Agency for Electronic Communications

Wholesale Leased Lines, Duct Rental and Dark Fibre Inception Report

March, 2012

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1. INTRODUCTION

1.1 Previous Reports/Engagements

1.1 This Inception Report builds upon a previous engagement Deloitte has undertaken for AEC:

> Bottom-Up LRIC Model for Fixed Operator Services Engagement – This engagement took place in 2009 and 2010 during which was calculated, the Long Run Incremental Cost (LRIC) of Unbundled Local Loop (ULL), Collocation services, Interconnection services, Call tariffs and Leased Lines using a Bottom-Up approach. Services were structured and modelled based on significant market power (SMP) operator's actual reference offers at the time of the engagement.

1.2 In this Inception Report we make extensive and repeated references to this previous engagement in general and the Inception Report and Final Report we prepared in particular. The Reader is referred to our previous Inception/Final Report in order to gain a full understanding of the approach set out in this Report. For example, we refer to, but do not describe, LRIC methodology in this Report. A description of LRIC can be found in our previous reports. This Inception Report will provide additional explanations in area of technical considerations using fibre optic technology, because this was not detailed explained in previous Report. Focus of this Report is on description of services in scope, and modelling principles for those services.

1.2 Workstreams

1.3 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 FiberWorkstream – This workstream models Ethernet aggregation dark fibre servicesas specified by the Agency.

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

1.3 Project Challenges

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

1.6 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 achievingEconomies of Scale (EoS). Taking into account that LRIC is based on EoSlogic,small input demand can highly influence model results.

1.7 Following AEC Bylaw on the Access and Use of Specific Network Devices, MakTel issued ReferenceOffer(RO) for physical access to telecommunication infrastructure and other capacities. ReferenceOffer 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 rental fee for dark fibre in the Ethernet aggregation segment of transmission.We stress out that dark fibre modelled within this project is not part of Next Generation Access (NGA). Also model will calculate price for dark fibre in the primary and secondarysegment of the access network. Dark fibre in primary and secondary segment of the network, is offered as a substitute service in case spare Transmission Network bores are not available.

1.8 MakTelcurrently offersWLLs in the format (as described incurrentReference Offer) of:

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

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

1.10 It is the view of AEK that WLLs should be modelled in line with AEK's view on future service structure. In particular, WLLs should be separated into Terminating Segments and Trunk Segments in line with European Commission terminology.In addition a new interconnection service is identified: Interconnection Circuit for WholesaleLeasedLines (ICWLL). This Interconnection Circuit is to be used to transfer the traffic from a WLL/PPC from a MakTelPoP to an OLO's own premises.

1.11 Since current referent offer does not recognize Terminated and Trunk Segments, the decomposition of WLLs into Terminating Segments and Trunk Segments is defined according to AEK's view of future services according to best practices.

1.12 This Inception Report represents the starting point for service modelling. Data gathering will represent an integral part of the process. It is the intention that infrastructure required for provision of these services reflects the requirements for the Macedonian market as set out by AEC.

1.13 During the data collection process AEK expects information/data from MakTel on required infrastructure and network topology. Final model will reflect those inputs and adjustments will be integrated into ourFinalReport.

1.4 Modeled services

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

1.15 The model will support 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.

Leased lines

1.16 Monthly rental of wholesale leased line will be modelled as two separate services: monthly rental for trunk segment and monthly rental for terminating segment.

1.17 Both terminating and trunk segment rental services will be modelled according to length and bandwidth

1.18 Model will model the following bandwidths:

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

1.19 Model will take into account the length factor. Terminating segmentwill be 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 kmin increments of 100m.
- Monthly rental for terminating segment between 3 km and 15 km of length in increments of 1 km

1.20 Trunk segment part will be 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

1.21 Current referent offer for LL rental does not specify interconnection link for leased lines. Definition and handling of interconnection between operators is described in detailed service description chapter.

1.22 Leased line length will be on air distance basis (not on cable length basis).

1.23 Detail service description with PoP positions is provided in following chapters.

1.24 In addition a new interconnection service will be identified in the model: Interconnection Circuit for Wholesale Leased Lines (ICWLL). This Interconnection Circuit is to be used to transfer the traffic from a WLL from a MakTelPoP to an OLO's own premises and due to its nature it will be treated asLeased Line terminating segment.

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

Duct Rental

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

1.27 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

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

1.29 Costs will be calculated for primary and secondary sub-segments of Access network, and Ethernet aggregation segments. If results for these sub-segments will be similar, one blended cost will be calculated.

1.30 The fee for duct rental include all costs for depreciation of primary resources (ducts, pipes, shafts) and the basic costs of their maintenance.

Dark fibre

1.31 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.

1.32 Following services are modelled:

- Dark fibre in Ethernet aggregation part of transmission network
- Dark fibre in access part of the network
  - Primary segment
  - Secondary segment

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

1.34 Modelled duct rental services is: monthly dark fibre rental per 1 km.

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

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

- Ethernet segment – one piece of fibre cable, splicing, bores, ducting, trenching and overhead cost excluding active equipment;
- Primary segment – one piece of fibre cable, splicing, bores, ducting, trenching, ODF and overhead cost;
- Secondary segment - one piece of fibre cable, splicing, bores, ducting, trenching excluding NTP and overhead cost.

2. WHOLESALE LEASED LINES (SERVICE DEFINITION)

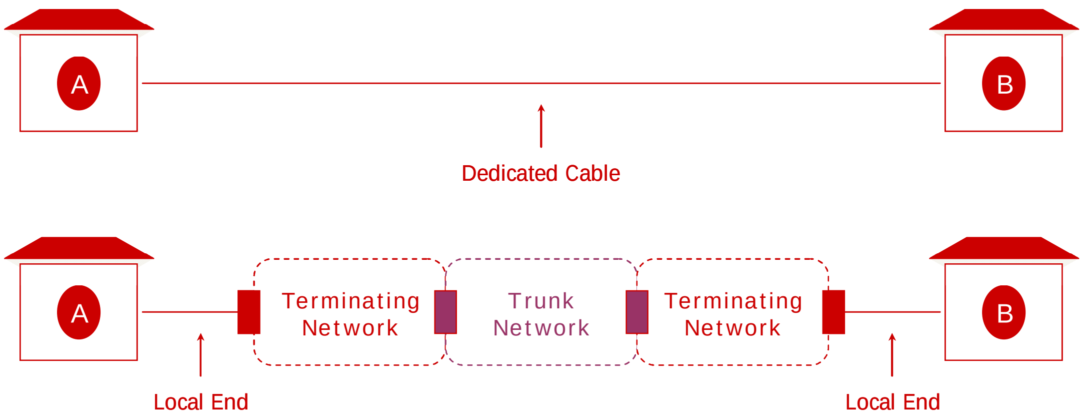
2.1 This Section provides WLL service description that will be modeled. The technical details of our modeling approach are discussed in other chapters. We begin, however, by discussing Retail Leased Lines[1].

2.1 Retail Leased Lines

2.2 The following chapter will provide service description while technical details of modeling approach will be discussed in other chapters.

2.3 A Retail Leased Line (RLL) is a permanent point-to-point (P2P)connection between two customer premises providing a transmission circuit of fixed bandwidth. The circuit is uncontended and provides dedicated capacity between customer premises. A RLL can be used for voice, video and data communications. For example, an RLL can be used to connect two geographically separated offices of a company.

Figure-2.1 Point-to-Point Retail Leased Line



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

Traditional Interface Symmetric Broadband Origination

2.5 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.

Alternative Interface Symmetric Broadband Origination

2.6 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

[1] We use the terms "leased line" and "private circuit" interchangeably.

- o 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.

2.7 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.

2.8 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.

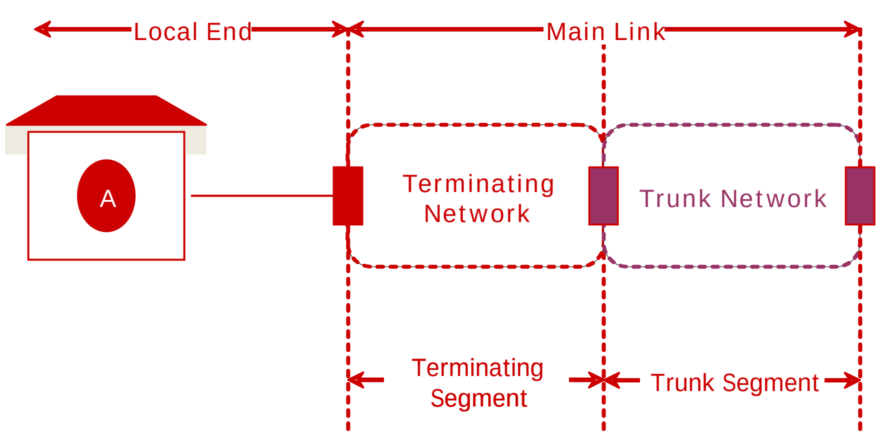
2.9 Leased Lines are typically provided using copper or fibre cables employing a variety of transmission technologies. An RLL can be provided by linking customer premises using dedicated copper/fibre cables (very rare) or can be provided by using copper/fibre local ends that connect the end customer to a Transmission Network (very common). This is illustrated in Figure-2.1. In this Draft Inception Report we model the latter, not the former.

2.2 Wholesale Leased Line Components – Common Definitions

2.10 The following chapter will provide service description while technical details of modeling approach will be discussed in other chapters.

2.11 Unfortunately, no operator or regulator defines Wholesale Leased Lines (WLL) in the same way. This creates confusion in the literature. For the purposes of this Inception Report, we differentiate between Network Components used to construct WLLs and WLLs themselves. Figure-2.2 presents the various Network Components used to provide WLLs based on commonly accepted nomenclature.

Figure-2.2 WLL Components



2.12 In defining what is a Partial Private Circuit (PPC) we use the following definitions:

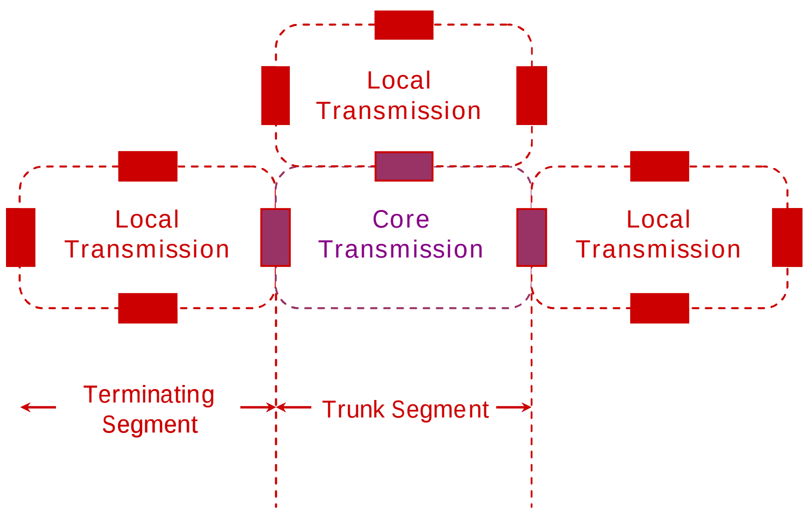
Local End – Defined as a dedicated cable from NTP at customer's premises A to a Distribution Frame located at a Leased Line Serving Exchange (LLSE). Since a Local End is provided over a dedicated cable, it is non-traffic sensitive and represents the Access Network component of a Leased Line.

Terminating Segment – Defined as the Local Transmission Ring that the LLSE is connected to. A Terminating Segment is both traffic sensitive (circuit related) and distance sensitive (length related). See Figure-2.3.

Trunk Segment – Defined as the Core Transmission Ring that the Local Transmission Ring is connected to. A Trunk Segment is both traffic sensitive (circuit related) and distance sensitive (length related).

2.13 Note that a Local End is equivalent to Unbundled Local Loop (ULL) in that the dedicated Access Network cable terminates on a Distribution Frame (DF), before being jumpered to either aMulti Service Access Node (MSAN), Terminal Multiplexor (TM) or an Add/Drop Multiplexor (ADM). As a result, we propose to update our ULL Model to reflect today's equipment prices.

Figure-2.3 Terminating and Trunk Segments



2.14 Note again that a Terminating Segment is part of a Local Transmission Ring (from DP to Local Exchange or nearest Core Transmission node) and that a Trunk Segment is part of a Core Transmission Ring. As a result, we propose to update our Transmission Network Module to reflect (i) today's equipment prices, (ii) actual voice traffic, (iii)actualbroadband traffic and (iv) actual number of WLLs.

2.3 Partial Private Circuit (PPC) – Common Definition

2.15 With a Partial Private Circuit (PPC), on the other hand, part of the circuit is provided by an incumbent operator and the rest of the circuit is provided by the OLO. For example, eircom defines a PPC as:[2]

[a] PPC is an interconnect service providing transparent (that is, not circuit switched)transmission capacity from an end user premises termination point to an OAO's Pointof Handover. The points of demarcation between the two

[2]See Partial Private Circuit Product Description V2.3, eircom Wholesale, 11th November 2009.

networks will be the Point Of Handover (PoH) between an eircom exchange and an OAO Point of Presence (PoP).

The point of demarcation between eircom and the end user is a termination point located in the end user premises. Where the end user is an OAO, the termination point may also be a DDF or ODF.

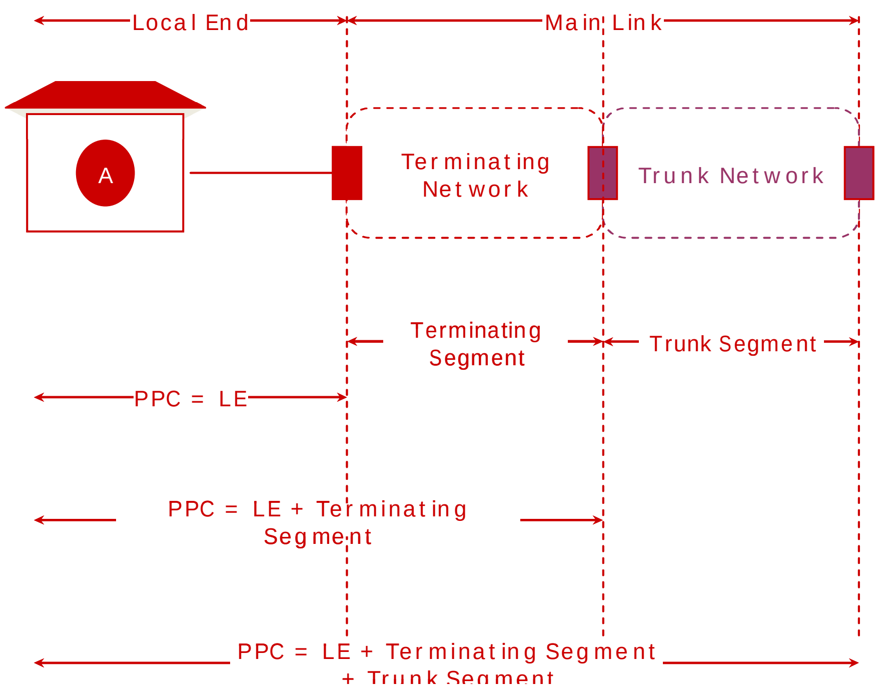
2.16 A similar definition is used by BT.

2.17 An OLO may not be able to provide point-to-point RLLs because it does not have a competing national network. Inthis case, the OLO leases that part of RLL that it cannot provide itself.

2.18 A PPC consists of (a) a Local End plus Interconnection Circuit or (b) a Local End plus Main Link plus Interconnection Circuit. In turn, a Main Link consist of (c) a Terminating Segment or (d) a Terminating Segment and a Trunk Segment.

2.19 Figure-2.4 illustrates potential PPCs.

Figure-2.4 Partial Private Circuits



2.20 All PPCs require an Interconnection Circuit that interconnects the incumbent's network with the OLO's network. This interconnection circuit <u>need not be</u> a voice interconnection circuit and they are distinguished within this engagement. For example, eircom defines

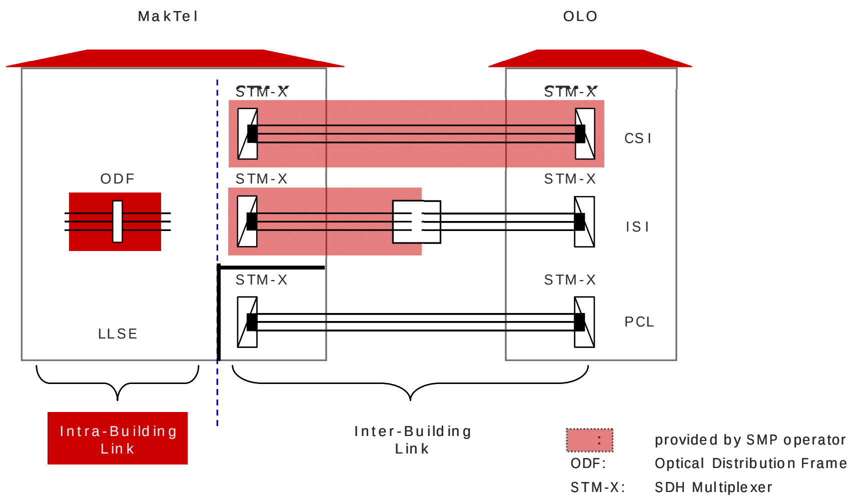
...a point to point 2mb, STM-1, STM-4 or STM-16 connection is provided by eircom between the eircom nominated serving exchange and the OAO's premises. This is provided over the eircom network. Eircom will terminate the connection on appropriate eircom-provided termination equipment in the OAO premises.

The PoH is at the eircom provided termination equipment in the OAO's premises, at which eircom will present the 2mb, STM-1, STM-4 or STM-16 to the OAO. Extraction of individual circuits is the responsibility of the OAO.

2.21 There are three (3) types of Interconnection Circuits: (i) Customer Sited Interconnect (CSI), (ii) In-Span Interconnect (ISI) and (iii) Physical Co-Location (PCL). With CSI, the incumbent operator provides all required infrastructure. With PCL, the OLO provides all required infrastructure.

2.22 Interconnection Circuits are illustrated in Figure-2.5.

Figure-2.5 Interconnection Circuits



2.23 Interconnection Circuits for voice traffic are not considered part of MakTel's Wholesale Leased Line Reference Offer. As a result, Interconnection Circuits for voice traffic are not part of this engagement and as a result are not modeled.

2.4 Partial Private Circuit (PPC) – MakTel Definition

2.24 The general definition of a PPC above applies in Macedonia. That is, a PPC consists of (a) a Local End and (b) a Main Link. However, these components are not provided (or priced) separately. Moreover, no distinction is made between a Terminating Segment and a Trunk Segment. Finally, a PPC is not provided by MakTel to connect a third party to an OLO's network (as it is in Ireland and the UK).

2.25 Instead, a PPC in Macedonia is used to connect mobile Base Transceiver Stations (BTSs) to a MakTel nominated Point of Presence (PoP). An Interconnection Circuit is then used to connect MakTel'sPoP to the OLO's network.

2.26 We understand that an Interconnection Circuit in Macedonia is specifically defined to carry voice traffic from an OLO's network to a nominated (circuit) switch in MakTel's network. As such, the Circuit includes a 2048 kbit/s line card (or port) on a switch block.

2.5 Wholesale Leased Lines – AEC's view of future service

2.27 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:

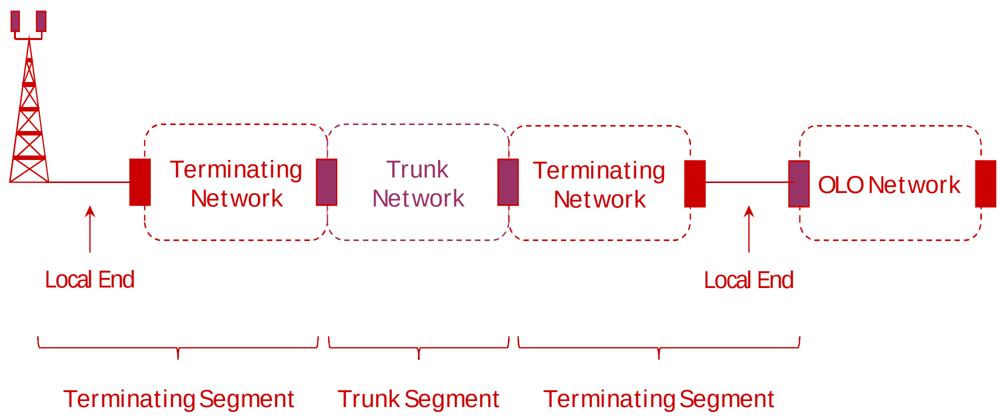
Terminating Segment – Defined as Local End + Terminating Segment as above.

Trunk Segment – Defined as above.

2.28 According AEC's view of future Wholesale Leased Lines services a new interconnection service will bedefined: Interconnection Circuit for Wholesale Leased Lines (ICWLL). This Interconnection Circuit is to be used to transfer the traffic from a WLL/PPC from a MakTelPoP to an OLO's own premises.

2.29 A PPC, according to AEC's future vision of the service (similar to the approaches taken into other countries), will be transformedintoeither (a) one(1) Terminating Segment or (b) one(1) Terminating Segment + one (1) Trunk Segment.Interconnection link will be transformed into Interconnection Circuit for Wholesale Leased Lines (ICWLL).This is illustrated in Figure-2.6.

Figure-2.6 PPC (AEC)



2.30 The main differences between the Agency's definition and current MakTel's definition is twofold. First, a PPC is divided into two (2) separate components (Terminating Segment and Trunk Segment). Second, an Interconnection Circuit is no longer required. The Interconnection Circuit (as defined by MakTel) is replaced with a Terminating Segment(Interconnection Circuit for WLL/PPC described in Paragraph 110)or ICWLL.

2.31 ICWLL is analogous to CSI described in Paragraph 2.21.

2.32 The Agency's definition of a PPC is in fact formally the same as a point-to-point wholesale leased line.

2.6 Point-to-Point Wholesale Leased Line (P2PWLL)

2.33 This is formally identical to a Point-to-Point Retail Leased Line (P2PRLL). Some operators are not required to provide P2PWLLs. Instead, if an operator wants to connect two, say, switches in its network with a transmission circuit, it purchases a P2PRLL.

2.34 Three (3) types of P2PWLL are possible. These are presented in Table-2.1.

Table-2.1 P2PWLLs

Local End	TER Seg	TRK Seg	Description
2	0	0	Both Local Ends are connected to the same LLSE. As a result, the Transmission Network is not used.
2	1	0	Both Local Ends are connected to two different LLSEs. The two (2) LLSEs are part of the same Local Ring.
2	2	1	Both Local Ends are connected to two different LLSEs. The two (2) LLSEs are not part of the same Local Ring. As a result, the Core Ring is required to connect two (2) separate Local Rings.

2.35 It is not the subject of this Draft Inception Report to define a P2PWLL. This Report, however, presents methodology to calculate the costs of the three components used to provide wholesale leased lines (Local End, Terminating Segment and Trunk Segment).

2.7 Bandwidth Modelled

2.36 We propose to model MakTel's existing WLL bandwidths. Since PPCs require a Local End, the availability of any given WLL will depend on which cable technology is available in the Access Network.

2.37 The bandwidths we propose to model, together with the minimum cable technology, are presented in Table-2.2.

Table-2.2 WLL Bandwidths

Bandwidth	Copper Cable (Cu)	Fibre Optic Cable (F)
nx64 kbit/s	1 copper pair	-
2 Mbit/s	2 copper pairs	-
34 Mbit/s	-	Yes
155 Mbit/s	-	Yes

2.38 Note from Table-2.2 that 34 Mbit/s and 155 Mbit/s circuits are fibre optic cable only technologies[3].

2.39 Including 34 Mbit/s and 155 Mbit/s WLLs significantly complicates the analysis for both the Access Network and Transmission Network. For the Access Network, the existing ULL Model will need to be amended to include fibre optic cables as 34 Mbit/s and 155 Mbit/s circuits are fibre optic cable only technologies.Including 34 Mbit/s and 155 Mbit/s WLLs, however, significantly complicates the analysis for the Transmission Network. In particular, VC3 and VC4

[3]In case a 34 Mbit/s PDH PPCexists, SDH will be the MEA for PDH since SDH is itself a fibre optic cable technology. It is possible to deliver a 34 Mbit/s circuit over coaxial (copper) cable. However, fibre is the MEA of coaxial cable. Hence we shall not model 34 Mbit/s circuits delivered over coaxial cable.

line cards will have to be explicitly modelled and accounted for edge multiplexors. This creates a related issue of how much "spare" capacity to model. We discuss each of these three (3) issues (fibre in Access Network, VC3 and VC4s in Transmission Network and "spare" capacity) in turn.

2.40 Capacity of transmission network will be increased by capacity of every leased line by its structure. That means that if input parameter is 5 leased lines of 34 Mbit/s with length of up to 15 km in city centre morphology, capacity of local rings that connect city centre morphology will be increased for 170 Mbit/s.

Fibre in Access Network

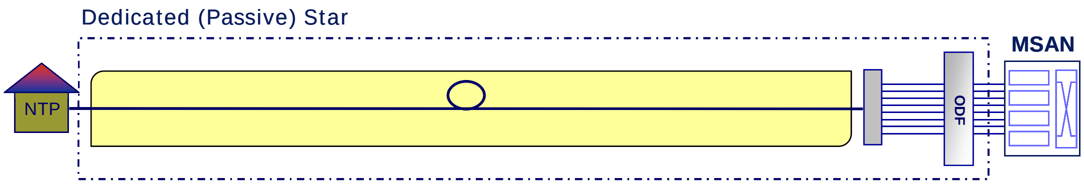
2.41 There are three possible fibre architectures in the Access Network:

1. Dedicated (Passive) Star
2. Active Double Star
3. Passive Star

Dedicated (Passive) Star

2.42 Under this architecture each subscriber has a dedicated fibre pair from the MDF to the NTP. The use of dedicated fibre means that each subscriber would have to be provided with an LED transmitter and optical receiver at the MDF. In addition, each subscriber would have to be provided with a new NTP which also housed an LED transmitter and optical receiver. This is illustrated in Figure-2.7.

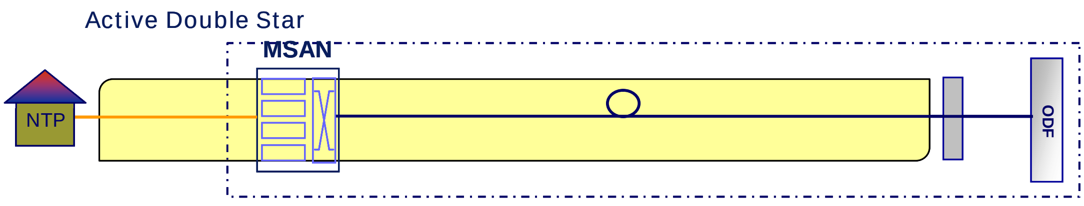
Figure-2.7 Dedicated (Passive) Star



Active Double Star

2.43 Under this architecture subscriber lines are multiplexed (using either TDMA or WDMA) on a common fibre pair to a remotely located Multi Service Access Node (MSAN). The circuit from the MSAN to the NTP is carried on a dedicated metallic cable. This is illustrated in Figure-2.8.

Figure-2.8 Active Double Star



2.44 This network architecture is considerable less expensive than a dedicated passive star because all active optical equipment is shared amongst subscribers. In addition, from a practical implementation point of view, an Active Double Star hybrid copper/fibre Access Network is less expensive to implement because it takes advantage of existing copper cables. That is, MakTel would not have to lay metallic cables from the cabinet to the NTE.

Passive Star

2.45 Under this architecture subscriber lines are multiplexed (using either TDMA or WDMA) on a common fibre pair. The signal is then passively split using optical couplers and transmitted over individual fibre pairs to subscribers. This network architecture is sometimes referred to as Telephony on a Passive Optical Network (TPON).

2.46 The main cost components of a fibre optic cable Access Network are largely the same as a metallic cable Access Network. In particular, the cost driver for the Access Network is the demand for lines (PSTN and Leased Lines) and not the volume of traffic that each line generates. The cost of the Access Network is determined very much by subscriber density (that is the size of cables) and the length of cables.

2.47 The main cost components of the Access Network are presented in Table-2.3.

Table-2.3 Access Network Main Cost Components

Cost Component	Description
Ducting	Ducting refers to the infrastructure that carries telephone cables (whether they are access or transmission cables). The main cost component in building a duct network is the capitalised civil engineering cost of labour required to dig and fill underground trenches. The civil engineering cost of building a duct network varies depending on whether the ducting is laid under carriageway (road), footway (pavement) or soft surfaces. Manholes for access and jointing chambers to "joint" cables together can vary in spacing depending on whether the ducting is in urban or rural areas.
Bores	Refers to the infrastructure that carries cables. Modern day bores are made from PVC tubing.
Cables	Refers to cables that are pulled trough bores and jointed/spliced in jointing chambers.
Distribution Frame	Refers to a frame located in an exchange building on which cables are terminated.

2.48 Fibre optic cables and metallic cables are never pulled through the same bores. Instead, each type of cable is pulled through separate bores. There are different bores for metallic versus fibre optic cables.

2.49 As a result, it is also necessary to specify the mix of metallic and fibre optic cables if MakTel is to provide 34 Mbit/s and 155 Mbit/s leased lines.

2.50 In a very real sense, ducting and bores represent a source of fixed costs in the Access Network, since the same cost is incurred whether one pair cable or 1200 pair cable is laid. Fixed costs give rise to economies of scale. As a result, the cost of Access Network fibre will depend critically on the number of fibre pairs per bore and the number of bores per trench.

2.51 Permanent connections between fibre optic cables are made by splicing. This differs from jointing metallic (copper) cables which requires far less precision. With fibre optic cables the cores of the two cable ends to be mated have to be (i) square and (ii) precisely aligned. Square ends can be achieved by cleaving fibres under mild bending stress.

2.52 Two splicing techniques are currently used. The first aligns the cable ends in a V-shaped groove in a metal block and then joined with a quick setting epoxy resin. The second technique fuses the ends together using a gaseous arc. However, gaseous arc fusing is now the most common splicing technique.

2.53 Fibre optic cables come in spools of various lengths (depending on the size of the cable). Individual cables can be anywhere from 1000m to 5000m. As a result, it is possible that no splicing is required if fibre optic cables are deployed in MakTel's Access Network. As a result, the number of splices per fibre optic cable should be a User defined input parameter.

2.54 At either end of a fibre optic cable, a non-permanent connection may be required. This is achieved by using a connector. Many different types of connectors are available. The User should be able to select the type of connector used from a drop down menu box.

2.55 Table-2.4 summarises the main differences between an all metallic and an all fibre Access Network.

Table-2.4 Access Network Metallic vs Fibre Cables

Component	Metallic	Fibre
Ducting	Civil engineering excavation.	No difference.
Bores	Large (110mm) PVC tubes.	Smaller (50mm or less) tubes.
Cables	Large insulated cables.	Smaller insulated cables.
Splicing	Crimped or soldered.	Spliced.
Connectors	NA	Standardised optical connector.
Frame	Main Distribution Frame	Optical Distribution Frame

2.56 From Table-2.4, most of the difference between an all metallic cable Access Network and a fibre optic Access Network is in the cost of individual components (such as cables, splicing, distribution frames, etc). As a result, it is not necessary to construct a separate fibre Access Network model.

2.57 One important difference between an all fibre optic cable Access Network and an all metallic cable Access Network is the amount of spare cable plant. Many operators Access Networks contains a large number of unused (spare) metallic cables. In part this is the result (i) of cables being laid at a time when copper prices were considerable lower than they are today and (ii) certain services (ISDN Primary Rate Access and certain DSL technologies) require more than one cable pair.

2.58 This situation does not arise if fibre optic cables are used. This is because fibre optic cables are capable of transmitting very high bandwidth. The amount of spare fibre optic cable plant will be a User defined input parameter.

2.8 Circuit Related WLL Costs

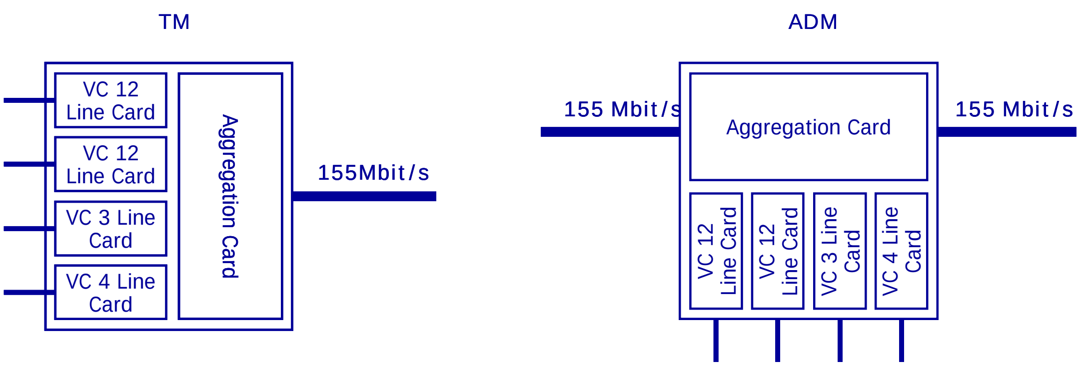
2 Mbit/s/34 Mbit/s/155 Mbit/s Wholesale Leased Lines

2.59 Since the basic operating bandwidth of a concentrator and circuit switch is 2 Mbit/s (E1), there is no need to differentiate between an E1 port on a line system used for voice traffic from an E1 port used to provide a 2 Mbit/s leased line. As far as transmission line systems are concerned, they are the same[4].

2.60 Including 34 Mbit/s and 155 Mbit/s leased lines, however, significantly complicates the analysis for the Transmission Network. In particular, VC3 and VC4 line cards will have to be explicitly modelled and accounted for.

2.61 SDH-4/1 is a common name for equipment with the functionality to multiplex, demultiplex and switch tributaries from 2Mbit/s/VC12s to 140Mbit/s/VC4s into STM-N, where N =1,..,4. There are three types of SDH-4/1: Terminal Multiplexors (TMs), Add-Drop Multiplexors (ADMs) and Digital Cross-Connects (DXCs). A TM multiplexes and de/multiplexes tributaries from/to a common STM-N in one direction, whereas an ADM drops tributaries from and adds tributaries to STM-N in two directions.

Figure-2.9 TMs and ADMs



2.62 Similarly, SDH-4/4 is a common name for equipment with the functionality to multiplex, demultiplex and switch VC 4s (ie STM-1).

2.63 Ordinary telephone switches (or exchanges) are called Fast Switches because a connection is maintained for the duration of the call and then cleared down (ie not permanent). In addition, because a call may take any one of several routes through a network, the entire circuit is switched in real-time, and may change from call to call despite the fact that the same telephone number is being called. In Fast Switches, the connection is controlled by the switch's CPU.

2.64 However a digital switch can be used to provide semi-permanent connections. In this way the switch functions as a distribution frame for digital connections. Such a switch is referred to as a Digital Cross-Connect (DXC) or sometimes a Slow Switch. The connections made by a digital cross-connect are called nailed-up time slots. Because the connection is semi-permanent, it need not be controlled by a CPU. Instead, it can be controlled by the network management system.

2.65 DXCs perform two functions: grooming and consolidation. Grooming describes the process by which channels on incoming trunks are separated for routing onto similar outgoing trunks. Consolidation, on the other hand, describes the process by which channels on incoming trunks are cross-connected to a smaller number of outgoing trunks.

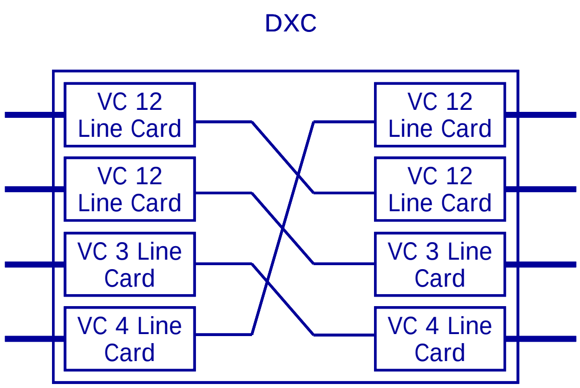
[4] Obviously factors such as routings and resilience differ between PSTN voice traffic and leased lines.

2.66 A DXC unit does not resemble a fast switch (which has 100s of incoming and outgoing trunks) in any way. In fact, DXCs are more closely related to transmission equipment than switching equipment.

2.67 SDH is backwards compatible with PDH. In particular, any PDH tributaries up to 140Mbit/s can be multiplexed into STM-1. With SDH multiplexing, the bytes from a tributary are assembled into what is called a container. Then Path Overheads (POHs) are added to form a Virtual Container (VC). A VC is transmitted through the network as a complete unit until it is demultiplexed.

2.68 There are three (3) types of VC within STM-1. These are presented in Table-2.5 below together with their PDH equivalent and STM-1 capacity. Hence, a SDH 2Mbit/s tributary is mapped into a VC 12, and STM-1 has a capacity of 63 VC 12s.

Figure-2.10 Digital Cross-Connect



2.69 In turn, a typical SDH-1 TM can accommodate three (3) VC 12 tributary line cards, each with 21 VC12 (E1) ports.

Table-2.5 STM 1 VCs

Virtual Container	PDH Equivalent	STM-1 Capacity
VC 12	2 Mbit/s (E1)	63
VC 3	34/45 Mbit/s (E3)	3
VC 4	144 Mbit/s (E4)	1

2.70 In general, SDH multiplexors consist of the following broad components:

(1) chassis;
(2) tributary line cards;
(3) aggregation line card;
(4) power card(s); and
(5) management card.

2.71 Only tributary line cards are specific to voice traffic or leased lines. All other components are common. From Table-2.5, a 2 Mbit/s leased line requires a VC 12 tributary card (where each VC 12 tributary card has 21 2 Mbit/s ports), a 34 Mbit/s leased line requires a VC 3 tributary card while a 155 Mbit/s leased line requires a VC 4 tributary card. Hence it is possible to differentiate PSTN voice traffic, 2 Mbit/s leased lines, 34 Mbit/s leased lines and 155 Mbit/s leased lines by tributary cards.

2.72 In particular, we define a TM, ADM or DCX to be an Edge Multiplexor if its tributary card ports are connected to either (i) a circuit switch E1 or (ii) a 2/34/155 Mbit/s leased line[5]. In general, an Edge Multiplexor is the first multiplexor that circuit switch E1s or leased lines are connected to. We define a Core Multiplexor to be a TM, ADM or DXC that is performing pure multiplexing.

2.73 Suppose a firm produces three (3) services A, B and C. Let SAC(A) equal the Stand Alone Cost of service A, SAC(A,B) equal the Stand Alone Cost of A and B and SAC(A,B,C) equal the Stand Alone Cost of A, B and C. Then the LRIC(A) is given by:

$$(2.1)\ \ \mathrm{LRIC(A)} = \mathrm{LRTC}(\mathrm{A} \cup \mathrm{B} \cup \mathrm{C}) - \mathrm{LRTC}(\mathrm{B} \cup \mathrm{C}) = \mathrm{SAC(A,B,C)} - \mathrm{SAC(B,C)}$$

where LRTC = Long Run Total Cost.

2.74 LRAIC(A) is, in turn, given by:

$$(2.2)\ \ \mathrm{LRAIC(A)} = \frac{\mathrm{LRTC}(\mathrm{A} \cup \mathrm{B} \cup \mathrm{C}) - \mathrm{LRTC}(\mathrm{B} \cup \mathrm{C})}{\mathrm{A}} = \frac{\mathrm{SAC(A,B,C)} - \mathrm{SAC(B,C)}}{\mathrm{A}}$$

2.75 Equations (2.1) and (2.2) are the fundamental equations of LRIC/LRAIC.

2.76 Let VC12 = the number of VC12 line cards installed in Edge Multiplexors, Let VC3 = the number of VC3 line cards installed in Edge Multiplexors and Let VC4 = the number of VC4 line cards installed in Edge Multiplexors.

2.77 Then:

$$(2.3)\ \ \mathrm{LRAIC(VC12p)} = \frac{\mathrm{LRTC}(\mathrm{VC12} \cup \mathrm{VC3} \cup \mathrm{VC4}) - \mathrm{LRTC}(0 \cup \mathrm{VC3} \cup \mathrm{VC4})}{\mathrm{VC12p}}$$

where VC12p = the number of active VC12 ports[6].

2.78 That is, the LRIC/LRAIC of all VC12 Edge tributary cards is given by running the full transmission module with all Edge tributary cards (VC12s, VC3s and VC4s) in place and then running the transmission module again with all VC12 tributary cards removed.

2.79 LRIC(VC3) and LRIC(VC4) are calculated in a similar way.

2.80 We are now in a position describe the methodology for modelling 2 Mbit/s, 34 Mbit/s and 155 Mbit/s WLLs.

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[5] Of course it is possible that a TM, ADM or DXC could be a mixed use multiplexor in that some tributary cards could be edge cards whilst others are core cards.

[6] In reality equation (2.2) should be refined to distinguish between PSTN VC 12 ports and nx64/2 Mbit's leased line ports.

2.81 Step 1 is to express the cost of an Edge SDH-1 TM/ADM on a VC12, VC3 or VC 4 per port basis. This is achieved by using Table-2.6.

Table-2.6 SDH-1 per Port Costs

	2 Mbit/s	34 Mbit/s	155 Mbit/s
Chassis	÷ 63	÷ 3	÷ 1
Line Card	÷ 21	÷ 1	÷ 1
Aggregation Line Card	÷ 63	÷ 3	÷ 1
Power card	÷ 63	÷ 3	÷ 1
Management Card	÷ 63	÷ 3	÷ 1

Incremental Cost

2.82 So, for example, for a 2 Mbit/s port, the chassis cost of a SDH-1 TM or ADM is divided by 63.

2.83 Step 2 of the methodology is to restrict the provision of 34/155 Mbit/s WLLs to City Centre and Urban MDF morphologies. nx64 kbit/s and 2 Mbit/s WLLs will be available in all morphologies.

2.84 Step 3 is to install two (2) VC12 ports, one (1) VC3 tributary card and one (1) VC4 tributary card at each MDF (keeping in mind that in fact an ODF will be required) in addition to the number of VC 12 ports/tributary cards required for PSTN voice traffic.

2.85 Step 4 is to calculate LRAIC (VC12p), LRAIC(VC3p) and LRAIC(VC4p). LRAIC(VC3p) then represents the circuit related LRIC of a 34 Mbit/s leased line[7]. This is illustrated in Figure-2.11.

Component Specific Fixed Costs (CSFCs)

2.86 There are fixed costs (Component Specific Fixed Costs and Common and Joint Costs) in the Transmission Network defined by a network for coverage. A network for coverage is defined as:

(a) The number of 2 Mbit/s ports/multiplexors (Edge and Core) required to transmit one call from any telephone currently connected to MakTel's PSTN to any other telephone connected to the PSTN.

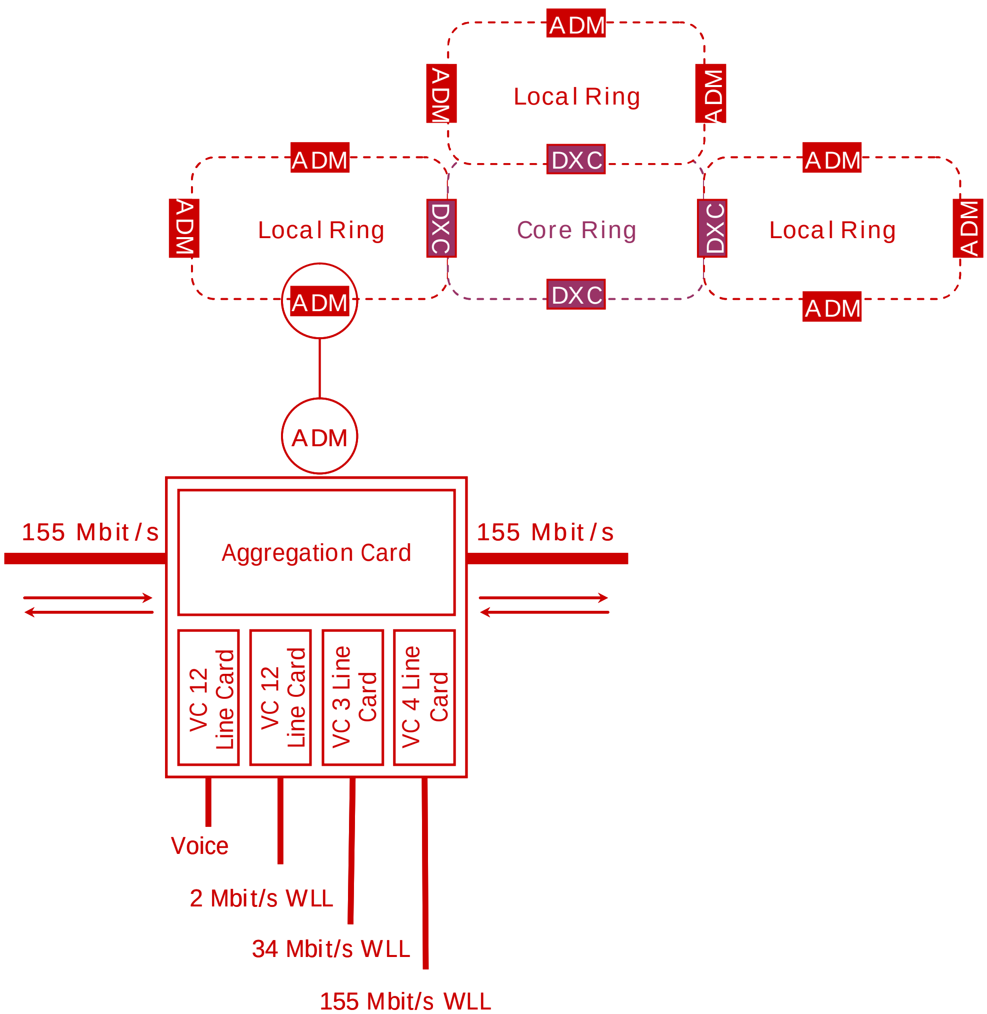
(b) The number of 2 Mbit/s ports/multiplexors (Edge and Core) required to provide one (1) nx64 kbit/s and one (1) 2 Mbit/s P2PWLL from any MDF to any other MDF.

(c) The number of multiplexors (Edge and Core) required to provide one (1) 34 Mbit/s P2PWLL from any City Centre/Urban ODF to any other City Centre/Urban ODF (any-to-any connectivity).

(d) The number of multiplexors (Edge and Core) required to provide one (1) 155 Mbit/s P2PWLL from any City Centre/Urban ODF to any other City Centre/Urban ODF (any-to-any connectivity).

[7] We discuss below how to calculate length related LRIC of a 2 Mbit/s, 34 Mbit/s or 155 Mbit/s leased lines.

Figure-2.11



2.87 In particular, the CSFC of, say, 34 Mbit/s leased lines (or VC3s) is given by the cost of VC3 tributary cards located on Edge Multiplexors under a network for coverage. Similarly, the CSFC of 155 Mbit/s leased lines (or VC4s) is given by the cost of VC4 tributary cards located on Edge Multiplexors under a network for coverage.

Common and Joint Costs (CJCs)

2.88 All other (non tributary card) costs under a network for coverage are defined as a CJC for VC12s, VC3s and VC4s.

2.9 Length Related WLL Costs

2.89 The discussion above concerned circuit (or traffic) related costs. Thus it focused on electronic line systems and excluded length related costs such as duct and cables. In modelling length related costs, we shall update our previous Transmission Model to reflect today's equipment prices.

2.90 This will calculate Local Ring Duct and Cable and Core Ring Duct and Cable costs. These costs are then allocated to PSTN traffic and WLLs as follows. Let p_{PSTN} = the number of (active) PSTN ports, p_{nx64} = the number of (modelled) nx64 kbit/s WLL ports, p_2 = the number of (modelled) 2 Mbit/s WLL ports, p_{34} = the number of (modelled) 34 Mbit/s ports and p_{155} = the number of (modelled) 155 mbit/s ports Table-2.7 presents the (percentage) allocation

Table-2.7 Length Related Cost Allocation

	Ports	**Allocation**
PSTN Voice Traffic	$p_{PSTN} \div 2 \div 63$	$(p_{PSTN} \div 2 \div 63)/\Sigma$
nx64 kbit/s WLL	$p_{nx64} \div 2 \div 63$	$(p_{nx64} \div 2 \div 63)/\Sigma$
2 Mbit/s WLL	$p_2 \div 2 \div 63$	$(p_2 \div 2 \div 63)/\Sigma$
34 Mbit/s WLL	$p_{34} \div 2 \div 63$	$(p_{34} \div 2 \div 63)/\Sigma$
155 Mbit/s WLL	$p_{155} \div 2 \div 63$	$(p_{155} \div 2 \div 63)/\Sigma$
Total	**Σ**	**100%**

2.91 Dividing each allocation in Table-2.7 by total route metres yields length related costs per metre.

2.92 Additionally to all mentioned, leased lines are commonly charged by capacity and length. Length between points is often represented as straight line distance (air distance). Since communication network do not connect two points in straight line, curve factor will be introduced in model as user input parameter to calculate cable length representation of demanded leased line lenght.

2.93 We propose to achieve this by multiplying the linear distance hLL by a Road Network coefficient (RNLL). RN will be calculated following two step approach.

Step 1 – For any two addresses (represented by postcodes), calculate the linear distance between the two (LD_{LL}).

Step 2 – For the same two addresses, calculate the road distance between the two (RD_{LL}) using an on-line road motoring site.

2.94 Given LDLL and RDLL, RNLL = RDLL/LDLL.

2.10 "Spare" Capacity

2.95 Our previous LRIC Model employed a "scorched node" assumption, where existing Exchange Buildings are fixed in their current locations. Given that PSTN subscribers and call traffic has achieved a relatively steady sate (and in fact is declining), it is fairly straightforward to model Busy Hour Traffic (BHT) capacity.

2.96 The same cannot be said about WLLs (and RLLs for that matter) in Macedonia. In particular, Macedonia is characterised by the existence of very few WLLs/RLLs. In this regard, it is not possible to model an existing P2PRLL or P2PWLL. Any future WLL may take a different route and be of a different length than existing WLLs.

2.97 As a result, the approach adopted above simply reserves (spare) capacity for nx64 kbit/s, 2 Mbit/s, 34 Mbit/s and 155 Mbit/s WLLs. The underlying implicit assumptions behind this approach are that it is possible to provide one and only 64/2/34/155 Mbit/s WLL from any given Local Exchange (A) to any other Local Exchange (B). The same is true for any unique pair of

Local Exchanges. However, it is not possible for any given Local Exchange to provide more than one 64/2/34/155 Mbit/s WLL

2.11 Charges Modelled

2.98 We shall model (i) monthly rental charges only. All other charges such as connection, testing/feasibility, account management, co-location, Interconnection Links, etc. will not be modelled.

2.99 However, we shall separately model (ii) the monthly rental charge for Customer Premises Equipment (CPE).

2.12 Key WLL modelling principles and assumptions

2.100 Finally and additionally to all previously mentioned, network components that are included in leased lines segments from modeling point of view:

- 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) located at local/core ring network access node
  - active devices located from the end customer up to the PoP (Point of Presence) located at local/core ring network access node
- trunk segment
  - starting MUX (including line card)
  - core network cabling (including ducting and trenching) between two PoP (Point of Presence)
  - core network active equipment between two PoP (Point of Presence)
  - ending MUX (including line card)

2.101 Since this kind of leased line structuring and costing is new to market, we will need to conduct detailed data from SMP about network infrastructure, possibilities and dominant type of leased lines currently in use. Those data will determine our final approach to model leased lines.

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

2.103 Due to current Macedonian situation model will be developed according to locations of PoP (Point of Presence) 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

2.104 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.

2.105 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.

2.106 Trunk segment does not include terminating segment.

2.107 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.

2.108 Final model result will provide service costs (structure presented in 2.91) 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 as explained in point 2.6.

3. DUCT RENTAL

3.1 Access Network Duct Rental

3.1 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).

3.2 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.

3.3 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.

3.4 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.

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

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

3.7 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.

3.8 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.

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

3.10 Modelling the rental cost of Access Duct per kilometre involves the following four step process:

Step 1 – Run Model with cable costs, cable splicing costs and distribution frames costs.

Step 2 – For each of the three distribution frames areas morphologies modelled, subtract the cable costs (including splicing and connectors) and distribution frames costs. This will leave only ducting and bore costs.

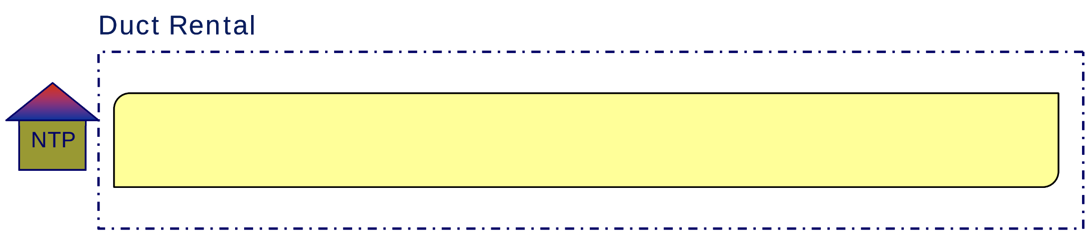
Step 3 – Spare bore capacity fill with smaller diameter tubes following user input rules including costs of installation.

Step 4 – Calculate the number of Bore Metresfor each morphology and bore type. The number of Bore Metres is simply given by the sum of the length of each bore times the number of bores. For example, if there were 9 bores of 500 metres in length and 27 bores of 2000 metres in length, then the total number of Bore Meters is 58500.

Step 5 – Divide the costs calculated in Step 2 to used and spare big diameter bores by arithmetic distribution and then dived part of costs for spare big diameter bores to small diameter bores by percentage of big diameter bore space usage. Finally calculated costs for small diameter bores divide by the number of Bore Metres calculated in Step 4 to arrive at the cost per bore per metre.

3.11 Duct Rental is illustrated in Figure-3.1.

Figure-3.1 Access Duct Rental



3.2 Ethernet aggregation duct rental

3.12 The model will calculate the cost of ducts in Ethernet aggregation segments in the same way as it is done for Access network.

4. DARK FIBRE

4.1 Service Definition

4.1 In general, Dark Fibre refers to “unlit” Fibre Optic cable. Dark Fibre is only possible if an operator has unused (or spare) fibre strands in its Network. The cost of Dark Fibre would then consist of all length related costs such as Ducting, Bores, cables, etc. and are discussed in Table-2.3.

4.2 The objective is to calculate the Dark fibre service cost primarily in Ethernet segment, because Bylaw on the access and use of specific network devices allows dark fibre rental in primary and secondary segment just in case that other possibilities (duct rental, rerouting etc.) are not sufficient.

4.3 As we mentioned in introduction, LRIC results are highly dependent on economies of scale. For model that means that final result is highly dependent on input demand. Current deployment of dark fibre in primary and secondary segment are low, so that can imply low input demand in model which we implicitly result unreal cost result. Therefore input demand for dark fibre in primary and secondary access network segment will be user input parameter. This input parameter will be populated with MakTel estimated number of dark fibre use in next years or AEC forecast of service penetration.

4.4 Model will directly include above defined parameter.

4.5 We would like to note that usage of dark fibre is dependent on duct availability (as specified in MakTel’s referent offer) and demand of that service cannot be linked solely to availability of fibre optic infrastructure or deployment of fibre optic access services.

4.6 Due to facts pointed out in this text, results of these calculations cannot be used within the NGA regulation, only in regulation of dark fibre as a supplement when ducts are not available.

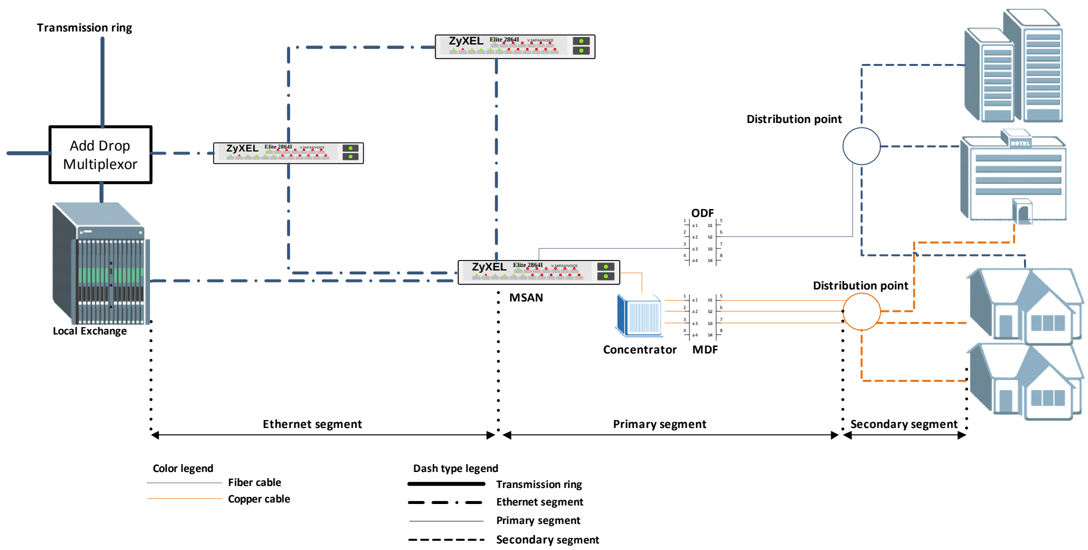
4.2 Charges Modelled

4.7 We shall model monthly rental charges only. All other charges such as connection, testing/feasibility, account management, co-location, Interconnection Links, etc. will not be modelled.

4.3 Methodology

2.109 We propose to calculate dark fibre service cost on a basis of our previous LRIC Model (Passive Star Dark Fibre structure shown in Figure 4.1).

Figure-4.1 Dark fiber passive star



4.8 Dark fibre service costs are different in three identified segments. They include following main costs categories:

Ethernet segment –one piece of fibre cable, splicing, bores, ducting, trenching and overhead cost excluding active equipment;
Primary segment–one piece of fibre cable, splicing,bores, ducting, trenching, ODF and overhead cost;
Secondary segment - one piece of fibre cable, splicing,bores, ducting, trenching excluding NTP and overhead cost.

4.9 We would like to remind that our previous LRIC Model models four different MDFA morphologies. Whilst overground fibre optic cables are available, we do not propose to model overground fibre connections.

4.10 The model will contain fibre connections in primary and secondary segment within City Centre and Urban MDFA morphologies. Ethernet aggregation segment will be present in all morphologies.

4.11 In our view, modelling Dark Fibre in Ethernet segment as defined above is no different from modelling fibre costs in the Transmission Network in general. This is because it is not possible to model specific Dark Fibre routes and lengths.

4.12 In particular,we propose to use our Transmission Network (for Ethernet part)module of our LRIC Model to calculate the rental cost of Dark Fibre.

4.13 Modelling the rental cost of dark Fibre per metre involves the following four step process:

Step 1 – Run Transmission Module with fibre optic cable costs, fibre optic cable splicing costs and Optical Distribution Frame (ODF) costs.

Step 2 – For each of the four MDFA morphologies modelled, calculate the number of “lit” fibres.

Step 3 – Calculate the number of Cable Metres for Ethernet segment. The number of Cable Metres is simply given by the route length of duct times the average number of lit cables. For example, if there are 10000 km of duct routes and the average number of lit fibres is 12, then there are 120000 Cable Metres.

Step 4 – Divide the costs calculated in Step 1 by the number of Cable Metres calculated in Step 3 to arrive at the cost per metre.