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

Version 2

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NON-CONFIDENTIAL

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Table of Contents

1 Introduction 3
1.1 Review of pro-competitive conditions 3
1.2 Stakeholder workshop, modelling guide, shell models 4
1.3 Decision on methodology 4
1.4 Top-down information collection process 5
1.5 Structure of this document 5
2 Economic depreciation and WACC 6
2.1 Economic depreciation 6
2.2 Weighted average costs of capital 7
3 Bottom up mobile network 9
3.1 Overall approach 9
3.2 Summary tab 12
3.3 Tab 1 Volumes 13
3.4 Tab 2a Network parameters 14
3.5 Tab 2b Routing factors 16
3.6 Tab 3 Volumes for network demand (3a) and output (3b) – Mbps, Erlang 17
3.7 Tab 4a Network– sites, RAN 18
3.8 Tab 4b Network – BSC, RNC, backhaul 25
3.9 Tab 4c Network – core, transmission 26
3.10 Tab 5 Cost Results 27
3.11 Economic depreciation tabs 27
3.12 Additional tabs, notes and considerations 27
4 Top-down mobile model 29
5 Fixed line bottom up and top down networks 29
6 Appendix A - Acronyms 30

1 Introduction

1.1 Review of pro-competitive conditions

1.1.1 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.

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 Top-down information collection process

1.4.1 Stakeholders were invited to submit information on TD models by 6 October 2023, in order to provide calibration information for the BU models.

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

1.4.2.1 Telkom on 21 September 2023,

1.4.2.2 MTN on 10 October 2023,

1.4.2.3 Cell C on 12 October 2023, and

1.4.2.4 Vodacom on 13 October 2023.

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

1.5 Structure of this document

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

1.5.2 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 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], 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 Ofcom[5].

2.1.2 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. Stakeholders are encouraged to comment on the time period for analysis, and the current approach in excluding terminal volumes.

[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

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

2.1.3 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.

2.1.4 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.

2.1.5 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.

2.1.6 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. Stakeholders are encouraged to comment on this issue.

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 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:

[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

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:

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

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)

$Em - rf$ is the market risk premium (the premium over risk-free returns

2.2.3 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.

2.2.4 The re-calculated WACC is 21.18% in 2023. Stakeholders are encouraged to comment on all the parameters and assumptions.

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

Major inputs	Assumptions	Source
Risk-free rate (10-year government bond)	2018-2022: 8.3% - 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 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 3 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:

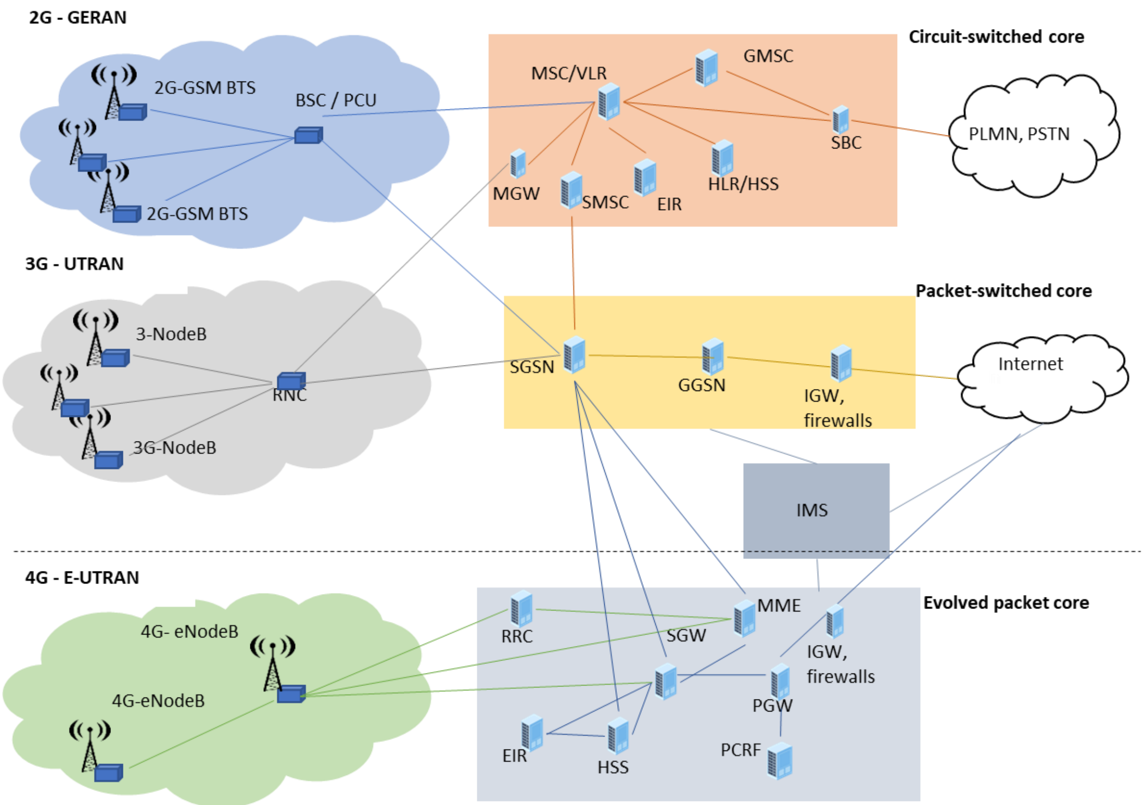
3.1.3.1 The fact that only two mobile operators have close to full-coverage networks,

3.1.3.2 Remaining MNOs have varying levels of network coverage and typically rely to a substantial extent on network sharing.

3.1.4 Stakeholders are encouraged to comment on these aspects of the model.

3.1.5 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



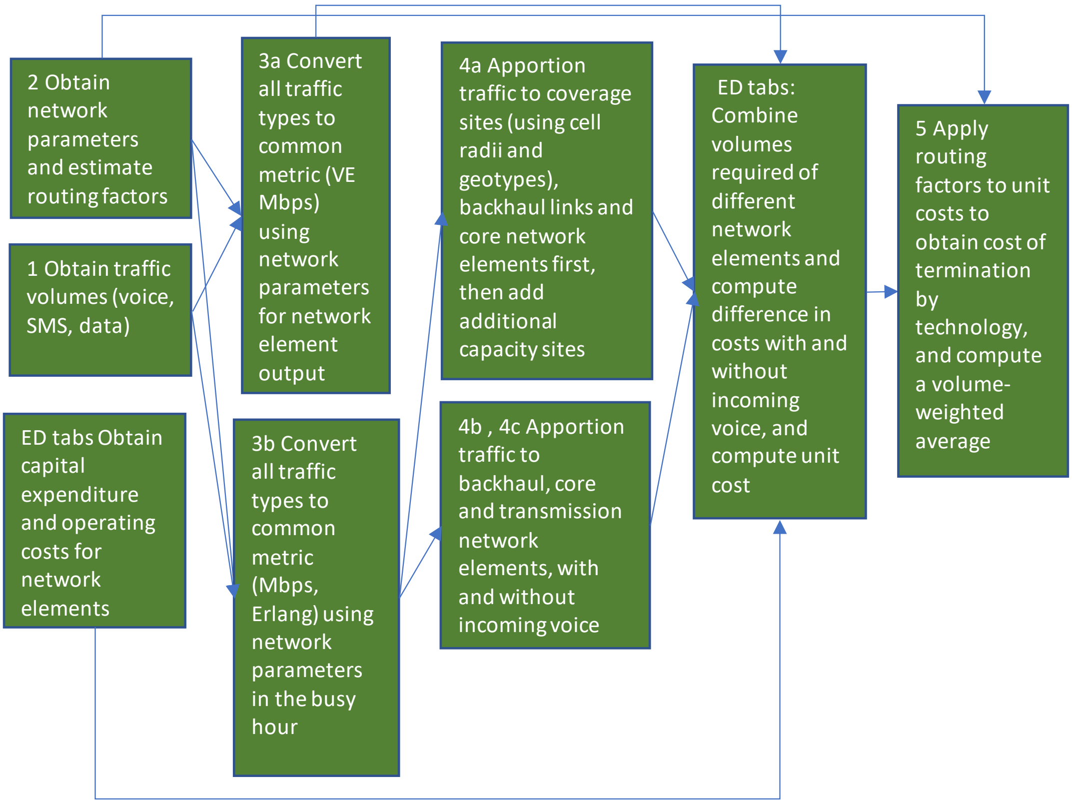
Sources: Acacia analysis adapted from: https://telecominfraproject.com/naas-playbook-post-launch/ and Haryadi, S. (2018). The Concept of Telecommunication Network Performance and Quality of Service., available at: https://osf.io/mukqb/

3.1.6 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.

3.1.7 Stakeholders commented that the level of granularity apparent in version 2.2 of the model, while significantly expanded including by using inputs from the ICASA 2018 model, still does not capture all of the details needed to assess the costs avoided with no incoming voice in South Africa. This is because ICASA's 2018 model was intended to model LRAIC+ while the present model estimates pure LRIC. This comment has been taken into account in v3 of the model, which provides for additional granularity, including in permitting the costs of equipment to vary not only on average (such as by sector) but also by the number of transceivers and carriers, not included in the ICASA 2018 model. Stakeholders are encouraged to provide input costs, forecasts, and dimensioning assumptions for these new parameters, since the data are not available from the ICASA 2018 model. Stakeholders are also encouraged to comment on how the ICASA 2018 model parameters might change with the incorporation of additional equipment types. For instance, costs for carriers and transceivers might replace costs for spectrum bands.

3.1.8 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



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 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.) and reduced total spectrum availability to account for 5G use, which falls outside of the model. In order to calculate available spectrum:

3.2.2.1 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, and excluding the 2300MHz and 2600MHz band pre-2024.

3.2.2.2 Second, total available spectrum in each band is multiplied by the market share, and rounded up. Spectrum is then apportioned to technologies in tab 2a, again rounding up where needed. 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, including actual TDD assignments.

3.2.3 The summary tab no longer includes a scorched node allowance following a stakeholder recommendation, and a site rental model scenario has also been added.

3.2.4 A stakeholder commented about modelling the 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] In this context, a question arises as to whether sites, backhaul or transmission capacity that vary with incoming voice in the absence of 5G will vary as 5G is rolled out in South Africa, since MNOs are likely to expand site density and related backhaul and core transmission capacity whether there is incoming voice or not. In other words, 2G, 3G or 4G sites that might not have been required in the absence of incoming voice are likely to continue to be required for 5G. Stakeholders are encouraged to comment on this issue and the impact on pure LRIC termination rates.

3.2.5 Stakeholders may comment further on all issues, including in respect of network coverage assumptions and the extent of network sharing, 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

[7] See ICASA, 2021, ‘5G ANNUAL REPORT - 2021’, available at: https://www.icasa.org.za/uploads/files/ICASA-2021-5G-Annual-Report.pdf

2018 model, it has been excluded from the current model as it is not a widely used service in South Africa.

3.3.2 In respect of updates to the model:

3.3.2.1 The CAGR formulas in v2.2 have been corrected in v3.

3.3.2.2 Voice and SMS volumes from the State of the ICT Sector Report were used for the 2018 to 2022 period.

3.3.2.3 Data and voice traffic splits between the 4 geotypes are now based on stakeholder submissions on aggregated site volumes in each location. SMS traffic split follows that of voice traffic. This provides for a more balanced traffic split between geotypes.

3.3.2.4 Volumes are assumed to be static beyond 2031, following stakeholder submissions that previous models assume static volumes after a reasonable forecast period.

3.4 Tab 2a Network parameters

3.4.1 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).

3.4.2 The following corrections / updates were made in v3:

3.4.2.1 There were missing formulae in v2.2 in number of carriers / channels per sector for rural 4G in the 2100MHz band prior to 2024, which has now been corrected in v3.

3.4.2.2 The spectrum portfolios were adjusted to ensure that a reasonable number of sites are computed in v3.

3.4.2.3 One stakeholder questioned the purpose of the scorched node allowance is. The purpose of this was to allow for some inefficiencies in network design, resulting in lower cell capacity and thus a greater number of cells. This is a conservative assumption and results in a higher termination rate. This allowance has been removed following a stakeholder recommendation, in the interests of balancing the need for transparency and minimal complexity with having a model that has sufficient granularity.

3.4.2.4 The spectrum re-use factor for 2G was changed to 12 in v3 following a stakeholder comment and considering the fact that Ofcom 2021 used this factor.

3.4.2.5 The bitrate for 4G voice was changed to 12.65kbps, following the approach in the Ofcom 2021 model.

3.4.2.6 Stakeholders submitted information suggesting that a far greater proportion of sites are shared than was assumed in the ICASA 2018 model, and so the split between shared and non-shared has been changed significantly.

3.4.2.7 The asset life of core network equipment (6 years for all elements except 5 years for SMSC), core transmission leased lines (10 years), backhaul leased and microwave lines (11 years), and transmission leased lines (11 years) were incorporated in the model based on a stakeholder submission.

3.4.2.8 A stakeholder indicated that the model misses as many as 25 core network equipment items. With the exception of three items, the additional core network items did not form part of the 2018 ICASA model, the exceptions being the Wholesale Billing System, Network Management System, and IMS/VoLTE. However, both the Network Management System and IMS/VoLTE do not vary with incoming voice in the ICASA 2018 model.

3.4.2.9 Just 4 of the 25 additional core network items recommended by the stakeholder were included in the Ofcom 2021 model. They are the Network Management System and three IMS network items namely, Call Server Hardware, SBC, and Telephony Application Server. Of these four core network items, only the Call Server Hardware varies with incoming voice in the Ofcom 2021 model.

3.4.2.10 Based on the ICASA 2018 and Ofcom 2021 models, the model now includes a Wholesale Billing System and Call Server Hardware. The remaining additional core network items were not incorporated in this model but may be incorporated in future if there are compelling reasons for this. The Wholesale Billing System parameters are from the ICASA 2018 model while the Call Server Hardware parameters are from the Ofcom 2021 model and stakeholder submissions. With the additional core network items, the core network comprises 4% of voice terminational incremental costs, a significant increase from 0.07%, which a stakeholder had commented was relatively low.

3.4.3 Comments that were considered but that did not result in changes were as follows:

3.4.3.1 A stakeholder commented about the routing factor used for media gateway traffic in the ICASA 2018 model was almost 2, whereas in the currently model it is 0.96. Since interconnection traffic only flows through one media gateway, it does not make sense to use a factor of 2. While the mobile operators tend to deploy a greater number of media gateways than implied by the v3 of the model, this is because of the commercial imperative to hand over off-net traffic to other operators as close as possible to the calling party (i.e. stakeholders have more media gateways than implied by traffic due to geographic deployment of points of interconnection). Stakeholders are nonetheless encouraged to comment on this issue, and indeed on all routing factors applied in the model.

3.4.3.2 In addition, a stakeholder comment suggested that additional variation in the busy hour be modelled. Again, stakeholders are encouraged to comment on this, and provide input parameters for the model if they consider this to have a significant impact.

3.5 Tab 2b Routing factors

3.5.1 This tab converts traffic into a common unit, megabits per second, and routes traffic through appropriate network element groups. For instance, incoming call minute volumes have a basic routing factor of 0.96 since 4% of incoming voice calls go to voicemail. On-net calls have a basic routing factor of 1.96 since the call will make use of almost double the network resources of an incoming call (accounting for the fact that 4% of calls are routed to voicemail).

3.5.2 This process involves several steps:

3.5.2.1 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).

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

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

3.5.3 The routing table was corrected as follows:

3.5.3.1 To ensure that the data downlift for voice services only applied in the RAN.

3.5.3.2 The final adjustment table that captured whether costs vary with incoming traffic or not was removed, as was the resulting table below it.

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).

3.6.2 Updates/corrections in v3 include:

3.6.2.1 There were several cell cross-referencing errors in version 2.2 of the BU mobile model, which have now been corrected and updated in V2.

3.6.2.2 The bitrate for 4G core voice services has been amended to the 2G voice RAN bitrate rather than the previous 64kbps.

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).

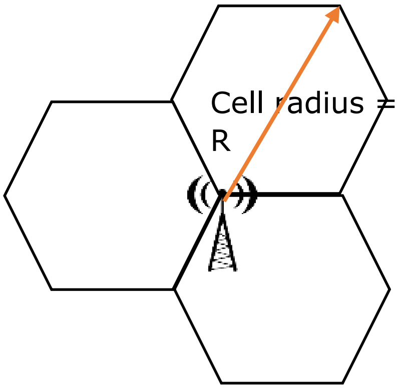
Coverage network

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.

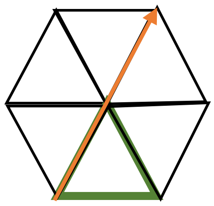
3.7.3 The network is dimensioned based on cell radii and a standard model of cell coverage, assuming a mobile site that has three sectors. In order to calculate site coverage, a hexagon shape for a cell sector is assumed, and this is divided into 6 triangles (described on Figure 3). There are 3 sectors 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

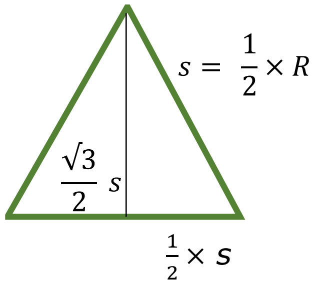
Step 1: Assume a 3-sector cell with cell radius R



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:[8]

"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."

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

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

attributed to the wholesale call termination increment. This is because coverage networks would be required for all three technologies regardless of whether inbound calls were available or not.

3.7.6 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 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

3.7.7 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] within South Africa sorted by population density, and add up the geographic area, by geotype.

3.7.8 Stakeholders suggested considering the Authority's previous 2018 geotypes. In addition, the World Bank definition of three degrees of urbanisation were also considered:[10]

"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)."

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

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

3.7.9 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. 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).

3.7.10 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] were overlaid in R, with square kilometres calculated in R and the population densities calculated within the excel cost model.

3.7.11 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

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

from Statssa, to calculate the small area layer populations for 2020 (See Equation 1).

3.7.12 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.

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

Equation 1: Estimating the 2020 small area layer population[12]

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

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%

3.7.14 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. Cell radii assumptions from stakeholders were used, though these give rise to an

[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.

unusually low number of coverage sites in South Africa, and stakeholders are thus encouraged to comment on this issue.

RAN dimensioning

3.7.15 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 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.

3.7.16 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.

3.7.17 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.

3.7.18 The following corrections and updates to version 2.2 of the model were made to RAN dimensioning in version 3:

3.7.18.1 In respect of spectrum band calculations, the number of cells calculation was changed from the maximum of capacity and coverage sites to the sum of capacity and coverage sites.

3.7.18.2 Carriers and channels per sector were rounded up to the nearest integer.

3.7.18.3 2G transceivers per sector were rounded up to the nearest integer.

3.7.18.4 A non-homogeneity factor for 2G was added to the model based on the Ofcom 2021 model.

3.7.18.5 Only one 2G transceiver, 3G spectrum channel, and 4G spectrum channels, were used to compute capacity from coverage sites in the model, rather than the total number of transceivers and channels implied by spectrum assignments.

3.7.18.6 Cell breathing was removed from the calculation of 3G coverage sites.

3.7.18.7 3G sector capacity was adjusted for maximum utilisation.

3.7.18.8 Additional 4G macrocell and rooftop sites: computation corrected to link to sites and not sectors.

3.7.18.9 Maximum 4G bitrate per geotype and site type calculation corrected to link to carriers in different geotypes.

3.7.18.10 4G carrier capacity reduced to reflect ICASA 2018 model assumption.

3.7.18.11 Calculation of additional 4G sites needed for capacity: cells references now corrected for in-building solutions, microcells and lampposts/billboards.

3.7.18.12 Calculation of cell types: Microcells now mapped to lampposts / billboards.

3.7.19 Stakeholder proposals that were not implemented are as follows:

3.7.19.1 A stakeholder commented that v2.2 of the model only implemented a non-homogeneity factor for 3G services, and that one needs to be implemented for 2G and 4G. A non-homogeneity factor has been implemented in v3 of the model for 2G services as explained above. A non-homogeneity factor has been implemented for 4G services in v2.2, taking into account the ratio of peak to cell edge speeds, following the approach in the Ofcom 2021 model. Stakeholders are encouraged to further comment on this.

3.7.19.2 In addition, there was a comment to the effect that using 1800MHz for the 4G coverage network resulted in an unusual investment profile. This was the approach adopted by ICASA in 2018 and Ofcom 2021 for various geotypes, and in the absence of comments as to what spectrum to use for the 4G coverage network, this remains in v3 in the model.

3.7.19.3 A stakeholder commented that ICASA ought to model the impact of reduced traffic volumes arising from no inbound calls on each and every site, and model the impact on network resources for each site, rather than assessing the impact within geotypes. However, there is no precedent for this in any of the pure LRIC models reviewed, and so it is not clear that this would impact on the model outcome, and it may result in unnecessary complexity. Stakeholders are nonetheless encouraged to comment on such a simulation at the site level.

3.7.20 Stakeholders are encouraged to comment on all of the issues discussed above.

<u>Economic life of assets</u>

3.7.21 Active equipment on passive sites depreciate over 8 years, while passive sites depreciate over 21 years.

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. 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 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.

3.8.3 Revisions in v3 of the mode include:

3.8.3.1 An additional 2Mbps backhaul link has been added.

3.8.3.2 The calculation of number of links has been computed based on utilisation.

3.8.3.3 The number of BSCs is based on the number of 2G transceivers rather than the number of 2G sites, bringing it in line with the ICASA 2018 model.

3.8.4 Stakeholders also commented that:

3.8.4.1 Backhaul links should be permitted on a capex basis rather than an opex basis. Stakeholders are encouraged to provide the data needed to do so, including on (i) dimensioning assumptions (i.e. what proportion of microwave links, for instance, are built on a capex vs opex basis), (ii) unit costs, and (iii) unit cost trends.

3.8.4.2 One stakeholder noted that the sizing of aggregation transmission ignores 2G capacity requirements with dimensioning the aggregation transmission required. The dimensioning of the 500mbps leased line is based on both the 2G transmission traffic in the busy hour as well as the number of BSCs, which in turn is based on the required number of 2G transceivers or the number of 2G sites (whichever is larger).

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

3.9.2 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.

3.9.3 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.

3.11 Economic depreciation tabs

3.11.1 The following updates / corrections were made:

3.11.1.1 Macrocell_base: (i) formulae for asset demand now complete for entire rows; and (ii) references to capex asset demand corrected.

3.11.1.2 The number of carriers and transceivers has been added to the macrocell, microcell and in-building solution base tabs.

3.11.1.3 A core IMS tab has been added.

3.11.1.4 2Mbps backhaul ED tabs for microwave and leased lines have been added.

3.12 Additional tabs, notes and considerations

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

3.12.2 V3 of the model applies asset demand that has been smoothed over time considering the following factors:

3.12.2.1 Network assets are removed only after the asset has been fully depreciated;

3.12.2.2 Network assets are replaced according to network demand over time.

Spectrum costs

3.12.3 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:

3.12.3.1 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] It is thus difficult to see how spectrum holdings would decline in the event there was no incoming voice.

3.12.3.2 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.

3.12.3.3 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.

3.12.4 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

[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

deducting joint and common costs from LRAIC costs when computing pure LRIC.

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

3.12.6 Stakeholders are encouraged to comment on all of the issues raised above.

4 Top-down mobile model

4.1.1 The purpose of the top-down information gathering process is to calibrate the bottom-up models. A range of TD information has been provided. Stakeholders are encouraged to supply and further TD information on network-related capital and operating expenditure, network inventory, and the like, that can be used to compare with the outcomes of the BU model.

5 Fixed line bottom up and top down networks

5.1.1 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.

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.

5.1.3 A stakeholder commented that ICASA needs to explain what factors would be taken into account when considering whether to apply symmetric fixed and mobile termination rates. Stakeholders are encouraged to comment on what factors might be relevant, and how these should be considered in South Africa for setting mobile and fixed termination rates.

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