Invitation for public hearing

Draft Model Reference Paper Wholesale Leased Lines, Duct Rental and Dark Fibre





Invitation for public hearing

Dear all,

With this invitation we invite all interested parties in period of 30 days starting from day of publication of “Draft Model Reference Paper Wholesale Leased Lines, Duct Rental and Dark Fibre” to submit their views and comments about proposed subject of public hearing.

On the meeting held on 22.11.2011 the Agency for electronic communications informed interested parties that starts with upgrades of Bottom-up LRIC model for fixed lines for calculating the prices of terminating and/or trunk segments of leased lines for different length of the leased lines circuit, prices for sub-ducts and prices for dark fibres. The upgrade was developed in cooperation with Deloitte-Croatia based on contract for consultant services.

**Agency for Electronic Communications**

**Macedonia**

**Model Reference Paper**

**Wholesale Leased Lines, Duct Rental and Dark Fibre**

**July 2012**

Dtten280

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# 1. Introduction

## 1.1 Project communication structure

This document is a part of the formal communication within the AEC’s bottom up modelling project for services Wholesale Lease Lines, Duct Rental and Dark Fibre.

As announced during the above mentioned project has four main communication stages:

* **Inception Report** – Report that contains information about the engagement, explains what will be modelled, what are basic assumptions, explains services and provides descriptions, and explains cost types and how the costs will be modelled.
* **Data request** – Series of documents used to gather the data from SMP operator.
* **Model reference paper** – Document that extends the Inception report, explains how the methodology described within the Inception report is integrated into the model, describes modelling process and presents modelling assumptions that were adopted during the modelling process. Model reference contains results presented in the public consultation processes.
* **Model results** – Report that containing results and outputs from the model.

Model and Model reference paper are based by Inception report so it is important to note that statements expressed within the Inception Report are valid for this document unless specified otherwise.

## 1.2 Workstreams

We have divided the engagement into the following three broad workstreams:

**Wholesale Leased Line Workstream** – This workstream models Wholesale Leased Lines (WLLs) structured in a different way than actual leased line services offered by MakTel.

**Duct Rental Workstream** – This workstream models Duct Rental whereby Other Licensed Operators (OLOs) pull their own cables through MakTel bores.

**Dark Fiber Workstream** – This workstream models dark fibre services as specified by the Agency.

These workstreams represent extensions of our previous engagement. As such, our previous computer model(s) is extended to include WLLs, Duct Rental and Dark Fibre wholesale services.

## 1.3 Project Challenges

As with our previous engagement, we once again point out that the results and accuracy of our modelling will depend entirely on information/data supplied by MakTel.

We recognise the challenge of the engagement due to the fact that Duct Rental and Dark Fibre services are new services on the market and there is no historical usage data or trends. This leads to the fact that service demands may not satisfy minimum quantities for achieving Economies of Scale (EoS). Taking into account that LRIC is based on EoS logic, **small input demand can highly influence model results**.

Following AEC Bylaw on the Access and Use of Specific Network Devices, MakTel issued Reference Offer (RO) for physical access to telecommunication infrastructure and other capacities. Reference Offer and Bylaw are basic documents for defining part of services modelled in this engagement. In terms of these documents, we define and model:

**Duct Rental** – Monthly fee for rent of ducts in Access Network (terminating, feeder and aggregation segment). Costs are calculated on per kilometre per bore diameter basis, for 40mm, 32mm, 10/8.5 mm and 5/3.5 mm diameters.

**Dark fibre** – Monthly fee for rent of dark fibre in backhaul and feeder segments. **We stress out that dark fibre modelled within this project is not considered nor part of Next Generation Access (NGA)**. Service specified here is offered as a substitute service in case there is no available bores for duct rental.

MakTel currently offers WLLs in the format (as described in currently available Reference Offer) of:

**Partial Private Circuit (PPC)** – service offered on wholesale level to offer connection from customer premises to PoI.

**Point to Point (P2P)** – service offered on wholesale level to offer connection between two locations.

Taking into account fact that MakTel is mostly offering WLLs on PPC basis, the Reference Offer does not separate WLLs into Terminating Segments and Trunk Segments.

It is the view of AEK that WLLs are modelled in line with AEK’s view on future service structure. In particular, WLLs are separated into Terminating Segments and Trunk Segments in line with European Commission terminology and according to best practices. Separation faced the challenge structuring the service according to their availability on the market and expectation for the future.

In addition a new interconnection service is identified: Interconnection Circuit for Wholesale Leased Lines (ICWLL). This Interconnection Circuit is to be used to transfer the traffic from a WLL/PPC from a MakTel PoP to an OLO’s own premises.

## 1.4 Terminology

In order to eliminate any doubts or inconsistencies within this report and the model we have adopted naming policies that precisely identify either part of the service discussed, either the part of the network where particular service is implemented.

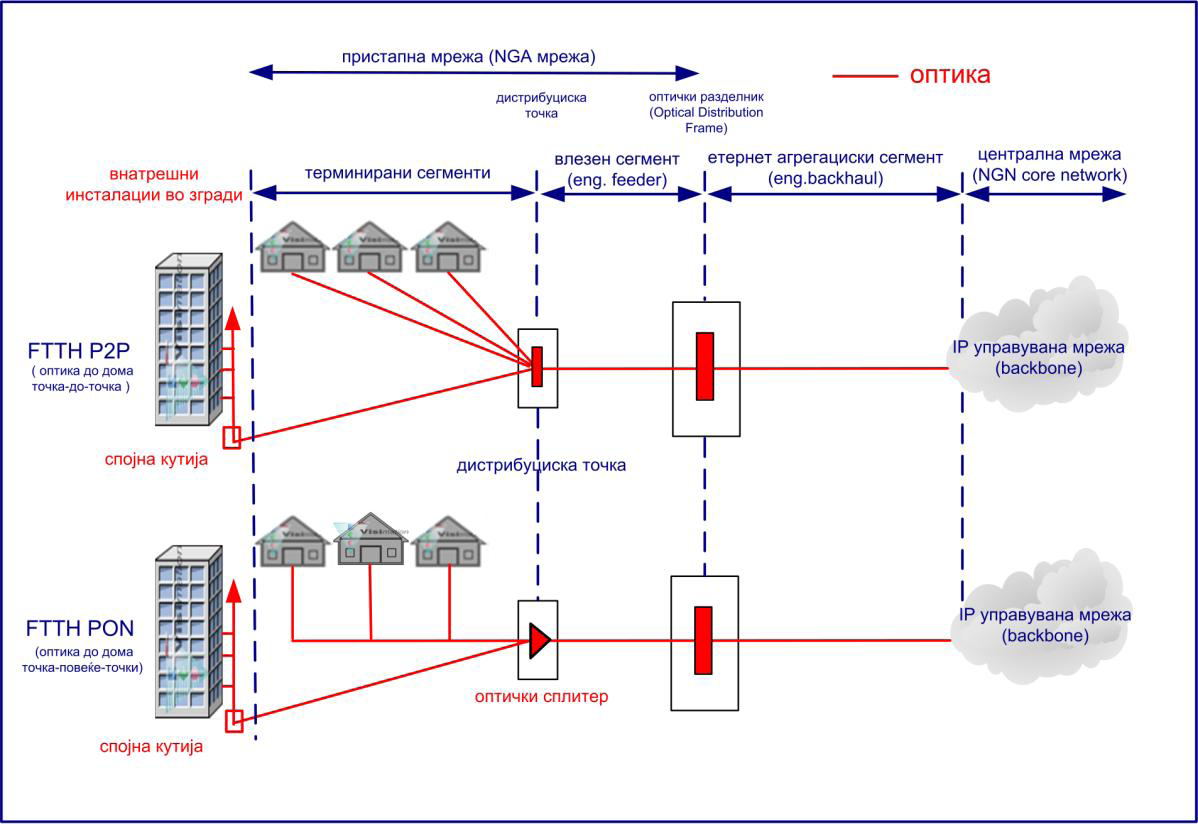
Access and aggregation network recognizes three main parts of the network that follow the principles described in bylaw on the access and use of specific network devices[[1]](#footnote-1):

**Terminating segment** – Part of the access network from end customer to distribution point.

**Feeder segment** – Part of the access network from distribution point to distribution frame (DF)

**Backhaul segment** – Part of the network utilized for aggregation between distribution frame (DF) and core network.

The structure of network segments is visible on the picture below that is taken from the bylaw on the access and use of specific network devices document.



In addition to these three terms, we will use additional term when specifying the service of wholesale leased lines as follows:

**Local End** – network section between end user and distribution frame (terminating and feeder segment comprised in one section)

However, when referring to services modelled and provided over the network document uses terms that are commonly used. Terms used in describing each part of the service are specified in the chapters below.

## 1.5 Modelled services

This section describes services covered by the model. Detailed service description is available in following chapters.

The model supports LRIC calculation for following group of services: monthly fee for wholesale leased lines (separated into the *terminating* and *trunk* segments), monthly fees for duct rental, and monthly fees for dark fibre.

***Wholesale Leased lines***

Currently offered service offered on the wholesale market is offered as single wholesale leased line, without separation into *terminating* and *trunk* segment. As specified in Inception report the model produces results for *terminating* and *trunk* monthly rental segments separately.

The separation to terminating and trunk segment is fully aligned with service elements specified in MakTel’s referent offer where:

**Terminating segment** – segment of wholesale leased line from end user to POI

**Trunk segment** – segment of wholesale leased line between two POIs.

It must be noted that “terminating segment” used when referring to wholesale leased lines is different from “terminating segment” used when referring to segment of the network. Detailed specification of service segments is provided in section where modelled services are described further in the document.

Both terminating and trunk segment rental services are modelled according to length and bandwidth.

Model calculates the following bandwidths:

* 64 kbit/s
* 2 Mbit/s
* 34 Mbit/s
* 155 Mbit/s

Model takes into account the length factor of the wholesale leased line for both terminating and trunk segments as follows:

* **Terminating segment** is divided into the following sections (separated according to bandwidths):
  + Monthly rental for terminating segment up to 300m
  + Monthly rental for terminating segment between 300m and 3 km in increments of 100m.
  + Monthly rental for terminating segment between 3 km and 15 km of length in increments of 1 km
* **Trunk segment** part is expressed in following sections (separated according to bandwidths):
  + Monthly rental of trunk segment up to 50 km of length in increments of 1 km
  + Monthly rental of trunk segment between 50 km and 200 km of length in increments of 10 km

Lengths referred above when specifying the sections of Wholesale leased lines are based on optical length (not on cable length basis). That represents different approach from the one that is adopted in currently available wholesale referent offer. The algorithm for calculating optical distance is elaborated further down in the document.

Current referent offer for WLL rental does not specify interconnection link for leased lines. Definition and handling of interconnection between operators is described in detailed service description chapter within Inception Report. New interconnection service will be defined by AEC: Interconnection Circuit for Wholesale Leased Lines (ICWLL). This Interconnection Circuit is to be used to transfer the traffic from a WLL from a MakTel PoP to an OLO’s own premises and due to its nature it will be treated as Leased Line terminating segment. ICWLL specific charges are not calculated with this model.

As stated before modelling of other charges and fees related to the service of wholesale leased lines rental are not subject to this project.

Often, a distinction is made between Traditional Interface Symmetric Broadband Origination (TISBO) RLLs and Alternative Interface Symmetric Broadband Origination (AISBO) RLLS.

TISBO RLLs provide symmetric capacity between a customer’s premises. The capacity is symmetric because traffic can be carried at the same rate in both directions.

AISBO RLLs are defined by the following:

* + they have different (predominately Ethernet IEEE 802.3) interfaces;
  + they can be used to carry many different types of data; and
  + they can generally only be used over short distances without re-amplification, although this is not the case where such services are provided over WDM technology.

In contrast, TISBO RLLs have (i) a CCITT G.703 interface, (ii) can easily be used to carry voice or data, (iii) can be used over any distance, and (iv) are generally provided using SDH or PDH technologies.

**We have reviewed MakTel’s Wholesale Leased Line Reference Offer. Wholesale Leased Lines (WLLs) are only offered on a TISBO basis. Accordingly, we shall model WLLs on a TISBO basis only**.

***Duct Rental***

Duct rental monthly fees are structured according to tube size and length. The fees are expressed in per kilometre basis. The service includes the rent of particular tube within the duct for the length of one kilometre

Modelled duct rental services are as follows:

* Monthly duct rental for tube 40mm per 1km
* Monthly duct rental for tube 32mm per 1 km
* Monthly duct rental for tube 10/8.5 mm per 1 km
* Monthly duct rental for tube 5/3.5 mm per 1 km

Modelling of other charges and fees related to the service of wholesale duct rental are not subject to this project.

Costs are calculated for terminating, feeder and backhaul segments separately and structured according to the bode diameter.

***Dark fibre***

When modelling dark fibre rental service, it is taken into account that this service demand is not driven by NGA take-up. Since wholesale dark fibre rental service is a substitute service for wholesale duct rental (when duct capacities are not available), modelling process took into account that new capacities will not be introduced specifically for this service. It is assumed that demand will be within the boundaries of currently available infrastructure.

Following services are modelled:

* Dark fibre in feeder segment of the network
* Dark fibre in backhaul segment of the network

Dark fibre in terminating segment of the network is not modelled.

Dark fibre rental monthly fees are proposed on the market according to length. The fees are expressed in “per kilometre” basis. The service includes the rent of one kilometre of one fibre straw.

Modelling of other charges and fees related to the service of wholesale dark fibre monthly rental are not subject to this project.

# 2. Model Overview

Previously developed model that calculated the costs for service of fixed network has been extended to calculate Wholesale Leased Lines costs, Duct rental costs and Dark fibre costs.

While the methodological approach was described in Inception Report, this chapter provides the overview of the model structure.

The model consists of five main parts as follows:

1. Data Input Module
2. Network Dimensioning Module
3. Cost Allocation Module
4. Cost Structure Module
5. Service Costing Module

**Data Input Module** contains input data acquired through data gathering process. The data is structured into main groups: Access network engineering, Core network engineering and Financial inputs. Beside network data, this module contains engineering rules and description of components that are modelled in later stages of the model.

**Network dimensioning module** creates network dimensioned according to engineering rules and input data provided within the Data Input Module.

**Cost allocation module** manages cost categories where costs are allocated to network components based on driver definition.

**Cost structure module** represents basis for cost calculation where all cost categories, cost drivers, network components and services are listed on one place.

**Service costing module** aggregates all relevant costs associated for particular service determined by routing factors

***Modelling process***

Based on engineering input rules, morphology characteristics and relevant traffic figures (number of users, average traffic etc.) data model is first creating and optimizing physical network. Model distinguish and separately building access, switching and transmission network.

Access network is built and dimensioned taking into account main drivers: morphologies, number of subscribers, distribution density, busy hour traffic and grade of service.

Model is building hybrid network using combination of copper and fibre cable technology.

First step in building access network is stratifying main distribution frames in morphologies. After that model is calculating representative MDF/ODF with its characteristics and representative ODF/MDFs are located into territory using scorch node approach. Every MDF area is represented with equivalent hexagon. Model then calculate network structure for one segment of hexagon (hexagon has 6 segments). Curve factor is used to adjust straight lines calculated between points within hexagon.

Spare capacity is driven by input parameters and it is accounted in building access network. Access network optimization is done based on cost effective principle and it is done different points:

* Number and type of cables used for primary, secondary and terminating segment
* Usage of underground or over ground technology
* Depth and width of trench needed for duct
* MDF configuration

Optimizations are based on linear programming.

One of main cost driver for access network is civil work to provide underground cabling technology. To reflect real cost of civil work user can define surface (3 types) and sub-surface (3 types) of terrain. Surface and sub-surface terrain is defined for every of 4 morphologies. Financial input follow definition of terrain types.

Switching network is represented with concentrator units and exchanges. Model position concentrator unit in same location (collocate) with exchange in exchange building. All other concentrator units are positioned remotely together with main distribution frames. Geographical scorched node approach is used for modelling number and positions of exchanges.

Main driver for dimensioning switching network components are: number of active lines, busy hour traffic, originating and terminating traffic on exchange and grade of service. Optimization of switching components on cost effective principle is done on:

* Remote concentrator unit - number of ports, line cards and racks
* Switching - number and capacity of switching blocks, line cards, CPUs, software and signalling units

Transmission network is built separately for following levels:

* RCU to LE route
* Local level of transmission rings and
* Core level of transmission.

RCU to LE transmission is modelled for every RCU in two ways if RCU is closer to ring than RCU is connected to ring in other case RCU is directly connected to LE. Backup path is created between two nearest RCU to provide network resistance. Input parameter defines for which morphology backup path is needed. Model is utilizing electric transmission over copper cables if traffic on RCU - LE path is below certain volume (user defined input parameter) otherwise fibre optic technology is used. Same principle is used for utilization of TDM or WDM technology.

Local and core rings are created using position of RCUs, local and transit exchanges and finding optimal path for connection. Every RCU and exchange is positioned on map and rings are drown in map following geographical characteristics of terrain and built objects. After positioning transmission routes model calculate traffic on every transmission network segment and optimize capacity and number of active equipment used for providing service. Optimization is done on cost effective principles for: size and number of transmission equipment and tributary line card. Also model is calculating and using cost effective methodology for cabling solution (over ground or underground).

Fibre elasticity factor is used to adjust fibre flexibility challenge while user defined input parameter is the approach used to define ring protection mechanism (2f MSPring or 4fMSPring). In order not to doubling civil work costs trench is shared between transmission and access network in ratios defined by user and by every network segments. Also active transmission equipment is collocated in same building where it is possible with exchanges and RCUs.

Finishing building main network components model is calculating number, capacity and cost of other important network components (manholes, distribution boxes, poles, power equipment, regenerators et.). Those calculations are based on route length, shared route length and network segment traffic.

Engineering part of model calculate summary for every network segment relevant for cost allocation model. Before grouping cost into homogenous cost categories (HCC) CAPEX was annualised using asset life, tilt and weighted average cost of capital. OPEX costs are input parameters provided by incumbent.

Results of engineering model are two different network types: network for coverage and full network. Network for coverage represent minimal network cost for providing basic level of services for minimal number of service demand. Full network represent network able to provide full demand for all services.

Cost allocation model works on standard LRIC cost allocation mechanism as previously described in Inception Report. Costs calculated in engineering part of model are grouped into HCCs. Cost driver is used to allocate cost from HCCs to network components. Network for coverage cost are used to identify fixed cost and difference between full network and network for coverage represent values of variable cost. Common and joint costs and independent costs are determined defining dedicated matrix. Allocating cost from network components to services are done using routing factors and service demand.

Routing factors are consisted using incumbent input or by using service definition presented in inception report (for newly introduced services). Service demand is entered as it is now or minimal demand for services that not meet minimal demand required for model to run.

Cost allocation is done using:

* 158 homogenous cost categories
* 54 cost drivers
* 48 network components

# 3. Modelling assumptions

This Section provides insight how the assumptions presented in Inception Report (and adopted during the modeling process) were implemented within the model.

## 3.1 Service demand assumptions

Project team was faced with demand challenges as follows:

* Services Duct Rental and Dark Fiber were introduced recently and at the time of the model development there were no wholesale customers using or applying this service.
* Demand for Duct Rental and Dark Fiber is expected to increase with new bylaw that regulates the access network development.
* Dark Fiber is offered as a replacement services only in case there is no available duct space when Duct Rental is requested.
* Wholesale leased lines are mostly used by other operators as Partial Private Circuits and Point-to-Point wholesale leased lines
* Wholesale leased lines are currently offered as end-to-end service however due to the mature of usage it is assumed that current demand remain in separated leased lines to terminating and trunk segments

Although the modeling challenges were explained in the Inception Report, certain assumptions had to be taken into account. In order to overcome these challenges the team created demand based on following assumptions:

* Duct rental is offered on spare ducts only. There is no expectation that specific duct investment will be made by SMP operator to build additional duct specifically for duct rental service.
* Dark fiber is offered on available spare straws only. There is no expectation that specific fiber investment will be made by SMP operator to build additional fiber connections specifically for dark fiber service.
* Wholesale leased line demand for terminating and trunk segments is in line with current demand for PCCs and point-to-point.

## 3.2 Aerial distance for wholesale leased lines

As specified in the Inception Report, costs for whole leased line terminating and trunk segments are structured to reflect actual distance covered, not the distance determined by the path of infrastructure (access network, network site positions and network routes).

Costs for wholesale leased lines terminating and trunk segments are transformed to aerial (optical) distances using the additional module within the model.

The transformation is based on curve factor.

Curve factor is calculated as geometrical average of all ratios between aerial distance and network path distance. Calculation process was following next steps:

1. Complete network routes calculated by model are positioned on map of Macedonian.
2. Sufficient number of random points all over Macedonian territory covering all MDF areas
3. Aerial distance (dA) of one to every other point is calculated based on geographical coordinates, for all points.
4. Network path (dN) was calculated as sum of direct path to nearest network terminating distribution point and shortest network path between two distribution points.
5. Simple ratio of aerial distance and network path (R= dN/dA) is calculated for all pair of selected points.
6. Finally curve rate was calculated as geometrical mean of all ratios calculated for all point pairs.

Calculated curve factor is applied on cable length.

# 4. Services modelled

## 4.1 Wholesale leased lines

Although Inception Report provided the description of the services modeled, we would like once again to point out how the services are modeled within the model.

First we would like to present the definition of wholesale leased line (WLL) terminating and trunk segments.

**A**

**Terminating**

**Network**

**Trunk Network**

**Local End**

Segment

Trunk Segment

**A**

**Terminating**

**Network**

**Trunk Network**

Trunk Segment

Terminating

POI

POI

The Agency’s objective in modeling WLLs is to (re)define WLLs using the terminology Terminating Segment and Trunk Segment as defined above. In particular:

**Terminating Segment** represents the part of the WLL that covers Local End on the network (from end user to the distribution frame, or to be more precise, terminating and feeder segment of the access network) and Terminating Network (part of the transmission and cable network from distribution frame to nearest point of presence within incumbent operator network). The reason for including Terminating network in wholesale leased line terminating segment is that incumbent’s point of presence is not positioned on all MDF’s. In order to provide connectivity, the distance between MDF and POI must be bridged.

**Trunk Segment** represents the part of the WLL that covers Trunk Network (transmission and cable network used that connects two points of POIs within incumbent’s network).

This approach is in line with referent offer for wholesale leased lines currently available where both WLL segment types are recognized and described. However the WLL service is not offered as combination of two independent segment types, but only as one direct circuit (either as P2P, either as PPC). Therefore technical specification of the service also does not recognize two independent WLL segment types.

In order to follow the principle of separated WLL segment types that can be offered on the market independently (as required by the AEC), certain assumptions were integrated when modeling WLL terminating and trunk segments. In transition from point to point leased line (as it is currently offered) to new services of separately offered terminating and trunk segments, it is expected that the technical underlying solution will change. Therefore, this change was required to be adopted in order to structure independent services.

Assumptions are as follows:

* Due to definition of service, existing PoPs are positioned within trunk segment
* In order to offer independent terminating segment, incumbent operator would need to ensure POI for all terminating segments as well and therefore have additional cost that must be taken into the consideration

Network components that are included in leased lines segments from modeling point of view are as follows:

* **Terminating segment**
  + Local end including
    - network termination equipment
    - end line access cabling (including ducting and trenching)
    - distribution frame
  + Cabling from distribution frame to PoP (Point of Presence) of LL trunk network located at local/core Ring
  + Active devices located from the end customer up to the PoP (Point of Presence) of LL trunk network located at local/core ring
  + Active equipment used for transfer of traffic from terminating segment on the PoP (Point of Presence) of LL trunk network
* **Trunk segment**
  + Starting MUX (including line card)
  + Core network cabling (including ducting and trenching) between two PoP (Point of Presence) of LL trunk network
  + Core network active equipment between two PoP (Point of Presence) of LL trunk network
  + Ending MUX (including line card)

LRIC builds theoretical model, **number of leased lines by capacity and morphology is a user input parameter**, but distribution of leased lines over ODFA within morphology will be uniform.

Due to current Macedonian situation model will be developed according to locations of PoP (Point of Presence) of LL trunk network of MAKTELpublished refference offer for Leased Lines:

Kumanovo 11-tiOktomvri

ŠtipKuzmanJosifovski – Pitu

KočaniMaršal Tito

StrumicaMaršalTito

VelesBlagojGorev

TetovoIlindenska

GostivarIlindenska

KičevoMaršalTito

OhridMakedonskiprosvetiteli

BitolaRuzveltova

PrilepGočePetrov

SkopjeOrceNikolov

SkopjeN.LisičeVidoe Smileski

SkopjeKarpošNikola Rusinski

SkopjeČairKemal Sejfula

Actual leased line service is offered by capacity and length and SMP operator is able to provide this kind of data, model will assume that:

* leased lines up to 2 km will engage just access network within one ODFA,
* leased lines up to 5 km will engage access network and transmission network between ODF to local exchange,
* leased line up to 15 km will engage access network, transmission network between ODF to local exchange and local transmission rings,
* leased line up to 50 km will engage access network, transmission network between ODF to local exchange and local transmission rings.

Above mentioned represents cost structure and modelling view. Within the model the cost structure will be transformed to meet AEK’s future vision of price structure that is in accordance with best practices. As we mentioned only monthly capacity rental charges will be calculated within this engagement. While previous chapter demonstrated the modelling view on providing the service, this chapter provides price structure. End model results(cost of service) will be structured, calculated and expressed using following principle:

* Terminating segment
  + up to 300 meters,
  + from 300 meters up to 3 kilometers with increment of 100 meters,
  + from 3 kilometers up to 15kilometers with increment of 1 km.
* Trunk segment
  + up to 50 kilometers with increment of 1 km,
  + from 50 up to 200 kilometers with increment of 10 km.

Trunk segment does not include terminating segment.

Main result will be provided in physical length. However since AEK’s view on future service structure is to calculate in optical visibility distance between two points, the results will be transformed again to meet that requirement.

Final model result will provide service costs for terminating and trunk segment expressed in distance of LL as optical visibility distance between two points (starting and ending part) of the LL segment. Actual (cable) distance between point will be calculated using actual routing factors and curve factor.

Due to new service structure alternative operators will be able to lease different bandwidths through the network (e.g. multiple 2Mbit/s terminating segments and one single 34 Mbit/s). If this is the case multiplexing of these lines on transfer point from terminating to trunk segment is solely responsibility of the operator leasing the lines.

## 4.2 Dark fibre

Output of the modelling exercise is the results of dark fibre for backhaul and feeder segments. We stress out again that **dark fibre modelled within this project is not part of Next Generation Access (NGA).**

When modelling dark fibre rental service, it is taken into account that this service demand is not driven by NGA take-up. Since wholesale dark fibre rental service is a substitute service for wholesale duct rental (when all duct capacities are not available), modelling process will take into account its own specific demand.

Monthly fee for dark fibre will be modelled to include following costs:

* Backhaul network segment – one piece of fibre cable, splicing, bores, ducting, trenching and overhead cost excluding active equipment;
* Feeder network segment – one piece of fibre cable, splicing, bores, ducting, trenching, ODF and overhead cost;

## 4.3 Duct rental

In modelling Access Network Duct Rental costs per kilometre there are two possible technically feasible options. Under the first option, space exists within existing fibre optic cable bores for additional cables to be pulled through. Under the second option, Telekom Macedonia’s fibre optic cables are carried in separate bores than those of the interconnecting operator. In reality this is more likely to be the case for legal reasons. Pulling cables through bores that already contain cables may result in damage and possible interruption to services (potential principal and third party damages).

In reality both options result in the same costs. As already discussed, the main cost of the Access Network is determined very much by subscriber density (that is the size of cables) and the length of cables and not whether cables share bores or not.

Bylaw on the access and use of specific network devices regulate duct rental offering as service that allows usage of existing spare duct capacity. That implies that only “tube in tube” can be rented as duct rental service and that only small diameter tubes (40mm, 32mm, 10/8.5 mm and 5/3.5 mm) are used to fill the large diameter tubes (e.g. 110mm) can be rented.

Ducts (and costs related to duct) are different in core network from access network. Since focus is on access network ducting, only access network ducts will be modelled. Additionally, costs will be calculated for terminating, feeder and aggregation sub-segments of Access network (as defined in Bylow). If results for these sub-segments will be similar, one blended cost will be calculated.

The results will be related only to access duct (it cannot be applied for core network due to different duct structure).

Like with cables, spare bores are also laid during network building, so number of spare bore will be user input into the model.

It is common that big diameter tube is filled with small diameter tubes following certain rules. Since number of possible combinations can be high and that it depends on various external factors, rules for filling 110 mm diameter tube by network segments will be user input parameter.

Clearly the cost of Duct per metre does not depend on cables, since the interconnecting operator is supplying its own cables. However, the cost of Duct (perkilometer) depends on the number of bores laid in each trench. In turn, the number of bores laid in each trench depends on the number of cables to be pulled. Thus model will optimize number and diameter of bores needed to build network infrastructure in every of three segments. Also based on number and type of bores, model will optimize trench dimension needed for laying calculated number of bores. Model trenching principals is described in our previous report.

After all main network components that directly influence Duct rental costs are: trenching, duct installation and overhead costs.

# 5. Model results

## 5.1 Introduction

In preparing results, we have relied upon a number of third party reports (AEC subscriber/traffic spreadsheets, operator supplied network/cost data, etc). We have not undertaken any form of investigation, verification, audit or other work in relation to such information. In particular, the scope of our work has not included validating subscriber, traffic, tariffs (revenues) and cost assumptions contained in third party source documents. Accordingly we express no view on the reasonableness of said third party source documents.

## 5.2 Wholesale leased lines

Costs defined in the table below correspond to the structure and definition of the WLL product agreed with AEC and in detail described in Inception Report and in previous chapters of this document.

Since new product structure takes into account physical distance between, users and SMP operator are require to calculate the sum of costs. The relation of cost according related to distance is presented below in the separate table and graphs for each bandwidth

Total product cost is calculated from results as follows:

Since the monthly costs for rent of wholesale leased lines is both circuit and length related this is taken into consideration when calculating the final price for both terminating and trunk segments of the leased lines. In this view, the model determines circuit related costs and length related increment costs (per meter or kilometre of length) for the border lengths (300m, 3km and 15 km for terminating segment, which is 50 km and 200 km for trunk segment).

If the actual length of leased line exceeds the border lengths than the pertaining cost should be determined by taking into consideration both circuit and the length related costs of the next border length.

Total cost of terminating segment is calculated by adding the circuit related cost and by multiplying the length of the line by the determined length increment for the same border length.

***Total cost = border length circuit related cost + length of leased line\* incremental cost of the same border length related cost***

For example, if the length of terminating segment is 2,5 km, than the costs are calculated as follows:

* The length of the leased line exceeds the minimum of 300 m, but it is below the next border level of 3 km. Therefore, the relevant boarder length is 3 km.
* Costs of 2,5 km is therefore the circuit related costs of 3 km increased by the 2500 m times the increment cost per 100 m of the 3 km length related cost.

*Total cost = 3 km circuit related cost + 2,5 km\* incremental cost for 3 km*

Furthermore, it the actual leased line length is above 3 km, than the next border length is that of 15 km. The stated means that the cost for length of above 3 km should be the total of circuit related cost of 15 km and increment cost for length related 15 km. For example, if the actual leased line is 5 km in length, than the total cost is as follows:

*Total cost = 15 km circuit related cost + 5 km\* incremental cost for 15 km*

Finally, when it comes to the trunk segment of the leased lines, the minimum border length is set at 50 km. This means that when calculating the trunk segment costs of all leased lines below 5o km in length, both circuit and length related costs of 50 km will be the starting point. Again, the total cost is calculated using the formula stated under point.

For example, if the trunk segment is of 10 km length, its related cost will be calculated as stated below:

*Total cost = 50 km circuit related cost + 10 km \* increment cost for 50 km*

For all trunk leased line segment above 50 km, the border line of 200 km will be the relevant point for calculating both circuit and length related costs.

The results for air distance LL are as follows:

|  |  |
| --- | --- |
| **Service** | **MKD** |
| *64 kbit lease line terminating segment - 300 m* | 2.583 |
| *64 kbit lease line terminating segment - 3 km* | 2.539 |
| *64 kbit lease line terminating segment - 3 km increment 100 m* | 11 |
| *64 kbit lease line terminating segment - 15 km* | 2.546 |
| *64 kbit lease line terminating segment - 15 km increment 1 km* | 91 |
| *64 kbit lease line trunk segment - 50 km* | 1.515 |
| *64 kbit lease line trunk segment - 50 km increment 1 km* | 4 |
| *64 kbit lease line trunk segment - 200 km* | 3.031 |
| *64 kbit lease line trunk segment - 200 km increment 10 km* | 10 |
| *2 Mbit lease line terminating segment - 300 m* | 10.015 |
| *2 Mbit lease line terminating segment - 3 km* | 9.930 |
| *2 Mbit lease line terminating segment - 3 km increment 100 m* | 22 |
| *2 Mbit lease line terminating segment - 15 km* | 10.175 |
| *2 Mbit lease line terminating segment - 15 km increment 1 km* | 154 |
| *2 Mbit lease line trunk segment - 50 km* | 6.982 |
| *2 Mbit lease line trunk segment - 50 km increment 1 km* | 9 |
| *2 Mbit lease line trunk segment - 200 km* | 12.301 |
| *2 Mbit lease line trunk segment - 200 km increment 10 km* | 24 |
| *34 Mbit lease line terminating segment - 300 m* | 32.236 |
| *34 Mbit lease line terminating segment - 3 km* | 30.785 |
| *34 Mbit lease line terminating segment - 3 km increment 100 m* | 373 |
| *34 Mbit lease line terminating segment - 15 km* | 56.277 |
| *34 Mbit lease line terminating segment - 15 km increment 1 km* | 427 |
| *34 Mbit lease line trunk segment - 50 km* | 52.401 |
| *34 Mbit lease line trunk segment - 50 km increment 1 km* | 85 |
| *34 Mbit lease line trunk segment - 200 km* | 84.224 |
| *34 Mbit lease line trunk segment - 200 km increment 10 km* | 332 |
| *155 Mbit lease line terminating segment - 300 m* | 51.389 |
| *155 Mbit lease line terminating segment - 3 km* | 49.938 |
| *155 Mbit lease line terminating segment - 3 km increment 100 m* | 373 |
| *155 Mbit lease line terminating segment - 15 km* | 66.297 |
| *155 Mbit lease line terminating segment - 15 km increment 1 km* | 534 |
| *155 Mbit lease line trunk segment - 50 km* | 97.180 |
| *155 Mbit lease line trunk segment - 50 km increment 1 km* | 256 |
| *155 Mbit lease line trunk segment - 200 km* | 192.650 |
| *155 Mbit lease line trunk segment - 200 km increment 10 km* | 995 |

## 5.3 Duct rental

According to the presented modelling methodology in Inception report and within Model reference paper the model results for duct rental are as follows:

|  |  |
| --- | --- |
| **Service** | **MKD** |
| *Monthly duct rental 5/3,5 (per km) - terminating* | 1.836,30 |
| *Monthly duct rental 5/3,5 (per km) - feeder* | 1.259,44 |
| *Monthly duct rental 10/8,5 (per km) - feeder* | 1.799,20 |
| *Monthly duct rental 32 mm (per km) - feeder* | 3.838,30 |
| *Monthly duct rental 40 mm (per km) - feeder* | 4.797,87 |
| *Monthly duct rental 5/3,5 (per km) - backhaul* | 1.540,55 |
| *Monthly duct rental 10/8,5 (per km) - backhaul* | 2.200,79 |
| *Monthly duct rental 32 mm (per km) - backhaul* | 4.695,02 |
| *Monthly duct rental 40 mm (per km) - backhaul* | 5.868,77 |

## 5.4 Dark fibre

**We stress out that dark fibre modelled within this project is not considered nor part of Next Generation Access (NGA)**. Service specified here is offered as a substitute service in case there is no available bores for duct rental.

According to the presented modelling methodology in Inception report and within Model reference paper the model results for one piece dark fibre cable rental are as follows:

|  |  |
| --- | --- |
| **Service** | **MKD** |
| *Dark fibre feeder per Km* | 5.049,71 |
| *Dark fibre backhaul per Km* | 939,73 |

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