**Guide on costing modelling**

**for the determination of mobile**

**and fixed-line wholesale**

**voice call termination rates**

Version 4.1

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# Introduction

## Review of pro-competitive conditions

The Independent Communications Authority of South Africa (‘the Authority’/’ICASA’) 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.

The Authority made various determinations including the following:

* + - 1. Licensees must charge cost-based pricing.
			2. Mobile termination rates will move to symmetry within a transitional period of twelve months.
			3. New licensees will qualify for asymmetry for a limited period of three years after entry into the market.
			4. South African licensees must charge reciprocal international termination rates for voice calls originating outside of South Africa.

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]](#footnote-2) 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 models were published on the Authority’s website together with the notice.

## Stakeholder workshop, modelling guide, shell models

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.

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]](#footnote-3) 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.

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.

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.

## Decision on methodology

Stakeholder submissions on the Authority’s methodology were considered at a Committee meeting on 10 August 2023 and at a Council meeting on 22 August 2022, and the Authority made the following decisions, captured in a separate Methodology Briefing Note:

* + - 1. The pure LRIC approach will be used to model termination costs;
			2. Economic depreciation will be applied to model termination costs;
			3. Fixed termination costs will be modelled separately to mobile termination costs;
			4. The top-down spreadsheets will be used to sense-check and calibrate bottom-up model outcomes; and
			5. Asymmetric costs will not be modelled.

Bottom-up information collection process

Stakeholders were invited to submit information on BU models by 15 November 2023, in order to provide calibration information for the BU models.

There were one-on-one stakeholder meetings to discuss top-down information with:

* + - 1. MTN on 22 November 2023,
			2. Cell C on 24 November 2023, and
			3. Vodacom on 24 November 2023.

Operators also provided comments on the BU model during the course of this process.

Structure of this document

The purpose of this document is to provide a report on the BU models and also on the recent one-on-one stakeholder meetings.

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.

# Economic depreciation and WACC

## Economic depreciation

As explained above, the Authority 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]](#footnote-4), 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]](#footnote-5) and Ofcom[[5]](#footnote-6).

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 lower here than in other countries. At the same time, the model likely results in a higher termination rate as a result, as explained below in Section 3.1.

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.

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. The volumes and resulting unit costs are trended by the price index applicable to each cost element in order to more closely replicate outcomes in competitive markets.

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.

#### Stakeholder comments

While a comment from a stakeholder indicated that a shorter time period might be warranted given forecasting uncertainties, the same stakeholder proposed following the approach in previous models in maintaining volumes at the same level after a period of time. In this case, volumes have been forecast until 2030, and then remain the same subsequently.

A stakeholder commented that the economic depreciation calculation in v3 did not follow price trends we would observe in competitive markets. The economic depreciation calculation now follows price trends for individual cost items, as explained above.

## Weighted average costs of capital

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 to identify the annualised costs of capital (sometimes referred to as CAPEX), as follows:[[6]](#footnote-7)

* + - 1. $CAPEX=\left(Gross value-cumulated depreciation\right)\*WACC$
			2. The WACC, in turn, can be represented as follows:
			3. $WACC=\left[Ke×\frac{E}{D+E}\right]+\left[Kd×(1-t)×\frac{D}{D+E}\right]$
			4. where:
			5. Ke is the cost of equity, typically determined using the Capital Asset Pricing Method (CAPM) model, explained below
			6. 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)
			7. E is the proportion of equity in the firms’ capital structure (or the market value of equity)
			8. D is the proportion of debt in the firms’ capital structure (or the market value of debt)
			9. t is the rate of tax

The CAPM model, in turn, defined as follows:

$Ke = rf+ β×(Em-rf)$

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 (the levered beta)

* + - 1. $Em-rf$ is the market risk premium (the premium over risk-free returns

The pre-tax nominal WACC per annum is based on data contained in stakeholder submissions. The WACC formula has been corrected to use the levered beta rather than the unlevered beta. Furthermore, a risk-free rate for South Africa has been used, which will to some degree capture the impact of power cuts and the risks inherent in the broader economy.

The re-calculated WACC is 21.18% in 2023.

Table 1: WACC assumptions

| **Major inputs** | **Assumptions** | **Source** |
| --- | --- | --- |
| % debt that is capital | 27.5% | Stakeholder submissions |
| Asset beta (unlevered beta) | 0.81-1.19 | Stakeholder submissions |
| Equity beta (levered beta) | 1.02-1.51 | Stakeholder submissions |
| Debt premium | 1.3%-2% | Stakeholder submissions |
| Equity risk premium | 5%-5.8% | Stakeholder submissions |
| Company tax rate | 2018-2021: 28%2022-2037: 27% | [Orbitax](http://) |
| Risk-free rate (10-year government bond) | 2018-2022: 8.3% - 10.2%2023-2037: 10.3% | [World Government Bonds](http://) |

#### Stakeholder comments

Changes made in v4.2 of the model:

* + - 1. Discount factors in sheet WACC / exchange rates were adjusted to the WACC index at the beginning of the year, since capex in the model takes place at the beginning of each period.

# Bottom up mobile network

## Overall approach

There are several costing approaches to BU-LRIC models:

* + - 1. Scorched earth: a model is built from the ground up (i.e. no existing network topologies are taken into account);
			2. Scorched node: existing network topologies are used, and network elements not related to voice traffic are removed;
			3. Modified scorched node: an efficient network is constructed, based on existing network topologies.

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.

Stakeholders commented that the hypothetical operator modelled needs to have a reasonable market share and network coverage, as well as reasonable network assignments. While there were five mobile network operators in South Africa in 2018, there are even more licensees that have access to IMT spectrum. At the same time, there is extensive network sharing in South Africa. Taking these comments into account, version 4 of the model considers as the default an operator market share of 33%. While five mobile operators were modelled for radio frequency spectrum caps for instance in ICASA’s recent spectrum auction, for present purposes for establishing the pure LRIC of mobile call termination, it may be more appropriate to model a hypothetical operator that has a market share of 33%, and the higher coverage levels set out in the v3, taking into account:

* + - 1. The fact that only two mobile operators have close to full-coverage networks.
			2. Remaining MNOs have varying levels of network coverage and typically rely to a substantial extent on network sharing.

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/](http://) and Haryadi, S. (2018). The Concept of Telecommunication Network Performance and Quality of Service., available at: [https://osf.io/mukqb/](http://)

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.

In the following sections, the details of the 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



#### Approach to benchmarking inputs

Stakeholders provided a range of often divergent information on network design parameters and unit costs. This information was compared with information used in previous models, and best estimates of parameters and costs applied by a hypothetical efficient operator were used in the model.

#### Model limitations

The cost model likely over-estimates the costs of pure-LRIC, for the following reasons:

* + - 1. There is no production volume nor asset terminal value beyond 2037, which means that the volumes over which costs are recovered over the asset’s lifetime are understated, or there is value in the network elements beyond 2037 that would be recoverable at end of the business life. These assumptions have been made in the model so as to limit the forecasting period to be within a reasonable timeframe, as explained above.
			2. The volumes do not adjust for changes in technology beyond 2030. This means that the volumes of 2G voice services, including 2G voice, are almost certainly overstated in later years, and so the costs of pure LRIC call termination are overstated. Again, this assumption is based on stakeholder comments that previous models, including the Ofcom 2021 model, applies static volumes beyond a reasonable forecast period.
			3. Backhaul networks in South Africa in dense urban and urban areas are almost certainly built by mobile operators for additional services, including fibre to the premises. The likelihood of backhaul links being disconnected in at least these areas is thus likely overstated in the model.

Summary tab

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.

#### Spectrum

In relation to spectrum assignments, the model reflects 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.), the upcoming auction to be held in 2024, and reduced total spectrum availability to account for 5G use, which falls outside of the model. In order to calculate available spectrum:

* + - 1. First, total available spectrum in each band for each period has been calculated. This has been conservatively estimated, excluding additional TDD assignments in the 1800MHz and 2100MHz bands throughout the period.
			2. Second, total available spectrum in each band is multiplied by the market share, and then rounded down according to the maximum carrier bandwidth for each band.
			3. There are some adjustments depending on the scenario:
				1. In the 33% market share scenario, 0.2MHz of spectrum is added to the 1800MHz band, accounting for the slightly greater share of spectrum available as a result of network sharing, and also accounting for the fact that not all spectrum in the 900MHz band is used in the model due to the assumed spectrum reuse factor of 12, even though in practice this spectrum is available to the hypothetical operator.
				2. In all scenarios, the hypothetical operator is assumed to have a minimum of 2x 11.5MHz in the 900MHz band, and 2x12MHz in the 1800MHz band, since this reflects the significant coverage levels assumed in the model.
			4. Spectrum is then apportioned to technologies in tab 2a, following stakeholder submissions. The latter assumptions are reasonable given the conservative overall estimate of available total spectrum explained above. An overall check is provided in the summary tab to ensure that the total spectrum applied in the model does not exceed actual total spectrum, subject to the comments above.

#### Coverage

The coverage level of the 4G network before 2023 can now be adjusted in the model. Since 900MHz is now used in the model before 2024 for the coverage network, the baseline coverage assumption is similar coverage levels before and after the release of 700/800MHz spectrum for 4G.

#### Impact of 5G

It seems highly likely that the rollout of 5G will take place in higher frequency spectrum bands, requiring substantial site densification,[[7]](#footnote-8) and thus fewer sites that are sensitive to inbound call volumes. However, a stakeholder commented that since 5G is outside of the scope of the current modelling process, it would be difficult to consider how 5G might impact on MTRs. The model therefore does not make any adjustments for the rollout of 5G.

#### Stakeholder comments

Changes to the model flowing from stakeholder comments:

* + - 1. The total amount of 900MHz spectrum has been increased from 2x11 to 2x11.5MHz before 2024 based on stakeholder submissions.
			2. The total available spectrum has been reduced to exclude TDD spectrum in the 1800MHz and 2100MHz bands not widely used commercially, resulting a total of 410MHz pre-2024. Total available spectrum post-2024 has also been reduced to exclude 3.5GHz spectrum, used for 5G, which is outside of the scope of the model.

Stakeholder comments that did not result in changes to Version 4 of the model are as follows:

* + - 1. A stakeholder commented that sub-1GHz spectrum holders had only 76MHz of spectrum before the auction in 2022, and that there is a spectrum cap of 187MHz per operator overall, and 2x21MHz in sub-1GHz bands, currently. However, in South Africa, the effect of multiple-operator core network (MOCN) and roaming arrangements mean that large operators, MTN and Vodacom, installing and rolling out networks for smaller rivals (Cell C, Liquid Telecom, and Rain) using the latter’s radio frequency spectrum assignments to do so, mean that effective access to spectrum far exceeds the spectrum caps applicable to spectrum assignments to MTN and Vodacom. It would be unreasonable to consider only the 76MHz or 187MHz available to the latter entities when modelling the hypothetical efficient operator for the purposes of modelling the costs of call termination.
			2. A stakeholder commented that the scorched node allowance ought to be reintroduced in order to accommodate for the fact that modelling a hypothetical operator may not result in a network similar to any in place in South Africa, and so the scorched node allowance may be used as a factor to adjust for this. However, the model currently does produce networks that are reasonable approximations of networks observed in South Africa, and so a scorched node allowance is not reintroduced in version 4.

## Tab 1 Volumes

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.

In respect of updates to the model:

* + - 1. Subscriber growth and technology split for the 2031-2037 period have been made static to match 2030’s values.
			2. The CAGR and decay values for incoming and on-net voice (usage per subscriber) have been adjusted to align with off-net voice.
			3. Geotype technology splits for 2017-2022 have been adjusted based on stakeholder submissions, the ICASA 2018 model, and overall subscriber technology splits. Since only one stakeholder provided information on this, a reasonable proportion of the latter stakeholder’s information was used in combination with subscriber technology splits and ICASA 2018 data.

## Tab 2a Network parameters

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).

#### Non-homogeneity factor

There are differences in traffic load between different sites in a single geography, and between sectors on sites.

In version 3, this non-homogeneity between sectors and sites was accounted for by reducing available transceiver / carrier capacity. This has now been changed to increase volume demanded for all sites.

There is a debate as to how to model such a non-homogeneity factor. Ultimately, the number of network elements built in the model should be broadly reflective of actual networks with comparable market shares in South Africa. This has now been achieved in version 4 of the model.

#### Stakeholder comments

The following corrections / updates were made in v4.2:

* + - 1. A floor was introduced to spectrum assignments, rather than rounding up in v3, in order to accommodate stakeholder comments that rounding up can result in more spectrum than is available, and also accommodating the fact that combining spectrum through MOCN arrangements do not give rise to equivalent spectrum holdings.
			2. The proportion of calls going to voicemail was changed to adjusted based on stakeholder submissions.
			3. The proportion of site types.
			4. Percentage of traffic in the busy hour was updated based on stakeholder submissions.
			5. Alternative 4G downlift factor applied using stakeholder submissions.
			6. Voice equivalent Mbps calculated for 4G using spectrum efficiency for voice services.
			7. Factors for non-homogeneity have been added to the model.
			8. Backhaul splits between microwave and leased lines.
			9. A variety of additional parameters were updated, including
				1. Maximum utilisation factors,
				2. Economic life of electronic equipment,
				3. Economic life of physical sites,
				4. Percentage of traffic going to voicemail,

Comments from stakeholders not implemented in v4.2:

* + - 1. A stakeholder commented that cell breathing ought to be removed from the model, since this was taken into account in cell radii calculations for the coverage network. Nonetheless, cell breathing needs to remain for capacity sites.
			2. Site sharing data provided by one stakeholder reflected a very high proportion of non-shared sites, which contradicted information on the extend of site sharing in South Africa particularly given the recent sales of towers to tower companies. While the proportion of sites that are shared have been updated in the model, the hypothetical efficient operator would choose between the least cost option of renting versus owning sites, and the site rental option is thus the default scenario in the model. The site-ownership scenario (setting sites rented to ‘No’) should be used with caution, and likely results in an over-estimate of the cost of pure LRIC call termination services.
			3. A stakeholder commented that substantial revisions would be needed to assumptions of number of sectors in order to implement non-homogeneity factors, the upshot of which was that only 1 sector per site would be modelled. However, this would not accurately reflect how mobile networks are built, since they often have a number of sectors per site. The number of sectors in turn affects costing in the ED tabs. Instead, the non-homogeneity factors have been applied to demand as suggested by the stakeholder, and calibrated to arrive at reasonable numbers of sites observed in South Africa.

## Tab 2b Routing factors

This process involves several steps:

* + - 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).
			2. Second, a basic routing factor for each service type is implemented through each cost element.
			3. Third, final routing factors are computed, transforming all types of traffic into voice-equivalent megabits per second.

#### Stakeholder comments

Updates to this tab in v4.2 as a result of stakeholder comments are as follows:

* + - 1. The final routing factor table was previously multiplied only by incoming voice, rather than the full set of conversions to megabits per second. This has now been corrected.
			2. Core network routing factors have been updated to be consistent with core transmission traffic routing factors.

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

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).

#### Stakeholder comments

Adjustments in v4.2 of the model as a result of stakeholder comments:

* + - 1. RAN demand has been inflated using site and sector non-homogeneity allowances.

Comments not implemented in v4.2:

* + - 1. A stakeholder commented that tab 3b could be deleted since (i) the increment is all incoming voice, not incoming voice split by technology, and (ii) there is an element of ‘cost allocation’ between technologies. However, a standard approach to computing pure LRIC termination rates, such as that applied by Ofcom in 2021, computes output per network element group, some of which are only applicable to specific technologies (2G, 3G, and 4G). In the absence of computing pure LRIC per cost element in the ED tabs using output volumes from 3b, it would not be possible to use individual cost trends for individual cost elements, and thus outcomes in competitive markets would not be as accurately reflected in the model. It is thus reasonable to compute pure LRIC termination rates for each cost element, and then compute a blended rate. Nonetheless, a single pure LRIC termination rate has also been computed in the calibration tab on LRIC revenues, costs, for comparison purposes.

## Tab 4a Network– sites, RAN

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

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.

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)^2.

Figure 3: Cell coverage area

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

Cell radius = R

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

E

$$s= \frac{1}{2}×R$$

$\frac{1}{2}×$ *s*

$$\frac{√3}{2} s$$

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

$\frac{1}{2} ×\frac{√3}{2} s ×\frac{1}{2}s$ *=*$ \frac{√3}{8}s^{2}$

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

$6×2×\frac{√3}{8}s^{2}=2,6 s^{2}=2,6  \left(\frac{1}{2}R\right)^{2}$

Step 3: Each triangle has a 30 degree, 60 degree, 90 degree angle, ratio of lengths is 1 : 2 : √3

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:[[8]](#footnote-9)

“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.”

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. This is because coverage networks would be required for all three technologies to offer mobile services, including voice, SMS and data, regardless of whether inbound calls were available or not.

The properties of the coverage network provide for standard network dimensions to achieve a basic level of network coverage, and not merely an abstract bare minimum set of infrastructure needed to produce one 2G voice call. One stakeholder commented that, for example, the coverage network should provide for only 1 2G transceiver per site for coverage purposes. However, the previous models reviewed to prepare the version 3 model, including the ICASA 2018 model, the Eurorate model and the Ofcom model, modelled standard coverage networks for 2G, 3G and 4G networks using standard network parameters. The same approach is thus followed here.

#### Geotypes

In order to construct the coverage network, a dataset from Statistics South Africa was used. This contains Census 2011 data on populations and geographic areas in the 21 588 sub-places[[9]](#footnote-10) within South Africa sorted by population density, and add up the geographic area, by geotype.

Stakeholders suggested considering the Authority’s previous 2018 geotypes. In addition, the World Bank definition of three degrees of urbanisation were also considered:[[10]](#footnote-11)

“1. Cities, which have a population of at least 50,000 inhabitants in contiguous dense grid cells (>1,500 inhabitants per km2);

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 km2; and

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

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 km2, 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 km2). 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 km2 in the 2018 model to 1 500-6 499 people per km2. 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 km2) than in the previous model (330-2 400 people per km2).

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[[11]](#footnote-12) were overlaid in R, with square kilometres calculated in R and the population densities calculated within the excel cost model.

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 the 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).

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.

**Equation 1****: Estimating the 2020 small area layer population**[[12]](#footnote-13)

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

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 kilometres 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 model uses cell radii assumptions similar to those from ICASA’s 2018 model, which are in turn similar to those used in models in other jurisdictions, since stakeholder-provided cell radii give rise to an unusually low number of coverage sites in South Africa.

#### RAN dimensioning

Network demand is then computed based on converted volumes per geography.

* + - 1. 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.
			2. Total network demand for the baseline and no incoming voice is then calculated.
			3. Overprovisioning factors for maximum capacity, soft handover, and the like, are accounted for.
			4. Additional volumes are absorbed by applying capacity spectrum to coverage sites.
			5. Next, the model determines the active capacity sites required in addition to coverage sites to meet the quantity demanded in terms of capacity 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.

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.

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.

#### Number of transceivers and carriers

The number of transceivers/carriers demanded has been calculated by first calculating total demand per sector by technology, and then adjusting for maximum transceiver/carrier utilisation. Average demand is then multiplied by the number of sectors to compute the number of transceivers and carriers.

#### Economic life of assets

Active equipment on passive sites depreciate over 8 years, while passive sites depreciate over 17 years.

#### Stakeholder comments

The following corrections and updates were made in version 4:

* + - 1. The 900MHz band has been used for 4G coverage sites, rather than the 1800MHz band, following stakeholder inputs. A lower spectrum carrier size was used for this, again based on stakeholder inputs.
			2. 3G cell breathing has been added in the computation of the number of 3G carriers.
			3. The uplift for peak to achieved rate in 4G was computed for the number of 4G carriers.
			4. The number of spectrum cells is the sum of the maximum 2G, 3G and 4G cells used for coverage and capacity respectively, reflecting spectrum band activation per site rather than per cell, in line with cost information provided by a stakeholder.
			5. The links in the formula for the number of transceivers available per site for 1800MHz has been corrected.
			6. The computation of voice equivalent Erlang uplift has been corrected to link to all years for the 900MHz and 1800MHz bands.
			7. The mark-up for soft handover was removed in 4a since this was counted twice from 2a.
			8. The deduction of 4G coverage carriers was removed from the 1800MHz band for 4G since this band is no longer used for coverage.

Stakeholder proposals that were not implemented in v4.2 are as follows:

* + - 1. Stakeholders provided much higher cell radii, giving rise to a much smaller coverage network. These cell radii gave rise to an unusually low number of coverage sites, and so cell radii similar to ICASA’s 2018 model were used.
			2. A stakeholder commented that when computing the number of spectrum bands activated on a site per band, the number of bands should be added across technologies. However, unit costs have been provided on bands activated per site and not per technology for the spectrum bands calculations, and so the maximum rather than the sum has been used.

## Tab 4b Network – backhaul

The approach to calculating backhaul links is as follows:

* + - 1. First, average demand per site by technology (2G, 3G and 4G) is calculated.
			2. Second, the number of single-technology and shared-technology sites is computed.
			3. Third, average demand for per site is calculated, for each geotype and site type.
			4. Next, the number of 2mbps links is calculated per site type and geotype, for shared and single-technology sites, based on whether it would in fact be more economical to upgrade to one 30mbps link rather than multiple 2mbps links.
			5. The average demand for 30mbps backhaul links, 100mbps backhaul links and 500mbps backhaul links is then calculated following a similar process.
			6. Finally, average demand per site is multiplied by the number of sites for each geotype and site type for shared sites and single technology sites, and then aggregated.

Several corrections were made to the calculation of backhaul links in v4.2, including the total number of links is now included in the model, rather than the average links per site in v3.

#### Stakeholder comments

Backhaul errors were corrected, following the steps applied above, many of which were suggested by stakeholders.

A stakeholder commented that backhaul links ought to be computed taking into account that not all technologies are available at each site. This has now been taken into account in the computation of backhaul links by first computing single-technology sites, and then shared-technology sites.

Stakeholders provided submissions that showed substantial own-build and dark-fibre rentals, particularly in dense urban and urban areas, but at the same time provided leased line pricing for 30mbps, 100mbps, and 500mbps links that make own-build uneconomical purely for the purposes of backhaul. Stakeholders are thus likely using their self-build networks for other purposes, such as fibre to the premises, in addition to backhaul. As mentioned above, this means that the backhaul costs avoided in the absence of incoming calls are likely overstated. The lowest cost backhaul alternative was used in the model.

## Tab 4c Network – BSC, RNC, links

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. Both BSCs and RNCs vary by scenario.

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 are assumed to be 218 kilometres long on average and do not vary by the number of sites. 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.

A revisions in v4.2 of the model is that the calculation of the number of BSCs and RNCs computed based on cells has now been changed to take into account cells rather than sites, counting 2 cells for instance where 2 spectrum bands were activated for 2G.

## Tab 4d Network – core, transmission

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. Of the core network equipment, only the SBC, MGW, MSCS, Wholesale Billing System, and IMS Call Server Hardware vary by scenario.

In addition to these elements, the core network leased links and total length of leased lines have also been calculated. Again, the assumptions and approach are broadly in line with the ICASA 2018 model. However, the core transmission leased lines have been assumed to be 32 kilometres 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. The number of links and total length of leased lines do not vary by scenario.

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

## Tab 5 Cost Results

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.

## Economic depreciation tabs

The following updates / corrections were made:

* + - 1. The number of carriers and transceivers has been deleted from the macrocell, microcell and in-building solution base tabs since stakeholders broke up costs very differently and the costs of an hypothetical efficient operator were applied in the model.
			2. Unused cells were removed from various tabs.
			3. The economic depreciation calculation now takes into account price trends.
			4. The costs of backup power have been added to the base cell tabs.

## Additional tabs, notes, and considerations

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

The model applies asset demand that has been smoothed over time considering the following factors:

* + - 1. Network assets are removed only after the asset has been fully depreciated;
			2. Network assets are replaced according to network demand over time.

In respect of general updates:

* + - 1. Several unused formula names were removed.
			2. Network assets are now replaced one year prior to when replaced in v3.

#### Spectrum costs

A stakeholder commented that reduction in the value of radio frequency spectrum avoided without inbound calls ought to be taken into account in the cost model. However, it would be unreasonable to include costs of avoided spectrum in South Africa, since:

* + - 1. There are substantial spectrum constraints as evidenced by the value yielded in ICASA’s recent spectrum auction, and there are no examples of licensees surrendering IMT spectrum for any purpose, in at least the 700MHz-3.6GHz spectrum bands. Rather, the opposite. Licensees have avoided in-band migrations in the 900MHz to avoid giving up even 1MHz of spectrum, the deadline for which was 31 March 2020, and which had not been achieved by December 2022.[[13]](#footnote-14) It is thus difficult to see how spectrum holdings would decline in the event there was no incoming voice.
			2. Moreover, spectrum investments in the latter IMT bands are made to accommodate growing demand for data services, and have very little, if anything, to do with voice. The value of existing holdings of radio frequency spectrum and future acquisitions is thus unlikely to vary materially with and without inbound calls.
			3. Furthermore, the value of net interconnection revenues to the mobile operators accounts for a very small (less than 0.5%) proportion of revenues for the mobile operators, as set out in the ICASA’s decision on the methodology for setting termination rates. The link between the value of radio frequency spectrum and the absence of inbound calls is thus negligible.

It is thus highly unlikely that any spectrum costs in the above IMT bands would be avoided in the absence of inbound calls. The costs of annual IMT spectrum fees and spectrum purchased at auctions are thus excluded from the model. This was also the approach in ICASA’s 2018 model when computing pure LRIC, which the 2018 model estimated by deducting joint and common costs from LRAIC costs when computing pure LRIC.

The costs of avoided microwave spectrum used for backhaul purposes is included in the model.

# Calibration tabs

Calibration tabs are designed to provide network element unit counts, operating expenditure and capital expenditure.

The purpose of the top-down information gathering process was to calibrate the bottom-up models. A range of TD information has been provided, and used to compare with the outcomes of the BU model.

#### Stakeholder comments

A stakeholder commented that asset counts by asset be provided over time, and the present value of capex and opex ought to be calculated. This is now provided in the calibration tabs. Asset counts by asset for many assets were already provided in version 3. This has now been provided for all assets.

A stakeholder also commented that a LRAIC model would assist the Authority to assess whether all costs have been taken into account in the modelling process. However, Version 4 of the model includes present values of mobile network investments which correspond to top down information provided by stakeholders, and so a separate LRAIC model is not needed.

# Fixed line bottom up and top down networks

The bottom-up fixed line model broadly follows 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.

In respect of the individual tabs:

* + - 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.
			2. The “2 Dimensioning” 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).
			3. The “3 Network Demand” tab contains the number of network elements to be used as inputs in the capital and operating cost calculations of the model.
			4. The “4 Cost – Capital” tab calculates the total capital expenditure of the core network between the years 2018-2037.
			5. The “5 Cost – Opex” tab calculates the total operating expenditure of the core network between the years 2018-2037.
			6. A summary of the model results is presented in the termination costing tab. Discounted values of Capex and Opex are brought into a table in this tab to determine the pure LRIC termination cost. The present value of revenue recovery is compared to the present value of costs to ensure that revenues are recovered. The capex tariff and opex tariff amounts that are combined to produce the pure LRIC termination rate. This is done by a series of price trends being applied to capex and opex figures respectively and considering the volumes applicable to each of these categories, capex and opex.
			7. The Asset – HCA tab within the calibration tab section contains the historical and book value of assets purchased in each year between 2018–2037.
			8. The Revenues, costs tab within the calibration tab section computes the revenue outcomes from the tariffs and tariff profile.
			9. Volume projections tab takes data from the ICT Sector Report tab, and the ITU data tab and State of the ICT Sector Report tab is populated with data from the State of the ICT Sector Report 2021. The ITU tab is populated with data from the ITU Datahub.
			10. The “Core Costs” tab calculates the total capital expenditure that has been trended according to a specified capital expenditure price trend and price index. This tab does the same calculations to determine a total operating expenditure that has been trended according to an inflation trend and an operating expenditure price index.
			11. In the core costs tab, submissions from stakeholders were compared against other models, and the best estimate of the two have been used in version 4 of the model. The value of OPEX as a percentage of CAPEX has been updated from the previous version as per a stakeholder’s submission.
			12. The “Financial inputs” tab provides information on various elements that are used throughout the model, such as exchange rates, weighted average cost of capital indexes, inflation rates over time, etc.
			13. The “Erlang B” tab from version 3 of the model has been deleted as it is no longer in use.

# 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 |

1. Government Gazette No. 48660. Page 429. Available [https://www.icasa.org.za/legislation-and-regulations/call-termination-rate-review-notice](http://). [↑](#footnote-ref-2)
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](http://). [↑](#footnote-ref-3)
3. See: [https://www.gsma.com/mobilefordevelopment/resources/the-setting-of-mobile-termination-rates-best-practice-in-cost-modelling/](http://) [↑](#footnote-ref-4)
4. See: [https://www.comreg.ie/media/dlm\_uploads/2019/05/ComReg-1948b.pdf](http://) [↑](#footnote-ref-5)
5. See, for example, [https://www.ofcom.org.uk/consultations-and-statements/category-2/2021-26-wholesale-voice-markets-review](http://) [↑](#footnote-ref-6)
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](http://) [↑](#footnote-ref-7)
7. See ICASA, 2021, ‘5G ANNUAL REPORT - 2021’, available at: [https://www.icasa.org.za/uploads/files/ICASA-2021-5G-Annual-Report.pdf](http://) [↑](#footnote-ref-8)
8. See: [https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009H0396](http://) [↑](#footnote-ref-9)
9. One sub-place (Kwareyathlose SP) was removed as it did not have an area figure. [↑](#footnote-ref-10)
10. See: [https://blogs.worldbank.org/sustainablecities/how-do-we-define-cities-towns-and-rural-areas](http://) [↑](#footnote-ref-11)
11. See: [https://www.datafirst.uct.ac.za/dataportal/index.php/catalog/517/get\_microdata](http://) [↑](#footnote-ref-12)
12. 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. [↑](#footnote-ref-13)
13. See: Government Gazette 47788, 20 December 2022, available at: [https://www.icasa.org.za/uploads/files/Radio-Frequency-Spectrum-Assignment-Plan-for-the-frequency-band-880-MHz-to-915-MHz-and-925-MHz-to-960-MHz.pdf](http://) [↑](#footnote-ref-14)