



**TSLRIC price review determination
for the Unbundled Copper Local
Loop and Unbundled Bitstream
Access services**

Model documentation

Commerce Commission

Ref: 2014-20-DB-ML – BU models

Public Version

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0 Introduction

0.1 Background

Unbundled Copper Local Loop (UCLL) and Unbundled Bitstream Access (UBA) are services that allow alternative operators' access to the local loop infrastructure of Chorus.

The Telecommunications Act 2001 (the Act) requires the Commerce Commission (the Commission) to determine a price for the UCLL and UBA services. In the first instance the Commission is required to benchmark prices against comparable countries under the 'initial pricing principle' (IPP). If an access seeker or Chorus Limited is not satisfied with the price (either the UCLL or UBA) determined under the IPP, the Act provides that the party can ask the Commission to calculate a price for that service in accordance with the 'final pricing principle' (FPP), which is Total Service Long Run Incremental Cost (TSLRIC) for UCLL and UBA.

The Commission reviewed the benchmarked UCLL price on 3 December 2012 and determined the UBA benchmarked price on 5 November 2013. However, the Commission has received FPP requests both for UCLL and UBA: the UCLL FPP request was received in February 2013, the UBA FPP request was received in January 2014. Therefore, the Commission needs to determine a price for the UCLL and UBA services in accordance with the FPP.

TERA Consultants (TERA) has been mandated by the Commission to calculate a price for the UCLL and UBA services in accordance with the FPP which is TSLRIC.

A consultation paper on conceptual issues of UCLL cost modelling was issued by the Commission in December 2013. A further consultation paper focusing on UBA¹ was also issued in early February 2014. Responses from interested parties were received in February 2014.

The Commission issued a paper which set out its preliminary views on its proposed regulatory framework for the UCLL and UBA TSLRIC cost modelling exercises and its preliminary views on a number of fundamental assumptions for the development of a TSLRIC cost model for the UCLL and UBA services². Having reviewed the Commission paper, TERA has provided its views on some key methodological choices related to the calculation of TSLRIC in the document "Modern Equivalent Assets and relevant scenarios".

¹ Commerce Commission, Determining a TSLRIC price for Chorus' unbundled bitstream access service under the final pricing principle, (7 February 2014)

² Commerce Commission, Consultation paper outlining our proposed view on regulatory framework and modelling approach for UBA and UCLL services, (9 July 2014)

The Commission sought the view of interested parties on all topics and has reviewed the submissions and the cross-submissions sent by all the interested parties.

Based on these consultations and on the papers previously published, the Commission has made a number of decisions regarding the modelling and the pricing of the different regulated services. These decisions are defining the criteria for developing the access network cost model, the core network cost model. They are listed in the Model Reference Paper.

Based on the model reference paper, the Model Specification describes how the criteria have been followed to derive the price of the different regulated services.

This paper describes the details of the modelling.

0.2 Structure of this document

This document details the methodology and algorithms used when building the cost models for UCLL and UBA. The document has the following structure:

- **Section 1** – Model implementation (see §1): gives a high level view of how the different parts of the model interact together;
- **Section 2** – Architecture of the cost models (see §2): details the architecture of each file part of the access network cost model, the core network cost model and the opex model;
- **Section 3** – Opex model (see §3): details the implementation of the Opex model;
- **Section 4** – Dimensioning the access network (see §4): describes how the dimensioning of the access network is carried out;
- **Section 5** – Costing the access network (see §5): details how costs of the access network are calculated;
- **Section 6** – Core network cost model (see §6): describes the implementation of the core network cost model; and
- **Section 7** – How to use the models (see §7): explains the procedures to follow in order to derive the prices of the different regulated services.

1 Model implementation

This section describes the modelling approach of the three cost models:

- The Access network cost model which is made of two following files:
 - “2014-20-DB-ML-ComCom - Access network.accdb”: in this file, the access network is dimensioned;
 - “2014-20-DB-ML-ComCom - Access network cost model.xlsb” in this file, the access network is cost;
- The Opex model is made of the file named “2014-20-DB-ML-ComCom-OPEX model.xlsm”
- The Core model is made of the file named “2014-20-DB-ML-ComCom - UBA model.xlsb”.

1.1 General architecture

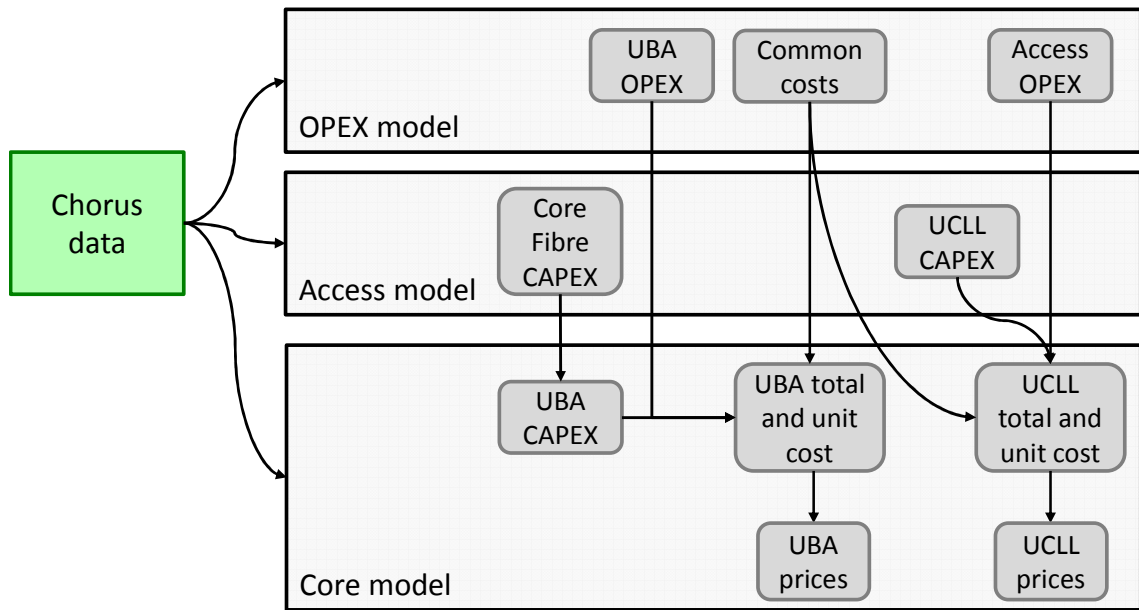
Three models have been developed to derive the price of the different regulated services:

- The Access model that derives the inventory and the cost of all passive assets;
- The Opex model that derives the opex, the indirect capex, the common costs and the transaction charges;
- The Core model that derives the inventory and the cost of all active assets. This model also allocates the common costs to the different services and **therefore derives the prices of all the regulated services.**

1.2 Interactions between the different cost models

The three models interact on a one-way basis. The Access model is an independent model. The Opex model is also an independent model. A very limited number of allocation keys used in this model are taken from the Core model. However, these are “frozen” and are not supposed to change (e.g. when a sensitivity analysis is performed). The Core model relies on the results provided by the opex and the Access models as shown in the figure below:

Figure 1 - Interaction between the different cost models



Source: TERA Consultants

The results of the modelling are all located in the Core model.

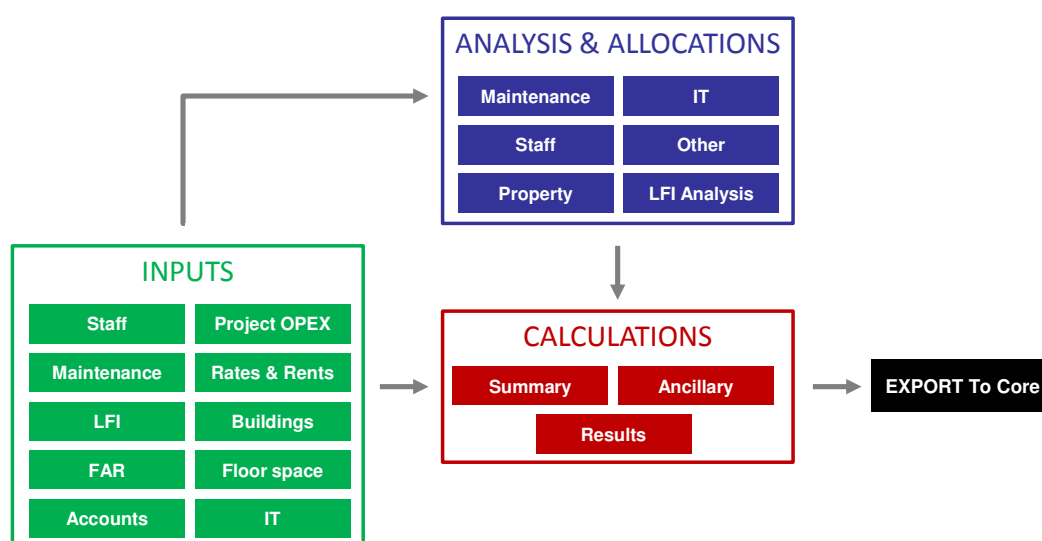
2 Architecture of the cost models

This section aims at describing the architecture of each cost model

2.1 Opex model

The Opex Excel model (“2014-20-DB-ML-ComCom-OPEX model”) assesses the amount of opex per line for UCLL and UBA services per MDF. The architecture of the model is described by the following figure:

Figure 2 – Architecture of the Opex model



Source: TERA Consultants

The figure above provides the logical calculation flow for the spreadsheets of the model:

- The green spreadsheets are input spreadsheets;
- The blue spreadsheets are analysis and allocation spreadsheets;
- The red spreadsheets are calculations spreadsheets;
- The dark spreadsheet is the output for the core network cost model.

2.2 Access network cost model

The Access model is made of two main files:

- The Microsoft Access model, that performs the dimensioning of the access network, i.e. that derives the inventory of the access network;
- The Microsoft Excel model, that performs the costing of the local access network, given the output of the Microsoft Access model;

And two source files:

- The ‘Inputs’ Microsoft Excel file that gathers the inputs that have been used to feed the model (parameters, unit costs); and
- A dedicated ‘Inputs for trenches’ Microsoft Excel file that gathers the inputs specific to the trenches costs, and their calculations.

The Microsoft Access model provides four outputs to the Excel model:

- Asset inventory for the copper network when overhead;
- Asset inventory for the copper network when underground;
- Asset inventory for the fibre network when overhead;
- Asset inventory for the fibre network when underground;

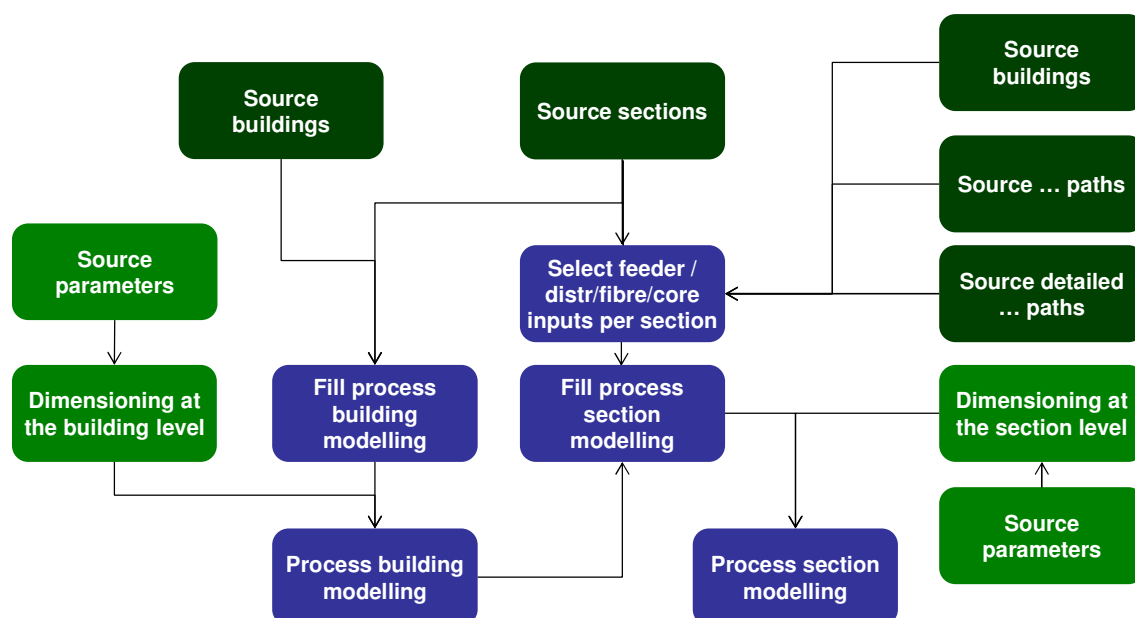
Then, the Microsoft Excel model combines those four inventories, implements macro parameters onto the network (e.g. share of overhead) and unit costs to all the assets, and then provides the cost of the local access network (annualised/capex) as an output.

The Access and Excel models also provide costs for the core network model regarding the assets that share paths with the local access network (e.g. trenches, fibre cables).

2.2.1 Microsoft Access – Network dimensioning

The Microsoft Access model uses the dimensioning rules from the data requests and geospatial data as inputs to dimension all assets at each building and at each section (a section is the road portion located between two consecutive intersections), regardless of whether the network is fibre or copper, underground or overhead.

Figure 3 - Access model architecture 1/2



Source: TERA Consultants

For each section/building, features of the section/buildings, such as the number of lines going through the section, are computed with SQL queries (blue boxes) from the geospatial data (dark green boxes).

First, the outputs at the building level are computed through a VBA routine (“Dimensioning at the building level”) listing input parameters and written into “Process building modelling”. Some of these outputs are recast into section features.

Then, the outputs at the section level are computed through another VBA routine (“Dimensioning at the section level”) and written in “Process section modelling”.

Finally, the outputs at the building and section levels are aggregated at the MDF level in four scenarios (cf. §5.4):

- Copper overhead network,
- Copper underground network,
- Fibre overhead network,
- Fibre underground network.

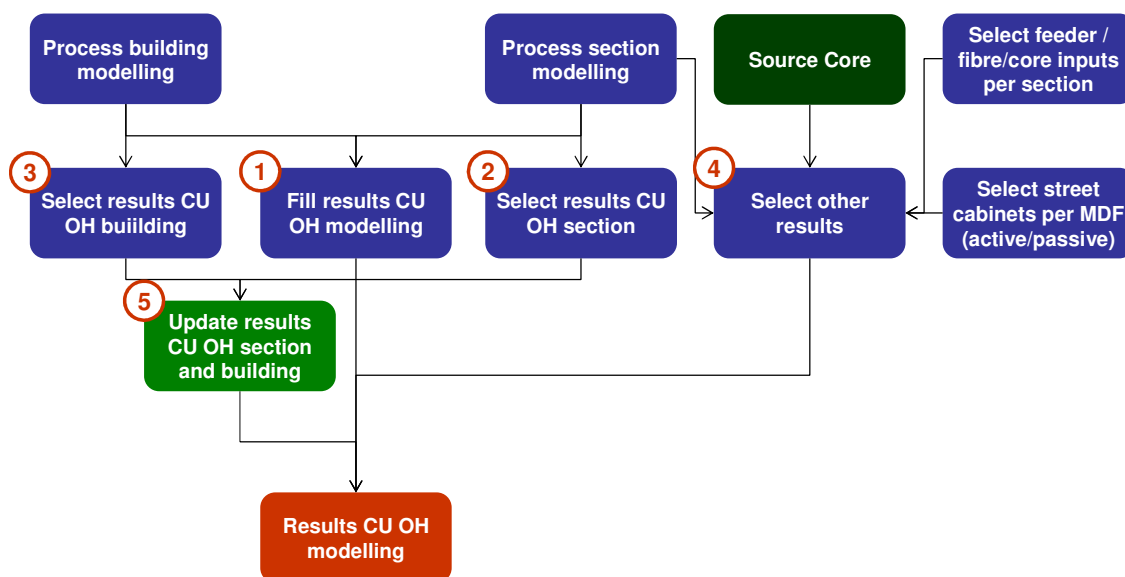
For technical reasons, the aggregation referred above is made within five steps:

1. The inventory of trenches by size is computed through the query “FILL RESULTS MODELLING” from the tables “PROCESS BUILDING MODELLING” and “PROCESS SECTION MODELLING” and written in first place in “RESULTS MODELLING”;
2. The inventory of assets related to sections is aggregated from the “PROCESS SECTION MODELLING” table through the query “SELECT RESULTS SECTION³” and written in an interim table;
3. The inventory of assets related to buildings is aggregated from the “PROCESS BUILDING MODELLING” table through the query “SELECT RESULTS BUILDING” and written in an interim table;
4. The inventory of other assets related to MDF or core network is aggregated through the query “SELECT OTHER RESULTS” from the tables “PROCESS SECTION MODELLING”, “SOURCE_CORE”, “SELECT FEEDER INPUTS PER SECTION” and “SELECT STREET CABINETS PER MDF”, shared among the four scenarios, and written in an interim table;
5. The output table “RESULTS MODELLING” is then updated with the values written in the three interim tables aforementioned.

³ stand for the scenario, e.g. CU OH – for copper overhead –, or FB UG – for fibre underground.

Figure 4 - Architecture of the Access model (2/2)

Illustration for the copper overhead⁴ scenario



Source: TERA Consultants

The four result tables (“RESULTS CU OH MODELLING”, “RESULTS CU UG MODELLING”, “RESULTS FB OH MODELLING” and “RESULTS FB UG MODELLING”) are then exported to the Excel access cost model to proceed to the costing.

2.2.2 Microsoft Excel – Network costing

The model is made of three Excel files:

- ‘Access network cost model’: the Excel model that proceeds to the costing;
- ‘Inputs’ where the unit costs are sourced; and
- ‘Inputs for trenches’ where the unit costs for trenches are sourced.

The Excel model takes the Access output inventories (four results tables described above) and the unit costs as an input and returns:

- Export to the core model;
- Aggregate costs of the copper network and fibre network;
- Detailed costs of the copper network and fibre network.

Costs are provided as capex and as annualised costs, MDF by MDF, national, urban and rural.

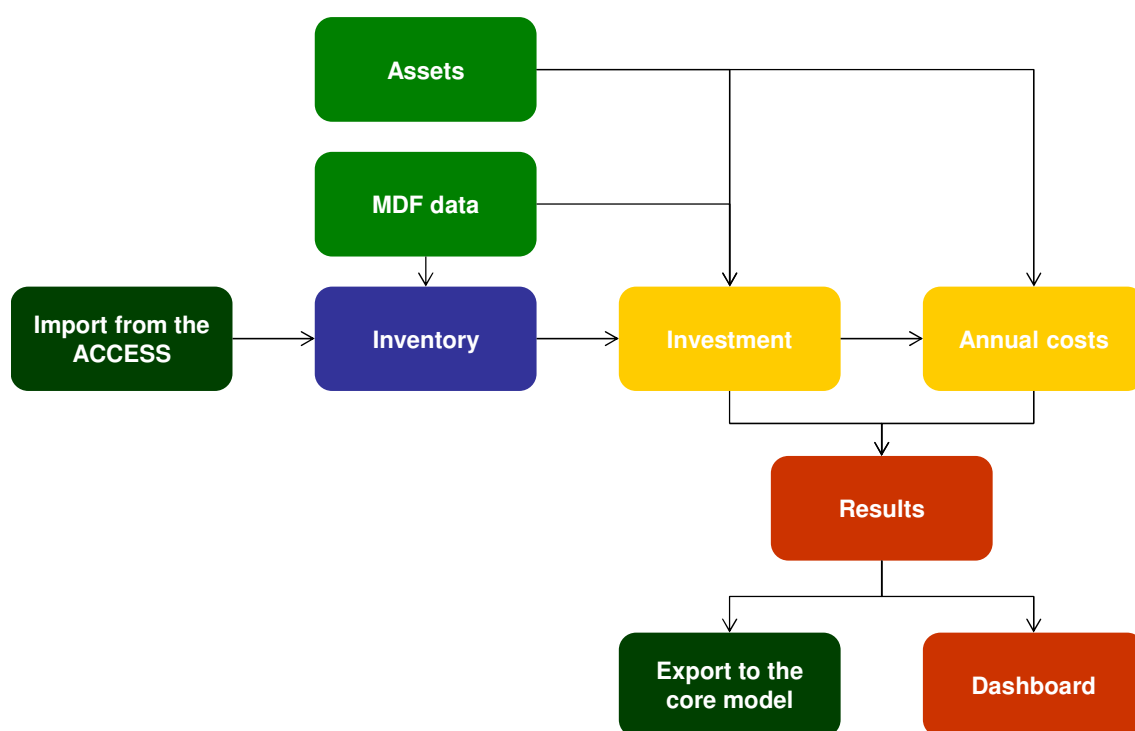
The “Access network cost model” Excel is made of nine spreadsheets:

- Dashboard: controlling the key parameters and monitoring the main results;
- Results: detailed results of asset costs per network level;

⁴ The Access model produces four outputs inventories for the four cases: CU OH, CU UG, FB OH and FB UG. The architecture and data flows of each output production are identical.

- Import from the Access: inventories from the Access model;
- Export to the core model: export 2015-2019 investment and yearly costs for each network level to the core model;
- Assets: lists all assets used, their lifetime and costs;
- MDF data: MDF-specific parameters, e.g. regarding the share of overhead;
- Inventory: inventory of all assets used in the fibre and copper networks, after applying the overhead/underground mix;
- Investment: corresponding to the inventory, after applying cost reduction due to shared infrastructures;
- Annual costs: annualised costs of the investment, i.e. depreciated investment.

Figure 5 - Architecture of the Access network cost model



Source: TERA Consultants

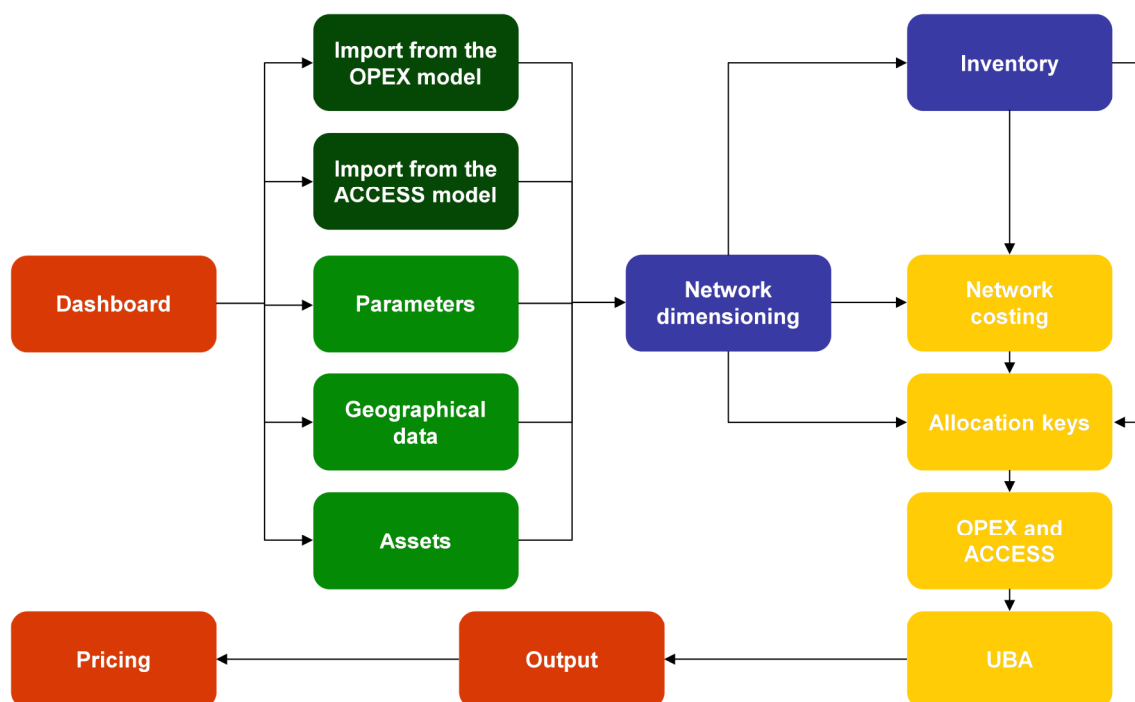
2.3 Core network cost model

The model is made of two files:

- The Core model; and
- The 'UBA input' file that gathers most of source documents provided by Chorus that has been used to feed the model.

The architecture of the core network cost model is described by the following figure:

Figure 6 – Architecture of the core network cost model



Source: TERA Consultants

The figure above provides the logical calculation flow for the 14 spreadsheets of the model:

- The green spreadsheets are input spreadsheets, the darker ones take the input from the other models (see section 6.2);
- The blue spreadsheets are dimensioning spreadsheets (see section 6.3);
- The yellow spreadsheets are financial spreadsheets (see section 6.3);
- The red spreadsheets are the most important spreadsheets: the Dashboard, the Outputs and the Pricing (see section 6.5).

The following spreadsheets are involved:

- Dashboard: allows the user to specify the financial and volumes parameters;
- Parameters: allows the user to specify the network parameters;
- Import from the ACCESS model: data imported from the access model;
- Import from the Opex model: data imported from the Opex model;
- Geographical data: provides the topology of the network, and the distribution of customers;
- Assets: provides the information related to the dimensioned assets in the network;
- Network dimensioning: dimensions the network equipment;
- Inventory: provides an overview of the assets in the network and some space, power and cooling information;
- Network costing: calculates the cost of the network;
- Allocation keys: provides allocation keys used to allocate the different costs;

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- OPEX and ACCESS: allocates specific costs among different services;
- UBA: allocates the relevant costs to the UBA service;
- Outputs: Calculates values used for the final pricing;
- Pricing: provides the results of the model.

3 Opex model

This section documents the Opex model.

The Opex model contains the allocation of Chorus' expenses related to their regulated and unregulated activities on the UCLL and UBA services, adjusted for efficiencies.

Data to develop a bottom-up model for operating costs is not always available. A limited number of opex cost categories can generally be assessed with a true bottom-up model. This includes power costs (the required MWh is assessed based on the demand of all network assets and multiplied by the MWh unit price) or space rental costs (the required square meters are assessed based on the demand of all network assets and multiplied by the square meter unit price). However, the majority of opex are either supplier costs or staff costs. For these costs, the best practice is generally to use top-down data as a starting point. Hence, a mixture of bottom-up approach and top-down approach with evolution over the time is carried out.

In addition, it must be emphasised that a bottom-up model assesses the cost of a 'new' network (with potentially high capex and low opex) whereas top-down costs reflect the costs of an older network (with potentially lower capex and higher opex).

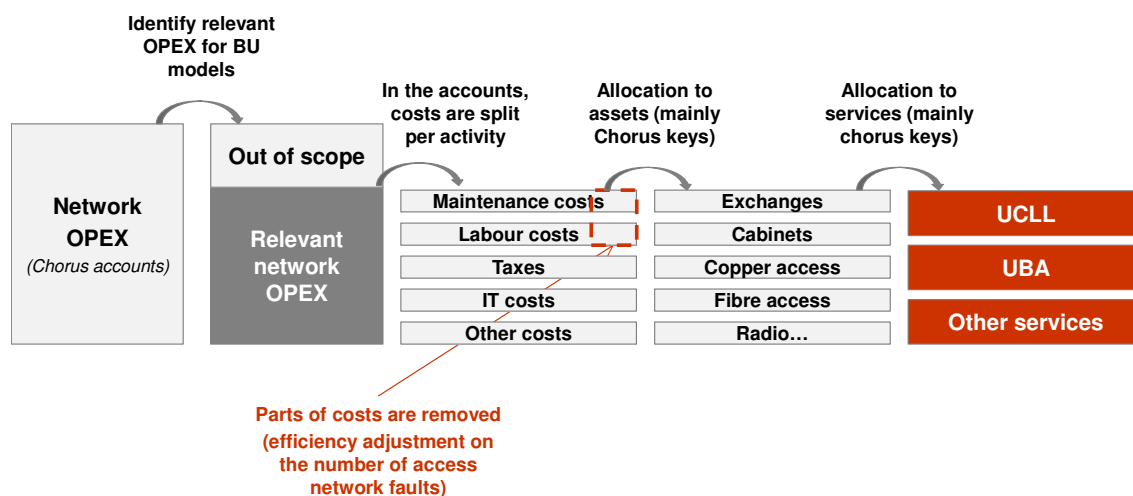
The opex modelling is mainly based on Chorus' 2014 financial accounts except IT costs. Expenses related to network expenses have been distinguished from expenses related to "non-network" expenses.

Chorus provided separately network opex and non-network opex files. However, for some costs, this categorization has been reviewed in order to take into account all costs.

As a consequence, the following steps are followed in the Opex model (see the figure below):

- Identify the relevant network opex for the network cost models;
- Allocate these costs between the different services, regulated and unregulated, by splitting those operating expenses to the different equipment;
- Adjust top-down costs to reflect relevant costs for a bottom-up (BU) modelling;
- Identify the relevant non-network opex for the BU model and allocate those costs to the different relevant services;
- Calculate specific costs (indirect capex) that are inputs for the core network cost model.

Figure 7 – Model opex approach



Source: TERA Consultants

Once costs are allocated to equipment, they are then allocated to the different regulated services using a routing matrix (see Table 21).

This section is made of three main parts:

- presentation of the reference files;
- presentation of the inputs spreadsheets;
- presentation of the calculation spreadsheets;
- presentation of outputs spreadsheets.

3.1 Reference files

The model (“2014-20-DB-ML-ComCom-OPEX model”) is comprises one Microsoft Excel file.

All inputs provided by Chorus and used in the model are gathered in the “INPUT” sections. Chorus’ accounts used in the Opex model are accounts for the year to June 2014 except for IT costs that are derived from the accounts for the year to June 2013 (as 2014 figures have not been provided).

The following table describes how the data provided during the data collection have been used to derive the inputs of the model:

Table 1 – Opex model reference files

| File reference | Content | Usage |
|----------------|---|--|
| 6.19.6 | Fixed Asset Register | “FAR” spreadsheet |
| - | Chorus detailed accounts | “Accounts” spreadsheet |
| 6.13 | Number of faults | “LFI” spreadsheet |
| - | Buildings valuation | “Buildings valuation” spreadsheet |
| 6.18.12 | Square meters of MDFs | “Buildings Info” spreadsheet |
| 6.6.1 | Buildings information | “Buildings Info2” spreadsheet |
| 3.1.2 | Floor space information | “Floor space” spreadsheet |
| 6.19.1 | Count of staff and associated gross personnel costs (GPC) | “1. Staff” spreadsheet |
| 6.19.1 | Detailed GPC per team | “Detailed staff” spreadsheet |
| 6.19.1 | Clarification of core network technicians team | “FurtherPayCostInfo” spreadsheet |
| 6.19.2 | Council rates | “2. Rates and taxes” spreadsheet |
| 6.19.3 | Maintenance costs | “3.a. Maint Summary”, “3.a. Maint Exchange”, “3.a. Maint Chorus Net”, “3.a. FurtherInfoRadio”, “3.a. Maint Alcatel”, “3.a. Project i”, “3.a. Project ii”, “3.a. Project iii”, “3.a. Project iv” spreadsheets |
| 6.19.3.a.v | IT network expenses | “3.a IT” spreadsheet |
| 6.19.3.b (i) | Labour costs | “3.b Labour” spreadsheet |
| 6.19.3.b (ii) | Provisioning costs | “3.b Provisioning” spreadsheet |
| 6.19.3.b (iii) | Network maintenance summary | “3.b Network maint” spreadsheet |
| 6.19.3.b (iv) | Rents and rates related to network expenses | “3.b Rates & Rent”, “3.b Rates & Rent bis” spreadsheets |

| File reference | Content | Usage |
|----------------|---|--------------------------------------|
| 6.19.3.b (v) | Property maintenance costs | “3.b Property maint” spreadsheet |
| 6.19.3.b (vi) | Electricity costs | “3.b Electricity” spreadsheet |
| 6.19.3.b (v) | Insurance costs | “3.b Insurance” spreadsheet |
| 6.19.3.b (v) | Others costs related to network expenses | “3.b Other costs” spreadsheet |
| 6.19.4.ii | IT costs (non-network operations) | “4.IT” spreadsheet |
| 6.19.4.iii | Insurance costs (non-network operations) | “4.Insurance” spreadsheet |
| 6.19.4.iv | Consultants (non-network operations) | “4.Consultants” spreadsheet |
| 6.19.4.iv | Rents and rates (non-network operations) | “4.Rent and rates” spreadsheet |
| 6.19.4.i | Labour costs (non-network operations) | “4.Labour” spreadsheet |
| 6.19.4.vi | Property maintenance (non-network operations) | “4.Property maintenance” spreadsheet |
| 6.19.4.vii | Electricity (non-network operations) | “4.Electricity” spreadsheet |
| 6.19.4.vii | Others (non-network operations) | “4.Other” spreadsheet |

Source: TERA Consultants

3.2 Inputs

The Opex model is fed by five types of input sheets:

- parameters;
- buildings data;
- network expenses data;
- non-network expenses data;
- others type of data (accounts, etc.)

These types of spreadsheets are described in the following sections.

3.2.1 Parameters

This sheet contains the main parameters of the model.

The main parameters are:

- the year of the modelling;
- the type of maintenance costs that are used in the modelling (project opex⁵);
- the inclusion of rents related to microwaves;
- the inclusion of network IT costs;
- the surface occupied by a rack (that comes from the core network cost model);
- the financial parameters (WACC);
- the parameters used to calculate the building valuations (asset life, price trend, type of costs included);
- the parameters used to calculate opex trends;
- the targeted line fault index used in the model to calculate maintenance costs.

3.2.2 Buildings data

Four sheets provide information on the buildings:

Table 2 – Buildings sheets

| Sheet | Description |
|---------------------|---|
| Buildings Valuation | Evaluation of exchanges properties |
| Missing sites | Information of sites that were missing in the other files |
| Buildings Info | Evaluation of exchange square meters |
| Buildings Info2 | Information on the owner of each exchange (Spark or Chorus) |

Source: TERA Consultants

3.2.3 Network expenses data

The following sheets provide information on the network expenses data.

⁵ “Project OPEX” are specific large maintenance work such as the replacement of an entire cable. “Project OPEX” is the terminology used by Chorus.

Table 3 – Network opex sheets

| Sheets | Description |
|--------------------|---|
| 1. Staff | Headcount of the different teams |
| Detailed staff | Detailed account on staff |
| FurtherPayCostInfo | Detailed labour costs information |
| 2. Rates & Taxes | Rates and taxes paid by Chorus |
| 3.a Maint Summary | Summary of maintenance costs |
| 3.a Maint Exchange | Maintenance costs related to exchanges |
| 3.a Maint Alcatel | Maintenance costs done by Alcatel |
| 3.a Project i | Summary of different project opex |
| 3.a Project ii | Detailed cost of project opex |
| 3.a Project iii | Summary of other project opex |
| 3.a Project iv | Detailed cost of project opex |
| 3.a IT | Detailed costs of IT related to network |
| 3.b Labour | Detailed costs of staff related to network operations |
| 3.b Provisioning | Details costs related to provisioning services |
| 3.b Network maint | Summary of network maintenance costs |
| 3.b Rates & Rent | Rates & rents related to network operations |
| 3.b Property maint | Property maintenance opex |
| 3.b Electricity | Information about electricity consumption and price |
| 3.b Insurance | Detailed cost of insurance regarding network operations |
| 3.b Other costs | All others costs related to network operations |
| IT costs details | Allocation of IT costs to services |

Source: TERA Consultants

3.2.4 Non-network expenses data

The table below summarises the sheets relating to non-network opex.

Table 4 – Non-network opex sheets

| Sheets | Description |
|-------------------|---|
| 4. IT | Detailed costs of IT related to non-network |
| 4. Insurance | Detailed cost of insurance regarding non-network operations |
| 4. Consultants | Detailed cost of consultants (network and non-network) |
| 4. Rent and rates | Rates & rents related to non-network operations |
| 4. Labour | Detailed costs of staff related to non-network operations |
| 4. Property maint | Property maintenance opex |
| 4. Electricity | Information about electricity consumed for non-network properties |
| 4. Other | All others costs related to non-network operations |

Source: TERA Consultants

3.2.5 Other types of data

Some other sheets are present in the model and related to the distribution of lines per MDF for example.

Table 5 – Other sheets

| Sheets | Description |
|----------------------|--------------------------------------|
| Distribution per MDF | Distribution of active lines per MDF |
| Inputs – Forecasts | Number of lines forecast |
| Model | Description of the model sheet |
| Lists | Lists used in the model |
| MDF Lists | List of MDFs used in the Opex model |

Source: TERA Consultants

3.3 Calculations

The Opex model comprises calculation, allocation, analysis and costing spreadsheets:

- Maint allocation (allocation spreadsheet);
- Property maint allocation (allocation spreadsheet);
- Pay cost allocation (allocation spreadsheet);
- Rent & Taxes allocation (allocation spreadsheet);
- Energy allocation (allocation spreadsheet);
- IT allocation (allocation spreadsheet);

- Other costs (allocation spreadsheet);
- LFI analysis (analysis spreadsheet);
- FAR analysis (analysis spreadsheet);
- Buildings analysis (analysis spreadsheet);
- Alloc key (allocation spreadsheet);
- Costs summary (costing spreadsheet);
- Results (costing spreadsheet).

The following sheets comprise two parts: the first part deals with network opex and the second one with non-network opex:

- Property maint allocation;
- Rent & Taxes allocation;
- Energy allocation;
- IT allocation;
- Other costs allocation.

3.3.1 Maintenance allocation

Chorus provided different files regarding maintenance network opex. Each file deals with a specific issue. This part of the document describes each type of cost and points out reprocessing that has been done.

Maintenance activities are mainly operated by contractors. Chorus provided different files related to maintenance costs. The model retains this organisation in the Microsoft Excel sheet related to maintenance costs.

3.3.1.1 Chorus maintenance costs

Chorus maintenance costs are divided into two main cost items: contractors' (including both labour and materials) and overhead costs.

A few cost categories are not considered as relevant maintenance costs in the file provided by Chorus. Those costs are either related to non-relevant services for the modelling (baseband service for example) or related to customer network maintenance (maintenance not done on Chorus' networks).

The table below summarises costs that are not taken into account and the reason why they are not in the column "Commentary".

Table 6 - Costs not relevant in Chorus maintenance costs

| Code | Description | Commentary |
|------|--|--------------|
| [] | Inside Fault (Telehousing/Collocation) | Out of scope |

| | | |
|-----|--|-------------------------------|
| [] | [] CNZRI CMAR (Customer Multi Access Radio) maintenance (1 yearly) | Baseband service ⁶ |
| [] | [] CNZRI CMAR configuration backup and time setting (3 monthly) | Baseband service |
| [] | [] CNZRI digital microwave maintenance (twelve monthly) | Baseband service |
| [] | [] CNZRI DMR links maintenance (12 Monthly) | Baseband service |
| [] | Mobile [] CNZRI External Alarms Cell Sites (12 Monthly) | Customer maintenance |
| [] | Mobile [] CNZRI Air Filters | Customer maintenance |
| [] | [] CNZRI Proactive Maintenance on Paging Transmitter site (12 Monthly) | Customer maintenance |
| [] | [] CNZRI Mobile Equipment Sites & Shelters Safety And General Inspection (12 MONTHLY) | Customer maintenance |
| [] | Wind Generation System []CNZRI for Air-X and Ampair Wind Generators | Customer maintenance |

Source: TERA Consultants

Chorus' overhead maintenance costs depend on the amount of the different costs presented below (Chorus maintenance contracts include a % of contractor overhead fees). In order to reflect disregarded costs, they have been apportioned over the amount of relevant costs (see sheet "Maint allocation"; "Allocation of Chorus maintenance costs" and "with overhead" section).

3.3.1.2 Engineering services costs

Engineering services costs are maintenance costs related to Exchange buildings. Those costs deal with maintenance of items such as air conditioning, switchboards, etc.

All engineering services costs have been considered as relevant for network opex.

3.3.1.3 Alcatel Lucent specific costs

Alcatel service fee charges are related to the ALU Network Operations Centre Services (NOC) and are made of different costs that are all relevant for the modelling.

⁶ The OPEX model aims at calculating the OPEX cost of the copper local loop. As a consequence, "baseband" service specific costs are disregarded.

3.3.1.4 Project opex

“Project OPEX” are specific maintenance costs, related to large maintenance works. For example, the replacement of a total cable is considered as an “OPEX project”.

In the case of a newly built network, these material works are unlikely. As a consequence, project opex are disregarded.

3.3.1.5 Other maintenance costs

Four types of costs comprise the “other maintenance costs” category. Not all of those costs are relevant for the modelling.

The table below presents costs that are not relevant.

Table 7 – Costs not relevant for other maintenance costs

| Code | Description | Commentary |
|-----------|------------------------------|----------------------------|
| [] | Customer Network – overheads | Customer maintenance costs |
| [] | Customer Network | Customer maintenance costs |
| [] CNZRI | NMR - Customer Network | Customer maintenance costs |

Source: TERA Consultants

3.3.2 Property maintenance allocation

3.3.2.1.1 Network expenses

Property maintenance relates to costs incurred to maintain Chorus’ network property. Property maintenance costs deal either with electricity or building maintenance costs. They are differentiated in order to calculate the cost of electricity per MWh and the cost of building per square meter. Indeed, those costs have to be taken into account in various types of costs:

- cost of buildings that is an input to the core network cost model;
- cost of building for co-location;
- cost of electricity that is an input to the core network cost model;
- cost of electricity for co-location.

A unit cost per MWh and a unit cost per square meter are derived from those costs. The following table summarizes this implementation.

Table 8 – Property maintenance cost allocation

[] CNZRI

Source: TERA Consultants

3.3.2.1.2 Non-network expenses

All the costs related to non-network expenses within the property maintenance cost category are considered as relevant in the modelling. As a consequence, no part of this cost category is disregarded.

3.3.3 Labour costs allocation

Chorus provided four files dealing with labour costs. Two of those files detail the calculation of the net personnel costs. These costs include salary costs, contractor costs, holiday pay, bonuses and commissions, allowances. These costs exclude capitalised labour as this is already accounted for in the Capex model (installation costs)..

3.3.3.1 Chorus allocation of labour costs

Chorus provided a split of labour costs into the following categories:

- management and professional services;
- finance, payroll, human resources and administration;
- sales and marketing;
- general customer services, and customer services technical support;
- network design and planning, and network operations including and network engineers required for the access network;
- network design and planning, and network operations including and network engineers required for the core platforms;
- access network technicians;
- core network technicians;
- other.

The following section describes the labour cost allocation approach.

3.3.3.2 Chorus data reprocessing

The first step consists in allocating the different labour costs between network and non-network expenses. The second step specifies the proportion of network labour costs related to maintenance, provisioning, IT or “network build” operations.

The table below provides the allocation of each labour cost.

Table 9 – Pay costs

| Description | Commentary |
|--|--------------------------|
| Management and professional services | Non-network labour costs |
| Finance, payroll, human resources and administration | Non-network labour costs |
| Sales and marketing | Non-network labour costs |

TSLRIC price review determination for the Unbundled Copper Local Loop and Unbundled
Bitstream Access services
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| | |
|---|---|
| General customer services, and customer services technical support | Allocation between maintenance, provisioning and non-network expenses. (details below) |
| Network design and planning, and network operations including and network engineers required for the access network | This cost is not taken into account in the OPEX modelling but it is an input to the Capex model as it is related to networks assets installation |
| Network design and planning, and network operations including and network engineers required for the core platforms | Non-network labour costs |
| Access network technicians | This cost is not taken into account in the OPEX modelling but it is an input to the Capex model as it is related to networks assets installation (network deployment) |
| Core network technicians | Allocation between maintenance, provisioning and non-network expenses. (details below) |
| Other | A part of this cost is allocated to building treatments. Others are allocated to non-network expenses. (details below) |

Source: TERA Consultants

In order to provide the relevant cost for maintenance, Chorus provides a detailed file of labour costs and a file that details the “core network technicians” allocation.

The following tables detail the allocation of the different teams.

Table 10 – Details of general customer services

| Code | Description | Allocation |
|-----------|----------------------|---|
| [] CNZRI | GM customer services | Allocated to the teams below on a pro-rata basis (The cost of the general manager is allocated to other sub-categories) |
| [] CNZRI | Customer operations | Non-network labour costs |
| [] CNZRI | Service Delivery | Provisioning labour costs |

| | | |
|-----------|--|---|
| [] CNZRI | Co-location and customer | Co-location labour costs |
| [] CNZRI | Operational excellence | Non-network labour costs |
| [] CNZRI | Provisioning Customer Services | Provisioning labour costs |
| [] CNZRI | [] CNZRI | Provisioning labour costs |
| [] CNZRI | Assure Customer Services | Maintenance labour costs (only related to access network) |
| [] CNZRI | Customer Service Commercial Arrangements | Non-network labour costs |

Source: TERA Consultants

Table 11 - Details of core network technicians

| Code | Description | Allocation |
|-----------|--|--|
| [] CNZRI | Head of NGA | Provisioning labour costs |
| [] CNZRI | Field Services – Operations | Maintenance and provisioning labour costs |
| [] CNZRI | FS Commercial Arrangements | Non-network labour costs |
| [] CNZRI | Field Services – Regional – North | Maintenance, provisioning and “build network” labour costs |
| [] CNZRI | Field Services – Regional – Auckland | Maintenance, provisioning and “build network” labour costs |
| [] CNZRI | Field Services – Regional – Wellington | Maintenance, provisioning and “build network” labour costs |
| [] CNZRI | Field Services – Regional – South | Maintenance, provisioning and “build network” labour costs |

Source: TERA Consultants

In order to distribute core network technicians’ labour costs to the categories, Chorus data is used. [] CNZRI. This allocation is used to allocate the total amount of each team to the relevant categories.

Costs relevant to “building network” cost are added to labour costs that are inputs to the core and access network cost models.

Table 12 – Details of other costs

| Code | Description | Allocation |
|------------|-------------------------|--|
| [CNZRI | Property Infrastructure | Specific treatment: allocation to network building costs. This cost is used to calculate the cost per square meter and the co-location costs |
| [CNZRI | Corporate Property | Non-network costs |
| [CNZRI | [] CNZRI | Non-network costs |

Source: TERA Consultants

3.3.4 Rent & Taxes allocation

3.3.4.1 Network expenses

3.3.4.1.1 Taxes

Taxes considered in this section are taxes related to buildings, water, etc. For the avoidance of doubts, corporate taxes are not included within this section (these are captured when depreciation is performed in the Capex model).

All tax payments provided by Chorus are taken into account in the calculation of OPEX.

Chorus provided an allocation of taxes to the following services: UCLL, UBA, other services.

3.3.4.1.2 Rents

Two GL codes are related to rents in Chorus' accounts.

- [] CNZRI, T2 property charges represents the OPEX portion of payments made to Spark under the exchange property sharing arrangements. This entire amount is used in the model.
- [] CNZRI is related to other rents used for the network (exchanges, microwaves sites, land mobile, electricity cables, etc.).
 - The total amount related to exchange or cabinet rent is taken into account in the modelling.
 - All amounts related to CMAR and land mobiles are out of scope (as they relates to legacy networks).
 - Amounts related to railways crossing, telecommunication cables and electricity cables are taken into account.
 - Amounts related to microwave site rents can be used or not in the OPEX modelling. An option in the 'parameter' sheet is available (these are taken into account in the base case).

Figure 8 – Microwave site rent option

[] CNZRI

Source: TERA Consultants

3.3.4.2 Non-network expenses

All the costs related to non-network rent expenses are identified as relevant costs in the modelling (i.e. no costs are disregarded). Examples of these are office rental, equipment costs, rental building costs and rental of car parks.

3.3.5 Energy allocation

Electricity costs are made of a fixed part (Chorus Line Charges, Smart Power Management costs for example) and a variable part depending on the network's power consumption which was provided by Chorus with a associated spot price.

Those amounts are used to calculate a price per MWh. It is an input for the core network cost model and an input to calculate the electricity co-location price.

3.3.6 IT allocation

Chorus provided two files regarding IT costs: one related to IT network operating expenses and the other related to IT non-network operating expenses.

For network operating expenses, Chorus has provided a list of all its IT platforms and has specified for each one whether it is directly⁷ related to UCLL and/or UBA services, indirectly⁸ related to UCLL and/or UBA services or not linked⁹ to UCLL and/or UBA services.

On this basis, the following rules have been used:

- “Direct” systems have been fully allocated to UCLL and/or UBA. In case the system is “direct” for both UCLL and UBA, an allocation is made based on the number of lines.
- “Indirect” systems have first been allocated between regulated and unregulated services based on the “revenue allocation key” (see §3.3.12.3.2). The part

⁷ Direct: systems/costs that are those that:

- are directly associated with the service, i.e. are used directly in the provision of the service (e.g. relevant network assets);

- are used by business processes which support the service or assets used in the provision of the service (e.g. service assurance systems, network management systems); or

- maintain information about the service or assets used in provision of the service (e.g. logical and physical inventories).

⁸ Indirect: systems/costs that are those that are necessary to operate the Chorus business but are not directly used to support UCLL and UBA services

⁹ No linkage: systems/costs that are not associated with the specific service, but are used to support other services provided by Chorus.

allocated to regulated services has then been allocated to UCLL and UBA as for the “direct” systems.

- Costs related to “no linkage” systems have not been allocated to UCLL and UBA.

Non-network IT expenses have been allocated based on an EPMU approach (with the “revenue allocation key” - see §3.3.12.3.2).

3.3.7 Other costs

3.3.7.1 Network expenses

Other costs are divided into three categories: insurance, consultant costs and other costs.

The table below summarises insurance costs that have been excluded.

Table 13 – Costs not relevant for insurance costs

| Code | Description | Commentary |
|------|-------------|----------------------------------|
| [] | [] | Financial insurance, not network |
| | [] CNZRI | Financial insurance, not network |

Source: TERA Consultants

The table below summarises other costs that have been excluded. All costs related to third party networks have been disregarded.

Table 14 – Costs not relevant for other costs

| Code | Description | Commentary |
|------|-------------|--|
| [] | [] | Out of scope: fibre cost (mainly core product) |
| [] | [] | Out of scope |
| [] | [] | Out of scope |
| [] | [] | Out of scope |
| [] | [] | Project opex already counted |
| [] | [] | Project opex (disregarded) |
| [] | [] | Capitalised of 450286 which is not used |
| [] | [] | Cost already counted in the maintenance costs (engineering services) |
| [] | [] | Cost already counted in the maintenance costs (engineering services) |
| [] | [] | Cost already counted in the maintenance costs (engineering services) |
| [] | [] | Cost already counted in the maintenance costs (engineering services) |
| [] | [] | Cost already counted in the maintenance costs (engineering services) |
| [] | [] | Cost already counted in the maintenance costs (engineering services) |
| [] | [] | Cost already counted in the maintenance costs (engineering services) |
| [] | [] | Out of scope: business equipment |
| [] | [] CNZRI | Not material |

Source: TERA Consultants

The following table details the allocation of other costs used in the model. Costs can be allocated to maintenance costs, exchange costs, co-location costs or non-network costs.

Table 15 – Details of other costs

| Code | Description | Allocation |
|------|-------------|-----------------------------------|
| [] | [] | Non-network cost |
| [] | [] | Non-network cost |
| [] | [] | Maintenance and provisioning cost |
| [] | [] | Maintenance and provisioning cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance and provisioning cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance and provisioning cost |
| [] | [] | Maintenance and provisioning cost |
| [] | [] | Maintenance and provisioning cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance cost |
| [] | [] | Co-location cost |
| [] | [] | Co-location cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance cost |
| [] | [] | Maintenance cost |
| [] | [] | Non-network cost |

| | | |
|-----|-----------|------------------|
| [] | [] | Non-network cost |
| [] | [] | Maintenance cost |
| [] | [] | Non-network cost |
| [] | [] | Maintenance cost |
| [] | [] | Exchange cost |
| [] | [] | Non-network cost |
| [] | [] | Maintenance cost |
| [] | [] | Non-network cost |
| [] | [] | Maintenance cost |
| [] | [] | Non-network cost |
| [] | [] CNZRI | Non-network cost |

Source: TERA Consultants

Maintenance costs are allocated to the different assets.

Consultants costs related to network are taken into account as well as network expenses.

3.3.7.2 Non-network expenses

All the costs related to non-network rents expenses are identified as relevant costs in the modelling except financial charges (bank charges, foreign exchange gains and losses, brokerage) that fall out of the scope of the TSLRIC modelling.

3.3.8 LFI analysis

This sheet aims at summarising the number of Chorus copper active lines and the line fault index (LFI) per 100 lines per MDF from 2009 to 2013.

It enables to calculate the LFI (%) for each MDF.

3.3.9 FAR (Fixed Asset Register) analysis

This sheet aims at calculating two different costs:

- Investment costs that are not modelled in access and core network cost models: some of relevant costs are not modelled in network costs models and have to be taken into account in the modelling. Hence they are taken into consideration on a top-down approach using the FAR inputs;
- Investment costs that need to be used for the co-location price calculation.

3.3.9.1 Indirect capex – inputs for the Core model

In addition to network costs modelled in the access network cost model and in the core network cost model, an operator faces other investments that are not modelled. They are named “Indirect Capex” and have to be allocated to the different services in the core network cost model.

Two types of indirect capex are included:

- IT costs indirect capex; and
- miscellaneous indirect capex.

The IT cost includes hardware and software costs related to customer services, network, billing platforms, network management platforms, VoIP/Voice platforms, Information system platforms, etc.

The Miscellaneous indirect capex include costs related to office equipment, furniture, tools and plants, and motor vehicles.

The table below summarises the costs used.

Table 16 – Costs retained for indirect capex

| Code | Description | Commentary |
|------|-------------|------------------------------|
| [] | [] | Miscellaneous indirect capex |
| [] | [] | Miscellaneous indirect capex |
| [] | [] | Miscellaneous indirect capex |
| [] | [] | Miscellaneous indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
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| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |

| | | |
|-----|-----------|-------------------|
| [] | [] | IT indirect capex |
| [] | [] | IT indirect capex |
| [] | [] CNZRI | IT indirect capex |

Source: TERA Consultants

3.3.9.2 Costs relevant for co-location costs

The electricity price for co-location has to include the cost of air conditioning equipment, battery equipment, etc.

For the UCLL and UBA prices, those costs are modelled in the Core model. Hence, there is no need to take it into account in the indirect capex categories.

The table below summarises indirect capex relevant for the co-location electricity price.

Table 17 – Relevant costs for co-location electricity price

| Code | Description | Commentary |
|------|-------------|----------------------------|
| [] | [] | Electricity indirect capex |
| [] | [] CNZRI | Electricity indirect capex |

Source: TERA Consultants

3.3.10 Building analysis

3.3.10.1 Approach

The “building analysis” sheet is used to calculate an average rental price per square meter for exchange buildings.

The starting point is the list of 720 exchanges of the Capex model. For each of them, it is necessary to derive the annual cost and the corresponding surface (in square meters) in order to calculate a unit cost (NZD per square meter).

There are two types of sites:

- sites that are rented from Spark or another company;
- sites that are owned by Chorus.

Chorus provided different files that enable to have information about the exchange square meters.

The amount paid by Chorus for rented sites has been described in the section 3.3.4.1.2.

For sites that are owned by Chorus, a yearly cost is derived by the valuation of the exchange (knowing the associated square meters, the price trend, the asset life and the WACC).

3.3.10.2 Implementation

The first table summarises the following information per MDF:

- the code of the MDF;
- the name of the MDF;
- the number of the MDF;
- information about the owner of the MDF (it can be Chorus, Telecom or NA (no information));
- the type of building (the type of building provides information about the floor space);
- the number of square meters of the MDF (we have aggregated information from two files¹⁰);
- the valuation of property fit outs¹¹;
- the valuation of buildings;
- the valuation of the land.

The last column of the table calculates the annual charge per square meter based on the valuation provided in the input files.

The following cases can be found:

- 641 sites owned by Chorus and for which the investment of property fit outs, buildings and land is known (a rented cost is calculated on the basis of depreciation formulas);
- 47 sites owned by Chorus and for which the land valuation is unknown (a rented cost is calculated based on property fit outs and buildings valuations). The cost of the land is assumed to be equal to the cost of rented sites related to exchanges and detailed in the previous section;
- 29 sites are owned by Telecom and the cost of rent is detailed in previous sections.

Once the different costs are calculated, an average cost per square meter can be calculated.

Table 18 – Building analysis

[] CNZRI

¹⁰ The two files that can provide the information are: 20140605_Confidential_Q 6.17.15-20 floor-racks and 20140822_Confidential_Q 3.1.2 (c) Floor Space Allocation

¹¹ Furniture within the building

3.3.11.1.2 Exchanges

As it is described in Figure 9, exchanges buildings can host different network equipment. Given they are used for different services, exchanges costs need to be allocated between the different equipment.

Two allocation keys are calculated for exchange buildings: one related to “active equipment” and one related to “passive equipment” (general building maintenance, cleaning). These two allocation keys are detailed hereafter.

Passive equipment

Passive costs are related to proactive building maintenance costs for example. Those costs are allocated to all equipment installed in Exchange buildings.

The allocation key is based on the floor surface occupied by the MDFs, the DSLAMs, the first level of EAS and the remaining level of EAS. Those data are coming from the core and the access network cost models. Given that only the first level of EAS is modelled, it is supposed that all EAS occupy the same floor surface.

Figure 10 – Exchanges allocation key

[] CNZRI

Source: TERA Consultants

Active equipment

Costs which deal with “active equipment” are mainly costs related to DSLAMs, Ethernet switches, etc. Those costs are not allocated to the MDF part of the Exchange, because the MDF is passive equipment. Hence, all costs related to air conditioning, air filters are allocated with this key.

The “active” allocation key is calculated on a pro-rata basis of the “passive” allocation key, between the first level of EAS and the remaining level of EAS.

Figure 11 – Passive and active allocation keys

| Maintenance | Unit | Exchange | | |
|-------------------|------|----------|----------------------------|------------------------------|
| | | MDF | DSLAM & First level of EAS | Remaining EAS & Others Equip |
| Exchange | | | | |
| Passive equipment | % | 54% | 41% | 5% |
| Active equipment | % | 0% | 89% | 11% |

Source: TERA Consultants

3.3.11.1.3 Cabinets

Regarding costs of Chorus maintenance, Chorus provided the allocation between active and passive cabinets. However, for other maintenance costs, this allocation is not provided and the following section describes the approach that has been used.

Two types of cabinets coexist in the network: active and passive cabinets. Active cabinets contain active equipment such as DSLAMs for example.

In the model, cabinets are split into two categories: “DSLAM & Active Equipment” and “Passive Equipment”.

Costs related to passive equipment are allocated on a pro-rata basis of the number of active and passive cabinets.

Figure 12 – Active cabinet allocation key

| Maintenance | Unit | Cabinet | |
|-------------------|------|------------------------|-----------------|
| | | DSLAM & Active Equipmt | Passive Equipmt |
| Cabinet | | | |
| Passive equipment | % | 65% | 35% |
| Active equipment | % | 100% | 0% |

Source: TERA Consultants

Costs related to active equipment are fully allocated to the “DSLAM & Active Equipment” category.

3.3.11.1.4 Copper Access

As described in the network figure above, the copper access is made of two parts: the D-Side/Lead-in part and the Feeder part. Costs related to copper access maintenance costs have to be allocated among those two parts.

The allocation key is calculated on a pro-rata basis of the km-pairs used for the distribution (D-Side) on the one hand and the Feeder on the other hand (see Figure 16). This information is derived from the access network cost model.

Figure 13 – Copper access allocation key

| Copper access allocation key | Unit | Copper Access | |
|------------------------------|------|---------------|----------------|
| | | Feeder | D-Side/Lead-in |
| Inputs | | | |
| Length of km-pairs | m | 3,419,249 | 5,577,083 |
| Allocation key | | | |
| Allocation key | % | 38% | 62% |

Source: TERA Consultants

3.3.11.1.5 Fibre Access

The aim of the Opex model is to assess the opex of a copper line. As a consequence, fibre access costs are disregarded.

Opex for the fibre scenario as discussed in §8.2.

3.3.11.1.6 Radio links

Some costs are related to radio links.

The model assumes the radio links can be used for the feeder, the core links related to the UBA services and other core links (e.g. links between other levels of EAS). Chorus provided two types of allocation regarding radio costs:

- costs related to feeder only (100% allocated to the feeder category);
- costs related to a mix of core, feeder and distribution links (in absence of information, it is assumed that 50% of this mix is related to UBA links and 50% to other core links).

Figure 14 – Radio links allocation key

| Radio | | | | | | |
|--------------------------------|---|------|----|-----|-----|--|
| Mix core, feeder, distribution | % | 0% | 0% | 50% | 50% | |
| Feeder only | % | 100% | 0% | 0% | 0% | |

Source: TERA Consultants

3.3.11.2 Property maintenance costs

All property maintenance costs are allocated to exchanges.

3.3.11.3 Taxes

Rates are allocated to UCLL and UBA services thanks to an allocation key provided by Chorus for those specific costs.

3.3.11.4 Labour costs related to core network technicians

Labour costs related to core network technicians are distributed among maintenance costs, provisioning costs and building costs.

3.3.12 Costs summary

This sheet summarises all the costs described in the previous section. The objective of the sheet is to allocate relevant opex amount to UCLL and UBA services.

Three main activities are performed in this sheet:

- adjustment of top-down figures to reflect relevant costs for a replacement cost modelling;
- allocation of network opex;
- allocation of non-network opex (other costs are treated as well in this section).

3.3.12.1 Adjusting top-down figures to reflect relevant costs for a replacement cost modelling

3.3.12.1.1 General approach

The level of fault (LFI) within Chorus network is not necessarily representative of the LFI of a recently built network and has to be benchmarked.

Maintenance costs mainly vary with the number of line faults occurring in the access network. To estimate an efficient level of costs, **maintenance costs can be adjusted by using an ‘efficiency factor’**. This factor can be defined as “Efficiency Adjustment”.

3.3.12.1.2 Focus on LFI

A targeted LFI is used to adjust the level of maintenance costs. Details of the value that is used are described in the annex of this document.

3.3.12.2 Network opex

The part related to network opex is divided into two sections:

- costs allocated to equipment (all costs except rates¹² and IT costs);
- costs allocated to services (only rates and IT costs).

3.3.12.2.1 Costs allocated to equipment

Two tables summarise those costs: one related to maintenance costs only and one related to other costs.

For each cost category, the “efficiency adjustment” column determines whether the cost category should be adjusted with the efficiency factor or not.

It has to be noted that maintenance costs are allocated per MDF. This allocation is done on a pro-rata basis of the number of faults per MDF.

Figure 19 – Maintenance costs summary

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Source: TERA Consultants

The same type of table summarises Labour costs, rents, insurance costs, etc.

Figure 20 – Costs summary (except maintenance costs)

[] CNZRI

Source: TERA Consultants

Once all the different costs are allocated, the model uses a routing table to select costs that are relevant to each service.

The total cost per service per year can then be derived.

The table below presents the costs used for the different services. (When the value is one, it means the cost of the equipment is allocated to the service)

¹² “Rates” refer in the current document to taxes (land & water rates, land rates,...) see sheet “Rent&Taxes allocation”

Table 21 – Routing table

| Type | Equipment | UCLL Copper | UBA |
|---------------|----------------------------|-------------|-----|
| Exchange | MDF | 1 | - |
| | DSLAM & first level of EAS | - | 1 |
| | Remaining EAS | - | - |
| Cabinet | DSLAM & active equipment | - | 1 |
| | Passive equipment | 1 | - |
| Copper Access | Feeder | 1 | - |
| | D-Side/Lead-in | 1 | - |
| Fibre Access | Feeder | - | - |
| | D-Side/Lead-in | - | - |
| Radio | Copper Feeder | 1 | - |
| | Fibre Feeder | - | - |
| | UBA only | - | 1 |
| | Others | | |
| Others | - | - | - |

Source: TERA Consultants

Given the number of copper active lines and the number of UBA lines, costs can be allocated and a maintenance cost per month per line is derived.

Figure 22 – Maintenance costs summary

[] CNZRI

Source: TERA Consultants

3.3.12.2.2 Costs allocated to services

As described in the previous parts of this document, costs are allocated either per equipment or per service. Major parts of costs are allocated per equipment as explained in the previous section. Only rates and IT costs have been allocated by Chorus per service.

Figure 23 – Cost allocated per service

[] CNZRI

Source: TERA Consultants

The same approach as the one described in the previous section is used to calculate a cost per line per month.

3.3.12.3 Non-network opex (other costs are treated as well in this section)

This section of the document aims at describing the methodology used to take into account non-network costs in the modelling.

3.3.12.3.1 Non-network costs summary

The following table summarises the different non-network costs used in the Opex model:

- Labour costs not related to maintenance, provisioning or building activities;
- property maintenance costs of non-network buildings;
- rent of non-network buildings;
- corporate electricity cost;
- non-network insurance and consultants costs;
- other costs network and non-network costs (as it is described in previous section, costs that are not allocated to services or equipment are treated as non-network costs).

Figure 24 – Non-network costs summary

[] CNZRI

Source: TERA Consultants

Those non-network costs are allocated to different services in the Opex model:

- regulated services (UCLL and UBA);
- co-location services;
- ancillary charges services.

3.3.12.3.2 Revenue allocation key

Chorus provides a file that includes all the revenues. These can be used as a proxy for costs as costs are not allocated to services within Chorus accounts.

On this list, only revenues of relevant services (modelled services) are considered to calculate the non-network cost total amount related to the modelling.

Three allocation keys are calculated to allocate non-network costs.

Table 25 – Revenue used for the different services

| Services | Revenues used |
|-------------------|---|
| UCLL and UBA | Basic Copper revenue, Enhanced Copper revenue |
| Co-location | Infrastructure revenue |
| Ancillary charges | Field services revenue |

Source: TERA Consultants

78% of non-network costs are allocated to UCLL and UBA. 1.8% and 3.7% of non-network costs are respectively allocated to co-location and ancillary charges.

Once the amount related to non-network costs for UCLL and UBA services is calculated, it is allocated between the two services with an EPMU approach based on the total opex of each service. Knowing the number of lines for UCLL and UBA, an opex amount per line per month is derived.

The table below summarizes those calculations.

Table 26 – Non-network cost allocated to UCLL and UBA

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Source: TERA Consultants

3.4 Outputs

Two sheets can be qualified as “outputs” sheets:

- Results sheet;
- EXPORT sheet.

3.4.1 Results

The results sheet is divided into three main parts. The first part deals with the final calculation of opex per line per service. The second part summarises the network planning labour costs and the last one calculates costs of co-location.

3.4.1.1 Opex per line

Costs that are calculated in the “Cost summary” sheet are copied in this spreadsheet and allocated to the MDF.

The end of the first table in this spreadsheet parts analyses the part of each cost in the total opex amount per MDF and per line for the year 2014 to 2019. Results can be updated by clicking on the “update” macro button.

3.4.1.1.1 Maintenance costs

The UCLL maintenance cost total amount is allocated per MDF on a pro-rata basis of the number of faults per MDF. By contrast the UBA total amount related to maintenance costs is equally distributed per line for all MDFs.

3.4.1.1.2 Non-maintenance costs

Non-maintenance costs and non-network costs are not distributed per MDF and are equally distributed on the total number of lines.

3.4.1.1.3 Other costs for core network cost model

The cost per MWh for electricity is copied in this spreadsheet.

The cost of building per square meter is provided in this spreadsheet as well and divided into three parts: the average building cost per square meter, the property maintenance cost related to building and the labour costs that deal with property infrastructure.

3.4.1.1.4 Indirect capex for core network cost model

Indirect capex summarised in the table are capex from the fixed asset register that are not modelled in the network cost models but needs to be included.

3.4.1.2 Network planning costs

The table summarises costs related to the design and the construction of the access network. It is an output for the core network cost model as these are related to the network deployment.

3.4.1.3 Co-location costs

3.4.1.3.1 Approach

The previous section describes how the cost of electricity per MWh and the cost of building per square meter are calculated. Those two amounts are used in the core network cost model.

In order to calculate co-location costs, non-network costs, labour costs and other costs related to co-location have to be added to the costs previously calculated. Those costs

are allocated between electricity and building costs on a pro-rata basis of the total amount of building costs related to co-location and the total amount of electricity costs related to co-location. The proportion of costs related to co-location is calculated on the basis of co-location floor space required per MDF (The same allocation key is used for electricity and building).

In addition to those costs, some indirect capex have to be taken into account in the electricity co-location cost. Those indirect capex are not used for the cost per MWh that is provided to the core network cost model because they are modelled directly in the core network cost model.

3.4.1.3.2 Implementation

The last table of the Results spreadsheet provides calculations for co-location costs. Hence, electricity co-location costs is made of the cost of the MWh previously calculated, the part of indirect capex related to power equipment and the part of miscellaneous non-network costs.

Figure 15 – Co-location costs

[] CNZRI

Source: TERA Consultants

3.4.2 EXPORT

This sheet contains the outputs of the Opex model to the Core model. Results are provided on a yearly basis from 2015 to 2019.

In order to fill and update results, a macro has been made. By clicking on the button “fill”, results will be updated.

4 Dimensioning the access network

This section covers the methodology implemented in the Microsoft Access component of the access network cost model, dealing with the dimensioning of the access network and producing as output inventories of the assets of the access network.

Each of the inventories corresponds to a different scenario:

- Full overhead copper network;
- Full underground copper network;
- Full overhead fibre network;
- Full underground fibre network.

The split between overhead and underground is then determined in the Excel model (see section 5).

A glossary provides definitions of the terminology used.

4.1 Reference files

The access network input file gathers all the necessary data for the dimensioning, from network roll-out rules (e.g. number of copper cable pairs/fibres per dwelling) to physical characteristics of the assets used (e.g. diameter of cables).

Those inputs are mainly used in the VBA routine that performs the dimensioning.

In the following table,

- The file reference is the index of the issue (as indexed in the data request to Chorus) to which the data collection provided by Chorus in their data submissions;
- Content summarises the question asked and the answer provided;
- Usage indicates where the input is used.

Table 27 - Reference files

| File reference | Content | Usage |
|----------------|---|---|
| 6.14.1.e.v | Average and maximum distance between poles | “SOURCE_PARAMETERS_COMMON” table |
| 6.14.1.e.iv | Location of manholes in the local access network | “SOURCE_PARAMETERS_COMMON” table |
| 6.14.1.f | Technical characteristics of the copper and fibre cables used in the local access network | “SOURCE_INVENTORY_COPPER” and “SOURCE_INVENTORY_FIBRE” tables |
| 6.14.1.e.i | Number of pairs and fibres per premise | “SOURCE_PARAMETERS_COPPER” and “SOURCE_PARAMETERS_FIBRE” tables |
| 6.12.c | Service lead-in allocation | “SOURCE_PARAMETERS_COPPER” and “SOURCE_PARAMETERS_FIBRE” tables |

Source: TERA Consultants

4.2 Inputs

The access network model is fed by geospatial data:

- “SOURCE_SECTIONS and SOURCE_BUILDINGS” provide data regarding respectively individual sections (e.g. the geotype of the section¹³, the length of the section, whether the section is distributed through a FWA site, to which MDF the section is linked, to which SC¹⁴ the section is linked) and individual buildings (e.g. length of the dedicated path from the road to the building, whether the building is on the right or left side of the section);
- “SOURCE_MDF_SC_PATHS”, “SOURCE_MDF_BUILDING_PATHS”, “SOURCE_SC_BUILDING_PATHS” provide the ID of the shortest paths between, respectively, MDF, MDF and street cabinet, and street cabinet, building and building. It also provides the location (section) of both ends of the path and, in the “SOURCE_MDF_SC_PATHS” table, whether the street cabinet is active or passive.

Furthermore, it shall be noted that, in the “SOURCE_SC_BUILDING_PATHS” table, ID_SC includes MDF IDs as some sections are directly to the MDF: the MDF is then considered as a street cabinet.

Those three tables are the output of the geospatial work;

¹³ The geotype of the section may differ from the geotype of its MDF as, in this table, the geotype is based on the Corelogic definitions of urban and rural areas.

¹⁴ Including MDF IDs when the distribution cable links directly the section to the MDF.

- “SOURCE_DETAILED_MDF_SC_PATHS”, “SOURCE_DETAILED_MDF_BUILD_PATHS”, “SOURCE_DETAILED_SC_BUILDING_PATHS” provide the detailed paths of the aforementioned paths, i.e. all the sections taken by each path, sorted from the start (MDF, street cabinet) to the end (street cabinet, building). As the non-detailed paths, those three detailed tables are the output of the geospatial work;
- “SOURCE_CORE” lists all the sections shared with the core network (inter-EAS network and Exchange-to-first data switch network) and indicates whether the section is connected through fibre, microwave or submarine link. It should be noted that the paths followed by the core links are not Chorus’ actual paths as these paths have been optimised;
- “SOURCE_FWA” provides the location (section) of the fixed wireless access sites.

And by input parameters:

- “SOURCE_PARAMETERS_COMMON” provides the shared parameters, in particular civil engineering parameters (e.g. diameters of ducts, distance between poles);
- “SOURCE_PARAMETERS_COPPER” provides the parameters that are specific to the copper network, in particular regarding the copper cable terminals design rules, the number of pairs per dwelling or the surpluses to be added to copper cables;
- “SOURCE_PARAMETERS_FIBRE” is the equivalent of “SOURCE_PARAMETERS_COPPER” for the fibre network;
- “SOURCE_INVENTORY_COPPER” provides data regarding the copper cables used in the copper network (number of pairs, external diameter, drum length);
- “SOURCE_INVENTORY_FIBRE” is the equivalent of “SOURCE_INVENTORY_COPPER” for the fibre network.

4.2.1 Geospatial data

The geospatial data describes the network section by section and provides:

- Section-specific features: lengths, locations of buildings;
- Shortest paths from sections to network nodes (MDF, cabinets);
- Location of assets on the sections.

It should be noted that the geospatial data does not include the GPS coordinates of the sections.

4.2.1.1 Source sections

The ‘SOURCE_SECTIONS’ table provides data regarding individual sections.

Table 28 - Description of the "SOURCE_SECTIONS" table

| Field | Description |
|-------|-------------|
|-------|-------------|

| Field | Description |
|-----------------|--|
| ID_SECTION | Unique ID of each section |
| LENGTH | Length of the section in meters |
| ID_MDF | ID of the MDF in which the section is located |
| ID_SC | ID of the SC in which the section is located |
| URBAN | If the section is urban then "True", otherwise, i.e. the section is rural, "False" |
| SOIL | Type of soil: "1", "2", "3", "4" or "5" when rural, "town" when urban |
| ROADWIDTH | Width of the road |
| SERVED_BY_FWA | In the fibre network, whether the section is distributed through point-to-point fibre cable ("False") or by fixed wireless access ("True") |
| MW_SITE | Number of Microwave sites on the section |
| DWDM_SITE | Number of DWDM sites on the section |
| LANDING_STATION | Number of submarine landing sites on the section |
| TSO | Whether Chorus can benefit from subsidies for the access network roll-out on the section ("False" if so, "True" otherwise) |

Source: TERA Consultants

4.2.1.2 Source buildings

The 'SOURCE_BUILDING' table provides data regarding individual section.

Table 29 - Description of the "SOURCE_BUILDINGS" table

| Field | Description |
|-------------------|---|
| ID_BUILDING | Unique ID of each building |
| NB_TOTAL | Number of dwellings inside the building |
| ID_SECTION | Unique ID of each section |
| HORIZONTAL_LENGTH | Length in meter of the horizontal part of the lead-in |
| VERTICAL_LENGTH | Length in meter of the vertical part of the lead-in, from the building to the road |
| RIGHT_SIDE | Whether the building is on the side of the section hosting the majority of buildings ("major side") |

Source: TERA Consultants

4.2.1.3 Source MDF to street cabinets paths

The "SOURCE_MDF_SC_PATHS" provides the start and end sections of the paths from the MDF to street cabinets.

This table is used to retrieve the paths of the copper cables in the feeder level on the local access network.

Table 30 - Description of the "SOURCE_MDF_SC_PATHS" table

| Field | Description |
|----------------|-----------------------|
| ID_PATH_MDF_SC | Unique ID of the path |
| ID_MDF | ID of the MDF |
| ID_SC | ID of the SC |

| Field | Description |
|----------------|---|
| NB_OF_SECTIONS | Number of sections required to link the MDF and the SC together |
| SC_SECTION_ID | ID of the section on which the MDF is located |
| MDF_SECTION_ID | ID of the section on which the SC is located |
| ACTIVE_CABINET | Whether the street cabinet is active or passive |

Source: TERA Consultants

4.2.1.4 Source MDF to buildings paths

The “SOURCE_MDF_BUILDING_PATHS” provides the start and end sections of the paths from the MDF to buildings.

This table is used to retrieve the paths of the fibre cables (in the fibre network and in the FWA network).

Table 31 - Description of the "SOURCE_MDF_BUILDING_PATHS " table

| Field | Description |
|----------------------|---|
| ID_PATH_MDF_BUILDING | Unique ID of the path |
| ID_MDF | ID of the MDF |
| NB_OF_SECTIONS | Number of sections required to link the MDF and the building together |
| BUILDING_SECTION_ID | ID of the section on which the building is located |
| MDF_SECTION_ID | ID of the section on which the MDF is located |

Source: TERA Consultants

4.2.1.5 Source street cabinets to buildings paths

The “SOURCE_SC_BUILDING_PATHS” provides the start and end sections of the paths from the street cabinets to the buildings.

This table is used to retrieve the paths of the copper cables in the distribution level of the access network.

Table 32 - Description of the "SOURCE_SC_BUILDING_PATHS" table

| Field | Description |
|---------------------|--|
| ID_PATH_SC_BUILDING | Unique ID of the path |
| ID_SC | ID of the street cabinet |
| NB_OF_SECTIONS | Number of sections required to link the street cabinet and the building together |
| SC_SECTION_ID | ID of the section on which the street cabinet is located |
| BUILDING_SECTION_ID | ID of the section on which the building is located |

Source: TERA Consultants

4.2.1.6 Source MDF to street cabinets detailed paths

The “SOURCE_DETAILED_MDF_SC_PATHS” provides the detailed path from the MDF to street cabinets.

This table is used to retrieve the paths of the copper and fibre cables in the feeder level of the copper network.

Table 33 - Description of the "SOURCE_DETAILED_MDF_SC_PATHS" table

| Field | Description |
|----------------|--|
| ID_PATH_MDF_SC | Unique ID of the path |
| SECTION_NUMBER | Index of the section within the path (starting from the MDF to the SC) |
| ID_SECTION | ID of the section crossed by the path |
| ID_MDF | ID of the MDF |

Source: TERA Consultants

4.2.1.7 Source MDF to buildings detailed paths

The "SOURCE_DETAILED_MDF_BUILD_PATHS" provides the detailed path from the MDF to buildings.

This table is used to retrieve the paths of the fibre cables (in the fibre network and in the FWA network).

Table 34 - Description of the "SOURCE_DETAILED_MDF_BUILD_PATHS" table

| Field | Description |
|----------------------|--|
| ID_PATH_MDF_BUILDING | Unique ID of the path |
| SECTION_NUMBER | Index of the section within the path (starting from the MDF to the building) |
| ID_SECTION | ID of the section crossed by the path |
| ID_MDF | ID of the MDF |

Source: TERA Consultants

4.2.1.8 Source street cabinets to buildings detailed paths

The "SOURCE_DETAILED_SC_BUILDING_PATHS" provides the detailed path from the street cabinets to the buildings.

This table is used to retrieve the paths of the copper cables in the distribution level of the access network.

Table 35 - Description of the "SOURCE_DETAILED_SC_BUILDING_PATHS" table

| Field | Description |
|---------------------|---|
| ID_PATH_SC_BUILDING | Unique ID of the path |
| SECTION_NUMBER | Index of the section within the path (starting from the SC to the building) |
| ID_SECTION | ID of the section crossed by the path |
| ID_SC | Id of the street cabinet |

Source: TERA Consultants

4.2.1.9 Source core

The "SOURCE_CORE" table provides where the inter-EAS and Exchange-to-FDS links are located and what type of links are used.

Table 36 - Description of the "SOURCE_CORE" table

| Field | Description |
|---------------|--|
| ID_SECTION | ID of the section where an Exchange-to-DSLAM or inter-EAS link is deployed. The ID appears several times in case several cables or links are on the same section |
| NETWORK_LEVEL | Whether inter-exchange ("CoreExchange") or inter-EAS ("CoreEAS") |
| TYPE_OF_LINK | Type of link: microwave, submarine, DWDM or fibre |

Source: TERA Consultants

4.2.1.10 Source FWA

The "SOURCE_FWA" table provides where the FWA sites are located.

This table is combined with the "SOURCE_MDF_BUILDING_PATHS" and "SOURCE_DETAILED_MDF_BUILD_PATHS" tables to obtain the path of the FWA fibre cables from the exchange (optical data frame co-located with the main data frame) to the FWA site.

Table 37 - Description of the "SOURCE_FWA" table

| Field | Description |
|----------|---|
| FWA_SITE | ID of the section where the FWA site is located |

Source: TERA Consultants

4.2.2 Input parameters

The input parameters are gathered in the five tables aforementioned:

- "SOURCE_PARAMETERS_COMMON";
- "SOURCE_PARAMETERS_COPPER";
- "SOURCE_PARAMETERS_FIBRE";
- "SOURCE_INVENTORY_COPPER";
- "SOURCE_INVENTORY_FIBRE";

"SOURCE_PARAMETERS_COPPER" and "SOURCE_PARAMETERS_FIBRE" are very similar: the two tables contain similar if not identical parameters, with different parameter values. However, as the levels of networks and the implementation of design rules may differ in the two scenarios, those two tables are not identical.

The input parameters are the parameters that TERA have used in the model. [JCNZRI

Table 38 - "SOURCE_PARAMETERS_COMMON" table

| ID | Unit | Parameter Value | Description |
|-------------|------|-----------------|---|
| Duct110Diam | mm | 110 | External diameter of ducts used for local access and core network |
| Duct50Diam | mm | 50 | External diameter of ducts used for lead-in |

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| ID | Unit | Parameter Value | Description |
|----------------------------|------|-----------------|--|
| DuctInefficiency110 | % | 0.4 | 40% of the 110 mm duct surface (set by the ext diameter) is not filled, 60% is filled |
| DuctInefficiency50 | % | 0.4 | 40% of the 50 mm duct surface (set by the ext diameter) is not filled, 60% is filled |
| SubductDiam | mm | 32 | External diameter of subducts, in which fibres are protected, used for fibre cables and filled in ducts 110 |
| Poleheight | m | 4.5 | Height of Poles |
| MaxSpanUrban | m | 65 | Distance between two poles in urban areas |
| MaxSpanRural | m | 100 | Distance between two poles in rural areas |
| DistanceManhole | m | 100 | Distance between two manholes (limited by drum length and pulling in tension limits) |
| ActivateLeadinThreshold | | 0 | When 1, non-standard lead-in is not dimensioned. When 0, all lead-in assets are dimensioned |
| LeadinThreshold | m | 100 | Above 100 m in vertical length, the building is deemed non-standard |
| ActivateTSO | | 1 | When 1, only areas inside the TSO-derived boundary are dimensioned for the access network. When 0, the nationwide network is dimensioned |
| IncurredLeadinRural | % | 88.0% | Share of section-specific lead-in assets incurred by Chorus when lead-in threshold is activated (in rural areas) |
| IncurredLeadinUrban | % | 98.4% | Share of section-specific lead-in assets incurred by Chorus when lead-in threshold is activated (in urban areas) |
| PeakThroughputperCustomer | kbps | 250 | Peak throughput per FWA customer |
| PeakThroughputperFWASector | kbps | 16 666 | Peak throughput per FWA cell |

Source: TERA Consultants

Table 39 - "SOURCE_PARAMETERS_COPPER"

| ID | Unit | Parameter Value | Description |
|----------------------------------|-------|-----------------|---|
| CuSurplusOHETP | M | 3 | Cable surplus at ETP |
| CuSurplusUGETP | M | 3 | Cable surplus at ETP |
| CuSurplusOHCCT | M | 3 | Cable surplus at distribution point |
| CuSurplusUGCCT | M | 3 | Cable surplus at distribution point |
| CuSurplusOHJoint | M | 3 | Cable surplus at joints |
| CuSurplusUGJoint | M | 3 | Cable surplus at joints |
| CuSurplusOHSC | M | 3 | Cable surplus at street cabinet |
| CuSurplusUGSC | M | 3 | Cable surplus at street cabinet |
| CuSurplusOHMDF | M | 3 | Cable surplus at MDF |
| CuSurplusUGMDF | M | 3 | Cable surplus at MDF |
| CuCurvatureOHLeadIn | % | 0.5% | Curvature factor in Lead-In |
| CuCurvatureUGLeadIn | % | 0.5% | Curvature factor in Lead-In |
| CuCurvatureOHDistr | % | 1% | Curvature factor in Local Distribution |
| CuCurvatureUGDistr | % | 1% | Curvature factor in Local Distribution |
| CuCurvatureOHFeeder | % | 1% | Curvature factor in Feeder Network |
| CuCurvatureUGFeeder | % | 1% | Curvature factor in Feeder Network |
| AverageToMaxLeadInSurface | % | 60% | On a section, if 2*n cables are led in from a CCT, there is on average 0.6*n cables along the section |
| CuCableLeadIn | # | 1 | # cables per dwelling at the lead-in level |
| CuPairsSDULeadIn | pairs | 2 | # pairs for single dwellings at the lead-in level |
| CuPairsUGMDULeadIn | pairs | 2 | # pairs for UG multidwellings at the lead-in level |
| CuPairsOHUrbanMDULeadIn | pairs | 1.5 | # pairs for aerial multidwellings in urban areas at the lead-in level |
| CuPairsOHRuralMDULeadIn | pairs | 1.33 | # pairs for aerial multidwellings in rural areas at the lead-in level |
| CuSparePairsDistribution | % | 11% | % of spare pairs to add at the distribution level |
| CuSparePairsFeeder | % | 11% | % of spare pairs to add at the feeder level |
| CuMaxOHUrbanLeadInDist | M | 300 | Max distance b/w an aerial distribution point and the CCT in urban areas |
| CuMaxOHRuralLeadInDist | M | 300 | Max distance b/w an aerial distribution point and the CCT in rural areas |
| CuMaxUGUrbanLeadInDist | M | 300 | Max distance b/w a UG distribution point and the CCT in urban areas |
| CuMaxUGRuralLeadInDist | M | 300 | Max distance b/w an UG distribution point and the CCT in rural areas |
| CuMaxOHUrbanLeadInBuildingsMajor | # | 4 | Max number of buildings per aerial distr. point in urban areas |
| CuMaxOHRuralLeadInBuildingsMajor | # | 4 | Max number of buildings per aerial distr. point in rural areas |
| CuMaxOHUrbanLeadInBuildingsMinor | # | 4 | Max number of buildings per aerial distr. point in urban areas |

| ID | Unit | Parameter Value | Description |
|----------------------------------|------|-----------------|--|
| CuMaxOHRuralLeadInBuildingsMinor | # | 4 | Max number of buildings per aerial distr. point in rural areas |
| CuMaxUGUrbanLeadInBuildings | # | 8 | Max number of buildings per UG distr. point in urban areas |
| CuMaxUGRuralLeadInBuildings | # | 8 | Max number of buildings per UG distr. point in rural areas |

Source: TERA Consultants

Table 40 - "SOURCE_PARAMETERS_FIBRE" table

| ID | Unit | Parameter Value | Description |
|------------------------|------|-----------------|---|
| Fcount_FWA | FO | 24 | Fibre count per FWA cable |
| Fcount_Core_DSLAM | FO | 12 | Fibre count per Core_DSLAM cable |
| Fcount_Core_Exchange | FO | 24 | Fibre count per Core_Exchange cable |
| Fcount_Core_EAS | FO | 24 | Fibre count per Core_EAS cable |
| Fcount_LeadIn | FO | 2 | Fibre count per dwelling in Lead-in |
| Fcount_Distr | FO | 1 | Fibre count per dwelling in Distribution |
| FbCoreUGCurvature | % | 0.5% | Curvature factor for underground core cables |
| FbDistrOHCurvature | % | 0.5% | Curvature factor for overhead distribution Cables |
| FbDistrUGCurvature | % | 0.5% | Curvature factor for underground distribution Cables |
| FbLeadInOHCurvature | % | 1% | Curvature factor for overhead lead-in Cables |
| FbLeadInUGCurvature | % | 1% | Curvature factor for underground lead-in Cables |
| FbSurplusOHETP | m | 3 | Cable surplus at ETP |
| FbSurplusUGETP | m | 3 | Cable surplus at ETP |
| FbSurplusOHFAT | m | 8 | Cable surplus at fibre access terminal |
| FbSurplusUGFAT | m | 8 | Cable surplus at fibre access terminal |
| FbSurplusOHJoint | m | 15 | Cable surplus at joints |
| FbSurplusUGJoint | m | 15 | Cable surplus at joints |
| FbSurplusOHMDF | m | 3 | Cable surplus at MDF |
| FbSurplusUGMDF | m | 3 | Cable surplus at MDF |
| FbMaxOHUrbanLeadInDist | m | 300 | Max distance b/w an aerial FAT and the ETP in urban areas |
| FbMaxOHRuralLeadInDist | m | 300 | Max distance b/w an aerial FAT and the ETP in rural areas |
| FbMaxUGUrbanLeadInDist | m | 300 | Max distance b/w a UG FAT and the ETP in urban areas |
| FbMaxUGRuralLeadInDist | m | 300 | Max distance b/w an UG FAT and the ETP in rural areas |

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| ID | Unit | Parameter Value | Description |
|----------------------------------|------|-----------------|---|
| FbMaxOHUrbanLeadInBuildingsMajor | # | 4 | Max number of buildings per aerial FAT in urban areas |
| FbMaxOHRuralLeadInBuildingsMajor | # | 4 | Max number of buildings per aerial FAT in rural areas |
| FbMaxOHUrbanLeadInBuildingsMinor | # | 4 | Max number of buildings per aerial FAT in urban areas |
| FbMaxOHRuralLeadInBuildingsMinor | # | 4 | Max number of buildings per aerial FAT in rural areas |
| FbMaxUGUrbanLeadInBuildings | # | 8 | Max number of buildings per UG FAT in urban areas |
| FbMaxUGRuralLeadInBuildings | # | 8 | Max number of buildings per UG FAT in rural areas |

Source: TERA Consultants

The two source inventory tables provide information about the cables used in the TERA fibre and copper network.

Table 41 - "SOURCE_INVENTORY_COPPER" table

| ID | Pairs | Diameter | Length | Description |
|--------------|-------|----------|--------|-------------------------------------|
| AccessOH0004 | 4 | 15.4 | 500 | 4 pairs aerial copper cable |
| AccessOH0010 | 10 | 20.2 | 500 | 10 pairs aerial copper cable |
| AccessOH0015 | 15 | 20.8 | 500 | 15 pairs aerial copper cable |
| AccessOH0025 | 25 | 24.6 | 500 | 25 pairs aerial copper cable |
| AccessOH0050 | 50 | 24.5 | 500 | 50 pairs aerial copper cable |
| AccessUG0004 | 4 | 6.4 | 1000 | 4 pairs UG copper cable |
| AccessUG0005 | 5 | 6.7 | 500 | 5 pairs UG copper cable |
| AccessUG0007 | 7 | 7.5 | 2000 | 7 pairs UG copper cable |
| AccessUG0015 | 15 | 9 | 1000 | 15 pairs UG copper cable |
| AccessUG0025 | 25 | 13.5 | 2000 | 25 pairs UG copper cable |
| AccessUG0050 | 50 | 15.5 | 1000 | 50 pairs UG copper cable |
| AccessUG0100 | 100 | 21. | 1000 | 100 pairs UG copper cable |
| AccessUG0200 | 200 | 27.2 | 500 | 200 pairs UG copper cable |
| AccessUG0300 | 300 | 27.1 | 500 | 300 pairs UG copper cable |
| AccessUG0400 | 400 | 37.4 | 200 | 400 pairs UG copper cable |
| AccessUG0800 | 800 | 43.8 | 500 | 800 pairs UG copper cable |
| AccessUG2000 | 2000 | 67 | 500 | 2000 pairs UG copper cable |
| LeadinOH0002 | 2 | 8.2 | 300 | 2 pairs lead-in aerial copper cable |
| LeadinOH0004 | 4 | 8.9 | 300 | 4 pairs lead-in aerial copper cable |
| LeadinUG0002 | 2 | 5.6 | 2500 | 2 pairs UG copper cable |

Source: TERA Consultants

Table 42 - "SOURCE_INVENTORY_FIBRE" table

| ID | Pairs | Diameter | Length | Description |
|----|-------|----------|--------|-------------|
|----|-------|----------|--------|-------------|

| ID | Pairs | Diameter | Length | Description |
|--------|-------|----------|--------|------------------|
| Fb0002 | 2 | 5.0 | 2000 | 2F fibre cable |
| Fb0004 | 4 | 5.6 | 2000 | 4F fibre cable |
| Fb0012 | 12 | 8.1 | 2000 | 12F fibre cable |
| Fb0018 | 18 | 10.0 | 2000 | 18F fibre cable |
| Fb0024 | 24 | 7.9 | 6000 | 24F fibre cable |
| Fb0036 | 36 | 10.0 | 6000 | 36F fibre cable |
| Fb0048 | 48 | 7.9 | 6000 | 48F fibre cable |
| Fb0072 | 72 | 10.0 | 6000 | 72F fibre cable |
| Fb0096 | 96 | 10.0 | 6000 | 96F fibre cable |
| Fb0120 | 120 | 12.0 | 6000 | 120F fibre cable |
| Fb0144 | 144 | 10.8 | 4000 | 144F fibre cable |
| Fb0216 | 216 | 13.4 | 4000 | 216F fibre cable |
| Fb0312 | 312 | 16.2 | 4000 | 312F fibre cable |

Source: TERA Consultants

4.3 Calculations

4.3.1 Schematic overview of the local access network

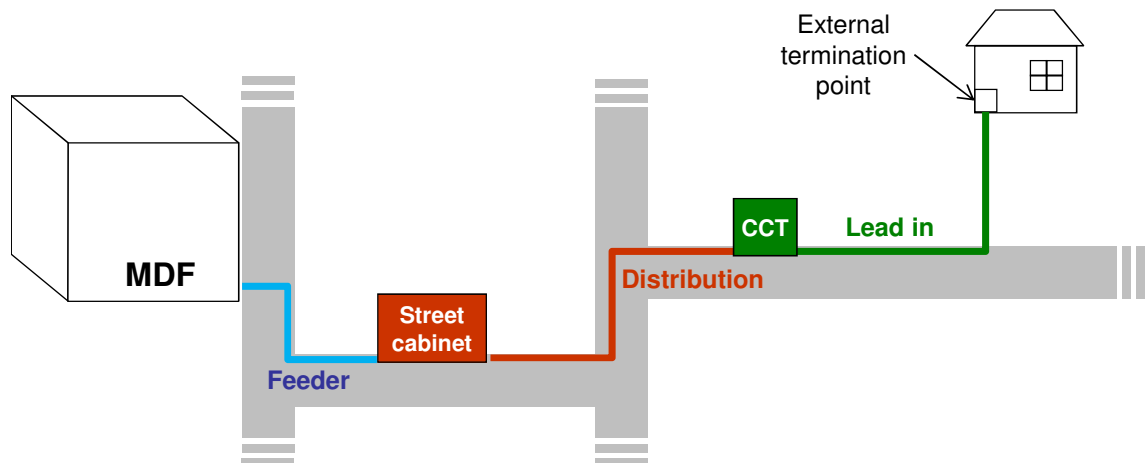
The Access model computes four types of local access networks, from the exchange to the external termination point at the foot of the building:

- Copper overhead network;
- Copper underground network;
- Fibre overhead network;
- Fibre underground network.

In the copper networks, the dwellings are connected:

- From the external termination point (ETP) to a copper cable terminal (CCT) through the lead-in cable;
- From the CCT to a street cabinet through the distribution cable;
- From the street cabinet to the MDF. In some cases, the MDF is used as a street cabinet.

Figure 16 - Overview of the copper access network (whether overhead or underground)

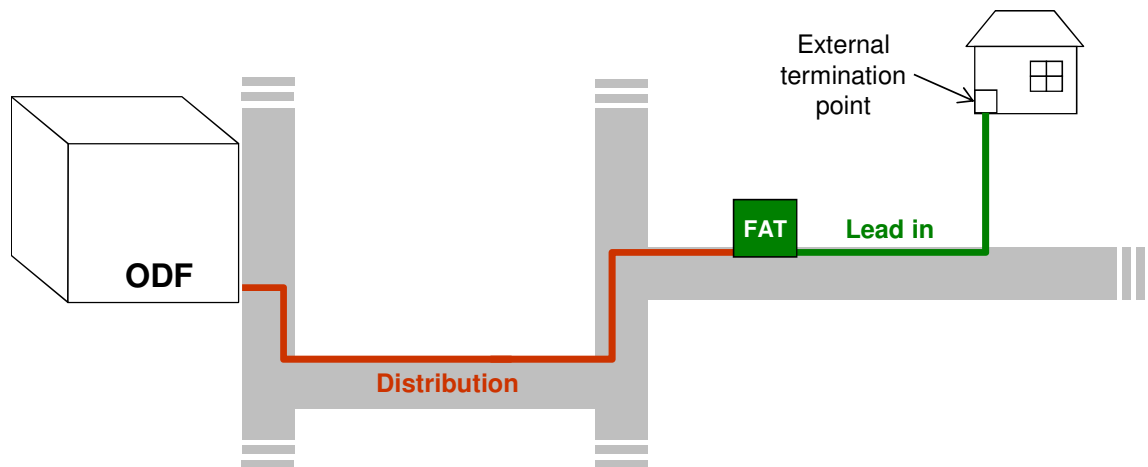


Source: TERA Consultants

In the fibre networks, the dwellings are connected:

- From the ETP to a fibre access terminal (FAT) through the lead-in cable;
- From the FAT directly to the MDF through a distribution cable following the shortest path from the FAT to the MDF.

Figure 17 - Overview of the fibre access network (whether overhead or underground)



Source: TERA Consultants

Furthermore, sections can be shared with cables from the core network and from the fixed wireless access network (FWA). Hence, each section can host on its horizontal part:

- Lead-in cables;
- Distribution cables;
- Feeder cables (in the copper networks);
- Core and FWA cables.

4.3.2 Pre-processing of the geospatial data

4.3.2.1 TSO-derived boundary

As described in attachment J of the Commission’s draft determination for UCLL and attachment H for UBA, the access network can be divided into two areas

- Areas inside the TSO-derived boundary in which it is assumed for the purpose of this modelling that the hypothetical efficient operator would not be able to benefit from any capital contribution for the access network roll-out;
- Areas outside the TSO-derived boundary in which it is assumed that the hypothetical efficient operator would be able to benefit from capital contributions.

As the areas outside the TSO-derived boundary are fully funded, the network capital cost in these areas should not be accounted for.

However, in order to assess the costs of the nationwide network (including areas outside the TSO-derived boundary), the access network must also be modelled for the sections areas outside the TSO-derived boundary.

Thus, the TSO field is replicated into the TSO_ADJUSTED field.

- When the ActivateTSO = 1 (in the table SOURCE_PARAMETERS_COMMON), TSO_ADJUSTED is identical to TSO.
- When ActivateTSO = 0, the field TSO_ADJUSTED is always true: all the sections are taken into account for the network access dimensioning.

The field TSO_ADJUSTED is added onto the table SOURCE_SECTIONS and updated at the very beginning of the modelling.

4.3.2.2 FWA coverage

The table SOURCE_SECTIONS provides for every section the FWA site cell area in which the section is located, in the field “TX_ID” (approximately 1,500 cells, i.e. three cells per FWA site). When the section is outside any FWA cell area, the field is blank.

As detailed in the Model Specification, as the FWA cells have a limited capacity, then FWA coverage is limited to the most expensive lines within the FWA site cell areas and replaces fibre access roll-out for those lines.

The cost per line is calculated through the distance to ODF and the number of lines passing through the section:

$$\text{Cost per line} = \frac{\text{Distance to ODF}}{\text{Number of lines}}$$

An important feature of that cost assessment is that the cost per line on a section is always lower than on its rear area. In rear sections, the distance to the ODF is greater and the number of lines may be smaller.

The selection of the most expensive lines per area is computed within three steps:

- First, the cost estimated by the formula above is assessed and written in the table “PROCESS FWA”;
- Then, the sections are ranked, area by area, in the table “PROCESS FWA RANKED”;
- Finally, the capacity limit is applied in the VBA routine “ShrinkFWACoverage”.

For instance, if the sections i_1, i_2 and i_3

- Contain n_1, n_2 and n_3 dwellings; and
- Have an estimated cost per line c_1, c_2 and c_3 , with $c_1 > c_2 > c_3$;

Then, their associated rank would be $n_1, n_1 + n_2$ and $n_1 + n_2 + n_3$.

The cost per line for each section is computed in the query “SELECT FWA COVERAGE” and written into the table “PROCESS FWA” thanks to the query “FILL PROCESS FWA”.

As the access network roll-out is not incurred by the hypothetical efficient operator outside the TSO-derived boundary, those are not cost optimised with FWA coverage. Hence, only the sections for which the field “TSO_ADJUSTED” is true are included in the table “PROCESS FWA”.

Secondly, the sections are ranked, area by area, and weighted by the number of dwellings belonging to the section, in the query “SELECT FWA COVERAGE ORDERED”.

The sections outside any FWA cell area are excluded from the computation. Those sections are flagged with a blank TX_ID.

The ranking is performed through the SQL sub-query:

RankingTotal: (Select SUM(NB_Total) as Total From [PROCESS FWA] as T Where T.TX_ID=[PROCESS FWA].TX_ID and T.FWA_COST_Score>=[PROCESS FWA].FWA_COST_Score)

Where NB_Total is the number of dwellings per section and FWA_COST_Score the cost assessment computed and written in the table “PROCESS FWA”.

The cost rank is then written in the table “PROCESS FWA RANKED”.

Finally, if the rank of a section within an area falls under the capacity, i.e. belongs to the most expensive sections of the area, then it is served by FWA and the field “SERVED_BY_FWA” in the table “SOURCE_SECTIONS” is updated accordingly, thanks to the VBA routine “ShrinkFWACoverage”

The cell limit is the cell capacity divided by the peak throughput per customer.

4.3.3 Dimensioning the local demand (at the section level)

At first, the local demand at the section level is computed through several queries. The local demand is divided into single dwelling units (SDU) and multi dwellings units (MDU) as the design for copper pairs allocations are different.

4.3.3.1 Local demand at the section level for the copper distribution network

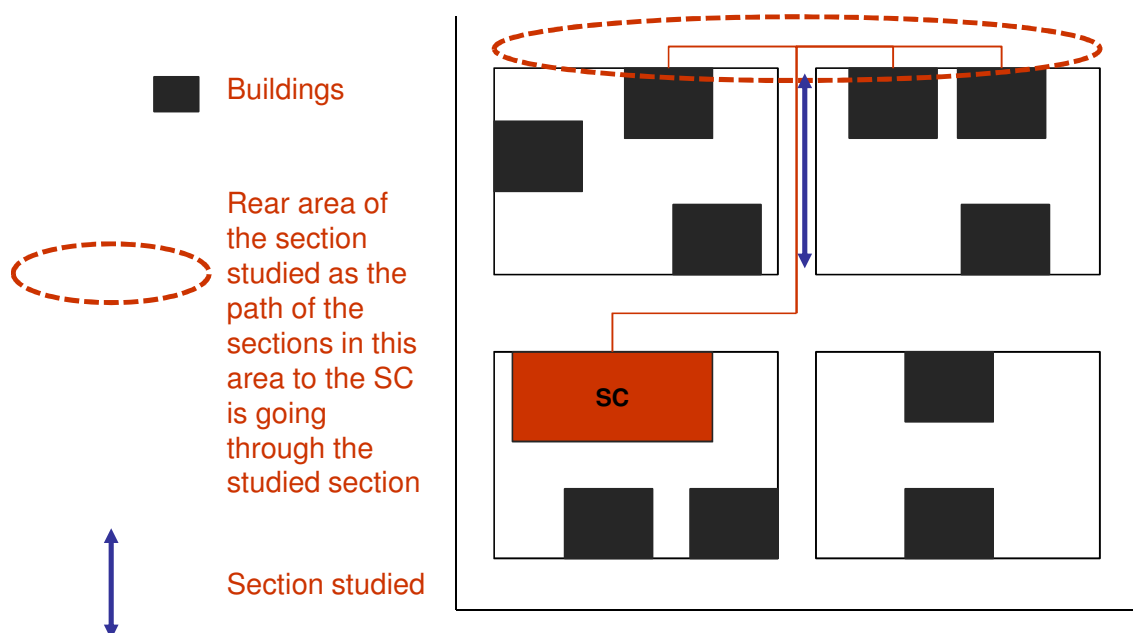
The demand at the section level is made of two components¹⁵:

- The demand of the current section: all the SDU and MDU located on this section; and
- The demand of the rear area of the section: all the lines from SDU and MDU to street cabinets that go through the section (see the next figure).

This demand is addressed through the distribution cable of the major side of the section.

Having computed all the shortest paths required, it is then possible to compute the demand at the section level.

Figure 18 – Demand at the section level



Source: TERA Consultants

These two data (distribution SDU and MDU) are computed through the queries “SELECT NB DISTR DWELLINGS PER SECTION” and “SELECT NB DISTR SDU PER SECTION”. Each of the two queries consists of adding the SDU and MDU of an end-of-path section to every section of the path.

Similarly, when the section is trenched on both sides, a distribution cable is deployed on the minor side and distributes the SDU and MDU of the minor side of the section. Hence, the queries “SELECT NB DWELLINGS ON MINOR PER SECTION” and “SELECT NB SDU ON MINOR PER SECTION” compute the total number of dwellings and the number of SDU on the minor side of each section.

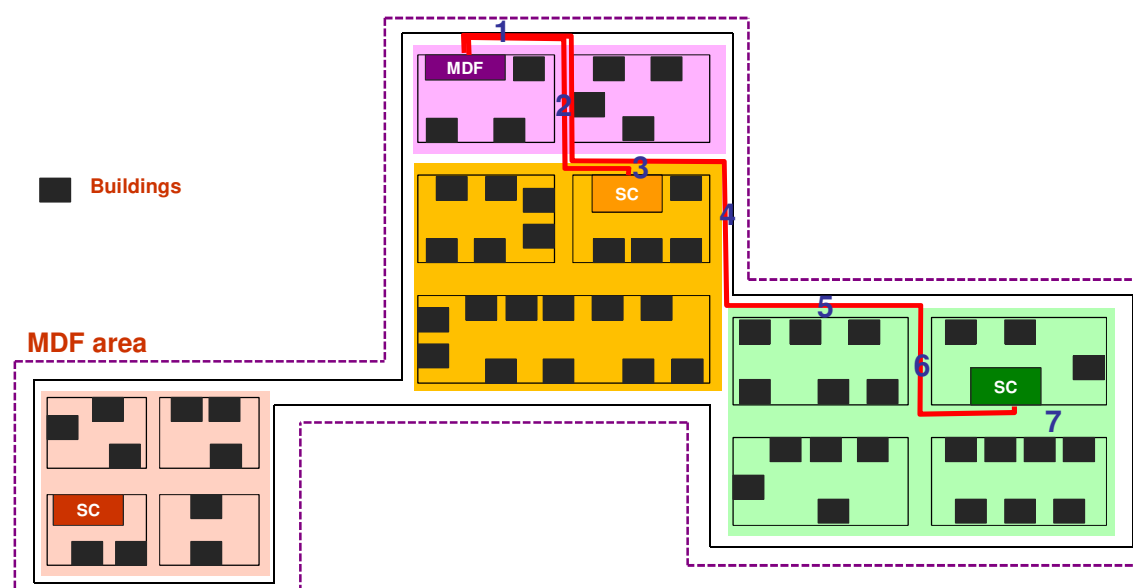
¹⁵ See the Modeling approach in the “Model specification” paper.

4.3.3.2 Local demand at the section level for the copper feeder network

As the dwelling units are distributed from street cabinets, the street cabinets are fed by the MDF of the exchange area.

When a path from an MDF to a street cabinet goes through a section, then a feeder cable that can feed the street cabinet (i.e. the distribution demand of the street cabinet) and the cabinet coverage area goes through the section. This “cabinet coverage area” of the cabinet x represents the potential feeder demand of other street cabinets whose path passes through the section of the street cabinet x .

Figure 19 - MDF and SC coverage areas, and feeder inputs per section



Source: TERA Consultants

The path from the MDF to the green SC passes through the section 3, on which the yellow street cabinet is located. Hence, the feeder demand of the sections 1 to 3 are formed by the distribution demand of the yellow street cabinet and by the distribution demand of the green street cabinet, while the feeder demand of the sections 4 to 7 are formed by the only distribution demand of the green street cabinet.

In a similar way as for the distribution local demand, the feeder demand at the section level is computed using the paths from MDFs to street cabinets and the distribution demand at the sections where street cabinets are located, an output of the aforementioned queries (“SELECT NB DISTR DWELLINGS PER SECTION” and “SELECT NB DISTR SDU PER SECTION”).

The two outputs (feeder SDU and feeder dwellings per section) are computed through the query “SELECT FEEDER INPUTS PER SECTION”.

4.3.3.3 Local demand at the section level for the fibre distribution networks

In the fibre access networks, there is no feeder network but only a distribution network. FATs are directly connected to the exchange (or optical distribution frame, ODF) through the shortest path.

The local distribution demand for the fibre networks is computed similarly to the local distribution demand for the copper networks, with the following differences:

- The relevant paths are those from MDF to buildings;
- The sections served by FWA are excluded from the computation as there is not fibre roll-out for those sections.

Plus, as the design rules for fibre allocations in lead-in make no difference between SDU and MDU, a single output per section, the number of distribution dwellings, is sought. This is made through the query “SELECT FIBRE INPUTS PER SECTION”.

4.3.3.4 Core and FWA network cables on the section

4.3.3.4.1 FWA network cables on the section

The table “SOURCE_FWA” provides the location of all FWA sites. It is assumed FWA sites are connected to the closest exchange, following the shortest path algorithm, through a single fibre cable (24F).

The query “SELECT FWA INPUTS” computes the number of FWA cables on each section. When several FWA sites belong to the same exchange area, it might occur that some sections will host several FWA cables.

In addition, in the fibre access networks (overhead and underground), sections that are distributed through FWA sites are not distributed through fibre, then are withdrawn from the calculation of the aforementioned distribution and feeder local demand.

4.3.3.4.2 DSLAM-to-Exchange core cables on the section

In the copper access networks, when a street cabinet is an active street cabinet, i.e. hosts a DSLAM, it is not fed through a copper cable belonging to the local access network, but through a fibre cable belonging to the core network: the SLU backhaul. The SLU backhauling is referred in the Access and Excel model as the “Core DSLAM” network.

It is assumed the Core DSLAM network uses a 12F fibre cable each time an active street cabinet is fed. Sections that host one or several Core DSLAM cables are computed through the queries “SELECT CORE DSLAM INPUTS” and “SELECT CORE DSLAM INPUTS interim”, using the “SOURCE_MDF_SC_PATHS” and “SOURCE_DETAILED_MDF_SC_PATHS” tables.

As there is no street cabinet in the fibre access networks, the Core DSLAM is not relevant there.

4.3.3.4.3 Exchange-to-First Data Switch core cables on the section

In the copper access networks as well as in the fibre access networks, the table “SOURCE_CORE” lists the sections where core links from the Exchange-to-First Data Switch (“Core Exchange”) and inter-EAS (“Core EAS”) networks are located – as many times as the section hosts a core cable – and whether those links are fibre cables (24F), submarine links or microwave links.

The query “SELECT CORE INPUTS” computes the number of fibre cables from the Core Exchange and Core EAS networks on each section.

4.3.3.4.4 Inter-EAS core cables on the section

This is addressed jointly with “DSLAM-to-Exchange core cables on the section” in paragraph 4.3.3.4.3.

4.3.4 Dimensioning at the building level

4.3.4.1 Overview

This section of the document aims at describing all the rules and assumptions used to dimension the network at the building level.

The number of assets dedicated to a building will depend on the number of dwellings in the building, the section configuration, the engineering rules, the lists of assets available and the parameters of the model, and are computed in the VBA routine “Dimensioning at the building level”, for the four modelled networks (fibre and copper, overhead and underground). The output of the “Dimensioning at the building level” fills the table “PROCESS BUILDING MODELLING”, given key characteristics of the building, recasted from “SOURCE_BUILDINGS” and other tables through Access SQL queries.

The table “PROCESS BUILDING MODELLING” does not include any section in the areas outside the TSO-derived boundary (according to the field TSO_ADJUSTED); as no lead-in asset has to be accounted for those areas.

Plus, when the lead-in threshold is activated (ActivateLeadinThreshold = 1) and when the building is non-standard, i.e. beyond 100 meters, then the lead-in assets are not taken into account for the building.

However, the distribution points and the poles that bear distribution points remain being dimensioned at that level.

Table 43 - Description of the "PROCESS BUILDING MODELLING" table

| Field | Description | How is it filled ? |
|-------------------|--|--------------------|
| ID_BUILDING | ID of the building | Query |
| ID_SECTION | ID of the section on which the building is located | Query |
| HORIZONTAL_LENGTH | Horizontal length, from the beginning of the section to the building | Query |
| VERTICAL_LENGTH | Vertical length, from the road boundary to the building | Query |
| NB_TOTAL | Number of dwellings (incl. business and industrial) | Query |
| RIGHT_SIDE | Is the building located on the major side ("YES" or "NO") | Query |
| ROADWIDTH | Width of the road of the section on which the building is located | Query |
| URBAN | Is the building in Urban or Rural area ("YES" or "NO") | Query |

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| Field | Description | How is it filled ? |
|-----------------------------|---|--------------------|
| NB_BUILDING | Number of buildings on the section on which the building is located | Query |
| NB_BUILDING_MINOR | Number of buildings on the minor side of the section on which the building is located | Query |
| HORIZONTAL_LENGTH_MAX_MINOR | On the minor side, maximum horizontal length on the section (from the beginning of the section to the last building) | Query |
| HORIZONTAL_LENGTH_MIN_MINOR | On the minor side, minimum horizontal length on the section (from the beginning of the section to the first building) | Query |
| HORIZONTAL_LENGTH_MAX_MAJOR | On the major side, maximum horizontal length on the section (from the beginning of the section to the last building) | Query |
| HORIZONTAL_LENGTH_MIN_MAJOR | On the major side, minimum horizontal length on the section (from the beginning of the section to the first building) | Query |
| SERVED_BY_FWA | Whether the building is distributed through an FWA site or through a point-to-point fibre cable (fibre network) | Query |
| LEAD-IN_PAIRS | Number of pairs per dwelling in the lead-in | VBA |
| LEADIN_UG_CABLE_LENGTH_CU | Length of lead-in copper cables dedicated to the building (when underground) | VBA |
| LEADIN_OH_CABLE_LENGTH_CU | Length of lead-in copper cables dedicated to the building (when overhead) | VBA |
| CCT_MINOR | Number of copper cable terminals on the minor side (when underground) | VBA |
| CCT_MAJOR | Number of copper cable terminals on the major side (when underground) | VBA |
| CCT_OH | Number of copper cable terminals on the section (when overhead) | VBA |
| DUCT_LENGTH_CU | Length of lead-in ducts dedicated to the building (copper network) | VBA |
| ONE_TRENCH | Is the section trenched once (Yes) or twice (No) | VBA |
| LEAD-IN_POLES_CU | Number of lead-in poles dedicated to the building (copper network) | VBA |
| LEAD-IN_TRENCH_CU | Length of the lead-in trench dedicated to a building (copper network) | VBA |
| NB_DUCTS_50_CU | Size of the dedicated trench (in multiples of 50 mm ducts) (copper network) | VBA |
| LEAD-IN_FCOUNT | Fibre count per dwelling in the leadin | VBA |
| LEADIN_UG_CABLE_LENGTH_FB | Length of lead-in fibre cables dedicated to the building (when underground) | VBA |
| LEADIN_OH_CABLE_LENGTH_FB | Length of lead-in fibre cables dedicated to the building (when overhead) | VBA |
| FAT_MINOR | Number of fibre access terminals on the minor side (when underground) | VBA |
| FAT_MAJOR | Number of fibre access terminals on the major side (when underground) | VBA |
| FAT_OH | Number of fibre access terminals on the section (when overhead) | VBA |
| DUCT_LENGTH_FB | Length of lead-in ducts dedicated to the | VBA |

| Field | Description | How is it filled ? |
|-------------------|--|--------------------|
| | building (fibre network) | |
| SUBDUCT_LENGTH_FB | Length of lead-in subducts dedicated to the building (fibre network) | VBA |
| LEAD-IN_POLES_FB | Number of lead-in poles dedicated to the building (fibre network) | VBA |
| LEAD-IN_TRENCH_FB | Length of the leadin trench dedicated to a building (fibre network) | VBA |
| NB_DUCTS_50_FB | Size of the dedicated trench (in multiples of 50 mm ducts) (fibre network) | VBA |

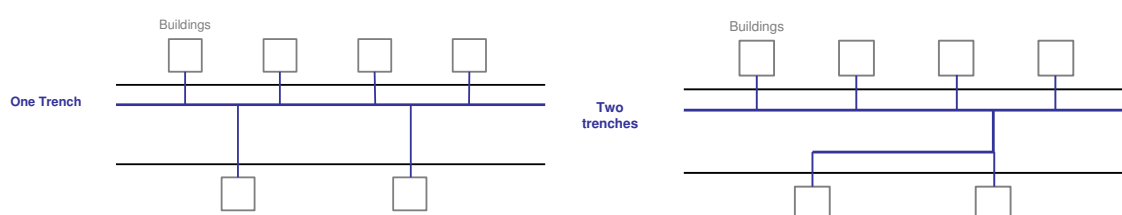
Source: TERA Consultants

4.3.4.2 Major and minor sides

In the underground scenario, the assets that are dedicated to a building (e.g. length of lead-in cable) depend on the position of the distribution points (CCT and FAT), in particular on which side of the section they are located.

Two configurations may appear for the trenches. There can be trenches on one side or on two sides of the section as it is described in the figure below.

Figure 20 - Section configuration



Source: TERA Consultants

The VBA function `IsSectionOneTrench()` computes whether the section is trenched on the major side only or on both sides, by comparing the length of trenches in the two cases:

If $\#Buildings_{Minor} * Width_{Road}$ is greater than $Building Length_{Minor} + Width_{Road}$, where $Building Length_{Minor}$ represents the distance between the first and last buildings on the minor side, then it is cost effective to dig trenches on both sides of the section.

As described in the Model Reference Paper, costs are assumed to be optimised when distances are optimised, i.e. cables between section endpoints follow the shortest path.

In the overhead scenario, it is assumed the distribution cable, hence the CCT/FAT, is located only on the major side of the section.

4.3.4.3 Distribution points (CCT and FAT)

The number of distribution points (CCT when copper, FAT when fibre) depends on the metrics of the section, the number of buildings of the section and whether the section is trenched once or twice.

If the section is trenched once, then there are distribution points on the major side only and the distribution points are dimensioned as if all buildings were on the same side. If not, the distribution points are dimensioned on each side of the section.

The number of distribution points depends on two parameters:

- A maximum length between the distribution point and the building;
- A maximum number of buildings led in by the distribution point.

In the overhead case, the assumed number of distribution points depends on three parameters:

- A maximum length between the distribution point and the building;
- A maximum number of buildings on the major side led in by the distribution point;
- A maximum number of buildings on the minor side led in by the distribution point.

Hence, the number of distribution points is obtained by rounding up to the next integer the maximum of:

- $\text{Building length} / (2 * \text{Max length})$; and
- $\# \text{Building} / \text{Max} \# \text{buildings}$;

with the building length and the number of buildings on the relevant side of the section (or of the whole section).

The number of distribution points is capped by the number of buildings of the section.

$$\#DP = \text{Min}(\#Buildings, \text{Max}(\frac{\text{Building length}}{2 * \text{Max length}}, \frac{\#Buildings}{\text{Max} \# \text{buildings}}))$$

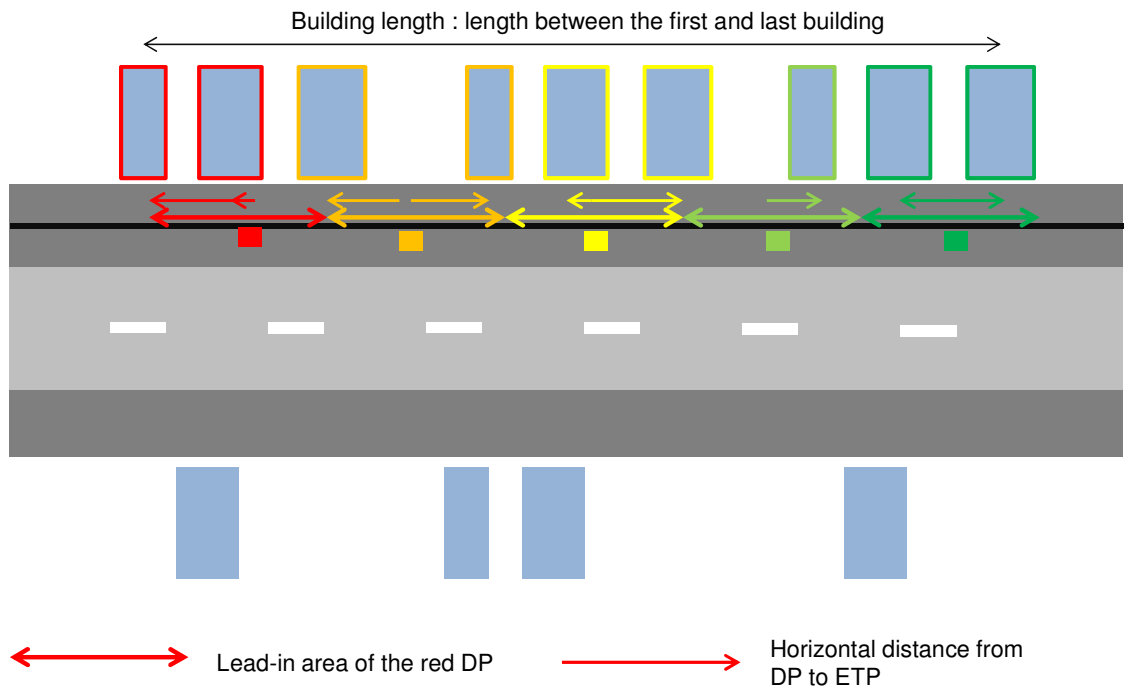
The number of distribution points on the section is computed through the VBA functions GetCCTMajor(), GetCCTMinor(), GetCCTOH(), the interim function GetNbCCTperUGsidewalk(), and GetFATMajor(), GetFATMinor(), GetFATOH() and the interim function GetNbFATperUGsidewalk().

The distribution points are then uniformly distributed along the section, between the first and the last building of the side or section.

The segment between the first and last building is thus divided into distribution point areas (or DP area; CCT in the copper network, FAT in the fibre network): buildings are assigned to a DP area according to their horizontal location, and are led in through the DP of the area, which is located at the centre of the area.

The location of the DP that led in the current building is computed within the VBA function GetLeadInUGOneTrenchCableDist() (and equivalent for overhead – OH – and fibre).

Figure 21 - Location of the distribution points



Source: TERA Consultants

4.3.4.4 Lead-in cable (and joints)

As each dwelling has a dedicated lead-in cable, the number of cables per building is the number of dwellings of the building.

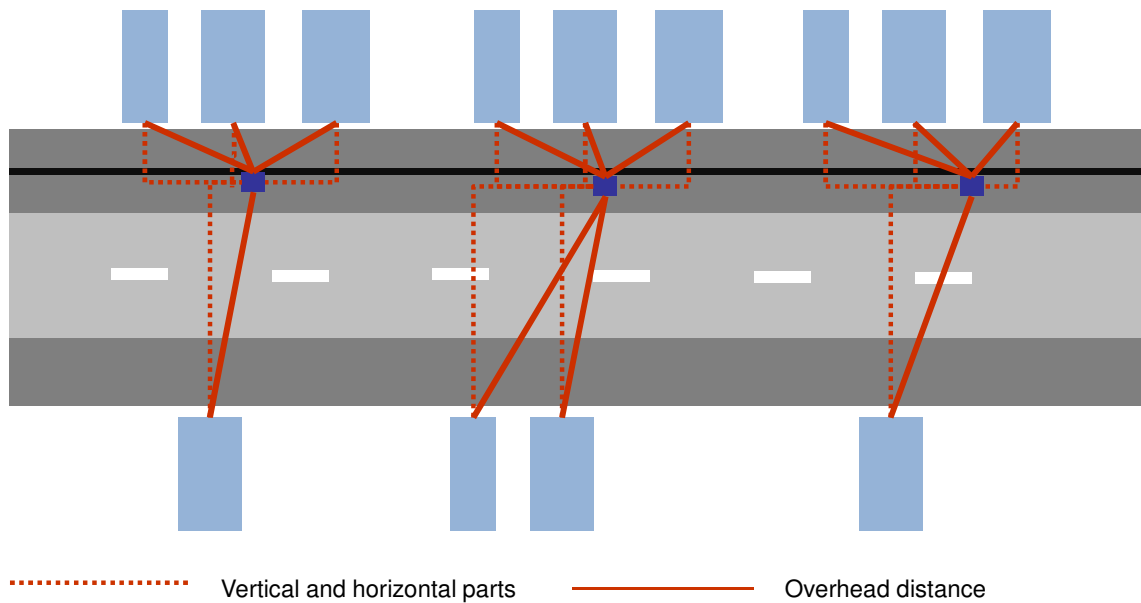
The length of the cable depends on the distance to the distribution point, whether the network is overhead (straight line distance) or underground (cable along the section, then orthogonal to the section), whether the section is trenched once or twice.

In the underground network, the length per dwelling of lead-in cables is the addition of:

- The vertical length: length from the building to the road + road width when the section is trenched once and the building is on the minor side;
- The horizontal length: the horizontal length of the building minus the horizontal length of the distribution point that leads in it.

In the overhead scenario, the length per dwelling is the hypotenuse of the triangle formed the vertical length and the horizontal length.

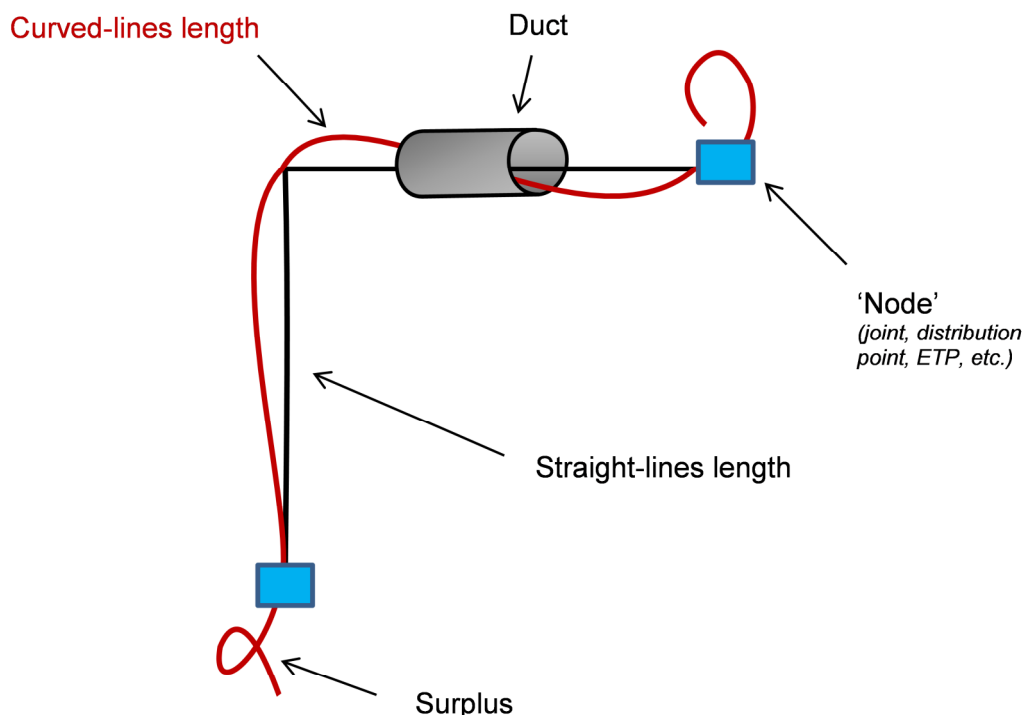
Figure 22 - Underground and overhead lead-in lengths



Source: TERA Consultants

In addition, a sag factor is applied to the above length, in order to take into account the curvature of the cable, and surpluses are added at both ends of the cable.

Figure 23 - Curvature and surplus adjustments to cable length



Source: TERA Consultants

Those lengths are computed in `GetLeadinUGCableLength()`, `GetLeadinOHCableLength()`, `GetLeadinUGFibreLength()` and `GetLeadinOHFibreLength()`.

Finally, no joints are modelled between the dwelling and the distribution point.

4.3.4.5 Ducts and subducts

Ducts are dedicated to each building and are rolled out on the vertical and horizontal parts of the path from the building to the distribution point. However, ducts can be shared among the dwellings of a building.

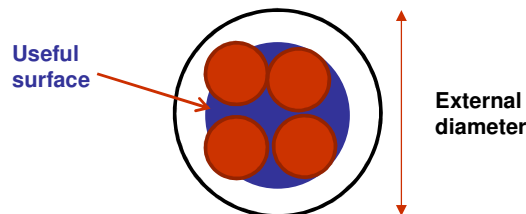
At the lead-in network level, it is assumed ducts with 50mm diameter are used.

Plus, in the fibre network, each fibre cable is protected within a dedicated subduct.

Ducts are shared on the basis of the cable surface (or subduct surface in the case of fibre cables):

$$\#ducts = \left\lceil \frac{Total\ cable\ surface}{Useful\ duct\ surface} \right\rceil = \left\lceil \frac{Total\ cable\ surface}{Duct\ surface * (1 - Inefficiency\ factor)} \right\rceil$$

Figure 24 - Filling of ducts



Source: TERA Consultants

The number of ducts needed per building is computed in `GetNb_CuDucts50_Building()` and `GetNb_FbDucts50_Building()`.

The duct length is based on the length of cable per dwelling before curvature and surplus adjustments and is computed in `GetCuLeadinUGDuctLength()` and in `GetFbLeadinUGDuctLength()`.

The subduct length is computed in the function `GetFbLeadinUGSubductLength()`.

4.3.4.6 Trench

Each building has a dedicated trench on the vertical part. On the horizontal part, the trench is shared with the distribution, feeder and core networks and is computed within the “Dimensioning at the section level” using section averages instead of building-specific data.

The dedicated trench is based on the aforementioned vertical length and is computed in `GetBuildingTrenchLength()`. The size of the trench is the cut surface of the trench and can be represented as a multiple of the number of ducts, computed in the functions `GetNb_CuDucts50_Building()` and `GetNb_FbDucts50_Building()`.

4.3.4.7 Poles

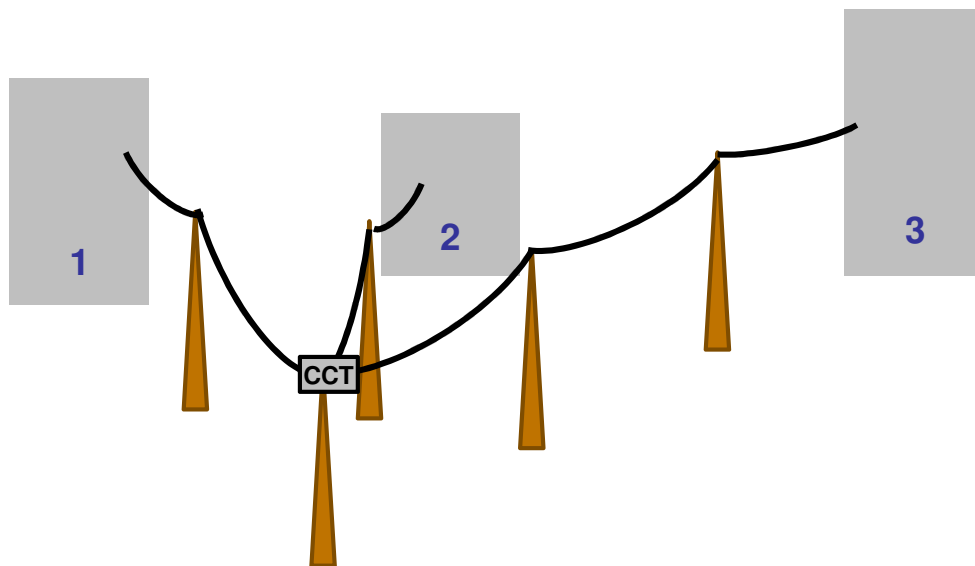
In the overhead networks, poles are located along the section and along the lead-in cables. The “horizontal” pole that bears the CCT/FAT is allocated to the lead-in (thus withdrawn to the distribution and feeder network levels).

Hence, for each building, a share of “horizontal pole” is added to the poles dedicated to the building. That share is computed as:

$$\frac{\#CCT_{section}}{\#Buildings_{section}}$$

The dedicated poles are computed comparing the maximum allowed length between poles and the drum length of the cable used.

Figure 25 - Lead-in poles



Source: TERA Consultants

In the above figure,

- 1 pole is shared among the three buildings;
- 1 pole is dedicated to building #1, then 1.33 pole is allocated to building #1;
- 1.33 pole is allocated to building #2;
- 2.33 pole are allocated to building #3.

The lead-in poles are computed in the VBA functions GetCuLeadInPoles() and GetFbLeadInPoles().

4.3.5 Dimensioning at the section level

4.3.5.1 Overview

This section of the document aims at describing all the rules and assumptions used to dimension the network at the section level.

The assets of the section are computed in the VBA routine “Dimensioning at the section level” given:

- The distribution demand (copper and fibre) and the feeder demand (copper), computed through queries;
- How the section is trenched (on one side or on both sides), which is computed in the VBA routine “Dimensioning at the building level”;
- How many distribution points are dimensioned for the section, which is also computed in the VBA routine “Dimensioning at the building level”.

The number of assets will depend on the engineering rules, the lists of assets available and the parameters of the model.

The network is modelled for all areas, inside and outside the TSO-derived boundary, as FWA and core infrastructures are incurred by Chorus in any case. However, the access network assets are not taken into account in the areas outside the TSO-derived boundary.

Furthermore, when the lead-in threshold is activated, i.e. when the non-standard lead-in are not dimensioned, a discount rate is applied to the section-specific lead-in assets (share of underground infrastructures). A different rate is applied in rural and urban areas.

The output of the “Dimensioning at the section level” fills the table “PROCESS SECTION MODELLING”, given key characteristics of the section, recasted from “SOURCE_SECTION”, outputs at the building level, from “PROCESS BUILDING MODELLING” and other tables through Access SQL queries.

Table 44 - Description of the "PROCESS SECTION MODELLING" table

| Field | Description | How is it filled ? |
|-----------------------|---|--------------------|
| ID_SECTION | ID of the section | Macro |
| LENGTH | Length of the section | Macro |
| ROADWIDTH | Width of the section | Macro |
| NB_DWELLING | Nb of dwellings belonging to the section | Macro |
| NB_BUILDING | Nb of buildings belonging to the section | Macro |
| URBAN | Urban or rural | Macro |
| NB_SDU_MINOR | Nb of SDU on the minor side | Macro |
| NB_DWELLING_MINOR | Nb of dwellings on the minor side | Macro |
| NB_SDU_DISTR | Nb of SDU distributed (minor, major and rear) | Macro |
| NB_DWELLING_DISTR | Nb of dwellings distributed (minor, major and rear, copper network) | Macro |
| NB_DWELLING_FIBRE | Nb of dwellings distributed (minor, major and rear, fibre network) | Macro |
| NB_SDU_FEEDER | Nb of SDU fed (copper network) | Macro |
| NB_DWELLING_FEEDER | Nb of dwellings fed (copper network) | Macro |
| HORIZONTAL_LENGTH_MAX | Length to the last building of the sections | Macro |
| BUILDING_LENGTH_MIN | Length between extreme buildings on the | Macro |

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| Field | Description | How is it filled ? |
|--------------------------|--|--------------------|
| OR | minor side | |
| TWO_TRENCHES | Whether the section is trenched on the major side ("False") or on both sides ("True") | Macro |
| CCT_MINOR | Number of CCT on the minor side (underground, copper network) | Macro |
| CCT_MAJOR | Number of CCT on the major side (underground, copper network) | Macro |
| CCT_OH | Number of CCT on the major side (overhead, copper network) | Macro |
| FAT_MINOR | Number of FAT on the minor side (underground, fibre network) | Macro |
| FAT_MAJOR | Number of FAT on the major side (underground, fibre network) | Macro |
| FAT_OH | Number of FAT on the major side (overhead, fibre network) | Macro |
| SERVED_BY_FWA | Whether the section is distributed through an FWA site or through a point-to-point fibre cable (fibre network) | Macro |
| MDF_ON_SECTION | Number of exchanges (MDF or ODF) on the section | Macro |
| SC_ON_SECTION | Number of MDF on the section | Macro |
| FWA | Number of cables for FWA | Macro |
| CORE_DSLAM | Number of cables for core DSLAM-Exchange | Macro |
| CORE_EXCHANGE | Number of cables for core Exchange-FDS | Macro |
| CORE_EAS | Number of cables for core inter-EAS | Macro |
| PAIRS_UG_DISTR_MAJOR | Number of pairs for the distribution on the major side (underground, copper network) | VBA |
| PAIRS_UG_DISTR_MINOR | Number of pairs for the distribution on the minor side (underground, copper network) | VBA |
| PAIRS_OH_DISTR | Number of pairs for the distribution on the major side (overhead, copper network) | VBA |
| PAIRS_UG_FEEDER | Number of pairs for the feeder (underground, copper network) | VBA |
| PAIRS_OH_FEEDER | Number of pairs for the feeder (overhead, copper network) | VBA |
| LENGTH_UG_DISTR_MAJOR_CU | Length of the distribution cable on the major side (underground, copper network) | VBA |
| LENGTH_UG_DISTR_MINOR_CU | Length of the distribution cable on the minor side (underground, copper network) | VBA |
| LENGTH_OH_DISTR_CU | Length of the distribution cable on the major side (overhead, copper network) | VBA |
| LENGTH_UG_FEEDER_CU | Length of the feeder cable (underground, copper network) | VBA |
| LENGTH_OH_FEEDER_CU | Length of the feeder cable (overhead, copper network) | VBA |
| JOINTS_UG_DISTR_MINOR_CU | Number of joints for the distribution on the minor side (underground, copper network) | VBA |
| JOINTS_UG_DISTR_MAJOR_CU | Number of joints for the distribution on the major side (underground, copper network) | VBA |

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| Field | Description | How is it filled ? |
|--------------------------------------|---|--------------------|
| JOINTS_OH_DISTR_CU | Number of joints for the distribution (overhead, copper network) | VBA |
| JOINTS_UG_FEEDER_CU | Number of joints for the feeder (underground, copper network) | VBA |
| JOINTS_OH_FEEDER_CU | Number of joints for the feeder (overhead, copper network) | VBA |
| JOINTS_FWA | Number of joints for FWA | VBA |
| JOINTS_CORE_DSLAM | Number of joints for core Exchange-to-DSLAM network | VBA |
| JOINTS_CORE_EXCHANGE | Number of joints for core FDS-to-Exchange network | VBA |
| JOINTS_CORE_EAS | Number of joints for core inter-EAS network | VBA |
| SIZE_TRENCH_MINOR_CU | Size of the trench of the minor side (cut surface expressed in multiples of 110 mm duct's surfaces, copper network) | VBA |
| LENGTH_TRENCH_MINOR_LEAD_IN_CU | Length of the minor trench (allocated to lead-in, copper network) | VBA |
| LENGTH_TRENCH_MINOR_DISTR_CU | Length of the minor trench (allocated to distribution, copper network) | VBA |
| SIZE_TRENCH_CROSS_CU | Size of the crossroad trench (copper network) | VBA |
| LENGTH_TRENCH_CROSS_DISTR_CU | Length of the crossroad trench (fully allocated to distribution, copper network) | VBA |
| SIZE_TRENCH_MAJOR_CU | Size of the major trench | VBA |
| LENGTH_TRENCH_MAJOR_LEAD_IN_CU | Length of the major trench (allocated to lead-in, copper network) | VBA |
| LENGTH_TRENCH_MAJOR_DISTR_CU | Length of the major trench (allocated to distribution, copper network) | VBA |
| LENGTH_TRENCH_MAJOR_FEEDER_CU | Length of the major trench (allocated to feeder, copper network) | VBA |
| LENGTH_TRENCH_MAJOR_FWA_CU | Length of the major trench (allocated to FWA, copper network) | VBA |
| LENGTH_TRENCH_MAJOR_CORE_DSLAM_CU | Length of the major trench (allocated to core DSLAM-Exchange, copper network) | VBA |
| LENGTH_TRENCH_MAJOR_CORE_EXCHANGE_CU | Length of the major trench (allocated to core Exchange-FDS, copper network) | VBA |
| LENGTH_TRENCH_MAJOR_CORE_EAS_CU | Length of the major trench (allocated to core inter-EAS, copper network) | VBA |
| LENGTH_DUCTS_DISTR_CU | Length of the ducts allocated to the distribution (major + cross + minor, copper network) | VBA |
| LENGTH_DUCTS_FEEDER_CU | Length of the ducts allocated to the feeder (copper network) | VBA |
| LENGTH_DUCTS_FWA_CU | Length of the ducts allocated to FWA (copper network) | VBA |
| LENGTH_DUCTS_CORE_DSLAM_CU | Length of the ducts allocated to core DSLAM-Exchange (copper network) | VBA |
| LENGTH_DUCTS_CORE_EXCHANGE_CU | Length of the ducts allocated to core Exchange-FDS (copper network) | VBA |
| LENGTH_DUCTS_CORE | Length of the ducts allocated to core inter- | VBA |

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| Field | Description | How is it filled ? |
|---------------------------------|--|--------------------|
| _EAS_CU | EAS (copper network) | |
| LENGTH_SUBDUCTS_FWA | Length of the subducts dedicated to FWA | VBA |
| LENGTH_SUBDUCTS_CORE_DSLAM | Length of the subducts dedicated to core DSLAM-Exchange | VBA |
| LENGTH_SUBDUCTS_CORE_EXCHANGE | Length of the subducts dedicated to core Exchange-FDS | VBA |
| LENGTH_SUBDUCTS_CORE_EAS | Length of the subducts dedicated to core inter-EAS | VBA |
| POLES_DISTR_CU | Number of poles allocated to distribution (copper network) | VBA |
| POLES_FEEDER_CU | Number of poles allocated to feeder (copper network) | VBA |
| MANHOLES_MINOR_DISTR_CU | Number of manholes on the minor side (fully allocated to distribution, copper network) | VBA |
| MANHOLES_MAJOR_DISTR_CU | Number of manholes on the major side (allocated to distribution, copper network) | VBA |
| MANHOLES_MAJOR_FEEDER_CU | Number of manholes on the major side (allocated to feeder, copper network) | VBA |
| MANHOLES_MAJOR_FWA_CU | Number of manholes on the major side (allocated to FWA, copper network) | VBA |
| MANHOLES_MAJOR_CORE_DSLAM_CU | Number of manholes on the major side (allocated to core Exchange-to-DSLAM, copper network) | VBA |
| MANHOLES_MAJOR_CORE_EXCHANGE_CU | Number of manholes on the major side (allocated to core FDS-to-Exchange, copper network) | VBA |
| MANHOLES_MAJOR_CORE_EAS_CU | Number of manholes on the major side (allocated to core inter-EAS, copper network) | VBA |
| FIBRE_FWA | Length of fibre (24F) for FWA | VBA |
| FIBRE_CORE_DSLAM | Length of fibre (12F) for core Exchange-to-DSLAM | VBA |
| FIBRE_CORE_EXCHANGE | Length of fibre (24F) for core FDS-to-Exchange | VBA |
| FIBRE_CORE_EAS | Length of fibre (24F) for core inter-EAS | VBA |
| FCOUNT_UG_DISTR_MAJOR | Fibre count for the distribution on the major side (underground, fibre network) | VBA |
| FCOUNT_UG_DISTR_MINOR | Fibre count for the distribution on the minor side (underground, fibre network) | VBA |
| FCOUNT_OH_DISTR | Fibre count for the distribution on the major side (overhead, fibre network) | VBA |
| LENGTH_UG_DISTR_MAJOR_FB | Length of the distribution cable on the major side (underground, fibre network) | VBA |
| LENGTH_UG_DISTR_MINOR_FB | Length of the distribution cable on the minor side (underground, fibre network) | VBA |
| LENGTH_OH_DISTR_FB | Length of the distribution cable on the major side (overhead, fibre network) | VBA |
| JOINTS_UG_DISTR_MINOR_FB | Number of joints for the distribution on the minor side (underground, fibre network) | VBA |
| JOINTS_UG_DISTR_MAJOR_FB | Number of joints for the distribution on the major side (underground, fibre network) | VBA |

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| Field | Description | How is it filled ? |
|--------------------------------------|--|--------------------|
| JOINTS_OH_DISTR_FB | Number of joints for the distribution (overhead, fibre network) | VBA |
| SIZE_TRENCH_MINOR_FB | Size of the trench of the minor side (cut surface expressed in multiples of 110 mm duct's surfaces, fibre network) | VBA |
| LENGTH_TRENCH_MINOR_LEAD_IN_FB | Length of the minor trench (allocated to lead-in, fibre network) | VBA |
| LENGTH_TRENCH_MINOR_DISTR_FB | Length of the minor trench (allocated to distribution, fibre network) | VBA |
| SIZE_TRENCH_CROSS_FB | Size of the crossroad trench (fibre network) | VBA |
| LENGTH_TRENCH_CROSS_DISTR_FB | Length of the crossroad trench (fully allocated to distribution, fibre network) | VBA |
| SIZE_TRENCH_MAJOR_FB | Size of the major trench | VBA |
| LENGTH_TRENCH_MAJOR_LEAD_IN_FB | Length of the major trench (allocated to lead-in, fibre network) | VBA |
| LENGTH_TRENCH_MAJOR_DISTR_FB | Length of the major trench (allocated to distribution, fibre network) | VBA |
| LENGTH_TRENCH_MAJOR_FWA_FB | Length of the major trench (allocated to FWA, fibre network) | VBA |
| LENGTH_TRENCH_MAJOR_CORE_EXCHANGE_FB | Length of the major trench (allocated to core Exchange-FDS, fibre network) | VBA |
| LENGTH_TRENCH_MAJOR_CORE_EAS_FB | Length of the major trench (allocated to core inter-EAS, fibre network) | VBA |
| LENGTH_DUCTS_DISTR_FB | Length of the ducts allocated to the distribution (major + cross + minor, fibre network) | VBA |
| LENGTH_DUCTS_FWA_FB | Length of the ducts allocated to FWA (fibre network) | VBA |
| LENGTH_DUCTS_CORE_EXCHANGE_FB | Length of the ducts allocated to core Exchange-FDS (fibre network) | VBA |
| LENGTH_DUCTS_CORE_EAS_FB | Length of the ducts allocated to core inter-EAS (fibre network) | VBA |
| LENGTH_SUBDUCTS_DISTR_FB | Length of the subducts allocated to the distribution (major + cross + minor, fibre network) | VBA |
| POLES_DISTR_FB | Number of poles allocated to distribution (fibre network) | VBA |
| MANHOLES_MINOR_DISTR_FB | Number of manholes on the minor side (fully allocated to distribution, fibre network) | VBA |
| MANHOLES_MAJOR_DISTR_FB | Number of manholes on the major side (allocated to distribution, fibre network) | VBA |
| MANHOLES_MAJOR_FWA_FB | Number of manholes on the major side (allocated to FWA, fibre network) | VBA |
| MANHOLES_MAJOR_CORE_EXCHANGE_FB | Number of manholes on the major side (allocated to core FDS-to-Exchange, fibre network) | VBA |
| MANHOLES_MAJOR_CORE_EAS_FB | Number of manholes on the major side (allocated to core inter-EAS, fibre network) | VBA |

Source: TERA Consultants

4.3.5.2 Selection of cable

4.3.5.2.1 Distribution and feeder

Each level of network (distribution and feeder) is addressed with one or several dedicated cables.

Given the local demand (distribution and feeder) and whether the section is trenched on the major side or on both side, and given the pairs/fibre allocation per SDU and MDU and spare capacity, the smallest cables available are chosen to address the local demand.

$$\text{Local demand} = \left(\#SDU * \text{Pairs}/SDU \frac{\text{Pairs}}{SDU} + \#MDU * \text{Pairs}/MDU \frac{\text{Pairs}}{MDU} \right) * (1 + \text{spare capacity})$$

When the local demand exceeds the largest cable available (2000 pairs in copper underground, 50 pairs in copper overhead, 312F in fibre, overhead and underground), the local demand is addressed with multiples of the largest cable.

That design rule results from roll-outs best practices similar in other countries.

E.g. in copper overhead, if there is a distribution demand of 36 SDU and 18 MDU, hence $(36 * \text{pairs}/SDU + 18 * \text{pairs}/MDU) * (1 + \text{spare})$ i.e. $(36 * 2 + 18 * 1.5) * (1 + 1/9) = 110$, then this demand is addressed with three overhead 50 pairs copper cables.

The choice and the number of cables is computed through the VBA module “Equipment selection” and through the VBA functions GetDistrUGPairsMajor(), GetDistrUGNbCablesMajor() and equivalent functions for minor side, feeder level, overhead and fibre in the VBA modules “Copper cables” and “Fibre cables”.

4.3.5.2.2 FWA and core

It is assumed the FWA, Core Exchange and Core EAS always use 24F fibre cables, as many times as there is a FWA/Core Exchange/Core EAS cable on the section (cf. 4.3.3.4).

It is assumed, in the copper network, that the Core DSLAM always uses 12F fibre cables, as many times as there is a Core DSLAM cable on the section (cf. 4.3.3.4).

4.3.5.3 Length of cable

4.3.5.3.1 Distribution

When underground, the distribution cables are located on the major side as well as on the minor side when the section is trenched twice. When overhead, the distribution cable is located only on the major side.

4.3.5.3.1.1 Major side

Once the number of cables is known, the length of cable depends on the length of the section and of the location of buildings on the section and whether the section has a rear area.

When there is no rear area, the distribution cable is deployed from the start of the section to the location of the last building of the section, i.e. is “Horizontal_Length_Max” long.

When there is a rear area, the distribution cable is deployed from the start to the end of the section, i.e. is “Length” long.

The rear area is measured by the difference between the distribution demand (“Nb_Dwelling_Distr”) and the dwellings of the section (“Nb_Dwelling”). If $Nb_Dwelling_Distr > Nb_Dwelling$, then the section has a rear area.

The length is then multiplied by the number of cables (cf. 4.3.5.2), by a curvature factor and eventual surplus at joints (cf. 4.3.4.4).

Those computations are made in the VBA functions GetDistrMajorUGCableNominalLengthperCable(), GetDistrMajorUGCableNominalLength() and GetDistrMajorUGCableLength() and the equivalent functions for overhead and fibre.

4.3.5.3.1.2 Minor side

When the section is trenched twice, there is a distribution cable on the minor side.

$$Nominal\ length_{minor} = Road\ width + Building\ length_{minor},$$

where the $Building\ length_{minor}$ represents the distance between the first and last buildings on the minor side.

The length is then multiplied by the number of cables (cf. 4.3.5.2), by a curvature factor and surplus at joints.

Those computations are made in the VBA functions GetDistrMinorUGCableNominalLengthperCable(), GetDistrMinorUGCableNominalLength() and GetDistrMinorUGCableLength() and the equivalent functions for fibre.

4.3.5.3.2 Feeder

If a feeder cable goes through a section, then it is assumed it always goes from the start to the end of the section, i.e. is “Length” long. The length is then multiplied by the number of cables (cf. 4.3.5.2), by a curvature factor and eventual surplus at joints.

Those computations are made in the VBA functions GetFeederUGCableNominalLengthperCable(), GetFeederUGCableNominalLength() and GetFeederUGCableLength() and the equivalent functions for overhead and fibre.

4.3.5.3.3 FWA and core

If an FWA or core link goes through a section, then it is assumed it always goes from the start to the end of the section, i.e. is “Length” long. The length is then multiplied by the number of cables (cf. 4.3.5.2), by a curvature factor and eventual surplus at joints.

Those computations are made in the VBA function GetCoreFibre().

4.3.5.4 Number of joints

4.3.5.4.1 Distribution

4.3.5.4.1.1 Major side

The number of joints depends on the length of cable (per cable), the drum length of the cable used, existence of other equipment that can be used as joints and whether there is a rear area to the section.

When there are several cables per network level (e.g. three 50-pairs cables in for overhead copper distribution), the computation of the joints is made first for each cable, then multiplied by the number of cables and adjusted with the other equipment and rear area.

It is assumed that CCTs/FATs on the major side, MDFs/ODFs and street cabinets can replace joints.

Plus, it is assumed that a joint must be located at the end of the section at the intersection with the rear area if there is a rear area to the section.

The number of joints of the major side is computed in the VBA function `GetDistrUGJointsMajor_Cu()` and the equivalent function for overhead and fibre.

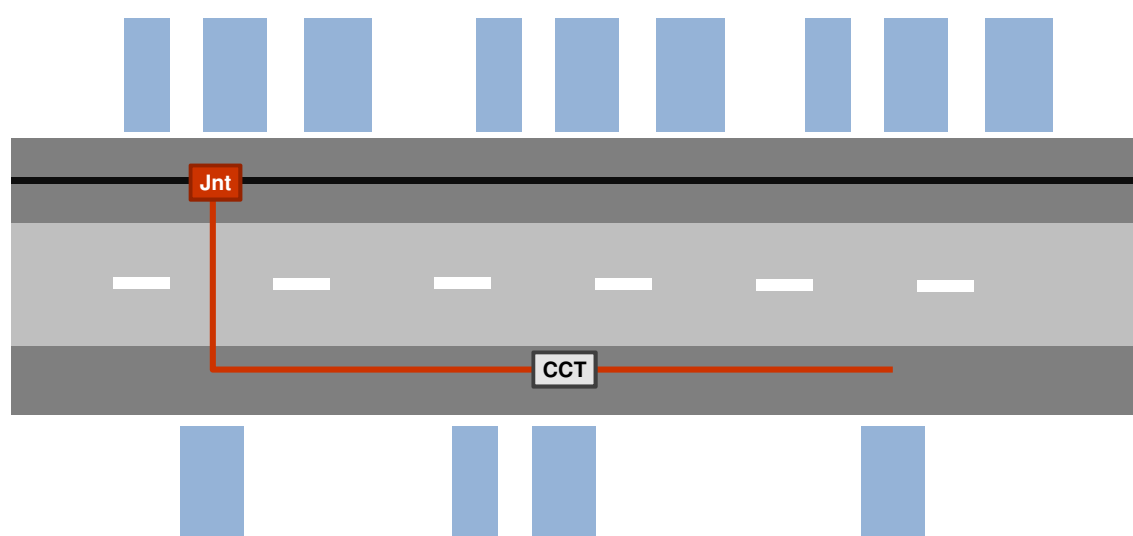
4.3.5.4.1.2 Minor side

When there is a minor distribution cable, the number of joints depends on the length of cable (per cable), the drum length of the cable used and existence of other equipment that can be used as joints – namely CCT/FAT on minor.

It is assumed the CCT/FAT on the minor side can replace joints.

Plus, it is assumed there is at least one joint at the intersection with the major side.

Figure 26 - Joints on the minor side



Source: TERA Consultants

The number of joints on the minor side is computed in the VBA functions `GetDistrUGJointsMinor_Cu()` and `GetDistrUGJointsMinor_Fb()`.

4.3.5.4.2 Feeder

The number of joints on feeder is computed in a similar manner as for the distribution network level. It depends on the length of cable (per cable), whether there is a feeder rear area and existence of other equipment that can be used as joints (street cabinet, MDF/ODF).

The computation is made in the VBA function GetFeederUGJoints() and is equivalent for overhead and fibre.

4.3.5.4.3 FWA and core

The number of joints on FWA and core is computed in a similar manner as for the distribution network level. It depends solely on the length of cable (per cable) and on the fibre cable used ([] CNZRI or [] CNZRI).

The computation is made in the VBA function GetCoreJoints().

4.3.5.5 Trenches and ducts

4.3.5.5.1 Length of trenches and ducts

In the copper network, it is assumed the ducts can be shared among distribution and feeder. In the fibre network, a duct is dedicated to distribution.

If there is a minor side, a duct is dedicated to the minor distribution cable, crossing the road and along the minor side.

In both networks, it is assumed the ducts can be shared among FWA and core networks.

Recall that the lead-in trenches are already dimensioned in the VBA routine “Dimensioning at the building level”.

Hence, three sets of ducts are dimensioned on each section.

However, the trenches are shared among

- Lead-In – the segment of Lead-In on the horizontal part;
- Distribution and feeder; and
- FWA and core, and allocated on the basis of ducts’ surface.

Plus, on the major side, trenches – and ducts – are as long as the longest cable of the section. In particular, if there is a feeder, FWA or core cable on the section, the duct is as long as the section, even if the distribution cable goes only until the last building of the section.

For each trench (major, minor and cross), the size of the trench is uniform along the trench.

The trench is allocated on the basis of the duct surface area to the lead-in, the distribution, the feeder, the FWA link and the core network.

4.3.5.5.2 Size of the trench

For each section, it is assumed that the lead-in ducts are uniform along the section and can be approximated as an average according to the following calculation.

The lead-in share of the trench is dimensioned according to:

- The average number of dwellings per building on the section
- The resulting number of 50 mm ducts per building
- The average cut surface of ducts, following the formula:

Average number of ducts

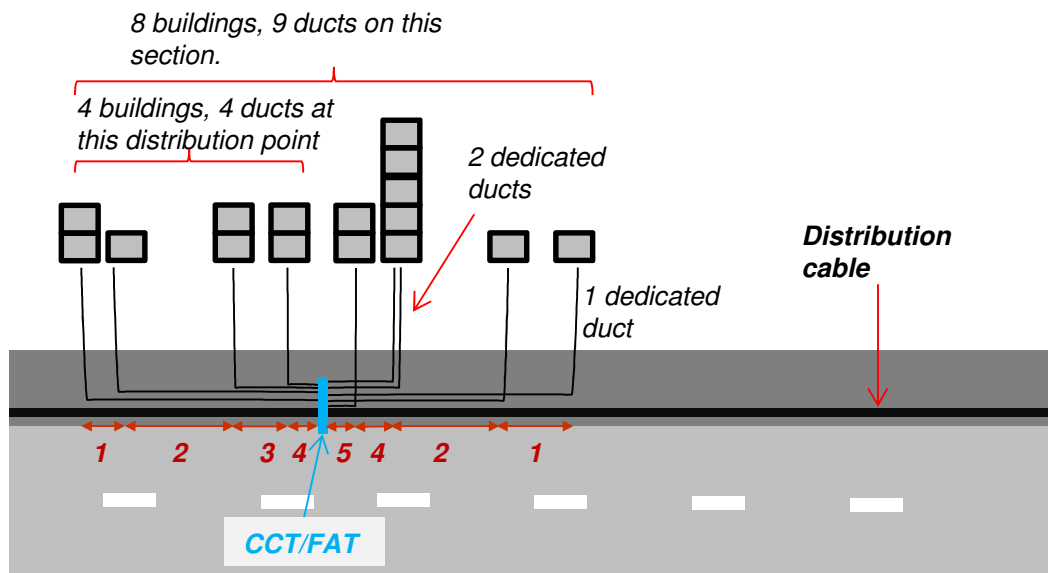
$$= Av - to - max_{factor} * ducts\ per\ building * \frac{\# buildings}{2 * \#CCT}$$

Indeed, if the section is divided into CCT/FAT areas, then there are ducts dimensioned for $\frac{\# buildings}{\#CCT}$ at each CCT/FAT, i.e. at maximum $\frac{\# buildings}{2 * \#CCT}$ on both sides of the CCT/FAT.

This resultant maximum has to be adjusted with an average-to-max ratio, since the cut surface of ducts decreases with distance to the CCT (see figure below). The average-to-max ratio can be estimated at 60%¹⁶.

This is computed in the VBA functions GetSizeTrenchLeadIn_Cu() and GetSizeTrenchLeadIn_Fb() and it is assumed the lead-in share of the trench size is the same on major and on minor sides.

Figure 27 - Average surface of lead-in ducts



Source: TERA Consultants

In the copper network, the distribution and feeder 110 mm duct(s) is dimensioned and allocated according to the cross-section surface of cables¹⁷ (same methodology as

¹⁶ With 8 buildings led in through a CCT/FAT, the average cut surface of ducts on one side or the other of the CCT can be estimated by the mean of the series 1 to 4, i.e. 2.5, hence an average to max ratio of 5/8.

¹⁷ See glossary

4.3.4.5). In the fibre network, the dimensioning and allocation to the different network levels (feeder, distribution, lead-in, etc.) is made on the basis of the subducts' surface, instead of cable surface, as each fibre cable is protected in a dedicated subduct.

It is computed in the VBA functions `GetSizeTrenchMajor_Cu_DistrandFeeder()` and `GetSizeTrenchMajor_Fb_Distr()`.

In the core network, the 110 mm duct(s) is dimensioned and allocated according to the surface of the subduct used for each cable.

It is computed in the VBA functions `GetSizeTrenchMajor_Cu_OtherNetworks()` and `GetSizeTrenchMajor_Fb_OtherNetworks()`.

The total sizes of the trenches are then:

- On the major side, the sum of
 - The average lead-in cut surface¹⁸,
 - The number of ducts for distribution and feeder,
 - The number of ducts for FWA and core.
- On the minor side, the sum of
 - The average lead-in cut surface,
 - The number of ducts for minor distribution.
- On the cross road, the number of ducts for minor distribution.

The sizes of trenches are computed in the VBA functions `GetSizeTrenchMajor_Cu()`, `GetSizeTrenchMinor_Cu()` and `GetSizeTrenchCross_Cu()`.

4.3.5.5.3 Allocation keys

The trenches on minor and major sides of the road are allocated according to the duct surface.

Hence, the allocation key for the lead-in is (on minor and major) the ratio of the average lead-in cut surface to the trench size (minor or major).

The allocation key for distribution is the compounded ratio (and in an equivalent manner for feeder):

$$\frac{Cable\ surface_{distr}}{Cable\ surface_{distr+feeder}} * \frac{\#ducts_{distr+feeder}}{Size_{trench}}$$

The allocation key for one of the core networks is, in a similar way

$$\frac{\#cables_x}{\#cables_{FWA+Core}} * \frac{\#ducts_{FWA+Core}}{Size_{trench}}$$

Furthermore, a discount is applied to the lead-in to reflect the share of non-standard lead-in, which are not incurred by Chorus. A different rate applies to urban and rural areas, as the share of the non-standard lead-in is significantly greater in rural areas.

¹⁸ Expressed in terms of 110 mm duct surface, using the ratio $(50/110)^2$.

Ultimately, the length of trench allocated to each level of the network is the product of the length of trench (cf. 4.3.5.5.1) with the allocation key.

The allocation keys are computed in the VBA module “Allocations”.

4.3.5.5.4 Ducts

110 mm ducts are allocated to the distribution, feeder, FWA, Core DSLAM, Core Exchange and Core EAS in the copper network, and distribution, FWA, Core Exchange and Core EAS in the fibre network.

It shall be noted that 50 mm ducts dedicated to buildings are already computed in the “Dimensioning at the building level” VBA routine.

The length of ducts can be retrieved by multiplying the outputs of the trenches calculations, e.g. for distribution:

$$Length_{duct}^{distr} = Length_{trench}^{distr} * Size_{trench}$$

Indeed,

$$Length_{trench}^{distr} * Size_{trench} = Length_{trench} * \frac{Cable\ surface_{distr}}{Cable\ surface_{distr+feeder}} * \#ducts_{distr+feeder}$$

And $\frac{Cable\ surface_{distr}}{Cable\ surface_{distr+feeder}} * \#ducts_{distr+feeder}$ is the share of duct allocated to distribution.

The length of ducts is computed in the “Dimensioning at the section level” VBA routine through the command lines

```
ProcessModellingRecordset("LENGTH_DUCTS_FEEDER_CU")           =
ProcessModellingRecordset("SIZE_TRENCH_MAJOR_CU")             *
ProcessModellingRecordset("LENGTH_TRENCH_MAJOR_FEEDER_CU")
```

and following.

Subducts are allocated to the FWA and core networks on the basis of one subduct per cable, and to the distribution in the fibre network, on the same basis of one subduct per cable.

Subducts’ lengths are computed through the VBA functions GetSubductLength() and GetLengthDistrSubduct().

4.3.5.6 Manholes

4.3.5.6.1 Dimensioning

The number of manholes depends on the manholes per cable in distribution, feeder, FWA and core.

For each network level, the number of manholes per cable determines the need of manholes. E.g. for the distribution, the need for manholes is set by $\frac{\#CCT+\#Joints}{\#Cables}$.

It is assumed that all equipment for each cable are co-located, so the total need for manholes for each side of the section is the maximum need for manholes per network level.

Plus, the number of manholes is computed comparing the maximum allowed distance between manholes – due to pulling in tension limits – and the need of manholes.

This computation is made in the VBA functions GetManholesMinor_Fb(), GetManholesMajor_Fb() and equivalent for copper.

4.3.5.6.2 Allocations

Manholes allocation follows the same allocation keys as for trenches.

It is assumed that no manhole is allocated to the lead-in level, so the share of lead-in manhole is shifted to the distribution level.

$$\#manholes_{major}^{distr} = \#manholes_{major} * (key_{major}^{distr} + key_{major}^{lead\ in})$$

The allocated number of manholes is allocated in the “Dimensioning at the section level” VBA routine through the command lines

```
ProcessModellingRecordset("MANHOLES_MAJOR_FWA_FB") =  
GetManholesMajor_Fb(Length, Horizontal_Length_Max, Nb_Dwelling,  
Nb_Dwelling_Fibre, Nb_UGMajor_Equipment_Distr_Fb, FATMajor, CoreNetwork_Fb) *  
GetTrenchLengthMajor_FWA_FbKey(Length, Horizontal_Length_Max, Nb_Dwelling,  
Nb_Dwelling_Fibre, CoreNetwork_Fb, Nb_Building, FATMajor, FATMinor, FWA)
```

and following.

4.3.5.7 Poles

Poles are allocated to distribution and feeder, as FWA and core cables are always buried and lead-in poles are already allocated in the “Dimensioning at the building level” routine.

The number of poles depends on the equipment per cable in distribution and feeder, and on the maximum length between poles parameter.

Plus, poles that bear CCT/FAT are withdrawn from the computation as they are already computed and allocated to the lead-in level.

Poles are computed in the function GetSectionPoles_Fb() and equivalent for copper.

In the fibre network, the section poles are entirely allocated to distribution.

In the copper network, the section poles are allocated to distribution and feeder on the basis of the number of equipment that require poles.

E.g., if there are 1 distribution cable with 4 equipment and 4 feeder cables with 8 equipment, then the share of poles allocated to distribution is 4/12 and the share of poles allocated to feeder is 8/12.

Allocations are computed through the VBA functions GetDistrPolesKey() and GetFeederPolesKey().

4.4 Outputs

4.4.1 Output architecture

The outputs of the Access model are four inventory tables, aggregated at the exchange level:

- Two for the copper network:
 - Overhead,
 - Underground.
- Two for the fibre network
 - Overhead,
 - Underground.

The two copper tables contain the same fields. In the underground table, all the overhead assets are set to zero, while, in the overhead table, some underground assets can be needed, as the overhead network contains underground sections (cf. 4.4.3).

Table 45 - Description of the copper output tables

| Field | Description |
|----------------|--|
| F-MDF | Requested size of the MDF (copper pairs) |
| L-LeadinOH0002 | Length of lead-in cables (overhead) |
| L-LeadinUG0002 | Length of lead-in cables (underground) |
| D-AccessOH0004 | Length of distribution 4-pairs cables (overhead) |
| D-AccessOH0010 | Length of distribution 10-pairs cables (overhead) |
| D-AccessOH0015 | Length of distribution 15-pairs cables (overhead) |
| D-AccessOH0025 | Length of distribution 25-pairs cables (overhead) |
| D-AccessOH0050 | Length of distribution 50-pairs cables (overhead) |
| D-AccessUG0004 | Length of distribution 4-pairs cables (underground) |
| D-AccessUG0005 | Length of distribution 5-pairs cables (underground) |
| D-AccessUG0007 | Length of distribution 7-pairs cables (underground) |
| D-AccessUG0015 | Length of distribution 15-pairs cables (underground) |
| D-AccessUG0025 | Length of distribution 25-pairs cables (underground) |
| D-AccessUG0050 | Length of distribution 50-pairs cables (underground) |
| D-AccessUG0100 | Length of distribution 100-pairs cables (underground) |
| D-AccessUG0200 | Length of distribution 200-pairs cables (underground) |
| D-AccessUG0300 | Length of distribution 300-pairs cables (underground) |
| D-AccessUG0400 | Length of distribution 400-pairs cables (underground) |
| D-AccessUG0800 | Length of distribution 800-pairs cables (underground) |
| D-AccessUG2000 | Length of distribution 2000-pairs cables (underground) |
| F-AccessOH0004 | Length of feeder 4-pairs cables (overhead) |
| F-AccessOH0010 | Length of feeder 10-pairs cables (overhead) |
| F-AccessOH0015 | Length of feeder 15-pairs cables (overhead) |
| F-AccessOH0025 | Length of feeder 25-pairs cables (overhead) |
| F-AccessOH0050 | Length of feeder 50-pairs cables (overhead) |
| F-AccessUG0004 | Length of feeder 4-pairs cables (underground) |
| F-AccessUG0005 | Length of feeder 5-pairs cables (underground) |
| F-AccessUG0007 | Length of feeder 7-pairs cables (underground) |
| F-AccessUG0015 | Length of feeder 15-pairs cables (underground) |
| F-AccessUG0025 | Length of feeder 25-pairs cables (underground) |

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| Field | Description |
|-------------------|--|
| F-AccessUG0050 | Length of feeder 50-pairs cables (underground) |
| F-AccessUG0100 | Length of feeder 100-pairs cables (underground) |
| F-AccessUG0200 | Length of feeder 200-pairs cables (underground) |
| F-AccessUG0300 | Length of feeder 300-pairs cables (underground) |
| F-AccessUG0400 | Length of feeder 400-pairs cables (underground) |
| F-AccessUG0800 | Length of feeder 800-pairs cables (underground) |
| F-AccessUG2000 | Length of feeder 2000-pairs cables (underground) |
| D-JntAccessOH0004 | Number of distribution 4-pairs joints (overhead) |
| D-JntAccessOH0010 | Number of distribution 10-pairs joints (overhead) |
| D-JntAccessOH0015 | Number of distribution 15-pairs joints (overhead) |
| D-JntAccessOH0025 | Number of distribution 25-pairs joints (overhead) |
| D-JntAccessOH0050 | Number of distribution 50-pairs joints (overhead) |
| D-JntAccessUG0004 | Number of distribution 4-pairs joints (underground) |
| D-JntAccessUG0005 | Number of distribution 5-pairs joints (underground) |
| D-JntAccessUG0007 | Number of distribution 7-pairs joints (underground) |
| D-JntAccessUG0015 | Number of distribution 15-pairs joints (underground) |
| D-JntAccessUG0025 | Number of distribution 25-pairs joints (underground) |
| D-JntAccessUG0050 | Number of distribution 50-pairs joints (underground) |
| D-JntAccessUG0100 | Number of distribution 100-pairs joints (underground) |
| D-JntAccessUG0200 | Number of distribution 200-pairs joints (underground) |
| D-JntAccessUG0300 | Number of distribution 300-pairs joints (underground) |
| D-JntAccessUG0400 | Number of distribution 400-pairs joints (underground) |
| D-JntAccessUG0800 | Number of distribution 800-pairs joints (underground) |
| D-JntAccessUG2000 | Number of distribution 2000-pairs joints (underground) |
| F-JntAccessOH0004 | Number of feeder 4-pairs joints (overhead) |
| F-JntAccessOH0010 | Number of feeder 10-pairs joints (overhead) |
| F-JntAccessOH0015 | Number of feeder 15-pairs joints (overhead) |
| F-JntAccessOH0025 | Number of feeder 25-pairs joints (overhead) |
| F-JntAccessOH0050 | Number of feeder 50-pairs joints (overhead) |
| F-JntAccessUG0004 | Number of feeder 4-pairs joints (underground) |
| F-JntAccessUG0005 | Number of feeder 5-pairs joints (underground) |
| F-JntAccessUG0007 | Number of feeder 7-pairs joints (underground) |
| F-JntAccessUG0015 | Number of feeder 15-pairs joints (underground) |
| F-JntAccessUG0025 | Number of feeder 25-pairs joints (underground) |
| F-JntAccessUG0050 | Number of feeder 50-pairs joints (underground) |
| F-JntAccessUG0100 | Number of feeder 100-pairs joints (underground) |
| F-JntAccessUG0200 | Number of feeder 200-pairs joints (underground) |
| F-JntAccessUG0300 | Number of feeder 300-pairs joints (underground) |
| F-JntAccessUG0400 | Number of feeder 400-pairs joints (underground) |
| F-JntAccessUG0800 | Number of feeder 800-pairs joints (underground) |
| F-JntAccessUG2000 | Number of feeder 2000-pairs joints (underground) |
| L-CCT_OH | Number of overhead CCT |
| L-CCT_UG | Number of underground CCT |
| L-Duct50 | Length of 50 mm lead-in ducts |
| D-Duct110 | Length of 110 mm distribution ducts |
| F-Duct110 | Length of 110 mm feeder ducts |
| C1-Duct110 | Length of 110 mm FWA ducts |
| C2-Duct110 | Length of 110 mm Core DSLAM ducts |
| C3-Duct110 | Length of 110 mm Core Exchange ducts |
| C4-Duct110 | Length of 110 mm Core EAS ducts |
| C1-Subduct | Length of FWA subducts |
| C2-Subduct | Length of Core DSLAM subducts |

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| Field | Description |
|-----------------|--|
| C3-Subduct | Length of Core Exchange subducts |
| C4-Subduct | Length of Core EAS subducts |
| L-Trench_S | Length of small lead-in trenches |
| L-Trench_M | Length of medium lead-in trenches |
| L-Trench_L | Length of large lead-in trenches |
| L-Trench_XL | Length of very large lead-in trenches |
| L-Trench_XXL | Length of extra large lead-in trenches |
| D-Trench_M | Length of medium distribution trenches |
| D-Trench_L | Length of large distribution trenches |
| D-Trench_XL | Length of very large distribution trenches |
| D-Trench_XXL | Length of extra large distribution trenches |
| F-Trench_M | Length of medium feeder trenches |
| F-Trench_L | Length of large feeder trenches |
| F-Trench_XL | Length of very large feeder trenches |
| F-Trench_XXL | Length of extra large feeder trenches |
| C1-Trench_M | Length of medium FWA trenches |
| C1-Trench_L | Length of large FWA trenches |
| C1-Trench_XL | Length of very large FWA trenches |
| C1-Trench_XXL | Length of extra large FWA trenches |
| C2-Trench_M | Length of medium Core DSLAM trenches |
| C2-Trench_L | Length of large Core DSLAM trenches |
| C2-Trench_XL | Length of very large Core DSLAM trenches |
| C2-Trench_XXL | Length of extra large Core DSLAM trenches |
| C3-Trench_M | Length of medium Core Exchange trenches |
| C3-Trench_L | Length of large Core Exchange trenches |
| C3-Trench_XL | Length of very large Core Exchange trenches |
| C3-Trench_XXL | Length of extra large Core Exchange trenches |
| C4-Trench_M | Length of medium Core EAS trenches |
| C4-Trench_L | Length of large Core EAS trenches |
| C4-Trench_XL | Length of very large Core EAS trenches |
| C4-Trench_XXL | Length of extra large Core EAS trenches |
| L-Pole | Number of lead-in poles |
| D-Pole | Number of distribution poles |
| F-Pole | Number of feeder poles |
| D-RuralManhole | Number of rural distribution manholes |
| F-RuralManhole | Number of rural feeder manholes |
| C1-RuralManhole | Number of rural FWA manholes |
| C2-RuralManhole | Number of rural Core DSLAM manholes |
| C3-RuralManhole | Number of rural Core Exchange manholes |
| C4-RuralManhole | Number of urban Core EAS manholes |
| D-UrbanManhole | Number of urban distribution manholes |
| F-UrbanManhole | Number of urban feeder manholes |
| C1-UrbanManhole | Number of urban FWA manholes |
| C2-UrbanManhole | Number of urban Core DSLAM manholes |
| C3-UrbanManhole | Number of urban Core Exchange manholes |
| C4-UrbanManhole | Number of urban Core EAS manholes |
| C1-Fb0024 | Length of FWA fibre cables (24F) |
| C2-Fb0012 | Length of Core DSLAM fibre cables (12F) |
| C3-Fb0024 | Length of Core Exchange fibre cables (24F) |
| C4-Fb0024 | Length of Core EAS fibre cables (24F) |
| C1-JntFb0024 | Number of FWA fibre joints (24F) |
| C2-JntFb0012 | Number of Core DSLAM fibre joints (12F) |

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| Field | Description |
|--------------------|---|
| C3-JntFb0024 | Number of Core Exchange fibre joints (24F) |
| C4-JntFb0024 | Number of Core EAS fibre joints (24F) |
| C3-SubmarineLength | Length of Core Exchange submarine links |
| C4-SubmarineLength | Length of Core EAS submarine links |
| C3-LandingStation | Number of Core Exchange landing stations |
| C4-LandingStation | Number of Core EAS landing stations |
| C3-MWSite | Number of Core Exchange microwave sites |
| C4-MWSite | Number of Core EAS microwave sites |
| D-PassiveSC | Number of passive street cabinets |
| D-ActiveSC | Number of active street cabinets |
| C1-ODF | Requested size of the ODF (F count) for FWA |
| C2-ODF | Requested size of the ODF (F count) for Core DSLAM |
| C3-ODF | Requested size of the ODF (F count) for Core Exchange |
| C4-ODF | Requested size of the ODF (F count) for Core EAS |
| ODF | Cumulated requested size of the ODF |
| C3-DWDMsite | Number of Core Exchange DWDM sites |
| C4-DWDMsite | Number of Core EAS DWDM sites |

Source: TERA Consultants

Similarly, the two fibre tables contain the same fields.

Table 46 - Description of the fibre output tables

| Field | Description |
|----------------|---|
| D-ODF | Requested size of the ODF (fibre count) |
| L-Fb0002_OH | Length of lead-in cables (overhead) |
| D-Fb0002_OH | Length of distribution 2F cables (overhead) |
| D-Fb0004_OH | Length of distribution 4F cables (overhead) |
| D-Fb0012_OH | Length of distribution 12F cables (overhead) |
| D-Fb0018_OH | Length of distribution 18F cables (overhead) |
| D-Fb0024_OH | Length of distribution 24F cables (overhead) |
| D-Fb0036_OH | Length of distribution 36F cables (overhead) |
| D-Fb0048_OH | Length of distribution 48F cables (overhead) |
| D-Fb0072_OH | Length of distribution 72F cables (overhead) |
| D-Fb0096_OH | Length of distribution 96F cables (overhead) |
| D-Fb0120_OH | Length of distribution 120F cables (overhead) |
| D-Fb0144_OH | Length of distribution 144F cables (overhead) |
| D-Fb0216_OH | Length of distribution 216F cables (overhead) |
| D-Fb0312_OH | Length of distribution 312F cables (overhead) |
| D-JntFb0002_OH | Number of distribution 2F joints (overhead) |
| D-JntFb0004_OH | Number of distribution 4F joints (overhead) |
| D-JntFb0012_OH | Number of distribution 12F joints (overhead) |
| D-JntFb0018_OH | Number of distribution 18F joints (overhead) |
| D-JntFb0024_OH | Number of distribution 24F joints (overhead) |
| D-JntFb0036_OH | Number of distribution 36F joints (overhead) |
| D-JntFb0048_OH | Number of distribution 48F joints (overhead) |
| D-JntFb0072_OH | Number of distribution 72F joints (overhead) |
| D-JntFb0096_OH | Number of distribution 96F joints (overhead) |
| D-JntFb0120_OH | Number of distribution 120F joints (overhead) |
| D-JntFb0144_OH | Number of distribution 144F joints (overhead) |
| D-JntFb0216_OH | Number of distribution 216F joints (overhead) |
| D-JntFb0312_OH | Number of distribution 312F joints (overhead) |
| L-Fb0002_UG | Length of lead-in cables (underground) |

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| Field | Description |
|----------------|--|
| D-Fb0002_UG | Length of distribution 2F cables (underground) |
| D-Fb0004_UG | Length of distribution 4F cables (underground) |
| D-Fb0012_UG | Length of distribution 12F cables (underground) |
| D-Fb0018_UG | Length of distribution 18F cables (underground) |
| D-Fb0024_UG | Length of distribution 24F cables (underground) |
| D-Fb0036_UG | Length of distribution 36F cables (underground) |
| D-Fb0048_UG | Length of distribution 48F cables (underground) |
| D-Fb0072_UG | Length of distribution 72F cables (underground) |
| D-Fb0096_UG | Length of distribution 96F cables (underground) |
| D-Fb0120_UG | Length of distribution 120F cables (underground) |
| D-Fb0144_UG | Length of distribution 144F cables (underground) |
| D-Fb0216_UG | Length of distribution 216F cables (underground) |
| D-Fb0312_UG | Length of distribution 312F cables (underground) |
| D-JntFb0002_UG | Number of distribution 2F joints (underground) |
| D-JntFb0004_UG | Number of distribution 4F joints (underground) |
| D-JntFb0012_UG | Number of distribution 12F joints (underground) |
| D-JntFb0018_UG | Number of distribution 18F joints (underground) |
| D-JntFb0024_UG | Number of distribution 24F joints (underground) |
| D-JntFb0036_UG | Number of distribution 36F joints (underground) |
| D-JntFb0048_UG | Number of distribution 48F joints (underground) |
| D-JntFb0072_UG | Number of distribution 72F joints (underground) |
| D-JntFb0096_UG | Number of distribution 96F joints (underground) |
| D-JntFb0120_UG | Number of distribution 120F joints (underground) |
| D-JntFb0144_UG | Number of distribution 144F joints (underground) |
| D-JntFb0216_UG | Number of distribution 216F joints (underground) |
| D-JntFb0312_UG | Number of distribution 312F joints (underground) |
| L-FAT_OH | Number of overhead FAT |
| L-FAT_UG | Number of underground FAT |
| L-Duct50 | Length of 50 mm lead-in ducts |
| D-Duct110 | Length of 110 mm distribution ducts |
| C1-Duct110 | Length of 110 mm FWA ducts |
| C3-Duct110 | Length of 110 mm Core Exchange ducts |
| C4-Duct110 | Length of 110 mm Core EAS ducts |
| L-Subduct | Length of lead-in subducts |
| D-Subduct | Length of distribution subducts |
| C1-Subduct | Length of FWA subducts |
| C3-Subduct | Length of Core Exchange subducts |
| C4-Subduct | Length of Core EAS subducts |
| L-Trench_S | Length of small lead-in trenches |
| L-Trench_M | Length of medium lead-in trenches |
| L-Trench_L | Length of large lead-in trenches |
| L-Trench_XL | Length of very large lead-in trenches |
| L-Trench_XXL | Length of extra large lead-in trenches |
| D-Trench_M | Length of medium distribution trenches |
| D-Trench_L | Length of large distribution trenches |
| D-Trench_XL | Length of very large distribution trenches |
| D-Trench_XXL | Length of extra large distribution trenches |
| C1-Trench_M | Length of medium FWA trenches |
| C1-Trench_L | Length of large FWA trenches |
| C1-Trench_XL | Length of very large FWA trenches |
| C1-Trench_XXL | Length of extra large FWA trenches |
| C3-Trench_M | Length of medium Core Exchange trenches |

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| Field | Description |
|--------------------|---|
| C3-Trench_L | Length of large Core Exchange trenches |
| C3-Trench_XL | Length of very large Core Exchange trenches |
| C3-Trench_XXL | Length of extra large Core Exchange trenches |
| C4-Trench_M | Length of medium Core EAS trenches |
| C4-Trench_L | Length of large Core EAS trenches |
| C4-Trench_XL | Length of very large Core EAS trenches |
| C4-Trench_XXL | Length of extra large Core EAS trenches |
| L-Pole | Number of lead-in poles |
| D-Pole | Number of distribution poles |
| D-RuralManhole | Number of rural distribution manholes |
| C1-RuralManhole | Number of rural FWA manholes |
| C3-RuralManhole | Number of rural Core Exchange manholes |
| C4-RuralManhole | Number of urban Core EAS manholes |
| D-UrbanManhole | Number of urban distribution manholes |
| C1-UrbanManhole | Number of urban FWA manholes |
| C3-UrbanManhole | Number of urban Core Exchange manholes |
| C4-UrbanManhole | Number of urban Core EAS manholes |
| C1-Fb0024 | Length of FWA fibre cables (24F) |
| C3-Fb0024 | Length of Core Exchange fibre cables (24F) |
| C4-Fb0024 | Length of Core EAS fibre cables (24F) |
| C1-JntFb0024 | Number of FWA fibre joints (24F) |
| C3-JntFb0024 | Number of Core Exchange fibre joints (24F) |
| C4-JntFb0024 | Number of Core EAS fibre joints (24F) |
| C3-SubmarineLength | Length of Core Exchange submarine links |
| C4-SubmarineLength | Length of Core EAS submarine links |
| C3-LandingStation | Number of Core Exchange landing stations |
| C4-LandingStation | Number of Core EAS landing stations |
| C3-MWSite | Number of Core Exchange microwave sites |
| C4-MWSite | Number of Core EAS microwave sites |
| C1-ODF | Requested size of the ODF (F count) for FWA |
| C3-ODF | Requested size of the ODF (F count) for Core Exchange |
| C4-ODF | Requested size of the ODF (F count) for Core EAS |
| ODF | Cumulated requested size of the ODF |
| C3-DWDMsite | Number of Core Exchange DWDM sites |
| C4-DWDMsite | Number of Core EAS DWDM sites |
| C1-FWASite | Number of FWA sites |

Source: TERA Consultants

4.4.2 Trenches

Regarding the trenches, the output of the two tables, PROCESS BUILDING MODELLING and PROCESS SECTION MODELLING, consists of providing for each trench, its size and its allocated length, hence 15 outputs.

Table 47 - Interim outputs of the Access model regarding trenches

| Trench location | Size | Lead-in | Distribution | Feeder | FWA | Core DSLAM | Core Exchange | Core EAS |
|-----------------|------|---------|--------------|--------|--------|------------|---------------|----------|
| Vertical part | Size | Length | | | | | | |
| Minor side | Size | Length | Length | | | | | |
| Road cross | Size | | Length | | | | | |
| Major side | Size | Length | Length | Length | Length | Length | Length | Length |

Source: TERA Consultants

Then, for each network level, the Access model provides the length of trenches for a given set of trench sizes (see Table 48 - Outputs of the Access model regarding trenches).

The “PROCESS BUILDING MODELLING” provides the length of trenches for the small and medium trenches allocated to the lead-in.

The “PROCESS SECTION MODELLING” provides the length of trenches for the medium to largest trenches allocated to the lead-in, distribution, feeder, FWA, CoreDSLAM, Core Exchange and Core EAS.

Table 48 - Outputs of the Access model regarding trenches

| Size | | Lead-in | Distribution | Feeder | FWA | Core DSLAM | Core Exchange | Core EAS |
|---|---|-------------|--------------|--------|-----|------------|---------------|----------|
| ≥ 1 50-mm ducts and ≤ 2 50-mm ducts | S | Vert | | | | | | |
| ≥ 3 50-mm ducts; or ≥ 1 110-mm duct and < 2 110-mm ducts ¹⁹ | M | Vert Hor | Hor | Hor | Hor | Hor | Hor | Hor |
| ≥ 2 110-mm ducts and | L | Hor | Hor | Hor | Hor | Hor | Hor | Hor |

¹⁹ As the size of the trench aggregates 110-mm ducts for distribution to core and 50-mm ducts for lead-in, it can be a non-integer real number.

| Size | | Lead-in | Distribution | Feeder | FWA | Core DSLAM | Core Exchange | Core EAS |
|---------------------------------------|-----|---------|--------------|--------|-----|------------|---------------|----------|
| < 3 110-mm ducts | | | | | | | | |
| ≥ 3 110-mm ducts and < 4 110-mm ducts | XL | Hor | Hor | Hor | Hor | Hor | Hor | Hor |
| ≥ 4 110-mm ducts | XXL | Hor | Hor | Hor | Hor | Hor | Hor | Hor |

Hor: horizontal trench;
Vert: vertical trench

Source: TERA Consultants

The inventory of trenches by size is aggregated from vertical and horizontal trenches.

However:

- No trench can be smaller-than-one 110-mm duct on the horizontal parts of the section. If there is no distribution, no feeder and no core cable, there cannot be any lead-in cable that would result in a smaller-than-one trench. Hence, the small trenches can only be vertical trenches.
 - Horizontal trenches, computed in the VBA routine “Dimensioning at the section level” are added to all network levels, and are aggregated into M to XXL trenches (but no S trenches).
- As there are very few buildings with more than 4 or 5 dedicated ducts, it is assumed vertical trenches are no larger than medium trenches.
 - Vertical trenches are aggregated into small and medium trenches, for the lead-in.

For the copper and fibre underground networks, the dedicated lead-in trenches, computed in the table “PROCESS BUILDING MODELLING”, are aggregated through the queries “SELECT VERT TRENCHES FB” and “SELECT VERT TRENCHES CU”.

The horizontal trenches, computed in the table “PROCESS SECTION MODELLING”, are aggregated through the queries “SELECT HOR TRENCHES FB” and “SELECT HOR TRENCHES CU”.

For the copper and fibre overhead networks, only horizontal trenches are aggregated (see assumptions in 4.4.3), through the queries “SELECT TRENCHES CU OH” and “SELECT TRENCHES FB OH”.

It is important to have mind that there is neither feeder level nor Core DSLAM level in the fibre network. Hence, there are only $5 \times 4 + 1$ trench outputs in the fibre network, instead of $7 \times 4 + 1$ as in the copper network.

4.4.3 Overhead assumptions

The overhead networks (copper and fibre) contain some underground assets such as cables, trenches and ducts.

As such, when a FWA or core cable goes through a section in an overhead network, then the distribution and feeder cables are buried, with the lead-in network staying overhead, which occurs for approximately one tenth of the sections (weighted by their length).

This assumption is implemented in the aggregation queries (see section 2.2): for each section, it is checked whether there is a FWA or core cable in the section in the table “PROCESS SECTION MODELLING”.

If so, the underground asset is added into the result table. Otherwise, the overhead asset is added into the result table.

E.g. for the cables, if there is no core network, then the overhead cable and the number of pairs of the cable is assigned to the relevant overhead asset (e.g. “D-AccessOH0025”), else the underground cable and the number of pairs of the cable is assigned to the relevant underground asset.

The same principle applies to trenches, ducts, manholes, joints, and distribution points.

As poles are already adjusted in the “Dimensioning at the section level”, they are not tested in the aggregation queries.

As aforementioned (4.3.5.5.3 and 4.4.2), when a core network goes through the section, the trench has the same length as if the network was underground, but its size is adjusted as there is no lead-in duct.

Those assumptions are computed in the queries “SELECT RESULTS CU OH BUILDING”, “SELECT RESULTS CU OH SECTION”, and “FILL RESULTS CU OH MODELLING” and their equivalents for fibre.

4.4.4 Underground assumptions

In the underground networks, no overhead is taken into account. The queries that perform aggregation at MDF level consist in aggregating the underground assets and assigning to zero the overhead assets (overhead cable and joints, poles, overhead CCT/FAT).

This selection and aggregation is computed in the queries “SELECT RESULTS CU UG BUILDING”, “SELECT RESULTS CU UG SECTION”, and “FILL RESULTS CU UG MODELLING” and their equivalents for fibre.

5 Costing the access network

This section covers the methodology implemented in the Microsoft Excel component of the access network cost model, dealing with the costing of the access network given an inventory of assets produced in the Microsoft Access component of the access network cost model.

5.1 Reference files

The local access input file gathers from the Chorus data collection all the unit costs used in the local access network, in addition to data and parameters necessary for the dimensioning.

All the unit costs are used in the “Assets” spreadsheet.

In the following table,

- The file reference is the index of the issue (as indexed in the data request to Chorus) to which the data collection provided by Chorus answers;
- Content summarises the question asked and the answer provided;
- Usage indicates where the input is used.

Table 49 - Reference files

| File reference | Content | Usage |
|----------------|-----------|-------------------------|
| [] | [] | “Assets” |
| [] | [] | “Assets” |
| [] | [] | “Assets” |
| [] | [] | “Assets” and “MDF data” |
| [] | [] | “MDF data” |
| [] | [] | “Assets” |
| [] | [] | “Assets” |
| [] | [] | “Assets” |
| [] | [] CNZRI | “Assets” |

5.2 Inputs

The access network cost model is fed by four inputs sheets (see section 2.2.1):

- Import from the ACCESS;
- Assets;
- MDF data;
- Dashboard.

5.2.1 Import from the ACCESS

The access network cost model is fed by four inputs from the Microsoft Access model:

- Copper overhead inventory;
- Copper underground inventory;
- Fibre overhead inventory;
- Fibre underground inventory.

These four tables provide for each MDF/ODF the inventory of assets (from cables to trenches).

The four tables do not provide the MDF/ODF used (from a catalogue) but the requested size of the MDF and ODF. The choice and allocation of MDF/ODF is made in the access network cost model.

Those four tables are described in the section 4.4.1.

5.2.2 Assets

The “Assets” table lists all the assets used in the fibre and copper networks. For each asset, the table indicates:

- Which type of asset it is (e.g. cable, joint, trench);
- Whether it is an infrastructure (and is eligible to cost mitigation);
- Unit cost and year of input price;
- Lifetime;
- Price trend; and
- Tax depreciation rate.

In this spreadsheet the depreciation factor is computed.

5.2.3 MDF data

5.2.3.1 Overview

The “MDF data” spreadsheet gathers MDF-specific parameters that stem from the Commission data collection:

- Macro parameters (when the parameter is not provided at the MDF level, a national parameter is used):
 - Whether the MDF is urban or rural;
 - Percentage of cost allocated to leased lines;
 - Percentage of overhead network - Lead-In;
 - Percentage of overhead network – Distribution;
 - Percentage of overhead network – Feeder;
 - Percentage of shared overhead infrastructure;
 - Percentage of shared underground infrastructure;
 - Percentage of cost reduction due to shared overhead infrastructure;
 - Percentage of cost reduction due to shared underground infrastructure.
- Trenching unit costs:

- Small trench unit cost;
- Medium trench unit cost;
- Large trench unit cost;
- Very large trench unit cost;
- Extra large trench unit cost.

5.2.3.2 Trenching unit costs

Trenching unit costs are provided by BECA for six soil types and for a large set of sizes (driven by the number of ducts).

First, the unit costs are averaged to match the five trench sizes defined in the model:

- Small: 1 or 2 50 mm duct(s);
- Medium: 3 or more 50 mm ducts or 1 110 mm duct;
- Large: 2 110 mm ducts;
- Very large: 3 110 mm ducts;
- Extra large: 4 or more 110 mm ducts.

The weights used for the small, medium and extra large trenches are the inverse of the number of ducts, as the occurrence of large trenches decreases sharply with the size. For instance:

$$Cost_{XXL} = \frac{\frac{1}{4} Cost_{4 \text{ ducts}} + \dots + \frac{1}{10} Cost_{10 \text{ ducts}}}{\frac{1}{4} + \dots + \frac{1}{10}}$$

The unit costs of the trenches for 4 to 10 ducts are averaged using “harmonic” weights of the sizes.

Secondly, a soil type distribution is calculated at the MDF level.

MDF-specific trenching unit costs are obtained using weighted averages of soil-specific trenching unit costs and soil type distribution per MDF.

Finally, duct installation costs can be either taken into account in the trenching cost or in the duct unit cost, using the parameter “Include duct labour”. This does not have material impact of the cost modelling but induces a different distribution of cost items.

In the base case scenario, following international best practices, duct installation costs are included in the trenching costs.

Those computations are performed in the Excel file “Inputs for trenches” and copied into the access cost model, in the spreadsheet “MDF data”.

5.2.4 Dashboard

The “dashboard” spreadsheet provides for the key financial parameters of the model:

- Year of calculation;
- Corporate tax rate;

- Post-tax nominal cost of capital;
- The yearly spectrum cost;
- Whether capital contributions are taken into account for standard lead-ins
 - Such capital contribution applies only to standard lead-in when lead-in threshold is activated.
 - In the base case scenario, where standard and non-standard lead-in are dimensioned, no capital contribution is taken into account, neither for the standard lead-in (parameter disabled), nor for the non-standard lead-in.
- The size (in squared meters) of the active cabinets.

The dashboard also exposes the key results of the local access cost model.

5.3 Calculations

5.3.1 Assets

For each asset, given the WACC, the tax depreciation rate and the corporate tax rate, an adjusted WACC is computed and is applied, jointly with the asset lifetime, to the asset to obtain a depreciation factor.

In addition, the unit cost is adjusted with the relevant price trend when the year of input price differs from the year of investment.

5.3.2 Inventory

5.3.2.1 Overview

The four inventories are split into inventories for each network level (from lead-in to Core EAS) in the “Inventory” spreadsheet.

In the copper network, as well as in the fibre network, overhead and underground are combined thanks to the MDF-specific parameters regarding the share of overhead and underground for each network level (see next section). In addition, in sub-sections 1.3 and 2.3 of the Investment sheet, the assets are aggregated at an asset type level (e.g. copper cable, trench), in order to provide metrics and control tests for the network dimensioning (e.g. total length of cable, total length of ducts). At this stage, the mix between overhead and underground is implemented for each level of network.

While all the lines of the inventory tables consist in simple aggregation functions, the lines related to MDF and ODF perform MDF and ODF dimensioning and ODF allocation. Indeed, the Access model provides as an output for fibre and copper the needed size of the MDF/ODF, as well as the need stemming from the FWA and core networks.

5.3.2.2 Infrastructure sharing implementation

Underground and overhead infrastructures might be shared or rented to utility networks, leading to cost reduction, according to ComCom data.

Such infrastructure sharing is performed through four parameters when assessing the local access network investment:

- Percentage of shared overhead infrastructure;
- Percentage of shared underground infrastructure;
- Percentage of cost reduction due to shared overhead infrastructure;
- Percentage of cost reduction due to shared underground infrastructure.

For overhead (respectively underground), the cost reduction applied to the investment is:

$$\% \text{ Cost reduction} = \% \text{ Shared infra} \times \% \text{ Cost reduction when shared}$$

This compound rate is applied to infrastructures investment, checking whether the asset is an underground infrastructure (“UG”), an overhead infrastructure (“OH”) or not an infrastructure (“FALSE”) in column Investment!H:H : “Is infrastructure?”.

For each asset, the inventory (here, Inventory!L2147) is multiplied by its current unit cost (here, \$I2151) and eventually discounted with the compound cost reduction (here, either 0%, 1-‘MDF data’!\$24*‘MDF data’!\$25 or 1-‘MDF data’!\$26*‘MDF data’!\$27).

Figure 28 - Screenshot of the "Investment" spreadsheet: infrastructure sharing implementation (with utilities)

| | A | B | C | D | E | F | G | H | I | J | K | L |
|------|---|---|---|---|---|-----------|----------------|------|----------|----------------|-----------------|--------|
| 2148 | | | | | | JntFb0312 | fibre joint OH | FAUX | 6,848.45 | - | - | |
| 2149 | | | | | | FAT_OH | fat OH | FAUX | 1,513.09 | - | - | |
| 2150 | | | | | | FAT_UG | fat UG | FAUX | 1,445.19 | 424,520,508.28 | 345,400.64 | 747,11 |
| 2151 | | | | | | Duct50 | duct | UG | 7.62 | 243,524,666.02 | = \$I2151*Inven | 403,51 |
| 2152 | | | | | | Duct110 | duct | UG | 11.54 | - | - | |

Source: TERA Consultants

Furthermore, underground infrastructure assets are also subject to another cost reduction, which stems from the access part of fibre leased lines (see Model specification).

This cost reduction is applied in the sub-sections “1.3 Copper network investment” and “2.3 Fibre network investment” of the “Investment” spreadsheet (and “Annual cost” spreadsheet), for the ducts, trenches and manholes.

As, at this stage, the mix between overhead and underground is already implemented, the share of leased lines (here, ‘MDF data’!\$21) is only applied to the share of underground investments (here, 1-‘MDF data’!\$22).

Written as an equation, it can be summarised as, for each MDF area:

$$\Sigma(\text{Lead in capex in OH net} \mid \text{If asset is "duct"}) * \% \text{OH in lead in} \\ + \Sigma(\text{Lead in capex in UG net} \mid \text{If asset is "duct"}) * \% \text{UG in lead in} * (1 - \% \text{Leased lines})$$

With net = network, OH = overhead, UG = Underground, %OH = percentage of overhead infrastructure, %UG = 1- %OH = percentage of underground infrastructure,

%LeasedLines = % of length of the underground network which is shared with access fibre leased lines.

Figure 29 - Screenshot of the "Investment" spreadsheet: infrastructure sharing implementation (with leased lines)

| | F | G | H | I | J | K | L |
|------|---------------------------|-----|--------|------|-------------|-----------|----|
| 2629 | Core_EAS | NZD | fat OH | VRAI | - | - | |
| 2630 | | | | | | | |
| 2631 | Duct | | | VRAI | | | |
| 2632 | Lead In | NZD | duct | VRAI | 320,072,752 | =SUMME.SI | 53 |
| 2633 | Distribution | NZD | duct | VRAI | 605,766,330 | 1,240,790 | 54 |
| 2634 | FWA | NZD | duct | VRAI | 65,292,476 | 747,640 | 12 |
| 2635 | Core_Exchange | NZD | duct | VRAI | 278,208,087 | 565,103 | 16 |
| 2636 | Core_EAS | NZD | duct | VRAI | 251,219,064 | - | |
| 2637 | Access - Fibre (inc. BTO) | | duct | VRAI | 80,029,406 | 148,754 | 7 |

Source: TERA Consultants

5.3.3 Investments

The “Investment” spreadsheet performs the capex computation given:

- The inventory;
- The unit costs;
- Possible cost reduction stemming from infrastructure sharing.

For each asset, MDF and network level, it multiplies the number of assets with the unit costs and the possible cost reductions (shared infrastructure, leased lines).

Cost reductions are applied to infrastructures (poles, ducts, trenches, manholes) with the compound rate:

$$\text{Cost reduction} = (\% \text{ shared infrastructures}) \times (\% \text{ cost reduction when shared})$$

A different rate applies to underground and to overhead infrastructures. The rate is implemented by checking the field “Is infrastructure?” defined for each asset (FALSE, UG or OH).

Regarding leased lines, a share of underground infrastructures is withdrawn to each level of network.

For the copper and fibre network, it combines the overhead and underground investments using the “MDF data” percentage of overhead.

Figure 30 - Screenshot of the "investment" spreadsheet

| Fibre network investm | Unit | Asset Type | Check | Total | AAI | ABB | ABY | AH | AHA |
|---------------------------------|------|-----------------|-------|----------------|------------|------------|------------|------------|-----------|
| Total | | | | | | | | | |
| Lead In | NZD | | | 14,696,766,011 | 22,577,469 | 17,170,876 | 3,693,050 | 24,989,249 | 3,598,425 |
| Distribution | NZD | | | 12,357,460,195 | 43,785,332 | 6,980,626 | 13,269,397 | 23,210,702 | 7,605,164 |
| FWA | NZD | | | 226,829,855 | 4,823,712 | 795,349 | - | 149,598 | - |
| Core_Exchange | NZD | | | 2,213,644,600 | - | 635,213 | 1,463,099 | 980,025 | 2,391,532 |
| Core_EAS | NZD | | | 2,034,750,033 | 3,094,176 | 635,213 | 2,924,584 | 4,478,038 | - |
| Access - Fibre (inc. | NZD | | | 344,516,033 | 688,560 | 267,606 | 275,192 | 660,495 | 174,650 |
| Copper cable underground | | | VRAI | | | | | | |
| Lead In | NZD | copper cable UG | VRAI | - | - | - | - | - | - |
| Distribution | NZD | copper cable UG | VRAI | - | - | - | - | - | - |
| FWA | NZD | copper cable UG | VRAI | - | - | - | - | - | - |
| Core_Exchange | NZD | copper cable UG | VRAI | - | - | - | - | - | - |
| Core_EAS | NZD | copper cable UG | VRAI | - | - | - | - | - | - |
| Copper cable overhead | | | VRAI | | | | | | |
| Lead In | NZD | copper cable OH | VRAI | - | - | - | - | - | - |
| Distribution | NZD | copper cable OH | VRAI | - | - | - | - | - | - |
| FWA | NZD | copper cable OH | VRAI | - | - | - | - | - | - |
| Core_Exchange | NZD | copper cable OH | VRAI | - | - | - | - | - | - |
| Core_EAS | NZD | copper cable OH | VRAI | - | - | - | - | - | - |
| Fibre cable underground | | | VRAI | | | | | | |
| Lead In | NZD | fibre cable UG | VRAI | 2,725,314,165 | 4,114,175 | 3,398,660 | 631,157 | 4,347,080 | 611,281 |
| Distribution | NZD | fibre cable UG | VRAI | 2,238,095,108 | 9,964,602 | 1,362,074 | 2,087,671 | 3,823,427 | 1,149,163 |
| FWA | NZD | fibre cable UG | VRAI | 51,502,968 | 1,261,592 | 147,877 | - | 36,434 | - |
| Core_Exchange | NZD | fibre cable UG | VRAI | 619,900,149 | - | 185,576 | 291,609 | 275,866 | 573,784 |
| Core_EAS | NZD | fibre cable UG | VRAI | 575,715,378 | 708,689 | 185,576 | 535,804 | 1,138,535 | - |
| Fibre cable overhead | | | VRAI | | | | | | |
| Lead In | NZD | fibre cable OH | VRAI | 1,104,373,272 | 1,654,862 | 1,325,317 | 269,890 | 1,729,658 | 243,962 |
| Distribution | NZD | fibre cable OH | VRAI | - | - | - | - | - | - |
| FWA | NZD | fibre cable OH | VRAI | - | - | - | - | - | - |
| Core_Exchange | NZD | fibre cable OH | VRAI | - | - | - | - | - | - |
| Core_EAS | NZD | fibre cable OH | VRAI | - | - | - | - | - | - |

Source: TERA Consultants

Hence, the investment is allocated to each of the seven (copper) or five (fibre) network levels and to each asset type and summed to form the total investment per network level and per MDF.

In the case of underground infrastructure (ducts, trenches, manholes), a share of the costs is withdrawn and allocated to leased lines as an eighth/sixth network level, according to the “MDF data” parameter “Percentage of cost allocated to leased lines”.

5.3.4 Annual costs

The “annual costs” spreadsheet annualises the capex resulting from the “investment” spreadsheet using for each asset the depreciation factor computed in the “assets” spreadsheet.

For the four network assumptions (copper overhead, copper underground, fibre overhead, fibre underground), each asset investment is multiplied by its depreciation factor.

Then, for the copper and for the fibre networks, the annual costs are combined using the share of overhead, and summed in the Total sub-table (in “Annual costs”, 1.3 and 2.3).

Finally, the total annual costs for the fibre network and for the copper network are copied into the “Export to the core model” sheet using a macro.

5.4 Outputs

The Access network cost model performs three outputs:

- Export to the UBA model;
- Results;
- Dashboard.

5.4.1 Export to the UBA model

The export to the UBA model contains the following data for the years 2015 to 2019:

- Costs: It provides the total annual costs per exchange of UCLL and Copper Local Loop, and the network investment and annual capex split by level of network (Access, Core aggregation and Core transmission);
- Volumes: It provides the total number of lines and the surface for MDFs.

The computation is performed through a macro function, `Fill_the_results()`, that increments the year of investment (from 2015 to 2019), run the model and writes in the outputs in the “Export to the UBA” spreadsheet, the UCLL and copper yearly costs and the network total investment, as well as the MDF volumes.

Figure 31 - Screenshot of the "Fill_the_results()" VBA macro

```
Sub Fill_the_results ()

    Dim currentYear As Double, year As Double, Status As Double

    Application.ScreenUpdating = False

    Status = 0
    currentYear = Range("PRM_Year").Value

    For year = 2015 To 2019
        Application.StatusBar = "Calculations : " & Format(Status, "0%") & " completed."
        Status = Status + 1 / (2019 - 2015 + 1)
        Range("PRM_Year").Value = year
        Calculate

        Range("UCLL_YearlyCost").Copy
        Range("UCLL_YearlyCost_" & CStr(year)).PasteSpecial Paste:=xlPasteValues, Transpose:=True
        Range("Copper_YearlyCost").Copy
        Range("Copper_YearlyCost_" & CStr(year)).PasteSpecial Paste:=xlPasteValues, Transpose:=True

        Range("AccessCopper_Investment_" & CStr(year)).Value = Range("CopperInvestment_LeadIn") + Range("Co
        Range("AccessFibre_Investment_" & CStr(year)).Value = Range("CopperInvestmen_AccessFibre").Value
        Range("CoreDSLAM_Investment_" & CStr(year)).Value = Range("CopperInvestment_CoreDSLAM") + Range("Co
        Range("CoreExchange_Investment_" & CStr(year)).Value = Range("CopperInvestment_CoreExchange").Value
        Range("CoreEAS_Investment_" & CStr(year)).Value = Range("CopperInvestment_CoreEAS").Value

        Range("AccessCopper_YearlyCost_" & CStr(year)).Value = Range("CopperYearlyCost_LeadIn") + Range("Co
        Range("AccessFibre_YearlyCost_" & CStr(year)).Value = Range("CopperYearlyCost_AccessFibre").Value
        Range("CoreDSLAM_YearlyCost_" & CStr(year)).Value = Range("CopperYearlyCost_CoreDSLAM") + Range("Co
        Range("CoreExchange_YearlyCost_" & CStr(year)).Value = Range("CopperYearlyCost_CoreExchange").Value
        Range("CoreEAS_YearlyCost_" & CStr(year)).Value = Range("CopperYearlyCost_CoreEAS").Value

        Range("ShareSLU_" & CStr(year)).Value = Range("ShareSLU").Value

    Next year

    Range("PRM_Year").Value = currentYear
    Calculate

    Application.StatusBar = False

    Application.ScreenUpdating = True

End Sub
```

Source: TERA Consultants

The macro is run when pressing the “Update the results” button on the Dashboard spreadsheet.

5.4.2 Results

The results table provides the capex and annual costs of the local access network for each MDF and for each type of network level, aggregating data from the “Investment” and “Annual costs” spreadsheets.

5.4.3 Dashboard

The dashboard contains the key parameters of the model (WACC, tax rates) and presents the main results of the Access network cost model:

- Costs of the UCLL and copper networks, and FTTN SLU, at national, urban and rural levels;
- Key indicators of the UCLL and copper networks (e.g. total investments, total annual costs, by level of network).

6 Core network cost model

6.1 Reference files

The model is made of two files:

- The UBA model; and
- The “UBA input” file that gathers most of table documents provided by Chorus that have been used to feed the model.

Most of the inputs provided by Chorus and used in the model are gathered in the “UBA Input” file, in which three main output spreadsheets are computed:

- Geographical data;
- Assets; and
- Inputs for the Dashboard.

The following table describes how the data provided during the data collection have been used to derive the inputs of the model:

Table 50 – Core network cost model reference files

| File reference | Content | Usage |
|--------------------------------|--|---------------------------------|
| 2.3.2 | List of sites | “Geographical data” spreadsheet |
| 2.1 | Distribution of xDSL customers per site | “Geographical data” spreadsheet |
| 3.1.1 of s98 sent in September | Distribution of xDSL customers per site | “Geographical data” spreadsheet |
| 2.2.3 | Distribution of SHDSL customers per site | “Geographical data” spreadsheet |
| 6.17 | Description of the assets | “Assets” spreadsheet |
| 6.19.6 | Asset lives | “Assets” spreadsheet |
| 6.15.3 | Unit costs | “Assets” spreadsheet |
| 3.1.1 of s98 sent in September | Number of customers | “Dashboard” spreadsheet |
| 2.2.3 of s98 sent in September | Number of customers | “Dashboard” spreadsheet |

Source: TERA Consultants

6.2 Inputs

The UBA model is fed with six input spreadsheets.

- Dashboard;
- Import from the ACCESS model;
- Import from the OPEX model;
- Parameters;
- Geographical data; and
- Assets.

These spreadsheets are described in the following sections.

6.2.1 Dashboard

The dashboard contains the main parameters of the model and the main results.

The main parameters are:

- The financial parameters (that comes from the Access model);
- The demand for each service; and
- The pricing approach for the different UBA services.

The main results are:

- The price of UCLL at the national level, in the urban areas and in the rural areas; and
- The price of the 4 UBA services (BUBA, EUBA40, EUBA90 and EUBA180).

6.2.2 Import from the ACCESS model

This spreadsheet contains the data that is needed from the access network cost model:

- Costs: It provides the total annual costs per exchange of UCLL and Copper Local Loop, and the network investment and annual capex split by level of network (Access, Core aggregation and Core transmission);
- Volumes: It provides the total number of lines and the surface for MDFs.

6.2.3 Import from the OPEX model

This spreadsheet contains the data that is needed from the Opex model:

- Opex (total opex per exchange for both UCLL and UBA);
- Unit costs for power and buildings;
- Indirect capex related to regulated services; and
- Labour costs dedicated to the access network.

6.2.4 Parameters

The “Parameters” spreadsheet is composed of several single inputs and parameters of the model. It is composed of:

- The year of calculation;

- The REN interconnection links capacity;
- Site equipment parameters (site, power and cooling parameters);
- Share of civil engineering allocated to UBA;
- The speed of the different UBA offers; and
- Spare capacity calculation parameters for line cards.

6.2.5 Geographical data

This spreadsheet details the geographical distribution of customers and the network topology:

- The “Access at cabinet” table provides the number of customers per service per cabinet and the parent exchange of each cabinet; and
- The “Access at Exchange” table provides the number of customers per service per exchange and to which FDS site each of the exchange is connected to.

6.2.6 Assets

This spreadsheet gathers all dimensioning and costing data regarding active network equipment (DSLAMs and FDS) and site equipment (power equipment, air conditioning and security).

6.3 Network dimensioning

The UBA cost model is made of two dimensioning spreadsheets and four costing spreadsheets:

- Network dimensioning (dimensioning spreadsheet);
- Inventory (dimensioning spreadsheet);
- Network costing (costing spreadsheet);
- Allocation keys (costing spreadsheet);
- OPEX and ACCESS (costing spreadsheet); and
- UBA (costing spreadsheet);

These spreadsheets are described hereafter.

6.3.1 Network dimensioning

The aim of this spreadsheet is to dimension the active cabinets and the exchange sites, i.e. to assess the number of assets needed for all the categories of assets.

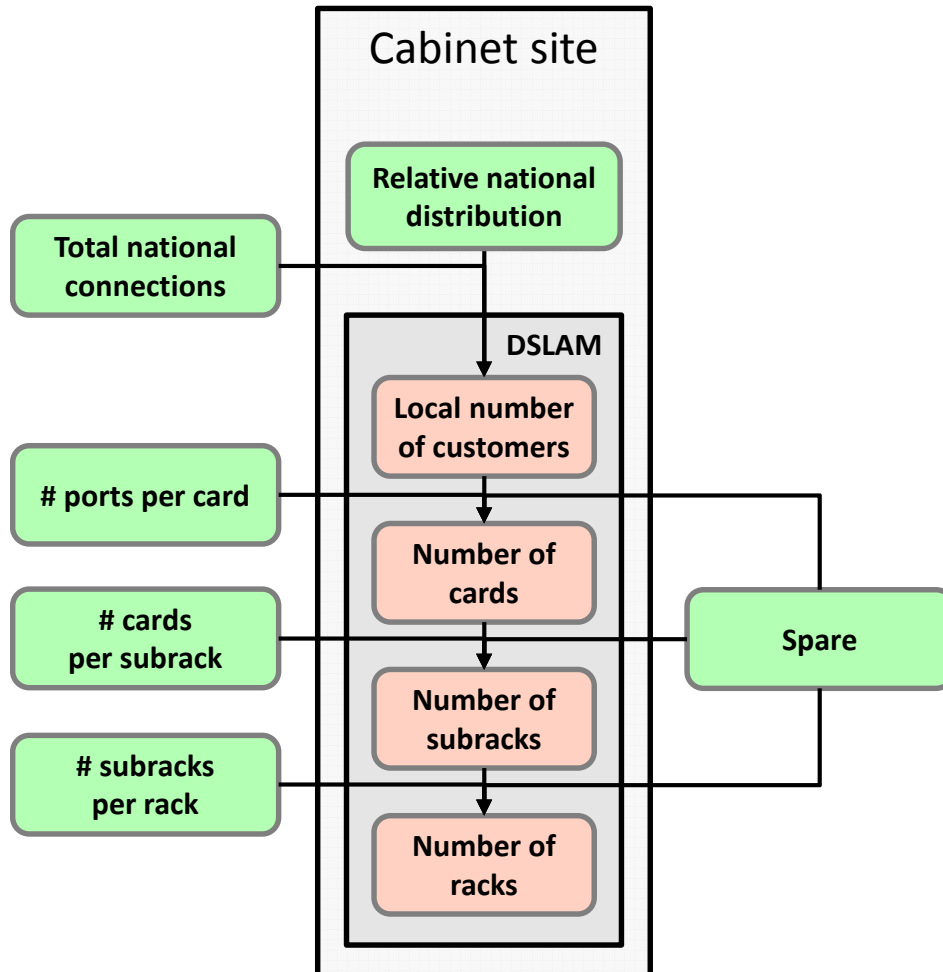
6.3.1.1 Cabinet

Dimensioning a cabinet means dimensioning all the assets that are included in the cabinet:

- The line card;
- The subrack holding the line cards; and
- The rack holding the subracks.

The dimensioning principle of the cabinet is described in the following figure:

Figure 32 - Equipment dimensioning - Cabinet dimensioning



Source: TERA Consultants

This dimensioning is carried out in the table 1 of the spreadsheet “Network dimensioning”.

6.3.1.2 Exchange

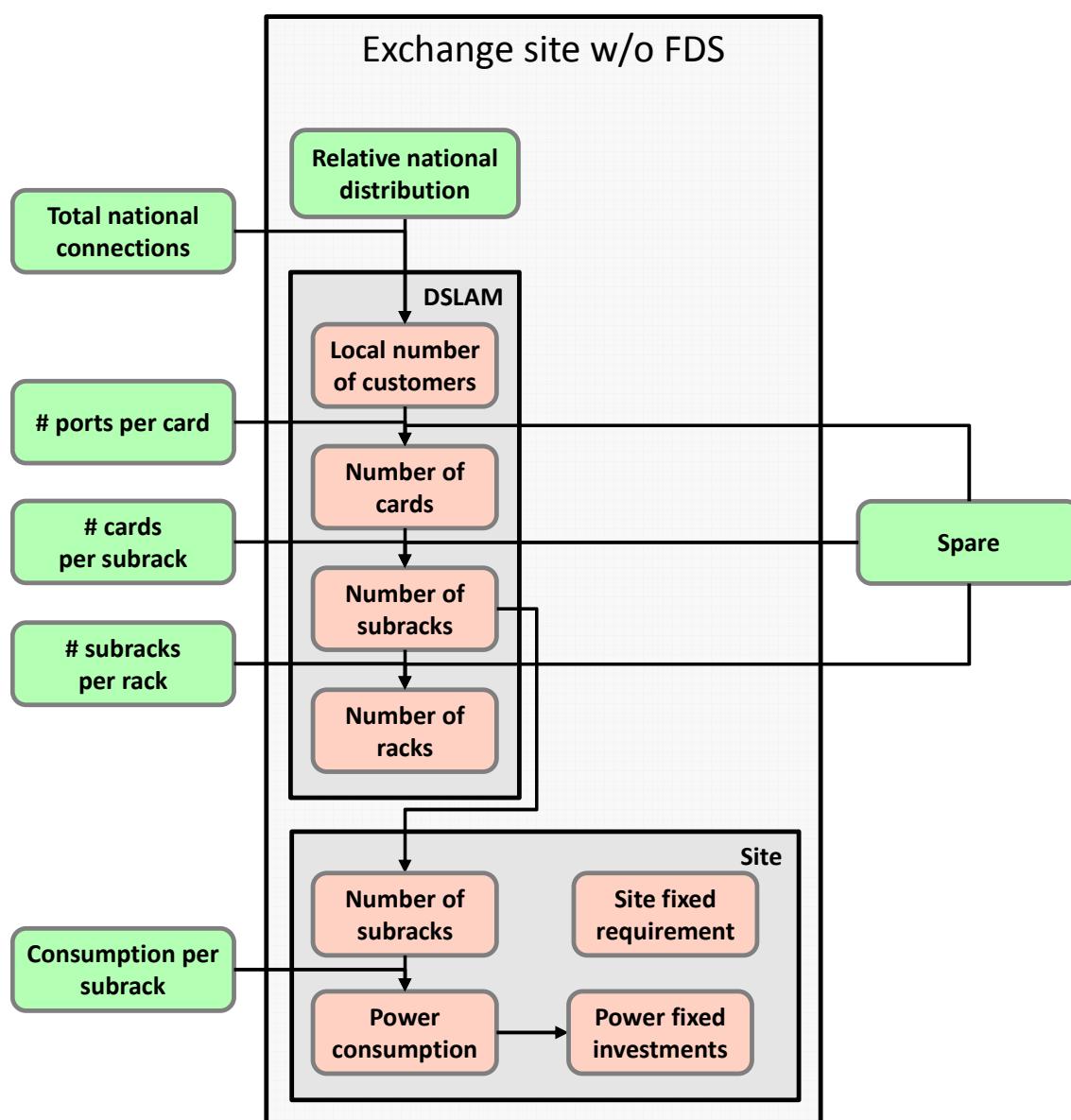
There are two types of exchanges:

- Exchanges without switch; and
- Exchanges with switches (EAS).

Both types of exchanges contain DSLAMs for which the dimensioning is similar to the dimensioning of the DSLAMs located in the cabinets. The DSLAMs located in the exchanges are made of the exact same assets as the DSLAMs located in the cabinets:

- The line card;
- The subrack holding the line cards; and
- The rack holding the subracks.

Figure 33 – Dimensioning of an exchange with no FDS



Source: TERA Consultants

The exchanges with switches contain switches which are made of the following assets:

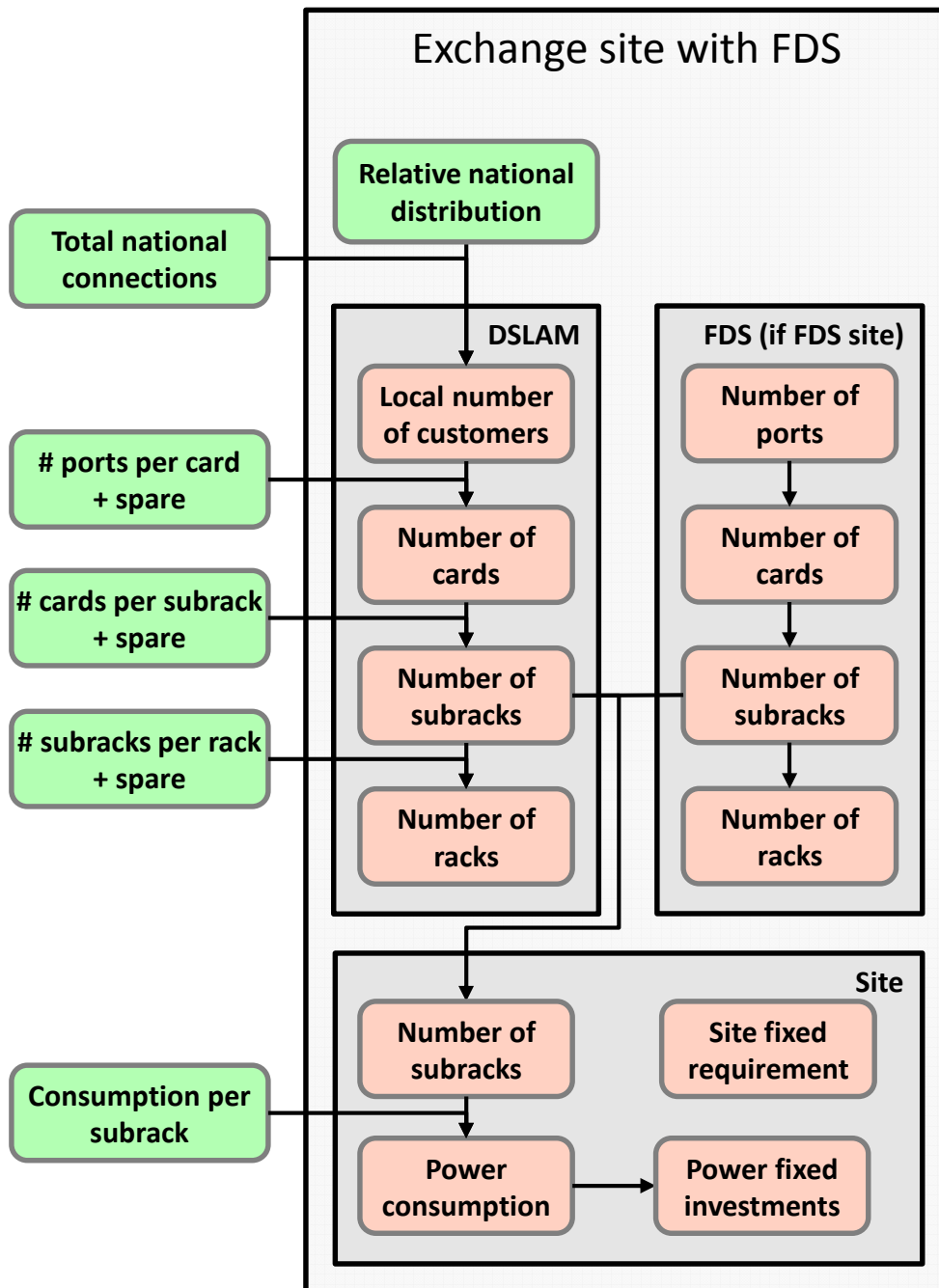
- The small form factor pluggable (SFP);
- The card;
- The subrack; and
- The rack.

The number of ports required on the FDS is the sum of the number of ports reserved to interconnect the switch to the REN, the number of ports reserved by RSP (Retail Service Providers) to collect the BSA traffic and the number of ports required to plug all the DSLAMs it aggregates.

All DSLAMs are connected with a 1G port to the switch, the FDS is considered to be interconnected to the REN with two 1G ports. The number and the capacity of ports used by RSPs has been provided by Chorus for each site.

The dimensioning principle of the exchange with a switch is described in the following figure:

Figure 34 – Dimensioning of an exchange with a switch



Source: TERA Consultants

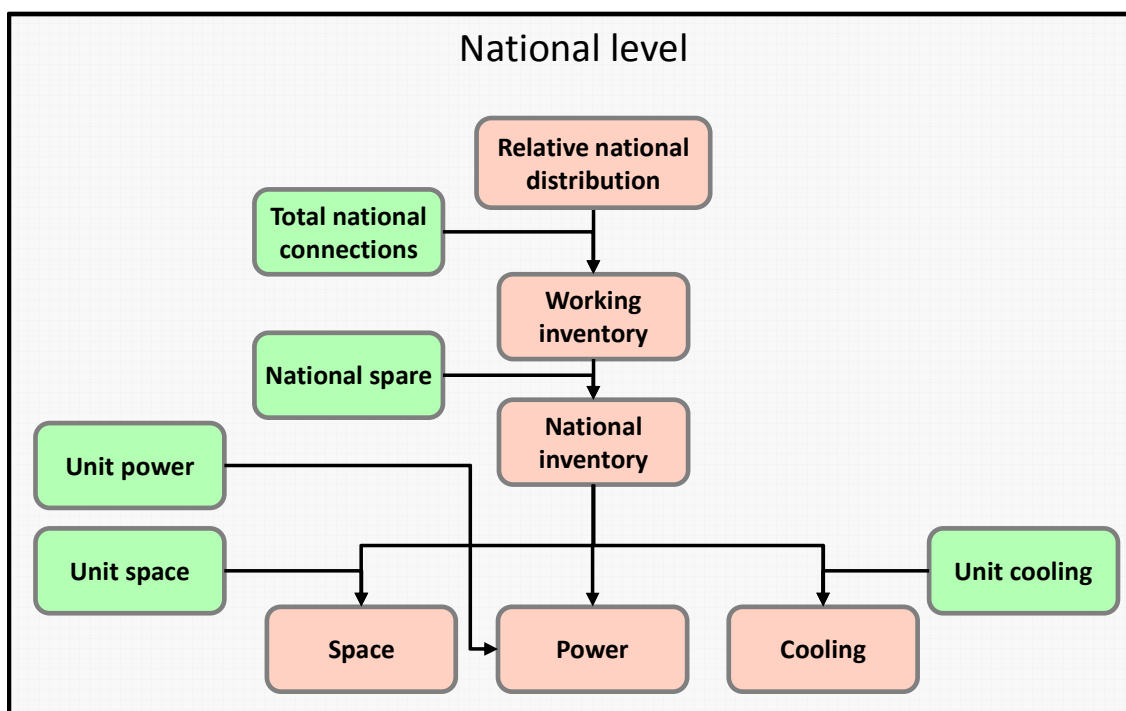
The dimensioning of the exchanges is made of four tables:

- In the first table, the demand is derived per exchange based on the network topology;
- In the second table, the DSLAM in all the sites are dimensioned;
- In the third table, the FDS (i.e. the switches) are dimensioned;
- In the fourth table, the fixed cost related to power investment is dimensioned.

6.3.2 Inventory

The aim of this spreadsheet is to derive the network inventory including the network power usage and the network space requirements.

Figure 35 - Inventory and Buildings



Source: TERA Consultants

Based on the number of assets required to handle the demand (the working inventory), the model includes some spare capacity. This constitutes the national inventory.

Based on the inventory, it also dimensions space, power and cooling variable parts which are proportional to the number of network assets deployed.

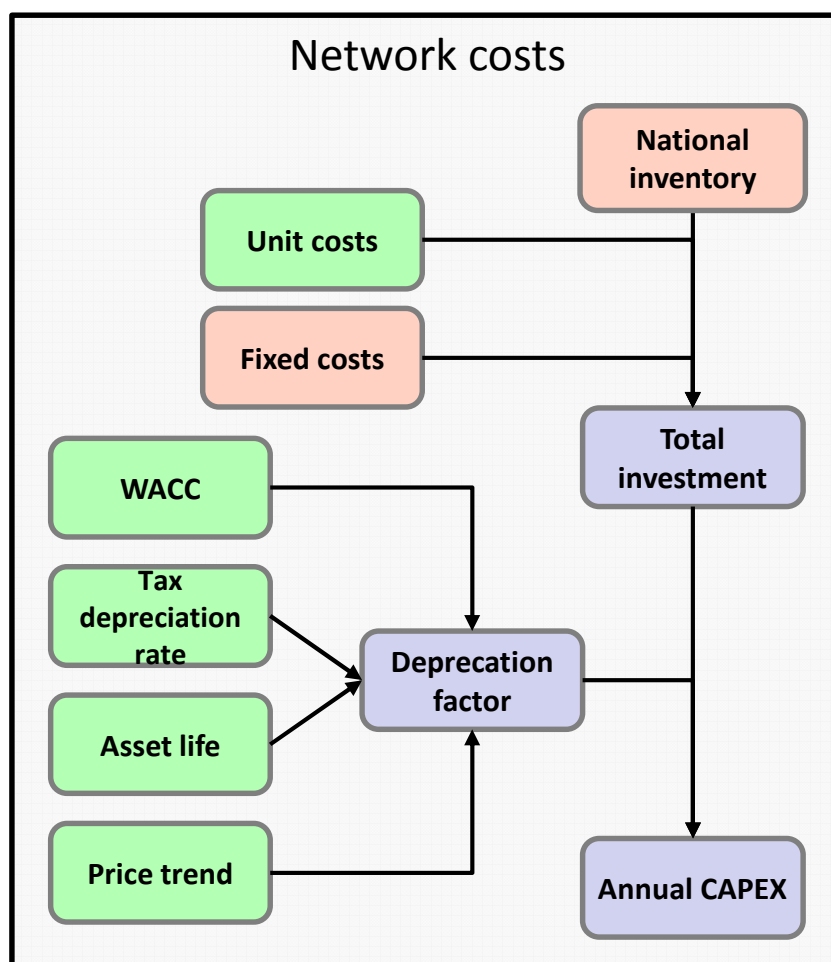
Each asset has been provided with its power consumption, a cooling requirement and a unit space per asset. The multiplication of these units by the inventory gives the total power, cooling and space requirement.

6.4 Financial calculation

6.4.1 Network costing

The aim of this spreadsheet is to derive the network total investment and the network annual capex.

Figure 36 - Network costing



Source: TERA Consultants

The network total investment is derived by adding the fixed costs (computed in the spreadsheet “Network dimensioning”) with the variable costs which are obtained by multiplying the assets quantities by their unit cost. In accordance with criterion 34 of the Model Reference Paper, the cost of the DSLAM included in the RBI program has been removed from the total investment used to calculate UBA additional costs.

The network annual capex is derived from the network total investment by multiplying by the depreciation factor.

6.4.2 Allocation keys

The aim of this spreadsheet is to derive two sets of allocation keys.

The first set of allocation keys are used to allocate the non-network costs. The following keys provide a split between UBA and UCLL:

Table 51 - Allocation keys of non-network costs

| Allocation key | Description |
|----------------|---|
| Investment | Allocation proportional to the total investment |
| Annual capex | Allocation proportional to annual cost |
| Active lines | Allocation proportional to the number of active customers |
| Access | All costs allocated to the UCLL |
| UBA | All costs allocated to UBA |

Source: TERA Consultants

The second set of allocation keys are used to allocate the annual cost of the core network assets between the different services that use them. All the following keys are split among xDSL customers at cabinet, xDSL customers at Exchange, SHDSL customers at cabinet and SHDSL customers at Exchange:

Table 52 - Allocation keys of core network assets

| Allocation key | Description |
|--------------------------|--|
| Customers | Allocation based on all customers |
| Exchange customers | Allocation based on customers connected directly to an exchange site |
| xDSL exchange customers | Allocation based on xDSL (i.e. ADSL and VDSL) customers connected directly to an exchange site |
| SHDSL Exchange customers | Allocation based on SHDSL customers connected directly to an exchange site |
| Cabinet customers | Allocation based on customers connected to a cabinet |
| xDSL cabinet customers | Allocation based on xDSL (i.e. ADSL and VDSL) customers connected to a cabinet |
| Customers and ports | Allocation based on all customers and on the number of ports |
| SHDSL cabinet customer | Allocation based on SHDSL customers connected to a cabinet |

Source: TERA Consultants

6.4.3 OPEX and ACCESS

The aim of the “OPEX and ACCESS” spreadsheet is to allocate non-network costs and to derive the annual cost per line of the local loop.

6.4.3.1 Non-network costs

There are four types of non-network costs that should be taken into account and allocated to the different relevant services:

- The IT costs;
- The miscellaneous costs;
- The access specific costs;
- The UBA specific costs.

For each of these non-network costs, a specific allocation key has to be determined. The allocation keys are selected among the allocation keys computed in the spreadsheet “Allocation keys”. The allocations keys are identified in the following table:

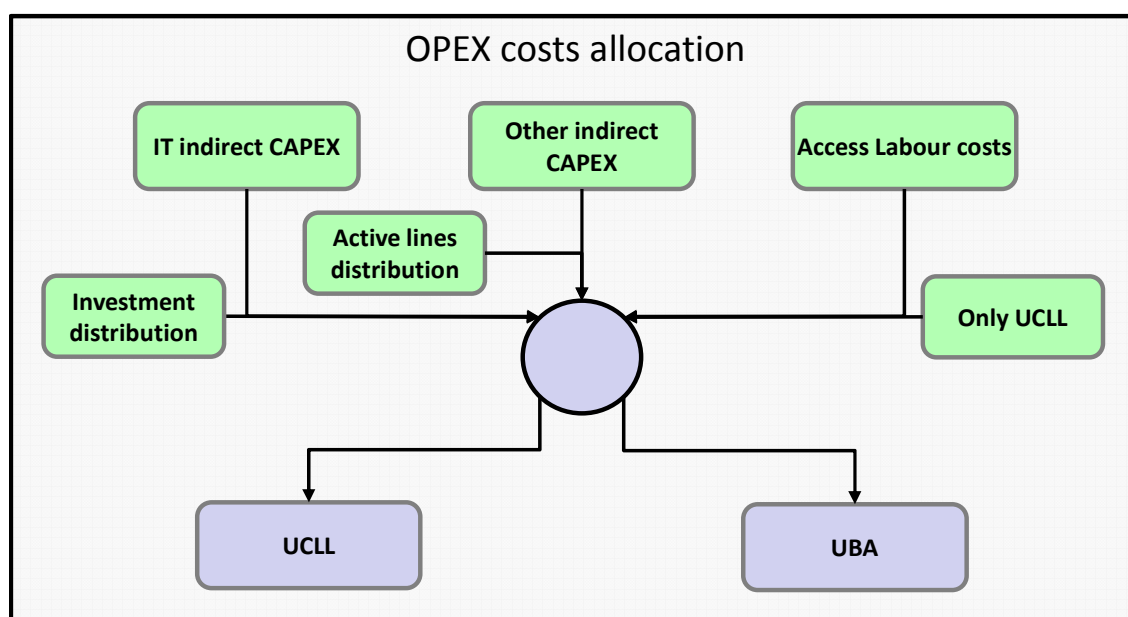
Table 53 - Non-network costs allocation keys

| Cost | Allocation key |
|------------------------|----------------|
| IT costs | Investment |
| Miscellaneous indirect | Active lines |
| Access | Access |
| UBA | UBA |

Source: TERA Consultants

All four non-network costs are outputs of the Opex model.

Figure 37 - Opex and Access Allocations - Indirect Capex + Access Labour costs allocation



Source: TERA Consultants

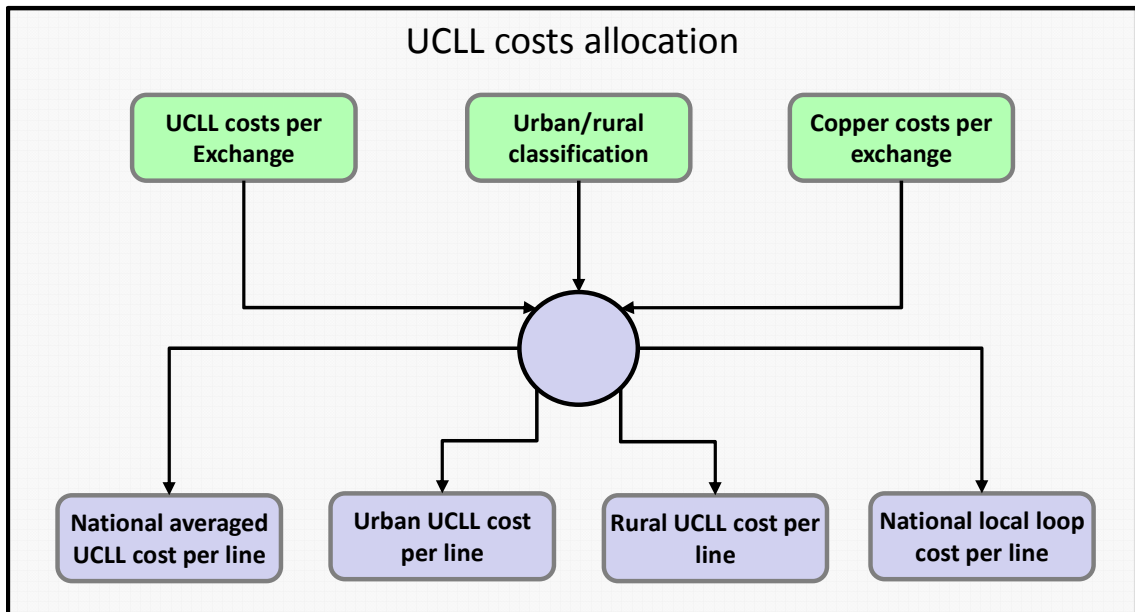
All four non-network costs are national cost, i.e. there are no regional variations.

6.4.3.2 Cost of the access network

The access network cost model derives annual capex per exchange for the copper local loop and the UCLL.

The objective of the second table is to derive a cost per line (annual capex + opex + all non-network costs) at a national level and to provide a cost for the urban and rural geotypes.

Figure 38 - Opex and Access Allocations - UCLL and Copper Local Loop cost calculation



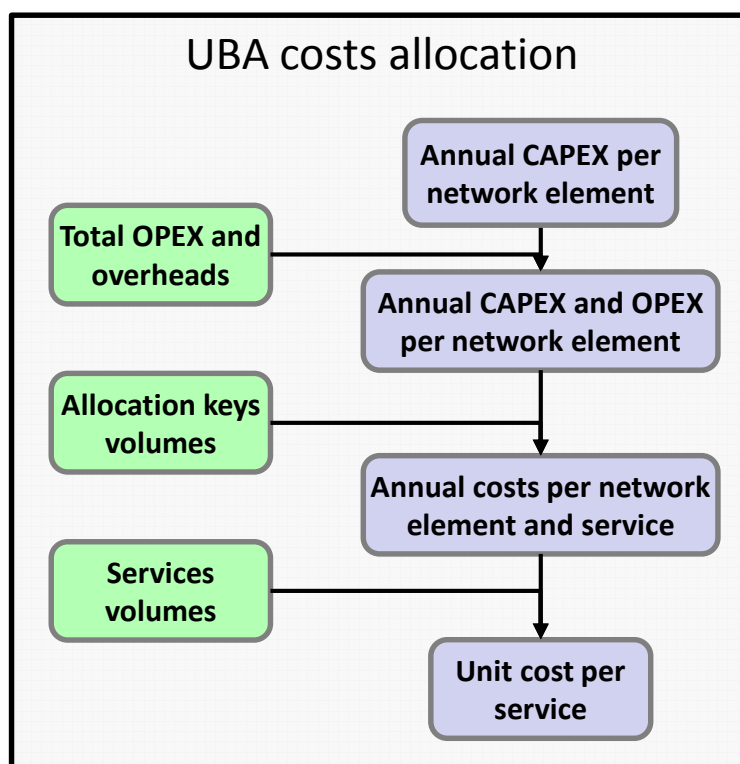
Source: TERA Consultants

The opex are computed per MDF, however the non-network costs are national costs. They are therefore allocated to each MDF using the EPMU approach.

6.4.4 UBA

The aim of this spreadsheet is to derive the unit cost of the UBA service. The following figure provides an overview of the approach followed:

Figure 39 - UBA costs allocation



Source: TERA Consultants

The first step is to derive the annual cost of the network which is the sum of:

- The annual capex as computed in the spreadsheet “Network costing”;
- The annual opex as computed in the spreadsheet “OPEX and ACCESS”;
- The annual non-network costs as computed in the spreadsheet “OPEX and ACCESS”.

The second step is to allocate the network annual cost between the different services using the parts of the core network that are modelled. These include the following services:

- xDSL services (composed of UBA and VDSL services);
- SHDSL services; and
- Interconnection.

The allocation is made asset by asset. For each asset, a specific allocation key is determined. Following the capacity based allocation approach, the allocation key is selected so that it is consistent with the dimensioning driver. Each asset has therefore a specific allocation key that has been computed in the spreadsheet “Allocation keys”. The allocation key of each asset is identified in the following table:

Table 54 - UBA Allocation keys

| Asset | Allocation key |
|-----------|-------------------|
| MDF Sites | Exchange Customer |

| Asset | Allocation key |
|--------------------------------|-------------------------|
| Cabinet xDSL Cards | xDSL cabinet Customer |
| Cabinet SHDSL Cards | SHDSL cabinet Customer |
| Cabinet DSLAM Racks and sites | Cabinet Customer |
| Cabinet-Exchange fibres | Cabinet customer |
| Exchange xDSL Cards | xDSL exchange Customer |
| Exchange SHDSL Cards | SHDSL exchange Customer |
| Exchange DSLAM Racks and sites | Exchange Customer |
| Exchange-FDS fibres | Customer |
| FDS | Customers and ports |

Source: TERA Consultants

The third and last step is to derive the unit cost of the UBA service. It is achieved by dividing the annual costs allocated to UBA by the number of customers of this service.

6.5 Outputs

The output of the model is made of two spreadsheets:

- The “Output” spreadsheet; and
- The “Pricing” spreadsheet.

These two spreadsheets are described in the following sections.

6.5.1 Output

The Output spreadsheet takes as input results from the rest of the model using a macro. The button “Update the results” calculates for each year between 2015 and 2019 the results of the model for:

- Total capex investment related to DSL services and Total annual capex allocated to DSL; and
- ‘Annualised TSLRIC cost of the ULL’ and ‘Annualised TSLRIC cost of SLUBH’ for both rural and urban geotypes.

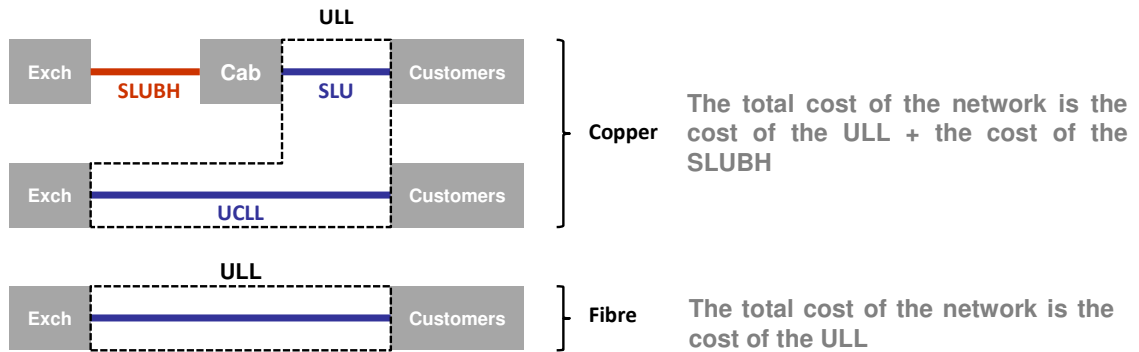
6.5.1.1 The UBA service

The ‘Total annual capex allocated to DSL’ is used to derive an average cost per DSL customer, based on the total number of DSL customers. This average cost is then adjusted to build different offers depending on the quality of service provided using a gradient.

6.5.1.2 The ULL services

The Access model outputs a total cost for the ULL network.

Figure 40 - ULL cost as outputted by the access model



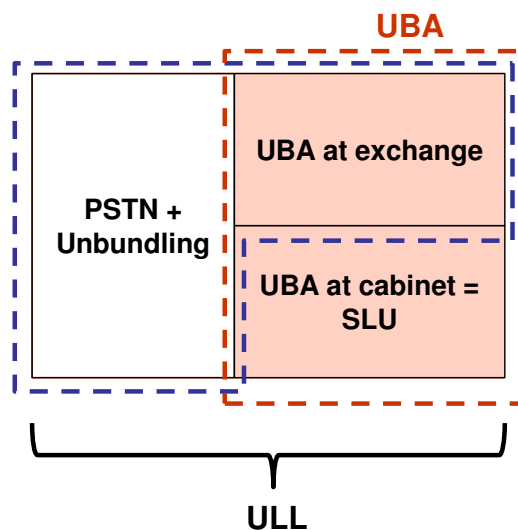
Source: TERA Consultants

Due to geographical scope differences, in the fibre network case, the cost of the ULL is the difference between the cost of the fibre ULL minus the cost of the copper SLUBH.

In both case, the total cost of the network is therefore the cost of the ULL + the cost of the SLUBH.

The total cost of connecting all customers to the exchange is the cost of the ULL + the cost of the SLUBH.

Figure 41 – Venn diagram of different customers' demand



Source: TERA Consultants

Chorus has provided the total ULL demand (calculated as the number of copper connections + the number of fibre connections), and the total UBA demand split between cabinet and exchange.

Two assumptions have been defined:

- The SLU demand has been considered as equal to the UBA demand at cabinet (meaning that all active lines at cabinet are UBA lines);
- The demand for SLU backhaul is equal to the SLU demand (all RSP use SLU backhaul for DSL products at cabinet).

The inputs available in the core model are therefore:

- C_{ULL} : The ULL total cost.
- C_{SLUBH} : The SLU backhaul total cost.
- $\#_{ULL}$: The total ULL demand.
- $\#_{UCLL}$: The total UCLL demand.
- $\#_{UBA}$: The total UBA demand.
- $\#_{SLU} = \#_{SLUBH}$: The UBA demand at cabinet = the SLU demand = the SLUBH demand.

The following namings will be used below:

- P_{UCLL} : The unit cost of a UCLL line.
- P_{SLU} : The unit cost of a SLU line.
- P_{SLUBH} : The unit cost of a SLU Backhaul service.
- C_{SLU} : The total cost of the SLU.
- C_{UCLL} : The total cost of the UCLL.
- $C_{Network}$: The total cost of the whole copper network including the SLUBH.

Two axioms have been defined:

- $P_{UCLL} = P_{SLU} + P_{SLUBH}$: Each full line should have a same price.
- $C_{Network} = C_{ULL} + C_{SLUBH}$: The total cost of the network (cost of connecting all customers) is the total cost of the copper network (UCLL + SLU = ULL) plus the total cost of the SLU Backhaul.

The objective of the model is to calculate the unit cost of UCLL, SLU and SLUBH (P_{UCLL} , P_{SLU} and P_{SLUBH}).

$$C_{UCLL} = P_{UCLL} \times \#_{UCLL} = P_{SLU} \times \#_{UCLL} + P_{SLUBH} \times \#_{UCLL}$$

$$\begin{aligned} C_{Network} &= C_{UCLL} + C_{SLU} + C_{SLUBH} \\ &= P_{SLU} * \#_{UCLL} + P_{SLUBH} * \#_{UCLL} + P_{SLU} * \#_{SLU} + P_{SLUBH} * \#_{SLU} \\ &= (P_{SLU} + P_{SLUBH}) \times (\#_{UCLL} + \#_{SLU}) = P_{UCLL} \times \#_{ULL} \end{aligned}$$

Therefore we get the three unit costs defined as follow:

- $P_{UCLL} = \frac{C_{Network}}{\#_{ULL}}$
- $P_{SLUBH} = \frac{C_{SLUBH}}{\#_{SLU}}$

- $P_{SLU} = P_{UCLL} - P_{SLUBH}$

Cross-checks - cost recovery:

Total revenues = $R = \#_{UCLL} \times P_{UCLL} + \#_{SLUBH} \times P_{SLUBH} + \#_{SLU} \times P_{SLU}$

- $P_{UCLL} = \frac{CULL + CSLUBH}{\#ULL}$
- $P_{SLUBH} = \frac{CSLUBH}{\#SLUBH}$
- $P_{SLU} = P_{UCLL} - P_{SLU} = \frac{CULL + CSLUBH}{\#ULL} - \frac{CSLUBH}{\#SLUBH}$

$$R = \#_{UCLL} * \frac{CULL + CSLUBH}{\#ULL} + \#_{SLUBH} * \frac{CSLUBH}{\#SLUBH} + \#_{SLU} * \left(\frac{CULL + CSLUBH}{\#ULL} - \frac{CSLUBH}{\#SLUBH} \right)$$

- $\#_{SLU} = \#_{SLUBH}$
- $\#_{SLU} + \#_{UCLL} = \#_{ULL}$
- $R = (\#_{ULL} - \#_{SLU}) * \frac{CULL + CSLUBH}{\#ULL} + CSLUBH + \#_{SLU} * \left(\frac{CULL + CSLUBH}{\#ULL} - \frac{CSLUBH}{\#SLU} \right)$
- $R = C_{ULL} + C_{SLUBH}$
- $R = \text{Cost of the network}$

Cross-checks - The unit cost of UCLL should be equal to the average unit cost of a line.

By construction of the price:

$$P_{UCLL} = P_{SLU} + P_{SLUBH}$$

$$\begin{aligned} P_{SLU} * \frac{\#_{SLU}}{\#_{ULL}} + P_{UCLL} * \frac{\#_{UCLL}}{\#_{ULL}} &= \frac{CSLU}{\#_{SLU}} * \frac{\#_{SLU}}{\#_{ULL}} + \frac{CUCLL}{\#_{UCLL}} * \frac{\#_{UCLL}}{\#_{ULL}} \\ &= \frac{CSLU}{\#_{ULL}} + \frac{CUCLL}{\#_{ULL}} \\ &= \frac{CULL}{\#_{ULL}} \\ &= P_{ULL} \end{aligned}$$

6.5.2 Pricing

The “pricing” spreadsheet is gathering all the prices that have been derived.

7 How to use the models

7.1 Opex model

To update the Opex model, the user can change some parameters that are located in the spreadsheet “Parameters” such as:

- The WACC;
- The targeted LFI;
- The trend used for forecasts;
- The type of costs used for the building cost.

Some other parameters can easily be easily changed in the spreadsheet “Inputs allocationkey”:

- Floor space related to MDF and EAS (inputs from the Access and the Core models);
- The number of active and passive cabinets; and
- The length of km-pairs from the Access network cost model.

In order to model results that are exported to the Core network cost model, the user has to click on the “Fill” macro button present in the spreadsheet “EXPORT”.

This sheet has to be copy-pasted in the spreadsheet ‘Import from the OPEX model’ of the Core network cost model.

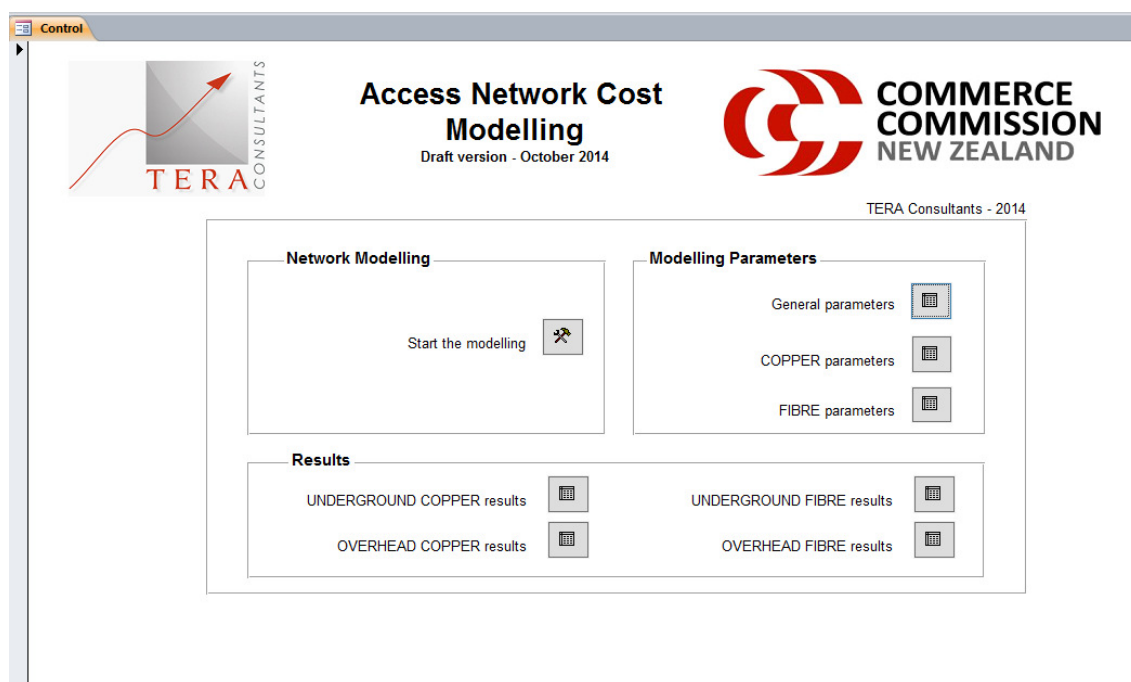
Detailed results per type of cost for opex per line can be updated by clicking on the “Update” macro button in the spreadsheet “Results”. This macro enables to run the model for all years within the control period.

7.2 Access network cost model

To update the access network cost model, the user can change:

- a. The input parameters for the dimensioning in the Excel file “Local access network sources”:
 - i. Open the Microsoft Access model, import the five parameter tables from the Excel file “Local access network sources”;
 - ii. In the Microsoft Access model, press the button “Start the modelling” in the control page;
 - iii. Open the four outputs result tables pressing the four “Results” buttons;
 - iv. Open the Excel network access cost model, and copy the four result tables into the sheet “Import from the ACCESS”;
 - v. Press the button “Update the results” in the Dashboard sheet;
 - vi. Copy and paste the sheet “Export to the UBA model” to the UBA cost model.

Figure 42 - Screenshot from the Microsoft Access model - Control page



Source: TERA Consultants

- b. The geospatial data for the dimensioning in the Microsoft Access model
 - i. Import the new geospatial tables into the Microsoft Access, adding a suffix “new” to the new tables;
 - ii. Update the old geospatial tables with the new tables using “Update”-type SQL queries;
 - iii. Process to the steps (ii) to (vi) described above in (a).
- c. The input costs:
 - i. Open the table “Local access network sources”;
 - ii. Update the inputs costs;
 - o E.g. withdraw or include the design costs, or switch the ducting installation costs from ducts to trenching costs using the control cells in the “4. Costs’ sheet”
 - iii. Copy and paste the sheet “Export to the cost model“ to the “Access network cost model” Excel file, in the sheet “Assets”;
 - iv. Process to the steps (v) and (vi) described in (a).

Once results of the opex and Access models are pasted in the Core model, the core model can be parameterized in the Dashboard for the financial and demand parameters, and in the spreadsheet parameters for all network-related parameters.

The results are shown in the “Pricing” spreadsheet after the button “Update the results” present in the “Dashboard” and the “Pricing” spreadsheet is pressed.

8 Annexes

8.1 Annex: focus on LFI

8.1.1 Context

The TSLRIC concept aims at modelling the costs of a recently built efficient network. Not only the capex but also the opex should be in line with this principle. While using the incumbent's opex as a starting point is common, it is very likely that the opex of the incumbent are much higher than the opex of a new efficient network, especially in the access network. As a consequence, it would not be consistent to add the capex of a new network (which are probably higher than the capex of a legacy network) and the opex of a legacy network (which are probably higher than the opex of a new efficient network).

The fact that the opex of a legacy network are higher than the opex of a new efficient network is implicitly confirmed by Chorus which explains in its "Management Commentary" of August 2014 that network degradation is one of the factors explaining the level of faults: *"One of the key drivers for reported faults is the weather. During the year ended 30 June 2014, severe weather events in September 2013, March 2014 and April 2014 resulted in 10% more reactive maintenance required compared to the year ended 30 June 2013. Approximately 77% of the reactive maintenance work was on the Chorus network and this was not recoverable (compared to 74% on the Chorus network in the year to 30 June 2013). The level, type and cost of faults is affected by factors such as rainfall, lightning, network degradation, labour costs, material costs and network growth"* (underlined by the author)²⁰

As a consequence, efficiency adjustments must be applied on Chorus' opex for the access network, and in particular to maintenance opex.

For the avoidance of doubts, no efficiency adjustments have been performed on the UBA core network opex as the level of faults is supposed to reflect a much newer network.

8.1.2 Proposed approach

Maintenance opex can be calculated as follows:

| |
|---|
| Maintenance opex = Number of faults x Time to repair a fault x Cost per manhour |
|---|

The number of faults is affected by the age of the network and by network degradation. This is less clear for the "Time to repair a fault" and it is obvious that the cost per

²⁰ Chorus - "Management Commentary" of August 2014

manhour does not depend on the age of the network (but rather on economic local conditions). As a consequence, the most straightforward and obvious approach to adjust Chorus maintenance opex to reflect the costs of a new efficient network is to assess the number of faults of a new network.

Assuming that the maintenance opex evolve proportionally with the number of faults on the network is a reasonable assumption:

- 1 This is logic from the formula above;
- 2 This is what we observed in Ireland where the incumbent owns a resource management tool which enables to observe that when the number of faults decreases the maintenance opex decrease proportionally;
- 3 With respect to Chorus, we understand the following costs vary proportionally:
 - a. Maintenance contractors field costs (as we understand these are paid on a 'per task' basis);
 - b. Maintenance contractors overheads (to be discussed but these would be probably lower in case the number of tasks to be performed is significantly lower);
 - c. Chorus own maintenance staff (their work load is also linked to the number of faults).

As a consequence, it is necessary to assess the number of faults of a new network.

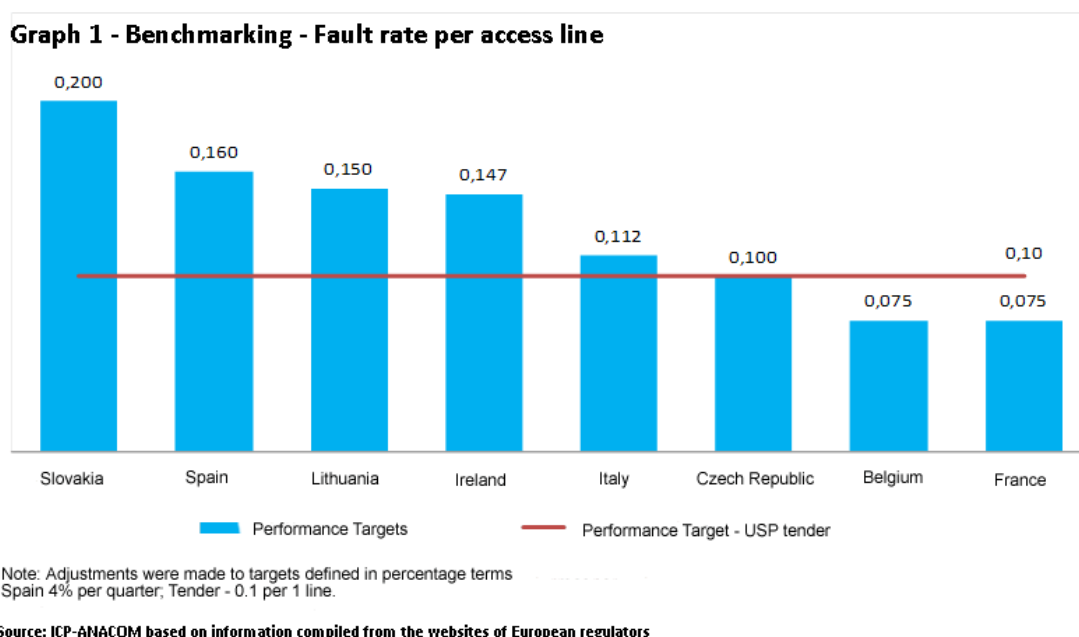
8.1.3 Number of faults assessment

8.1.3.1 General approach

Statistics for the number of faults are generally expressed using the Key Performance Indicator called “Line Fault Index” (LFI). For the last year available (2013), [] CNZRI

Portuguese NRA Anacom has performed an international benchmark giving a view on the observed LFI in several European countries:

Figure 43 – International benchmark on LFI



Source: <http://www.anacom.pt/render.jsp?categoryId=345519>

This benchmark tends to show that Chorus LFI ([]CNZRI) is rather in the high range as compared to these countries. However, it provides no insight on the level of LFI that would be observed on a new network as in all these countries, the network has been deployed several decades ago.

During the data collection process, Chorus stated they are unable to provide NZ-based assumption for a new network. In particular, it has not been possible to isolate the LFI for a recent copper deployment in a sample area.

As a consequence, the LFI of a new network cannot be assessed using Chorus data. An alternative approach would be to set the target LFI on the basis of benchmarked data for a new network. However, to our knowledge this information is not usually published by NRAs.

The only available option for the Commission is to use the target LFI set by the Irish National Regulatory Authority (NRA) ComReg in the context of copper LLU/SLU cost modelling:

“ComReg believes it is reasonable and proper to conclude that a maximum LFI of 8% is appropriate given that the modelled network relates to that of an efficient network (based on underground and overhead infrastructure) that had invested appropriate amounts in the renewal of the network over time.

*Conclusion in relation to the LFI of the network: A Line Fault Index not exceeding 8% is used within the BU-LRAIC model in determining the maximum LLU and SLU monthly rental charges.*²¹ (underlined by the author)

8.1.3.2 Relevance of Irish values in the specific context of New Zealand

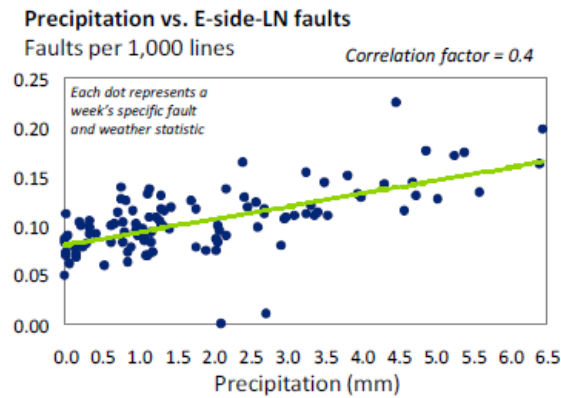
Several factors could mean that the efficient LFI of a new network found in Ireland is significantly different from the efficient LFI of a new network in New Zealand:

- Rainfalls;
- Humidity;
- Wind.

Indeed, a significant level of correlation between these factors and the number of faults at several levels of the network has recently been underlined by British wholesale operator Openreach:

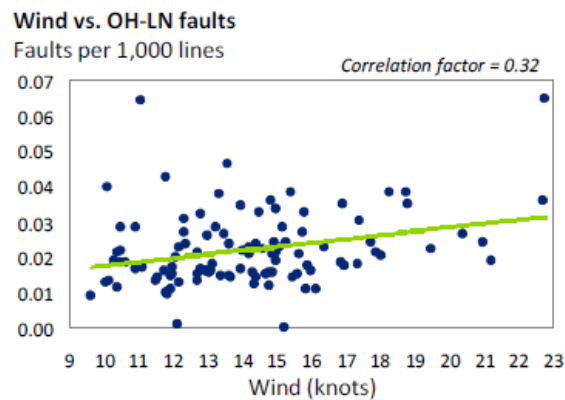
²¹ http://www.comreg.ie/_fileupload/publications/ComReg1010.pdf

Figure 44 – Correlation between rainfalls and feeder (e-side) faults



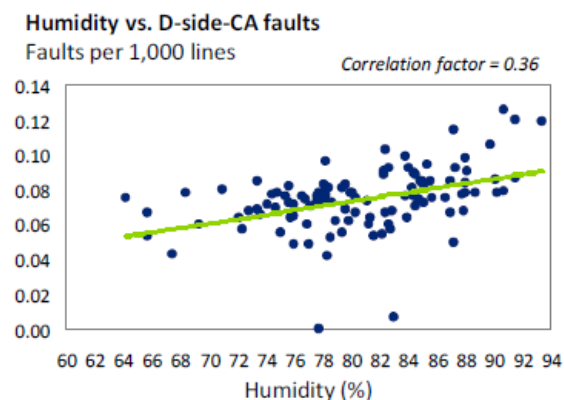
Source: Openreach, fault data analysis

Figure 45 – Correlation between wind and overhead network faults



Source: Openreach, fault data analysis

Figure 46 – Correlation between humidity and d-side faults



Source: Openreach, fault data analysis

This section aims at comparing that New Zealand and Ireland for these different topics.

8.1.3.2.1 Rainfalls

Higher rainfall can lead to a higher number of faults. It rains 55% more in New Zealand as compared to Ireland:

Figure 47 - Yearly rainfalls in Ireland as compared to NZ

| Country | Total Rainfalls |
|---------|------------------|
| NZ | 1732 mm per year |
| IRL | 1118 mm per year |

Source:

http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Australia&ThisCCode=NZL

http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Europe&ThisCCode=IRL

However, there are great regional differences in how much it rains in New Zealand (e.g. very high rainfall in Fiordland). Consequently, the difference in average rainfall in New Zealand vs Ireland probably overstates the difference in the relevant measure (number of faults cause by rain).

8.1.3.2.2 Humidity

More humidity can lead to a higher number of faults. Humidity rates are similar in Ireland and in New Zealand:

Figure 48 – Humidity % in Ireland as compared to NZ

| North Island | | South Island | | Ulster | | |
|-------------------------|----|-----------------------------------|----|-----------------------------------|------|------|
| Average annual humidity | | Annual relative humidity averages | | Average annual humidity | | |
| Place | % | Place | % | Place | 9 am | 3 pm |
| Auckland | 82 | Alexandra | 77 | Clones | 86 | 75 |
| Gisborne | 76 | Blenheim | 76 | Malin Head | 82 | 79 |
| Hamilton | 85 | Christchurch | 85 | | | |
| Kaitia | 87 | Dunedin | 76 | Munster | | |
| Masterton | 84 | Hokitika | 84 | Annual relative humidity averages | | |
| Napier | 73 | Invercargill | 83 | Place | 9 am | 3 pm |
| New Plymouth | 83 | Kaikoura | 73 | Cork | 87 | 77 |
| Palmerston North | 81 | Lake Tekapo | 73 | Roches Point | 85 | 79 |
| Rotorua | 82 | Manapouri - Te Anau | 85 | Shannon | 84 | 72 |
| Taupo | 82 | Milford Sound | 92 | Valentia | 83 | 77 |
| Tauranga | 79 | Mt Cook, Hermitage | 78 | Leinster | | |
| Wanganui | 79 | Nelson | 81 | Average daily humidity | | |
| Wellington | 83 | Queenstown | 76 | Place | 9 am | 3 pm |
| Whangarei | 84 | Timaru | 82 | Birr | 85 | 73 |
| | | Westport | 84 | Clondalkin | 84 | 74 |
| | | | | Dublin | 83 | 73 |
| | | | | Kilkenny | 84 | 71 |
| | | | | Mullingar | 86 | 75 |
| | | | | Wexford | 84 | 78 |
| | | | | Connacht | | |
| | | | | Annual relative humidity | | |
| | | | | Place | 9 am | 3 pm |
| | | | | Belmullet | 84 | 79 |
| | | | | Claremorris | 87 | 77 |

Source: <http://www.currentresults.com/Weather/New-Zealand/humidity-annual-average.php>

<http://www.currentresults.com/Weather/Ireland/humidity-annual.php>

8.1.3.2.3 Wind

More wind can lead to a higher number of faults on the overhead network. The average wind appears to be lighter in New Zealand (circa 13-14 kph) than in Ireland (between 14 and 25 kph depending on the regions).

Figure 49 – Average wind speed in New Zealand

Table 8. Monthly input data and surface characteristics for mean daily wind speed (km/hr).

| Month | Mean | Range | Root GCV | Root MSE |
|-----------|------|--------|----------|----------|
| January | 13.5 | 4 - 36 | 5.26 | 2.63 |
| February | 12.6 | 4 - 35 | 5.01 | 2.50 |
| March | 12.3 | 3 - 33 | 4.92 | 2.45 |
| April | 11.7 | 3 - 35 | 4.60 | 2.27 |
| May | 11.9 | 3 - 33 | 4.85 | 2.41 |
| June | 11.4 | 2 - 36 | 4.47 | 2.21 |
| July | 11.6 | 2 - 37 | 4.77 | 2.37 |
| August | 12.3 | 3 - 35 | 4.65 | 2.31 |
| September | 13.7 | 4 - 34 | 5.38 | 2.68 |
| October | 14.6 | 5 - 40 | 5.69 | 2.84 |
| November | 14.5 | 5 - 38 | 5.53 | 2.75 |
| December | 13.8 | 4 - 34 | 5.38 | 2.69 |

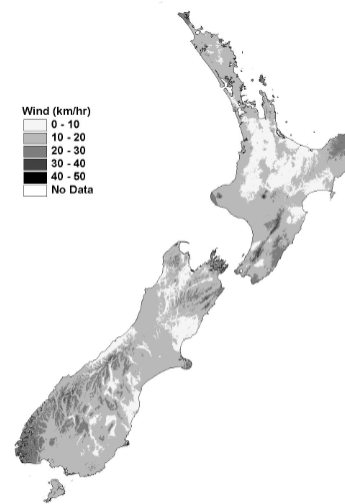


Fig. 7. Estimates, derived from the wind surface, of mean annual wind speed for points on a 1 km grid across New Zealand.

Source:

https://www.landcareresearch.co.nz/_data/assets/pdf_file/0020/21809/Climate_Surfaces_for_New_Zealand_revised.pdf

Figure 50 – Average wind speed in Ireland



| m/s | km/h |
|-----|------|
| 4 | 14,4 |
| 5 | 18,0 |
| 6 | 21,6 |
| 7 | 25,2 |

Source: <http://www.met.ie/climate/wind.asp>

8.1.3.2.4 Conclusion

The comparisons performed on the weather conditions (rainfalls, humidity, rain) show no clear reason for NZ conditions to be more/less favourable than Irish ones.

As a consequence, Irish new network LFI figures appear relevant in the NZ case.

However, in order to take into accounts NZ specificities, an adjustment has been performed: a cross-multiplication between real and target LFI:

$$Target_LFI_{NZ} = Target_LFI_{IRL} \times \frac{Real_LFI_{NZ}}{Real_LFI_{IRL}}$$

Figure 51 – Real/Target LFI adjustment

| Country | Real LFI | Target LFI |
|--------------------|-------------------|------------------|
| Ireland | [] ²² | [] |
| New Zealand | [] | [] CNZRI |

Source: TERA Consultants

As a consequence a new network LFI of 9.9% seems reasonable for the NZ case.

8.2 Annex: Opex for a FTTH network

Due to the status of FTTH deployment in New Zealand, no accounting information on fibre opex for a nationwide network is available at this stage. As a consequence, FTTH opex should be assessed based on copper network opex with adjustments if needed.

Even if they are rare because FTTH is only being currently deployed in many countries, FTTH public presentations often report that FTTH opex should be significantly reduced as compared to copper network opex.

Ericsson, one of the biggest providers of telecommunications equipment in the world, emphasises that the absence of active equipment in an FTTH network will lead to a lower level of opex compared to copper/FTTN and HFC networks:

“Compared to copper and hybrid fibre-coax (HFC) networks, OPEX will be considerably lower as P2P fibre provides the best distance-bandwidth solution with fewer number of active elements required in the network. This reduction in active elements in the OSP also results in a lower OPEX.”²³

The industry organisation FTTH Council Europe also explains that the level of opex for FTTH will be lower than for copper/FTTN networks and lists the potential saving opportunities:

“An additional motivator for service providers is that FTTH networks have lower operating costs (OPEX) than existing copper or coaxial cable networks. FTTH

²² ComReg 14/44, page 9

²³ Ericsson, Point-to-point deep fiber access, 2010

*networks consume less electricity with some reports putting the figure at 20 times less than HFC or VDSL. Network operation and maintenance is simplified using full automation and software control, requiring fewer staff. Maintenance costs are also reduced as there is no active equipment in the field to maintain, and optical components are extremely reliable. Optical fibre is not affected by electromagnetic interference, which is a source of downtime in copper networks.*²⁴

Finally, in a presentation on next generation networks, the Italian NRA AGCOM compares copper and fibre networks and states that the fibre opex saving as compared to copper is circa 50%:

*“NTT / Verizon: 40-60% Opex decrease with FTTH networks w.r.t. copper local loop”*²⁵

As a consequence, the level of opex per line in the FTTH network should be considered as half the level of opex per line in the copper network.

²⁴ FTTH Council web site

²⁵ AGCOM (Italian NRA), Challenges in moving towards the Next Generation of Fixed and Mobile Networks, January 2010

8.3 Annex: Glossary of the network access

Table 55 - Glossary

| Acronym | Definition |
|------------------------|--|
| Geospatial data | Geospatial features of the sections (lengths, locations of buildings) and the shortest paths from the MDF to every section |
| ETP | External termination point: the equipment outside the building, to which the customer premises are linked |
| DP | Distribution point, either CCT in the copper network, or FAT in the fibre network |
| CCT | Copper cable terminal: distribution point in the copper network |
| FAT | Fibre access terminal: distribution point in the fibre network |
| Lead-In (copper) | Network level between the ETP and the CCT |
| Distribution (copper) | Network level between the CCT and the street cabinet |
| Feeder (copper) | Network level between the street cabinet and the MDF |
| Lead-In (fibre) | Network level between the ETP and the FAT |
| Distribution (fibre) | Network level between the FAT and the ODF |
| SC | Street cabinet: equipment between the feeder and distribution levels in the copper network |
| Passive street cabinet | Street cabinet that contains no active equipment |
| Active street cabinet | Street cabinet with active equipment (DSLAM). Linked to an ODF through fibre, and belonging to the core network (Core DSLAM) |
| MDF | Main distribution frame: first node of the local access network (copper) |
| ODF | Optical distribution frame: fist node of the local access network (fibre) |
| Section | Segment between two crossroads. As a consequence, a street can be composed of several sections |
| Building | Building, containing one or multiple dwellings |
| Dwelling | Smallest unit of the network (habitation, shop), that requires a line |
| Major side | Side of the section hosting the majority of buildings of |

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| Acronym | Definition |
|--------------------------------|---|
| | the section |
| Minor side | Opposite side of the section |
| FWA | Fix wireless access: network service using wireless links for remote locations |
| Core DSLAM | SLU backhaul (SLUBH): network level between the ODF and the DSLAM of the active street cabinets |
| Core Exchange | Core network level, from the Exchange (ODF, MDF), to the first data switch (FDS) |
| Core EAS | Core network level, between the data switches (EAS) |
| Rear area | The rear area of a section x is the set of sections y for which the links to the street cabinet go through the section x |
| Distribution demand | The distribution demand of a section is the number of copper pairs/fibres needed to serve the lines that go through the section, i.e. the lines corresponding to the dwellings of the section plus the lines corresponding to the dwellings of the rear area of the section |
| Feeder demand | The feeder demand of a section is the number of copper pairs needed to serve the street cabinets that are on the section or in the rear area of the section, i.e. which are linked to the MDF through the section |
| Cross-section surface of cable | <p>The cross-section surface of cable is the surface of the external cross-section of the cable, i.e.:</p> $\frac{\pi}{4}d^2$ <p>Where d is the external diameter of the cable.</p> |
| Cross-section surface of duct | Similarly with the cross-section surface of cable, the cross-section surface of duct (or subduct) is the surface of the external cross-section of the duct |

Source: TERA Consultants