Recommendations on new interconnection rates for ECTEL member states

Mobile BU-LRIC model user manual

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AXON

Contents

1. Introduction

This report describes how to use the Bottom-Up Long-Run Incremental Costs Model ('the model') for mobile networks commissioned by Eastern Caribbean Telecommunications Authority (hereinafter, 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 are found. 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: Resource unit costs calculation
- Step 5: Coverage and driver calculations
- Step 6: Geotype-dependent resource dimensioning
- Step 7: Storage of geotype dimensioning results
- Step 8: Non-geotype dependent resource dimensioning
- Step 9: Dimensioning results consolidation
- Step 10: Costing and allocation to services
- Step 11: Results storage
- Step 12: Incremental and common costs calculation
- Step 13: LRIC+ 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.

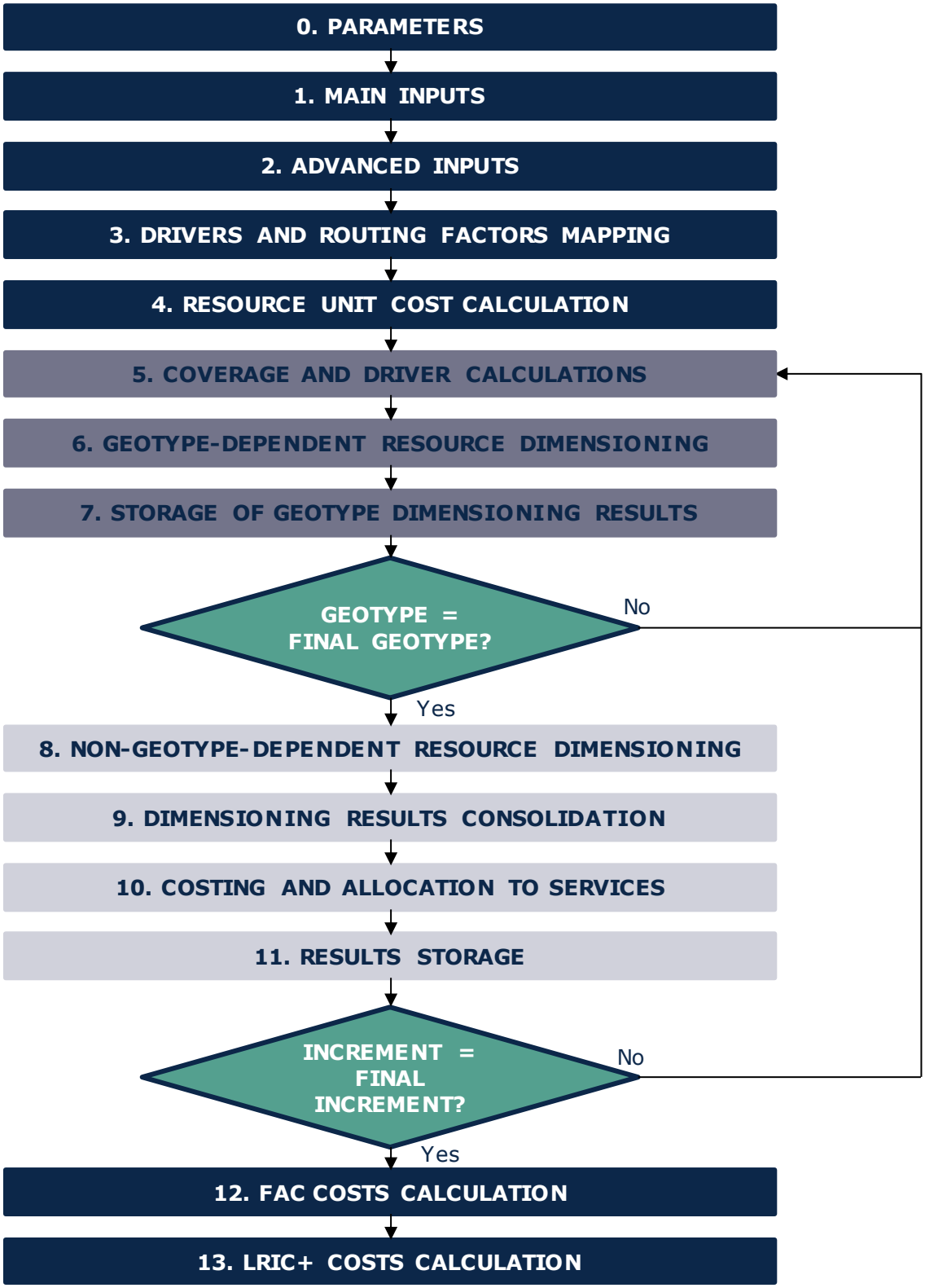

Exhibit 2.1: Calculation Flow of the Model [Source: Axon Consulting]

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

The worksheets contained in the blocks or calculation steps have been labelled according to the following structure (not applying to the "Support and Control worksheets" block):

- Step number and ordinal: It is composed of the step number (i.e. 0, 1, 2…) and the order in letter format (i.e. A, B…)
- Type of worksheet indicators:
  - *PARAM*: Definition of parameters
  - *INPUT*: Input worksheet
  - *MAC*: Storage of intermediate results, done by a Visual Basic Macro
  - *MAT*: Matrix obtaining the relationship between two dimensions
  - *MAP*: Mapping between two dimensions
  - *CALC*: Other calculations
  - *OUTPUT*: Results worksheet
- 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-section 2.1.1 does not strictly describe a block of the calculation flow; it describes 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	▶ Showing overall information about the model file (i.e. version, status and contacts). ▶ Providing a list and a brief description of the model worksheets.
CONTROL	▶ Modelling and network options for different analyses by selecting the desired inputs.
DISPLAY OPTIONS	▶ This worksheet offers the possibility to display only those worksheets related to the inputs/outputs of the model, hiding the calculation sheets.
MAP	▶ Providing a map of the model, showing dependencies between worksheets and the calculation flow.
QUICK LINKS	▶ Showing a list of the most important inputs and outputs to facilitate the navigation through the model.
COLOUR CODE	▶ Listing the set of colours being used, detailing each one's meaning.
CHECKS	▶ Ensuring the correct calculation process.

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

2.1.2. **Step 0: Parameters**

The ten (10) worksheets concerning the parameterisations taken into consideration in the model are defined in the table below:

Sheet name	Features
0A PAR EXT SERVICES	▶ Listing the end-user services considered in the model. ▶ Offering additional details about services such as the units in which services are measured and to which increment each service is associated.
0B PAR INT SERVICES	▶ Listing the internal services in the model. ▶ Introducing the list of increments the model will contemplate when running LRIC+ approach. ▶ These services will be used for the dimensioning of the network.
0C PAR RESOURCES	▶ Defining network resources (e.g. BSC, RNC, switches, leased lines) and cost items (e.g. spectrum licenses). ▶ Introducing other parameters related to the resource and cost items, such as to what attribution variable their costs are allocated.
0D PAR DRIVERS	▶ Defining the list of drivers considered in the BU-LRIC model. ▶ Drivers are the variables used for the dimensioning of the network (e.g. Erlangs, Mbps).
0E PAR KPI	▶ Parameterising the KPIs that will be used to allocate shared cost among technologies.
0F PAR TECHNOLOGIES	▶ Defining the access technologies considered in the model (i.e. GSM/GPRS, EDGE, UMTS, HSPA and LTE).
0G PAR TIME	▶ Configuring the years considered in the model.

Sheet name	Features
0H PAR CURRENCIES	▶ Defining the currencies in which the unitary costs can be introduced and in which the results are going to be obtained.
0I PAR SPECTRUM	▶ Introducing the different frequency bands.
0J PAR TX TECH	▶ Defining and characterising the technologies used for transmission (leased lines, fibre, microwaves, satellite).

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

2.1.3. **Step 1: Main inputs**

The main inputs are those which need to be regularly updated to better represent the current characteristics of the operator under study. A total of nine (9) worksheets have been defined in this calculation block and are defined in the following table:

Sheet name	Features
1A INP DEMAND	▶ Inputting the demand (subscribers and traffic) that is needed to be supported by the network. ▶ A total of five (5) different demand scenarios may be defined for every country in this worksheet, selectable through the control panel.
1B INP NW STATISTICS	▶ Introducing network statistics needed for the dimensioning of the network (e.g. average call duration, MMS average size).
1C INP COVERAGE	▶ Defining the percentage of population covered in each geotype (by year) for every country modelled. ▶ A total of five (5) different coverage scenarios may be defined in this worksheet, selectable through the control panel.

Sheet name	Features
1D INP SPECTRUM	▶ Inputting the spectrum that can be used by the modelled operator for each technology and band for each country modelled. ▶ It can evolve over the years and can be different for each geotype. ▶ A total of five (5) different spectrum scenarios may be defined in this worksheet, selectable through the control panel.
1E INP UNITARY COSTS	▶ Introducing the unitary costs (both OpEx and CapEx) of the resources (network elements, spectrum license, etc.) ▶ The currency can be selected for each element (e.g. USD for network equipment and local currency for electricity).
1F INP COST TRENDS	▶ Defining 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 the resources (differentiating OpEx and CapEx).
1G INP EXCHANGE RATES	▶ Introducing the exchange rates between the currencies considered.
1H INP TECHNOLOGY DIS	▶ Introducing the technology disaggregation (2G, 3G and 4G) as per service category (subscribers, data, voice, etc.) for every modelled country.
1I INP COST OVERHEADS	▶ Containing the overheads considered in the model (planning costs, supervision and G&A) for all the modelled countries.

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

2.1.4. **Step 2: Advanced inputs**

The second type of input, Advanced Inputs, is not expected to be updated regularly by the user, as it is expected that the parameters they contain will generally remain unchanged. They are related to geographical information and busy hours, among other things. Thirteen (13) worksheets have been defined in this step, and they are detailed in the table below:

Sheet name	Features
2A INP NW	▶ Introducing network parameters needed for the dimensioning of the network (e.g. equipment capacity, GSM standard constants).
2B INP BUSY HOUR	▶ Inputting the percentage of traffic during the busy hour for the categories of services defined.
2C INP GEO	▶ Containing the data required for the definition of the geotypes (area, population, etc.) for all the modelled countries.
2D INP GEO CORE	▶ Containing the information needed for the definition of the core network for all the modelled countries.
2E INP GEO LINKS	▶ Inserting the information related to the backbone links of all the modelled countries.
2F INP IDLE	▶ Defining 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.
2G INP RESOURCES LIFE	▶ Defining the useful lives for the annualisation of the cost of resources.
2H INP ERLANG	▶ Defining the Erlang tables (used by engineers for network dimensioning).

Sheet name	Features
2I INP UNIT CONVERSION	▶ Containing the conversion factor between services and dimensioning drivers.
2J INP DL PERC	▶ Inputting the percentage of traffic that is transmitted in the uplink and downlink for the relevant drivers.
2K INP HORIZON	▶ Defining 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.
2L INP TX TECH AVAIL	▶ Inputting the percentage of each transmission technology (leased lines, fibre and microwaves) that is available in each geotype (e.g. due to isolation of the sites, unavailability of leased lines offer).
2M INP BACKHAUL TOP	▶ Configuring the topology of the backhaul network (point to point or ring) by geotype.

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

2.1.5. **Step 3: Drivers and routing factors mapping**

The six (6) 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 EXT.SERV 2 INT.SERV	▶ Allocating the external services (end-user services) to internal services of the model and relating their dimensioning drivers.
3B MAP SERV2DRIV	▶ Defining the relationship between services and dimensioning drivers. ▶ Drivers will be used to dimension the network and to allocate the cost of resources to services when selected on the control panel.
3C MAP ROUTING FACTORS	▶ Defining the relationship between services and resources. ▶ Routing factors will be used to allocate the cost of resources to services when selected on the control panel.
3D MAP EQUIPMENT - TECH	▶ Allocating from resources categories to technologies (2G, 3G, 4G).
3E MAT SERV2DRIV	▶ Calculating a relationship matrix between services and drivers, used for obtaining dimensioning drivers.
3F MAT RF - SERV	▶ Mapping of routing factors from resources to services.

Exhibit 2.6: Drivers and Routing Factors Mapping worksheets. [Source: Axon Consulting]

2.1.6. **Step 4: Resource unit costs calculation**

The objective of the four (4) worksheets introduced in this section is to calculate the unitary OpEx and CapEx costs of the resources for the years the model is being simulated. These worksheets are defined in the table below:

Sheet name	Features
4A CAPEX COST CONSOL	▶ Consolidating CapEx unitary costs in a table with a predetermined format to be used through the model. ▶ Considering trends to obtain the costs.
4B OPEX COST CONSOL	▶ Consolidating OpEx unitary costs in a table with a predetermined format to be used throughout the model. ▶ Considering trends and overheads to obtain the costs.
4C G&A COST CONSOL	▶ Consolidating G&A unitary costs in a table with a predetermined format to be used through the model. ▶ Considering trends and overheads to obtain the costs.
4D COST ESTIMATION FOR TX	▶ Estimating unitary costs per transmission link (including all the resources needed). ▶ This table is used to select the optimum technology for transmission links.

Exhibit 2.7: Resource Unit Costs Calculation worksheets. [Source: Axon Consulting]

2.1.7. **Step 5: Coverage and driver calculations**

There is a total of five (5) worksheets in this step. The first four sheets are related to the coverage available per geotype and how it affects the effective demand per scenario. The two last sheets are related to the calculation of the dimensioning drivers. The description of these worksheets is provided in the following table:

Sheet name	Features
5A CALC DEMAND INT SERV	▶ Calculating the demand of the internal services according to the allocation from external services to internal services.
5B CALC TRAFFIC PERC BY GEO	▶ Calculating the percentage of traffic per geotype, detailed per technology, based on its coverage.
5C CALC DEMAND GEOTYPE	▶ Calculating the demand for the geotype under execution, according to the percentage of traffic available in that geotype.
5D CALC DRIVERS GEO	▶ Calculating the volume of dimensioning drivers for the selected geotype (the one that is being run in a specific calculation moment).
5E CALC DRIVERS CONSOL	▶ Calculating the total volume of dimensioning drivers (in all geotypes).

Exhibit 2.8: Coverage and Drivers' Calculations worksheets [Source: Axon Consulting]

2.1.8. **Step 6: Geotype-dependent resource dimensioning**

The resource dimensioning of the access and backhaul networks (geotype dependent) is carried out in this step. The seven (7) worksheets defined in this step perform network dimensioning calculations, as well as consolidating their results. The description of these worksheets is detailed in the following table:

Sheet name	Features
6A CALC DIM GSM	▶ Performing the GSM Access network dimensioning.
6B CALC DIM UMTS	▶ Performing the UMTS Access network dimensioning.
6C CALC DIM LTE	▶ Performing the LTE Access network dimensioning.
6D CALC DIM SITES	▶ Dimensioning the radio sites.

Sheet name	Features
6E CALC DIM BACKHAUL	▶ Performing the backhaul network dimensioning.
6F CALC KPI CONSOL	▶ Consolidating the KPIs obtained in the previous dimensioning worksheets.
6G CALC RES CONSOL	▶ Consolidating the resources obtained in the previous dimensioning worksheets.

Exhibit 2.9: Geotype Dependent Resources Dimensioning worksheets. [Source: Axon Consulting]

2.1.9. **Step 7: Storage of geotype dimensioning results**

A macro program saves the results of the geotype dependent dimensioning step (the previous one). The results are stored in the six (6) worksheets that belong to this step. The description of each worksheet may be found in the table below:

Sheet name	Features
7A MAC GEOT RES CONSOL	▶ Saving the resource results obtained for each geotype.
7B MAC GEOT KPI	▶ Saving the KPIs obtained for each geotype.
7C CALC GEOT RES CUMUL	▶ Accumulating the resources stored in the previous sheet, for computational purposes. ▶ Calculating resource additions and removals.
7D CALC RES CONSOL	▶ Consolidating the resources of all geotypes in a table with a predefined format to be used by subsequent worksheets.
7E CALC GEOT KPI CUMUL	▶ Accumulating the KPIs stored in the previous worksheet for computational purposes.

Sheet name	Features
7F CALC KPI CONSOL	▶ Consolidating the KPIs of all geotypes in a table with a predefined format to be used by subsequent worksheets.

Exhibit 2.10: Storage of Geotype Dimensioning Results worksheets. [Source: Axon Consulting]

2.1.10. Step 8: Non-geotype-dependent resource dimensioning

The objective of the four (4) worksheets contained in this step is to calculate all the resources and KPIs needed for the proper deployment of the core network. The details of the functions of each worksheet are provided in the table below:

Sheet name	Features
8A CALC DIM CORE C.SITE-C.SITE	▶ Dimensioning the transmission links between the core locations (backbone network).
8B CALC DIM CORE PLATF	▶ Dimensioning the platforms and equipment related to the core locations.
8C CORE RESOURCES CONSOLIDATION	▶ Consolidating the resources obtained in all the previous core dimensioning worksheets.
8D CORE KPI CONSOL	▶ Consolidating the KPIs obtained in all the previous core dimensioning worksheets.

Exhibit 2.11: Non-geotype-Dependent Resources Dimensioning. [Source: Axon Consulting]

2.1.11. Step 9: Dimensioning results consolidation

The two (2) worksheets contained in this step consolidate the resources and KPIs calculated in the previous steps. The description of these worksheets is provided in the following table:

Sheet name	Features
9A TOTAL RES CONSOLIDATION	▶ Consolidating all the resources obtained in the access and core network dimensioning blocks.
9B TOTAL KPI CONSOL	▶ Consolidating all the KPIs obtained in the access and core network dimensioning blocks.

Exhibit 2.12: Dimensioning Results Consolidation worksheets. [Source: Axon Consulting]

2.1.12. **Step 10: Costing and allocation to services**

This step contains nine (9) worksheets related to the costing and allocation of the costs to services. A detailed explanation about these worksheets is provided in the following table:

Sheet name	Features
10A CALC RES OPEX	▶ Calculating OpEx associated with resources installed in the network.
10B CALC RES DEPRE	▶ Calculating resource depreciation using a tilted annuity method.
10C CALC RES COC	▶ Calculating resource cost of capital using a tilted annuity method.
10D CALC RES G&A	▶ Calculating the G&A costs per network element and year based on a mark-up approach.
10E CALC RES COST CONSOL	▶ Consolidating resource costs. ▶ Providing the OpEx of these resources.
10F TOTAL KPI ADJ	▶ Adjusting the KPIs obtained in the previous worksheet to enable the allocation of costs under the LRIC standard.
10G CALC MAP SERV2TECH	▶ Calculating the percentage of costs attributed to each technology per resource.

Sheet name	Features
10H CALC DEMAND ADJ	▶ Calculating the demand for the internal services.
10I CALC SERVICES COST	▶ Allocating the cost of resources to services through routing factors.

Exhibit 2.13: Costing and Allocation to Services worksheets. [Source: Axon Consulting]

2.1.13. Step 11: Results storage

The seven (7) worksheets contained in this step store the results of previous steps. The detail of these worksheets is provided in the table below:

Sheet name	Features
11A MAC SERVICES TOTAL TRAFFIC	▶ Storing service traffic when FAC mode is being run.
11B MAC RESOURCES TOTAL	▶ Storing the number of required resources when FAC mode is being run.
11C MAC KPIs TOTAL	▶ Saving KPI results when FAC mode is being run.
11D MAC DRIVERS TOTAL	▶ Storing adjusted driver volume.
11E MAC SERVICES COST	▶ Storing service costs.
11F MAC RES COST	▶ Storing resource costs.
11G MAC MAP SERV2TECH	▶ Storing the mapping percentage of costs attributed to each technology per resource under the FAC standard.

Exhibit 2.14: Results Storage worksheets. [Source: Axon Consulting]

2.1.14. **Step 12: Incremental and common costs calculation**

The objective of this step is to obtain the LRIC+ costs of services. The five (5) worksheets contained in this step are detailed below:

Sheet name	Features
12A CALC SERV INCREMENTAL COST	▶ Calculating service LRIC costs.
12B CALC RES COMMON COSTS	▶ Calculating resources common costs.
12C CALC SERVICES NW COMMON	▶ Attributing common costs to services based on an efficient capacity methodology.
12D CALC SERVICES NON-NW COMMON	▶ Calculating non-network common costs attributed to services.
12E CALC SERVICES LRIC+ COST	▶ Consolidating total LRIC+ costs per external service.

Exhibit 2.15: Incremental and Common Costs Calculation worksheets. [Source: Axon Consulting]

2.1.15. **Step 13: LRIC+ cost calculation**

The following worksheet offers concise information about the results of the model. Further details of the content of these worksheets is provided in the table below:

Sheet name	Features
13A OUT SERVICES LRIC+ UNIT COST	▶ Consolidating the unitary LRIC+ costs per service.

Exhibit 2.16: LRIC+ Cost Calculation worksheets. [Source: Axon Consulting]

3. Getting Started

Computer Requirements

The BU-LRIC Model is an Excel file. To run the model, a computer with at least 1GB of RAM and Microsoft Excel 2007 (or a newer version) is required. For enhanced performance, we recommend running the model on computers with at least 2GB of RAM and Microsoft Excel 2010.

Opening the Model

The execution of the model is based on macros (embedded programs in Visual Basic). Therefore, they need to be enabled to run the model. If macros are not enabled when opening the model, the following warning will appear[1]:

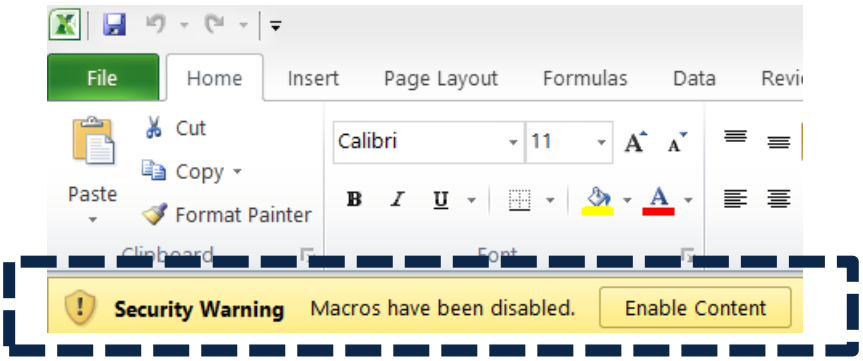

Exhibit 3.1: Warning appearing in Microsoft Excel 2010 when model is open and macros are not enabled. [Source: Axon Consulting]

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

Important warning: As previously stated, the execution of the model is controlled by macros. Therefore, it is strongly recommended not to press F9 to run it.

[1] If the warning shown does not appear, disregard further steps described in this section.

4. Understanding the Control Panel

The control panel represents the main interface 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.

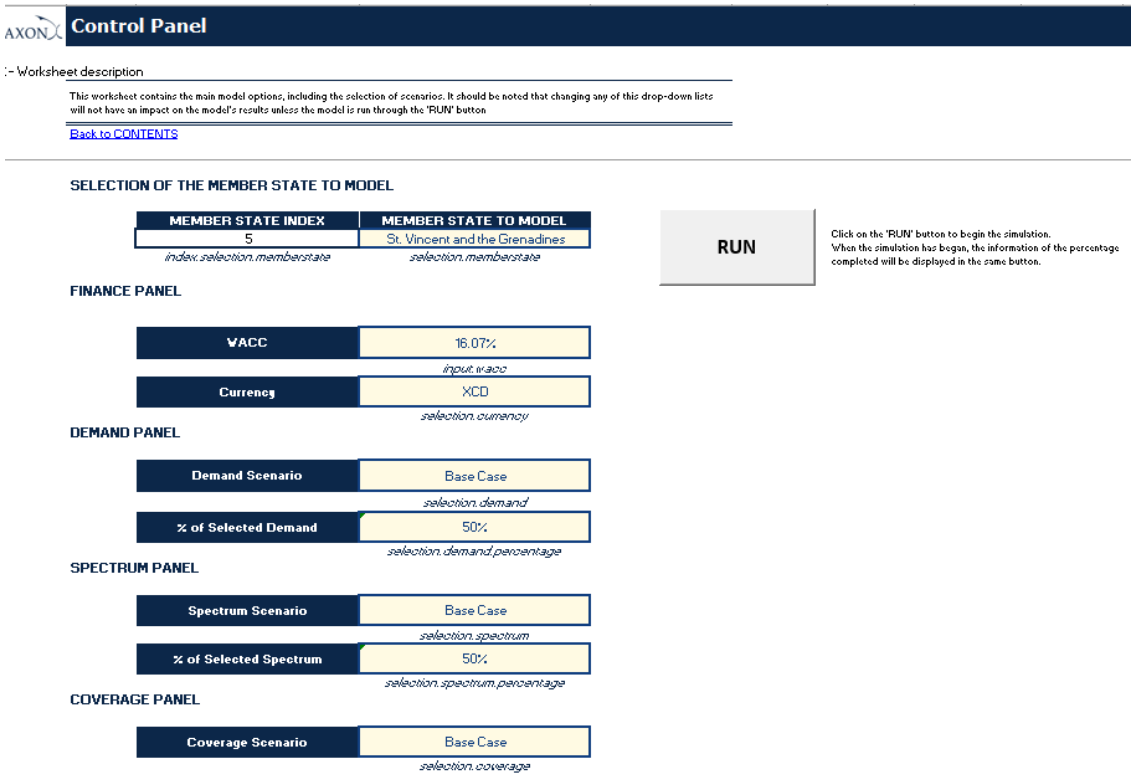

Exhibit 4.1: Snapshot of the control panel [Source: Axon Consulting]

The control panel is divided into the following blocks:

- Selection of the member state to model
- Run button
- Finance panel
- Demand panel
- Spectrum panel
- Coverage 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. Selection of the member state to model and run button

The execution panel contains the elements used to control the model's execution. These are:

- The control (button) to run the model
- The control (drop-down lists) to select the member state to be modelled

Button for Running the Model

This button is used to run the model. The text on the button will change during execution. Once pressed, the model will reset and the button will show "Resetting". After reset is complete, the model will automatically run and this button will show the execution process percentage, as shown below:

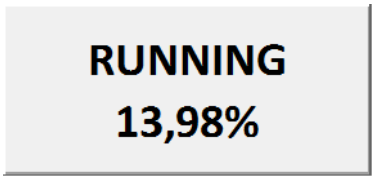

Exhibit 4.2: Illustrative example of execution percentage shown in the "Run" button [Source: Axon Consulting]

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

Control to select the member state to be modelled

The model includes the possibility to choose the member state to run the model for:

- *Dominica*
- *Grenada*
- *St Kitts and Nevis*
- *St Lucia*
- *St Vincent and the Grenadines*

4.2. Finance panel

The Finance panel includes two options that affect 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. The particular manner in which the cost of capital is calculated depends on the selected annualisation method.

- **Currency:** This drop-down list allows the selection of the currency to be employed in the model to get the results.

4.3. **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:

- **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 results.

- **Percentage of selected demand:** This parameter defines the percentage of the total demand introduced in the previous parameter that will be taken into account.

In case the demand input refers to a specific operator this parameter should be set to 100%. Otherwise, the demand input would refer to the total market and thus this value should reflect the market share of the operator considered.

4.4. **Spectrum panel**

This panel allows the choice of inputs employed to define the amount of spectrum considered for the modelled operator. The inputs affecting the spectrum are introduced in worksheet "1D INP SPECTRUM".

The panel contains the following options:

- **Spectrum scenario:** Several spectrum scenarios can be defined in worksheet "1D INP SPECTRUM". This drop-down list allows the user to select one of the scenarios defined.

- **Percentage of selected spectrum:** The amount of spectrum defined in the selected scenario will be multiplied by this factor. This feature allows the user to input the total spectrum available in the market, modelling a reference operator by setting a certain percentage of the total spectrum.

4.5. **Coverage panel**

This panel allows the user to select the coverage inputs that will be considered in the execution of the model. Coverage figures are considered in this model in percentages of population covered by geotype.

- **Coverage scenario:** This drop-down list allows the user to choose one of the coverage scenarios defined in the worksheet "1C INP COVERAGE".

5. Modifying inputs

The model inputs are identified by the following formats:

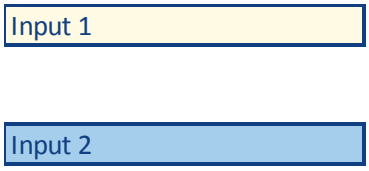

Exhibit 5.1: Format that identifies model inputs [Source: Axon Consulting]

As shown above, two different type 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 modify the model calculations significantly. For instance, if the routing factor definition is modified, the costs allocation may be incorrect.

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

Please note that the model should be executed in order that changes in the inputs are propagated to the results.