Cooperative Network Infrastructure

Digital infrastructure planning design guide

Guidance for Manchester City Council and its partners on objectives and practice

Version 3.2 draft for comment and review

Contents

Toolkit annexe

1. Summary

This document provides guidance for Manchester City Council on the deployment of digital infrastructure in new developments and construction projects.

It proposes principles to adopt and practices to pursue in order to realise the authority's wider social and economic objectives.

It focuses on the opportunities for the authority to influence the rational deployment of digital infrastructure:

- During construction and infrastructure upgrade activity, using a 'dig once' approach;
- During investments by operators to 'retrofit' new digital infrastructure.

By adopting a proactive dig-once approach, the authority can help:

- Minimise disruption to business and the public.
- Reduce the financial and environmental cost of digital infrastructure deployment, including the carbon footprint.

Using that approach and also adopting a proactive approach to investments to retrofit new digital infrastructure, the authority can:

- Ensure the deployment of high specification and 'future-proofed' infrastructure to match the city's ambitions.
- Potentially maximise opportunities for competition, innovation and local wealth creation.

Then the document addresses two questions in three contexts:

Two questions

- What are the design principles supporting the strategic aims?
- What are the recommended methods and specifications?

Three contexts

- Planned deployment of digital infrastructure in new residential and commercial developments.
- Opportunistic deployment of digital infrastructure in other infrastructure developments (for example road upgrades, cycleways, EV charger infrastructure) and in regeneration projects (for example environmental building upgrades).
- Planned investments by commercial operators and public sector to upgrade and renew digital infrastructure.

1.1. Versions

This is a living document that will evolve to keep pace with changing opportunities and to take account of the policy choices made by the council.

This is Version 3 - second draft following initial feedback 20 July 2021

2. Objectives

The city has ambitions and objectives that can be served by the *right sort* of digital infrastructure deployed in the *right way*. These include:

- Growing the digital-tech economy in the city and reinforcing Manchester's position as a leading digital city;
- Encouraging innovation in public, private and third sectors;
- Enabling productivity and efficiency gains in the wider economy and in the public sector;
- Providing new opportunities to citizens for learning and employment;
- Extending the benefits of digital and on-line services to the whole of the community.

2.1. The right sort of digital infrastructure

To maintain and enhance Manchester's status as a leading digital city demands digital infrastructure that meets key criteria for the delivery of digital services now and into the future:

- At sufficient data transmission speed;
- With capacity to accommodate growing numbers of connected users and devices;
- Supporting new services, including those not yet conceived.

Given the cost and disruption caused by the deployment of new digital infrastructure, it should meet these criteria over an extended period. This means in the coming decades and at least through the transition to net zero carbon.

While it is not possible to see into the future, it is nevertheless possible to make rational choices about the technical design principles of the infrastructure[1].

These are summarised in the table below:

Principle	Rationale
Comprehensive, ubiquitous and dense optical fibre.	• We know that optical fibre, using light rather than radio frequency as the carrier, will support exponential growth of data transmission speeds for years to come. • We know that new wireless technologies, such as 5G, drive demand for increasing amounts of fibre. • We know that increasing numbers of devices, however they are connected to the network edge, also drive demand for fibre.
Frequent and flexible nodes where fibre terminates.	• We know that the hierarchical topology of the circuit-switched telephone network is not optimal for packet-switched data transmission, which is better served by a cellular topology. • We know that telecoms operators and service providers need to upgrade network electronics to support new services, and that these devices need to be deployed closer to the network edge.
Application-neutral architecture	• We know that current applications and usage profiles will change, and hence that application-specific choices should not be baked in to the design.

Counter example

[1] This has a parallel in the development of the Internet. The initial assumptions and design principles, made without any knowledge or foresight of future applications, enabled rapid innovation and the delivery of those unforeseen applications.

The importance of these design choices is well demonstrated in the recent costly deployment of FTTC[2] technology across the UK. This technology:

- Uses copper for part of the connection, so that the technology is already reaching the end of its life.
- Is designed almost exclusively to connect homes, so that many businesses have been left relying on older technology.
- Is not designed for, or capable of, supporting deployment of small-cell 5G radio and other devices.
- Relies on telephone exchanges connected to street cabinets, with consequent limitations: exclusion of premises in 'exchange only' areas; poor quality with distance from cabinet; baked-in contention ratios.
- Assumes download speed demands are much higher than upload, now much less the case following the explosion in video conferencing during the pandemic.

2.2. Deployed in the right way

Manchester's economic and social objectives can be supported by adopting the right approach in the deployment of infrastructure as well as ensuring it is of the right type. The right approach will:

- Support the growth of the local digital-tech sector, through supply chain development and a healthy ecosystem;
- Stimulate innovation by service providers and the digital-tech sector;
- Provide choice for end users.

While it is not possible for the public sector to build and operate the new digital infrastructure that the UK needs[3], nevertheless it can play an important role in promoting the right approach:

- Through leadership, encouraging collaboration and the adoption of design principles and standards;
- Through stewardship, ensuring that assets are sustained and held in trust for neutral access.

In playing this role, the public sector can ensure the maintenance of key principles. These are summarised in the table below.

Principle	Rationale
Access to dark fibre	• Dark fibre supply in the UK is constrained • Open access to dark fibre, rather than active wholesale services, helps operators and providers (including public sector) innovate and differentiate products • Open access to fibre rather than ducting brings the benefits of passive access to smaller businesses and public sector. • Investors in 5G deployment need dark fibre

[2] Fibre to the cabinet - the 'superfast' technology adopted by Openreach. Fibre is deployed from the telephone exchange to the street cabinet, with copper wires running the final metres from the cabinet to the end-user premises.

[3] Or at least, that is not under consideration

Principle	Rationale
Shared infrastructure	• No useful purpose is served by infrastructure investors overbuilding each other: an equivalent degree of competition is equally served if competing operators share fibre. • Competition to provide services on a shared infrastructure is not confined to the areas where there is overbuild • Smaller, local and innovating digital-tech businesses are better able to roll-out services on shared infrastructure
Neutral hosting	• Neutral hosted infrastructure ensures competition is not restricted to a small number of providers • Neutral hosting means different providers can deploy different technology solutions

Counter examples

Unregulated infrastructure competition encourages overbuilding in hotspots as investors seek to maximise returns.

Fibre owners, faced with the high costs of extending network prefer to 'sweat the asset' by selling further up the network stack to capture more of the value chain. This blocks growth paths for new and challenger operators and ISPs left with no way to capture more of the value chain or differentiate products.

Single investor-dominated builds make technology choices (such as PON[4] - see Home Run) that stifle innovation and competition[5].

[4] Passive Optical network. Fibres connecting multiple premises are served by a single backhaul fibre using 'passive optical splitting' rather than electronically. This necessarily requires that a single operator lights all fibres using the splitter.

[5] Unless deployed in ways specifically to ensure independent access to individual fibres serving premises

3. Policy guidance

There are policy choices concerning the type of digital infrastructure (deploying the right sort) that should be deployed during development and construction projects, and the approach to deployment (in the right way). These choices have consequences for the outcomes.

This section provides guidance on choices based on the principles outlined above.

These policy choices are summarised in the table below and then described in more detail.

This section also addresses the opportunity to develop an 'active thin layer' approach.

Policy choice	Description	Alternatives	Principles addressed
Home run	Fibre to each premises can be 'undbundled'. Also called point-to-point.	• PON (passive optical network)	• Frequent and flexible nodes where fibre terminates. • Application-neutral architecture • Access to dark fibre • Shared infrastructure • Neutral hosting
Dig-once accretion	Opportunistically deployed duct is held in trust for shared access	• Exclusive concession by lots	• Access to dark fibre Shared infrastructure • Neutral hosting
Stewardship and neutrality	Local authority 'adopts' infrastructure as neutral host, or makes similar arrangements for neutral stewardship	• Operator (eg Openreach, Virgin) deployment in developments • Retention by property owner	• Comprehensive, ubiquitous and dense optical fibre. • Access to dark fibre • Shared infrastructure • Neutral hosting
Positive engagement	Emphasis on carrot rather than stick in engagement with developers	• Strict enforcement • Do nothing/Laissez faire	• Comprehensive, ubiquitous and dense optical fibre.
Shared way-leaves	Operators wishing to provide connectivity to council properties can use a simplified global way-leave	• Council engages separately with each operator • Barrier busting	• Access to dark fibre • Shared infrastructure • Neutral hosting
Flexible collaboration	Active engagement with investors to create shared infrastructure using collaborative co-investment models	• Do nothing • Barrier busting • Formal JV	

3.1. Home run

Both the major incumbents (Openreach and Virgin) have committed to installation of Gigabit-capable infrastructure for new developments, at small or no cost to the developer. In general

this translates into deployment of full fibre at no cost[6]. We have probably reached a stage now where leadership from the council is not needed to persuade developers to take up one of these options.

However, not all full-fibre access[7] networks are equal, and Manchester can lead in ensuring that the best standards are adopted.

'Home-run' (point-to-point) fibre networks represent the 'gold standard' for full fibre. With home run, Internet providers can access fibre connections to individual premises in competition with one another. This is not possible with access networks being deployed by the incumbents.

With home run, each premises is connected with a fibre to a location, such as an active street cabinet, where ISPs can co-locate their own electronic equipment[8]. Individual fibres can be connected to one or other provider's equipment in the cabinet.

This gives them complete control over the service they deliver, so that they can innovate and differentiate product offerings. For example up speed vs down speed, but also other parameters such as contention, latency and jitter.

An example of this approach is STOC[9] in France, introduced by the French regulator ARCEP. This is covered in more detail in the Appendix.

Counter examples

In comparison other hybrid and full-fibre technologies are inferior.

Superfast and 'gigabit' technologies such as FTTC (including G.fast) and DOCSIS, all rely on copper. We are now nearing the absolute physical limit to how much data can be transmitted over copper.

PON (passive optical network) is a compromise full-fibre technology used by network builders such as Openreach. While it is a form of full fibre, it does not permit open passive access to individual premises. It helps reduce the cost of fibre deployment by using one fibre connection to serve multiple premises, without using any electronics - hence the term 'passive optical network'. GPON (and other PON technologies such as EPON and DPoE):

- Require a monopoly operator at the active layer - all premises served by the shared fibre must use the same active layer provider[10].
- Share up-stream bandwidth between premises so that users get slower up speeds than down speeds.

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[6] "The combined effect of these steps means that from 1stApril 2020, 95% of new build homes on sites being newly contracted with Openreach will get full fibre infrastructure for free, with the remaining 5% having a commercially attractive Developer co-funded option, capped at £2,000 per home." Clive Selley CEO Openreach, 2020 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959273/Letter_from_Clive_Selley__CEO_of_Openreach_to_the_Rt_Hon_Oliver_Dowden_MP_V2.pdf

[7] networks connecting premises, as opposed to spine networks

[8] Here we use the term 'home run' to describe a fibre topology where each end user has an independent fibre connection to an electronic device which can be re-assigned to a different device, not necessarily back to an exchange. Sometimes the term 'sub loop unbundling' is used to refer to home run in the sense we use it here, however it is a term that is more properly applied to FTTC.

[9] *sous traitance opérateur commercial*

[10] Nevertheless, the home run approach advocated in this document would allow an operator to deploy a PON splitter in the cabinet instead of electronics. In this way there is no monopoly since the fibre can be reassigned to a different provider.

3.2. Dig once accretion

There is a widespread understanding that a 'dig-once' approach to digital infrastructure deployment makes sense.

'Opportunistic dig-once' as used here means that ducting suitable for optical fibre is installed while construction works are underway. In this document 'opportunistic' is used to refer to situations, other than large scale new developments, where there will be excavations offering opportunities to deploy ducting at low cost. Examples may include:

- Road upgrades and new roads;
- New cycleways;
- Other infrastructure deployments and upgrades - eg EV charger infrastructure.

Rationale

The rationale is based on:

- **Cost**: the large part of the cost of new fibre network deployment is in deploying ducting. For a new deployment of fibre and ducting in existing roadway, duct deployment typically accounts for 90% or more of the cost.
- **Disruption and scars**: deploying new ducting involves significant disruption to citizens and businesses. Even with careful reinstatement new duct deployment will leave unsightly scars, particularly with special, decorative or heritage surfaces. Ducting deployed with foresight becomes particularly useful where a section 58 order is imposed.
- **Scarcity**: aside from Openreach ducting (see below), there is limited availability of ducting in which it is possible to deploy fibre. Further there is limited knowledge of where that ducting is and in what condition it may be in. Where ducting exists there are often complex legal and technical issues in accessing it.

Ofcom regulations require Openreach to make its ducting available for fibre deployment, and this is a valuable resource for operators wishing to build new fibre network capacity. However this ducting:

- Has limited capacity, more limited on some routes than others.
- Does not reach all places.
- Is sometimes significantly degraded.

While the rationale for dig-once is compelling, the marginal costs can outweigh benefits in some cases, for example, where the amount of new ducting is trivial.

Guidance on decision making with regard to costs and benefits is provided in Decision criteria.

Accretion

In any case, the assets created through application of a comprehensive dig-once policy will frequently be isolated from each other and from other usable digital infrastructure.

For this reason, the guidance here is to **adopt an accretive dig once policy**, that is to say to establish a mechanism for stewardship of new assets created and to prevent fragmentation of control and access to the assets. For example:

- Ownership of the ducting and associated assets may remain with the local authority, or some other neutral body charged with the stewardship of the assets.
- The stewardship body retains a register of assets and makes arrangements for their maintenance.

- Arrangements are made to permit non-exclusive access to the assets by public and private sector, referred to in this document as ‘Layer 0 neutral hosting’.

Counter example

The most common alternative to a dig-once accretion policy is to have no dig once policy at all. This is probably because local authorities have been reluctant to take responsibility or make other arrangements for stewardship.

Another alternative is to seek a partner for an exclusive concession on a new property or infrastructure development, for example following construction of a new cycle way. This approach:

- Makes no sense except in the case of large developments and in any case is unlikely to generate significant financial benefits for the sponsoring authority. Asset values are limited, particularly when the assets are isolated, and may have little coherence with the investment plans of potential concessionaires.
- Outsources responsibility for effective exploitation of the asset. The sponsoring authority has little or no control over how the asset is used and no way to ensure the desired economic and social benefits.
- Will require careful attention to procurement and subsidy control regulations. This may introduce significant complexity, for example including ‘claw-back’ or similar arrangements.

3.3. Stewardship and neutrality

Where ducting has been deployed using dig-once, either by arrangement with a property development, or as part of an opportunistic dig-once policy, someone needs to take ownership of the duct.

To maximise the benefits and in pursuit of the council’s objectives, attention needs to be paid to ensuring that the neutral host principle is applied, whatever form of ownership is agreed.

In this guidance we apply the term ‘neutral host’ to a fibre network in two ways:

- Layer 0 neutral host: where the fibre ducting and associated infrastructure is open for multiple operators to deploy their own fibre.
- Cooperative neutral host: where a neutral cooperative, such as CNI, deploys fibre on behalf of its operator members.

Either approach satisfies the neutral host principle, so enabling competition and encouraging service innovation and differentiation.

Thus there are broadly two[11] ways to satisfy the neutral host principle for dig-once ducting:

- Council adoption: the council ‘adopts’ the ducting and takes responsibility for it. While the council has no powers to adopt ducting in the same way that it can adopt roads, it is able to take responsibility for ducting by agreement with a land owner, and full ownership on public land. The council can then act as steward, making access available through a cooperative vehicle such as CNI, or through a trading arm.
- Cooperative stewardship: CNI or a similar body takes responsibility for the duct and acts as steward, by agreement with the land owner or the body commissioning and funding the duct deployment. Ownership could be with the council or with the property owner.

[11] There is potentially a third route, which is for CNI to take ownership, however it has been argued that this could be seen as a form of state aid if the commissioning body or property owner is in the public sector. The status in the new subsidy control regime is difficult to determine. Arguably ownership is not necessary to ensure neutral access.

With either solution there is a key role for the council in ensuring neutral access to the asset.

In the case of large property developments there is a revival of interest in MUSCOs (multi-utility service companies). In this case a single body takes responsibility for all the utility provision on site, with potential for environmental initiatives such as a heating network and grey water systems. It would be straightforward for a MUSCO to arrange for CNI or a similar body to act as neutral host.

Counter examples

It has been widespread practice for developers to assume that they have no responsibility for digital infrastructure. In 2020 the government received commitments from Openreach and Virgin Media to provide 'Gigabit capable' connectivity to all new build developments[12]. While developers are undoubtedly more aware now of the importance of good digital connectivity, not least to augment the property value, this commitment has probably reinforced the notion that developers can leave the problem to Openreach.

Aside from the fact that Gigabit capability will have a short life[13], Openreach (or Virgin Media) deployment by itself does not satisfy the principles outlined in Objectives, specifically the PON architecture deployed by Openreach[14] or Virgin Media[15] is not application neutral and does not provide access to dark fibre.

Deployments by the incumbents could offer a form of neutral hosting. Openreach is required by the regulator to allow other operators to deploy fibre in its ducting[16]. Virgin may also be required to open its ducting under proposals currently under consideration by the government[17]. However, to meet the principles outlined in Objectives (see Deployed in the right way) requires access to dark fibre. For PIA the conditions that operators must meet are arguably onerous, effectively excluding smaller providers. For Virgin no one has yet been able to access the ducting.

Nottingham City Council installed ducting as part of its tramway extension and offered an exclusive concession to deploy fibre in the ducting[18]. Following a procurement exercise the concession was won by ITS Technology[19]. Under the arrangement, ITS has sole rights to use the asset. The council cannot deploy its own fibre and must procure services from ITS in the normal way to take advantage. ITS make use of PON to connect premises and does not provide comprehensive access to dark fibre.

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[12] https://www.gov.uk/government/publications/new-build-developments-delivering-gigabit-capable-connections

[13] 'Nielsen's law' says that typical bandwidth demands double every 18 months. By this measure in 10 years' time we shall be talking about multi-Gigabit.

[14] Openreach uses GPON and XGS-PON

[15] Virgin Media uses EPON

[16] PIA (physical infrastructure access) https://www.openreach.co.uk/cpportal/products/passive-products/physical-infrastructure-access(PIA)

[17] https://www.gov.uk/government/publications/review-of-the-access-to-infrastructure-regulations-call-for-evidence/review-of-the-access-to-infrastructure-regulations-call-for-evidence

[18] https://committee.nottinghamcity.gov.uk/documents/s15470/DD1403.pdf

[19] Also a member of CNI. https://cni.coop/member/its

3.4. Positive engagement

Property developments

While the council could pursue a route effectively to require developers to deploy ducting for neutral hosting, for example using S106 planning conditions, the guidance in this document is to adopt a positive approach. Arguments for cooperation include:

- The developer can deploy ducting at a time and in a way to suit its own requirements, confident that the problem of ensuring that it is properly and effectively used will be taken care of.
- Neutral hosting, dark fibre access and home-run architecture provide maximum opportunity for service providers to compete with a variety of well-differentiated products, with positive impact on property values.
- Requirements on the developer can be limited to deployment of the duct according to a straightforward specification.

Depending on the approach taken to adoption by the council (see Stewardship and neutrality) the developer can be offered options:

- The council adopts the duct and takes responsibility for it, so that the responsibilities of the developer a fully discharged once the duct is handed over;
- The cooperative neutral host (eg CNI) takes on the role of steward and maintenance of the ducts, while ownership remains with the developer;
- The developer keeps ownership of the ducts and is responsible for maintenance, and charges a duct rental fee to CNI or a similar body, and potentially separately to individual operators.

It is likely that most developers would prefer one of the first two options.

Opportunistic dig once

A unitary authority has multiple opportunities to deploy dig once ducting in the course of projects it undertakes, including cycleways and road upgrades.

Other dig-once opportunities will rely on positive engagement with other public sector bodies. In Manchester this will include in particular opportunities to work with the combined authority and TfGM. So far in GM these opportunities have not been taken up to any significant degree.

For example, during the ‘big bang’ construction of new tramways, TfGM had the foresight to deploy significant duct capacity. However:

- No attempt was made to ensure that way leaves for the tramway included appropriate permissions for fibre deployment;
- Apart from the deployment by Tameside MBC on the Ashton line and a smaller deployment on the line to Media City by euNetworks (formerly The Loop), the ducts have not been used for this purpose.

There are potentially dig-once opportunities during any significant infrastructure renewal by utilities. However, we know of no progress in the UK on any comprehensive agreement with utility companies to deploy fibre ducting when upgrading utilities.

Manchester could lead on this notion using the notion of neutral stewardship and the cooperative neutral host to help reach positive agreement with utilities organisations. Such an agreement might include:

- Adoption of ducting by the council acting as guarantor of neutral access;
- Maintenance of a register of assets by the council or commissioned by the council.

Counter example

The main alternative to a dig once strategy is not to have one. Dig once is widely seen as a 'good idea'[20] but examples of systematic adoption in the UK are rare.

The term 'dig once' originated in the USA where a number of cities have adopted dig once strategies. For example San Francisco adopted a 'dig once' ordinance[21], which requires: "*the installation of City-owned communications infrastructure in excavation projects where the City has determined that it is both financially feasible and consistent with the City's long-term goals to develop the City's communications infrastructure.*"

Recommendation: Manchester could investigate whether such an ordinance is feasible in the UK

3.5. Shared way leaves

Operators may wish to deploy infrastructure on council property (or property belonging to partner organisations such as social housing providers) for a number of reasons, such as:

- To provide services procured by the council;
- To offer services to business or residential tenants in council properties;
- As part of a wider network build, or to gain access to other properties.

Some operators have powers to deploy under the Electronic Communications Code ('code powers'). The council will nevertheless need to engage with investing operators seeking to deploy equipment on council property, not least to ensure that works are conducted to a good standard and with proper attention to safety and environmental impact.

Making an arrangement for way-leave permissions to be designed so that they can be shared has benefits for both council and operators:

- Time savings for the council legal team;
- Reduced friction and faster turn-around for operators;
- Help evolve and ensure common standards.

One approach being pursued by Blackpool Council is to use the cooperative neutral host as the way-leave mediator, so that:

- Only one contract is needed between council and cooperative neutral host (eg. CNI), providing the framework for access to all or most council properties;
- Details for each deployment agreed by written agreement within the cooperative governance, rather than requiring contracts or contract schedules.
- Ensure compliance with standards using cooperative governance rather than contract dispute.
- Snap-back arrangements to cover instances where the investing operator ceases to be a member of the cooperative.
- Potential to incentivise investors to deploy on a neutral host basis.

Recommendation: Manchester can learn from the experience in Blackpool and potentially adopt a similar approach.

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[20] A well-know Heineken advert made this point years ago. https://www.youtube.com/watch?v=THoCE_9tyfk

[21] 2014 https://sfgov.legistar.com/View.ashx?M=F&ID=3319457&GUID=F4269889-DA96-4993-B243-AA71125C3847

Counter example

Investing operators regularly cite difficulty obtaining way leaves as a major obstacle to rapid deployment of new digital infrastructure. Recognising this, the government has committed resources through the 'Barrier Busting Task Force'[22].

Even where there is an attempt to reduce duplication of effort using way-leave templates, or authority-wide agreements, there are still significant impediments:

- Individual operators must each be engaged by the legal team.
- Individual operators seek permission to build according to their own standards, requiring legal and technical time.
- Ensuring completion to a good standard uses council resources.

A shared way leave approach overcomes these obstacles effectively by treating the grant of access itself as a resource to be shared.

3.6. Flexible collaboration

A dig once policy approach makes most sense in the context of a wider set of policies to encourage neutral and shared fibre infrastructure deployment.

This can be based on a straightforward rationale concerning the role of the local authority in digital infrastructure development:

- That it is appropriate for the local authority to concern itself with ensuring the widest possible availability of high-specification affordable digital connectivity;
- That it is appropriate for the local authority working with its partners in the public sector to build, own and operate its own digital infrastructure where this makes financial sense in the long term;
- That the rapid deployment of new digital infrastructure is served by encouraging collaboration between investors and builders, be they in the private or the public sector, and that it is appropriate for the local authority to play a leadership role in encouraging such collaboration.

Manchester City Council is already engaged in this policy agenda through its membership of CNI, alongside public sector partners such as Tameside MBC and NHS trusts.

Manchester could go further:

- Following the example of Tameside and Blackpool by investing in digital infrastructure as a way to save costs and promote innovation, rather than procuring services. This need not be an 'all-or-nothing' policy choice, rather a strictly pragmatic approach where savings are easily realised, and taking advantage of the collaborative opportunities for shared commercialisation of owned assets through CNI.
- Seeking government funds to deploy new digital infrastructure as a way to promote digital inclusion. For example to provide base-level services in social housing. There is potential now following the most recent regulatory changes to make more use of Openreach PIA infrastructure, deploying fibre at public expense to meet policy objectives (social inclusion), but equally as a 'market economy operator' making the fibre available for shared use on the cooperative neutral host model.

[22] https://www.gov.uk/government/publications/barrier-busting-task-force-next-steps

- Working with public sector partners to aggregate and share potential assets, for example unused ducting in the Metrolink tramways.
- Working with CNI and other GM authorities to promote community (business and citizens) investment in fibre deployment, again taking advantage of the new regulatory landscape for PIA. This would be a re-application of the highly successful B4RN community ownership model in an urban context.

Recommendation: Manchester could pursue all these opportunities.

Counter example

The alternatives to this active, pragmatic, collaborative approach for local authorities are:

- Do nothing and leave it to the market. Private investment in fibre networks has rapidly increased in the last three years, and this is no longer confined to the incumbents, with 'altnet' actors such as CityFibre and Hyperoptic expanding rapidly. However long experience in Manchester from the Nynet cable deployment in the 1990s, through to the FTTC investments by BT from 2008, shows that the outcome of such upgrades is patchy, with vital and critical areas of the city left in the slow lane for digital infrastructure investment, while large scale operators overbuild each other in other parts of the city.
- Engage with the BDUK gap-funded approach. During 2018-2020 BDUK pursued an infrastructure-led approach to government intervention (the LFFN programme), however it has now reverted to a service-led, gap-funded approach with the Gigabit programme. In this model the state subsidises private operators to upgrade infrastructure to meet defined service levels (in this case Gigabit) in areas where there 'is no business case' absent subsidy. While this may increase broadband speeds:
  - It would do little to help Manchester achieve its objectives (see Objectives).
  - Manchester as an urban area does not qualify for the current government interventions.

3.7. Further considerations

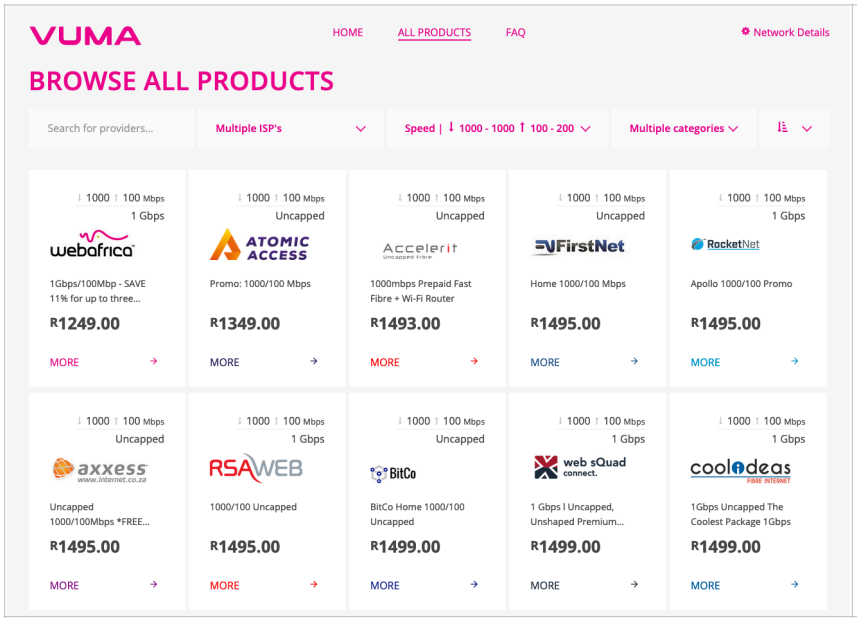
Active thin layer

Developers are interested in ensuring that tenants or buyers will have access to a wide range of service providers. This can be used as an argument for inviting Openreach to deploy infrastructure, since many ISPs do offer service over Openreach wholesale connections. This situation is evolving rapidly however, particularly as 'altnet' fibre investors connect an increasing proportion of UK premises.

One attractive option that may evolve in the UK in the next years is the so-called 'Swedish model'.

With this model, homes have routers preinstalled by a wholesale active service provider. On moving in, occupiers can connect immediately and are presented with a menu of service provider options to choose from. Having chosen a provider and provided billing details they can be connected immediately. The image shows an example from South Africa[23].

[23] https://shop.vumatel.co.za/



Vumatel 'shop front' screen showing 1Gbps offers.

The model assumes a wholesale active operator. This could be co-owned by ISPs using a form of cooperative neutral host. This would be an 'active thin layer'.

Recommendation: Manchester could help establish an Active Thin Layer partnership.

4. Method guidance

4.1. Opportunistic dig once

As outlined in the section on Positive engagement, there are various opportunities to deploy ducting during excavations. Success depends on the legal and commercial leverage of the council but principally on its ambition.

The table below shows some of the opportunities in order, starting with the most straightforward and ending with the most difficult.

Opportunity	Description	Challenges	Example
New road construction	Ducting installed while new road is being built	• Not all road building under the control of the council. • Short distances	Tameside inner ring road in Ashton-under-Lyne
Public realm works	Ducting installed during pedestrianisation and other public realm schemes	• Short distances	Glade of Light in the Cathedral Quarter
Road upgrades	Ducting installed during road upgrades requiring excavations	• Not all road building under the control of the council. • Short distances	Dualling of A2300 in Mid Sussex
Bus lanes and bus-ways	Ducting installed during road conversion requiring excavations	• May not be under council control. • Short distances	
Cycleway construction	Ducting installed during cycleway costruction requiring excavations	• May not be under council control. • Short distances	
Tramway construction	Ducting installed during tramway construction and fibre deployed.	• Requires partnership	Ashton line
Utility renewal	Ducting installed during renewal and upgrade of water, gas, electric or telecoms infrastructure	• Requires partnership • Short distances • Cost of deployment	

Decision criteria

Not all dig once opportunities make sense. The table below lists some of the criteria affecting a decision on whether to deploy dig-once ducting.

Criterion	Description	Success factors	Failure factors
Extent of excavation	How much excavation is required?	• Excavations required (or can easily be extended to) full extent of the works	• Excavation to such a limited extent that costs of varying contract etc outweigh the benefits
Length of excavation	What length of ducting could be deployed?	• Of sufficient length to justify the extra complication	• Too short so that the costs of varying contract etc outweigh the benefits
Depth of excavation	To what depth is the planned excavation?	• Excavation planned (or easily modified) to required depth (see Toolkit)	• Excavations generally too shallow, or costly to make deeper
Control or influence of the council	Does the council have direct commercial or legal leverage?	• Council commissioned project • Council can withhold permission • Partnership arrangement agreed in advance	• Weak relationship • Complex legal process
Cost ratio vs benefit	Is the cost of deployment (material and labour) low enough to justify variation?	• Cost is very low in comparison with the overall project cost • It is already known that the deployment will permit a valuable extension to the existing infrastructure	• Cost is a significant component of the overall project cost without a known application for the duct.

Using this table the council can create a decision process to determine whether or not to go ahead. A similar decision-making process has been adopted by Liverpool City Region CA for its extensive road upgrade programme.

Capacity considerations

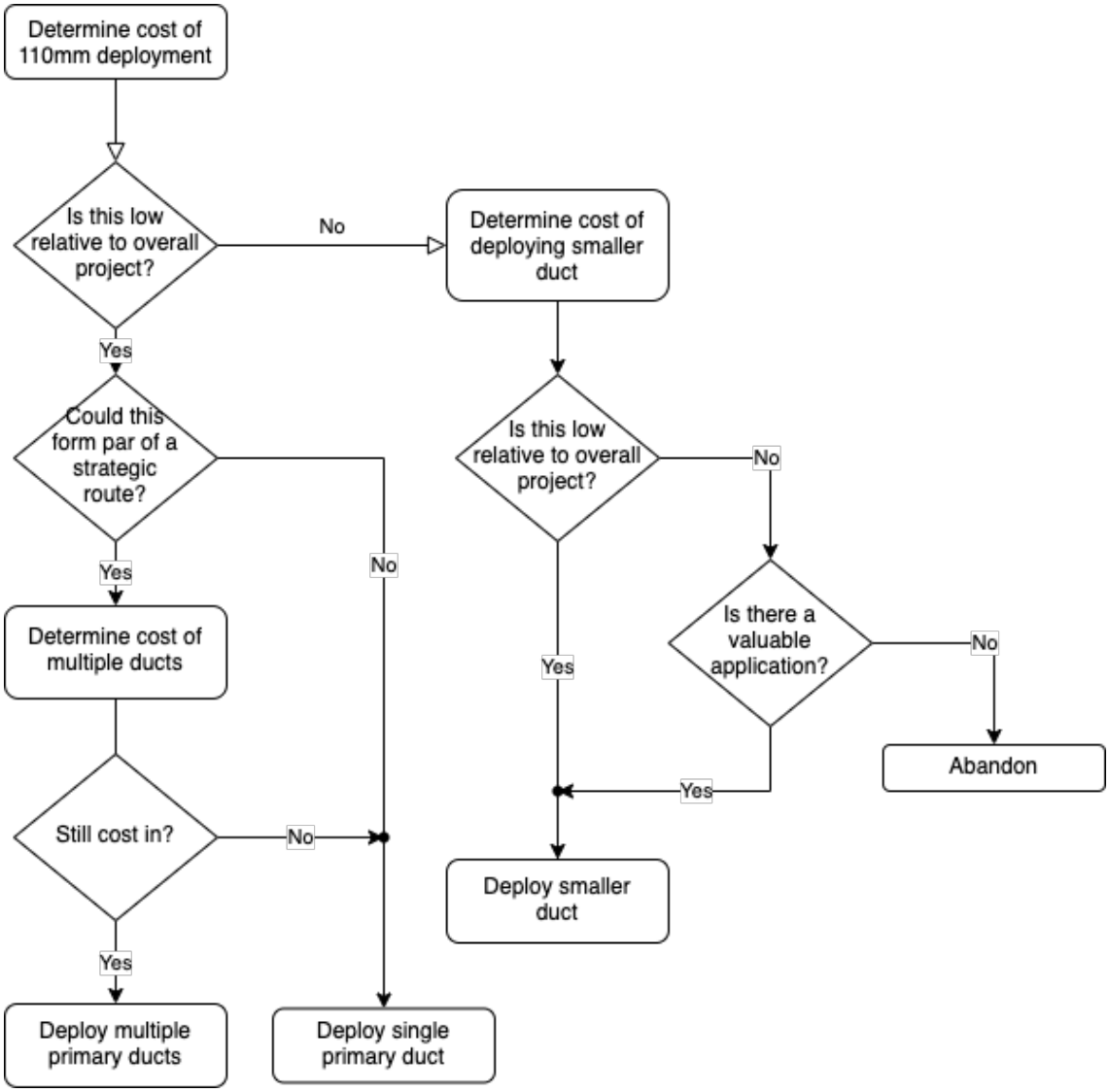
A consideration when deploying dig-once ducting opportunistically is what capacity to install.

By its very nature, opportunistic dig-once deployment is not in accordance with a predetermined network plan. Duct may be deployed without any certain idea what role it will play - if any - in some future network extension.

For this reason it is not possible to say what capacity is appropriate or called for. It is better to have too much capacity than not enough however, and a simple approach would be to deploy ‘primary’ (110mm) duct as a matter of course. This makes sense given that many opportunities, having passed the success criteria in the decision table above (see Decision criteria) are likely to be useful as a spine connection connecting areas rather than access connections to specific buildings. However:

- The rationale for dig-once is that the cost should be low enough that it is not a material consideration in the context of the overall project cost. The cost might be justifiable for a smaller duct deployment.
- The route may have an obvious strategic potential, and the costs low enough to deploy multiple primary ducts.

The flow diagram below suggests a decision-making procedure that could be followed:



Spine deployments

As explored above in Capacity considerations, opportunistic duct deployments (inasmuch as any future application can be predicted), are likely to be useful as spine duct.

In this case, and if the available budget allows, it also makes sense to deploy chambers at appropriate intervals.

In planning chamber installations the following factors are relevant:

- Generally chambers can be added later;
- However, chambers will be difficult to add if there is a section 58 in place;

- Chambers will be needed at turns, particularly sharp turns greater than 45 degrees;
- Chambers are likely to be more in demand in urban than in rural areas;
- Chambers are generally needed where there is a junction.

The table below gives a guide to chamber deployments.

Criterion	Rural	Urban major routes	Urban dense premises count
Description	*Long route infrequently passing habitations and potential users*	*Long route passing some distance from building clusters*	*Shorter route passing near to many buildings*
Turning chambers	Will be needed	Will be needed	Will be needed
Junctions	Will be needed	Will be needed	Will be needed
Likely application	Passing villages, hamlets or business parks	Passing routes giving access to building clusters such as housing estates or business parks	Regular spacing
Regular spacing	At least at limit of pulling (500m) or blowing (1km+) distance	More frequently than in rural areas eg every 200m	At least every 100m

Full details on chamber specifications for spine network sections are given in Spine Network Chambers.

4.2. New developments

Home run access network - commercial and funding

The council may adopt a home run policy as guidance to developers in pursuit of the highest standards in full fibre networks for new developments. The rationale for this is described in the section on Home Run in Policy Guidance.

Such policy guidance will be most effective if the council and its partners can reassure developers that it will be at little or no cost to them. See Positive engagement.

In many cases, a straightforward way to make this work is for the developer to deploy ducting as part of its works programme and then for cabinets and fibre to be deployed by the cooperative neutral host (for example CNI), either using its own funds or working with one of its members.

There are then two principal routes open (see Stewardship and neutrality) to the council:

- Take ownership of ('adopt') the ducting and take responsibility for its maintenance. In this case CNI and/or any other organisation then deploying fibre in the duct would pay a duct rental fee to the council. The council may also provide the (minimal) funds to purchase the ducting.
- Appoint CNI as the body to act as steward. In this case CNI would be responsible for maintenance but would not pay a duct rental fee[24].

[24] The question of duct ownership in this case is currently under review by CNI.

In either case the developer will want guidance on the network design detail. Some of this detail is covered in this document. Other details will necessarily vary from development to development. In general CNI working with its members will be able to provide network design assistance.

Other network builders

A well-designed and implemented home-run fibre network will be entirely suitable for use by any operator or ISP from a *technical* point of view:

- It provides independent fibre routes to each premises;
- Operators are free to deploy PON or active equipment in the cabinet;
- Operators can use any technology to light the fibre.

Further there are no in-principle commercial barriers since CNI products are priced competitively. All that is required is for the operator or ISP to join CNI.

Currently however some operators have strong preferences against using third party fibre. In this case it may still be possible for such an operator to use the home run infrastructure, rather than deploying its own, if it is permitted to deploy its own fibre alongside CNI.

CNI is best able to ensure equal and neutral access to duct asset by deploying fibre on behalf of its members, with equal right to access by any member. This is less easy to ensure if operators are permitted to deploy their own since capacity is limited[25].

Nevertheless, access to the ducting can be mediated by CNI if certain criteria are met. The advantage is that one set of ducts is used and complexity is reduced for the developer.

Openreach however is not prepared even to deploy its own fibre in other ducts. This policy may change as the government brings forward its proposals to force all duct owners to open access.

Thus developers may wish to invite Openreach to deploy its infrastructure in any case. This does not invalidate or lessen the case for deploying a home run network.

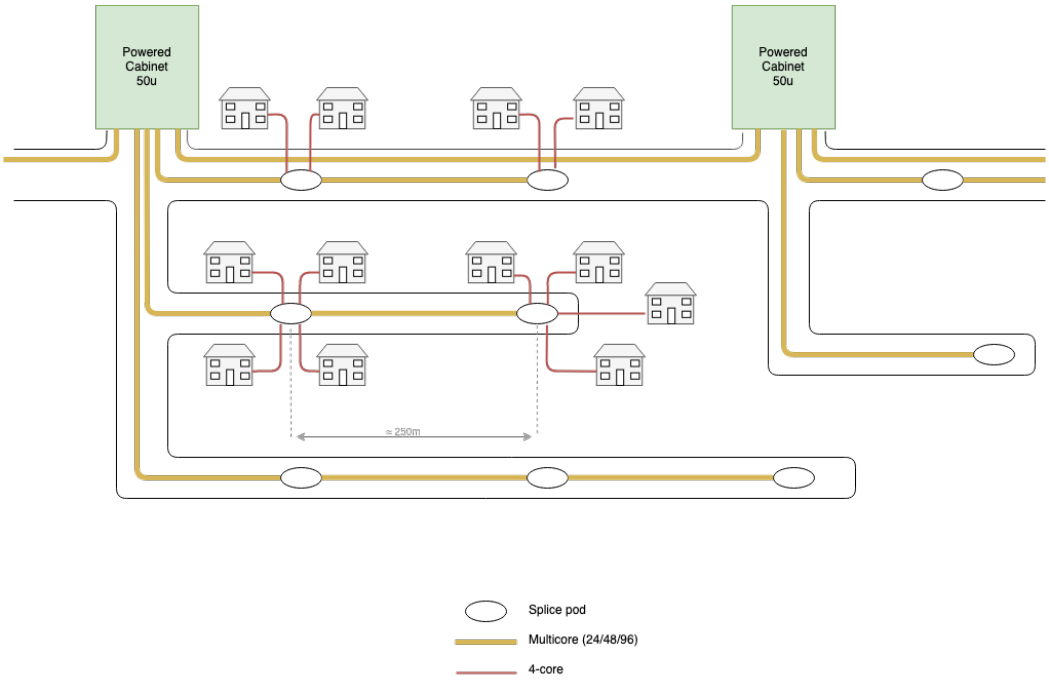
Home run design

The diagram shows an example of a home-run network design. In this example:

- Sub-spine ducting is deployed in the roadways passing all the premises.
- Multi-core cable, typically 96 core, is deployed in the sub-spines, connected back to a cabinet.
- Splice pods are installed in the sub-spine, each serving a smaller number of premises.
- Each premises is connected with a lead-in fibre cable, presenting 2 or possibly 4 fibres that connect back to a splice pod in the sub-spine.
- Fibres are terminated in each premises in a suitable box where ISPs can connect CPE[26].
- Depending on size, cabinets can serve up to 1000 premises.
- Cabinet size should be chosen to ensure adequate space for ISPs and operators to deploy active switches, typically able to serve 48 fibres in 1U.

[25] An analogy would be to permit train operators to lay railway tracks for tehir exclusive use along s for their

[26] Customer Premises Equipment - switch and WiFi router for example



A French ‘point de mutualisation’. These road-installed units typically connect 360 premises or as many as 1,000

5. Case studies

5.1. Opportunistic deployment and dig once in Tameside

Tameside Council was an early adopter of an opportunistic approach to infrastructure deployment, with an informal but highly effective approach to 'dig once'.

In 2009 the authority recognised that it was not at the head of the queue for the limited digital infrastructure renewal then promised by the roll out of FTTC and DOCSIS 3[27] and the authority adopted a 'do it ourselves' approach with three principal strands:

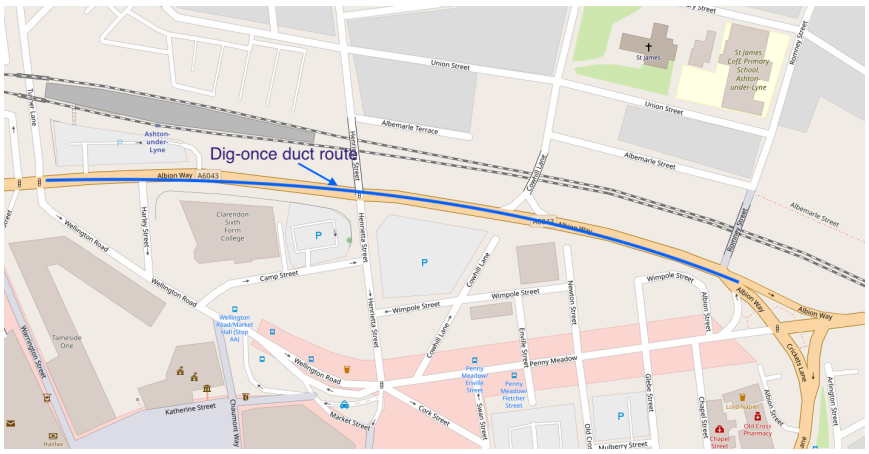
- Building infrastructure to save public funds and unlock innovation;
- Making use of opportunities to use public sector assets such as the ducting in the planned tramway to Ashton-under-Lyne;
- Adopting a 'dig once'[28] policy to deploy ducting on road upgrades and similar projects.

Since adopting this policy, Tameside has deployed over 50km of spine network.

An early opportunity to apply the dig once policy came with the construction of a section of inner ring road in Ashton-under-Lyne[29]. The council deployed ducting during road upgrade without any known application at the time but at minimal cost.

The section of duct came into use 5 years later during the construction of the 'Tameside 8' fibre core to support the council's wide area network, and is now a key part of the shared infrastructure.

Compared with conventional deployment without taking advantage of the dig-once opportunity, the saving to the council was approximately £40,000.



Duct deployment on the Ashton Northern Bypass

[27] The system used to encode broadband on coaxial copper connections used for cable TV. DOCSIS3 enables faster broadband speeds than DOCSIS2 partly by bringing fibre to street cabinets.

[28] The term 'dig once' wasn't used at the time

[29] Ashton Northern Bypass, Albion Way opened in 2012. https://www.manchestereveningnews.co.uk/news/local-news/joy-for-motorists-as-the-15m-ashton-relief-680815

5.2. The French approach

The French regulator Arcep places requirements on fibre investors to ensure fair competition.

In dense areas, fibre investors can compete and overbuild, however there can only be one fibre provider in an MDU (apartment block). The investing operator must provide access for competitors from a PM (*point de mutualisation*). Operators then have a dark fibre connection to each customer.

A similar 'mutualisation' also operates in 'AMII' areas - smaller cities and towns - where operators have been allocated a 'franchise' to construct the network. In these areas they must apply the 'mode STOC'. With STOC (*sous traitance opérateur commercial*) ISPs lease individual point-to-point fibres from the operator. The connection is made at a PM (*point de mutualisation*). Because each individual line is available to the ISP as a passive connection, this is a form of 'home run' architecture.

These arrangements account for a significant proportion of the market. For example in the Loire Département, STOC now accounts for 33% of the connections.

An issue with the STOC system has been maintaining quality, and this is now a focus of work by Arcep and operators.

Local authorities in France take a keen interest in fibre rollout. In Val d'Oise (north of Paris) the Département has instituted a programme for local artists to decorate the STOC cabinets.

Example of a cabinet from Val d'Oise

Toolkit annexe

This annexe provides materials that may be useful for sharing with developers and other partners

1. Network duct and chamber Specification

1.1. General considerations

Deployments should adhere to a common and consistent standard and should take account of:

- New Roads and Street Works Act (NRSWA) and Specification for Reinstatement of Highways (SROH) Edition 4.
- HAUC (Highway Authorities and Utilities Committee) documentation, and or Specification for Highway Works.

This specification provides guidance and does not replace contractor obligations under the NRSWA, HAUC, NJUG and CDM (2015) legislation.

All ducts entering a building or street cabinet should be sealed both externally and internally against the ingress of gas and water.

1.2. Spine Network Ducting

Spine Networks

Commonly spine networks are constructed:

- Using 110(94)mm x 6m twin wall HDPE pipe for primary ducts
- Many telecoms operators use magenta coloured ducting and this is recommended[30].
- Single primary ducts provide significant capacity. However in dig-once deployments two or more ducts may be deployed at small additional cost. A second primary duct provides additional options for renting space to operators, or for other applications such as electricity supply upgrades to support EV charging.
- Twin ducts do not need to be separated when laid side by side.

Depth to cover

Depth of cover regulations are covered in SROH[31], currently these are:

- In a footway at least 300mm
- In a carriageway at least 600mm

In exceptional circumstances it may be necessary to lay duct at shallower depths than those stated above. In such situations either steel duct should be used or the duct should be protected by the use of stockboard protection sheets, steel plating or concrete.

[30] However UK government guidance has also indicated that cyan should be used.

[31] Specification for the Reinstatement of Openings in Highways https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/977196/specification-for-the-reinstatement-of-openings-in-highways-fourth-edition.pdf

Excavation and Trenching best practice

Before excavation starts the presence of utilities needs to be tested, using:

- Visual inspections
- CAT scans
- Trial Holes excavated at regular intervals

The width of the excavated trench should be kept to the minimum.

Surfaces should be cut along each side of the line of the trench to produce straight cut edges.

The width of the trench, at the level of the duct nest should be 150mm wider than the duct formation to allow a 75mm gap each side.

The ducts should be surrounded by fine-fill material (Class 1, 2 and 3).

The trench should be excavated to the appropriate depth to give the standard depth of cover from the top of the duct nest to the surface.

In rocky or stony ground a further 75mm should be excavated and the resulting space filled with tamped fine-fill material free of stones and sharp objects.

Single way/first layer ducts

The duct shall be placed in the trench with its socket towards the duct layer. The first duct shall have its spigot and against a board acting as an anvil against which subsequent ducts can be driven home.

Fine-fill material compliant with HAUC recommendations should be placed and hand rammed between the outside of the ducts and trench sides and placed in such positions so as to fill the spaces between the ducts.

For duct routes between chambers bends may only be used where a turning chamber is not feasible. In such circumstances only standard 22 or 45 degree duct bends may be used[32].

Subsequent Layers

After the first layer of ducts has been laid, wooden stakes (or suitable alternative) should be placed approximately 3 metres apart and driven into the trench bottom so as to keep the layers of duct in place both vertically (ducts stacked one on another) and horizontally (ducts laid side by side).

Fine-fill material should be placed and hand rammed between the outside ducts and trench sides, and placed in such positions so as to fill the spaces between ducts when other layers are bedded down.

The second and subsequent layers should be jointed, placed and bedded down so as to touch the ducts in the layer below.

All duct joints should be staggered, to avoid touching.

Approximately 5.0 metres from any jointing chamber the duct formation should open out to give a 25mm space between ducts both vertically and horizontally, where they enter the chamber. All spaces between the ducts and to the trench sides should be filled with fine-fill material.

Uppermost Duct Layer

Fine-fill material should be placed and hand rammed in such positions so as to fill the spaces between the ducts and at the sides of the duct(s) in lifts equal to the size of duct. The material

[32] 90 degree bends may be used in other situations, such as to return to ground level adjacent to buildings

should be compacted by hand until the level of compacted material reaches 100mm above the duct.

Marker Tape

A yellow marker tape should be laid across the width of the trench 150mm above the uppermost duct stating “Fibre Optic Cable” in black writing, continually across the tape length and width.

Reinstatements

Backfill using suitable excavated or imported material compliant with HAUC / SHW recommendations up to sub-base level. The material should be placed in the trench in even layers of up to 100mm and mechanically compacted in accordance with SROH / SHW latest edition requirements.

Backfilling should be undertaken immediately after the ducting has been installed.

Contractor should:

- Backfill above the cable marking tape, duct or trough with Class 1, 2 or 3 material complying with HAUC / SHW and compacted to these requirements.
- Spread and compact the material evenly without dislodging, disturbing or damaging cables, ducts or troughs
- Avoid using power rammers within 300 mm of cables, ducts or troughs

Unless ducts terminate at cabinets or mounting posts or columns, their ends should be marked with marker blocks and location posts so that their location can be clearly identified without exploratory future excavation

Cleaning and proving

The cleaning and testing of the completed work should be carried out using a mandrel and brush.

The appropriate sized brush and mandrel should be pulled once through each duct-way, with the brush leading and avoiding excessive force.

The cleaning and proving process gives an opportunity to identify defects that need rectifying.

Draw Ropes

A blue nylon (gnaw proof) draw rope should be left in each duct-way, securely fitted to suitable jointing chamber furniture. After the cabling operation is complete all the duct entrances should be sealed with sealing compound.

1.3. Spine Network Chambers

Chambers General

The following table illustrates the types of chambers and the required standard depths:

Type of Chamber	Surface Type	Depth (base to underside of cover)	
		Standard (mm)	In close proximity of Carriageway with Road crossing (mm)
CH2 (450mm x 450mm)	Verge / Footway	450	N/A

Type of Chamber	Surface Type	Depth (base to underside of cover)	
CH4 (675mm x 675mm)	Verge / Footway	450	600
CH6 (1300mm x 650mm)	Verge / Footway	450	600
CCH4 (600mm x 600mm)	Carriageway	N/A	1050
CCH6 (1220mm x 675mm)	Carriageway	N/A	1050

- Refer also to Drawings pack
- Nominally chambers along the network will be located every 200m, or at obstructions (such as special engineering difficulties).
- Any change of direction will also require a chamber to be provided.
- Chambers should be located outside of known wheel tracks, but clearly visible within the carriageway / footway – subject to space available
- Chamber covers should be labelled. Depending on the deployment arrangements, this could be a brand mark.
- Footway and Carriageway frames and covers should be manufactured to BS EN124 Class D400.
- For footway covers in grass or unmade surfaces the frame should be surrounded with a 100mm wide strip of C35 concrete to the full depth of the frame.
- For covers in grass or unmade ground there should be a concrete surround to enable the safe removal of the covers by mechanical means.
- All spaces around the chamber should be filled with granular material or concrete and rammed. Care should be taken not to disturb the integrity of the chamber whilst compacting the material

Modular Chambers

Modular chambers are suitable for footways and off-carriageway cycleways. (All carriageway chambers should be constructed of in-situ concrete.)

- All modular chambers are constructed in sections that are stacked on top of each other. These chambers can be cut to accommodate existing services as detailed within the specification supplied by the manufacturer.
- In footway chambers the ducts should enter through the bottom ring (of standard-construction chambers) or at the standard depth of cover for the duct for that surface type.
- Ducts should be positioned at least 75mm from any adjacent wall. All duct entries should be flush with the face of the chamber wall and free from sharp edges.
- When modular chambers are used only the tap-out circular glands should be used for duct entry points. If the duct to be used is less than 96mm either the gland can be drilled to the correct duct size or if the gland has been removed, then the excess hole must be filled and sealed to prevent moisture / material ingress to the chamber.
- If the chamber cannot be modular, then the chamber should be constructed of brick or in-situ concrete as detailed below.

Non-modular chambers

Chambers can be constructed of brick or in-situ concrete as detailed below. (Footway chambers are of modular construction where possible.)

- All non-modular footway chambers should be constructed with C35 concrete with single wall steel reinforcement as standard
- All carriageway chambers should be constructed with C40 concrete with twin wall steel reinforcement as standard
- The reinforcement should be secured together using approved wire ties enough to prevent displacement of the reinforcement during the placement and compaction of the concrete.
- Timber shuttering should be of suitable thickness to ensure the structure should not move whilst the concrete is curing.
- The contractor should position plastic sheeting (1000gauge) between the excavation and the concrete of the chamber.

1.4. Bundled Microducting

Bundled Microduct types

A variety of direct-bury microduct specifications are available on the market.

A typical configuration is 7-way 14/10 HDPE, which is suitable for a number of spine and access network applications.

7-way 14/10 configuration

Depth to cover

Depth of cover regulations are covered in SROH[33], currently these are:

- In a footway at least 300mm
- In a carriageway at least 600mm

[33] Specification for the Reinstatement of Openings in Highways
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/977196/specification-for-the-reinstatement-of-openings-in-highways-fourth-edition.pdf

In exceptional circumstances it may be necessary to lay duct at shallower depths than those stated above. In such situations the duct bundles should be protected by stockboard protection sheets, steel plating or concrete.

Direct (In Ground) Installation

See also Excavation and Trenching best practice for general guidance on duct deployment. The following comments apply specifically to duct bundles.

- Bury duct bundle deep enough in the ground to prevent it being damaged by other utilities, rodents, tree roots and freezing ground water
- Ensure the bottom of the trench is level so that the duct bundle lies flat; this makes installing the fibre in the duct easier
- Avoid sharp bends in the duct to make fibre installation easier
- If possible, put a layer of clean fill in the bottom of the trench before installing the duct bundle to prevent damage by stones
- Backfill above and to the side of the duct bundle, to prevent damage by stones when you compact the backfill above the duct bundle
- When installing an access box, support the duct bundle to maintain its alignment where it passes through the access box

Micro Trenching with micrduct

- Ensure the bottom of the trench is level so that the duct bundle lies flat, to ease fibre installation in the duct.
- The bottom and sides of the slot trench must be dry and clear of debris.
- Avoid sharp bends in the duct to make fibre installation simpler.
- Depending on the roughness of the bottom of the slot, backfill the trench before installing the duct bundle, to prevent damage by stones.
- Backfill above the microduct to prevent damage.
- Optionally, install a backer rod (polycord) above the top backfill to prevent damage to the microduct from the reinstatement.

Mole Plough

- Ensure the ground is even – otherwise, as the mole plough follows the ground contours the route that the duct bundle takes may not be level.
- Bends in the route must be smooth and wide; if the route is not level and the bends are tight cabling distance is reduced.
- Mole plough only where there are no hard surfaces and there are unlikely to be other services.
- Choose a machine suitable for the type of ground: for soft ground, you will need a machine with wide profile tires or with tracks so that the machine does not sink into the ground.
- If tree roots or small stones are present use a vibrating plough.
- Choose a machine that carries the microduct or duct bundle with it - do not lay the duct out on the ground to be pulled after the machine, because it will be damaged and stretched.

In-duct (subduct) Installations

Assuming there is sufficient space in the primary duct:

- Allow an extra length of duct to compensate for the stretching that happens as the subduct is drawn into the duct.
- Allow for expansion of the subduct if air temperatures or storage temperatures are high.
- Allow 24 hours to pass before restraining the subduct to allow it to reach the same temperature as the duct and jointing chamber.
- When using a winch to pull in the subduct, do not exceed the maximum pulling force, by using a mechanical fuse; a fuse is not required if pulling in the subduct by hand.
- Always use a swivel to prevent the subduct twisting as it is pulled into the duct.
- Always use a pulling sock to distribute the pulling force over the first part of the subduct.

2. Fibre cable specification

2.1. General Requirements

- Fibre Cabling should be installed in accordance with the relevant specification and to ITU Standards.
- All primary ducting should be re-roped either during cable pulling or after cable pulling.
- After the cabling operation is complete all the duct entrances should be sealed by a suitable removable sealing compound.
- Cable identification labels should be applied.

2.2. Fibre Cable Specification

Fibre cabling for installation in core and access duct should meet the following specifications:

- Single mode optical fibres conforming to G.652.D standard
- Loose tube (gel filled), Dual Dielectric armoured design with HDPE Outer sheath
- Max installation tension must be at least 4,000N
- Minimum (at tension) bend radius no greater than 100mm
- IEC 60794-1-2-E1 – Fibre strain <= 0.4%, △α reversable @ 4,000N torsion (short term)
- IEC 60794-1-2-E3 - △α <= 0.05db @ 2,000N / 100mm crush
- IEC 60794-1-2-E4 - △α <= 0.05db @ 10J (300mm radius striking area)
- IEC 60794-1-2-E7 - △α <= 0.05db @ 100N, 10 cycles, +- 180° torsion (sustained)
- IEC 60794-1-2-E11 - △α <= 0.05db @ Bend Radius = 12 x Ø, 4 turns, 3 cycles
- IEC 60794-1-2-F1 - △α <= 0.05db @ -30°C to 70°C
- IEC 60794-1-2-F5B – No water ingress @ 1m
- Fibre cable will have length markers at 1m intervals

2.3. Installation Guidance

General

The following should be confirmed before installation:

- The location, type and span between the jointing chambers from the scheme plans.
- Cable length, cable size and kind of cable end (clockwise or counter clockwise) from the scheme plans.
- The position of an allocated duct bore from the cabling diagram.

Protection of Existing Cable

- Existing cables and other facilities should be adequately protected before installing others

Handling of Cable Drums

- Drums reeled with cable should be handled with special care to prevent deterioration of the fibre properties and other characteristics
- Drums should not be subjected to shock by allowing to drop down and should not be laid sideways during loading and unloading
- Drums should not be rolled on the ground for transportation purposes, except for short movement at installation sites

Cable Bending Radius

- When setting cables, the bending radius should be kept to more than 8 times the outer diameter of metallic cables and not less than 15 times the outer diameter of optical fibre cables.
- While installing cables, the bending radius of the cable should be kept to more than 100cm.

Rodding of Duct Way

- After the confirmation of a designated duct, the duct way should be rodded, cleaned and passed with a mandrel prior to placing the cable.
- Usually, the rodding and cleaning of the duct way and the mandrel test are performed in this order. When no remarkable debris is extracted during rodding work, cleaning the duct way and mandrel test are performed at the same time.

Setting Up Cable Drums

- Cables with a diameter of more than 10mm should be pulled by use of a cable grip. Where a pulling force of more than 9kN is anticipated, the cable grip should be bound tightly over the cable end.

Cable pulling and reeling out

After completion of rodding the duct way, setting up of the cable drum, installing the pulling accessories on a cable end, the cable to be pulled into jointing chambers should be reeled out carefully

- Best practice is to use a field-installed wire mesh pulling grip and swivel during cable pulls. Pulling grips provide effective coupling of pulling loads to the jacket, aramid yarn, and central member of fibre optic cables. The use of a swivel between the pull-line and pulling grip is required to prevent the pull-line from imparting a twist to the cable. A swivel that contains ball-bearings is recommended to prevent binding at high tensions.
- Cable pulling work should be carried out in close cooperation with the cable reeling-out work.
- To reduce tension on the cable, mid-point pulling is recommended. This is a method where the pulling force is distributed at intermediate points along the cable length. Where it is not

possible to pull the cable from end to end, the drum is set up at an intermediate point and the longer length cable is drawn in first. The cable remaining on the drum is then removed and piled on tarpaulins, layer upon layer in figure "8" formation about 3m x 6m. The piled cable can then be pulled to the other end.

- At the end where cable is being pulled out and where the level and direction of the cable changes, light weight pulleys or rollers should be used. The pulley should not introduce additional pulling force and the minimum bending radius should be maintained.
- The cable should be lubricated during installation with a suitable approved lubricant for the duct and the sheathing material of the cable. Cable lubricant is recommended for most fibre optic cable pulls as a means of lowering pulling tension. Short hand-pulls may not require lubricant. Considerations in choosing a lubricant are material compatibility, drying time, temperature performance, and handling characteristics.
- Cable lubricants must be compatible with the fibre optic cable's outer sheath. Refer to the lubricant manufacturer's specifications. Use of incompatible liquids, such as liquid detergent, for a lubricant can cause long term sheath damage and must not be used.
- Additional lubricant should be added before bends and known severe offsets and sections with "uphill" elevation changes.
- After preparing the pulling tools and devices, pull carefully the draw rope while winding, keeping the pulling speed as for the cable.
- The pulling team should stay in contact with the liaison person at the reeling side.
- The cable should be pulled gradually until the cable length necessary for bending, splicing and or testing is obtained.
- The cable ends should be sealed with appropriate sealing caps if required.
- A 8-10 metre cable service loop should be left neatly coiled within each chamber. Do not cable tie the service loop, leave it loose coiled.