Adapting products to new rights-of-way

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Summary

FTTx deployments impose new challenges for the installation of cables both in external and in-building environments. This document reviews the most popular new rights of way (RoW) and associated issues. It shows how the cable construction can adapt to these challenges, identifies the key enabling technologies with the new ITU-T G.657 bend insensitive fibres at the forefront.

Content

1. Introduction

FTTx is changing the paradigm for optical fibre cables. In long haul and in metro networks, specific infrastructures were built to install cables. The costs of these infrastructures were anyhow shared by millions of final users.

In FTTx, costs are shared by a few hundred users down to a single user in the final few meters. Costs must be reduced. As shown in figure 1, civil works account for more than 40% of the total cost of an FTTx installation. Any reduction in the cost of civil works will therefore have a significant impact on the total outlay.

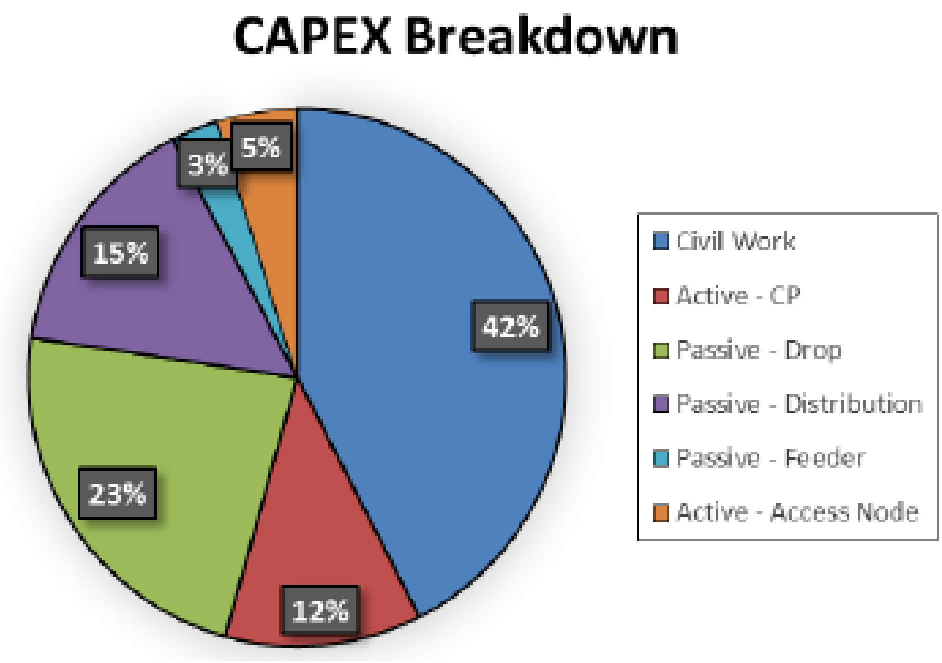


Figure 1: FTTx construction cost breakdown (Source FTTH Council Europe)

The most efficient way is to reuse as much as possible the existing infrastructures, being ducts or overhead. In green fields, new civil works are required although solutions are available to limit costs.

This document reviews the most popular cases and shows how the optical fibre and optical fibre cable industry can help reduce this cost.

2. Outside plant

2.1. Re-use existing RoW

2.1.1. Overhead

Overhead infrastructures are widely present in Europe. In many countries they are the only solutions for the low to moderate density conurbations, and even in large cities, overhead is used for the last mile connection in energy and telecommunication services. Re-using them is mandatory for the rapid deployment of FTTx.

One constraint however is the additional load they must support. The poles are often already overloaded. Cable load is not limited to the cable weight. The wind load and in many regions the ice load must be considered since they are responsible for the strain on the infrastructures. To limit these loads both the cable weight and the cable diameter must be reduced without compromising the cable strain resistance. ADSS (All Dielectric Self Supporting Cables) are generally a good and compact solution. In addition, as they do not include any metallic part, grounding is not necessary. It is a gain of time and cost at the installation, but also a reduction in the risk of fatal electrical accidents due to induced voltage or lightning effects on metallic cables.

ADSS can be designed using the loose tube or the micromodule technology. As micromodules are by essence more compact, smaller cables can be designed with this type of cable elements. In addition, micromodules are easier to handle in splice boxes, especially for mid-span operation. It is a key advantage when the job must be done several meters in the air.

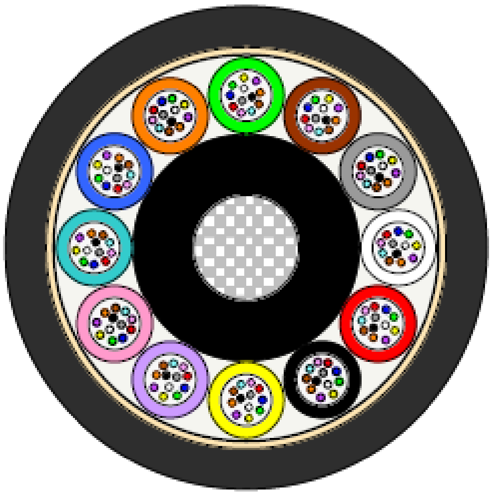
 - not to scale -	 - not to scale -
(a) loose-tube ADSS (Diameter: 15 mm)	(b) micro-module (Diameter: 12 mm)

Figure 2: Different constructions of 144 optical fibre ADSS cables for FTTx

2.1.2. Sewers

Sewers are another way to reach dwellings. In some cities they can be accessed by human beings. In any case, sewers are a harsh environment for cables as the combination of water, chemicals and rodents could be a challenge. Nevertheless, the cable industry has learnt how to meet these challenges. For illustration, several millions of kilometers of fibre have been installed in the Paris sewers for FTTH, fibres being protected in double sheath metallic armoured cables.

Figure 3: Metallic armoured sewer cable

2.1.3. Ducts

One straight forward solution is to use the existing ducts built for copper telecommunication cables. Often the available space is scarce. There is the need to optimize the number of optical fibres per duct. There are two strategies for that: pulling several cables together in the same duct or installing a bundle of micro-ducts in the existing duct and then blowing micro-cables inside the micro-ducts. This second approach offers the advantage of a pay-as-you-grow approach, installing capacity where and when needed.

In both cases cable sizes need to be reduced. This is always at the detriment of their intrinsic mechanical properties. It is worth recalling that for the micro-cables the mechanical resistance is provided by the combination of the micro-duct and of the micro-cable. The micro-cable can't be considered as a standalone product.

In both cases the reduction of size puts more constraints on the optical fibres that could translate into additional optical losses by the so-called micro-bending effects. This effect increases with the wavelength of the transmitted signal: the higher the wavelength, the higher the potential additional losses. One should keep in mind that the new GPON transmission systems (XGS-PON, NG-PON2) will use the highest transmission window (see figure 4).

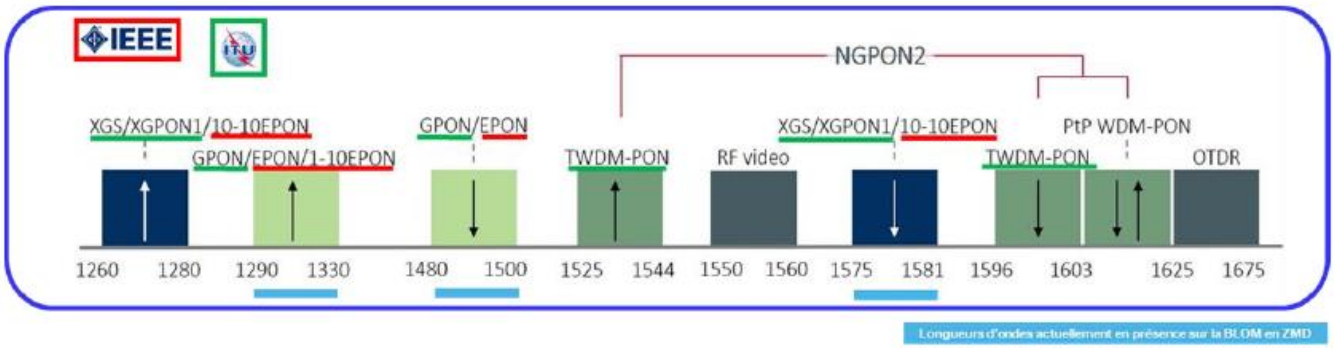
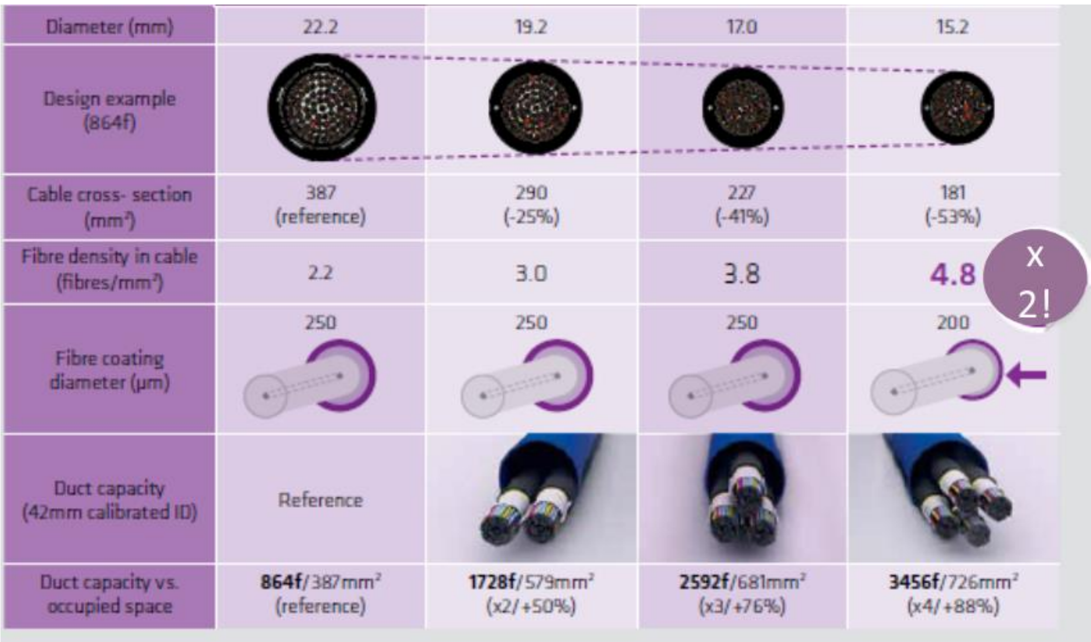


Figure 4: Different transmission technologies and the respective wavelengths used (source ITU-T & IEEE)

In this perspective, the optical fibres should be carefully selected. Relevant performances over the years couldn't be obtained without a high-quality fibre coating and a specifically designed fibre core. ITU-T G.657.Ax (G657.A1 and G657.A2), primarily defined to have good macro-bending performances, have proved as well to be less sensitive to micro-bending effects than G.652.D fibres. ITU-T G.657.A2 could be even described as micro-bend insensitive fibres and, as such, G.657.A2 fibres are the corner-stone of the most aggressive cable designs and they offer the possibility to cope with the most demanding environments.

To reduce the cable diameter, the fibre diameter of ITU-T G.657.Ax (G657.A1 and G657.A2) can be reduced from 250 µm to 200 µm or even down to 180 µm. The figure below illustrates the cable diameter and the gain in fibre count per duct obtained by the optimization of micromodules cables construction and by the reduction of the fibre diameter coating.



Diameter (mm)	22.2	19.2	17.0	15.2
Design example (864f)				
Cable cross- section (mm²)	387 (reference)	290 (-25%)	227 (-41%)	181 (-53%)
Fibre density in cable (fibres/mm²)	2.2	3.0	3.8	4.8 x 2!
Fibre coating diameter (µm)	250	250	250	200
Duct capacity (42mm calibrated ID)	Reference			
Duct capacity vs. occupied space	**864f**/387mm² (reference)	**1728f**/579mm² (x2/+50%)	**2592f**/681mm² (x3/+76%)	**3456f**/726mm² (x4/+88%)

Figure 5: Duct filling optimization with micromodules cables

2.2. Innovative new RoW

2.2.1. Introduction

When there is no existing infrastructure, it either needs to be created or a solution needs to be found to avoid costly conventional civil works. This alternative is illustrated below by two examples: micro-duct bundle associated with micro-cable and direct buried cables.

2.2.2. µ-duct

Associated with micro-trench or nano-trench technology, bundles of micro-ducts can be rapidly installed. Cables are then air blown or water jetted in the micro-ducts. The diameters of the cables have to fit with the micro-duct diameters. It is generally agreed that the cable section should not exceed around 67% of the tube cross section. The cable industry has made tremendous efforts to maximize the fibre density of cables for a range cross-sections. Such cables are available both with the loose tube technology (called the micro-loose tube technology) and with the micro-module technology.

Figure 6: Micro-duct bundle installation

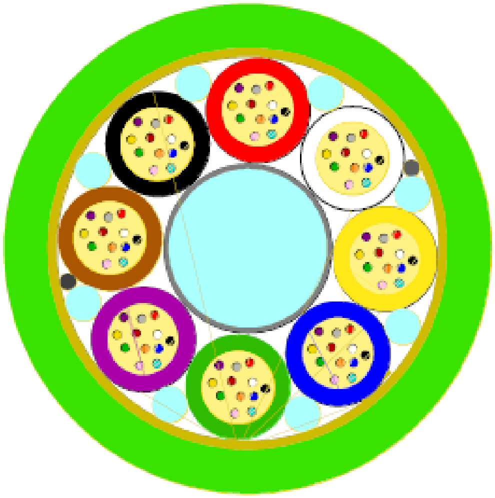
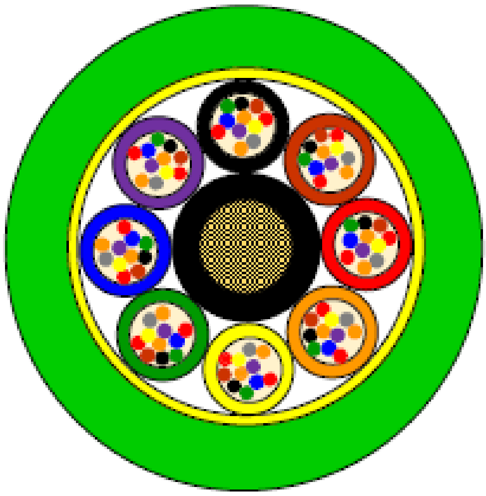
 	
(a) micro-loose-tube (Diameter: 6.5 mm)	(b) micro-module (Diameter: 6.5 mm)

Figure 7: Different constructions of 96 optical fibre micro-cable for installation by blowing

It is worth noting that solutions have been developed to install a second cable in a partly filled micro-duct that can permit to reuse some portions of an existing infrastructure. This can be of great help since it avoids expensive civil works (e.g. river crossing) or impact on car traffic (e.g. road crossing).

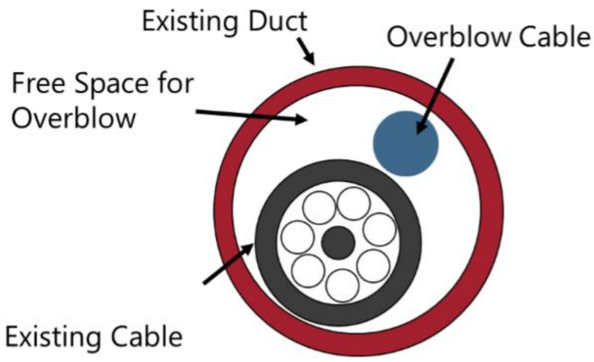


Figure 7: Over blowing

2.2.3. Direct buried

Direct buried cables are usually "stronger" e.g. with higher crush resistance, and are generally armoured. Their cost, the time needed to remove the different layers to access the fibres, limit their use in FTTH networks; unless the soil is soft enough (e.g. pure sand) thus negating the need for armouring.

In the Netherlands, direct buried cables have been used extensively. Associated with direct mid-span access this made the deployment quick and easy, and it contributed to a significant cost reduction. This technology has then been used in other regions.

Figure 8: Retractable direct buried cable

Figure 9: Direct mid-span access with adapted cable ([1] [2] windows opening; [3] cut of the designated module at the opening furthest from the access point; [4] retraction of the cut module; [5] push or blow the extracted module; Note: all the opening must be protected by appropriate boxes)

2.2.4. Limitations

The expected life time of passive optical networks is between 30 and 50 years. To reach such a target, the selection of passive components (fibres, optical cables, connectivity) and the quality of the installation require special care.

It should be clarified that the cable robustness decreases with the reduction of the cable sheath thickness and of the reinforcement elements. The quality of the raw material used for cable construction is then even more important. As mentioned, the mechanical resistance of a micro-cable-based installation is the combination of the mechanical resistance of the cables themselves and of the micro-ducts.

It should be underlined that the more the cables are buried to a shallow depth, during their lifetime the more these cables are at risk of crush or damage due to civil works.

3. Indoor

3.1. Introduction

When cables enter buildings, they should, by preference, use the existing cable paths. If not possible, their installation should create the least possible intrusion. Drilling is generally not appreciated by building owners. The necessity to reduce the size of the cables and of the connectivity boxes makes the use of “true” bend insensitive fibres (ITU-T G.657.A2 or G.657.B3) compulsory.

In any case, indoor cables are covered by the CPR (Construction Product Regulation) in the EU and therefore, they must meet the reaction to fire performance requirements set by the local regulators in application of the CPR.

3.2. Vertical cabling

In most of the modern multi dwelling units, there is a vertical shaft for the services. If the local regulation allows it, it can be advantageously used for optical fibre cable installation in a building where space is generally scarce. The cable itself is not an issue. The distribution boxes required on the floor is more of a concern.

Direct mid-span access technology associated with flexible modules and bend insensitive fibres, permit to limit the size of boxes as well as to gain time during the installation.

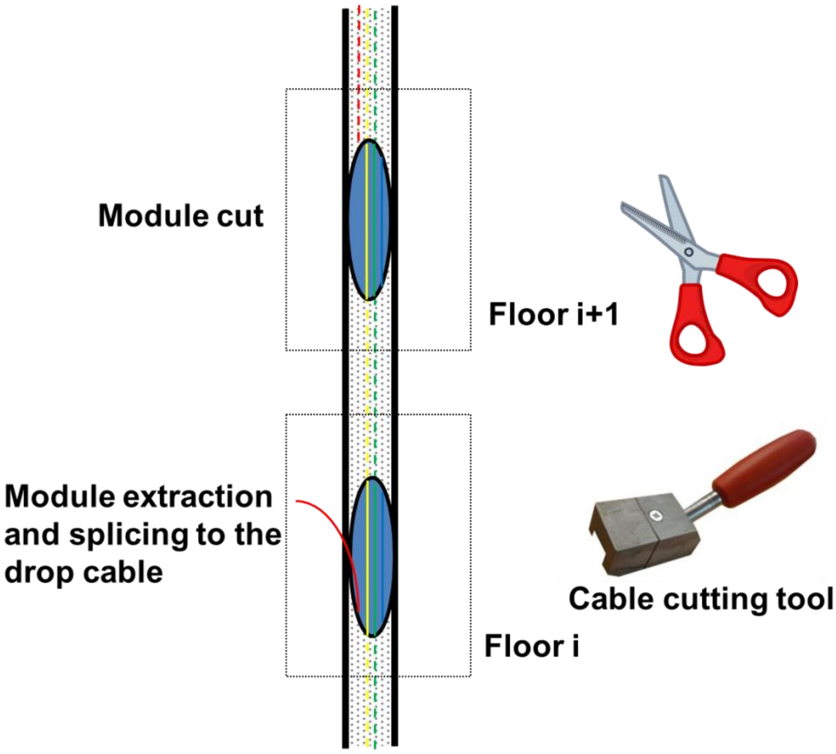


Figure 9: Riser cables for direct mid-span access

3.3. Horizontal cabling

The challenge is again to reuse the existing paths. Potentially, they are already occupied by copper cables and it is not always possible or allowed to remove them. Low size and flat "pushable" low friction cables could then be a solution. To cope with the local regulations, they could come with metallic strength members or be all-dielectric.

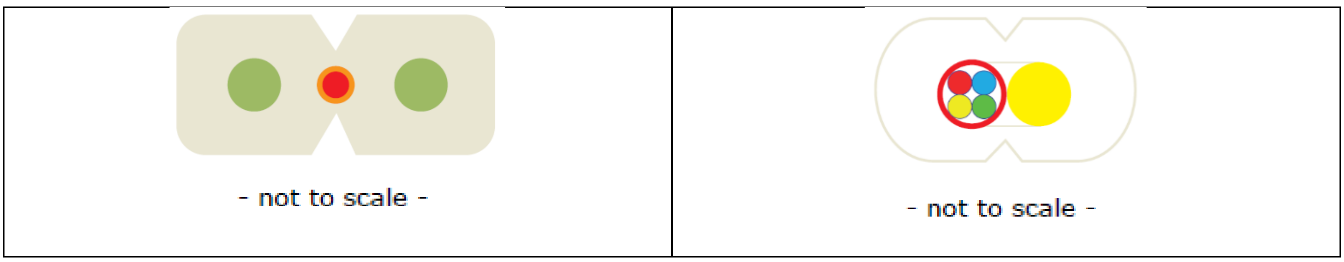


Figure 10: Different constructions of flat pushable low friction all dielectric drop cables

When it is not possible to reuse the existing pipes, the cables must be installed along the walls. They should be as discrete as possible. Many solutions are available on the market, typically with a diameter from 2 to 4 mm.

3.4. In-home cabling

In-home cabling offers the same challenges as horizontal cabling. The same solutions can be used. Cables with a protective sheath having a diameter under 3mm (typically about 2mm) could be installed along and through the wall. If the cable is not subjected to strain, it can be reduced to “tight buffer like” module of approximately 900 µm. The fibre is then extremely exposed. In any case it is generally associated with bend insensitive fibres, ITU-T G.657.A2 or B3.

4. Conclusion

FTTH offers new challenges to optical fibre cables. To keep the installation costs as low as possible, the cable industry has developed and commercialized a large variety of solutions both for the outside plant and for in-buildings. Cable miniaturization is a general trend, and bend insensitive fibres are a key enabling technology.