1.1 Technical requirements

The network design is taking into account the following principles:

- Flexibility to support different overlay network architectures to best fit retail ISP needs (ie. PoN, Active Ethernet, Fixed Wireless etc). PtP architectures should also be supported, up to a certain degree of realistic penetration.
- Ability to support multiple overlay retail ISP networks.
- Pragmatic dimensioning in order to accommodate the needs of the Greek telecoms market

The most important components of the network deployed in the public domain, are:

	Meaning	Description
	Feeder Segment / Backhaulling	The part of the network between the POP and the FCP
POP	Point of Presence	The starting point for every connection to the subscribers in the served area
RAP	Regional Aggregation Point	An optional point between the POP and the FCP where regional aggregation takes place. In the RAP, connections from several FCPs are concentrated to be subsequently connected to the POP
FCP	First Concentration Point	In the FCP, connections from several subscribers are concentrated to be subsequently connected (through the optional RAP) to the POP
	Drop Segment / Last Mile	Connects the FCP to the BEP (where applicable by the used technologies)
BEP	Building(s) Entry Point	Is the interface between the drop cabling (optical access network) and the "internal" network. Each BEP may serve up to two different buildings.

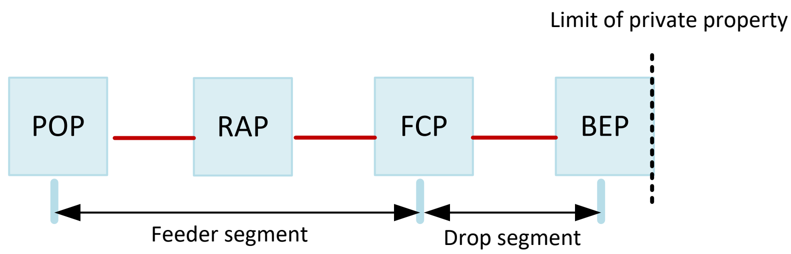

FIGURE 1: HIGH-LEVEL STRUCTURE OF THE NETWORK NODES AND SEGMENTS

1.1.1 Drop segment

1.1.1.1 Class A areas

In Class A areas, the infrastructure to be deployed should cover with 100 Mbps gigabit-capable service all subscribers. After the deployment of the infrastructure the maximum level of denials for service connection requests should be limited to 1% of each OCCA, while for the whole lot, the respective level should be limited to 0.5%.

In Class A areas, one BEP MUST be installed at the public domain[1] for every inhabited building (or at a maximum for every 2 inhabited buildings).

During the construction phase, the UFBB operator must deploy the part of the network from the POP to every single BEP in an area (Home passed). **This is the point until which**

[1] Outside from the private property

construction cost will be eligible within the UFBB project. Up to the BEP, technological and dimensioning requirements will be imposed (see below) in order to assure future-proof specifications and adequate capacity while for the access part of the network (from the BEP towards the end-user) the UFBB operator can deploy the technology of his choice.

After this point in time, the UFBB operator can accept service requests by new subscribers (coming through retail operators). Following a service request, the UFBB operator will have the obligation (if requested by a retail service provider)[2] to provide the part of the infrastructure from the BEP to the subscriber with the technology that he has selected and considers as the most appropriate for each case (provided that he can assure the offering of the requested service class). **For this part of the network, construction cost will NOT be eligible within the UFBB project. The cost will have to be borne by either the UFBB operator, or the retail operator who will use the service**. After this point in time the subscriber is connected.

The construction of fibre drop segment, applies only in Class A Areas, where fibre must reach the BEP. To fully accommodate the needs for Gigabit service, **a fibre pair for each served household is required to reach and be terminated to the corresponding BEP**. Each fibre pair will also be terminated to the corresponding FCP.

Given that there might be vague to assess how many households reside in a building (both during construction and during audits), it is important to define a clear and undisputable method for that purpose: Each "Home Passed" will be mapped to the electric power meter -which serves the respective household- by its unique serial number.

During construction, the UFB operator, will have to terminate in the BEP, at least as many fibre pairs as the number of the electric power meters, installed in the buildings, served by the specific BEP. It will also be required to provide the relevant data (Power meter serial number and geographic information) in order to be used for the project audits.

In order not to exclude aerial deployments, no requirements regarding ducts will be imposed in any part of the network.

The above-described topology is presented in the following figure. It is highlighted that a Point to Point topology is deployed between the Households and the FCP. It is also depicted that a BEP may be used to connect other BEPs in a daisy chain manner, as long as the FCB-Household, Point to Point topology is not affected.

[2] The UFBB operator will also have the obligation to publish detailed requirements for every technology that he will use in the BEP-subscriber part of the network in order to allow third parties (i.e. retail operators, building owners, installers etc.) to deploy by themselves this part of the network. Furthermore he will have the obligation to perform the necessary tests in order to integrate this third-party-installed part of the network in his operations and assume the operational responsibility of the network end-to-end.

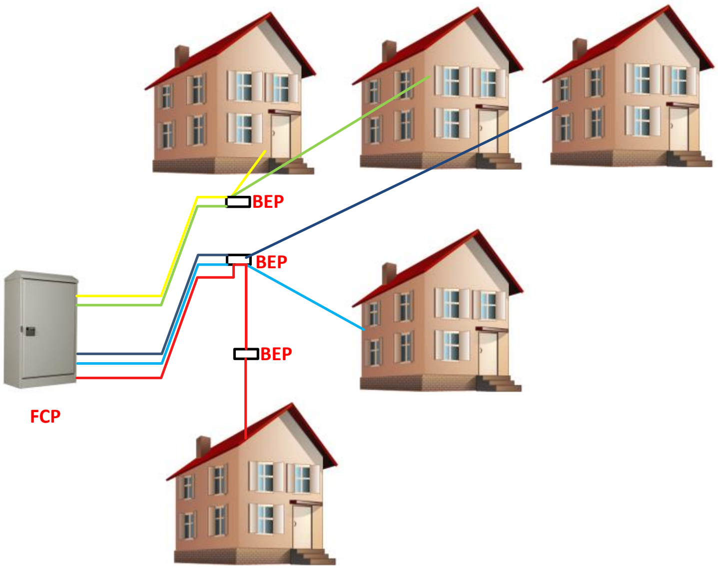

FIGURE 2: P2P TOPOLOGY IN THE DROP SEGMENT

1.1.1.2 Class B areas

In Class B areas, the infrastructure to be deployed should cover with 100Mbps service, the vast majority of the subscribers. After the deployment of the infrastructure the maximum level of denials for service connection requests should be limited to 1% of each OCCA, while for the whole lot, the respective level should be limited to 0.5%. While for Class B there is no requirement for immediate gigabit upgradability, all backhaul infrastructures should be dimensioned in such a way so as to be future proof and able to support gigabit for all subscribers in Class B areas.

In Class B areas, for every settlement with more than 100 inhabitants and for every OCCA with more than 40 active subscriber lines[3], **a fiber backhauled FCP must be installed.**

During the construction phase the UFBB operator must deploy the part of the network from the POP to every single FCP in an area and install the necessary equipment in the respective access nodes (Settlement/OCCA passed). **This is the point until which construction cost will be eligible within the UFBB project.** Up to the FCP, technological and dimensioning requirements will be imposed (see below), while for the access part of the network (from the access node towards the end-user) the UFBB operator can deploy the technology of his choice. After this point in time, the UFBB operator can accept service requests by new subscribers (coming through retail operators). Following a service request, the UFBB operator will connect the subscriber with the technology of his choice (provided that he can assure the offering of Class B service). **For this part of the network, any associated cost will NOT be eligible within the UFBB project. The cost will have to be borne by the UFBB operator or the retail operator(s) who will use the service**. After this point in time the subscriber is connected.

[3] The average number of inhabitants per active subscriber line is 0.43 (10.816.286 inhabitants for 4.742.229 active subscriber lines)

1.1.1.3 Provisions for sites of major socioeconomic drivers

Based on the project requirements, Major Socioeconomic Drivers (both within Class A and Class B areas) will be covered with gigabit-capable service. This includes schools and public libraries, train and long-distance bus stations, airports, ports, hospitals and health centres. Public administration buildings are served by Syzefxis project.

Regarding their connection requirements:

- The sites located in Class A areas or in Class B areas which are served by a fibre backhauled FCP, should (by the end of the construction phase) be ready to be connected to the corresponding POP through "Class A" E-line 1 Gbps Capacity Service (which will include L2 service between end-user ONT and the corresponding PoP). The necessary CPE and the actual provision of the service are not included within the project scope.
- The sites located in Class B areas which are not served by a fiber backhauled FCP, will be connected with "Class B" E-line 100 Mbps Capacity Service which will be demarcated to an ONT located to the end-user's premises (ie the school building) and not the FCP. The necessary ONT and the actual provision of the service are not included within the project scope.

1.1.1.4 Common requirements for Backhauling/Fronthauling and PoPs

Backhauling is needed to connect the dispersed passive network nodes (BEPs and FCPs) with concentration points (PoPs). Fronthauling is needed to connect the centralized radio controllers and the radio heads (or masts) at the "edge" of a cellular network. While this project respects the principle of technological neutrality, it sets the requirement that **BEPs and FCPs (serving more than 40 active subscriber lines), should be connected with fibre optic technology**. This technological 'exception' in the physical layer is considered as crucial, in order to assure that the network will be able to serve future needs (future-proof), adapt to technological changes (evolutionary and adaptable) and therefore, can provide once for all, the foundation for the gigabit society. It should be mentioned that this requirement does not impose technological restrictions on the access part of the network (from the BEP or FCP towards the end-user) or limitations concerning network layers above the physical one. The reasoning of the rationale concerning this requirement is set in order to ensure that the infrastructure to be deployed can provide the backhauling/fronthauling to accommodate the end-user needs for many years to come as more and more traffic and higher needs are becoming necessary for both fixed and wireless networks.

As previously discussed, our base assumption is that the feeder segment will be based on fibre technology. Point-to-Point wireless technologies may be used in specific parts where the FCPs serve less than 40 active lines in the OCCA area.

The optical feeder part of the network maybe either leased or built. In order to encourage infrastructure reuse, **no duct related technical requirements will be imposed in the case of infrastructure leasing. The same applies to the network segments deployed with aerial installation.** However at least 4 spare sub-ducts should be available at any part of the feeder part of the **new-built underground network** in order to be used for own future needs or leased to other operators. These sub-ducts are beyond and above any sub-ducts used by the UFB to host fibre cables needed for the rest of its own services provision.

Among other services, UFB operator will have to offer adequate capacity to all subscribers in the covered area. In order to accommodate the capacity needs, in Class A areas, a 32:1 PON fibre network architecture is assumed. Splitters will be installed in the FCP that will multiplex the optical signals from the drop segment to the feeder segment. Thus for K_A subscribers in the FCP served area, $K_A/32$ fibre pairs are needed for backhauling.

In Class B Areas, calculation is based on a 1:20 contention ratio, among the aggregate capacity of the drop section to the backhaul capacity. Thus for K_B subscribers in the FCP served area, the required backhaul capacity is calculated to:

$$K_B \text{ X } 100\text{Mbps} / 20 \text{ (expressed in Mbps)}$$

An additional 20% in fibre count is also required in order to enable Point to Point architectures and relevant services or ISP's who are willing to deploy their own drop infrastructure.

Summarizing, all FCP's backhauled with fibres should be connected to the corresponding POP or RAP (if applicable) with at least $((K_A+K_B)/32)*(1+20\%)$ fibre pairs.

The above rule applies to both new-built and leased infrastructure parts of the landline feeder network, regardless the installation method (underground or aerial).

Islands are an exemption from this rule, where the POP-RAP backhauling maybe substantiated with capacity instead of fibers. To backhaul a RAP installed on an island the required capacity by the end of each year should be adequate in order to serve all customers of the island RAP with maximum contention ratio of 1:20.

It has to be noted that any associated cost to capacity leasing, will NOT be eligible within the UFBB project. The cost will have to be borne by the UFBB operator.

1.2 Site selection criteria

PoPs (where retail operators could either be co-located or could gain access to VLU services in order to receive the wholesale services of the UFBB operator) should be big enough in order to be commercially interesting for retail operators to interconnect. Therefore a requirement that **PoPs must serve at least 10.000 subscribers was set**. Furthermore, POPs (with the exception of island) must be located in places where at least two Telecom Providers have their own fibre infrastructure installed and preferably in capitals of regional units (Περιφερειακές Ενότητες).

RAPs should be located up to 20km from the most distant BEP that they are serving. GPON architectures impose optical power losses and reduce the transmission distances to a maximum of 20Km. In order to cope with this limitation, and given that in some cases, the distance between the settlements and the PoP maybe larger, an intermediate Regional Aggregation Point (RAP) has to be created. RAPs should also be able to host active equipment (including UFB's OLT) providing space, power supply and ventilation. In islands where no PoPs are created, at least one RAP should be created. The maximum distance requirement from the most distant served BEP, will also apply in this case. **BEPs** (where retail operators could have access to fibre pairs) should be located in distances less than **30 meters** from each of the buildings they are serving (up to two buildings per BEP).

2 Implementation and operational aspects

2.1 Overall approach and prerequisites

The offered services portfolio should be broad enough to:

- Offer flexibility that will enable retail ISP's to design and build their own products on top of the UFB network infrastructure, regardless the technology they choose to use.
- Allow to smaller-lean ISPs to prepare service offerings without large nationwide investments in equipment or infrastructure deployment. In principal, higher level service offerings (like the Virtual Local Unbundling – VLU) are lowering the barried to entry to the market for smaller players.
- Foster competition by allowing the simultaneous use of the new infrastructures to a reasonable number of ISPs

At the same time, it is highly desirable to re-use existing infrastructures, where available, in order to drive down costs, expand network reach and increase the number of beneficiary citizens. However, infrastructure re-use, may be discouraged or even be impossible, if the project technical requirements are highly demanding. For example, the need for ubiquitous duct service offering may impose difficulties in reusing existing spare ducts which may be suitable for fibre cable installation, but not enough in order to accommodate a large number of sub-ducts available to the retail operators. It may also discourage the use of existing poles or other facilities, which may be used, to support aerial cables. Aerial deployment has significant cost benefits especially in rural areas and is highly desirable in certain parts of the network.

In order to deal with the above contradictory aspects, a meaningful set of minimum offered services is required. These services may differ based on the technology that the SPV used to build the new network (ie. underground, wireless or aerial) and whether the specific infrastructure is new-built or leased.

2.1.1 Broadband service offerings

2.1.1.1 Minimum Level 1 Services to be offered

Service	Characteristics
1.1: Long term leasing of dark fibre (Backhaul. With the exception of the islands for the RAP-PoP part where service 1.9 is available)	• Provision of 10 years IRU, without excluding the possibility of shorter or longer leasing periods. • Provision of a fibre pair with supporting (maintenance) services between any two of the following network points: ○ Fiber backhauled FCP's ○ The corresponding RAP's ○ The corresponding PoPs ○ Any manhole hosting fibre splicing enclosure, located on the above paths (for underground network spans) or

	○ Any pole or relevant facility, hosting fibre splicing enclosure, located on the above paths (for aerial network spans)
1.2: "Class A" Short term leasing of dark fibre (access)	• Provision of 12 months rental, without excluding the possibility of shorter or longer leasing periods. • Provision of a fibre pair with supporting (maintenance) services between any two of the following network points: ○ BEPs ○ The corresponding FCPs
1.3: Long term leasing of empty micro-duct (only where new underground infrastructures are deployed)	• Provision of 10 years IRU, without excluding the possibility of shorter or longer leasing periods. • Provision of an empty duct or micro-duct with supporting (cable installation and maintenance) services between any two manholes of the network
1.4: Long term right of use of poles (only if used by the UFBB operator)	• Provision of 10 years IRU, without excluding the possibility of shorter or longer leasing periods. • Provision of support services
1.5: Long term collocation in Wireless Transmission site (only if used by the UFBB operator)	• Provision of 10 years IRU, without excluding the possibility of shorter or longer leasing periods. • Collocation and power supply of outdoor cabinet inside the Node area. • Collocation of antennas (mounted on Node Towers). • Provision of support services
1.6: Collocation of passive equipment in FCP	• Provision of 3 years rental, without excluding the possibility of shorter or longer leasing periods. • Collocation of passive equipment equivalent to 1U. • Provision of supporting (passive equipment installation and maintenance) services
1.7: Collocation of equipment in PoP	• Provision of 3 years rental, without excluding the possibility of shorter or longer leasing periods. • Collocation of equipment equivalent to 10U. • Uninterrupted power supply. • Secured environment (fire detection/suppression, flood protection, access control, air conditioning etc.)
1.8: Collocation of equipment in RAP	• Provision of 3 years rental, without excluding the possibility of shorter or longer leasing periods. • Collocation of equipment equivalent to 2U. • Uninterrupted power supply. • Secured environment (fire detection/suppression, flood detection, access control, ventilation etc.)
1.9: Long term Wavelength leasing (only in islands and only if submarine cable is laid by the UFBB operator)	• Provision of 10 years IRU, without excluding the possibility of shorter or longer leasing periods. • Provision of a λ with supporting (maintenance) services between the following network points: ○ Island RAP ○ The corresponding PoP

TABLE 1: MINIMUM LEVEL 1 SERVICES TO BE OFFERED

2.1.1.2 Minimum Layer 2 Services to be offered

L2 Services will be offered between Network Termination Equipment inside subscriber's premises and the relevant PoP

Service	Characteristics
2.1: "Class A" VLU Services	• Offered in all «Class A» areas. • Provision of 12 months rental • Differentiated setup cost according to the existence or non-existence of the internal cabling to the end user premises • Includes L2 service between end user ONT and the corresponding PoP • 100/200/300/500/1000 Mbps downstream – upgradable to gigabit • Upstream speed at least 10% of the relevant downstream speed (i.e. for residential users) and symmetric (i.e. for business users) • At least 4 VLAN's (to support internet, IPTV, voice and equipment management traffic) matched to 802.1p CoS. Requirements for CoS traffic handling TBD. • Multicast support • Availability 99.9%.
2.2: "Class B" VLU Services	• Offered in all «Class B» areas. • Provision of 12 months rental • Differentiated setup cost according to the existence or non-existence of the internal cabling to the end user premises • Includes L2 service between end user ONT and the corresponding PoP • 100Mbps downstream • Upstream speed at least 10% of the relevant downstream speed • At least 4 VLAN's (to support internet, IPTV, voice and equipment management traffic) matched to 802.1p CoS. Requirements for CoS traffic handling TBD. • Multicast support • Availability 99.9%
2.3: "Class A" E-line 1 Gbps Capacity Services	• Offered in all "Class A" areas. • Provision of 12 months rental • Differentiated setup cost according to the existence or non-existence of the internal cabling to the end user premises • Includes L2 service between end user ONT and the corresponding PoP • Symmetrical leased line of 1Gbps • 1:1 Contention ratio • Availability 99.99%
2.4: "Class B" E-line 1 Gbps Capacity Services	• Offered in all "Class B" areas covered by a fiber backhauled FCP • Provision of 12 months rental • Includes L2 service between FCP and the corresponding PoP • Symmetrical leased line of 1Gbps • 1:1 Contention ratio • Availability 99.99%
2.5: "Class B" E-line 100 Mbps Capacity Services	• Offered in all "Class B" areas • Provision of 12 months rental • Includes L2 service between FCP and the corresponding PoP • Symmetrical leased line of 100 Mbps • 1:1 Contention ratio • Availability 99.99%

TABLE 2: MINIMUM LAYER 2 SERVICES TO BE OFFERED

2.1.1.3 Minimum Layer 3 Services to be offered

Service	Characteristics

3.1: «Class A» bit-stream Access	• Offered in all «Class A» areas.
	• Provision of 12 months rental
	• Differentiated setup cost according to the existence or non-existence of the internal cabling
	• 100/200/300/500/1000 Mbps downstream – upgradable to gigabit
	• Upstream speed at least 10% of the relevant downstream speed (i.e. for residential users) and symmetric (i.e. for business users)
	• 1:20 contention ratio
	• Availability 99%.
	• Includes bit-stream access plus backhauling of traffic to the respective PoP.
	• Can support QoS with the following alternative classes of service:
	  ○ Best Effort
	  ○ Guaranteed service with the following specifications: minimum of 32kbps constant data transfer, maximum latency of 80ms, maximum Jitter (undesired deviation) of 15ms.

3.3: «Class B» bit-stream Access	• Offered in all «Class B» areas.
	• Provision of 12 months rental
	• 100Mbps downstream
	• 10Mbps upstream
	• 1:20 contention ratio
	• Availability 99%.
	• Includes bit-stream access plus backhauling of traffic to the respective PoP.
	• Can support QoS with the following alternative classes of service:
	  ○ Best Effort
	  ○ Guaranteed service with the following specifications: minimum of 32kbps constant data transfer, maximum latency of 80ms, maximum Jitter (undesired deviation) of 15ms.

TABLE 3: MINIMUM LAYER 3 SERVICES TO BE OFFERED

3 Cost modelling

Bottom up approach was followed in order to calculate the cost of the new network. In cases were the technical requirements are leaving more than one options available, reasonable choices were assumed. **These choices are by no means binding for the project and are used only as a proxy for the overall project cost**. In our model we do not take into account wireless backhauling. We model however, the cost of deployment for submarine fiber routes in order to backhaul the islands that fall into the scope of the project and calculated their length.

3.1 Network model's Building Blocks

The proposed model utilizes the following types of network building blocks:

- In class A areas
    - Passive termination box as BEPs
    - Ruggedized Enclosures hosting fiber trays and splitters in large manholes as FCPs
- In class B areas

    - Active outdoor cabinets with VDSL vectoring equipment as FCPs
- Common building blocks
    - Active outdoor cabinets with Optical Line Terminators (OLTs) as RAP
    - Fiber routes that are being calculated separately through using the appropriate GIS tool.
    - POP nodes
    - NOC (1 per lot)

As far as topology is concerned:

- In class A areas
    - A Passive termination box is installed outside every inhabited building (or every two inhabited buildings) according to local conditions. In the network model, their number is approximated by the number of lines in an OCCA area.
    - One ruggedized enclosure with fiber splitters is installed in a manhole for every 144 lines. In case of isolated OCCA areas (ie isolated settlements), one is installed for every isolated OCCA even if the number of lines is less than 144.
- In class B areas
    - An Active outdoor cabinets with VDSL vectoring equipment is installed near each copper concentration point (KV)
- Common building blocks
    - A RAP is installed as needed by the local conditions in order to respect the power budget constraints, assuring that the overall distance between the most remote BEP to the RAP does not exceed 20 Km. At least one RAP is installed in every island.
    - Fiber routes for the access network (in Class A areas) are calculated based on a steiner tree graph on top of the road network, to pass all building in the respective OCCA area. Backhauling fiber routes based on a steiner tree graph on top of the road network, to serve all FCPs in the respective area.
    - POP nodes are installed in the regional units capitals with the exception of regional units with less than 10K lines, where the nearest neighbouring regional unit capital is used
    - A NOC is installed in every LOT.

3.1.1 Passive termination box - BEP

Passive termination boxes are ruggedized boxes, hosting splice trays, optical outlets, jack holders and mounting mechanisms

3.1.2 Ruggedized enclosures - FCPs

Ruggedized enclosures are shielded plastic boxes, most usually installed in manholes on the street side.

3.1.3 Active outdoor cabinets

Active outdoor cabinets are ruggedized telecom boxes, most usually installed on the street sideIn the UFB project model, active cabinets are used in Class B FCPs and in RAPs.

3.1.4 Fiber network routes

Fiber cables are installed in micro-ducts with typical diameters of 8,5/10 mm (inner/outer). An adequate number of ducts is assumed in order to host the fiber cables used by UFB for the provision of Class A and B services but also leave at least 4 spare ducts for future needs and leasing to other operators.

Manholes are installed on average every 500 meters for the distribution network in Class A areas and every 1200 for the feeder network, in order to facilitate cable blowing.

FIGURE 3: HIGH LEVEL DESIGN OF THE BACKHAUL NETWORK

Submarine cable routes lengths, were calculated on the GIS. Submarine cable installation cost varies significantly, since it depends largely on ship availability, water depth, seabed characteristics, exact landing point and a number of other parameters that are difficult to foresee. According to several sources[4,5], a startup cost of ~0,5EUR-1,5MEUR might be needed for ship mobilization/demobilization, while cable deployment is assumed to cost

[4] http://documents.worldbank.org/curated/en/551611480734099685/pdf/FINAL-101116-RVPApproved-PAD-11092016.pdf

[5] https://www.statnett.no/PageFiles/6553/Dokumenter/~3-Andre%20dokumenter/Nexia%20Fiber%20Evaluation%20Report.pdf

~28-35KEur/km. Additional costs apply for cable landing (trenching is required in the sea-bed in shallow waters) and landing station construction costs (~0,3-0,5M per landing). We blended these costs in the cost per km of the submarine cable laying.

FIGURE 4: MODELED SUBMARINE SPANS

3.1.5 POP nodes

POP nodes are rooms, where active network equipment is hosted. Uninterrupted power supply is provided as well as air-conditioning, fire detection and suppression, security and access control systems.

3.1.6 Network design assumptions and unit prices

The table below summarizes the key network design technical assumptions used for the modelling.

Parameter	Value
UFB Class A fiber network architecture between FCP and subscribers	1X Fiber pair per subscriber - Point to Point
UFB Class A fiber network architecture between FCP - RAP	GPON with Splitting Ratio 1:32.
FCP typical size (subsribers) for Class A areas	144 subscribers
Maximum number of inhabited buildings served by each BEP	2
Maximum distance between the BEP and each served building	30m
Number of fiber pairs per subscriber in Class A areas	1
UFB Class B Access technology	Vectored VDSL
Class B backhauling FCP-POP	Point to Point with 1 fiber pair for every 32 active lines in the FCP served area
Spare ducts in feeder network (FCP-POP) for UFB	1
Spare ducts in feeder network (FCP-POP) for leasing to ISPs	3

Maximum distance between end users and the corresponding RAP	20km
Feeder cable over dimensioning for P2P connections and future upgrades	20% over the fiber pairs used for UFB's own needs
POP size	>=10000 subscribers
Network construction method – lateral connections	Underground-mini trenching 6X30 cm
Network construction method – main trenches in access and backhaul	Underground-mini trenching 8X45 cm
Class A manhole density	500m
Feeder manhole density	1200m

The type of coverage decision (whether an OCCA area would be covered with Class A or B) was straightforward since Class A is mandatory for OCCAs in inner rings, where vectoring technology is not allowed by the NRA. In these areas, ~525.000 active lines exist. This is the minimum set of areas that UFBB has to cover with Class A. The remaining ~315.000 active lines were considered as Class B.

BoQ's calculation was based on detailed calculations in the areas where the available mapping data (building locations, demographic data) was available. Educated extrapolations were used for the remaining areas where no detailed mapping data was available. The high-level BoQ data of the model and the relevant costs are presented in the following.

Item	Unit	Quantity
Class B FCPs (Cabinets)	item	3.698
New-built feeder network	km	19.626
Leased feeder network	km	4.906
Submarine spans	km	1.270
Class A active lines	item	524.668
Class B active lines	item	315.981
PoPs	item	79
NOCs	item	7
RAPs	item	487

4 Penetration levels & ARPU

Penetration levels are assumed to reach saturation ~60% of active lines by year 10 from service introduction in Class B areas and by year 12 in Class A areas.

Years from introduction	Forecasted penetration for Class B areas (subscriptions/100 active lines)
1	2.51%
2	5.23%
3	10.40%
4	18.93%
5	30.25%
6	41.61%
7	50.23%

8	55.46%
9	58.24%
10	59.60%
11	60.24%
12	60.54%
13	60.67%
14	60.74%
15	60.76%

TABLE 4: FORECASTED PENETRATION FOR CLASS B AREAS

Years from introduction	Forecasted penetration for Class A areas (subscriptions/100 active lines)
1	2.51%
2	4.12%
3	6.64%
4	10.44%
5	15.83%
6	22.84%
7	30.99%
8	39.32%
9	46.80%
10	52.76%
11	57.09%
12	60.01%
13	61.89%
14	63.06%
15	63.78%

TABLE 5: FORECASTED PENETRATION FOR CLASS A AREAS

Regarding wholesale price we will use the ARPU of 15.08 € per month with a connection cost of 57.01 €.