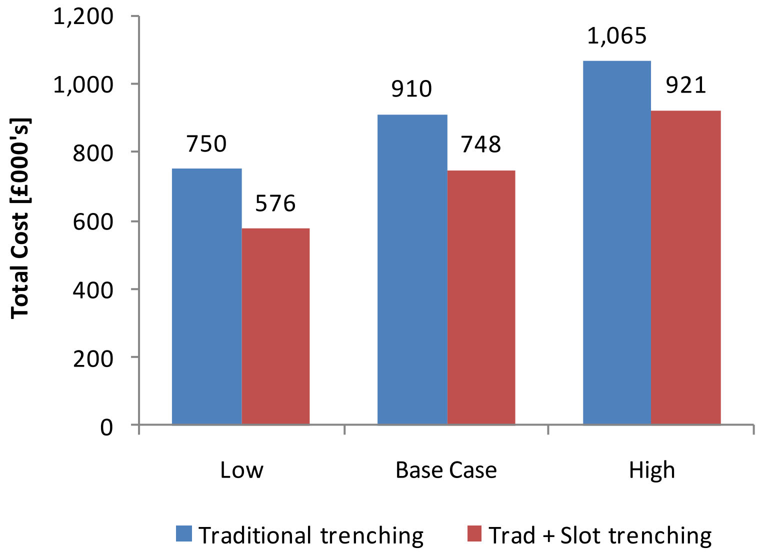

Figure 25: GPON network construction costs in urban cabinet district against civil cost assumptions

Figure 25 shows the mixed construction scenario (50/50 mix of traditional and slot trenching) enables a cost saving of between 14% and 23% versus traditional trenching alone. However, the sensitivity of the outputs to the range of assumed costs (low, high and base case) is more significant. Under traditional trenching alone, the high case is 42% higher than the low; the difference is 60% in the mixed construction scenario is higher due to the larger spread in slot trenching cost estimates (see Table 32).

5.6.4 Results for Point-to-Point Network in Suburban Geotype

The construction costs of a new-build Point-to-Point network connecting all homes in a cabinet district in the suburban geotype are shown in the chart below. The costs include civil works and fibre costs; other passive and active network elements (including CPE) are excluded.

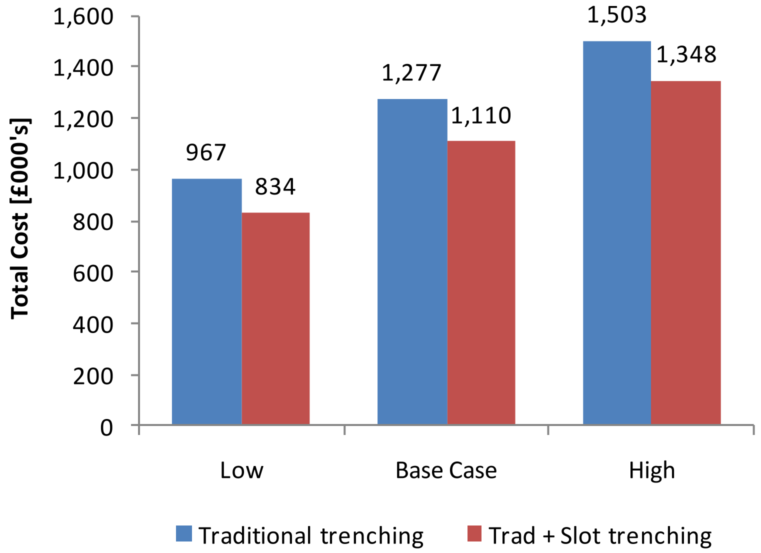

Figure 26: Point-to-point network construction costs in suburban cabinet district against civil cost assumptions

In the suburban geotype, the difference in cost between the two construction methods is smaller in percentage terms than the dense urban, with the mixed construction scenario being between 10% and 14% less expensive.

The sensitivity of costs to input assumptions (low, high and base case) is approximately the same across both geotypes.

5.6.5 Comparison of GPON and Point-to-Point network results

The results of the GPON and Point-to-Point construction analyses are compared in the cost stacks below. The base case cost inputs are used for this comparison.

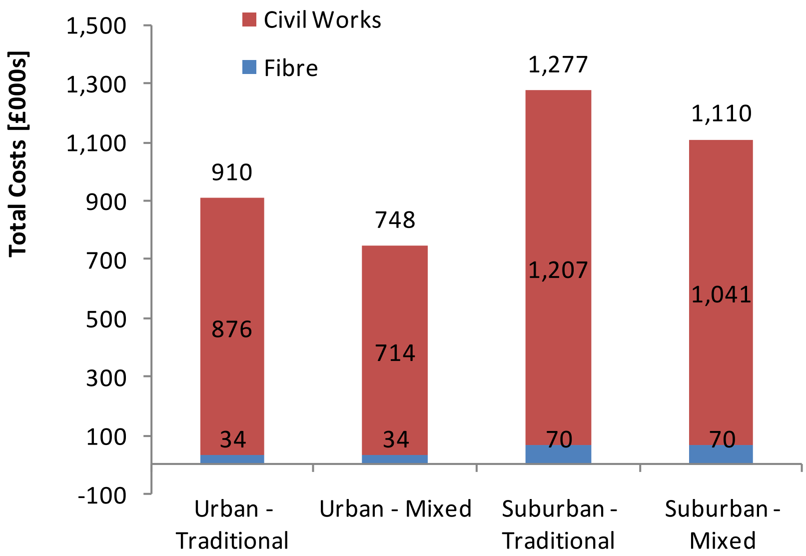

Figure 27: Cost stacks for cabinet district construction by geotype and construction scenario

Comparing the cost totals, the suburban geotype is 40% higher than the urban geotype under traditional trenching and 49% higher in the mixed construction scenario. The civil works costs dominate the cost stack and the greater duct lengths in the suburban scenario drive the higher costs.

The fibre costs in the suburban geotype are approximately double those of the urban geotype. Two drivers account for the difference: the greater distances (as for the civil works), and the additional fibre required for a point-to-point network architecture.

5.7 Summary of Representative Network Cost Illustration

The cost illustrations compare the cost of traditional trenching versus a 50/50 mix of traditional and slot trenching. The latter approach achieves a lower cost, saving c.18% in the urban geotype and c.13% in the suburban geotype.

Irrespective of construction method, costs in the suburban geotype are higher than those in the urban geotype due to the greater distances involved. The additional distance adds a significant amount of additional duct cost. Fibre costs are also higher, but in absolute terms the difference is minor versus the increase in civil works costs. .

6 CONCLUSIONS

The international case studies in Section 2 demonstrate that shared access to infrastructure has had some success in encouraging competitive network deployment. Whilst some infrastructure deployment pre-dates shared access (Canada and Portugal, for different reasons), there is evidence that the volume of shared access continues to grow in these and the other countries surveyed.

In considering the international case studies, key success factors include:

- Availability of infrastructure
- Quality and availability of records
- Planning restrictions on new build
- Regulatory regime
- Supply-side economics
- Demand-side economics

The supply-side economics, i.e. the cost of shared access relative to other entry options, is of obvious importance. In all of the countries examined, the national regulatory authority played a role in the pricing of access to incumbent infrastructure. In some instances, pricing was set by the regulator and in others the regulator settled disputes where pricing was deemed unreasonable. Cost-plus pricing methodologies were employed in all cases with some regimes allowing a contribution to common costs above the direct costs due to access.

The cost of competition analysis in Section 3 explores the additional cost to industry of duplicative investment in CP fibre networks under shared access.

Under base case conditions for a single network in the urban geotype the amortized cost per premises connected is £201 per annum at 31% penetration. The addition of a second network, using shared duct infrastructure, raises the amortized cost per premises connected by £88 to £289 per annum, an increase of 43%. In a competitive market with four CPs, the cost to industry per premises connected rises to £466 per annum, an increase of 132% on the costs with a single network. In the suburban geotype the static cost of competition is higher still with four competing networks adding £319 per annum to the amortized cost per premises connected with a single network (£289). Allowing for likely deployment challenges such as capacity limitations in ducts, and the potential requirement for CPs to deploy their own footway boxes raises the cost of competition with four CPs to £398 in the urban geotype and £480 for suburban.

In summary, infrastructure-based competition in the access network using shared duct access would significantly increase the costs to industry versus service-based competition on a single network. Competition on multiple networks may deliver dynamic benefits through competition and innovation, however an assessment of these benefits is outside the scope of this report.

The analysis economic comparison of entry options in Section 4 confirms that where available, shared access to infrastructure offers a significant opportunity for cost avoidance versus new build. In the two geotypes modelled, the upfront fixed costs to a CP using duct access were 81 – 84% less than new build. Taking an amortized cost view the saving was lower, but still significant at 34 – 40% of the cost per premises connected, assuming 31% penetration.

However, when compared to wholesale access using GEA, the set-up costs of duct access are high. GEA benefits from having very low upfront fixed costs, at c.£4,000 per cabinet district versus over £110,000 with duct access. In return for this high upfront investment, a CP using duct access would have complete control of its own infrastructure, maximising the scope for product differentiation. Duct access also offers lower subscriber-variable costs, improving the CP economics at scale. However, under the pricing assumptions in the model, the point at which duct access becomes less expensive per premises than GEA is high: 24% of premises in the urban geotype, or 45% for suburban. Put another way, at 75% penetration and fair market share there would be sufficient scale for two CPs (in addition to Openreach) to benefit from duct access in the urban geotype, but insufficient scale for any additional CPs in the suburban.

In assessing entry options, CPs would have to consider the likely scale they could achieve and the extent to which infrastructure ownership would confer strategic benefits in the marketplace. CPs would also need to consider how the GEA price may evolve over time. Should the price of GEA fall relative to the price of duct access, the breakeven point for duct access may not be reached. Given this risk, transition to duct access may therefore not happen unless the price margin between the two services is policed.

The research and analysis of the cost of new build in Section 5 leads to two main conclusions.

Firstly, network construction costs are highly variable. There are many local factors outside of a CPs control that can cause prices on two digs for the same broad category to be different by over 30%. Where new build does occur, these local factors are likely to be highly influential in determining how attractive individual areas are.

Secondly, alternatives to traditional duct construction have the potential to reduce construction costs in new build. Slot trenching in particular is an interesting technique that could play a role in some areas and pole deployment, where permitted, has a far lower deployment cost. However, even with these alternative methods, new-build still requires considerable upfront (and sunk) investment by a CP.

Finally, it should be noted that the analysis in this report considers mass-market deployment in residential geotypes. The benefits to a CP of owning an end-to-end fibre network are greater in the business market due to the requirements for higher bandwidths, bespoke services and exacting SLAs. Current examples of business sector CPs using infrastructure access in the UK include Energis' (now C&W) use of the electricity distribution network and Geo's use of the London sewer system.

APPENDIX A: RESEARCH PARTICIPANTS

The new-build construction cost data in Section 5 was obtained through interview-based research with industry experts. During the project, CSMG interviewed three UK Network Operators, one non-UK Network Operator, four Construction Contractors and one Water Utility. CSMG would like to thank all of the research participants for their time and support in this study.

Selected participants are profiled below. Note that some organisations requested that they remain anonymous.

Geo Networks Ltd.

Geo is focused on the design and build of bespoke dedicated fibre network solutions. Geo's revolutionary and flexible approach means that organisations can own and control their networks, ensuring that security, high bandwidth and resilience are guaranteed.

With an extensive range of solutions including fully managed networks, dark fibre and co-location services, Geo.National enables network solutions on a national scale, and Geo.Metro provides users with an Ethernet service within the London area.

http://www.geo-uk.net/

John Mee Construction Ltd.

John Mee Construction Ltd. offers a specialist operated plant service for the supply of vacuum excavation equipment to the construction and utility market throughout the UK.

With small trailer units, 7.5 t and 26 t truck mounted vacuum systems in our fleet, John Mee Construction Ltd.'s vacuum excavation service can offer the solution to all on-site safe excavation requirements.

While operations can realise significant savings using keyhole technologies, clients/consumers also benefit through less disruption and noise, quicker repair times, fewer and shorter service interruptions and reduced traffic inconveniences.

http://www.vac-ex.co.uk/

McNicholas Construction Ltd.

McNicholas is a service provider with wide experience of working in the utilities, communications, renewables and rail markets.

McNicholas has been helping develop and maintain the UK's infrastructure since the late 1940s.

To do this successfully, the company calls upon a range of professional disciplines in civil engineering, construction, mechanical and electrical engineering, information technology and general management.

It also provides a full design and planning service, traffic and risk management and health and safety training.

http://www.mcnicholas.co.uk

UNET BV

UNET is a triple-play service provider and one of the pioneers of next-generation access services in The Netherlands. The company was founded in 2003 and is part of the BBIS group. In March 2004, it started offering its fibre based Internet, VoIP telephony and IPTV services in Almere. UNET has now a strong footprint in the fibre network areas in the Netherlands; this includes over 40 business-parks in Amsterdam, Rotterdam, Utrecht, Almere, Lelystad, and a dozen smaller cities in the Netherlands.

http://www.unet.nl

APPENDIX B: ILLUSTRATIVE DUCT ACCESS PROCESSES

Introduction

The Australian Facilities Access Code provides detailed information on each step of the duct access process. The main points are summarised here for reference.

Overview

The Facilities Access Code defines a set of processes and procedures that carriers must follow in the absence of commercially agreed terms and conditions. It exists as a safety net for circumstances where parties cannot agree terms, and acts as a template that can be used in preparing commercial contracts.

The Code is specified to apply on a non-discriminatory basis. Furthermore, carriers are required to take all reasonable steps to ensure that, as far as practicable, carrier customers receive timely provision of access that is equivalent to that which the carrier provides to itself.

Access Process

The Code defines the carrier owning the infrastructure as the First Carrier, and the carrier requesting access as the Second Carrier.

Two preliminary steps in the Code must be completed before requests for access can be undertaken: the First Carrier must supply an Information Package containing inter alia details of ordering processes, confidentiality requirements, and any credit assessments that may be necessary; secondly, both carriers must enter into a master access agreement.

The process of obtaining access to specific facilities begins with a preliminary assessment. Following this, the Second Carrier then lodges a Facilities Access Application containing full details of the access required, including a full statement of work. If the Second Carrier seeks to visit an Underground Facility for the purpose of making a Facilities Access Application, it must notify the First Carrier of its intention. A First Carrier has the right to accompany a Second Carrier’s representative on a physical inspection at the Second Carrier’s expense, if it considers there is a significant risk to the integrity of its network from an unaccompanied inspection.

Assuming a Facilities Access Application meets basic requirements, the First Carrier can only reject the request on the basis of a technical problem. Should this happen and the carriers are unable to satisfactorily resolve the issue, they can enter into arbitration. The First Carrier must then apply to the Australian Communications and Media Authority (ACMA) for a written certificate declaring the access not technically feasible.

In determining whether compliance with a request for access is technically feasible, the ACMA gives regard to:

- significant difficulties of a technical or engineering nature;
- significant threat to the health or safety of persons who operate or work on the facility or at the site;
- whether there are practicable means of avoiding the above difficulties, including changing the configuration or operating parameters of the facility;
- a submission from the Second Carrier;
- other matters (if any) ACMA considers relevant.

Once a successful application is made, the next stage in the process is for the First Carrier to grant provision of access. The Make Ready Work (MRW) can then be undertaken as defined in the Facilities Access Application. For duct access MRW would include proving ducts, installing sub-ducts and manhole breakouts, and making alterations to the existing duct where necessary.

The Second Carrier would normally undertake the MRW, unless it is either not qualified to do so, or it requests that the First Carrier do the work on its behalf.

Finally, unless otherwise agreed, the two carriers must jointly inspect the work following completion.

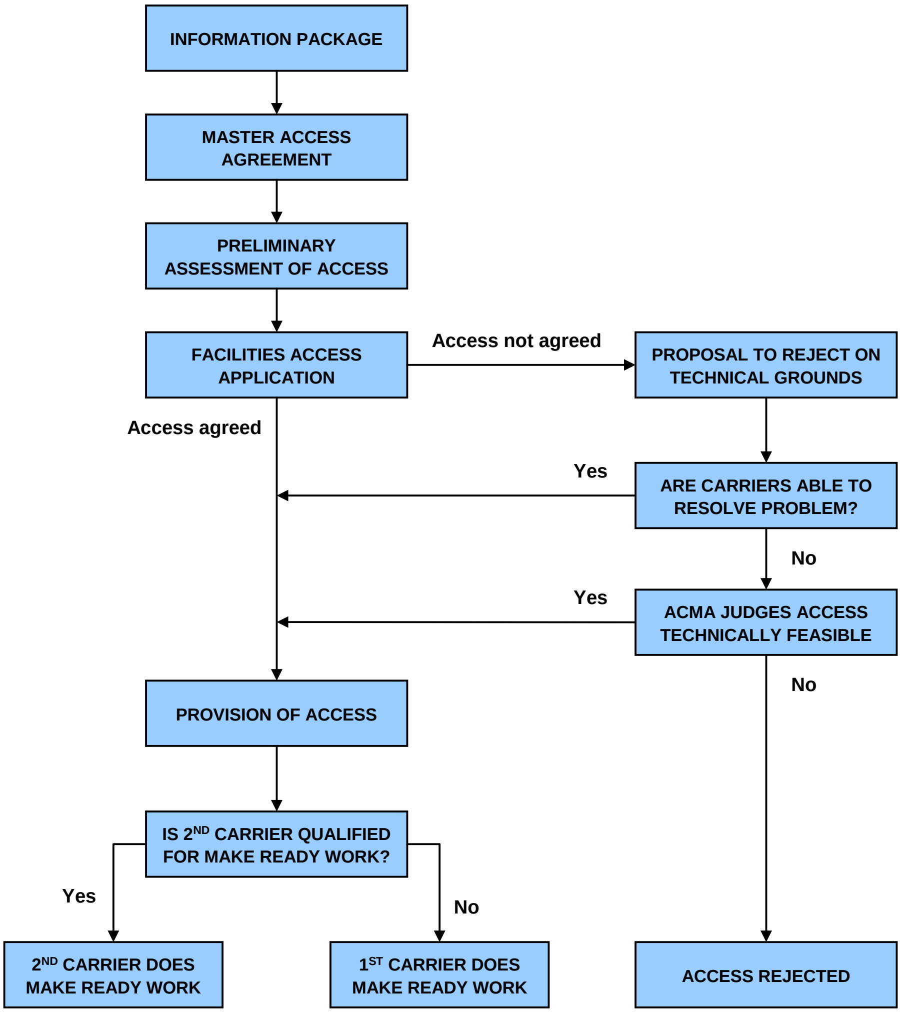

Figure 28: Flow diagram for access to existing facilities

Pricing and Rate Setting

Terms and conditions are negotiated commercially between the First and Second Carrier. Where the parties cannot reach an agreement, the ACCC can arbitrate. In disputes over the price of access, the ACCC will seek to determine the price that would occur if the provider of access faced effective competition, i.e. cost-oriented pricing. Such pricing will be influenced by factors including asset age, location, investment risk and available capacity. Price determinations may be achieved through benchmarking or efficient-cost modelling.

In cases where granting access to facilities prevents the First Carrier from using the facility to meet currently forecasted needs, the ACCC will consider the cost to the First Carrier of foregoing or delaying its current plans. In such cases, in determining the access charges, the opportunity cost to the First Carrier can be added to any modification costs to extend the original access to meet the forecasted needs.

GLOSSARY

'Active' wholesale product – Wholesale access to the network infrastructure through electronic equipment.

Communications Providers (CPs) – Companies which provide services to a customer's home, such as telephone and internet services, and which usually own some infrastructure.

Customer Premises Equipment (CPE) – Terminal equipment located at the customer's premises

Fibre to the Cabinet (FTTC) – An access network structure in which the optical fibre extends from the exchange to the cabinet. The street cabinet is usually located only a few hundred metres from the subscriber's premises. The remaining part of the access network from the cabinet to the customer is usually copper wire but could use another technology, such as wireless.

Fibre to the Premises (FTTP) – An access network structure in which the optical fibre runs from the local exchange to the end user's living or office space.

Local Loop Unbundling (LLU) – The process where an incumbent operator makes its local access network available to other CPs, by allowing them to deploy equipment in the incumbent's local exchange and offering connectivity to the access network.

Main Distribution Frame (MDF) – The local exchange building that houses the access network electronics

Next Generation Access (NGA) – Telecoms access networks capable of providing substantial improvements in broadband speeds and quality of service compared to today's networks; most often refers to fibre-based access, but can be based on a number of technologies including cable, fixed wireless and mobile.

Optical Distribution Frame (ODF) – A structured frame for the termination and cross-connection of optical fibres within a telecoms equipment room

Optical Line Terminal (OLT) – The access equipment of a GPON network, located in the local exchange

Service Level Agreement (SLA) – A negotiated agreement between the provider and customer of a service, regarding levels of availability, performance, or other attributes of the service; may involve agreed penalties if the service does not meet these levels.

CITATIONS

ACCC. "A Code of Access to Telecommunications Transmission Towers, Sites of Towers and Underground Facilities" (1999)

ACCC. Access Disputes, http://www.accc.gov.au/content/index.phtml/itemId/635059

ANACOM, Law of Electronic Communications, Law 5/2004 (2004)

Analysys Mason Group for BSG. “The costs of deploying fibre-based next-generation broadband infrastructure”, Sept 2008

ARCEP, “Scorecard for wholesale fixed broadband and ultra-fast broadband offers - 3rd Quarter 2009” (11 January 2010)

ARCEP, “The FTTx stakes” (July 2008)

ARCEP, Decision 2008-0835 (July 2008)

Association des Villes et Collectivités pour les Communications électroniques et l’Audiovisuel (2007)

AT&T. Structure Access Handbook. https://clec.att.com/clec/hb/shell.cfm?section=1714

Australian Govt. "Draft Legislation for Fibre in New Developments" (2009)

Australian Govt. "New National Broadband Network" (2009)

Australian Govt. Telecommunications Act of 1997

BT. “BT to expand footprint for UK's fastest broadband”, BT Press release (9 October 2009)

Canadian Telecom Policy Review Panel. Final Report (2006)

Commission des services electriques de Montreal. "Stratégies d’avenir" (2005)

Communications Infrastructure and Service Availability in Australia (2008)

Cook Report. “The Economics of Micro-trenching for Laying Fiber”, June 2008

CRTC. Communications Monitoring Report (2009)

CRTC. Telecom Decision No. 99-13 (1999)

CRTC. Telecom Decision CRTC 86-16 (1986)

CRTC. Telecom Decision CRTC 95-13 (1995)

CRTC. Telecom Notice of Consultation CRTC 2009-432 (2009)

CRTC. Telecom Notice of Consultation CRTC 2009-432 (2009)

European Commission. “Draft Recommendation on Regulated access to NGA Networks” (12 June 2009)

FCC. Docket 01-170 “Consolidated Partial Order On Reconsideration”, 25 May 2001.

France Law no. 2008-776, “Modernizing the Economy” (2008)

France Telecom, “Offre d’Accès aux Installations de Genie Civil de France Télécom pour les Reseaux FTTx” (29 April 2009)

Ofcom. “Delivering super-fast broadband in the UK” (23 September 2008)

Ofcom. “Delivering super-fast broadband in the UK” (3 March 2009)

OFWAT. PR09 cost base report

PT Communications, “ORAC Duct Sharing Offer.” (9 October 2008)

PT Wholesale, ORAC version 2.9 (27 August 2008)

Queensland Govt. Project Vista, http://www.dip.qld.gov.au/projects/telecommunications/project-vista.html

SNL Kagan. 2009

Sonaecom. Presentation at the Mid Cap Event Paris (29 September 2008)

Supreme Court of Canada. Barrie Public Utilities v. Canadian Cable Television Association, [2003], 1 SCC 28 (2003)

Tasmanian Electronic Commerce Centre Pty Ltd. TasCOLT Review-Report (2008)

Telstra Corp. SEC Filing 20-F/A (2002)

Total Telecom. “Openreach assesses FTTP economics” (9 September 2009)

US Public Law 95-234, February 21, 1978, “Communications Act Amendment of 1978”

Verizon. "Access to Poles, Conduits and Rights of Way", http://www22.verizon.com/wholesale/business/poleconduit/home/

Wall Street Journal Europe. "Paris Sewers Give City of Light A Fiber-Optic Edge" (2006)

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