Guide on costing modelling for the determination of mobile and fixed-line wholesale voice call termination rates

Version 1

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Table of Contents

1 Introduction

1.1 Review of pro-competitive conditions

1.1.1 The Authority is engaged in a review of the pro-competitive conditions imposed on licensees in terms of its Call Termination Regulations, 2014. A Findings Document was published on 28 March 2022 in which the Authority reviewed the market for wholesale voice call termination services as well as the effectiveness of competition in the telecommunications market.

1.1.2 The Authority made various determinations including the following:

1.1.2.1 Licensees must charge cost-based pricing.

1.1.2.2 Mobile termination rates will move to symmetry within a transitional period of twelve months.

1.1.2.3 New licensees will qualify for asymmetry for a limited period of three years after entry into the market.

1.1.2.4 South African licensees must charge reciprocal international termination rates for voice calls originating outside of South Africa.

1.1.3 The Authority published a notice of commencement of the cost modelling phase with respect to the review of pro-competitive conditions imposed on the relevant licensees in terms of the call termination regulations, 2014 (as amended) on 26 May 2023. The Authority stated, "*having determined that there are still competition issues in the call termination market that may require regulatory intervention in its Market Review Phase, the Authority is now embarking on the Cost Modelling Phase in order to determine the efficient cost of providing wholesale voice call termination services*".[1] The purpose of this notice was to outline the next steps and the timelines with respect to the cost modelling exercise. The bottom-up and top-down shell

[1] Government Gazette No. 48660. Page 429. Available https://www.icasa.org.za/legislation-and-regulations/call-termination-rate-review-notice.

models were published on the Authority's website together with the notice.

1.2 Stakeholder workshop, modelling guide, shell models

1.2.1 A stakeholder workshop took place on 31 May 2023, at the Authority's offices in Centurion. One-on-one meetings were held with Cell C, MTN, Telkom and Vodacom between 1 and 6 June 2023.

1.2.2 The Authority's Proposed Modelling Guide on bottom-up and top-down shell models for the determination of mobile and fixed-line wholesale voice call termination rates was published on 2 June 2023.[2] This guide also explained the methodology used to determine Pure Long Run Incremental Costs. It describes how the modelling approach is based on "*international best practices which aligns with the determinations above, while also considering South Africa's market dynamics"*. The guide further explains the cost modelling approaches available to the Authority, and recommends after an "analysis of economic efficiency, distributional effects, competitive effects, and commercial and regulatory consequences" that the Authority adopt the pure LRIC approach.

1.2.3 Stakeholders provided written comments on the notice of commencement of the cost modelling exercise on 7 June 2023, and the Authority provided written responses to those requests for clarification on 15 June 2023.

1.2.4 Stakeholders were then requested to comment on methodology aspects of the TD/BU cost models by 10 July 2023, later revised to 24 July 2023.

1.3 Decision on methodology

1.3.1 Stakeholder submissions on the Authority's methodology were considered at a Committee meeting on 10 August 2023 and at a Council

[2] See Guide on bottom-up and top-down shell models for the determination of mobile and fixed-line wholesale voice call termination rates. Published on 2 June 2023. Available https://www.icasa.org.za/legislation-and-regulations/mobile-and-fixed-termination-rates.

meeting on 22 August 2022, and the Authority made the following decisions, captured in a separate Methodology Briefing Note:

1.3.1.1 The pure LRIC approach will be used to model termination costs;

1.3.1.2 Economic depreciation will be applied to model termination costs;

1.3.1.3 Fixed termination costs will be modelled separately to mobile termination costs;

1.3.1.4 The top-down spreadsheets will be used to sense-check and calibrate bottom-up model outcomes; and

1.3.1.5 Asymmetric costs will not be modelled.

1.4 Structure of this document

1.4.1 The remainder of this report is structured as follows. In section 2, economic depreciation and WACC are discussed. The mobile bottom-up model is explained in Section 3, and in Section 4 the top-down mobile model is explained. The fixed bottom-up and top-down models are explained in Section 5.

2 Economic depreciation and WACC

2.1 Economic depreciation

2.1.1 The Authority has decided to follow the economic depreciation approach, rather than the tilted annuity method used in 2018, for the reasons explained in the Methodology Briefing Note. Applying economic depreciation results in outcomes we would observe in a competitive market. This involves applying modern equivalent asset values and considering the lifetime of a business rather than a narrow timeframe. This is the approach suggested by the GSMA[3], for example (noting that there are informational difficulties that may argue for the use of a simpler approach), and applied by regulators such as Comreg[4] and

[3] See: https://www.gsma.com/mobilefordevelopment/resources/the-setting-of-mobile-termination-rates-best-practice-in-cost-modelling/

[4] See: https://www.comreg.ie/media/dlm_uploads/2019/05/ComReg-1948b.pdf

Ofcom[5]. The approach applied in the current version of the model departs from previous models in that there is no terminal volume to the production volume when calculating the asset unit cost (and thus no uplift to accommodate this), and the model also considers a business life of 20 years, rather than 50 years, for example. While this may result in a somewhat higher mobile termination rate, it is important to take into account the much higher cost of capital in South Africa, linked in part to greater uncertainty here, which means that volumes and costs far into the future, after being discounted to the present day, are much lower here than in other countries. Stakeholders are encouraged to comment on the time period for analysis, and the current approach in excluding terminal volumes.

2.1.2 Applying the economic depreciation approach, each asset is purchased in the year in which it is needed, applying a cost for the asset based on a specific price trend for it. All of the capital and operating expenditure associated is added in each year and discounted to the beginning of the period using the WACC.

2.1.3 The call termination volumes produced by each asset group are also discounted to the present day using the WACC. The unit costs for each asset group are then calculated by dividing the total discounted costs by the total discounted termination volumes to arrive at a unit price.

2.1.4 A business period of 2018 – 2037 is considered, which balances the need to have realistic values of assets, costs and volumes, with the need to have a long enough life of business.

2.2 Weighted average costs of capital

2.2.1 A weighted average cost of capital (WACC) for telecommunications networks in South Africa is needed in order to provide a return on assets including when applying the economic depreciation methodology, so as

[5] See, for example, https://www.ofcom.org.uk/consultations-and-statements/category-2/2021-26-wholesale-voice-markets-review

to identify the annualised costs of capital (sometimes referred to as CAPEX), as follows:[6]

$$CAPEX = (Gross\ value - cumulated\ depreciation) * WACC$$

The WACC, in turn, can be represented as follows:

$$WACC = \left[Ke \times \frac{E}{D+E}\right] + \left[Kd \times (1-t) \times \frac{D}{D+E}\right]$$

where:

Ke is the cost of equity, typically determined using the Capital Asset Pricing Method (CAPM) model, explained below

Kd is the cost of debt, which sometimes uses the firms' actual cost of debt, which includes a premium over the risk-free rate applied to debt (often government treasury bonds)

E is the proportion of equity in the firms' capital structure (or the market value of equity)

D is the proportion of debt in the firms' capital structure (or the market value of debt)

t is the rate of tax

2.2.2 The CAPM model, in turn, defined as follows:

$$\mathrm{Ke} = \mathrm{rf} + \beta \times (\mathrm{Em} - \mathrm{rf})$$

where:

rf is the risk-free rate applied to debt (often government treasury bonds)

β is the risk of the company relative to the market

$\mathrm{Em} - \mathrm{rf}$ is the market risk premium (the premium over risk-free returns)

2.2.3 There can be risk premia applied where investments in new technologies are uncertain (e.g. copper and fibre). The present model, however, does not concern risky investments in new technologies but rather rates applying to 2G, 3G and 4G services, which have long-established business models and do not involve substantial risks.

2.2.4 The pre-tax nominal WACC from ICASA's 2018 model was used as a starting point and adjusted by inflation. Furthermore, a risk-free rate for South Africa has been used, which will to some degree capture the

[6] See, in this regard, the International Telecommunications Union (ITU), 2009, Regulatory Accounting Guide, available at: https://www.itu.int/ITU-D/finance/Studies/Regulatory_accounting_guide-final1.1.pdf

impact of power cuts and the risks inherent in the broader economy. Stakeholders are encouraged to further comment on all of these issues.

2.2.5 The re-calculated WACC is 20% in 2023, for example. In the updated model, parameters are often based on the 2018 model estimates, and stakeholders are encouraged to comment on all of the parameters and assumptions.

Table 1: WACC assumptions

Major inputs	**Assumption**	**Source**
% debt that is capital	37.5%	ICASA 2018 model
Asset beta (unlevered beta)	0.8	ICASA 2018 model
Debt premium	4%	NERSA's estimate of Eskom's debt premium
Equity risk premium	5.7%	ICASA 2018 model
Company tax rate	2018-2021: 28% 2022-2037: 27%	Orbitax
Risk-free rate (10-year government bond)	2018-2022: 8.2% - 10.2% 2023-2037: 10.3%	World Government Bonds

3 Bottom up mobile network

3.1 Overall approach

3.1.1 There are several costing approaches to BU-LRIC models:

3.1.1.1 Scorched earth: a model is built from the ground up (i.e. no existing network topologies are taken into account);

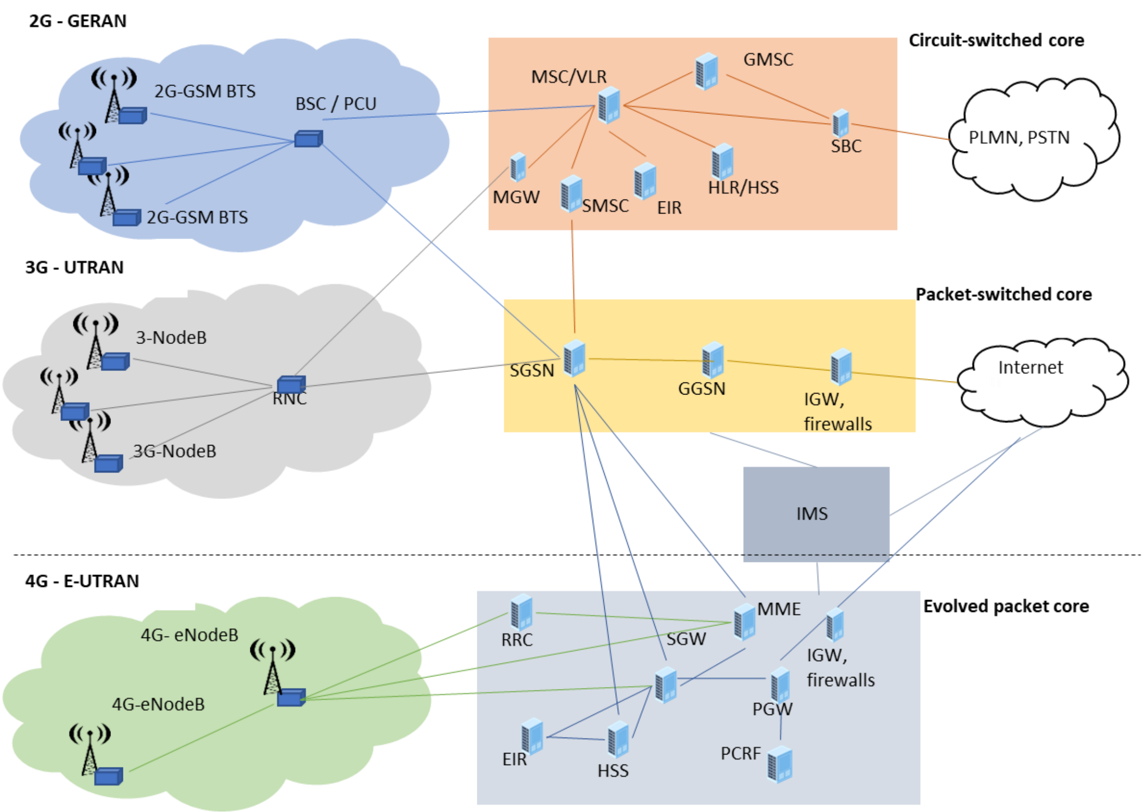
3.1.1.2 Scorched node: existing network topologies are used, and network elements not related to voice traffic are removed;

3.1.1.3 Modified scorched node: an efficient network is constructed, based on existing network topologies.

3.1.2 The modified scorched node approach, which takes into account existing networks and allows for efficiencies to be introduced in the network model, is often applied in practice. The main idea in respect of developing the BU-LRIC model for termination is to use network traffic demand to dimension a reasonable, representative network for South Africa, typically based on the number of operators.

3.1.3 A generic network topology is considered for the model, as shown on Figure 1 (see list of acronyms in Appendix A).

Figure 1: Network topology

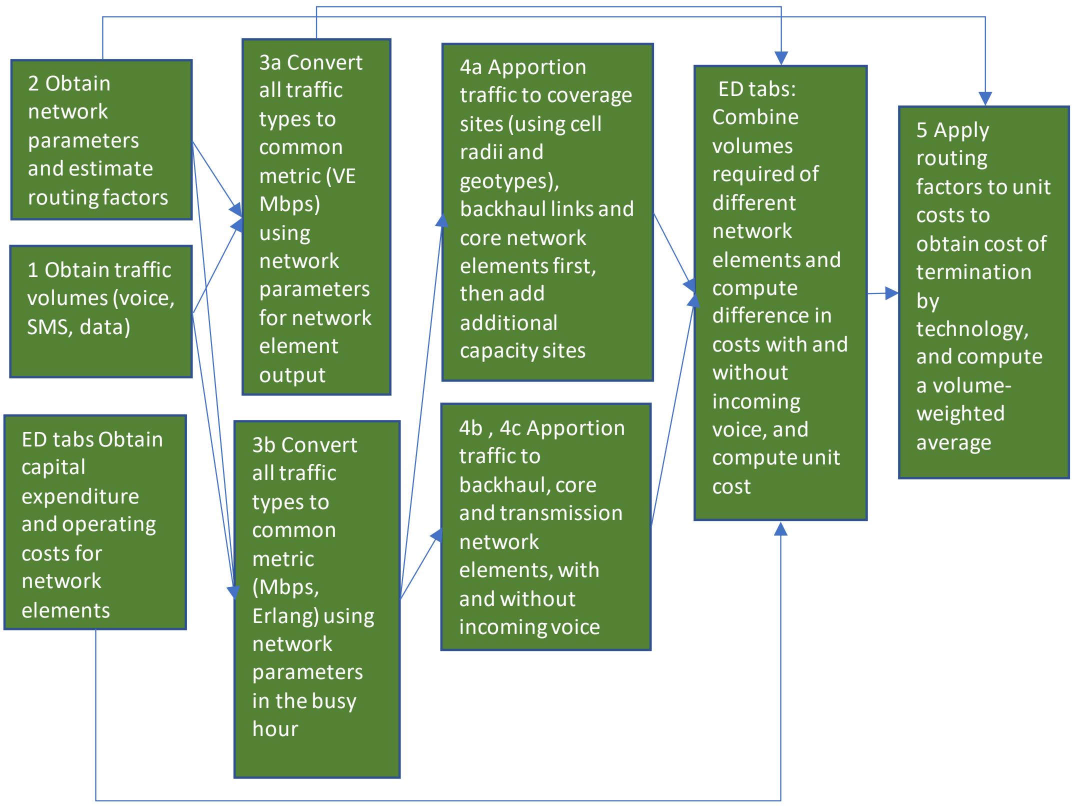


Sources: Acacia analysis adapted from: https://telecominfraproject.com/naas-playbook-post-launch/ and Haryadi, S. (2018). The Concept of Telecommunication Network Performance and Quality of Service., available at: https://osf.io/mukqb/

3.1.4 There is a balance to be struck between (i) developing a model for South Africa that is sufficiently granular to reasonably estimate the LRIC of termination costs, and (ii) developing a model that is so information intensive as to unduly burden licensees that have to provide that information. This is explained in the Authority's Methodology Briefing Note. Models including the ICASA 2018 model, the model used in Kenya by the Communications Authority of Kenya, the Eurorate model developed for the European Union, and the Ofcom model developed for the United Kingdom, were considered in order to arrive at a balanced approach.

3.1.5 In the following sections, the details of model are explained, for each of the tabs in the model. The overall plan for the model is shown below in Figure 2.

Figure 2: BU Plan



3.2 Summary tab

3.2.1 The summary tab shows the estimated LRIC termination cost per minute from the BU model for 2018-2037. It enables users to see how LRIC termination costs change by changing key assumptions.

3.2.2 In relation to spectrum assignments, the model has now been adapted to reflect changing spectrum assignments over time due to the Authority's spectrum auction in 2022 (made available in the model in 2023 due to delays with digital migration etc.), and reduced total spectrum availability to account for 5G use, which falls outside of the model. The effects of this are as follows:

3.2.2.1 In the revised model, only 144MHz is made available for 2G, 3G and 4G services, which allows for 40MHz for 5G services up to the spectrum cap of 184MHz. This corresponds, for example, to MTN's spectrum auction result for the 3.5GHz band, a primary 5G band.

3.2.3 The Authority determined during the course of its recent auction to consider a five-operator wholesale market, and indeed there are at least five mobile operators in South Africa that have control their own radio access network and IMT spectrum. There is thus no reason to depart from the five-operator market approach. The model has also been adapted to allow for different levels of coverage by technology. Stakeholders may nonetheless comment further on these issues, including in respect of network coverage assumptions and the extent of network sharing implied by a five-operator market, taking into account the nature of RAN sharing and roaming currently taking place in South Africa.

3.3 Tab 1 Volumes

3.3.1 The "1 Volumes" tab captures volume data for 2018-2037 for three different growth scenarios. The volume data used was largely extracted from the ICASA 2018 model. Although MMS traffic was included in the 2018 model, it has been excluded from the current model as it is not a widely used service in South Africa.

3.4 Tab 2a Network parameters

3.4.1 In this tab, network parameters have been separated out from the dimensioning tab since these parameters are used in various places and the user can more quickly and easily find the parameters they are looking for. This tab shows general parameters, network parameters (GSM, UMTS, LTE), core network dimensioning parameters, and conversion factors (units in the busy hour converted to megabits per second). It uses network parameters per technology (2G, 3G and LTE) to convert usage volumes of voice, SMS and data into megabits per second in the busy hour.

3.5 Tab 2b Routing factors

3.5.1 This new tab has been created so as to permit economic depreciation to be implemented for asset classes separately. Routing factors have been implemented using megabits per second in the busy hour across all service types, in order to estimate the costs of incoming voice. This involves several steps:

3.5.1.1 First, a set of basic services is selected, including incoming voice, based on previous models. The ICASA 2018 model further broke down services by geotype in the routing factors but this is not necessary for the computation of pure LRIC (traffic by geotype and site type is taken into account when calculating network demand).

3.5.1.2 Second, a basic routing factor for each service type is implemented through each cost element.

3.5.1.3 Third, final routing factors are computed, transforming all types of traffic into voice-equivalent megabits per second.

3.5.2 There is also a final adjustment table that explicitly captures whether costs vary with incoming traffic or not.

3.6 Tab 3 Volumes for network demand (3a) and output (3b) – Mbps, Erlang

3.6.1 Here, the routing factors from tab 2b are applied to the traffic volumes from tab 1 to compute volumes in the busy hour used for asset demand (tab 3a) and asset component output for each asset group (tab 3b).

3.7 Tab 4a Network– sites, RAN

3.7.1 In this tab, the network elements needed for the various services are apportioned into different geographic areas (dense urban, urban, towns and semi-dense, rural).

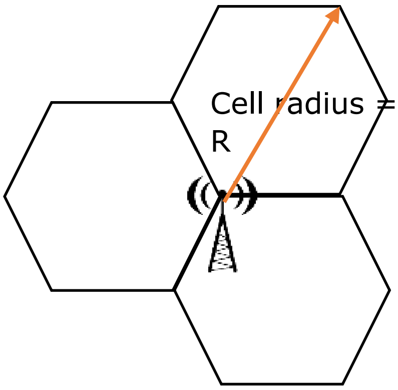
Coverage network

3.7.2 The model begins with site coverage radii and the geography of South Africa. First, a coverage network is built to a specified population coverage, and this coverage network provides for a basic layer of radio access network capacity using coverage spectrum. Next, traffic demand is used to assess the total capacity requirements, and first apportion traffic demand to coverage spectrum on coverage sites. Once the latter has absorbed capacity, then overlays to coverage sites absorb additional demand, and additional sites are added, until all demand is absorbed.

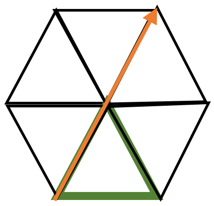
3.7.3 The network is dimensioned based on cell radii and a standard model of cell coverage, assuming a mobile site that has three sectors. In order to calculate site coverage, a hexagon shape for a cell sector is assumed, and this is divided into 6 triangles (described on Figure 3). There are 3 sectors per site with a hexagon factor of 2.6. The hexagon's coverage is then 2.6 * (1/2 X radius)$^{\wedge 2}$.

Figure 3: Cell coverage area

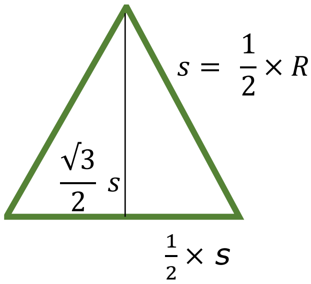
Step 1: Assume a 3-sector cell with cell radius R



Step 2: Divide one hexagon into 6 equi-lateral triangles



Step 3: Each triangle has a 30 degree, 60 degree, 90 degree angle, ratio of lengths is 1 : 2 : $\sqrt{3}$



Step 4: Area of triangle is (1/2 x base x height):

$\frac{1}{2} \times \frac{\sqrt{3}}{2} s \times \frac{1}{2} s = \frac{\sqrt{3}}{8} s^2$

Step 5: There are two right-angled triangles in our equilateral triangle, and 6 of the latter in hexagon:

$6 \times 2 \times \frac{\sqrt{3}}{8} s^2 = 2{,}6\, s^2 =$ $\mathbf{2{,}6\,\left(\frac{1}{2}R\right)^2}$

3.7.4 A coverage network is then constructed reaching, for example, 99% of the population in South Africa using low frequency spectrum, e.g. the 900MHz band for 2G and 3G and the 800MHz band for 4G. This approach to coverage sites follows the approach set out by the European Commission in 2009, as follows:[7]

"Coverage can be best described as the capability or option to make a single call from any point in the network at a point in time, and capacity represents the additional network costs which are necessary to carry increasing levels of traffic. The need to provide such coverage to subscribers will cause non-traffic-related costs to be incurred which should not be attributed to the wholesale call termination increment."

[7] See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009H0396

3.7.5 Coverage networks are required for 2G, 3G and 4G services, which will cause non-traffic-related costs to be incurred, and which are not attributed to the wholesale call termination increment.

3.7.6 In order to do so, a dataset from Statistics South Africa was used. This contains Census 2011 data on populations and geographic areas in the 21 588 sub-places[8] within South Africa sorted by population density, and add up the geographic area, by geotype.

3.7.7 Stakeholders suggested considering the Authority's previous 2018 geotypes. In addition, the World Bank definition of three degrees of urbanisation were also considered:[9]

"1. Cities, which have a population of at least 50,000 inhabitants in contiguous dense grid cells (>1,500 inhabitants per km^2);

2. Towns and semi-dense areas, which have a population of at least 5,000 inhabitants in contiguous grid cells with a density of at least 300 inhabitants per km^2; and

3. Rural areas, which consist mostly of low-density grid cells.") until 99% of the population is covered (Table 2)."

3.7.8 In South Africa, a substantial proportion of the population lives in cities, using the above definition. Given the fact that stakeholders typically consider additional geotypes for metropolitan areas and cities, and given that the Authority modelled 4 geotypes in 2018, a fourth category has been added to the above, that for dense urban areas. However, a definition of dense urban above 2 400-6 500 people per km^2, the approach in the 2018 process, does not correspond to the World Bank definition for towns and semi-dense areas, the delineation for which is 1,500 inhabitants per km^2). Furthermore splitting urban and dense urban using the latter demarcation results in a comparable split in the population. As a result, the definition of urban changes from 2 400-6 500 people per km^2 in the 2018 model to 1 500-6 499 people per km^2.

[8] One sub-place (Kwareyathlose SP) was removed as it did not have an area figure.

[9] See: https://blogs.worldbank.org/sustainablecities/how-do-we-define-cities-towns-and-rural-areas

Towns and semi dense areas and rural follow the World Bank's definition above, with the former category being less dense (300-1 499 people per km^2) than in the previous model (330-2 400 people per km^2).

3.7.9 The population density (not the minimum populations) are applied to sub-places in South Africa when computing data for the geotypes. Census 2011 population data from Statssa data and updated data from DataFirst at the University of Cape Town[10] were overlaid in R, with square kilometres calculated in R and the population densities calculated within the excel cost model.

3.7.10 The area and population figures for the four geotypes were built from South Africa's sub-place areas to provide better granularity of the network modelling of the geotypes, as requested by stakeholders. The final sub-place data set used in bottom-up mobile cost model analysis was constructed by processing three separate data sets. The first is the "enumeration-area-type" data set from DataFirst, which contains population figures by enumeration area, which was used to create the small area layer and district level population figures for 2011. The second data set, "District projections by sex and age", from Statssa contained population figures for 2020 by district, which together with the first data set was overlayed onto the map boundary data set, also from Statssa, to calculate the small area layer populations for 2020, see Equation 1.

3.7.11 This was used to calculate the 2020 sub-place area populations which was then used to categorise the data into the four geotypes. The final data set was transferred to the cost model where sub-places were arranged from most to least dense areas before calculating the area (square kms) and population figures for the four geotypes (see Table 2). The same process was followed when constructing 3G and 4G population coverage.

3.7.12 Table 2 shows that 2G networks cover 59 million people (6.9 million in rural areas) under the assumption of 99% coverage, which implies a

[10] See: https://www.datafirst.uct.ac.za/dataportal/index.php/catalog/517/get_microdata

total population of 59.6 million for 2020, consistent with official statistics.

Equation 1: Estimating the 2020 small area layer population[11]

$$SAL\ 2020\ pop = \frac{SAL\ 2011\ pop\ \times DC\ 2020\ pop}{DC\ 2011\ pop}$$

Table 2: 2G Population coverage

Geotypes	**Area (square kms)**	**Population (2020)**	**Percentage of total**
Dense urban (+6 500)	1 574	17 999 411	30.2%
Urban (1 500 to 6 499)	6 863	20 583 045	34.5%
Towns and semi-dense (300 to 1 499)	19 546	13 523 287	22.7%
Rural (<300)	328 234	6 894 037	11.6%
Total	356 217	58 999 780	99.0%

3.7.13 Based on assumptions about cell radii for each type of site (USM, GSM and LTE sub-1GHz and above-1GHz) in each of the four different geotypes, the site coverage in square kilometers can be estimated. The total kilometres per area divided by the site coverage provides an estimate of the sites needed for coverage across the country. The ICASA 2018 model cell radii assumptions were used as far as possible, in addition to volumes by service, technology and geotype use.

RAN dimensioning

3.7.14 This tab calculates how much network is demanded based on converted volumes per geography. First this involves calculating how much network capacity is available from the coverage network since these costs are excluded in the voice and SMS termination rate calculation. Total network demand for the baseline and no incoming voice is then calculated. Overprovisioning factors for maximum capacity, soft handover, and the like, are accounted for. Additional volumes are absorbed by applying capacity spectrum to coverage sites. Next, the model determines the active capacity sites required in addition to coverage sites to meet the quantity demanded in terms of capacity

[11] SAL 2020 pop, SAL 2011 pop, DC 2011 pop and DS 2020 pop refers to the estimated 2020 small area layer population, 2011 small area layer population, 2011 district populations and the 2020 district population, respectively.

spectrum under both scenarios. Note that these are required capacity sites. No capacity sites, once included in the network, are later removed when demand declines (such as for 3G data etc), since industry practice is only to remove equipment and sites once fully depreciated.

3.7.15 Six passive site types are considered: Shared towers, exclusive towers, rooftops, lampposts, in-building solutions, and microsites, which is the same number of site types used in the Authority's 2018 model.

3.7.16 Three active site types are implemented in the model, the same as those ultimately used in the Authority's 2018 model: Macrocells, microcells, and in-building solutions.

3.8 Tab 4b Network – BSC, RNC, backhaul

3.8.1 This tab calculates the number of 2G (BSC) and 3G (RNC) controllers. This has been done based on the assumptions and approach of the ICASA 2018 model, save for some differences. In particular, the number of 2G cells/sites rather than the maximum of the number of 2G transceivers or 2G cells/sites has not been used because of differences in dimensioning in this model relative to the ICASA 2018 model. Both BSCs and RNCs vary by scenario.

3.8.2 The model also estimates the number of backhaul links and transmission links, using the assumptions and approach of the ICASA 2018 model where possible, save for some differences. The transmission leased lines have been assumed to be 213 kilometers long on average and do not vary by the number of sites, unlike in the ICASA 2018 model. This number is from the ICASA 2018 model and relates to a large operator. Both the 500Mbps and the 10Gbps leased lines vary by scenario.

3.8.3 Transceivers, active equipment on passive sites, and controllers all depreciate over 8 years, while passive sites depreciate over 21 years.

3.9 Tab 4c Network – core, transmission

3.9.1 This tab contains the number of core network elements to be used as inputs in the capital and operating cost calculations of the model for the baseline and no incoming voice scenarios. The assumptions and broad approach of the ICASA 2018 model have been used. The number of units to buy are calculated for each year, taking into account that replicated units will have to be replaced. Only the MGW varies by scenario. In addition to these elements, the core network links have also been calculated. Again, the assumptions and approach are in line with the ICASA 2018 model. The number of links do not vary by scenario.

3.9.2 Stakeholders commented on various issues relating to the core network, and these issues are discussed in Section 3.4.

3.10 Tab 5 Cost Results

3.10.1 A summary of the model results is presented here. Unit costs from the various economic depreciation tabs are drawn into a table, and routing factors applied, to compute the final termination rate. The present value of revenue recovery is compared to the present value of costs to ensure that revenues are recovered. If not, an uplift factor is provided for.

3.11 Additional tabs

3.11.1 The model results in a variety of outcomes that can be calibrated using actual network equipment, operating and capital expenditure.

4 Top-down mobile model

4.1 Overall approach

4.1.1 The purpose of the top-down information gathering process is to calibrate the bottom-up models. Such information may be provided in the format that is used internally by stakeholders in order to limit the information burden on licensees while achieving the objective of the top down models, which is to calibrate the bottom up models (i.e. compare sites developed in the model with real world network sites, compare expenditure between the model and actual network expenditure, etc).

4.1.2 Stakeholders are encouraged to supply information on network-related capital and operating expenditure, sites, and the like, that can be used to compare with the outcomes of the BU model. For example, information on sites that could be used to calibrate the bottom up model is as follows:

4.1.2.1 Number of sites by site type and geotype;

4.1.2.2 Number of backhaul links by backhaul link category;

4.1.2.3 Number of core network elements by core network element category; and

4.1.2.4 Number of core links by core link category.

5 Fixed line bottom up and top down networks

5.1.1 The bottom-up fixed line model follows broadly the same approach as the bottom-up mobile network, except that, for fixed voice termination, only core network elements are relevant from a dimensioning perspective, and the common unit is voice minutes. This is because access network elements in a modern fixed line network do not vary with call termination. A similar approach to volumes, WACC and economic depreciation described above in respect of capex and opex is also used for the fixed bottom-up network.

5.1.2 The fixed top-down modelling approach again follows a similar approach to the mobile top-down approach described above, i.e. the top-down information will be used to calibrate the bottom-up model.

6 Appendix A - Acronyms

BSC	Base-station controller
DPI	Deep packet inspection
EDGE	Enhanced Data for GSM Evolution
EIR	Equipment Identity Register
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
GB	Gigabyte
GERAN	GSM EDGE Radio Access Network
GGSN	Gateway GPRS Support Node
GMSC	Gateway Mobile Switching Centre
GN	Gateway Node
GPRS	General Packet Radio System
GSM	Global System for Mobile communications
GWCN	Gateway Core Network
HLR	Home Location Register
HSS	Home Subscriber Server
ICT	Information and Communications Technology
IGW	Internet Gateway
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LTE	Long-Term Evolution
MB	Megabyte
Mbps	Megabits per second
MME	Mobility Management Entity
MNO	Mobile Network Operators
MOCN	Multi-Operator Core Network

MORAN	Multi-Operator Radio Access Network
MSP	Mobile service providers
MTR	Mobile Termination Rate
MVNO	Mobile Virtual Network Operators
NFV	Network Functions Virtualization
NNI	Network to Network Interface
OCS	Online Charging System
PCEF	Policy and Charging Enforcement Function
PCRF	Policy and Charging Rules Function
PCU	Packet Control Unit
PDN	Packet Data Network
PGW	Packet data Gateway
RAN	Radio Access Network
RNC	Radio Network Controller
RRC	Radio Resource Controller function of the MME
SBC	Session Border Controller
SDN	Software Defined Network
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
SMSC	Short Message Service Centre
UMTS	Universal Mobile Telecommunications Service
UTRAN	UMTS Terrestrial Radio Access Network
VLR	Visitor Location Register
WACC	Weighted Average Cost of Capital