eBook

# The Complete Guide to Fiber to the Premises Deployment

Options for the Network Operator

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# The FTTP Challenge

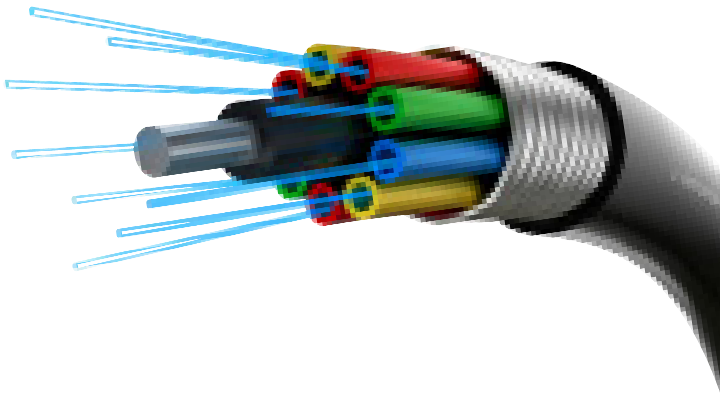
## Fiber optic cable is a truly remarkable technology. With a single strand of fiber glass no thicker than a human hair, it is possible to deliver crystal clear voice communications and virtually unlimited bandwidth direct to a premise.

The socio-economic benefits of fiber are beyond question. Fiber to the premise (FTTP) can boost economic development, spark innovation and improve the way people live and work.

So why is the technology not more widely available? While it is relatively easy and cheap to deploy fiber to the cabinet (FTTC), it is more expensive and complicated to deliver FTTP. With FTTC, a fiber connection runs all the way from the core network through to the local exchange, after which it runs into a street cabinet. From there, several connections split off from one cabinet into multiple homes. It is this last leg of the connection – termed in the industry the 'the last drop' – that poses the greatest challenge.

The cables that currently lead from the cabinet to the premise are typically copper twisted pairs or coaxial cables (in mature markets). Most operators in these markets have chosen to take the interim step of installing fiber to the cabinet and copper/coaxial to the premise because performance is good enough in the early stages, and because it makes sense for them to maximise the value of the existing (and already paid for) infrastructure. However, demand is growing for faster speeds than can be delivered through copper/coaxial, especially from businesses, which is why pressure is growing on operators to ramp up their FTTP rollouts.

According to the OECD (Organisation for Economic Co-operation and Development), the US currently lags behind when it comes to fiber adoption - with a penetration rate of around 11 per cent. While this figure is on the rise, it is significantly lower than the over 70 per cent penetration rate seen in countries such as Japan and South Korea. The last thing an operator wants to do after installing a new fiber network is to disappoint its customer base with delays. But nor does it want to invest in expensive cable and ancillary electronic equipment like set top boxes and wireless routers if there is not sufficient demand. It is vital that operators do their due diligence and get these calculations right prior to deploying a network.



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But the decision to deploy fiber is only the first step. When it comes to actually implementing an FTTP network, there are several factors that need to be taken into account. Choices have to be made based on landscape topography – there is a world of difference between deploying FTTP in a rural and urban landscape. Regulatory issues need to be addressed; they cannot simply be sidestepped. Technical factors must also be carefully weighed – techniques like cable blowing and pulling only work in certain situations. Then there is the matter of cost. Depending upon the solution chosen, operators may need to hire specialist staff and equipment at extra expense.

It is also critical that customers are not inconvenienced at any point during an FTTP implementation. No customer wants their property to be at the centre of a major civil engineering project. As we shall see later in the paper, this factor alone can dictate which technical solution is chosen for the last drop.

Lastly, network operators need to consider whether they want their solution to be future proof. Some cable can be ripped and replaced. But there are other options – such as direct unducted cable – which once installed cannot easily be removed.

The purpose of this eBook is to outline the choices available to network operators seeking to solve the last drop challenge. Over the course of the next few pages, we will investigate the advantages and disadvantages of using buried or aerial cable. We will then drill down further and explore the pros and cons of using cable, cable in duct, blown, pushable and pullable cable. Our intention is to give you a complete and impartial overview of the technical landscape so you can make the right choices for your business.



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# Market Drivers

Fiber has come of age. According to the OECD, there are currently 71.8 million fiber subscribers across 35 countries. In China, 80 per cent of broadband users are expected to be on fiber optic by the end of 2016. In the US, 25 per cent of users have a fiber connection. And in Europe the number of fiber users currently stands at more than 17.9 million. If we include the CIS countries, that figure rises to more than 35.9 million. Citizens in Lithuania, Norway, Sweden and Denmark already have virtually universal access to fiber.

There are compelling reasons why businesses, governments, network operators and consumers around the world are rushing to take advantage of the technology. In the first place, fiber is proven to stimulate economic growth. According to consultants McKinsey, the Internet is predicted to add $300 billion to Africa's Gross Domestic Product (GDP) by 2025. The advent of superfast broadband across the developing world is not only driving up living standards, but also allowing businesses of all sizes to compete on a local and global scale.

Governments are just as enthusiastic about the potential of fiber. The technology can speed up and improve the delivery of vital services like healthcare and education. Even in developed countries, which have established broadband networks, governments are keen to tout the benefits of fiber.

> “In Europe the number of fiber users currently stands at more than 17.9 million. If we include the CIS countries, that figure rises to more than 35.9 million.”

> “Fiber has come of age. Almost one in ten homes on the planet now has access to the technology.”

Fiber is also creating new opportunities for consumers. In some parts of the world, consumers can now receive their telephone, video, audio and television services through a single FTTP broadband connection. These bundled offerings are likely to be augmented with additional services over time. In fact, there are already plans to roll out 3D holographic high definition TV and games to consumers. While standard networks will undoubtedly struggle to take the strain, FTTP will one day have to be able to manage the estimated 30 gigabyte per second that 4K, 8K and other future entertainment services will require.

Lastly, FTTP is likely to spark the creation of products that haven't even been considered. Using the past as a guide, it is easy to see how the Internet has inspired products and services that weren't even conceived of a decade ago. FTTP may have the same effect in pushing forward concepts like the Internet of Things.

# Opportunities for FFTP expansion

While businesses, governments and network operators are united in agreeing that FTTP has huge potential, the take-up of the technology has been historically uneven. While there may be many millions of FTTH/B subscribers in Europe, the market is far from mature. This is partly due to the reluctance of established operators to write off the investments they have made in copper wire networks.

The situation is the opposite in the developing world. In many countries there is no extensive copper wire network. Operators are bypassing the copper stage and moving straight to all-fiber deployments for their new networks, helping to increase opportunities for people, governments and businesses.

In the Middle East, the sheer scale of new building is staggering, with whole new cities springing up in many states. Fiber is an integral part of these new builds, providing residents and companies with high speed access to services, from video on demand to IPTV.

> “Take-up has been historically uneven with operators in mature markets maximising their existing copper networks, while in some emerging markets fiber is being rolled out everywhere possible.”

The United States is a more mature market, but is currently going through a period of change. AT&T, Google and other players are in the process of implementing fast broadband services across the nation. The companies are rushing to meet the government’s stated goal of introducing 1Gbp/s speeds to every home in the country.

It is beyond the scope of this eBook to provide a comprehensive overview of each of these markets. Suffice to say, wherever a network company is operating – be it in London or Mogadishu – it still has to solve the challenge of the last drop. And therein lies the opportunity. If an operator can deliver FTTP in a quick and cost-effective manner it can capture market share from its competitors. It may even be able to dislodge its rivals and take control of the market.



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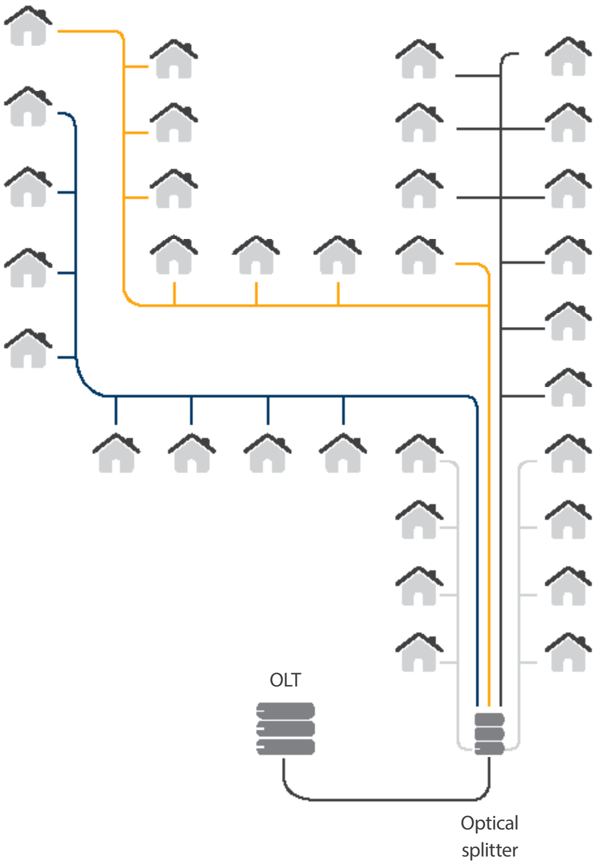
# PON and P2P

Before exploring in more detail the challenges posed by the last drop, it is worth looking briefly at the two of the most common fiber architectures – Passive Optical Networking (PON) and Point to Point (P2P).



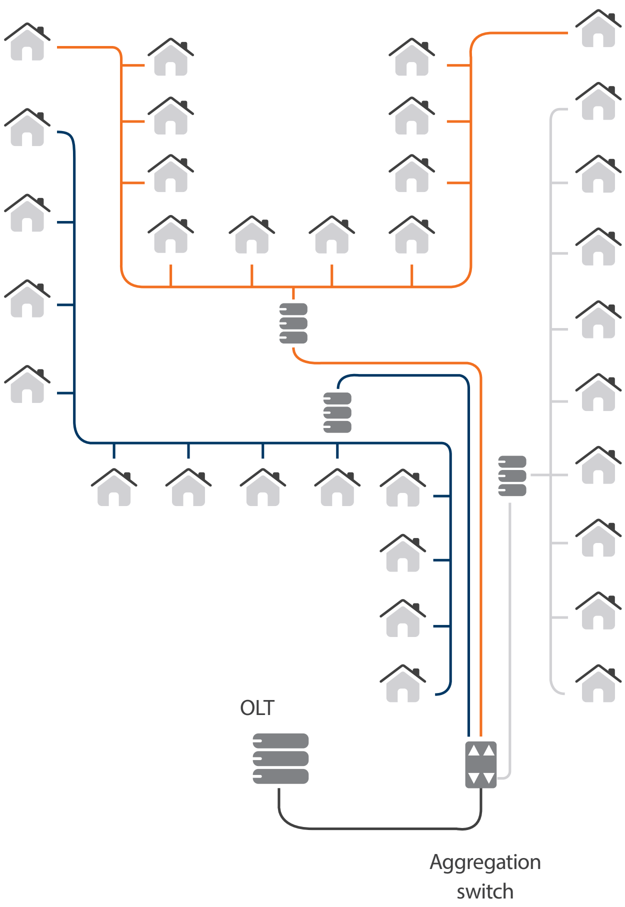

> "The PON equipment comprises an optical line terminal (OLT) in the point of presence (POP) or central office. One fiber runs to the passive optical splitter and a fan-out connects a maximum of 64 end users with each having an optical network unit (ONU) at the point where the fiber terminates."

A Point to Point (P2P) architecture has a core switch at the central office, which connects over optical fiber cables to an aggregation switch at the distribution point. These locations are typically street corners. The aggregation switches have many fiber ports and each port directly connects to an optical network termination (ONT), which is located inside or outside the customer's residence.

Each option has its own strengths and weaknesses. A PON infrastructure is much less expensive to implement and maintain than P2P. This is because it uses fewer ports to terminate fiber and less fiber cables. In addition, the fiber splitters that reside at the centre of a PON infrastructure don't require any power supply and can be located virtually anywhere.

However, PON infrastructures offer limited levels of bandwidth. There is no sharing of bandwidth with P2P. The bandwidth in each port of the aggregation switch is dedicated to individual residences. So higher bandwidth per port – and hence per premise – is possible with P2P. What's more, P2P provides symmetrical bandwidth, which is critical for applications like HD video conferencing and peer-to-peer file sharing.

Network operators need to consider these factors when designing their architectures. Inevitably, there will be a trade-off between cost and network efficiency, and the operator will have to decide which criterion is given preference.



# The Challenge of the Last Drop

Regardless of whether a PON or P2P architecture is chosen, the operator will still have to resolve the challenge of the last drop. Multiple factors need to be taken into consideration at this point. The operator will have to make a choice between buried or aerial cable. They will then need to deal with different soil types; handle the cost of labour and deliver a positive customer experience. Some operators may also want to consider whether it is necessary to create a future-proof network. Let's take a look at each of these.

## Choosing between aerial and buried deployments

The first decision an operator needs to make is whether they want to carry out an aerial or buried deployment. In both cases, they can use cable. Alternatively, they have the option of using cable in duct, blown fiber, and pushed or pulled fiber.

## Aerial deployment

Aerial cables/ducts are supported on poles and other tower infrastructures and represent one of the most cost-effective methods of deploying cables in the last drop to the customer. They allow operators to use existing pole infrastructure to link subscribers, avoiding the need to dig in roads to bury cables or ducts. Typically, with an aerial deployment, a multi fiber cable will be deployed to the cabinet and duct or blown fiber will be used for the final drop.

However, aerial cable is fragile. It will strain, sag and eventually break if it is exposed to extreme wind, large temperature variation and ice loading. If the cable is sharing space on the pole with an electric cable it needs to be properly insulated.

> "Operators can use existing pole infrastructure, avoiding having to dig up roads. However, aerial cable is fragile and can break when exposed to the elements."

> "Aerial cables represent one of the most cost-effective methods of deploying the last drop."

In addition, calculations on the strength of both the cable and poles need to be taken into account when determining span lengths. It may be the case that both poles and cable need to be made stronger – with all the implications this has for cost – for longer spans. In urban areas this can often cause conflicts with local planning authorities.

For these reasons, aerial is more suited to areas with existing pole networks or rural environments without urban restrictions. It is a good option for the final drop, providing cheap labour and material can be obtained.

## Buried deployment

Most local authorities and customers prefer their services, including optical cables and ducts, to be supplied by underground deployment. It generally avoids the planning problems posed by aerial cable. Buried deployments are immune to the wind and ice damage to which aerial routes are susceptible. This is because the optical cables and ducts are buried below the layer where the soil freezes. The reliability of underground deployments is frequently at least ten times better than aerial routes, especially where ice storms or exceptional wind events are common place.

But there are some downsides to burying cable. It needs to be buried deep in the ground to protect it from accidental damage. The deeper an operator has to dig the more costly the whole operation becomes. If a buried direct cable is broken it is expensive to repair. Unlike cable in duct solutions, buried direct cable cannot be removed and replaced because it tends to be firmly anchored into the ground.



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## Dealing with different soil types

The next most important factor for operators to consider is landscape, because it has a direct bearing on all the other aspects. The geology of a landscape – be it rural or urban – will directly determine which technical solutions are adopted for the last drop. If the terrain is rocky, for example, it won't be cost-effective to put poles in the ground to carry aerial cable. Unless there is a pre-existing infrastructure in the soil, the operator will have to create a shallow trench and install a buried cable. Given its proximity to the surface, the cable will need to be sufficiently robust to handle heavy contact.

Sandy soils are far easier to manipulate. They can also be excavated by hand. It is easy to create flat bottoms in trenches that are cut into sandy soil. This makes the soil perfect for cable and duct solutions. Sandy soil can also be used for buried cable.

Clay is much harder to excavate and can contain rocky particles. Stones can impinge on both the cable and duct and cause damage after burial. Operators can circumvent these challenges by digging deep trenches and using thicker walled cables or ducts. The downside is cost – deep trenches are expensive to excavate and thicker cable costs more. Buried cable can also be used in this environment, but it needs to be robust enought to withstand the pressure and hardship of being buried.

> "Rocky terrain makes installing poles for aerial cables difficult and expensive, while different soil types affect the size and depth of the trench for buried cable installation as well as how robust those cables need to be."

> "The geology of a landscape will directly determine which fiber solutions are adopted."

Within an urban setting, it makes sense to use existing infrastructure wherever possible. Drilling into a hard surface like asphalt or tarmac can be ten times more expensive than mole ploughing or shallow trenching in a rural environment. Ideally, the operator should use existing duct to carry microducts or cable into properties.

If there is no existing duct infrastructure, the operator may need to investigate the option of slot cutting. This process involves putting a thin 20 to 40 millimetre wide (0.75 inch to 1.5 inch) slot in the ground. Due to space constraints, the slot, which is typically 100 millimetres (4 inches) deep, can only be used to house microducts, which are usually placed one on top of each other. The disadvantage to using slot cutting is road re-surfacing. When a road is re-surfaced, the slot cut will be the uppermost utility in the ground and therefore vulnerable to damage. For this reason, some local authorities are reluctant to allow micro trenching on highways and roads.



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## Addressing the cost of labor and equipment

Labor cost is another important consideration. Some cable installation processes require specialist equipment and man power. Take cable blowing, for example. Large cable blowing machines can cost in the region of $16,860 and weigh several hundred kilograms. Gasoline-powered compressors cost at least $8,430 to purchase. It often takes hours to transport these machines, set them up and close down the site. And that's just for one premise – the entire process has to be repeated every time a customer in that locality requests a fiber connection.

Costs can also spiral when fusion splicing is required. This process involves using localised heat to melt or fuse the ends of two optical fibers together. Typically, an engineer will strip off the fiber's protective coating to get at the cable itself. Once the fiber has been exposed it is cleaned with alcohol before being inserted into a device called a fusion splicer. The device lines the fiber ends up and welds them together.

Fusion splicing isn't a simple operation – it requires the involvement of a highly experienced splicer or jointer. In developed countries these professionals generally work for large operators – companies like BT and Verizon – and are not freely available. Those that can be obtained on the open market often charge high rates. In many developing countries, trained splicers and jointers don't exist. They often have to be brought in from overseas at considerable expense.

## The customer experience

The customer is a very important factor in any FTTP installation. There is no simple way of getting fiber into the premise. In many cases, a small micro drop will have to be cut into the customer's garden or back yard so that the cable can be connected to the premise. Business customers want minimum disruption on site when fiber is being installed. Home owners are equally concerned about the potential damage an installation may cause to their properties. Unfortunately, there are a number of fiber installation practices that can potentially cause a great deal of inconvenience to both business and home owners. For example, there is always a risk when blowing cable into a premise that water, dirt and other material will be blown into the property. If the process is reversed and a cable blowing machine is brought into a property it may cause damage to carpets and other soft furnishings. Getting large blowing machines and compressors into a property also requires additional set-up and tear down. Even techniques like cable pushing can cause a certain amount of inconvenience to the customer if they need to find space to house excess cable.

When accessing different installation practices, it is vital that the operator keeps the customer in mind at all times. It is often this installation process which makes up the bulk of a customer's experience with the operator, so creating a good customer experience is vitally important.

## Future proofing

With planned builds, operators may want to simply get cable into the premise on day one and may not be overly concerned about creating a future proof network. In this situation, it may make sense to use buried cable if the ground is unlikely to be disturbed. However, if an operator wants to upgrade its network periodically with new fiber it will be better off using blown, pushable or pullable cable.

> "Customer experience is one of the most important factors in an FTTP installation. Customers can become understandably concerned when lawns have to be dug up or their premises invaded by big machines and workmen, so it's important to minimize the disruption as much as possible."



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# Making an FTTP Deployment Choice

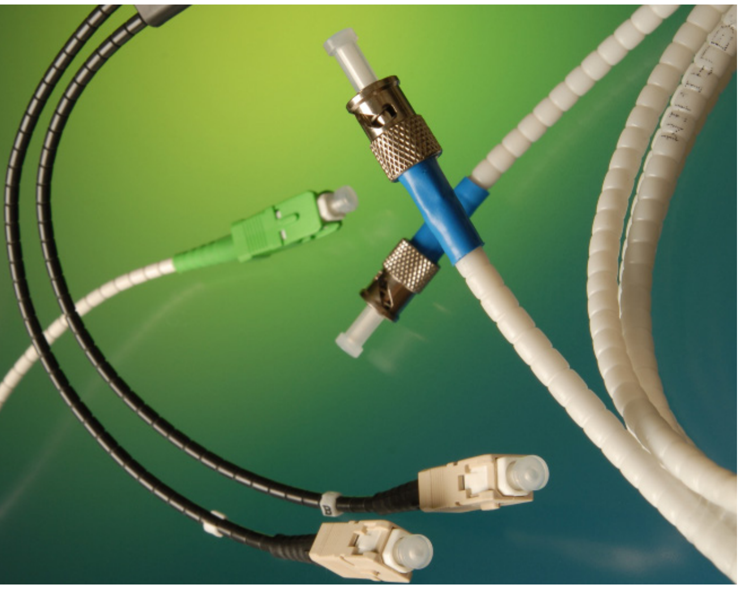
There are five principle installation methods that network operators can employ to cover the last drop. They can use aerial or buried deployments as previously discussed. If there is an existing duct infrastructure in the ground – or the operator has the ability to excavate and lay duct – they can use direct cable, cable pre-installed in duct, blown fiber or cable, and pullable or pushable cable.

In practice, operators will be restricted to one or possibly two of these options. They will make their determinations based on landscape, cost, speed of delivery and other factors relevant to their particular installation.

**So what are the pros and cons of the main techniques?**

## Direct cable

Cable laid directly from the last node to the customer is at first sight the obvious solution. It is a simple item to purchase and there are no compatibility issues in acquiring a matching duct. The product purchase price for direct cable products is frequently attractive due to the ease of manufacture and plethora of suppliers.



> "There are five principle installation methods to cover the last drop."

However, there are important concerns that may mitigate against this option.  Any last drop that uses direct cable cannot be easily upgraded, since for the buried version, excavation is required (often in built environments), and for direct aerial, links, towers or poles need to be accessed, which can necessitate specialised equipment (elevating platforms) and can create road disturbance. Direct buried cable is susceptible to impact damage from subsequent, unrelated digging activity and is difficult to repair. Service can usually only be restored by installing two new joints and a section of new linking cable. Inevitably, this requires two new joints per fiber, which can cause noticeable signal degradation.

The design life of direct cable is typically 25 years (notwithstanding the repair issues). This may seem beneficial, but the effective lifetime of optical fiber types before they become obsolete may be considerably less. For that reason, operators looking for a future-proof cable solution are well advised to avoid direct cable solutions, especially buried direct cable.

> "Operators can choose from direct cable, cable-in-duct, blown, pulled, or pushed deployments – their determination will be based on landscape, cost and installation speeds."

## Cable pre-installed in duct

Cable pre-installed in duct provides greater protection from accidental damage than buried cable. If a duct is struck by a digger, for example, it may collapse in on itself without necessarily damaging the fiber. Unlike direct buried cable, cable pre-installed in duct can also be replaced relatively easily. Both duct and cable can be purchased separately or together from manufacturers and re-installed in the ground.

One of the downsides of this option is that it limits operators to particular types of fiber. This may not be an issue for an operator that wants to install fiber in a planned build and get the project completed as quickly as possible. In other situations, it may make sense for operators to choose a solution that allows them to replace the fiber on an ongoing basis.

There are other disadvantages to using this solution. It generally costs more to purchase cable pre-installed in duct than the two products separately. Operators may be left with an expensive asset sitting in the ground if there isn't sufficient customer take-up. If the wrong type or amount of cable and duct are purchased from the manufacturer, the operator runs the risk of ending up with a sizeable amount of redundant stock.

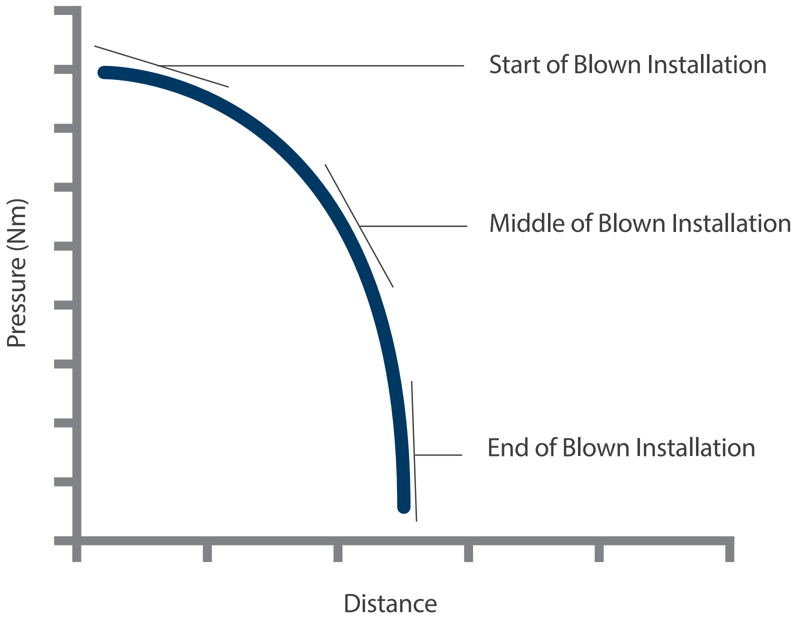
## Blown cable/fiber

A considerable proportion of fiber is installed by blowing. The technique involves using compressed air to blow a fiber or a cable down a small duct.

Blowing fiber is popular because it is a fast process, and the blown fiber can be installed over great distances.

Blown cable, on the other hand, is a more robust option. However, these cables are significantly larger and more expensive to both purchase and install and require larger blowing machines.

When cable blowing is used, the force application is distributed along the cable, rather than applied at a single point as with pulling and pushing. The propulsion for blowing comes from the pressure gradient caused when high pressure (in the blowing head) decays to atmospheric pressure at the route end. The force this imparts to the cable is related to the gradient of the pressure versus distance (as shown in the graph). The gradient has a very small magnitude at the start of the route but a much larger magnitude at the route end. Therefore, blowing distance is directly related to weight of cable, friction from duct liner, and pressure used.




Blowing pressure gradients.

Since the blowing force is higher at route end, the effect of bends at the end of the route is minimal compared with bends at the beginning. The impact of bends early in the route cascades through the whole length of the installation, reducing the achievable installation distances.

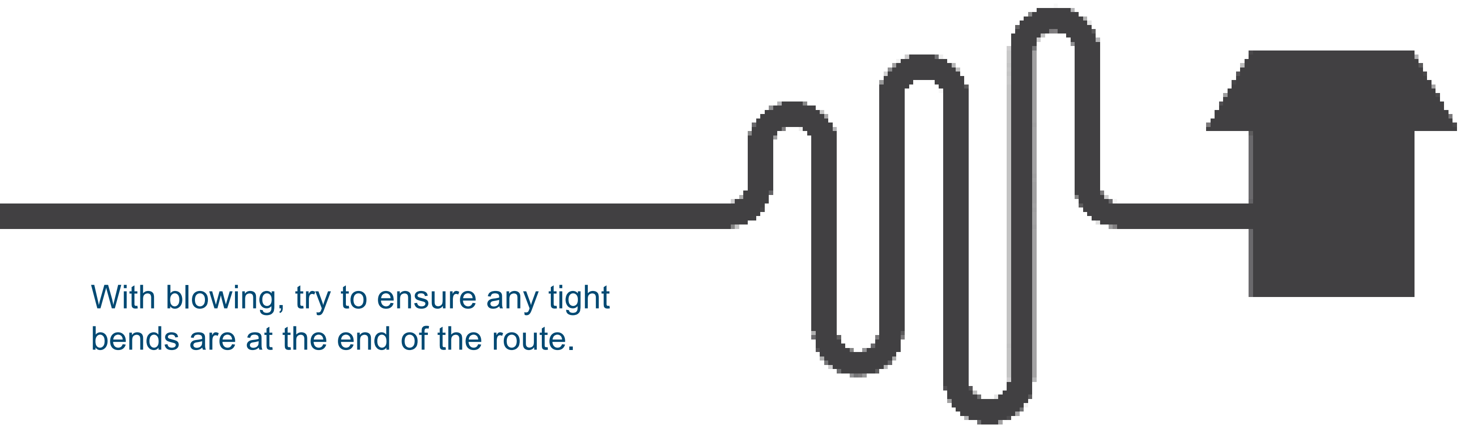
There are a number of downsides to using blown installation. The process can be costly – specialist equipment and labour are needed to blow the product. It can also cause considerable inconvenience to the customer. Despite the best intentions, engineers sometimes blow soil and water into the customer's premise during the installation process. Not surprisingly, customers aren't too pleased when they return to their properties to find them covered in mud and dirt!

Although blowing is designed for long distances, it can be economically inefficient for the operator if multiple short-runs are involved. Set up and tear down times can frequently exceed the amount of time allocated to blowing. This is particularly the case when large blowing machines are involved and installations are spread over an entire city. For example, an operator may need to do a single 50 metre installation (164ft). In this situation, it may take an hour to set-up and dismantle the blowing equipment, and just a couple of minutes to actually perform the blow installation.

## Pullable cable

Cable can also be pulled along a duct infrastructure. With the help of a pulling eye and swivel attached to the cable, a factory-installed duct pull cord is fitted to one cable end. The cable is then pulled through the duct by hand or with the help of a winch.

Pullable cable is a cost-advantage option because it requires no extra equipment. It is also suitable for installing short lengths of fiber cable, which makes it perfect for the last drop. However, pulling is a labour-intensive practice. Two people are needed to deploy the cable. One person has to make sure that the cable is paying off the reel correctly, otherwise it will become kinked and damaged. And another person has to do the actual pulling at the other end of the duct.



With blowing, try to ensure any tight bends are at the end of the route.

There are additional difficulties that come with pulling. For example, it might be necessary to change a micro duct in a particular route. In this scenario, a pushable connector will be added to the section where the duct has been cut. It isn't possible to continue pulling from one duct to the next with a draw string. It would be possible to knit or tie the pull cords together if there is enough slack. However, you will need to have sturdy knots, because if they come apart mid-pull, it is a real problem for the installer. If that happens he will then need to remove the pulled cable from the duct and replace it with blown or pushed cable. He may even need to blow in a new pull cord.

As the route length increases, the force required to pull the cable increases, which results in increased tension in the cable. Pullable cables are designed to withstand a specified pull force before the fiber is strained excessively. Once this force is exceeded there is a danger of damaging the optical fibers themselves.

If bends are present in the network the effect they have is more severe at the end of the route. This is because a bend effectively magnifies the tension in the cable by a factor that depends on the bend radius and the bend angle. Since the installation force is higher at the end of the route, the result of the magnification by bending is worse at the route end. It is advisable for operators to use trusted and skilled personnel to carry out cable pulling.

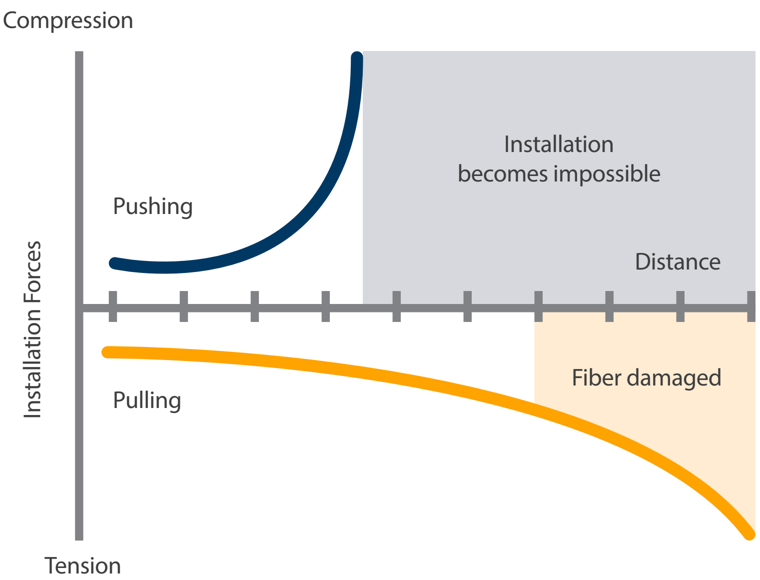
## Pushable cable

Fiber cable can be pushed either manually or using suitable equipment from the premise to the cabinet. The technique causes minimum disruption to the consumer. Unlike blowing, pushing doesn't bring water or dirt into the premise. If done in conjunction with pre-termination, the process is quick and efficient.

Pushable fiber can also save substantially on labour costs. When used with a pre-terminated pushable connector on one end and an industry standard connector on the other, all splicing and termination labour can be eliminated.

Installing the cable itself is very straightforward. It can be done with one person pushing by hand or with the help a simple machine – again saving on labour costs. Pushing cable by hand alone can be used for distances up to 100 metres (328ft).

The machines used in pushing are small enough for a person to carry by hand into a premise. Some machines also allow the use of low pressure air for longer distances (750 meters/2460ft or more). Instead of spending thousands of pounds on purchasing a blowing machine, operators can use these devices together with an inexpensive $842 electrical mains-fed compressor to push the fiber into the premise.




Pushing and pulling installation forces.

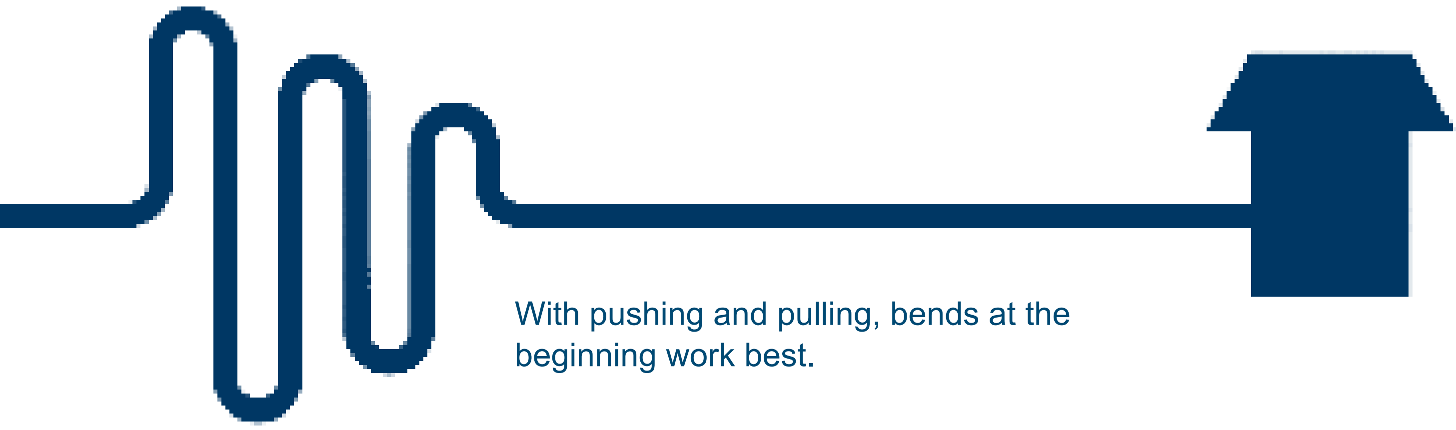
Should a fiber be cut or damaged, the pushable fiber can be located and pulled from the duct – and it serves as a “tape measure” so that the distance required for a replacement product is easily calculated. Once the microduct has been repaired, the replacement assembly can then be pushed back in – all without using a splicing machine.

Most optical fiber cables can be pushed to a limited extent. As with pulling the forces involved increase with the distance installed. However, in this case the force is seen as a compressive effect in the cable. The other key difference is that after a modest distance (depending on cable and duct properties) the force required to push increases rapidly, so that further pushing is effectively impossible and the cable becomes “locked” in the duct (see graph on page 13).

The effect of bends is similar to the pulling case (and opposite the case with blowing), with bends at the route end acting more severely. However, due to the “locking” issue, the route length (compared to pulling) will be shorter and the effect of any bend more severe. Unlike pulling, there is no danger of excessively straining the fiber. For pushing the limiting factor is the onset of cable buckling if the push force is too high (and the duct inner diameter too large). Cable buckling can be mitigated by a cable design with sufficient stiffness to push.

Not all operators will chose to use pre-terminated pushable cable. With a pushable pre-connectorized solution there is bound to be excess cable. This cable can either be coiled up in the cabinet or stored in a box on the customer’s premise. While the second option may be aesthetically unpleasing, it is a relatively easy operation to carry out.

There are downsides to using pushable cable, which are worth mentioning. The cable tends to be expensive when compared to other options. At present, a large duct is also needed to carry pushable fiber into a premise, which can add to material costs.



With pushing and pulling, bends at the beginning work best.

# Summarising the FTTP Options

Installing a FTTP network is no mean feat. Operators have to consider a bewildering range of choices. They need to determine whether it makes commercial sense to install a network in the first place. Then they have to factor in other elements like cost of labour, landscape and customer experience. Each choice will inevitably lead down a particular route and entail other critical choices. But if all of these factors are taken into account and are critically assessed, there is no reason why an operator cannot install a FTTP network practically anywhere in the world and get commercial value from it.

| | Direct Cable | Cable in Duct | Blown Fiber/Cable | Pulled Fiber | Pushed Fiber |
|---|---|---|---|---|---|
| Product purchase cost | $ | $$$ | $ | $$ | $$ |
| Relative installation equipment cost | $ | $ | $$$ | $ | $$ |
| Ease of installation | $ | $$ | $$$ | $$* | $* |
| Link reliability | Good | Good | Good | Fair | Good |
| Field replacable/upgradable | No | Yes | Yes | Yes | Yes |
| Customer experience | ☺☺ | ☺☺ | ☺ | ☺☺☺ | ☺☺☺ |
| Max installation distances | 20km | 4km | 2km | 500m | 100/750m** |

assumes Pre-Terminated Assemblies. ** 750m with use of low pressure air float.

# About PPC

PPC is a global leader in connective technology – we can keep you up to speed. We use the latest techniques to bring new and enhanced products to market fast.

Our state-of-the-art test laboratory is among the best in the business – and we hold more patents in connector technology than any other company in the world. PPC is the market leader for the 'last mile' of a broadband network. We offer xTTx™ solutions for coax, fiber and category cable around the world.

If you would like to discuss any of the topics in this eBook, please contact us directly. We'd be delighted to hear from you.

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