Development of Bottom-up Long Run Incremental Cost (BU-LRIC) models

Fixed BU-LRIC model user manual

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Contents

1. Introduction

This report describes how to use the Bottom-up Long Run Incremental Cost (BU-LRIC) Model for fixed networks ('the model') commissioned by the Eastern Caribbean Telecommunications Authority (hereinafter, the ECTEL).

The present document contains the following sections:

- **General Overview of the Model**, describing the structure of the BU-LRIC Model Excel file.
- **Getting Started**, detailing the main considerations and specifications to run the model.
- **Understanding the Control Panel**, describing the control panel of the model, which is the main user interface where the main options and scenarios are selected. Additionally, this worksheet contains a 'RUN' button to execute the model.
- **Modifying inputs**, explaining how inputs are identified in the model and how they should be modified.

2. General Overview of the Model

The model file is comprised of worksheets grouped in the following blocks or calculation steps:

- Support and Control Worksheets
- Step 0: Parameters
- Step 1: Main inputs
- Step 2: Advanced inputs
- Step 3: Drivers and routing factors mapping
- Step 4: Calculation of resource unit costs and drivers
- Step 5: Calculation of transmission ports
- Step 6: Resource dimensioning
- Step 7: Costs calculation
- Step 8: LRIC costing and allocation to services
- Step 9. Common Costs Calculation
- Step 10: LRIC+ unit costs calculation

The model has been developed based on a linear architecture in order to improve the execution performance and to reproduce the calculation flow logic.

The exhibit below shows the model calculation flow:

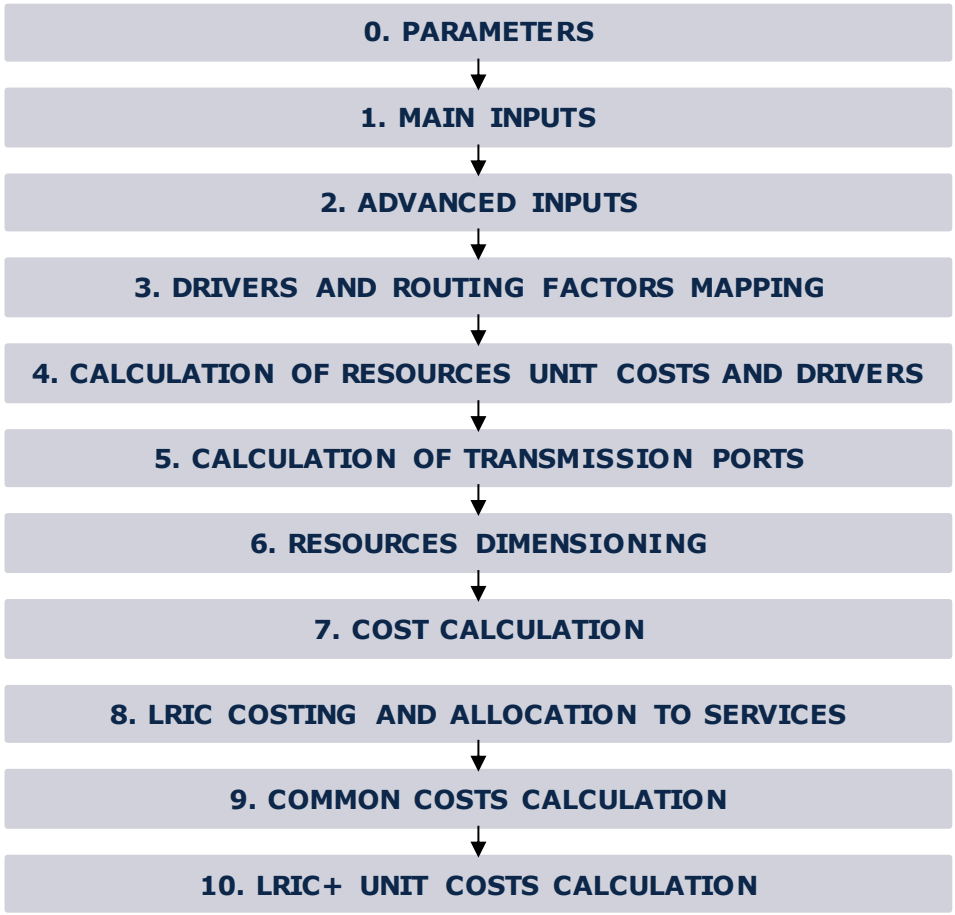

Exhibit 2.1: Calculation Flow of the Model [Source: Axon Consulting]

The "Support and Control worksheets" step has not been represented in the previous exhibit for clarity purposes. Each calculation step is introduced in section 2.1.

The worksheets contained in the calculation steps have been labelled according to the following structure (except "Support and Control worksheets"):

1. Step number and ordinal: It is composed of the number of the step (i.e. 0, 1, 2…) and the order in letter format (i.e. A, B…)

2. Type of worksheet indicators:

   - PAR: Definition of parameters
   - INP: Input worksheet
   - MAT: Matrix obtaining the relationship between two dimensions
   - MAP: Mapping between two dimensions
   - CALC: Calculations
   - OUT: Results worksheet

3. Name of the worksheet

As an example, the worksheet '1A INP DEMAND' is the first (A) worksheet of Step 1. It represents an input (INP) related to the demand (DEMAND).

2.1. Relationship between model calculation flow and worksheets

This section describes the calculation blocks, including a detailed description of the worksheets contained in each block. It should be pointed out that sub-sections 2.1.1 and 0 do not strictly describe a block of the calculation flow, but the supporting and control worksheets and the definition of parameters (or dimensions) used within the model.

2.1.1. Support and Control Worksheets

In the model there are seven (7) worksheets providing general information, supporting the calculation process and checking that execution has been performed correctly.

Sheet name	Features
CONTENTS	▶ Shows overall information about the model file (i.e. version, status and contacts). ▶ Provides a list and a brief description of the model worksheets.
CONTROL	▶ Modelling and network options to enable it to perform different analysis selecting the desired inputs.
DISPLAY OPTIONS	▶ This worksheet presents only those worksheets related to the inputs/outputs of the model, hiding the calculation sheets.
MAP	▶ Provides a map of the model showing dependencies between worksheets and the calculation flow.
QUICK LINKS	▶ Shows a list of the most important inputs and outputs to facilitate the navigation through the model.
COLOUR CODE	▶ Lists the set of colours used, detailing the meaning of each.
CHECKS	▶ Ensures the correct calculation process.

Exhibit 2.2: Support and Control worksheets. [Source: Axon Consulting]

2.1.2. **Step 0: Parameters**

The six (6) worksheets concerning the parameterisations taken into consideration in the model are defined in the table below:

Sheet name	Features
0A PAR SERVICES	▶ Lists the services considered in the model. ▶ Offers additional details about services, such as the units in which services are measured and to which increment each service is associated.
0B PAR RESOURCES	▶ Defines network resources and cost items.
0C PAR DRIVERS	▶ Defines the list of drivers considered in the BU-LRIC model. ▶ Drivers are the variables used for the dimensioning of the network (e.g. Erlangs, Channels).
0D PAR TIME	▶ The years considered in the model can be configured in this worksheet.
0E PAR CURRENCIES	▶ Defines the currencies in which the unitary costs can be introduced and in which the results are going to be obtained.
0F PAR TX TECH	▶ Defines and characterises the technologies used for transmission (fibre optic, microwaves).

Exhibit 2.3: Parameters worksheets. [Source: Axon Consulting]

2.1.3. **Step 1: Main inputs**

The main inputs are those that need to be regularly updated to better represent the current characteristics of the operator under study. A total of six (6) worksheets have been defined in this calculation block and are defined in the following table.

Sheet name	Features
1A INP DEMAND	▶ Allows the user to introduce the demand that must be supported by the network of each country. ▶ A total of five (5) different demand scenarios may be defined in this worksheet, selectable through the control panel.
1B INP NW STATISTICS	▶ Introduces network statistics needed for the dimensioning of the network (e.g. average call duration, average ringing time, etc.)
1C INP UNITARY COSTS	▶ Introduces the unitary costs (both OpEx and CapEx) of the resources (network elements, direct costs, etc.) ▶ The currency can be selected for each element (e.g. USD for network equipment and local currency for electricity).
1D INP COST TRENDS	▶ Defines the cost trends of the resources whose cost has been defined in the previous worksheet. ▶ This trend is used for forecasting the unitary prices of resources (differentiating OpEx and CapEx).
1E INP EXCHANGE RATES	▶ Introduces the exchange rates between the currencies considered.
1F INP COST OVERHEADS	▶ Contains the overheads considered in the model (OpEx working capital and G&A) for each of the countries modelled.

Exhibit 2.4: Main Inputs worksheets. [Source: Axon Consulting]

2.1.4. **Step 2: Advanced inputs**

The second type of inputs, Advanced Inputs, is not expected to be updated regularly by the user, as it is expected that the parameters they contain will usually remain unchanged. They are related to geographical information, busy hours, etc. Eleven (11) worksheets have been defined in this step, and they are detailed in the table below:

Sheet name	Features
2A INP NW	▶ Introduces network parameters needed for the dimensioning of the network (e.g. equipment capacity).
2B INP GEO ACCESS	▶ Contains the information for each country required to characterise the access network in terms of cabinet nodes.
2C INP GEO EDGE	▶ Contains the information required in order to properly characterise the distribution network in terms of edge nodes for each country.
2D INP GEO DIST	▶ Contains the information required in order to properly characterise the distribution network in terms of local and distribution nodes for each country.
2E INP GEO CORE	▶ The information needed for the dimensioning of the core network is introduced in this worksheet for each country.
2F INP GEO LINKS	▶ The information for each country related to the core links is introduced in this worksheet.
2G INP BUSY HOUR	▶ Contains the percentage of traffic during the busy hour for the categories of services defined.
2H INP IDLE	▶ Defines the idle traffic as the percentage of time that the user is using the network but is not being counted as traffic. These percentages are based on traffic statistics.

Sheet name	Features
2I INP RESOURCES LIFE	▶ Defines the useful lives for the annualisation of resource costs.
2J INP ERLANG	▶ Includes the Erlang tables (used by engineers for network dimensioning).
2K INP HORIZON	▶ Defines the planning horizon which represents the years in advance that are considered for the dimensioning of the network. ▶ Overcapacity is the security margin between maximum expected traffic and the capacity installed.

Exhibit 2.5: Advanced inputs worksheets. [Source: Axon Consulting]

2.1.5. Step 3: Drivers and routing factors mapping

The four (4) worksheets contained in this step are used to map the services with the drivers used for dimensioning and the definition of the routing factors. These worksheets are defined in the table below:

Sheet name	Features
3A MAP SERV2DRIV	▶ Defines the relationship between services and dimensioning drivers. ▶ Drivers will be used for dimensioning the network and to allocate resource costs to services when selected on the control panel.
3B MAP ROUTING FACTORS	▶ Defines the relationship between services and resources. ▶ Routing factors will be used to allocate resource costs to services when selected on the control panel.
3C MAT SERV2DRIV	▶ Contains a relationship matrix between services and drivers, used for obtaining dimensioning drivers.

Sheet name	Features
3D MAT RF - SERV	▶ Contains a matrix with the routing factors relating to resources and services.

Exhibit 2.6: Drivers and routing factors mapping worksheets. [Source: Axon Consulting]

2.1.6. Step 4: Calculation of resource unit costs and drivers

The five (5) worksheets introduced in this section are responsible for calculating the unitary OpEx, CapEx and G&A costs of the resources for the years the model is being simulated. These worksheets are defined in the table below:

Sheet name	Features
4A OPEX COST CONSOL	▶ Consolidates OpEx unitary costs in a table with a predetermined format to be used throughout the model. ▶ Considers cost trends to obtain future costs.
4B CAPEX COST CONSOL	▶ Consolidates CapEx unitary costs in a table with a predetermined format to be used throughout the model. ▶ Considers cost trends to obtain future costs.
4C GA COST CONSOL	▶ Calculates G&A costs per resource.
4D CALC DRIVERS CONSOL	▶ Calculates the volume of dimensioning drivers when the increment's traffic is removed.
4E CALC ALL DRIVERS CONSOL	▶ Calculates the volume of dimensioning drivers for the entire demand in the network.

Exhibit 2.7: Calculation of resource unit costs and drivers worksheets. [Source: Axon Consulting]

2.1.7. **Step 5: Calculation of transmission ports**

The following worksheet is related to the calculation of the number of transmission ports per technology. This worksheet is detailed in the table below:

Sheet name	Features
5A CALC TX PORTS	▶ Calculates the unit cost and maximum number of transmission ports per technology for NGN networks. Additionally, the unit cost evolution of the DWDM equipment is calculated.

Exhibit 2.8: Calculation of transmission ports worksheet. [Source: Axon Consulting]

2.1.8. **Step 6: Resource dimensioning**

The resource dimensioning of the network nodes and transmission equipment is done in this step. The seven (7) worksheets defined in this step perform network dimensioning calculations as well as consolidation of their results. The description of these worksheets is detailed in the following table[1]:

[1] Please see the technical manual for further description on the algorithms used.

Sheet name	Features
6A CALC DIM ACCESS	▶ Dimensioning the equipment required in access locations for the different scenarios of services provided for the selected country.
6B CALC DIM DISTR	▶ Dimensioning the equipment required in distribution locations for the different scenarios of services provided for the selected country.
6C CALC DIM CORE	▶ Dimensioning the platforms and equipment required in the core locations for the different scenarios of services provided.
6D CALC DIM TX BACKHAUL	▶ Dimensioning the backhaul transmission network for the different scenarios of services provided.
6E CALC DIM TX BACKBONE	▶ Dimensioning the backbone transmission network for the different scenarios of services provided.
6F CALC DIM DIRECT COSTS	▶ Dimensioning the direct costs for the different scenarios of services provided.
6G RES CONSOLIDATION	▶ Consolidating the resources obtained in all the previous dimensioning worksheets

Exhibit 2.9: Resource dimensioning worksheets. [Source: Axon Consulting]

2.1.9. **Step 7: Costs calculation**

This step contains five (5) worksheets related with the costing and annualisation of resource costs. A detailed explanation about these worksheets is provided in the following table:

Sheet name	Features
7A CALC RES OPEX	▶ Calculating OpEx of resources installed.
7B CALC RES DEPREC	▶ Calculating resource depreciation using a tilted annuity method.
7C CALC RES CoC	▶ Calculating resource cost of capital using a tilted annuity method.
7D CALC RES GA	▶ Calculating G&A associated with resources installed.
7E CALC SERV INC COST	▶ Allocates resources incremental costs (OpEx, depreciation, cost of capital and G&A) to services.

Exhibit 2.10: Costs calculation worksheets. [Source: Axon Consulting]

2.1.10. **Step 8: LRIC costing and allocation to services**

The objective of this step is to obtain the LRIC costs of services. The three (3) worksheets contained in this step are detailed below:

Sheet name	Features
8A MAC RES COSTS	▶ Storing the resource cost split by increment and type (OpEx, depreciation, cost of capital and G&A).
8B MAC SERV INC COST	▶ Storing the service cost split by increment and type (OpEx, depreciation, cost of capital and G&A).
8C CALC SERV LRIC COST	▶ Aggregating resource costs of each increment scenarios to services. These costs are split between OpEx, depreciation, cost of capital and G&A.

Exhibit 2.11: LRIC costing and allocation to services worksheets. [Source: Axon Consulting]

2.1.11. Step 9. Common Costs Calculation

The objective of this step is to obtain the common costs for services and resources. The four (4) worksheets contained in this step are detailed below:

Sheet name	Features
9A CALC RES COMMON COST	▶ Calculating common costs of resources installed.
9B CALC SERV COMMON COST	▶ Allocating resources common costs (OpEx, depreciation, cost of capital and G&A) of services through the efficient capacity method.
9C CALC SERV LRIC+ COST	▶ Calculating service LRIC+ costs. These costs are split between OpEx, depreciation, cost of capital and G&A.
9D CALC SERV OVERHEAD COSTS	▶ Calculating overhead LRIC+ costs of services.

Exhibit 2.12: Common costing and allocation to services worksheets. [Source: Axon Consulting]

2.1.12. **Step 10: LRIC+ unit costs calculation**

The objective of this step is to obtain the unit costs of services under LRIC+. The worksheet contained in this step is detailed below:

Sheet name	Features
10A OUT SERV LRIC+ UNIT COST	▶ Calculating LRIC+ service final unit costs.

Exhibit 2.13: LRIC+ unit costs calculation worksheets. [Source: Axon Consulting]

3. Getting Started

Computer Requirements

The BU-LRIC Model is an Excel file. To run the model, we recommend a computer with at least 1GB of RAM and Microsoft Excel 2010 (or a newer version). For enhanced performance, we recommend 2GB of RAM.

To ensure the model runs first time in a specific computer, press *Ctrl-Alt-Shift-F9* for a full calculation with dependency tree rebuild.

Opening the Model

The execution of the model can be performed by pressing F9[2]. However, a VBA macro has been developed to improve the performance of the calculations and increase the robustness of the file[3]. To use this option (see section 4.4), enable Macros. If Macros are not enabled when opening the model, the following warning will appear:

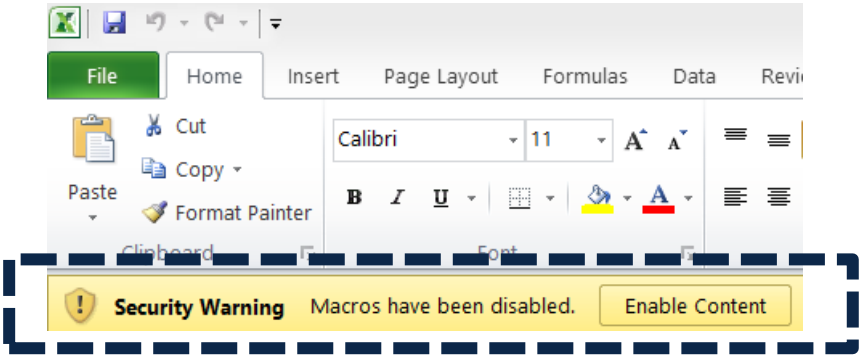

Exhibit 3.1: Warning appearing in Microsoft Excel 2010 when model is open and Macros are not enabled. [Source: Axon Consulting]

If the warning shown above appears, clicking the "Enable Content" button will enable Macros and allow the user to execute the model.

Additionally, in certain distributions of MS Excel the model file may crash while running. To solve this issue, a hard reset of Excel's calculation tree is required through the following steps:

1. Open the model
2. Press Ctrl+Alt+Shift+F9
3. Wait until Excel stops calculating (it may take some minutes)

[2] F9 is the default key in MS Excel for calculating the formulas.
[3] MS Excel may crash sometimes when handling big excel files (like this one).

4. Save the model (if the model is not saved, this process may need to be repeated the next time it is opened on the same computer).

4. Understanding the Control Panel

The control panel represents the main interface of the user-model. It is used to select the model's main available options, configure the execution mode and run the model. The following figure shows a snapshot of the control panel.

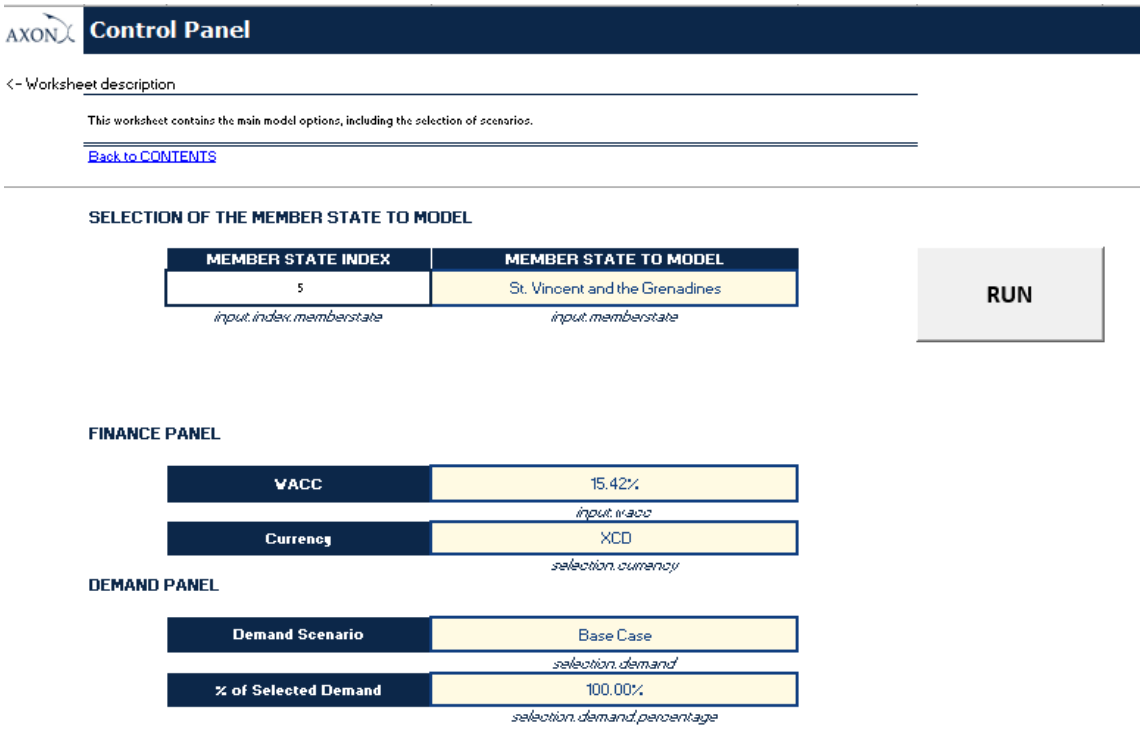

Exhibit 4.1: Snapshot of the control panel [Source: Axon Consulting]

The control panel is divided into the following blocks:

- Run button
- Member State panel
- Finance panel
- Demand panel

All these blocks are covered in the following paragraphs.

Important warning: the model needs to be run in order to see the impact on the results of any changes made in the control panel.

4.1. **Run button**

This button is used to run the model. The text in the button will change during execution. Once pressed, the model will automatically run and this button will show the execution process percentage[4], as it can be observed in the following figure.

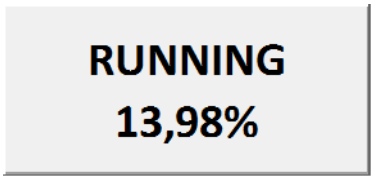

Exhibit 4.2: Illustrative example of execution percentage shown in the Run button [Source: Axon Consulting]

When the text in the button changes to "RUN" the model execution will be completed.

4.2. **Member State panel**

The Member State panel allows the user to select the country to be modelled.

4.3. **Finance panel**

The Finance panel includes two options affecting the way in which costs are calculated and presented:

- **WACC (Weighted Average Cost of Capital):** This parameter represents the average minimum remuneration required for the capital employed. The WACC is employed for the calculation of the cost of capital associated to fixed investments.
- **Currency:** This parameter allows the user to select the currency used in the model for the calculations and results.

4.4. **Demand panel**

This panel allows the choice of the set of inputs defining the required demand to satisfy the network. The following options are available:

[4] Some distributions of MS Excel may not represent the percentage.

- **Demand Scenario:** Several demand scenarios can be defined in the worksheet "1A INP DEMAND" (e.g. base case, aggressive forecast, conservative forecast), and then selected in this drop-down list, allowing a rapid selection of different demand assumptions to compare their results.
- **% of Selected Demand:** This option allows the user to introduce the market share of the operator to be modelled.

5. Modifying inputs

The model inputs are identified by the following formats:

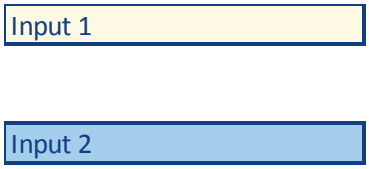

Exhibit 5.1: Format that identifies model's inputs [Source: Axon Consulting]

As shown above, two different types of inputs are considered in the model:

- Input 1: These inputs include the basic information of the model that we recommend updating (or at least reviewing) with each update of the model.
- Input 2: These inputs represent advance information that, if changed, could significantly modify the model calculations. For instance, if the routing factor definition is modified, the costs allocation may be incorrect.

Therefore, we recommend Input 2 not be modified except for people with advanced knowledge of the model technical mechanisms and algorithms.