Electro Rent

Enabling a Fibre-Based Future

electrorent.com

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Introduction

As demand for high-speed Internet services continues to grow exponentially, traditional access technologies are now being superseded by faster ones. There is increasing fibre-to-the-home (FTTH) and fibre-to-the-premises (FTTP) deployment activity being seen in both Europe and North America. Consequently, the number of subscribers able to benefit from fibre-based broadband is rising considerably.

Projections made by market research firm iDATE conclude that the total number of FTTH/FTTP subscribers in Europe will more than double between 2020 and 2026 - reaching 208 million by the end of this period. That will equate to almost 65% overall market penetration.

In order to keep pace with the expectations of the customer base, it is critical that fibre network installation work is completed within the shortest possible time frame. This will mean that broadband operators can bring services online quicker, so that revenue may then be generated.

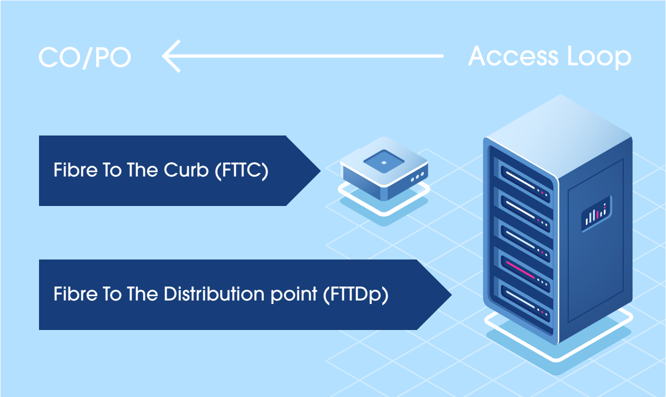
The key purpose of this Electro Rent white paper is to provide a comprehensive reference resource covering all the test activities relating to the FTTX rollout. Not only will it look at the technologies now being utilised, but also the equipment models available that support such technologies. The possible equipment sourcing strategies that are available will then be outlined - with details being given on how they should be applied to assure heightened effectiveness, while keeping the associated capital and operational costs to a minimum.

FTTH

Over the course of the last decade or so, operators across Europe have been implementing and fibre-to-the-curb (FTTC) technology, so that they could deliver faster data rates to their subscriber base. FTTC networks are comprised of a mix of fibre and copper cabling - with the operator deploying fibre to the street cabinet, then connecting to homes, residential buildings and offices via existing (and increasingly outdated) copper infrastructure.

This last element of the connection has caused data bottlenecks. It has meant there have been significant restrictions placed on the data rates that FTTC could support. The speeds that may be delivered using this approach are impacted upon by the age of the cabling, its length and the number of subscribers allocated to share it.

With subscribers broadband expectations having elevated acutely over the last few years, operators can no longer rely on FTTC to provide adequate user experiences. They must instead look to initiate widespread implementation of FTTH and FTTP - eliminating the limitations that copper places on the services provided to subscribers and markedly augmenting the data rates available to them. The different FTTC/FTTH/FTTP network configurations are outlined in Figure 1 right.



Though FTTC-based broadband networks have the capacity to deliver 100Mbps data rates to connected subscribers, FTTH technology can ramp this up by more than an order of magnitude - taking it beyond 1Gbps and in more recent times pushing it up to 10Gbps. Table 1 gives a comparison of the upload and download speeds that can be achieved for different home-oriented applications.

Table 1 below: Comparison of upload and download speeds.
(Source: FTTH Council Europe)

Time taken for:	1 GB photo album	4.7 GB standard video	25 GB HD video
1 Gbps download 1 Gbps upload	9 sec	39 sec	3 min 28 sec
100 Mbps download 100 Mbps upload	1 min 23 sec	6 min 31 sec	34 min 40 sec
50 Mbps download 10 Mbps upload	2 min 46 sec 13 min 52 sec	13 min 2 sec 1 hr 5 min	1 hr 9 min 5 hr 47 min
8 Mbps download 1 Mbps upload	19 min 0 sec 2hr 32 min	1 hr 29 min 11 hr 54 min	7 hr 55 min -

There are two main FTTH network architectures (as described in Figure 2). These are point-to-point and point-to-multipoint, with the latter accounting for the largest number of deployments to date. Point-to-multipoint is now generally referred to as a passive optical network (PON) and enables dramatic savings on fibre costs by aggregating multiple subscriber lines together using a branched arrangement of fibres and passive splitter/combiner units. The passive splitters mean that a single fibre can serve between 32 and 128 different premises. The fibre section from the splitter is normally terminated on the outside wall of a home, and a short fibre lead run inside to the fibre modem, which then provides an Ethernet connection to the broadband router. On conventional PON networks, downstream signals are transmitted at the 1490nm wavelength and upstream signals at the 1310nm wavelength.

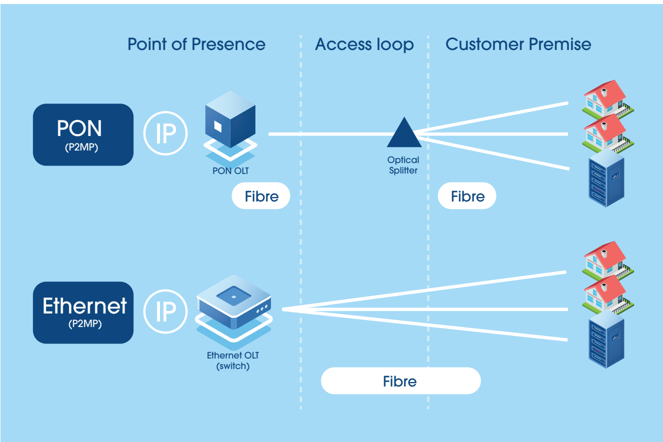


Figure 2: Different FTTH architectures

(Source: FTTH Council Europe)

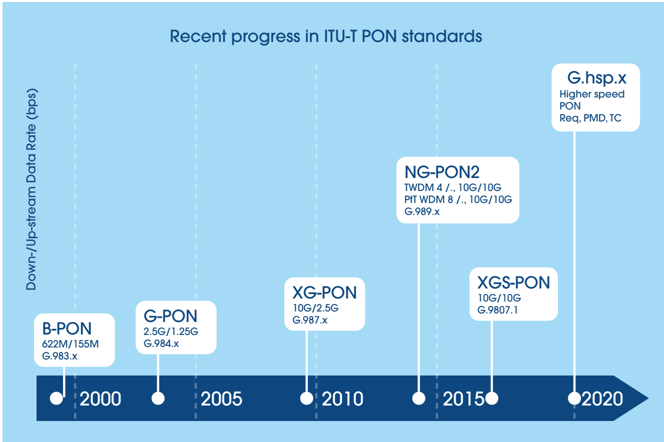


Figure 3: The PON standards introduced to date

(Source: International Telecommunications Union)

The migration towards the latest Gbit PON (GPON) protocols will be pivotal in enabling the 10Gbps performance levels already mentioned to be achieved. Fibre infrastructure based on the XGS-PON protocol allows single-channel data transmission at 10Gbps speeds in both directions, through wave division multiplexing (WDM). It employs 1577nm for downstream and 1270nm for upstream data transport. The NG-PON2 protocol utilises 1600nm for downstream and 1530nm for upstream. Thanks to time and wave division multiplexing (TWDM), it is able to support symmetric operation across 4/8 downstream and upstream channels respectively - thereby allowing the total capacity that can be attained by a single fibre to reach an impressive 80Gbps. This can then be shared by multiple subscribers.

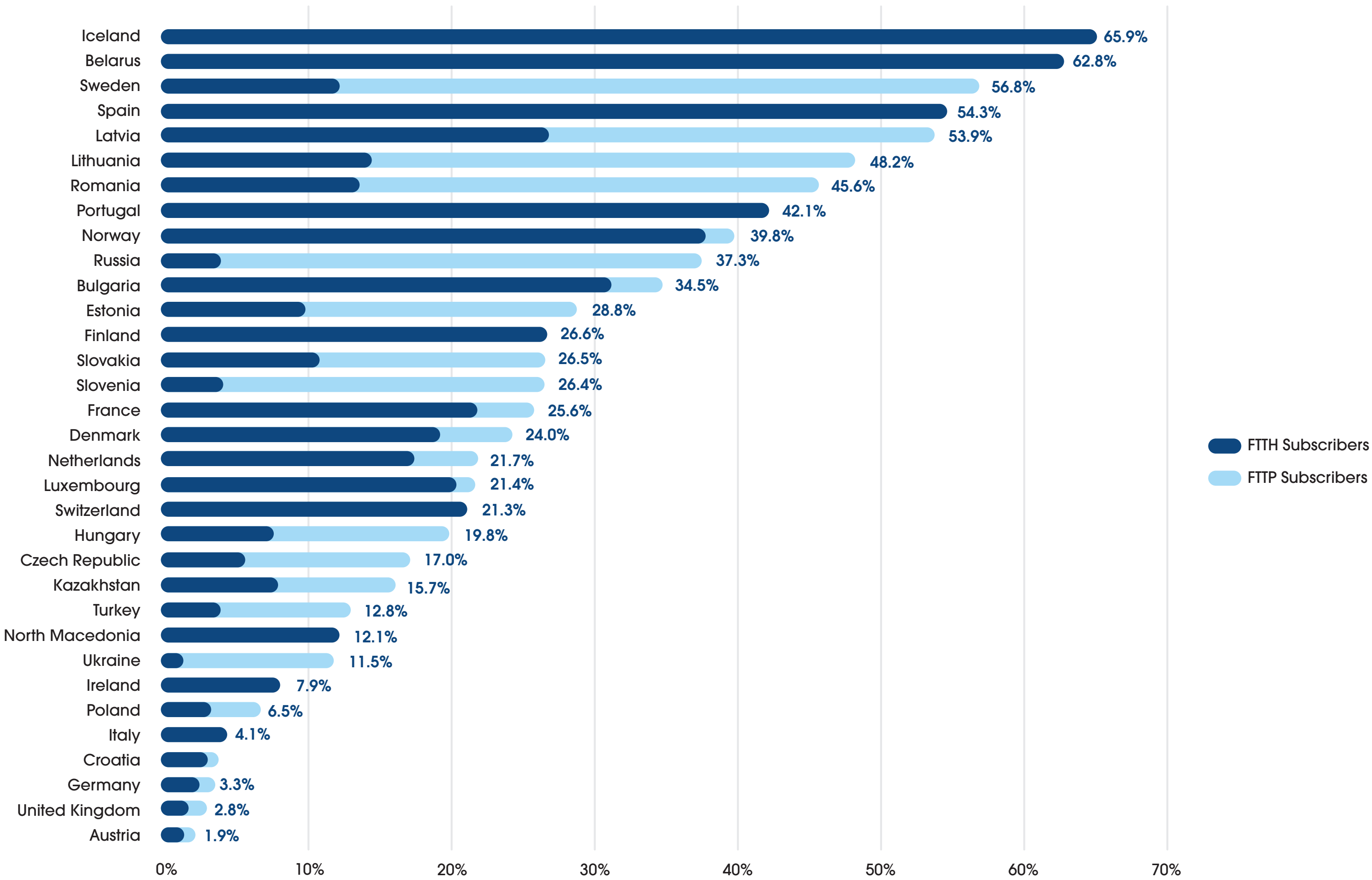


Figure 4: European FTTH/FTTP penetration figures 2020

(Source: FTTH Council Europe)

FTTH/FTTP Rollout in Europe

Subscriber uptake of FTTH/FTTP services is currently gaining momentum across the entire European continent. Figures that were, once again, compiled by iDATE (on behalf of the FTTH Council Europe) show that between 2019 and 2020, there were considerable increases witnessed in many countries within the region. France added almost 2.8 million new subscribers, Russia close to 1.7 million and Spain just over 1.4 million. Turkey and Germany both grew their subscriber base by approximately 0.7 million. Figure 4 gives detail of the current proportion of each European country's population served by FTTH/FTTP.

Best Practices and Essential Tools

During FTTX network implementations, there are three main groups of test activities which will need to be conducted. These are:

1. The testing of connectors and cabling

Connectors are key components in the network and are also major causes of loss (particularly in situations where they have become contaminated). Contaminants can arise from a number of potential sources. These include dust, dirt, pollen, plus oil from the hands of installers, etc. Dust particles are a serious concern. They can be retained on a fibre endface through electrostatic and will then block the light being transmitted. This will lead to insertion loss and optical return loss (ORL) figures that are above levels deemed acceptable. Dust particles can also cause permanent damage to the fibre interface, digging into the fibre and leaving pits that will create further ORL when mated. It is therefore vitally important to thoroughly inspect connectors as part of the installation process - so their cleanliness can be ascertained. Microscopes that are purposely designed for fibre endface inspection need to be sourced. A video microscope can magnify the connector endface image so that it may be viewed on either a laptop or portable display (depending on the particular model used). The P5000i intelligent fibre microscope from Viavi enables rapid inspection of fibre endface quality for certification purposes. It offers plug-and-play operation - delivering a simple pass/fail response. This means that it does not require a highly trained technician to operate. Operatives can toggle between low and high magnification levels in both live and analysis viewing modes. The results obtained can be forwarded onto Viavi test platforms, as well as laptops or mobile devices, for further examination. The company also offers the FiberChek Sidewinder, which is an all-in-one handheld inspection and analysis solution. This compact unit has a built-in touchscreen interface, plus an audible pass/fail mechanism. It supports fully autonomous operation and is simple for staff to use, with only minimal prior instruction being required. Data connections with other hardware can be established via USB or Wi-Fi.

Figure 5: Viavi P5000i and FiberChek Sidewinder

2. Quantifying losses

If fibre infrastructure is to adhere to the necessary certifications, its loss characteristics need to be kept at very low levels. Qualification of the link following installation involves measuring the end-to-end losses experienced. These consist of the losses from the connectors at each end, those at fibre sections and those within the splitter (connectors/splices and the splitter itself). As fibres operate bi-directionally, the testing must likewise be conducted in both directions. There are two main items of test equipment for measuring ORL and link distance - namely the optical time domain reflectometer (OTDR) and the ORL meter/optical loss test set (OLTS). Whilst OTDRs support faster testing procedures, requiring fewer test points and less work for the operative, their outputs can be more difficult to interpret. This is particularly true where there are complex networks involved, meaning that skilled technicians will be required.

Figure 6: The P-174631 FTTH contractors’ kit from Exfo

An ORL meter/OLTS will be more straightforward to use. However, two technicians will be required when conducting tests using this kind of equipment (placed at two different locations). Also considerably more test points will need to be accessed. Once the pair of units have been referenced and calibrated, they can take end-to-end measurements on any section of installed fibre (as shown in Figure 7). These tests enable verification of the different loss variables and can identify any transposed fibres.

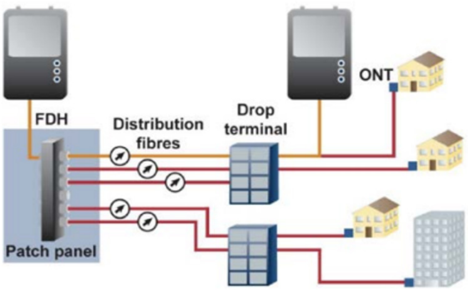


Figure 7: Testing with an OLTS/ORL meter
(Source: FTTH Council Europe)

OTDRs work by injecting optical pulses into the fibre under test and measuring the light that gets reflected back from various points along the fibre's length. The reflected light is used to characterise the fibre under test with the strength of the return pulses being integrated against time and plotted as a function of fibre length. By using an OTDR at various points in the network (as shown in Figure 8), the feeder and distribution sections of the network can be tested independently. The OTDR is able to identify and locate each network component and can measure splice loss, connector loss and reflectance,

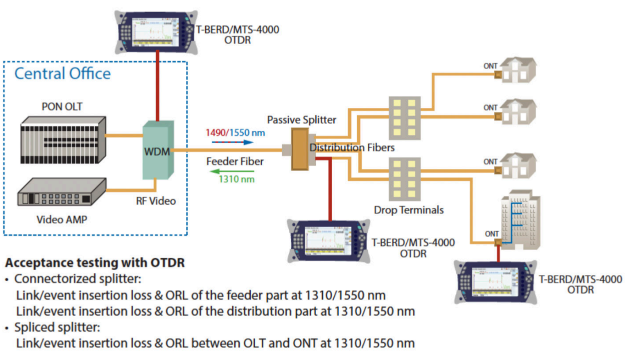


Figure 8: Testing Options Using OTDR
(Source: Viavi Solutions)

along with total end-to-end loss and ORL. The tests must be performed using two wavelengths, enabling detection of bends on the link which give higher losses at 1550nm than at 1310nm. By changing the OTDR pulse duration, testing from the optical network terminal (ONT) can be used to qualify the network, both up to the splitter and through the splitter to the optical network terminal (OLT). A sample output from the latter of these tests is described in Figure 9. OTDR tests can also be conducted from the exchange, out towards the customer premises - however, it should be noted that this requires a higher level of expertise and detailed knowledge of the network configuration in order to interpret the trace results.

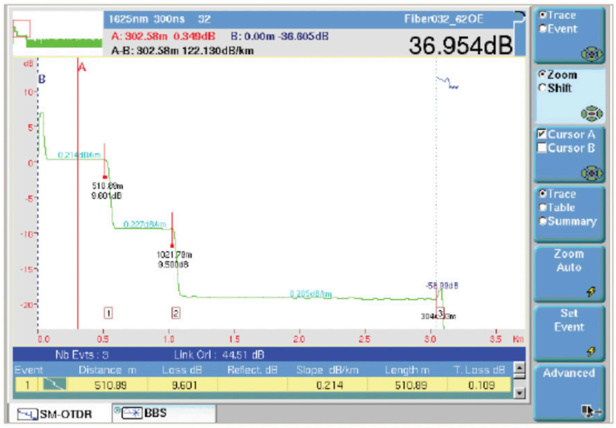


Figure 9: Sample OTDR output
(Source: Viavi Solutions)

In addition to employing an OTDR as a qualification tool, it may also be used for troubleshooting purposes - so that issues along the link can be pinpointed. There are a wide range of OTDR models on the market, each addressing different test and measurement needs. Key OTDR features, such as accuracy, resolution, measurement range and measurement speed, will all vary according to the model's cost.

The suitability of an OTDR for a specific test scenario will depend on a number of factors. These will include the network architecture, type of fibre (single-mode or multi-mode), maximum test distance and test types. Other factors to consider will be size and weight of the unit, display size, battery life, storage capacity, connectivity, post-processing software and available upgrade modules.

Given the distinctions between an OTDR and OLTS/ORL meter, equipment selection must therefore come down to finding the optimal balance between ease of use and overall cost. Furthermore, the equipment employed must also be approved for use - being fully aligned to the test workflow that has been stipulated by the network operator.

3. Determining the location of faults

A visual fault locator (VFL) is a simple tool, usually handheld, which test operatives can use for troubleshooting tasks. This instrument can determine where there are breakpoints, bends or cracks in the fibre by illuminating the fibre core with light from its laser emitter. Fluke's VisiFault and Viavi's FFL-100 are two of the most popular VFLs. The VisiFault can be applied to multimode fibres that are 3km in length or 4km long single-mode fibres, while the FFL-100 supports 5km lengths for multimode fibres and 7km lengths for single-mode fibres. In some cases, VFL functionality may also be integrated directly into an OTDR.

Figure 10: The VisiFault VFL from Fluke and the FFL-100 VFL from Viavi

There is another key item of equipment that is essential to fibre installations that has not been mentioned so far. The joining of fibre optic cables is not a straightforward procedure and there are several options available for undertaking such work. It is paramount to choose the right one for the assigned task. This is particularly important when working on installations in the field. Physical connectors can be applied in the field, but this is likely to lead to a reduction in signal quality. It can also be unreliable, as there is a strong possibility that water or dirt ingress will eventually impact on the connection. Factory terminated or pre-connectorised cables present a more reliable alternative, however they must be carefully planned and set up in the factory beforehand. This means they are not a flexible option in the field, with more cable often being used in practice than if the cables could be cut to length and joined on site.

Fusion splicing provides an effective, flexible option for field-based installations. The process joins fibres by bringing the two ends together and heating them, usually with an electric arc, in order to make a robust physical join. As the fibres are joined to form a single fibre, the amount of scattering and reflection at the join will be very low. A broad selection of fusion splicer models are available. While these vary in complexity, the splicing procedure is similar across all of them. First, the fibre is cut (or cleaved) with a specialist tool. Both ends must be cleaved to ensure they can be joined cleanly. Next, the cores are placed into the fusion splicer using guides to make certain they are in the correct position and then the tool will automatically align them and apply the necessary heat to join the fibres together. Some systems can handle cables with multiple cores, joining all the cores in a single step. This can greatly improve throughput and increase productivity when working on multi-core cables.

Once splicing has been completed, the join is protected with an outer sheath to prevent physical damage to the fibre core (from direct contact or stretching of the cable). As the fibres are physically joined, the resulting fibre is almost as strong as the initial fibre, but the sheath provides some extra robustness too. When the join has been completed, many modern fusion splicers will analyse the join to verify that it is of acceptable quality. If, for any reason, the quality of the join is below the required standard, it will need to be cut and re-made. The Fujikura 90S+ is a high-speed core alignment fusion splicer which can complete the entire splice process within less than 20s. Its capacious battery means that 300 splices may be carried out before the unit needs to be recharged.

Figure 11: The Fujikura 90S+ splicer

Implementing a Better Test Equipment Sourcing Strategy

If network operators and their installer partners are going to roll-out FTTX infrastructure in an efficient manner, then the test activities clearly need to be executed in a totally efficient manner. Test engineers have to be able to promptly access the relevant equipment, rather than being stuck waiting for it to come back after being assigned to another project. They must be assured that its maintenance and calibration have not been allowed to lapse through poor inventory management.

It is vital that stocked equipment is fully up to date, so that the latest network protocols can be addressed. Also, if there are unexpected peaks in test activity, then it may be necessary for the number of available units to be quickly ramped up to match demand levels. This degree of flexibility is not something that conventional equipment procurement is able to support.

Equipment rental has now proved itself to be of huge benefit to test engineers throughout a wide range of different industry sectors. It means that the right equipment can be sourced rapidly, as and when it is needed. High upfront capital costs can be avoided, and so can ongoing operational expenses (such as storage, insurance, finance repayments, servicing and calibration). Units can be added to or removed from the operation in line with demand fluctuations.

How Electro Rent Can Help

Electro Rent has unmatched experience of helping customers deploy equipment when and where needed in the most cost-effective way possible. With sourcing options covering rental, rent-to-buy, leasing, finance and used equipment purchase, customers do not have to worry about the capital and operational expenses that procuring brand new equipment will entail.

With almost €850 million invested in test equipment inventory worldwide, Electro Rent's is able to provide customers with the most expansive range of models direct from stock - mitigating the frustrations caused by lengthy lead times. Its team of over 350 specialists keep track of industry trends and the emergence of new standards, so that the company's equipment inventory is always able to attend to the market's current and future needs. This in-house expertise is supported by long-established relationships with the foremost equipment manufacturers - including the likes of Viavi, Exfo and Fluke.

Conclusion

FTTX will continue to be a priority for network operators, as they look to provide their subscribers with the broadband capacity necessary for them to enjoy increasingly data -intensive services and applications. Consequently, test work will need to be undertaken with the utmost efficiency. Given the anticipated rise in demand and the need for flexible and cost-effective sourcing, it will be important for any organisations involved in FTTX infrastructure roll-outs to have a secure supply chain for the test equipment they require. This is why engaging with a respected sourcing specialist, like Electro Rent, will be critical.

Smarter Solutions for Testing & Technology

About Us

Electro Rent is a leading global provider of test and technology solutions that enable customers to accelerate innovation and optimize asset investments. Our rental, leasing, sales, and asset optimization solutions serve innovators in communications, aerospace and defense, automotive, energy, education, and electronics industries, and we have been doing so since 1965.

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