

Fiber-To-The-Home (FTTH) in Greece

Lost Opportunities & Future Potentials of FTTx

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"Hard" Core Optical Networks

The current fast-growing Internet traffic, enabled through the World Wide Web, has led to a significant capacity requirement increase in the core network. This in turn, has resulted in the development and commercialization of advanced electronic and optical technologies capable of providing point-to-point links with bit-rates exceeding Terabit/Second, exploiting SONET/SDH over WDM technologies and evolving towards digital optical networks¹. Moreover, the advent of MPLS switching paradigm² in combination with research on optical label swapping has generated the required momentum for the development of future core transparent photonic networks that will be able to handle various traffic types fast and efficiently through dynamic lightpaths, offering triple play applications (Voice/Video/Data).

This rapid development of long-haul networks, triggered by the over-estimated internet growth rates during 2000, led to a fast cost-reduction in high-speed links, which in turn drove the internet world into the well-known telecom bubble. Overcoming technological hurdles, through massive investments, the industry responded to

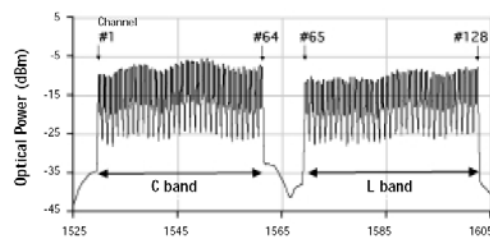
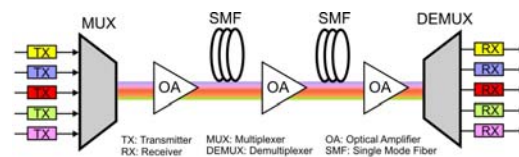


Figure 1 (a) WDM point-to-point link, (b) 5.12 Tb/s capacity using 128 channels in C- and L-bands at 40 Gb/s line-rate [Source: Alcatel]

the predicted growth rates of the time. However, the Internet simply did not grow as fast as had been predicted, leading to the complete crash of the telecom industry. The primary reason is technological, economic and also societal. The access network was not ready to provide and offer this immense bandwidth cost-effectively to the end-users, whereas the society was not mature enough to accept broadband services and information technology in their everyday life, as it was the case with the mobile telecom industry.

Access: Copper, Copper, Copper

Broadband access technologies have been in the forefront in the past years, in an effort to utilize the bandwidth offered by the backbone and metro networks to

¹ Infinera, www.infinera.com

² E. Rosen, A. Viswanathan, and R. Callon, "RFC 3031: Multiprotocol Label Switching Architecture", IETF Request of Comments, 2001

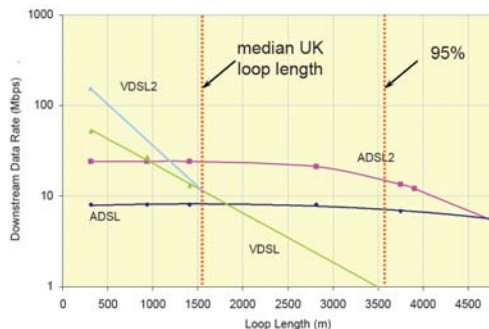


Figure 2 Downstream data-rate vs. loop length showing typical loop lengths in UK³.

the end-users. One of the most successful technologies, in terms of deployment, is undoubtedly ADSL, due to its ability to offer relatively high bandwidth over traditional twisted-pair networks. Alternative wire line access technologies (e.g. broadband-over-power lines) and wireless (e.g. WiMAX) are currently far from being considered as the enabling technologies capable of addressing such mass deployment and each one has its own technological, regulatory and safety issues to solve.

Without going into technical details, the above broadband access technologies have one common fundamental problem, stemming from the physical properties of the transmission medium used: the bandwidth limitation. The advantage of ADSL becomes a disadvantage of the technology, when it comes to the maximum bandwidth attainable over distance. ADSL can bring 1.544 to 8 Mb/s downstream and 16 kb/s to 1.1 Mb/s upstream on the existing wiring. Typical distance limitations for the *lowest* bit rates are about 5 km. Although ADSL offers a dedicated link per user, the maximum bandwidth varies with distance and local traffic, whereas the asymmetric nature of ADSL poses constraints on applications where large uplink is required. New technologies, such as

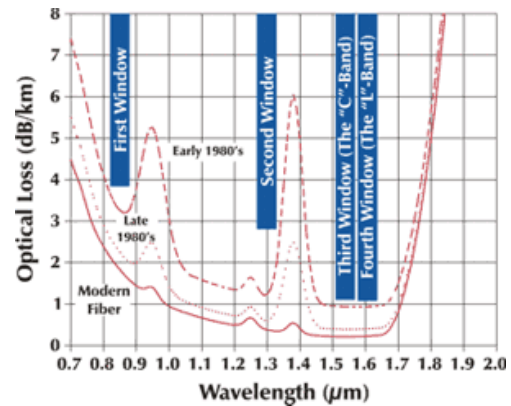


Figure 3 Fiber-optic communication windows, showing useable bandwidth.

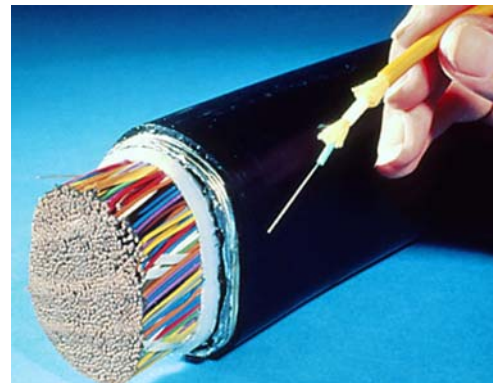


Figure 4 Comparison between bandwidth achievable through a single fiber compared to twisted-pair [Source: Corning].

VDSL2+ aims at providing over 50 Mb/s bandwidth with symmetric up/down speeds. This bandwidth, however, is offered for loop lengths of up to 500 m, after which, the throughput falls exponentially³.

In other words, twisted pair can indeed offer a significant bandwidth exploiting already-deployed infrastructures for short lengths. This stems from the limited electrical bandwidth available in the transmission medium, which is copper.

³ MUSE Project: Multiservice Access Everywhere

Is there life after xDSL?

A robust alternative for solving these bandwidth/distance limitations is to use fiber-optic links exploiting the practically unlimited bandwidth offered by the fiber and exploit similar physical properties used in the core network for transporting data. The advantages of fiber are well-known and amongst others are massive bandwidth (> 50 THz), low propagation loss (<0.5 dB/km) and immunity to electromagnetic interference. A single optical fiber can carry 10 million simultaneous phone calls (64x10 Gb/s) and is less than 2% in weight and size when compared to conventional twisted-pair cables⁴. Bringing fiber links closer to subscribers has been the center of attention in optical communications for over a decade now and has led to commercialization and standardization of several access technologies referred to FTTx solution, where “x” denotes the fiber reach, being the Neighborhood, Curb, Building and even Home.

Fiber-to-the-Home (FTTH) architectures can be classified into active and passive networks. Active FTTH network topologies are further classified into point-to-point or point-to-multipoint. Each topology has its own unique features and the optimum choice depends on the existing network, the deployment costs and number of potential subscribers in each case.

Point-to-multipoint Passive Optical Networks (PONs) are shared-medium topologies, where 16 or 32 users share the same bandwidth. Specifically, in PON topologies, an optical line terminal OLT located at the central office provides the connectivity to the optical

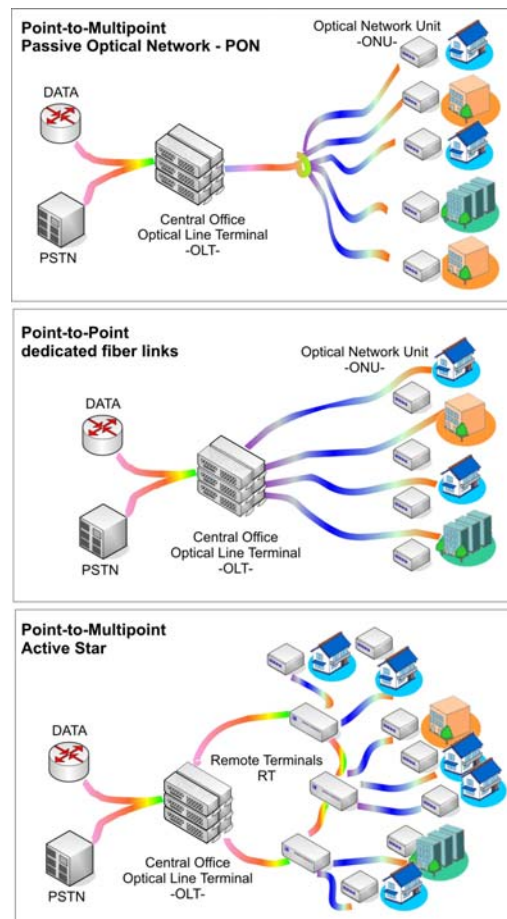


Figure 5 FTTH architectures: Passive Optical Networks (PONs), Point-to-point FTTH and Active Star topology.

network units located at the customer premises, with typical ranges from 10-20 km. The shared medium is offered through signal splitters that do not require any driving electronics or power. In point-to-point FTTH architectures, dedicated fibers connect each ONU to the OLT located in the Central Office. This approach offers a single “pipe” per end-user and hence can provide very high bandwidths in expense of increased fiber installation costs.

Finally, in active star architectures, multiple users can share one fiber through a remote node located between

⁴ Corning Optical Fiber, Broadband Market Development [www.corning.com]

	APON	EPON	GPON
Downstream	155 Mb/s to 1.25 Gb/s	1.25 Gb/s	1.25 Gb/s and 2.5 Gb/s
Upstream	622 Mb/s and 155 Mb/s	1.25 Gb/s	155 Mb/s to 2.5 Gb/s
Protocol	ATM	Ethernet	GEthernet
Maximum split	32	-	64
Reach	20 km	20 km	60 km

Table 1: PON networks and characteristics

the central office and the end-user. Optical Ethernet switches installed at the remote node provide fiber access aggregation and can be shared with a large number of end-users. The specific architecture offers dedicated fiber links to each user and also reduces the total amount of fiber required to be deployed, leading to a more cost-effective solution than the dedicated point-to-point case. In the physical layer, bidirectional data transfer is provided through two different wavelength channels (1310 nm for uplink and 1490 nm for downlink), and can also include an additional channel at 1555 nm for the provision of additional applications.

Existing standardized FTTH (or FTTx) architectures are APONs, GPONs and EPONs and their respective characteristics are summarized in table 2. APONs were amongst the first PON networks to be standardized by ITU-T through the G.983 series of standards, supporting ATM-based services and downstream capacity up to 1.25 Gb/s. EPONs (IEEE 802.3ah) on the other hand use Ethernet framing and data-rates of 1.25 Gb/s in both upstream and downstream directions. Finally, GPONs (ITU-T G.984) use gigabit Ethernet protocols and support downstream line-rate of 2.5 Gb/s and a variety of

upstream rates ranging from 155 Mb/s up to a full 2.5 Gb/s.

FTTH global market overview

The situation on a global scale shows that the FTTH market is growing rapidly, with leading markets being East Asia and more specifically, Japan, Korea and China. Japan is the most established FTTH market with more than 1.6 million subscribers in 2004, a number that has climbed to almost 3 million within 2006. Japan's aggressive FTTH deployment aims at connecting a total of 30 million homes with fiber by 2010. In 2005, the numbers in China and Korea showed that more than 1/4 and 1/8 of the total broadband subscribers respectively, used FTTx solutions and Ethernet LAN technologies. More interesting is the fact that Korea is now moving towards FTTH and aims at providing up to 100 Mb/s per subscriber in the near future, in order to offer triple-play applications. FTTx solutions are also gaining ground in the US as well, with Verizon being the first to lay fiber for FTTH solutions for providing up to 50 Mb/s at each subscriber. The number of US subscribers that use FTTH exceeded one million in the last quarter of 2006.

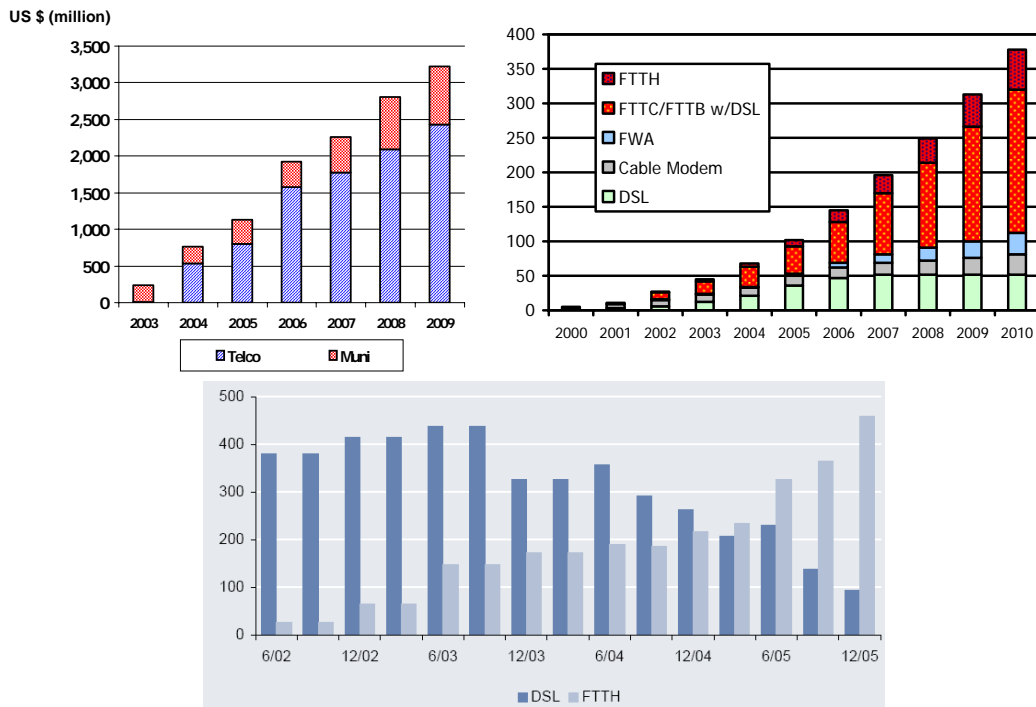


Figure 6 KMI research US forecast showing ratio of investment of telecom operators and municipalities, the Asia-Pacific forecast by KMI research showing different competing access technologies [Source: KMI Research, FTTH Council] and DSL/FTTH deployment in Japan [Source: NTT/ING Wholesale Banking, FTTH Council]

FTTH in Europe

The picture in Europe is somewhat different from the US and Asia, with broadband penetration being slow. The dominant broadband technology continues to be xDSL, in order to avoid investments in new infrastructures, required in solutions such as FTTx. The relatively slow penetration of high-speed services into European homes has been blamed on the LLU process, which has turned incumbents away from investing into new infrastructures. It is worth noting that from the small number of FTTx networks deployed in 2004, only 7% was done by incumbents and less than 9% by alternative operators, with municipalities and power companies taking the lead with almost 70%. At the

end of June 2005 there were around 650,000 FTTx subscribers in Western Europe and around 2.5mil homes and buildings passed by fiber networks. Nearly 97% of European FTTx subscribers are concentrated in less than 5 countries.

The Access Network in Greece

Focusing down in the Greek sector, until recently, internet access was available only through dial-up connections offered by the Greek incumbent telecom operator OTE. In 2003, broadband access made its appearance through ADSL and since then, several ISPs made their appearance by utilizing the incumbent's existing twisted-pair infrastructure, primarily through reselling and bit-stream access. More recently,

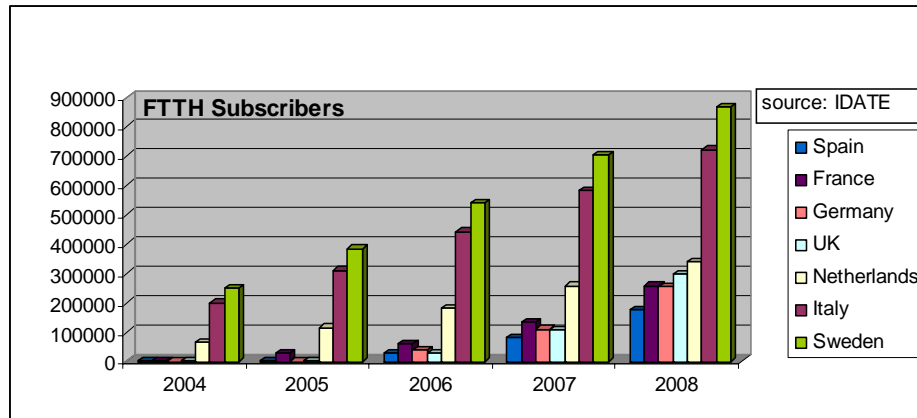
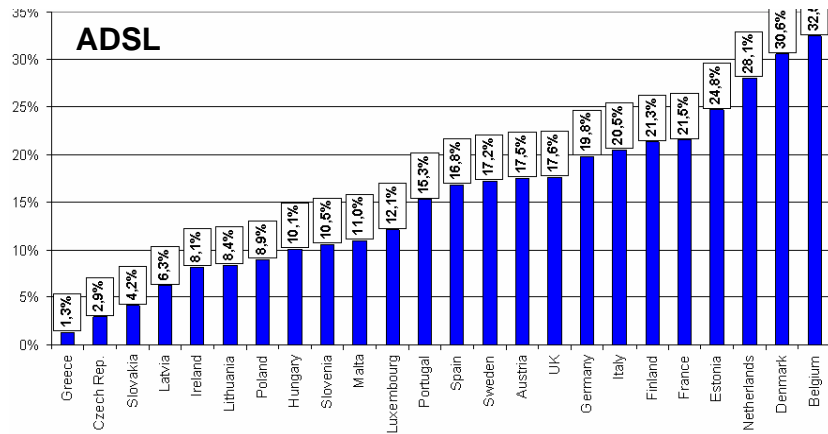


Figure 7 Broadband penetration in European countries through DSL (top), FTTH deployment in selected European countries and forecast (Source: IDATE)

Greek ISPs also have started to offer ADSL access through shared or full LLU, supervised by the Greek National Regulatory Authority. The LLU process has been relatively slow due to several reasons that are beyond the scope of this article. However, it is worth noting that ADSL is currently the only broadband standard in Greece, which has the lowest penetration of broadband technology amongst the EU countries (1.3%, in the first quarter of 2005).

VI. Piggy-bagging FTTH Costs

Given optical fiber ideal characteristics as a transmission medium, its deployment at the access network has

been slow primarily due to the higher cost associated with installation and particularly in Europe due to the unwillingness of incumbents to invest into new infrastructures at the access level. An alternative method for deploying FTTx networks and bringing fiber closer to end-users is either to exploit existing non-telecom infrastructures or to share installation costs with parallel infrastructure projects. There are several cases where FTTx was deployed in dense residential areas, where the fiber was deployed through power lines, sewage systems or natural gas pipes. Moreover, there has been significant development within this sector in order to produce robust and

cost-effective solutions for installing fiber cables in such infrastructures, avoiding excavation works and site re-building⁵. Concerning sewage systems, the necessary technological solutions and products currently exist that allow fiber cable deployment in sewage pipes in both man-entry and no-man-entry systems. Considering man-accessible sewer pipes, the usual procedure for installation is through a wheeled and powered cart that carries installation materials, power drills and other tools to be used by the technicians and in several cases, these carts also provide lighting and oxygen tanks. In sewer pipes not accessible by man, the fiber is deployed using advanced robotic

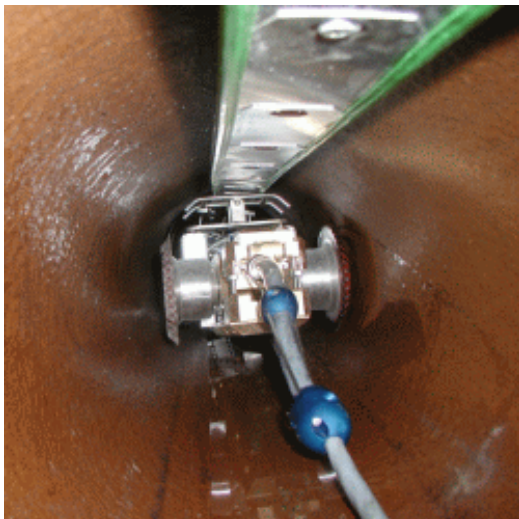


Figure 8 monitoring and deployment robots suitable for sewer systems [Source: Cable Runner]

⁵ North-American Society for Trenchless Technology
www.nastt.org



Figure 9 Fiber-in-Gas installation (Source: SEMPRA Fiber Links) and fiber over power lines (Source: ALCATEL solutions)

vehicles remotely controlled in the surface. Using robot-based approaches, fiber cables can be deployed at a rate of 800 meters per day, which is approximately 8 times faster than traditional methods, within sewage pipes having diameter as small as 20 cm.

Another relatively new concept of reducing FTTx deployment costs is the collaboration of telecom and energy industries, through the “fiber-in-gas” concept. In this scenario, fiber optic cables are installed inside low/medium pressure gas pipelines that run in neighborhoods and commercial districts

using approved and safe fittings and cable materials. Targeted areas of this technology are within dense urban areas where the cost of traditional excavation and trenching is high. In cases where there is ongoing natural gas installation, a key strategic initiative would be to incorporate additional tubes for installing fiber cables, thus sharing the total cost of deployment over both industries. A more straightforward approach that is also used for deploying metro networks is aerial fiber installation through power lines, a solution most suited for power companies willing to enter the broadband access market.

VI. FTTx Missed opportunities – A simple example

Taking into account the previous section on alternative and “dig-free” approaches for deploying FTTx, there are some obvious examples that cannot be overlooked. For instance, one can look into the massive infrastructure works carried out during the last years by the Greek Natural Gas company in Athens, where almost all pavements and sidewalks were trenched turning the city into a huge worksite. The window of opportunity in this case is obvious for FTTx, since natural gas pipelines were installed in neighborhoods running up to the entrance of each apartment block. A well-thought business plan and FTTx installation plan could have led to the development of a dense and state-of-the-art FTTC or FTTB network serving a large number of end-users, through a unified gas and telecom service provider. Moreover, fibers could also have reached apartments and homes for future network upgrade from FTTC to full-fledged FTTH network, bringing Athens to the forefront of high-speed broadband access. Having established the access network within the most

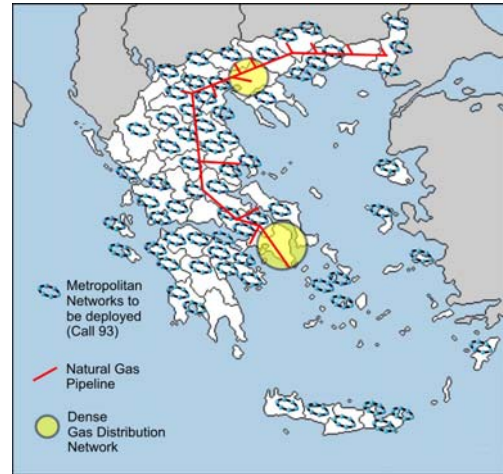


Figure 10. Map of Greece showing number of optical metro rings to be deployed, the natural gas backbone and the natural gas distribution network in Athens and Thessalonica.

densely populated city in Greece, the attention could also be focused on laying new fiber side-by-side with the main pipelines that connect the backbone of Greece. This would give high-speed connectivity required to most cities in Greece. Taking this simplistic plan one step further, the Natural Gas backbone optical network could be interfaced with the optical metropolitan area networks to be deployed within the frames of Operational Programme “Information Society”, through “Invitation Call 93”⁶. The specific program aims at developing a number of metro rings in numerous municipalities throughout Greece, in order to develop broadband infrastructures in remote and less-developed areas of Greece. Considering this simplistic, yet powerful, scenario, a new alternative non-telecom service provider could have entered the Greek broadband market with private optical links including access and backbone networks with the capability to override the incumbent and provide triple-play applications.

⁶ www.infosoc.gr

Conclusions

The picture in Europe and especially in Greece is going to change as ADSL technology is approaching its fundamental limits. New technologies over copper such as VDSL2+, although can offer plenty of bandwidth, they pose a constraint in the maximum reach, which means that fiber has to get closer to the subscriber. Greece's lowest broadband penetration rate throughout Europe suggests that something is going wrong in the broadband access picture. Since the first quarter of 2006, major European cities are aggressively investing in FTTx solutions, in order to provide fast and high-quality services to the end-user. Through already-deployed or new "dig-free" technologies, FTTx networks are steadily making their appearance in Europe to enable next-

generation information and e-entertainment services to end-users.

Concerning Greece, alternative ISPs need to form strong alliances to exploit economies of scale and take advantage of the advanced dig-free technologies available, so as to compress capital costs, when considering deployment of private networks. More importantly, the opportunities through non-telecom entities such as the Natural Gas, Power and even National Railway should not be overlooked, as careful design and techno-economical analysis can lead to the development of cost-effective backbone and access fiber networks.



EXELITE INNOVATIONS is the first R&D company established in Greece that designs and develops state-of-the-art products for optical communication networking, including the academic and industrial R&D sector, and further provides high quality services in the telecommunication and optical networking industry. EXELITE has a broad range of R&D optical product solutions, resulting from the unique research and innovation policy and stringent quality standards and control. EXELITE provides top-quality services in the telecommunication sector ranging from network installation and design, reliable telecom consulting services to training solutions in the fiber-optic communications.



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