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Report for Digicel Group

Review of ECTEL's draft BULRIC models

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1 Executive summary

The Eastern Caribbean Telecommunications Authority (ECTEL) is the regulatory body for telecommunications in its five member states (Dominica, Grenada, St Kitts and Nevis, St Lucia and St Vincent and the Grenadines). ECTEL hired Axon Partners (Axon) to produce cost models of both fixed core networks and mobile networks in all five member states. On 29 May 2017, ECTEL released draft models for consultation on the future pricing of voice termination.[1]

Digicel Group (Digicel) has appointed Analysys Mason to review the models and associated documentation issued by ECTEL to see how the approach taken compares with good practice seen in other jurisdictions, including some of those referenced by ECTEL itself in the final guidelines report published in January 2017.[2]

We have identified several areas of concern regarding the draft mobile long-run incremental cost (MLRIC) model and recommend work is undertaken to improve the approach taken. In particular:

- We would strongly question the use of the scorched-earth approach in the draft MLRIC model, as this goes against the approaches used in all but one of the benchmark countries used by ECTEL. Incidentally, although the benchmarking in the final guidelines report stated five countries use a scorched-earth approach, four of these were models developed by Analysys Mason and we can confirm they do not use a scorched-earth approach. To be correct, they use a scorched-node approach. Incidentally, ECTEL's benchmarking in the final guidelines report from January 2017 is wrong in several places and often considers models that have long since been superseded.

- There are inconsistencies in the geotyping inputs in the draft MLRIC model, as the inputs in the Excel file published by ECTEL differ from those indicated by the maps annexed to the mobile model documentation. Furthermore, the location data used for this modelling is of poor accuracy and appears to not adequately capture the population centres on the islands, especially on Dominica (where, for instance, Portsmouth has been missed almost entirely, as the location data is in the sea). We recommend that Axon should redefine its geotyping approach using a more reliable data source, such as that published by geoMinds.

- We have also identified that the coverage calculation does not consider the contiguous areas in a geotype. Therefore, the draft MLRIC model is calculating in at least one case (in St Vincent and the Grenadines) that the model can cover one geotype with one site, even though that geotype lies across three different islands, which is unrealistic.

1 See https://www.ectel.int/draft-cost-models-for-fixed-and-mobile-interconnection-rates

2 https://www.ectel.int/wp-content/uploads/2017/01/Axon-Consulting-final-principles-methodologies-guidelines-20161227.pdf

- The 10% overcapacity factors used to dimension spare capacity in the network assets are far too low. Of nine other models we have inspected, overcapacity factors should be significantly higher (over 50% in several cases). A more realistic capacity deployment using a higher factor is reasonable to build in real life, in order to handle the peaky nature of traffic across the day, year, and even in the busy hour as people move across the islands from home to work places. The lack of spare capacity in the network is highlighted by there being far fewer 2G transceivers (TRX) in the draft MLRIC model than there are in Digicel’s network.

- We have also indicated that the working capacity allowance should be set to a nonzero value. We recommend a value equivalent to 30 days of opex.

- We have also identified several aspects of the weighted average cost of capital (WACC) that should be updated. The description of the WACC calculation in the documentation was poor and we had to request clarification from ECTEL to obtain the necessary information for the derivation of this crucial input.

- We also note that lifetimes in both the draft fixed and mobile bottom-up long-run incremental cost models appear to be inconsistent and have recommended an alignment.

Data that is confidential to Digicel within this report has been redacted and is indicated by the use of square brackets and the scissor symbol ‘[✂…]’.

2 Introduction

Analysys Mason has been commissioned by Digicel Group (Digicel) to produce an independent expert report to supplement Digicel's response to the consultation of draft bottom-up long-run incremental cost (BULRIC) models published by the Eastern Caribbean Telecommunications Authority (ECTEL) in May 2017.[3]

The materials released by ECTEL in the consultation package are listed in Figure 2.1 below. For each item, we state how we refer to that item within this report. We also list the final version of the principles paper (guidelines report) released by ECTEL in January 2017, which should also underpin the modelling undertaken.[4]

Figure 2.1: Materials released for consultation by ECTEL [Source: Analysys Mason, 2017]

Document title	Reference used in this report
1 Draft Cost Models for Fixed and Mobile Interconnection Rates	Consultation document
2 Introduction to BULRIC Models Consultation	Consultation note
3 Description of the BULRIC Model for Fixed Networks	Fixed model documentation
4 Fixed BULRIC Model User Manual	Fixed user manual
5 BULRIC Fixed Model	Draft FLRIC model
6 Description of the BULRIC Model for Mobile Networks	Mobile model documentation
7 Mobile BULRIC Model User Manual	Mobile user manual
8 BULRIC Mobile Model	Draft MLRIC model
Recommendations on new interconnection rates for ECTEL member states	Final guidelines report

The main objective of our report is to comment on the approach taken by ECTEL and to assess it against economic principles, investment principles, realistic network deployment requirements and modelling best practice (as observed in other jurisdictions). We have focused in particular on the draft MLRIC model, although we have also made some observations on the draft FLRIC model.

This report also contains supplementary annexes setting out other issues we have identified.

When referring to model worksheets, we use the code at the start of the name. For example, we refer to the *10I CALC SERVICES COST* worksheet as "worksheet 10I".

3 https://www.ectel.int/draft-cost-models-for-fixed-and-mobile-interconnection-rates/

4 https://www.ectel.int/wp-content/uploads/2017/01/Axon-Consulting-final-principles-methodologies-guidelines-20161227.pdf

3 Review of the draft MLRIC model

3.1 The models are not transparent for ECTEL's target stakeholders

The models developed by Axon on behalf of ECTEL are for the price regulation of several companies operating on the five Eastern Caribbean member states. All these companies (not just Digicel) have limited resources within their regulatory functions to review such models. The models fail to take this into account, as shown by the issues highlighted in Figure 3.1.

Figure 3.1: Transparency issues identified in the draft MLRIC model [Source: Analysys Mason, 2017]

Issue	Example worksheet[5]	Description
Model size	–	The draft MLRIC model alone consists of almost 100 worksheets and 2.5 million cells. Such a large model effectively prevents the operators' employees from exploring and investigating the approach, interim calculations and variety of outputs from the models. The operators' employees have good knowledge of the networks and traffic-related issues prevailing in the different markets, but this cannot be effectively applied to test or improve the draft models. Instead, the companies require expert advisers, who have international experience but limited knowledge of the individual ECTEL markets. The model could have been constructed with fewer worksheets, therefore requiring less use of complicated inter-worksheet formulae like INDIRECT() or OFFSET(). These formulae are notoriously difficult to understand and check, especially for less experienced modellers within the operators.
Excessive run-time	CONTROL	The "run" macro requires 2.5 minutes to run for a single operator for one scenario. Any sensitivity test therefore requires 2.5 minutes to run. Most published LRIC models can re-calculate in a few seconds. It is difficult to understand how the calculations may be behaving, if it takes 2.5 minutes to follow each logical test.
Excessive detail	12A CALC SERV INCREMENTAL COST	Costs are reported by asset over time, separately by depreciation, cost of capital, opex and G&A. Each table is the sum of ten tables.
Redundant functionality	• 4D COST ESTIMATION FOR TX • 11E MAC SERVICES COST • 0C PAR RESOURCES • 1A INP DEMAND	• Out of 450 rows of calculation, fewer than 10% are actively used (i.e. contain a nonzero answer). • The model stores results for the costs calculated for 10 increments, even though only the first two are used. • Even when including the 4G assets (that are not used), almost 75% of the asset list is blank. • Even when including the 4G services (that are not used), almost 75% of the service list is blank.
Lack of auditability	• 11A–11E	• The model does not calculate using F9: generating outputs requires a macro to aggregate results by geotype, over time

5 We would, however, note that the prefixing of the worksheet names (0A–13A) is useful when documenting worksheets.

Issue	Example worksheet[5]	Description
		and by increment. Many interim steps are pasted values and therefore cannot be audited.
	• 1A INP DEMAND	• Understanding the use of a crucial input like the market share (selection.demand.percentage) cannot be done using the "Trace dependents" functionality on the Excel toolbar. This is because it multiplies an OFFSET() on worksheet 1A. The use of OFFSET() makes understanding and checking significantly harder for users.
Poor worksheet layout	1A INP DEMAND 1H INP TECHNOLOGY DIS	Many inputs are specified on an operator-by-operator basis, with input blocks for each of the islands side by side rather than underneath each other. Side-by-side input blocks make the model hard to navigate and understand. Inputs are sometimes placed beneath each other (our recommended method) e.g. worksheet 2D, but this should be the case throughout the model.
Use of custom formulae	3E MAT SERV2DRIV	The documentation does not describe the function of the custom formula array2mat(). Although we have sought to understand the function by looking at the custom formula definition (it appears to convert two pairs of indexed columns into two matrices for multiplication), it is likely to be unintelligible for most stakeholders. If the model had been dimensioned appropriately (with less unused functionality), then we expect that such a complicated approach would not be needed.
Poor use of pane freezing	3B MAP SERV2DRIV	This worksheet has been set up so that the frozen columns fill the whole desktop screen, meaning that users cannot (without changing settings) view the inputs themselves.
Lack of row grouping	11F MAC RES COST	Worksheets can be hard to navigate given the number of large calculation blocks present. The use of row and/or column grouping would help to address this.
Use of complicated formulae	10I CALC SERVICES COST	Such formulae are difficult to understand and critique, even for a proficient user of Microsoft Excel. An example is provided in Annex B. This example also demonstrates the excessive use of OFFSET(), within a formula which can only be 'trusted' to have all the correct cell references, column indexes, row indexes, term multipliers, brackets, etc.

Based on all the issues that we have identified and listed above, transparency of the cost modelling (and getting stakeholder buy-in and understanding of the calculation) is not of importance to ECTEL.

3.2 The use of scorched earth is entirely at odds with international best practice

ECTEL's decision to choose a scorched-earth approach in modelling the radio network goes against international best practice. Table 21 of ECTEL's own final guidelines report shows that most of its benchmark countries do not use scorched earth, as shown below.

Figure 3.2: Benchmark of mobile access network modelling [Source: ECTEL final guidelines report, 2017]

Network Topology Design – Access Network

	Brazil	Cayman Islands	Jamaica	Colombia	El Salvador	Spain	France	Norway	Sweden	UK	Oman	Bahrain	UAE	Saudi Arabia	Jordan	Zimbabwe	TOTAL
Scorched node	x	x	x	x	x	x	x	x	x	x	x	x	x	x	√	x	1/16
Modified scorched node	√	√	√	√	√	x	x	x	x	x	√	√	√	√	x	√	10/16
Scorched earth	x	x	x	x	x	√	√	√	√	√	x	x	x	x	x	x	5/16

Moreover, as Analysys Mason developed the mobile cost models in France, Norway, Sweden and the UK, we can state with confidence that they do not use the scorched-earth approach either (the above benchmark is in fact significantly wrong). Therefore, only one country out of the benchmark group of 16 has used scorched earth in its mobile access network modelling (i.e. Spain).

Best practice is to use the scorched-node approach in some form, by calibrating to operator site counts. This reflects the real constraints faced by operators in their deployments.

The scorched-earth approach implemented in the draft MLRIC model, with little or no cross-checking of results, leads to unreliable draft results (such as the assumption within the model that one radio site can be used to cover three separate islands). This is described below.

3.3 The approach to geotyping and calculating coverage is inadequate

We have reviewed the geo-analysis work underpinning the draft MLRIC model and found numerous flaws in the data and approach. ECTEL needs to improve all aspects of the approach to ensure that the model reflects a reasonable approach to radio network deployment on these islands, especially should it continue to place a (non-standard) reliance on a scorched-earth approach. We describe these issues in turn below.

3.3.1 The inputs in the model do not appear to be consistent and are based on inaccurate data

In the case of St Vincent and the Grenadines, the urban geotype data appears to be incorrect on row 158 of worksheet 2C. It is specified as two grid squares with a population of 15 people, but apparently has one population centre with a population of more than 100 people. The population in this geotype appears to be incorrect, especially since these grid squares could not be described as urban based on these characteristics.

Also, there are several cases where there appear to be fewer population centres than grid squares (including the example above). Our understanding of the approach from Section 5.2 of the mobile model documentation is that every grid square included in the modelling must have at least one population centre. The cases we have identified are below:

- Dominica: rural spread (mountainous)
- St Kitts and Nevis: rural spread (mountainous)
- St Vincent and the Grenadines: rural spread (non-mountainous) and urban.

As described in Section 5.2 of the mobile model documentation, population centres are used from the geonames website to identify areas requiring coverage. Our understanding is that these are the entries tagged as "city, village…" for each island. We believe that insufficient locations are being used, as there are further locations tagged under "spot, building, farm…". All relevant data for the islands can be downloaded from a webpage on the geonames website.[6]

Analysis of this data indicates that, whilst not all relevant to this modelling, there are important locations including airports, hotels/resorts, hospitals and schools/universities. Whilst not population centres in terms of *permanent habitation*, they are population centres in terms of *frequent occupancy* and therefore it is reasonable to expect that they need to be covered. We recommend that the geotyping is revised to include these locations to ensure that the level of coverage obtained better reflects real-world locations and levels of coverage on the islands.

The number of such locations by country is summarised below in Figure 3.3. As can be seen by comparing the third and fifth columns, this would lead to at least a 10% uplift in the number of population centres for all the islands (and more than 50% uplift in the case of St Lucia, which has a large number of hotels present).

Figure 3.3: Population centre by island [Source: www.geonames.org, mobile model documentation, 2017]

Island	Modelled population centres	Entries under "city, village"	Total entries under "spot, building, farm"	Relevant entries under "spot, building, farm"[7]
Dominica	106	112	30	14
Grenada	277	280	125	36
St Kitts & Nevis	120	119	209	27
St Lucia	227	191	125	103
St Vincent and the Grenadines	84	91	35	16
Total	**814**	**793**	**524**	**196**

We have also identified inconsistencies between the geotyping maps in the model documentation and the inputs included in the model. Figure 3.4 illustrates the geotypes for St Kitts and Nevis. The suburban dense geotype (red) is shown to have seven squares, but the model inputs indicate there should be 10 squares (cell G91 on worksheet 2C). Similarly, Figure 3.4 indicates 13 squares in the suburban geotype (orange), whereas the model inputs state there should be 15 squares (cell G90).

6 http://download.geonames.org/export/dump/

7 Assumed to be airports, airfields, hotels, hospitals, resorts, schools, universities and stadiums.

Regardless of the final approach taken, it is important for the transparency of the process that the documentation properly reflects the modelling inputs.

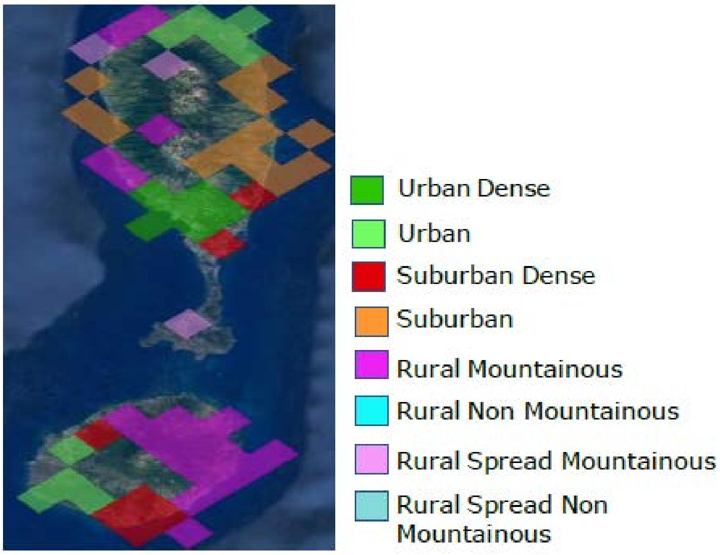


Figure 3.4: Illustration of geotypes defined for St Kitts and Nevis [Source: Mobile model documentation, 2017]

3.3.2 The subset of sampling grids is too small

We have identified a source of geographical data for the road segments across all five countries from a website called geoMinds.[8] We have also recreated the geotypes for each of the five countries shown in Annex A of the mobile model documentation, using the grid squares used by ECTEL (which we requested during the consultation period). When the road segments are overlaid, it is clear that several significant settlements are being missed using the current approach, particularly in Dominica.

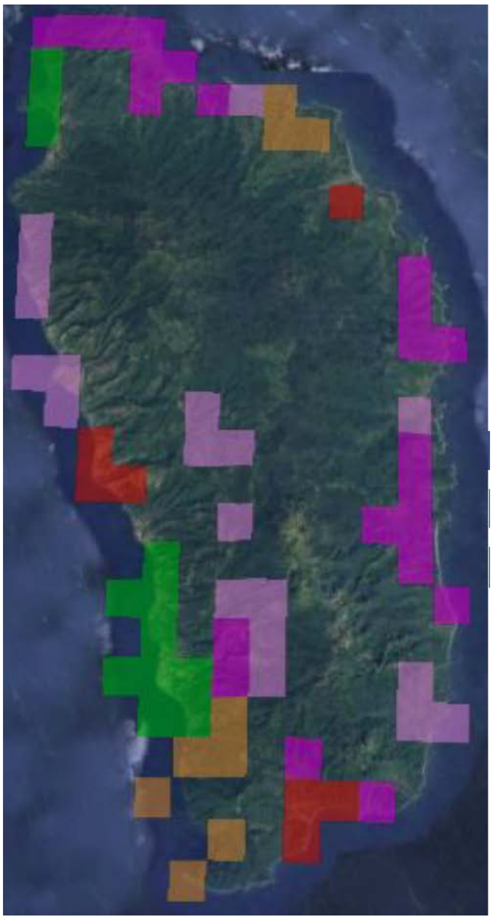
We illustrate this in Figure 3.5 below and have indicated the settlements which have been omitted (these can be identified visually by the road density and we have highlighted them using red dotted squares). In particular, the subset of grid squares used by ECTEL appears to omit some or all of the population centres in Dominica such as Portsmouth, Mero, Douglas Charles Airport, Marigot, Atkinson and Castle Bruce.

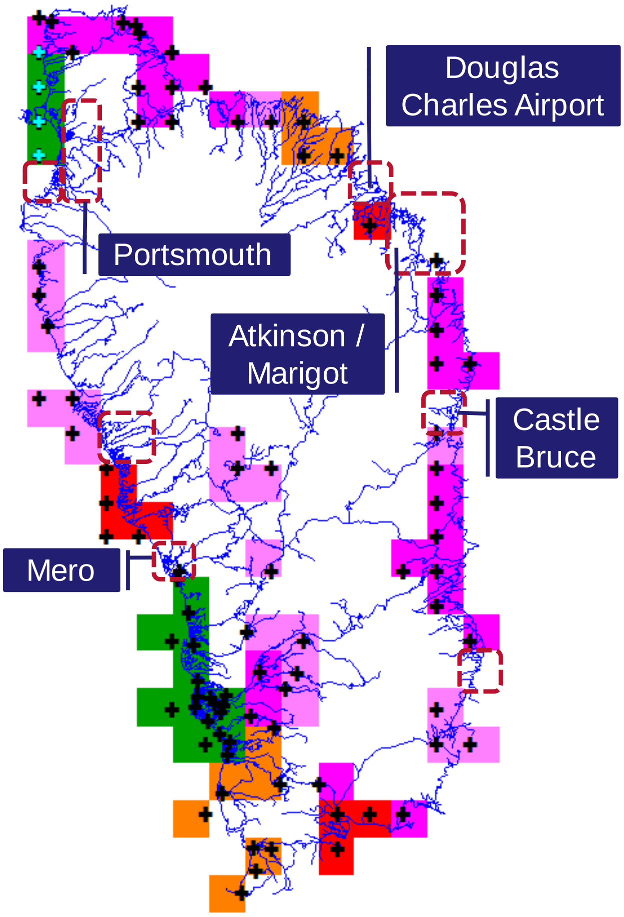
This is because (relatively inaccurate) locations have been used when population centres are in reality areas rather than points. This is particularly important given (i) the small scale of the geography of these islands and (ii) not all the island is to be covered given the distribution of population and the terrain.

The locations shown as crosses in Figure 3.5 below are those that we have downloaded from ECTEL's source (i.e. the geonames website).

8 We have used this data as allowed by the terms of the Open Database License (ODbL) v1.0 (http://opendatacommons.org/licenses/odbl/1.0/).

Figure 3.5: Geotypes in Dominica illustrated in the mobile model documentation (left); and our reconstruction using grid squares from ECTEL and available geodata (right) [Source: Analysys Mason, 2017]





The limitations of the locations used in the draft MLRIC model can be seen in the case of Portsmouth above (those locations from geonames closest to Portsmouth are highlighted as light blue crosses). These crosses highlight the lack of accuracy of the co-ordinate data used by ECTEL for modelling at the scale of these islands. The locations are insufficiently accurate to ensure that the correct squares are identified, with the co-ordinates appearing to be rounded to a limited number of decimal places.

To further illustrate this inadequacy in the model approach, we have calculated how many of Digicel's sites are currently captured within the grid squares included in the draft MLRIC model. The proportion of sites with the grid squares of each island for which we have data is shown below. We highlight that a significant proportion of the real-world sites in Dominica are not being covered. Figure 3.6 shows that between [✂] and [✂] of actual sites are not covered by the geotypes used by ECTEL. This leads to a significant understatement of coverage sites required.

Figure 3.6: Proportion of sites lying within the geotypes in the draft MLRIC model [Source: Analysys Mason analysis, 2017]

Type of site	Dominica	St Lucia	St Vincent and the Grenadines	Grenada
Equipped with 2G	[✂]	[✂]	[✂]	[✂]
Equipped with 3G	[✂]	[✂]	[✂]	[✂]

We recommend that the areas to be included in the geotyping are identified using better quality geodata than is currently used by ECTEL, such as that available from geoMinds.

We also understand that the National Telecommunications Regulatory Commissions in each member state have access to the site information for Digicel, so this cross-check of actual sites and the grid squares could have been undertaken as part of the modelling. We recommend that such checks are undertaken during the model finalisation.

3.3.3 The coverage calculation is significantly understating coverage site requirements

Figure 3.7 below sets out the definition of the geotyping used for St Vincent and the Grenadines, taken from Exhibit A.5 of the mobile model documentation.

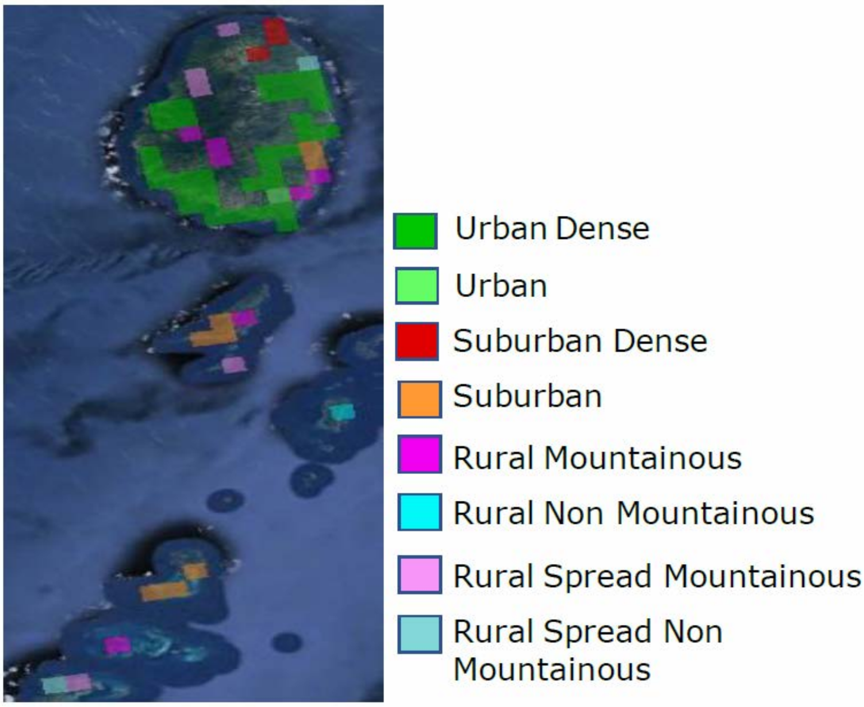


Figure 3.7: Illustration of geotypes defined for St Vincent and the Grenadines [Source: Mobile model documentation, 2017]

Running the calculations on worksheet 6A for each geotype separately, we have reproduced the base station volumes for the whole archipelago indicated on Exhibit 2.15 of the consultation document (just under 20 sites with a 2G presence in total, with little difference between using a 33% market/spectrum share or 50% market/spectrum share).

Figure 3.8 below extracts some information from the draft MLRIC model. We also state the number of contiguous areas for each geotype based on Figure 3.7 above. For example, there are 37 dark green urban dense grid squares, which are only on the northern island, but several are situated next to each other. They form five discernible separate areas when taken together.

Figure 3.8: Summary of geotype data for St Vincent and the Grenadines [Source: Analysys Mason, 2017]

Geotype	Grid squares ("samples")	Population centres	Contiguous areas of grid squares	2G BTS for coverage	Final 2G sites
Rural - non-mountainous	2	3	1	1	1
Rural-mountainous	8	10	6	4	4
Rural spread – mountainous	5	5	4	3	3
Rural spread - non-mountainous	3	2	2	1	1
Suburban	9	13	4	1	1
Suburban dense	3	4	2	1	1
Urban	2	1	2	1	1
Urban dense	37	46	5	4	4
Total	**69**	**84**	**26**	**16**	**16**

An immediate concern from this table is that the number of sites for coverage is, in most geotypes, lower than the number of contiguous areas in each geotype.[9]

If we take the suburban geotype (the orange areas in Figure 3.7 above), the model states that one BTS can provide coverage for this geotype, even though the suburban geotype is four separate areas across three geographically separate land masses. This is clearly implausible; the model is not producing a realistic network deployment. The coverage calculation should accommodate reality by assuming that enough coverage sites are deployed for at least one in each contiguous area of that geotype.

This demonstrates that the application of a "scorched-earth approach"[10] built using an Excel spreadsheet approximation cannot be expected to give a reasonable outcome for such a complex radio environment. Only a radio planning tool could achieve a realistic scorched-earth network. We believe this also demonstrates that the draft model is fundamentally flawed in its approach to aggregating geotypes for coverage purposes (irrespective of whether this is done under a scorched-earth principle or scorched-node principle).

9 All geotypes in the St Vincent and the Grenadines calculation are assumed to have at least 50% GSM coverage.

10 Determination 24, final guidelines report.

3.3.4 Cell radii are not being applied consistently in the model

The phrase "cell radii" seems to mean "sector radii" rather than "base station radii", based on the formulae used on worksheet 6A. Furthermore, the same input cell radius leads to a different sector size depending on whether the 2G base station is 2-sectored or 3-sectored. We consider this in the context of the St Vincent and the Grenadines calculation, for the urban geotype. The input cell radius for 900MHz is 8km, but this is adjusted by a factor of 40% to give a value of 3.2km. If 2-sectored base stations are being modelled, then row 146 of worksheet 6A gives an implied sector radius of 3.2km. If 3-sectored base stations are being modelled in that geotype, then the same row would give an implied sector radius of 2.13km. We illustrate these two base stations to scale in Figure 3.9 below. This would appear to be a flaw in the modelling approach: if a cell radius is a sector radius, then the sector should be the same size regardless of the sectorisation of the base station.

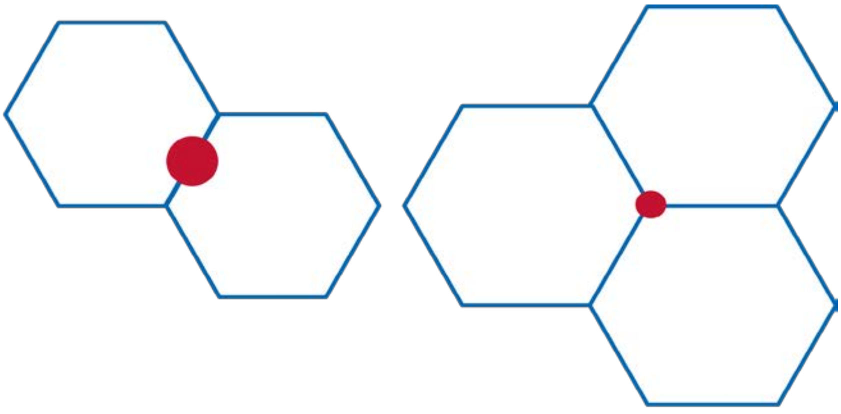


Figure 3.9: Implied 2-sectored and 3-sectored base stations for the same input cell radius [Source: Analysys Mason, 2017]

3.4 2G network equipment is being significantly under-dimensioned

We have compared the modelled TRX in 2017 (using a 50% market share) with actual TRX deployments in Digicel's current network. The modelled assets, as a proportion of actual deployments, are shown below in Figure 3.10 for the member states where we have data.

Figure 3.10: TRX deployed in the draft MLRIC model [Source: Analysys Mason analysis, 2017]

Modelled assets as a proportion of actual deployments	Dominica	St Lucia	St Vincent and the Grenadines	Grenada
TRX	[✂]	[✂]	[✂]	[✂]

As can be seen, the model is significantly under-dimensioning the requirement for these assets in all the islands and cannot therefore be relied upon to produce a realistic network design. This is partially related to the overcapacity factors assumed in the draft MLRIC model, which we describe further in Section 3.5.

3.5 The overcapacity factors should be significantly increased

Worksheet 2K specifies overcapacity factors for dimensioning assets. Cost models can account for overcapacity in several ways. They either uplift the assumed demand ('overcapacity factor') or reduce the assumed effective asset capacity ('efficient utilisation factor').

These are all set to 10% in the draft MLRIC model (except for radio sites, which are set to 0%). This is a significantly lower allowance for spare network capacity than is assumed in other models. We provide a benchmark of the overcapacity allowed in a range of other models, expressed as an overcapacity factor comparable to the draft MLRIC model.

For the avoidance of doubt, where the ECTEL draft MLRIC model assumes an overcapacity factor of x%, this corresponds to an efficient asset utilisation factor of 1/(1+x)%.[11] For example, ECTEL's overcapacity factor of 10% corresponds to an efficient utilisation factor of 91%.

We have inspected a wide range of the most recent mobile cost models in other countries, including several in the benchmark referenced by ECTEL in its final guidelines report. The nine countries we have used in our benchmark are Denmark, France, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the UK. We have collated the utilisation factors used for a more granular list of assets than is used in ECTEL's draft MLRIC model. We show the average and median values across the nine models.

We would note that the model built for the Spanish regulator was developed by Axon and uses an overcapacity factor of 25% in the radio network (and 43% in the core network), rather than the 10% value used by ECTEL.

Asset	Utilisation factor		Overcapacity factor	
	Average	Median	Average	Median
2G BTS	66%	70%	52%	43%
TRX	55%	50%	83%	100%
3G NodeB	67%	70%	50%	43%
CE	55%	52%	82%	92%
BSC	68%	70%	48%	43%
RNC	73%	75%	37%	33%
ATM last-mile backhaul	83%	80%	21%	25%
Ethernet last-mile backhaul	84%	80%	18%	25%
Hub-core transmission	62%	63%	60%	58%
Switches	68%	69%	47%	45%
Servers	76%	80%	32%	25%
Switch port cards	69%	70%	44%	43%
Core-core transmission	62%	60%	62%	67%
SMSC	65%	70%	54%	43%

Figure 3.11: Benchmark of overcapacity factors used in other cost models [Source: Analysys Mason, 2017]

11 Equivalently, a utilisation factor of y% corresponds to an overcapacity factor of (1/y)-1%.

As can be seen above, overcapacity factors far in excess of 10% are used in other models. We would highlight that the overcapacity factor used for TRX is over 80% across the other models. This would also explain why the TRX asset volumes in the modelled networks are so much lower than actual deployments.

We recommend that ECTEL implement more appropriate and realistic overcapacity factors in the MLRIC model, for example using the above table of values for reference. In particular, more spare capacity should be allowed for in the TRX deployments.

3.6 The effective capacity approach is undocumented and not transparently implemented

The mobile model documentation currently has no description of the effective capacity approach that ECTEL determined to use in Determination 14 of the final guidelines report. There is no documentation of the effective capacity approach in the mobile model documentation, except for one sentence stating "Aligned with the methodology, the common costs are allocated to services though routing factors (effective capacity approach)."

An example of the formulae on worksheet 12C of the draft MLRIC model that implement the effective capacity approach is shown below.

```
=IF(selection.geotype="All",((MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weig
hts.detailed)*TRANSPOSE(IF(services.internal.technology="GSM",OFFSET(services.totaltraffic,
0,D$13-1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),
IF(services.internal.technology="GSM",OFFSET(services.totaltraffic,0,D$13-1,,1),0)),0)),
OFFSET(resource.costs.opex.common,0,D$13-1,,1)*OFFSET(resources.mem.2g.services,0,D$13-
1,,1)))+(MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*
TRANSPOSE(IF(services.internal.technology="UMTS",OFFSET(services.totaltraffic,0,D$13-
1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),IF(services.internal.technology=
"UMTS",OFFSET(services.totaltraffic,0,D$13-1,,1),0)),0)),
OFFSET(resource.costs.opex.common,0,D$13-1,,1)*OFFSET(resources.mem.3g.services,0,D$13-
1,,1)))+(MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)
*TRANSPOSE(IF(services.internal.technology="LTE",OFFSET(services.totaltraffic,0,D$13-
1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),IF(services.internal.technology="L
TE",OFFSET(services.totaltraffic,0,D$13-1,,1),0)),0)),
OFFSET(resource.costs.opex.common,0,D$13-1,,1)*OFFSET(resources.mem.4g.services,0,D$13-
1,,1)))+(MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*TRANSP
OSE(OFFSET(services.totaltraffic,0,D$13-
1,,1))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),OFFSET(services.totaltraffic,0,D$13-
1,,1)),0)),OFFSET(resource.costs.opex.common,0,D$13-
1,,1)*OFFSET(resources.mem.common.services,0,D$13-1,,1)))),0)
```

It is unreasonable for ECTEL to expect any user of the model to understand the implementation of such a crucial part of the calculation, given the lack of documentation of the formulae, its length and its complexity.

3.7 Several inputs regarding the WACC need to be updated

The description of the WACC parameters in Section 2.3 of the consultation document was vague as to the derivation of the parameter values. It was stated that these parameter values were "based on the information provided by the operators."

After requesting clarification from ECTEL, this was not in fact found to be the case: several other sources were found to be used, as summarised below in Figure 3.12.

Figure 3.12: Sourcing of WACC parameters [Source: ECTEL, 2017]

Parameter	Source
Risk-free rate	Average of US Daily treasury yield curve rates for last 10 years. Average between 5-year, 7-year, 10-year and 20-year yields. Information obtained on 11 Oct 2016.
Country risk premium	Damodaran, information downloaded on 11 Oct 2016. Information from St Vincent & the Grenadines taken as a reference (no information available for other member states).
Debt premium	Damodaran, information downloaded on 11 Oct 2016. Cost of debt minus risk-free rate. "Telecom (Wireless)" for mobile services and "Telecom Services" for fixed services.
Equity Beta	Damodaran, information downloaded on 11 Oct 2016. Unlevered beta. "Telecom (Wireless)" for mobile services and "Telecom Services" for fixed services.
Market risk premium	Implied Equity Risk Premiums for US Market, using S&P 500. Average 2010-2015.
Gearing	Average gearing of latest 5 financial years, as provided by operators. Average of all member states.
Tax	Profit tax (% of profit) per Member state as published by World Bank. Average of all member states.

Our observations on these derivations are described below.

Risk-free rate

We have replicated the value derived, by averaging the daily yield measurements for all four bond durations specified above for the period 12 October 2006 to 11 October 2016. However, we disagree with the mixing of longer-term and medium-term bonds in the calculation and recommend that the 10-year bond only is used. Using ECTEL's approach, this corresponds to an average of 2.88%.

Country risk premium

We have identified this input and verified that none of the other four countries are available from Damodaran.

Debt premium

We have identified and verified this input.

Beta

We have downloaded the relevant file from the Damodaran website.[12] This indicates that the beta for mobile should be 0.65 (taken from C94 of the worksheet from the Damodaran website, corresponding to an average unlevered beta for Telecom (Wireless) services in the USA), not 0.6246 as in the consultation document. This should be updated.

Market risk premium

We have been unable to verify this input from the source data described.[13] The arithmetic average values over 2010–2015 for the three measures (i.e. S&P 500, 3-month Treasury Bill and 10-year Treasury Bond) for annual returns on investments on this webpage and none of them correspond to 5.55% (we derive 13.31%, 0.09% and 5.07% respectively).

Tax

We have replicated ECTEL's derivation of the tax assumption using the data from the World Bank website.[14] The value used is an average across the five countries for the year 2016 only. The data series contains data for four years in total and, if it is the appropriate data to use, all these years should be included to make the average a longer-term view (28.01% rather than 27.62%).

However, more generally, the input parameter that should be used is the corporate tax rate rather than the measure used by ECTEL. Using the same source for this data gives a significantly higher value, as shown below in Figure 3.13.

Figure 3.13: Corporate tax rates in the five countries [Source: World Bank, 2017]

Country	Tax rate	Webpage
Dominica	28%	http://www.doingbusiness.org/data/exploreeconomies/dominica/paying-taxes
Grenada	32%	http://www.doingbusiness.org/data/exploreeconomies/grenada/paying-taxes
St Kitts and Nevis	33%	http://www.doingbusiness.org/data/exploreeconomies/st-kitts-and-nevis/paying-taxes
St Lucia	30%	http://www.doingbusiness.org/data/exploreeconomies/st-lucia/paying-taxes
St Vincent and the Grenadines	32.5%	http://www.doingbusiness.org/data/exploreeconomies/st-vincent-and-the-grenadines/paying-taxes
Average	**31.1%**	

12 See http://www.stern.nyu.edu/~adamodar/pc/archives/betas15.xls

13 This can be found at http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/histretSP.html

14 See http://databank.worldbank.org/data/reports.aspx?source=2&series=IC.TAX.PRFT.CP.ZS&country=VCT&country=DOM&country=GRD&country=KNA&country=LCA

We have also identified from Deloitte a more up-to-date version of this data (as of 2017), with an average value of 30.1%.[15] We recommend that this is applied in ECTEL's models, in line with best practice.

The overall impact of our updates indicated above is shown below.

Figure 3.14: Revision of WACC parameters [Source: ECTEL and Analysys Mason, 2017]

Parameter	ECTEL value	Proposed amendment
Risk-free rate	2.71%	2.88%
Country risk premium	10.21%	10.21%
Debt premium	1.25%	1.25%
Cost of debt	14.16%	14.34%
Equity beta	62.46%	65%
Market risk premium	5.55%	5.55%
Return on equity	12.55%	13.12%
Gearing	40.00%	40.00%
Tax	27.62%	31.1%
WACC	**16.07%**	**17.00%**

3.8 A working capital allowance should be included

In many of the cost models of mobile networks developed by Analysys Mason for other regulators, a working capital allowance is included. This is defined as a fraction of yearly opex, and is intended to cover the cash running costs of the wholesale network business: essentially, having enough money in the bank to pay the operating costs expected in the month, while receiving wholesale (network) payments in arrears. This is estimated to be equivalent to 30 days of annual opex expenditure multiplied by the WACC. Assuming a WACC of 16.07% as specified in the consultation document, this would correspond to a working capital allowance of (30/365) × 16.07% = 1.32% of total annual opex.

Using our recommended changes to the WACC would correspond to a working capital allowance of (30/365) × 17% = 1.40% of total annual opex.

A list of regulators that have used this approach to working capital in their modelling of telecoms networks is shown below. It would be reasonable for ECTEL to include this allowance, as it has stated in its own final guidelines report (Determination 12).

[15] See https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-corporate-tax-rates.pdf

Figure 3.15: Examples of regulators that use the working capital allowance approach recommended by Analysys Mason [Source: Analysys Mason, 2017]

Regulator	Country	Regulator	Country
Erhvervsstyrelsen	Denmark	MCA	Malta
PTS	Sweden	Nkom	Norway
ACM	Netherlands	ICP-Anacom	Portugal
BIPT	Belgium (fixed modelling)		

3.9 Errors in the model benchmark in the final guidelines report

In Section 3.2, we indicated how the final guidelines report had incorrectly benchmarked several other cost models with respect to the scorched-earth approach. We can confirm that the benchmark is flawed in several other respects, based on our knowledge of the models developed by Analysys Mason in some of these countries (specifically, Brazil, Belgium, France, Norway, Sweden and the UK).

Several of the sources cited in Table 4 of the final guidelines report are considerably out of date. The worst example is the UK mobile model benchmark, based on a draft version published in 2010. Since that version, a final version was released in 2011, a draft update in 2014 and a final updated version in 2015. All of these versions are easily found on Ofcom's website. The updates undertaken in 2014/2015 were also particularly significant and several aspects of the modelling were revised. Examples of outdated benchmarks that we have identified are listed below in Figure 3.16.

Figure 3.16: Outdated benchmark in the final guidelines report [Source: Analysys Mason, 2017]

Country	Model	Date released in final report	Description of more recent releases
France	Mobile	March 2011	Model has been updated at least twice since then. Most recent version issued in 2017
France	Fixed	July 2013	Most recent version issued in 2017
Norway	Fixed (access)	September 2012	Updated in 2015
Norway	Fixed (core)	Not included	Most recent version in 2014
Sweden	Mobile	May 2011	Updated in 2016
Sweden	Fixed	November 2009	Updated several times until December 2013
UK	Mobile	April 2010	Significant update released in 2015

This benchmark is therefore flawed and cannot be used as it stands to justify conceptual or modelling decisions.

A sample of the errors that we have identified are given below, demonstrating the extent of the unreliability in the benchmark.

Figure 3.17: Errors identified in the benchmark in the final guidelines report [Source: Analysys Mason, 2017]

Table	Country(ies)	Description of error
5	UK	Though indicated in the benchmark as not considering G&A costs, both the fixed and mobile models do include them (e.g. in the mobile model Ofcom refers to them as "admin" costs).
9, fixed	Norway (footnote 19)	The Norway model of core networks does not use tilted annuity for core network equipment.
13, mobile	France, Norway, Sweden, UK	These models dimension the assets in the network in each year following the network size in previous years: they do not use the yearly approach.
14, mobile	UK, France	Both recent versions of the model use a modelling period of 50 years
18, mobile	Sweden	The version benchmarked did model 4G as a data overlay network. The most recent model version also considers 4G in the context of voice services.
18, mobile	UK, France	These models have been updated to include 4G networks as well.
19, mobile	UK	The UK model now includes an evolved core network.
23, mobile	UK	The UK model now includes RAN sharing.

4 Observations regarding the draft FLRIC model

We have not undertaken a comprehensive review of the draft FLRIC model for Digicel. However, whilst reviewing the consultation document, we identified several issues that we recommend are addressed in the model finalisation. We provide answers directly to questions stated in the consultation document.

Response to Question 27

The network resources specified in Table 3.7 of the consultation document are misleading to stakeholders, as they would indicate that all five countries have identical numbers of network nodes. This is only due to the document redaction process (which uses identical input tables for all five countries on worksheets 2A–2E). We recommend the first five rows of this table are deleted.

Response to Question 28

The lifetimes appear to be inconsistently implemented in the draft FLRIC model compared to the draft MLRIC model. The lifetimes in Table 2.7 of the consultation document for the draft MLRIC model can be summarised as follows:

- Access sites – 17 years
- Equipment hardware – 8 years
- Equipment software – 5 years
- Transmission equipment – 8 years
- Terrestrial fibre – 20 years.

Figure 4.1 below sets out the lifetimes assumed in the draft FLRIC model (according to Table 3.8 of the consultation document) and the comparable lifetime assumptions within the draft MLRIC model.

Figure 4.1: Comparison of lifetimes in ECTEL's BULRIC models [Source: Analysys Mason, 2017]

Asset type	FLRIC lifetime (years)	Proposed asset type from MLRIC model	MLRIC lifetime (years)
Network sites	40		
NGN chassis	5	Equipment hardware	8
Ethernet ports	5	Equipment hardware	8
Core equipment hardware	8		
Core equipment software	5		
Converters	8		
International exchange	5	Equipment hardware	8
MW hops	7	Transmission equipment	8
MW towers	11	Access sites	17
Fibre cable	20		
Transmission Ethernet chassis	5	Equipment hardware	8
Transmission Ethernet ports	5	Equipment hardware	8

In all cases shown, the lifetimes differ significantly between the fixed and the mobile models. There is no obvious reason or justification for very similar assets having different lifetimes in the core networks of fixed and mobile operators in the same countries. This has the effect of biasing the annualised costs in the models: higher for fixed, lower for mobile. We recommend that ECTEL consider that similar items have similar lifetimes, and align the assumptions used in the models.

Annex A Inconsistencies in the documentation

Below we set out several inconsistencies identified in the documents. We recommend that a comprehensive review of all the documentation is undertaken to ensure that it accurately documents the final ECTEL models.

Page 8, mobile model documentation	There is a reference to the "Sultanate" on page 8 of the mobile model which is incorrect.
Exhibits 6.3, 6.4 and 6.10, mobile model documentation	There are several references to "RAN sharing" in these flow diagrams. This is inconsistent with the final guidelines report, which indicates that RAN sharing is not being considered in the BULRIC models.
Page 34, consultation document	This page states "Ring Topology for urban areas and rural areas and Minimum Distance Tree Topology for Suburban and Rural areas". The modelling of the topologies in rural areas should be more clearly described, based on the inputs on worksheet 2F of the draft FLRIC model.
Worksheets 2A–2E, draft FLRIC model	These worksheets state in numerous places "This table contains the data regarding the core NGN locations of the reference Operator modelled. Due to the confidentiality of the information, the values shown are illustrative, which have been anonymised by + -30%". Since the input tables are completely identical for all five countries, this is clearly not the redaction process undertaken.
Table 2.7, consultation document	The lifetime for backhaul assets (fibre or leased line) is missing from the table, although a lifetime is included in worksheet 2G in the draft MLRIC model.
Table 3.7, consultation document	The top half of this table makes no sense to present, as it appears to show that all five countries have identical numbers of network nodes. This is only due to the redaction process and is therefore highly misleading for stakeholders.
Mobile model documentation	Worksheet 2C contains an input called "mobility factor" by geotype. If the value is not 1, then it affects the calculation. The value is 1 in some urban and suburban geotypes. The documentation should describe how this input is derived and why St Lucia is the only island where the urban/suburban geotypes have a mobility factor of 1.

Mobile model documentation	The use of the array2mat() custom formula is not described in the mobile model documentation. This should be described for those users without a modelling or mathematical background.
Draft MLRIC model	There are numerous references (e.g. on worksheets 2C and 6A) to municipalities. These are not relevant to the modelling, which uses population centres on the islands. These references should be revised accordingly.
Draft MLRIC model	Worksheets 6A, 6B, 6C and 6D contain the word “coubicated”, which we do not understand. We assume this should say “co-located”.

Annex B Illustration of non-transparent formula

We found this formula on worksheet 10I of the draft MLRIC model. We have reduced the font size to fit it onto one page. The complexity that we have previously described can be seen in this formula e.g. in terms of use of OFFSET(), MMULT(), IF() statements and numerous brackets.

```
=IF(selection.geotype="All",IFERROR((((MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*
TRANSPOSE(IF(services.internal.technology="GSM",OFFSET(demand.internal.services.adjusted,0,D$17-
1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),IF(services.internal.technology="GSM",
OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0)),0)),OFFSET(resource.costs.opex.selected,0,D$17-
1,,1)*OFFSET(resources.2g.services,0,D$17-1,,1)))+(MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*
TRANSPOSE(IF(services.internal.technology="UMTS",OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0))/
MMULT(TRANSPOSE(RF.matrix.weights.detailed),IF(services.internal.technology="UMTS",OFFSET(demand.internal.services.adjus
ted,0,D$17-1,,1),0)),0)),OFFSET(resource.costs.opex.selected,0,D$17-1,,1)*OFFSET(resources.3g.services,0,D$17-1,,1)))+
(MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*TRANSPOSE(IF(services.internal.technology="LTE",
OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),
IF(services.internal.technology="LTE",OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0)),0)),
OFFSET(resource.costs.opex.selected,0,D$17-1,,1)*OFFSET(resources.4g.services,0,D$17-1,,1)))+
(MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*TRANSPOSE(
OFFSET(demand.internal.services.adjusted,0,D$17-1,,1))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),
OFFSET(demand.internal.services.adjusted,0,D$17-1,,1)),0)),OFFSET(resource.costs.opex.selected,0,D$17-1,,1)*
OFFSET(resources.common.services,0,D$17-1,,1))))/SUM((MMULT(TRANSPOSE(IFERROR(
TRANSPOSE(RF.matrix.weights.detailed)*TRANSPOSE(IF(services.internal.technology="GSM",
OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),
IF(services.internal.technology="GSM",OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0)),0)),
OFFSET(resource.costs.opex.selected,0,D$17-1,,1)*OFFSET(resources.2g.services,0,D$17-1,,1)))+(MMULT(TRANSPOSE(
IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*TRANSPOSE(IF(services.internal.technology="UMTS",OFFSET(
demand.internal.services.adjusted,0,D$17-1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),
IF(services.internal.technology="UMTS",OFFSET(demand.internal.services.adjusted,0,D$17-
1,,1),0)),0)),OFFSET(resource.costs.opex.selected,0,D$17-1,,1)*OFFSET(resources.3g.services,0,D$17-
1,,1)))+(MMULT(TRANSPOSE(IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*TRANSPOSE(IF(services.internal.technology="
LTE",OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0))/MMULT(TRANSPOSE(RF.matrix.weights.detailed),
IF(services.internal.technology="LTE",OFFSET(demand.internal.services.adjusted,0,D$17-1,,1),0)),0)),
OFFSET(resource.costs.opex.selected,0,D$17-1,,1)*OFFSET(resources.4g.services,0,D$17-1,,1)))+(MMULT(TRANSPOSE(
IFERROR(TRANSPOSE(RF.matrix.weights.detailed)*TRANSPOSE(OFFSET(demand.internal.services.adjusted,0,D$17-1,,1))/
MMULT(TRANSPOSE(RF.matrix.weights.detailed),OFFSET(demand.internal.services.adjusted,0,D$17-
1,,1)),0)),OFFSET(resource.costs.opex.selected,0,D$17-1,,1)*OFFSET(resources.common.services,0,D$17-
1,,1)))))*INDEX(resource.costs.opex.total,0,D$17),0),0)
```