ANACOM AUTORIDADE NACIONAL DE COMUNICAÇÕES

# FINAL DECISION

# ON

# WHOLESALE MARKETS FOR VOICE CALL TERMINATION ON INDIVIDUAL MOBILE NETWORKS

# SPECIFICATION OF THE PRICE CONTROL OBLIGATION

**– JUNE 2018 –**

**Public Version**

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## 1. Introduction

### 1.1. Update and review of the mobile termination cost model

Under the Electronic Communications Law (ECL)[1], it is incumbent on Autoridade Nacional de Comunicações (ANACOM) to define and analyse relevant markets[2], declare companies with Significant Market Power (SMP) and determine suitable measures in respect of companies with SMP providing electronic communications networks and services[3], in compliance with principles of competition law.

Taking into account the price control obligation that falls on operators with SMP on wholesale markets for voice call termination on individual mobile networks (market 2[4]), ANACOM approved, by determination of 6 August 2015, a final decision on the specification of the price control obligation on wholesale markets for voice call termination on individual mobile networks, establishing that the price ceiling for voice call termination on mobile networks, to be applied by the three mobile operators with SMP, was 0.83 Euro cents per minute regardless of the origin of the call, on the basis of per-second billing throughout the call. In addition, the above-mentioned decision established that the price ceilings for 2016 and 2017 were 0.81 Euro cents and 0.75 Euro cents, respectively.

Given the time gap that elapsed in the meantime, and in the light of technological and market developments that took place in mobile communications in Portugal, ANACOM believes that it is appropriate to update the model so that these developments are reflected in termination rates of mobile network voice calls.

In order to render the price control obligation effective, the 2017-2019 Multi-Annual Activity Plan includes the review of Market 2 (mobile termination) in the light of the current regulatory framework.

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[1] Law No. 5/2004, of 10 February, as it stands.

[2] Article 56 of ECL.

[3] Article 18 of ECL.

[4] According to European Commission (EC) Recommendation of 9 October 2014 on relevant product and service markets within the electronic communications sector susceptible to *ex ante* regulation, in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services, available at http://eur-lex.europa.eu/legal-content/PT/TXT/?uri=uriserv:OJ.L_.2014.295.01.0079.01.POR

In this respect, ANACOM awarded the update and review of the mobile termination cost model, which is coherent and compatible with EC Recommendation[5] of 7 May 2009, on the regulatory treatment of fixed and mobile termination rates in the EU (hereinafter “EC Recommendation on termination rates”) to Analysys Mason, the company responsible for the construction of the current model.

ANACOM intends the model now made available, for which mobile operators contributed with relevant information, to support the review of the price control obligation which falls on operators with SMP in wholesale markets for voice call termination on individual mobile networks, as detailed in a separate and parallel document.

It should be noted that in the scope of the cost model update, not only concepts and parameters were analysed, and reviewed where appropriate, but also traffic estimates and the respective evolution were updated in the light of developments which were registered, in the meantime, as from the implementation and development of the original model. Given that this is an update of the cost model, a major part of concepts and assumptions used in the former model are maintained, although the use of the best available and up-to-date information (namely in terms of the definition of market evolution, penetration, traffic, forecasts of network migration and technological developments, geotypes and review of costs and capacity of network equipment) was always sought.

Following the analysis of comments from stakeholders to the draft decision (DD), ANACOM approved, by determination of 3 May 2018, the draft decisions to be notified to the European Commission, the Body of European Regulators for Electronic Communications (BEREC) and the national regulatory authorities of the other Member States of the European Union, on wholesale markets for voice call termination on individual mobile networks, covering the “definition of product markets and geographic markets, the assessment of significant market power (SMP) and the imposition, maintenance, amendment or withdrawal of regulatory obligations”, as well as the “specification of the price control obligation on this wholesale market”.

On 6.6.2018, the European Commission assessed the notified draft decisions, having submitted comments that focus on the determination of the weighted average cost of capital

[5] *Vide* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:124:0067:0074:PT:PDF

(WACC) included in the draft decision on “wholesale markets for voice call termination on individual mobile networks - Specification of the price control obligation”.

The letter of the European Commission was preceded by two requests for information, dated 17.05.2018 and 24.05.2018, as well as by the respective replies from ANACOM, sent on 22.05.2018 and 25.05.2018 respectively.

Following the issues raised by the European Commission on the calculation of the cost-of-capital, ANACOM detected a material error in the calculation of the beta parameter of the WACC formula, caused by an incorrect retrieval by consultants of leveraged beta values (considered to be unleveraged betas) from data sources used (Financial Times/Reuters). As such, ANACOM undertook to the European Commission to correct the referred error. On this occasion, given that a clear material error is at stake, ANACOM rectifies the referred error, under article 174 of the Administrative Procedure Code. This results in the establishment of an actual pre-tax WACC by 6.09% (formerly 10.48%). Given this correction, values of termination costs (and respective rates) resulting from the model decreased by around 7% compared to those presented in the draft decision.

In its assessment, the European Commission requested ANACOM to clearly indicate in its final measure the new WACC value by 6.09%, and to apply this value to all relevant cost calculations. The European Commission also requested ANACOM to clearly refer the new mobile termination rate of 0.42 Euro cents in its final measure.

**1.2. Development and implementation of a mobile termination cost model**

In the light of the price control obligation which falls on operators with SMP in wholesale markets for voice call termination on individual mobile networks, ANACOM awarded Analysys Mason Limited (hereinafter referred to as “consultant”), on 26/07/2017, the update and review of the mobile termination cost model, in the context already summarised in the preceding point. In the course of this process, the necessary information was collected from stakeholders, to ensure that the model corresponds as much as possible to the national reality, having been received three contributions with useful information for the calibration of the model.

Further to the conclusion of the model update, ANACOM launched a public consultation between 22/03/2018 and 05/03/2018, submitting also the referred draft decision to the prior hearing of stakeholders, both on the public version of the updated model and on new price ceilings for wholesale voice call termination on national mobile networks.

As such, the mobile termination cost model benefited from the analysis of the various contributions received in the meantime, leading to a more robust result, which was materialized in the "pure" LRIC cost model which supported the determination of the wholesale rate of call termination on individual mobile networks, in the scope of the price control obligation imposed on operators with SMP in Market 2, according to the EC Recommendation on termination rates, the public version of that model having been published in the Draft Decision (DD) that preceded the present decision.

Still as regards the public consultation and prior hearing previously carried out, it must be stressed that the respective report, together with ANACOM's position on comments submitted, as well as non-confidential contributions, may be consulted at ANACOM' website. It is stressed also that the prior hearing and public consultation report is deemed to be an integral part of this decision.

As referred in the prior hearing and public consultation report, on comments submitted by stakeholders, ANACOM decided together with the consultant to review the following aspects of the model: (i) increase of outdoor coverage at 800MHz from 90.0% to 95%; update of annual spectrum fee costs according to current values; (iii) update of the cell breathing value to 10%, and (iv) increase of voice traffic proportion for working days from 80.2% to 80.3%.

ANACOM intends the model now provided, for which mobile operators contributed with relevant information, to support the implementation in 2018 and following years of the price control obligation which falls on operators with SMP in wholesale markets for voice call termination on individual mobile networks.

For this purpose, ANACOM presents the "pure" Long Run Incremental Cost (LRIC) cost model, developed in collaboration with the consultant (*vide* annex I), which is deemed to be the most appropriate model for the definition of price ceilings of voice call termination on mobile networks, in the scope of the price control obligation. At the same time, the "*Mobile BU-LRIC model update - Model documentation*" (*vide* annex II) is also made available, to provide both mobile operators and stakeholders in general an adequate understanding of the various technical parameters that characterize the hypothetical efficient operator described in the model. In addition to the more technical component of the model, the consultant prepared the report "*Conceptual approach for a mobile BU-LRIC model*" (*vide* annex III) to allow an understanding of the rationale at the source of the various assumptions on which the implementation of this model is based.

To allow stakeholders to understand the main changes introduced in the model, the consultant prepared the document "*Update of the mobile LRIC model: proposal of changes"* (*vide* annex IV). It is noted that this report only records updates that have a significant impact on the calculation of termination costs, a comparison between the "updated model" and the "original model" (which corresponds to the model updated in 2014-2015) being provided, where appropriate.

## 2. Concepts and assumptions of the developed cost model

### 2.1. Characteristics of the model

Electronic communications networks developed by an operator are complex systems, which are developed over time, in an incremental way, whenever required. As such, the design of a network depends on several factors, such as, for example, demand market values, services intended to be provided, characteristics of the available technology, the demographic, geographic and orographic specificities of the area to be covered and the availability of spectrum for the provision of the service.

As such, a modelling exercise aimed at assimilating the main features of above-mentioned characteristics must necessarily involve some degree of simplification of the underlying reality, without however departing from the ultimate target to make the mobile termination cost model as representative of the national reality as possible.

In this sense, throughout this process, ANACOM, in close collaboration with the chosen consultant, was always motivated by the concern to balance benefits obtained by the increase in the degree of detail and accurateness impressed in the model against costs involved in its development and update, namely as regards the necessary collection, validation and processing of additional data and the greater complexity of the model itself. ANACOM considers that the model now updated to adjust to the current reality reflects a proper balance between development and maintenance costs of the model and the required level of detail and accurateness.

### 2.2. General description of the model

Together with the consultant, ANACOM developed in 2010 and updated in 2014 a mobile termination cost model intended to implement the EC Recommendation on termination rates, in order to regulate the price ceiling to be applied to the wholesale voice call termination on individual mobile networks. As referred earlier, given the time gap elapsed in the meantime, and in the light of technological and market developments that took place at the level of mobile communications in Portugal, it was deemed appropriate to update the cost model so that these developments were reflected on termination rates of voice calls to mobile networks, the review of which is articulated with a new analysis of the relevant market, with which this decision is intrinsically linked.

The EC Recommendation on termination rates considers that the imposition of the price control obligation by National Regulatory Authorities (NRA), as far as the wholesale voice call termination on individual mobile networks (mobile and fixed) is concerned, must be based on costs incurred by an efficient operator with the provision of that service. This efficient cost must be obtained using the long-run incremental costs (LRIC) cost model based on the “bottom-up” methodology, which considers the mobile termination service provided to third parties to be the relevant increment.

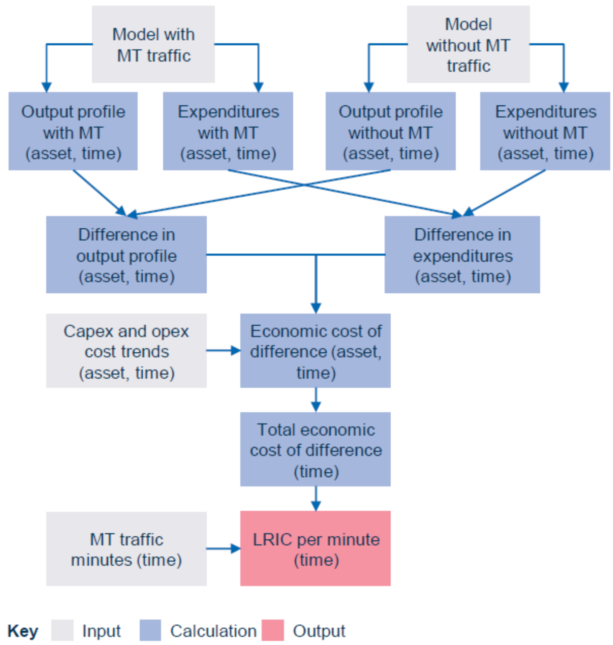
NRA as thus required to develop a “bottom-up” LRIC (BU-LRIC) cost model that enables the calculation of:

- total long-run costs of a hypothetical efficient operator that provides all services considered and
- total long-run costs of a hypothetical efficient operator that provides all services considered, except for termination of voice calls to third parties.

The difference between these two values calculated by the model thus represents the incremental (or “avoidable” cost) associated to the mobile termination service provision, which, divided by the number of termination minutes, results in the unit cost value of providing that service.

The model (*vide* Figure 1) generally calculates the costs of an efficient operator in Portugal, modelling the network that would be required to supply the whole of services traditionally provided by market operators.

**Figure 1 – General description of how the model works**



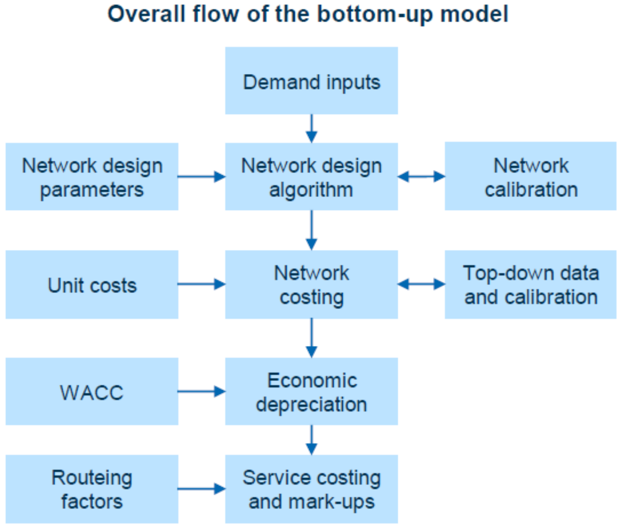

*Source: "Model documentation" drawn up by Analysys Mason*

The model subsequently calculates the costs borne by an efficient operator, taking into consideration traffic of the whole of services provided by the efficient operator, except for the mobile termination service provided to third parties.

The difference between costs determined by the model for the two described scenarios, taking into account, in particular, economic depreciation, estimated evolution of the mobile termination traffic, estimated evolution of the rate of equipment and of the cost of capital, reflects the incremental cost of the mobile termination service provided to third parties, which divided by the volume of minutes of the mobile termination traffic (*vide* Figure 1) results in the cost per minute for that service.

Figure 2 illustrates the main processes incorporated in the developed model and respective interactions, which are described in detail in annex II hereto, which also includes assumptions and concepts used in the modelling thereof.

**Figure 2 – Methodology used to develop the "bottom-up" cost model**




*Source: "Model documentation" drawn up by Analysys Mason*

The availability of macroeconomic and market data, compared to the date of the "original model", led to the update of the demand estimate for 2G, 3G and 4G services, which on its turn required the update of network parameters. In addition, all costs were recalculated, and expressed in real terms for 2017, based on estimates, validated by the consultant, of equipment costs and their evolution.

It is important to stress that, with a few exceptions, it is not possible to examine thoroughly the isolated impact of each of the technical characteristics implemented in the model, as in general these factors are not independent; on the contrary, a strong correlation exists with one or two factors. In this sense, the description of how the updated model works must be the subject of an integrated analysis.

In addition, given that the technical complexity and depth of some of the modelled key factors are likely to complicate an easy reading of this document, where a more detailed description of how the model operates is required, reference is made to technical documents prepared by the consultant, in annex to this document:

**Annex I** - LRIC cost model developed and updated in collaboration with the consultant, which is deemed to be the most appropriate model for the regulation of rates to be set in the scope of the price control obligation.

**Annex II** - the document "Mobile BU-LRIC model update - Model documentation" which includes more detailed information for an appropriate understanding of the various technical parameters used in the characterization of the modelled hypothetical efficient operator.

**Annex III** - the document "Conceptual approach for a mobile BU-LRIC model", drawn up by the consultant, which presents the rationale behind the different assumptions on which its implementation is supported.

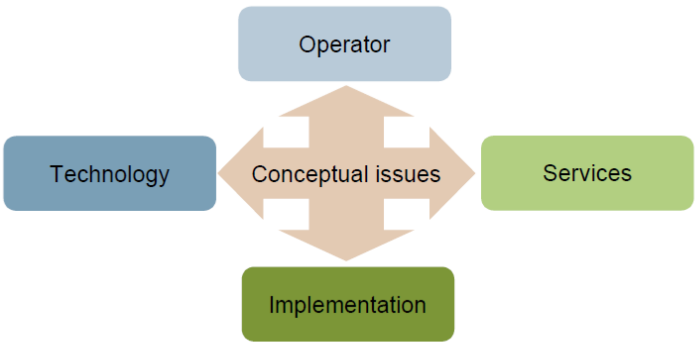
**Annex IV** - the document "Update of the mobile LRIC model: proposal of changes", drawn up by the consultant, which presents an overview of the main changes introduced in the model, and which must be read together with the "Model documentation" and the "Conceptual approach for a mobile BU-LRIC model".

### 2.3. Characteristics of the modelled operator

The different principles to be considered in the scope of the mobile termination cost model may be grouped in four different dimensions (Figure 3), which are related to:

- Operator;
- Technology;
- Services provided; and,
- Implementation of the model.

**Figure 3 – Framework for classifying conceptual issues**




*Source: "Conceptual approach for a mobile BU-LRIC model", drawn up by Analysys Mason*

### 2.3.1. Operator

#### 2.3.1.1. Type of Operator

The definition of the type of operator to be considered in the scope of the mobile termination cost model is of particular importance for its subsequent development, both as regards the structure of the model and parameters to be used.

As such, when the model was developed, four options were assessed as regards the type of operator that should be considered in the mobile termination cost model to be updated, which in brief correspond to:

**Option 1 - Actual market operators**

The mobile termination cost model to be developed considers the particular characteristics of each of the mobile providers, simulating for each of them the cost of providing the service.

**Option 2 - "Average" market operator**

The mobile termination cost model considers the particular characteristics of each of the mobile providers, in order to model an operator that is representative of the average active operator, for which the cost of providing the mobile voice call termination service to third parties is calculated.

**Option 3 - Hypothetical new entrant**

The mobile termination cost model considers the entry of a hypothetical new entrant, which enters the mobile communications market, with a network architecture employing the most efficient technology available at the date of entry.

**Option 4 - Hypothetical existing operator**

The mobile termination cost model considers a hypothetical operator, that rolled out a 2G and 3G network infrastructure as from 2005/2006, based on modern and efficient network architecture, and a 4G network as from the beginning of 2012. This operator is supposed also to have started the provision of services to customers in 2006/2007.

Annex III, drawn up by the consultant, presents in greater detail the various aspects deemed to be relevant as to the type of operator represented in the developed mobile termination cost model.

The option as regards the type of operator to be modelled was broadly discussed when the original model was developed, and ANACOM finds no objective reasons why the position taken in 2012, to take **Option 4 - Hypothetical existing operator** into account, should be changed. This is in fact the option which not only promotes regulatory certainty but better corresponds to national reality. Naturally, given the technological evolution in the Portuguese market which occurred since the development of the original model, the modelled operator must be adapted to this reality, namely as regards the inclusion of the 4G network, in the 2014 update, in its network infrastructure.

ANACOM thus takes the view that **Option 4 - Hypothetical existing operator** - is the most appropriate for the definition of a regulatory tool, taking into account the update of the price control obligation in Market 2, as it involves the incremental cost of the mobile termination service provided by an efficient operator, and furthermore it is an approach which does not break from the underlying reality, given that it is not possible for an operator to immediately achieve the minimum efficient scale (*vide* section 3.1 of annex III).

**Type of operator**

ANACOM thus opts for modelling a **hypothetical existing operator (Option 4)** that rolls out its network in 2005, and starts providing mobile services to customers in 2006. This operator uses the most efficient technology available at the time of entry, i.e. a combination of 2G and 3G networks and an NGN core. The launch of a 4G network is modelled as from 2012.

This option is characterized by a network based primarily on criteria of efficiency, using actual and available technology. The hypothetical existing operator will roll out a 4G mobile communications network as from the beginning of 2012, using the spectrum bands auctioned at the end of 2011. 800 MHz is the primary LTE coverage layer, and the 2600 MHz and 1800 MHz bands are used as secondary and tertiary capacity layers, respectively. The parallel 2G, 3G and 4G networks continue in operation for the long term, and thus a full migration to 4G network is not taken into consideration.

Consequently, it is deemed that this approach reasonably represents the reality of mobile operators designated as having SMP.

#### 2.3.1.2. Modelled coverage

The construction and implementation of any communications network is always associated to a given level of investment, required to guarantee a certain geographical coverage, involving costs which are not directly related to the volume of network traffic.

The EC Recommendation on termination rates considers that an appropriate segregation of costs (fixed and variable) must be performed, separating those that are directly related to mobile termination traffic, and which are a result of the increase of traffic of this service, from other costs, a distinction being thus made between coverage costs and capacity costs.

It must thus be ensured that, for the purpose of the developed model, only costs related to traffic volumes, and more specifically those directly associated to the mobile termination service, are considered in the regulation of the price ceiling for this service.

In general, current mobile communications networks in Portugal are almost fully ubiquitous as regards 2G (GSM 900 MHz) and 3G (UMTS 2100 MHz) coverage, and present also a significant 4G coverage in population terms, the developed cost model having sought to reflect this.

Notwithstanding, good outdoor coverage does not necessarily and on its own imply good indoor coverage, mainly due to building penetration losses, which in practise frequently requires operators to make additional investment, namely: (i) the installation of equipment to compensate loss of signal inside buildings; and (ii) the installation of micro/pico cells inside buildings.

ANACOM believes that the cost model must reflect the existing level of coverage, to which all users of mobile services currently have access. As such, for a hypothetical existing operator, the ubiquitous 2G coverage responds to the market's needs and standards and is consistent with customers' expectations both at the time of launch (2005) and at the current time (2017). As far as 3G/4G coverage is concerned, 100% coverage does not seem to be realistic, even in light of the adoption of UMTS technology in the 900MHz, adopted by only one out of three MNO. As regards 3G and 4G levels of coverage, they must be consistent with current implementations and coverage commitments as established in licenses. 3G is expected to maintain its current level of exterior coverage by 96.9% of the population in the 2.1 GHz band, while 4G coverage is likely to reach 95% of the population in the 800 MHz band in 2020 and 97% around 2030.

The model output as regards the coverage network may be consulted in more detail in the mobile termination cost model provided in annex I.

**Modelled coverage**

ANACOM takes the view that, for the purpose of the mobile termination cost model, the coverage to be considered must correspond to that currently provided by mobile operators designated as having SMP, thus the model considers a near-ubiquitous 2G coverage of 99.8% of population supported primarily on the 900MHz band (coverage) and the 1800 MHz band (for the purpose of the increase in capacity), mainly in urban areas[6]. The coverage is also complemented by 3G coverage, corresponding to a current coverage by 96.9% of the population in the 2.1 GHz band. 4G coverage is expected to reach 95% of the population in the 800 MHz band in 2020 and 97% in 2030 (*vide* section 3.2 of annex III).

Indoor coverage was modelled on the basis of estimates prepared by the consultant, calibrated according to micro/pico/indoor cells, which were implemented taking into consideration the information provided by national mobile operators.

### 2.3.1.3. Minimum efficient scale

The EC Recommendation on termination rates refers in the respective Explanatory Note[7] that once a minimum market share of 20% is achieved, the increase of the market share will not entail significant economies of scale. In addition, it refers that an operator with a lower market share will be able to achieve a 20% to 25% market share, insofar as it is efficient, referring in its Explanatory Note, and quoting the European Regulators Group

[6] Corresponding to the dense urban and urban geotypes, defined in the model according to the population density.

[7] Point 5.2.3. of the Explanatory Note accompanying Recommendation 2009/369/EC (SEC (2009) 600), which quotes UK's Competition Commission.

(ERG), that a new operator requires a period of around three to four years to achieve a market share of 15% to 20%.

Although the EC Recommendation on termination rates considers that to determine the minimum efficient scale, for the purposes of the cost model intended for the regulation of the mobile termination rate, the recommended approach is to set that scale at 20% market share, such share may be adjusted, in a duly justified manner, in accordance with the national context of each country.

Given that the observation of the mobile communications market shows that the market share of an operator is gradually obtained, ANACOM took the view that a time frame in which the operator accumulates market share and acquires scale should be considered, having opted for considering for this purpose a six-year period during which the modelled operator is able to reach a 20% market share.

As regards the time horizon to obtain the minimum efficient scale, ANACOM deems that it reasonable to assume that over the time limit estimated in the cost model - six years (between 2005 and 2011), a hypothetical and efficient operator is able to achieve the minimum scale, corresponding to a 20% market share, given that no impediments of a competitive nature exist as regards the establishment of the operator.

ANACOM considers that, as the model represents a competitive market which is not limited by competition concerns, it is likely that an efficient operator, not limited in its capacity to compete with other operators, is able to grow so as to reach a 33.3% market share in the shorter or longer term, having ANACOM modelled 2017 as the deadline for this purpose (*vide* Graph 1).

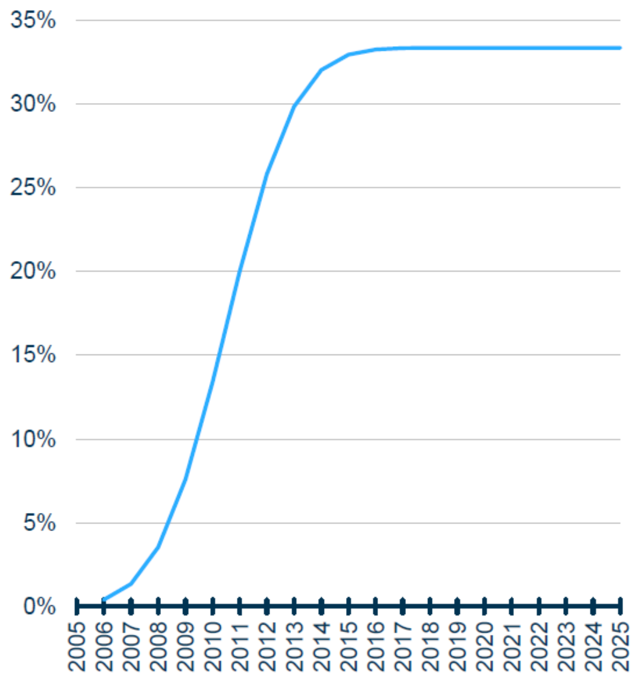
The modelling of an operator that achieves its minimum efficient scale (20%) over a period of six[8] years (2005–2011) and 33.3% market share in the long-run (calculated as 1/n, where “n” represents the number of mobile networks in Portugal, without prejudice to the existence of MVNO, which, however, hold a residual market share), ensures methodological consistency with:

- The EC Recommendation on termination rates;
- The previous version of the mobile termination model;

[8] Five years after the commercial launch (2006).

- the recently developed fixed termination model.

**Graph 1 – Subscriber market share of the hypothetical existing operator**




*Source: "Model documentation" drawn up by Analysys Mason*

The developed model thus reflects an operator that achieves a minimum efficient scale (by 20%) in 2011 (2005-2011), growing to achieve a 33.3% market share in 2017, which remains constant thereafter. This is consistent with a long-run market share in a competitive market with three[9] operators, where no obstacles or restrictions to the competition capacity or to the growth of the smaller operator exist.

**Minimum efficient scale**

ANACOM believes that, for the purpose of the mobile termination cost model, an efficient operator must be modelled, operating in a competitive market. Under these conditions, ANACOM supports that the modelling of a six-year period (from 2005 to 2011) is required to allow this operator to reach a 20% market share, calculated by reference to the overall traffic volume, further development being pursued to achieve in 2017 a 33.3% market share, this share remaining constant thereafter, for the purpose of this exercise.

[9] As referred earlier, only three operators were taken into account given that the current reality shows that MVNO hold a residual share compared to the three MNO.

An issue related to the minimum efficient scale of the hypothetical operator is the time horizon required by this operator to achieve that scale with appropriate network coverage. In this sense, a six-year time horizon was deemed appropriate for achieving a degree of network coverage similar to the one held by Portuguese mobile operators (*vide* section 3.3. of annex III).

### 2.3.2. Technology

ANACOM takes the view that the mobile termination cost model should be based, as much as possible, on the efficient technological choices available in the time horizon considered, a position which has also been adopted in the EC Recommendation on termination rates[10], reason for which technologies available in the period from 2005 to 2017 were taken into consideration.

#### 2.3.2.1. Radio network and spectrum assignment

The developed model corresponds to the modelling of a network owned by a hypothetical efficient operator using the most efficient technology available in the considered time horizon.

Current mobile networks implemented by operators are characterised by an intensive use of 2G and a gradual expansion to include 3G and 4G (that is, LTE), mainly driven by the emergence of new services associated to data traffic.

In this scope, when the model was developed, the required amount of spectrum to be assigned to the hypothetical existing operator to be modelled was taken into consideration, an amount which took account not only of the national reality, but also of the concern to ensure that it was enough to guarantee the provision of all services provided by the modelled operator, on the basis of estimates on the evolution of those services. As such, the model includes the assignment of spectrum to the hypothetical operator so as to ensure the provision of all services provided (*vide* section 4.1 of annex III).

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[10] Recital 12 of the EC Recommendation on termination rates: "*The cost model should be based on the efficient technological choices available in the time frame considered by the model, to the extent that they can be identified. Hence, a bottom-up model built today could in principle assume that the core network for fixed networks is Next-Generation-Network (NGN)-based. The bottom-up model for mobile networks should be based on a combination of 2G and 3G employed in the access part of the network, reflecting the anticipated situation, while the core part could be assumed to be NGN-based*."

**Radio network and spectrum assignment**

Given that all operators hold similar spectrum licenses in all bands, future spectrum- and coverage-related costs are assumed to be symmetrical. Taking into account the option taken when the model was developed, ANACOM believes that the mobile termination cost model must reflect the spectrum effectively allocated to the various mobile operators designated as having SMP, and for this purpose it is proposed that the hypothetical operator to be modelled operates with the following radio spectrum:

- 2x10 MHz of LTE 800 MHz spectrum;
- 2x8 MHz of GSM 900 MHz spectrum;
- 2x20 MHz of GSM and LTE 1800 MHz spectrum;
- 2x20 MHz of UMTS 2100 MHz spectrum;
- 2x20 MHz of LTE 2600 MHz spectrum.

#### 2.3.2.2. Value of spectrum

According to the EC Recommendation on termination rates, the cost incurred with the initial acquisition of spectrum is not directly associated to the termination service, and as such it should not be calculated as part of the incremental cost of the wholesale voice call termination service. As such, unless it is necessary to obtain additional spectrum intended specifically for the provision of the call termination service, these costs should not be considered as an increment to the provision of the wholesale mobile termination service.

Spectrum was assigned to mobile operators designated as having SMP through public tender and auction procedures, intended for the provision of different mobile communication services and not only the wholesale mobile termination service. As such, costs incurred in their assignment correspond to common costs (of a sunk or fixed nature), not to incremental costs of the mobile termination service.

Nevertheless, as this is an inherent and indispensable cost for the provision of the mobile electronic communications service, it must be incorporated in the model to be implemented, and several options exist as to how its value should be determined.

For this purpose, ANACOM assessed the following options:

**Option 1** - the spectrum assigned for the purpose of the operator to be considered in the mobile termination cost model is valued on the basis of actual amounts paid by operators designated as having SMP. Main advantages of this option include the simplicity of incorporation in the model and the high degree of correspondence to the national reality.

**Option 2** - the spectrum assigned for the purpose of the operator to be considered in the mobile termination cost model is valued on the basis of amounts likely to have been paid by an operator, if spectrum had been assigned through a different mechanism, such as an auction. The choice for this option implies an approach involving a benchmark of recent auctions that have been carried out.

**Option 3** - the spectrum assigned for the purpose of the operator to be considered in the mobile termination cost model is estimated on the basis of spectrum rates determined by other NRA, from a source other than auctions.

**Option 4** - the spectrum assigned for the purpose of the operator to be modelled is valued using a forward-looking estimate.

ANACOM maintains its position, considering that the spectrum assigned for the purpose of the mobile termination cost model should be valued according to **Option 1**, as this is simplest method to be implemented and the one that best ensures correspondence to the national reality.

**Value of spectrum**

As mentioned above, the EC Recommendation on termination rates considers that only spectrum assignment costs directly associated to the provision of the mobile termination service should contribute to determine the costs of the provision of this service. ANACOM takes the view that spectrum assigned for the purpose of the mobile termination cost model should be valued according to **Option 1**, as this is simplest method to be implemented and the one that best ensures correspondence to the national reality. However, it should be highlighted that the spectrum cost considered in the model is not relevant for the purpose of the increment used in the calculation of the cost of mobile termination of calls to third parties (vide section 4.1 of annex III).

#### 2.3.2.3. Switching network

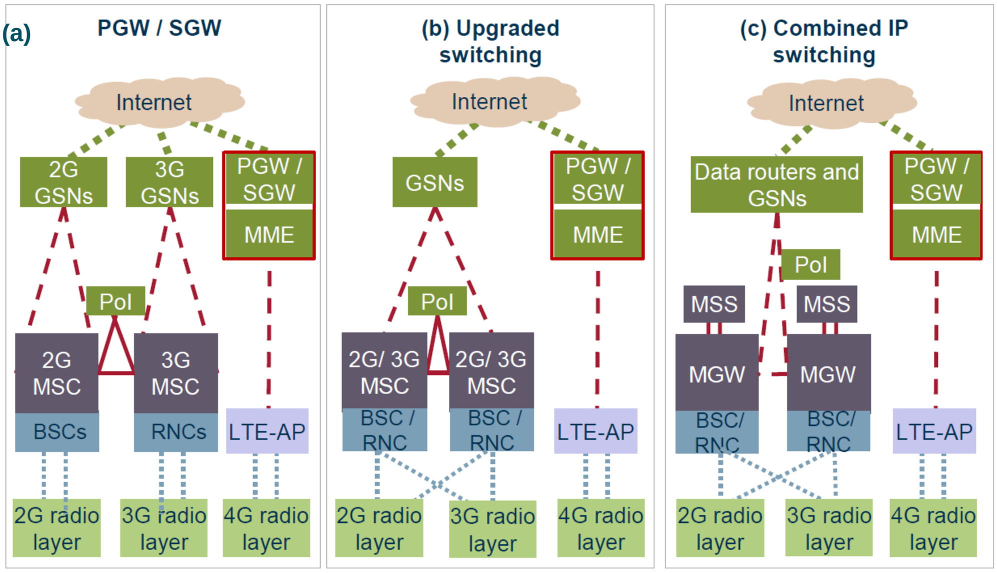
The EC Recommendation on termination rates proposes that the cost model intended for the determination of wholesale mobile termination costs incorporates a switching network of an efficient hypothetical operator, where mobile communication services are based on the most efficient technology available in the considered time horizon. As such, the main options (Figure 4) considered when modelling the switching network were:

**Option 1 -** parallel coexistence of three switching networks, each containing one or more interlinked mobile switching centres (MSC), a GPRS serving node (GGSN and SGSN) and points of interconnection (PoI) (corresponding to **Option (a)** of Figure 4);

**Option 2 -** an upgraded legacy structure with a combined transmission network, containing one or more interlinked MSC, GSN and PoI that are 2G- and 3G-compatible and a separate 4G structure (corresponding to **Option (b)** of Figure 4); and

**Option 3 -** a combined 2G+3G switching structure with a next-generation IP transmission network, linking pairs of MGW with one or more MSS, data routers and PoI, separated into circuit-switched (CS) and packet-switched (PS) layers and a separate 4G network (corresponding to **Option (c)** of Figure 4).

**Figure 4 – Switching architecture options**




*Note: In 4G networks the functionalities of the BSC/RNC are distributed between the eNodeB (i.e. 4G radio layer) and the MME (i.e. 4G core network)*

*Source: "Conceptual approach for a mobile BU-LRIC model", Analysys Mason, 2017*

In all these options, 4G was considered as an additional layer working in parallel, but separately, because it is fully based on a packet-switched (PS) network, whereas both 2G and 3G networks are mainly based on a circuit-switched (CS) architecture (HSPA is a CS–PS hybrid network).

Having analysed the various options, ANACOM considers, for the purpose of the mobile termination cost model to be developed, that **Option 1** on the switching network of the hypothetical operator to be modelled should be excluded, as its adoption would imply that the developed model incorporated a too lengthy historical legacy, where possible legacy costs and inefficiencies could be transferred to the model. It is recalled that the EC Recommendation on termination rates explicitly refers that these costs should not be taken into account in the development of cost models focused on the regulation of termination rates.

As far as **Option 2** is concerned, ANACOM takes the view that this option should also be excluded, given that the model to be developed must be supported on the most efficient technologies available in the considered time horizon, thus in principle the core network should be NGN-based, which is not the case for **Option 2**, based on more traditional, albeit optimized, switching technology.

While it is not questioned that networks maintained and exploited by national operators are characterized by some degree of technological overlap, which naturally results from the fact that these operators started their operation more than a decade ago, it should be stressed that the goal of the constructed model is to assess the costs of the wholesale call termination service provided by a hypothetical and efficient operator, using recent technology. In this light, given available options and the perspective of future evolution, ANACOM believes that it is highly probable that an operator that began the construction of its network in 2005, and who consequently had no past investments to capitalise on, would opt to implement an NGN-based switching network.

It is stressed nevertheless that the constructed model already incorporates some degree of technological overlap in fields other than the switching network, namely the simultaneous maintenance of 2G, 3G and 4G access networks, given that this overlap represents an efficient solution in the light of the characteristics of the operator to be modelled.

As such, in order to reflect a modern switching network, likely to have been implemented by a hypothetical existing and efficient operator who deployed the network in 2005, ANACOM maintains that **Option 3** is the one that best meets the proposed objectives.

In brief, the constructed model calculates - subject to capacity restrictions per class of equipment, for each of the modelled years and according to the volume of traffic to be carried - the needs of the following equipment: Base Station Controller (BSC), Radio Network Controller (RNC), Mobile Switching Centre (MSC)/Media Gateway (MGW) and LTE aggregation point (LTE-AP), which the hypothetical operator is required to operate in order to maintain its commercial operation. It must be referred that the mentioned capacity restrictions result directly or indirectly from elements supplied by national mobile operators, as illustrated in Table 1.

**Table 1 – Switching equipment capacity**

**Hypothetical efficient operator inputs**

| Item | Capacity measures | Minimum deployment | Source |
|---|---|---|---|
| BSC capacity in TRX | 2000 | 8 | Operator data |
| BSC capacity in E1 incoming ports | 300 | | Analysys Mason estimates based on operator data |
| BSC capacity in cells | 1000 | | Analysys Mason estimates based on operator data |
| PCU per BSC | 3 | | Analysys Mason estimates |
| RNC capacity in Mbit/s | 2458 | 8 | Operator data |
| RNC capacity in E1 incoming ports | 1450 | | Operator data |
| LTE-AP capacity in Mbit/s | N/A | # of RNCs | Analysys Mason estimate |
| LTE-AP capacity in E1 incoming ports | 5000 | | Analysys Mason estimate |

*Source: "Model documentation" drawn up by Analysys Mason*

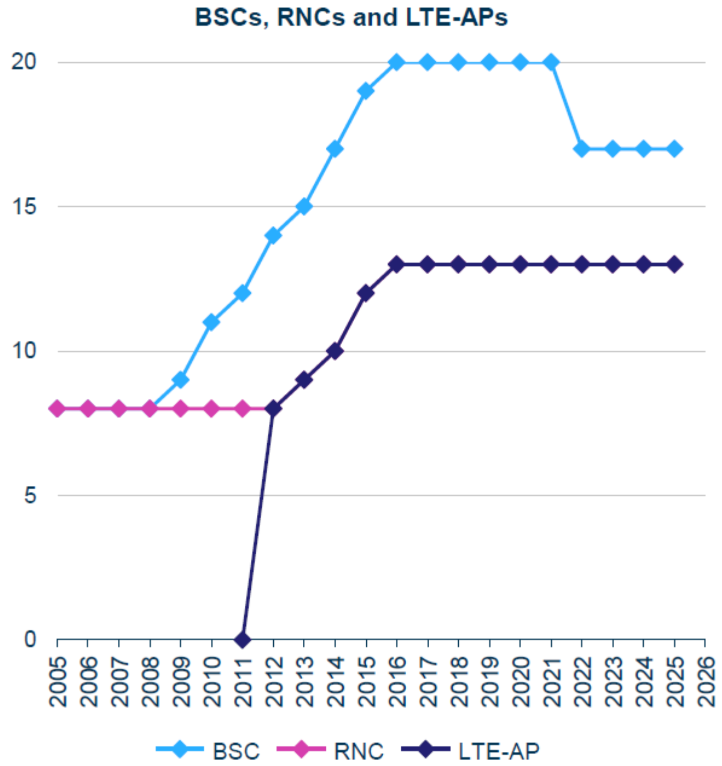
Given that all this equipment is associated to a whole set of planning and installation processes (i.e., placing the order, reception, installation, testing and activation), there is a time gap during which equipment fails to meet capacity needs of the operator, which was taken into account in the development of this model.

In this sense, the model incorporates the anticipation of activities related to the placing of the order, installation, testing and activation of the various network elements against the moment on which these elements are effectively required to ensure the proper dimensioning of the network to the underlying commercial activity.

Given that the model incorporates certain evolution trends in the chosen time horizon, the aggregated effect of which results in the gradual increase of the volume of traffic to be carried (mainly as a result of the increase of market share, of average traffic per subscriber and the number of users of mobile high speed data services), the application of algorithms that calculate the need for equipment tends to result in increasing values of installed capacity (*vide* Graph 2, Graph 3 and *Source: "Model documentation" drawn up by Analysys Mason*

Graph 4 on equipment evolution) over the lifetime of the modelled operator. As regards this dynamic, it must be recalled that, for the purpose of this exercise, all variables of the model remain constant as from 2025 (including variables concerning the amount of equipment items installed). Modelling a "stable status" for the market from 2025 onwards ensures the recovery of costs up to the end of the modelled operator's lifetime, subject to the continuous evolution of the real cost of modern equivalent assets (MEA) and of WACC. A model with a 45-year time horizon, which foresees the evolution of the Portuguese market up to 2025 and which assumes a "stable status" from that moment onwards, is deemed to be a reasonable proxy for the underlying reality, thereby reducing the unpredictability of estimates produced for the period subsequent to 2025.

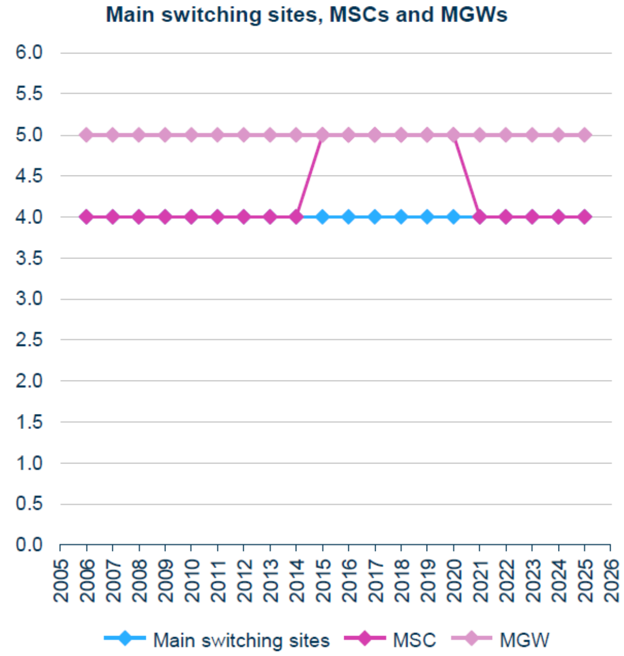
**Graph 2 – Evolution of equipment considered (BSC, RNC and LTE-AP)**




Unit: Amount of equipment items

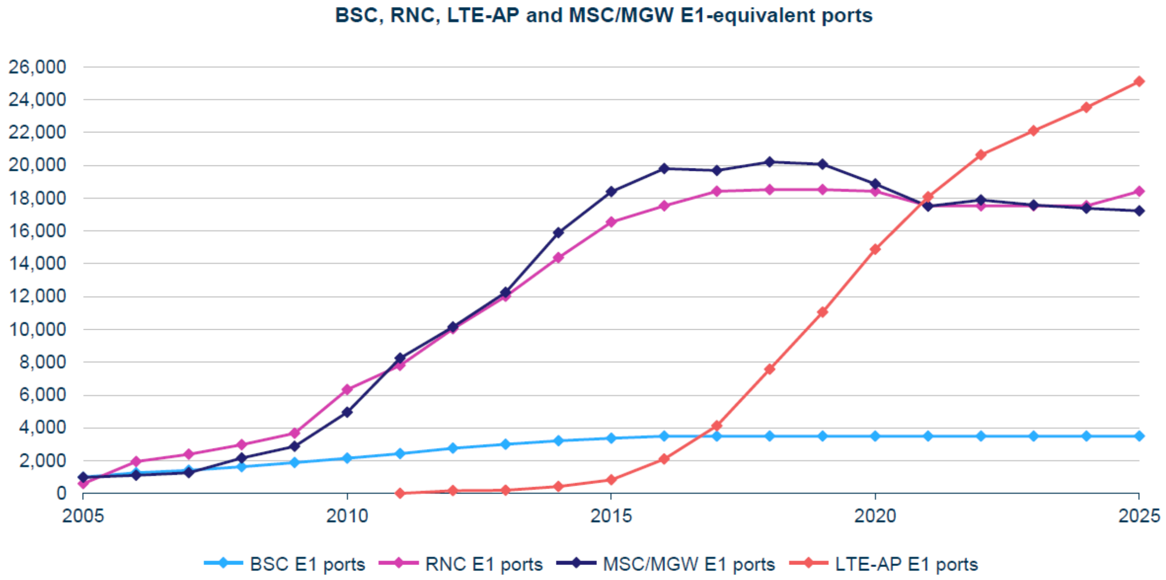
*Source: "Model documentation" drawn up by Analysys Mason*

**Graph 3 – Evolution of switching capacity**




*Source: "Model documentation" drawn up by Analysys Mason*

**Graph 4 – Evolution of switching capacity**




*Source: "Model documentation" drawn up by Analysys Mason*

Annex II, drawn up by the consultant, shows in detail the algorithms and assumptions used in the determination of equipment operated by the network of the hypothetical operator.

**Switching network to be modelled**

In the light of the above, ANACOM takes the view that the mobile termination cost model to be developed must incorporate **Option 3** (combined IP switching for voice and data traffic), as this is the option that best represents the most modern switching network, implemented by a hypothetical existing and efficient operator who deployed its network in 2005 and used the most modern technologies available in the considered time horizon (*vide* section 4.1 of section III).

The developed model dimensions the switching network in its main components over time.

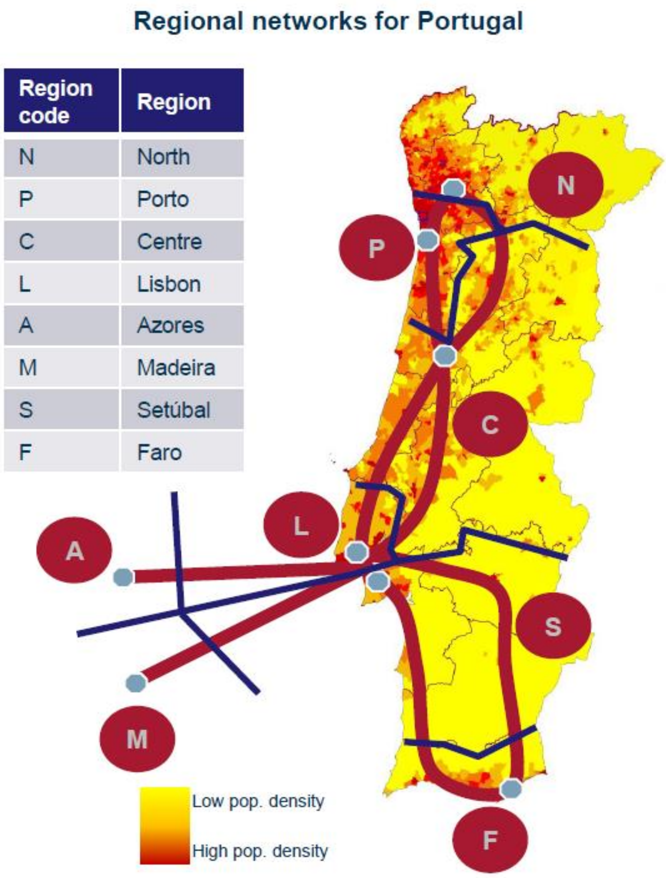
### 2.3.2.4. Transmission network

In the context of the modelled hypothetical operator, the transmission network responsible for the connection between the different network components may be subdivided in the various types of connections presented in more detail in annex III.

In brief, the developed model focuses on the dimensioning of the transmission network at three logic levels:

(i) national backbone, with a fibre ring architecture, constructed by the hypothetical operator (as opposed to the lease of infrastructures) which connects eight regional structures. It includes two submarine connections (Lisbon-Madeira and Lisbon-Azores), a total length of 1472 Km (excluding Atlantic connections) being assumed;

**Figure 5 – Structure of the modelled national backbone**




*Source: "Model documentation" drawn up by Analysys Mason*

(ii) regional backbones, constructed to support eight regions (North, Porto, Centre, Lisbon, Azores, Madeira, Setubal and Faro), on the basis of a fibre ring architecture with individual lengths between 162 Km and 1100 Km;

**Table 2 – Geographic and population dimension of modelled regional backbones**

**Regional rings and population distribution among them**

| Region | Length of regional ring (km) | Distribution of population per ring |
|---|---|---|
| Region N | 305 | 13.93% |
| Region P | 162 | 24.03% |
| Region C | 489 | 21.78% |
| Region L | 133 | 20.42% |
| Region S | 465 | 10.89% |
| Region F | 220 | 4.19% |
| Region A | 1100 | 2.41% |
| Region M | 168 | 2.36% |

*Source: "Model documentation" drawn up by Analysys Mason*

(iii) local (last-mile) access points, based on a technological combination of leased lines, microwave links or fibre. For the purpose of the model, a combination of technologies was adopted, according to information provided by national mobile operators, complemented with estimates generated by the consultant.

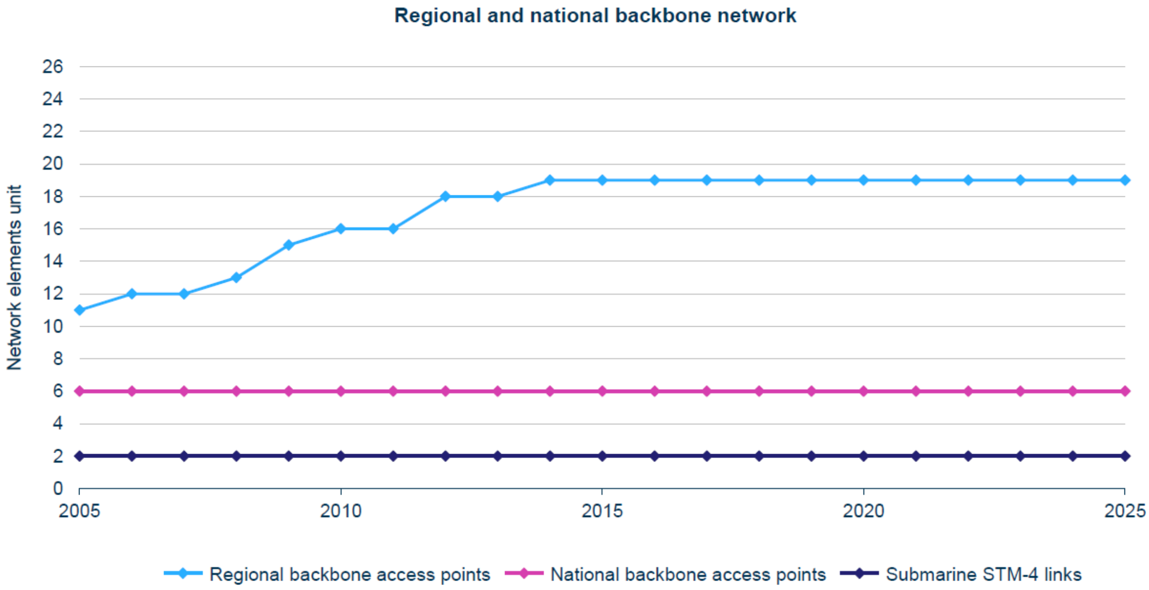
**Table 3 – Mix of transmission typologies used according to 2G / 3G and 4G technology**

| Technology | Geotype | Leased lines | Microwave | DSL | Fibre | Co-location |
|---|---|---|---|---|---|---|
| 2G | Dense urban | - | - | 10.0% | 90.0% | - |
| | Urban | - | 12.5% | 1.0% | 86.5% | - |
| | Suburban | 2.5% | 13.5% | 2.0% | 82.0% | - |
| | Rural | 2.5% | 32.5% | 2.5% | 62.5% | - |
| | Indoor | 20.0% | - | - | 80.0% | - |
| 3G | Dense urban | - | - | 10.0% | 90.0% | - |
| | Urban | 2.5% | 12.5% | 1.0% | 84.0% | - |
| | Suburban | 2.5% | 18.5% | 2.0% | 77.0% | - |
| | Rural | 2.5% | 25.0% | 2.5% | 70.0% | - |
| | Indoor | 20.0% | - | - | 80.0% | - |
| 4G | Dense urban | - | 10.0% | - | 90.0% | - |
| | Urban | 2.0% | 15.0% | - | 83.0% | 2.0% |
| | Suburban | 2.5% | 17.5% | - | 80.0% | 2.5% |
| | Rural | 5.0% | 25.0% | - | 70.0% | 5.0% |
| | Indoor | 20.0% | - | - | 80.0% | 20.0% |

*Source: "Conceptual approach for a mobile BU-LRIC model" drawn up by Analysys Mason*

The rhythm of implementation of the transmission network is gradual, so as to meet the growth of customers and of traffic to be carried. Moreover, as referred, the model considers that all variables remain constant from 2025 onwards (including variables on the amount of equipment items).

**Graph 5 – Evolution of the modelled national and regional backbone**




*Source: "Model documentation" drawn up by Analysys Mason*

It is stressed that annex II, drawn up by the consultant, shows in detail the algorithms and assumptions used in the determination of equipment operated by the network of the hypothetical operator.

**Transmission network to be modelled**

ANACOM considers that the mobile termination cost model must necessarily reflect the options taken by a hypothetical existing and efficient operator to develop a network based on current and efficient technology. These options are required to mainly include three levels (national, regional and local) along the general lines described in the preceding paragraphs. The model dimensions, every year, the equipment associated to the transmission network (*vide* section 4.1 of annex III).

The efficient operator's backhaul transmission technology was modelled, for all geotypes, on the basis of fibre complemented with microwave links and leased lines.

#### 2.3.2.5. Network topology

The modelling of a hypothetical efficient mobile communication network involves the identification of the type of equipment to be installed, as well as the respective amount and location, which in the present case must take into account the methodology laid down in the EC Recommendation on termination rates, which supports the adoption of a bottom-up methodology based on long-run incremental and forward-looking costs.

Electronic communications networks are complex systems which are developed over time by operators, in an incremental way, where their adjustment is required in view of changes in demand, and, for this reason, current networks can hardly be considered to be optimised.

The design of a network depends, among other things, on orographic specificities, the ideal location for the installation of the various items of equipment integrating a network not always being available. However, given that the model is a simplification of reality and that the mobile termination cost model is intended to represent national reality as much as possible, the various network components are quantified and qualified on the basis of optimization algorithms, which incorporate efficiency coefficients so that the best possible approximation is generated. In this regard *vide* also section 4.2 of annex III.

As regards this issue, that involves the definition of the modelled network topology, ANACOM considers that, in the light of the discussion already held when the original model was developed and the fact that the update does not entail major changes, as far as the model's conceptual principles are concerned, the **modified scorched-node approach** remains as the methodological option that best balances the need for efficiency parameters in the model and the concern not to make its practical development too complex. Moreover, this methodology allows the correspondence with the national reality to be maintained as much as possible, taking into consideration several restrictions faced by mobile operators as far as the development of their networks is concerned.

In addition, the calibration process carried out by the consultant, based on its sensitivity and experience, aims to ensure that the model generates realistic results, without prejudice to efficiency concerns (*vide* section 2.3.4.5 - Calibration of the model ).

**Network topology**

ANACOM takes the view that the **modified scorched-node approach** is the methodological option that best balances the need for efficiency parameters in the model to be developed and the concern not to make its practical development too complex. Moreover, this methodology allows the correspondence with the national reality to be maintained as much as possible, taking into consideration several restrictions faced by mobile operators as far as the development of their networks is concerned (*vide* section 4.2 of annex III).

### 2.3.2.6. Dimensioning of the network

One of the most important aspects in the dimensioning of mobile networks is the expected traffic load during "peak time". Traditionally, operators have considered as "peak time" the period with the highest level of voice traffic. The traffic volume which the network is required to carry in the period with the highest level of voice traffic will influence the dimensioning of the switching network, the network nodes and the number of radio sites.

However, the increase of mobile data over the last few years has led operators to develop and introduce HSPA and, more recently, to invest in LTE technology, in order to handle the growth of total voice traffic and especially data traffic. As such, the network of the hypothetical existing operator was modelled and dimensioned taking into account both voice traffic and data traffic (*vide* section 4.3 of annex III).

As a starting point, the model uses granularity at the level of *freguesias*, each of the granular areas being classified according to one of the considered geotypes (dense urban, urban, suburban and rural). These geotypes are defined according to the population density of each *freguesia*, consistently with the criterion shown below (*vide* Table 4).

**Table 4 – Characterization of Geotypes**

| Geotype | Population density (pop/km$^2$) |
|---|---|
| Dense urban | d > 14 000 |
| Urban | 1100 < d < 14 000 |
| Suburban | 100 < d < 1100 |
| Rural | d < 100 |

*Source: "Model documentation" drawn up by Analysys Mason*

The definition of geotypes resulted in an area and population distribution as shown in Table 5. This approach leads the dense urban geotype to be characterised by a high proportion of population while the contrary occurs for the rural geotype.

By applying the above-mentioned granularity, and as demonstrated by Table 5, the national territory is thus classified, in terms of area, as being: (i) 0.01% dense urban; (ii) 1.6% urban; (iii) 16.8% suburban and (iv) 81.6% rural. In terms of population, the country presents: (i) 1.7% in dense urban geotypes; (ii) 39.5% in urban geotypes; (iii) 40.9% in suburban geotypes and (iv) 17.9% in rural geotypes. As regards traffic generated in each of the geotypes, it is distributed unevenly among geotypes. Dense urban and urban areas are likely to have a higher proportion of traffic than population, and conversely, suburban and rural areas are most likely to have a lower proportion of traffic than population. Some of the reasons that explain why higher-density areas carry more traffic in relative terms are: i) urban areas are more prone to consume data/voice and to access technology; ii) many companies, that are large consumers of communication products, are located in these areas; iii) the fastest networks – such as HSPA and LTE – are usually deployed first in the most densely populated areas.

**Table 5 – Comparison of area, population and mobile traffic by geotype in Portugal**

**Comparison of area, population (individuals) and mobile traffic by geotype in Portugal**

| Geotype | Area | Population (2011 census) | Voice traffic | Data traffic |
|---|---|---|---|---|
| Dense urban | 0.01% | 1.7% | 4.3% | 3.4% |
| Urban | 1.6% | 39.5% | 54.4% | 49.8% |
| Suburban | 16.8% | 40.9% | 31.0% | 36.0% |
| Rural | 81.6% | 17.9% | 10.3% | 10.9% |
| **Total** | **100%** | **100%** | **100%** | **100%** |

*Source: "Model documentation" drawn up by Analysys Mason*

For each class of geotype, and for each frequency band, the model estimated the effective coverage per cell by applying the scorched-node coverage coefficient (SNOCC) (*vide* Figure 6) to theoretical cell radius (*vide* Table 6).

**Table 6 – Radio network calculations: theoretical and effective radii of cells**

**Theoretical cell radius (km)**

| Geotype | 800MHz | 900MHz | 1800MHz | 2100MHz | 2600MHz |
|---|---|---|---|---|---|
| Dense urban | 0.55 | 0.45 | 0.40 | 0.40 | 0.38 |
| Urban | 1.96 | 1.61 | 1.43 | 1.43 | 1.39 |
| Suburban | 5.42 | 4.46 | 3.95 | 3.95 | 3.84 |
| Rural | 7.59 | 6.24 | 5.53 | 5.53 | 5.44 |

**SNOCC**

| Geotype | 800MHz | 900MHz | 1800MHz | 2100MHz | 2600MHz |
|---|---|---|---|---|---|
| Dense urban | 0.475 | 0.573 | 0.579 | 0.519 | 0.585 |
| Urban | 0.518 | 0.625 | 0.631 | 0.566 | 0.638 |
| Suburban | 0.596 | 0.718 | 0.726 | 0.651 | 0.734 |
| Rural | 0.648 | 0.781 | 0.789 | 0.707 | 0.798 |

**Effective cell radius (km)**

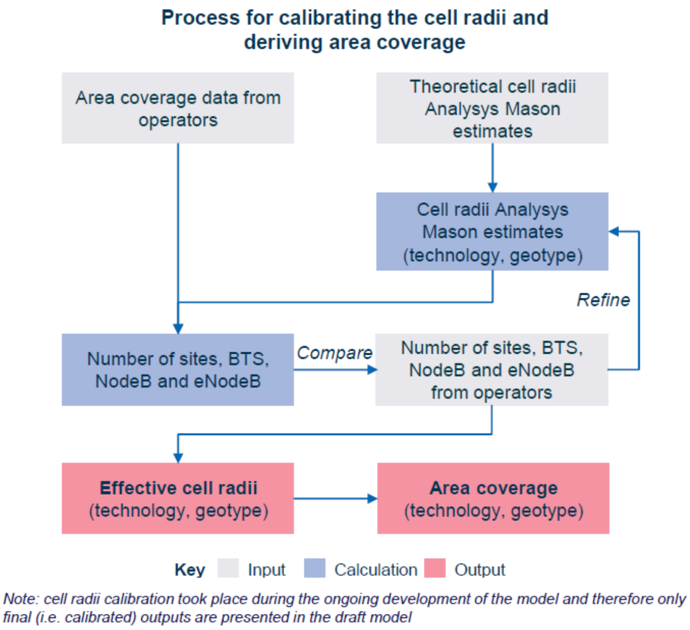
| Geotype | 800MHz | 900MHz | 1800MHz | 2100MHz | 2600MHz |
|---|---|---|---|---|---|
| Dense urban | 0.26 | 0.26 | 0.23 | 0.21 | 0.22 |
| Urban | 1.02 | 1.01 | 0.90 | 0.81 | 0.89 |
| Suburban | 3.23 | 3.21 | 2.87 | 2.57 | 2.82 |
| Rural | 4.91 | 4.88 | 4.36 | 3.91 | 4.34 |

*Source: "Model documentation" drawn up by Analysys Mason*

This estimate is based on a theoretical radius of action which could be obtained realistically, adjusted by a correction factor (SNOCC), the purpose of which is to model the fact that, for several reasons, it is not always possible to deploy a site at an optimal location (in terms of the overlap with adjacent cells) and that the propagation provided for radio signals is subject to interference from the surrounding environment, namely due to the presence of other buildings, and as a result the effective coverage of a given cell is usually lower than what could be expected theoretically. In more densely populated areas, this loss effect tends to be greater mainly because it is less likely that ideal locations for the installation of sites are available and due to a higher concentration of buildings and other infrastructures, which increase interferences at the level of signal propagation.

In order to ensure that the model maintains a reasonable correspondence to reality, results obtained by processes described above are checked against real data provided by national operators. In schematic terms, the calibration of the area effectively covered involves the steps described in Figure 6.

**Figure 6 – Modelled network calibration process**




*Source: "Model documentation" drawn up by Analysys Mason*

Having the need for cells been determined according to the technology and the geotype, on the basis of the analysis of information provided by operators, the consultant estimated the average number of sectors per site, according to the frequency band and the geotype, enabling the modelling of sites installed by the hypothetical operator.

**Table 7 – Average number of sectors per site**

| | Dense urban | Urban | Suburban | Rural | Micro/indoor |
|---|---|---|---|---|---|
| LTE 800MHz | 2.69 | 2.69 | 2.69 | 2.69 | 2.00 |
| GSM 900MHz | 2.62 | 2.62 | 2.62 | 2.62 | 2.00 |
| GSM 1800MHz | 2.62 | 2.62 | 2.62 | 2.62 | 2.00 |
| LTE 1800MHz | 2.59 | 2.59 | 2.59 | 2.59 | 2.00 |
| UMTS 2100MHz | 2.66 | 2.66 | 2.66 | 2.66 | 2.00 |
| LTE 2600MHz | 2.74 | 2.74 | 2.74 | 2.74 | 2.00 |

*Source: "Model documentation" drawn up by Analysys Mason*

In terms of practical implementation, the co-location of the different generations of mobile technology was taken into consideration, on the basis of the following drivers:

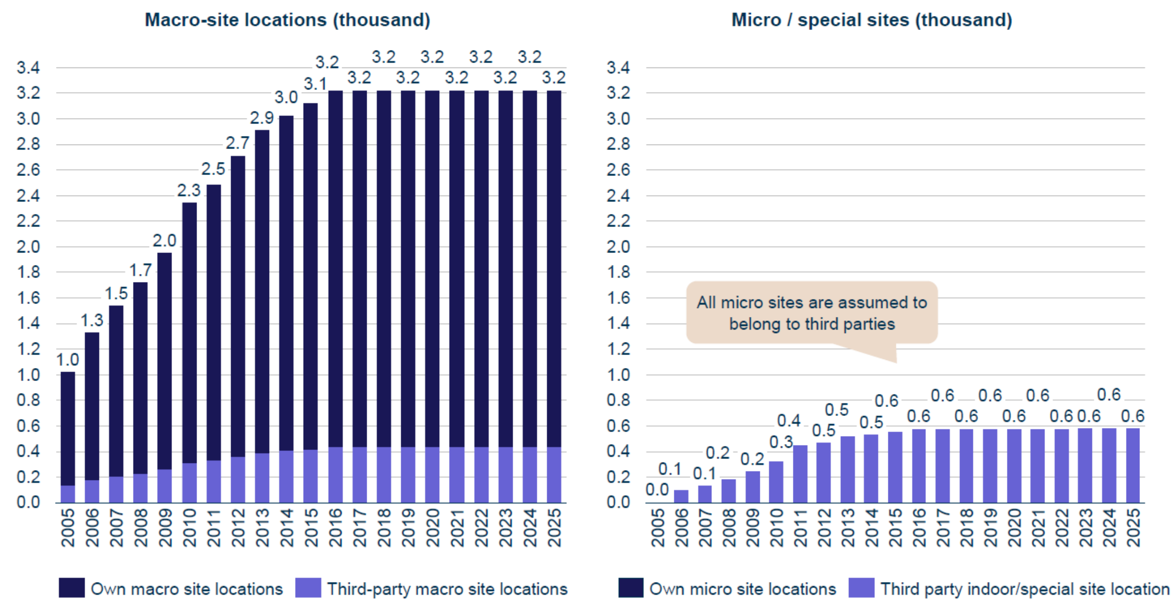
- sharing of 2G sites capable of hosting 3G sites
- sharing of 2G sites capable of hosting 4G sites

- sharing of 2G sites, without 3G, capable of hosting 4G sites
- sharing of 3G sites, without 2G, capable of hosting 4G sites

It was assumed that, as far as possible, mobile operators will reuse existing sites whenever a new technology is implemented, in order to optimise investments already incurred in. Radio sites can thus have the following technological configurations in the model: 2G, 3G, 4G, 2G + 3G, 2G + 4G, 2G + 3G + 4G and 3G + 4G.

As regards the elements required to ensure indoor coverage, on the basis of data supplied by operators, taking into account the future evolution of traffic, and maintaining the consistency between the proportion of traffic served by micro-sites/special sites[11] and real data provided by national operators, the consultant estimated and implemented the evolution of the need for micro-sites/special sites, as demonstrated in Graph 6 and Graph 7.

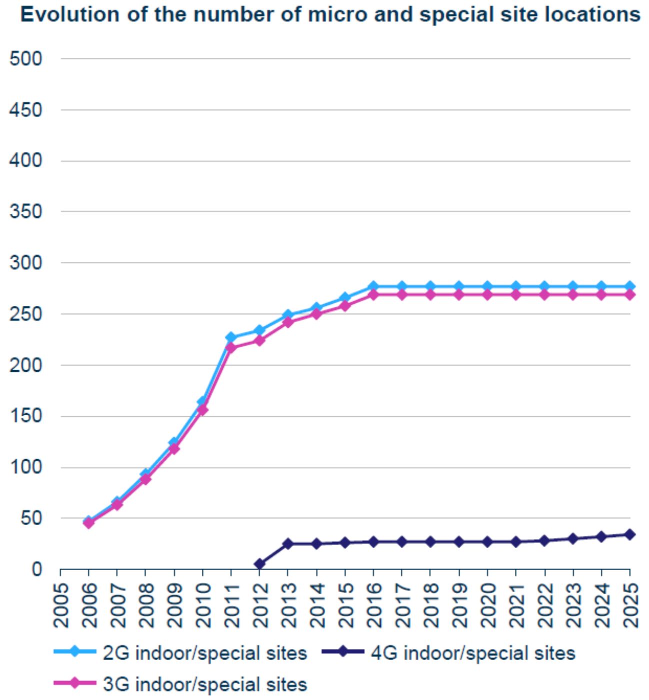
**Graph 6 – Evolution of sites and micro-sites in the modelled network**




*Source: "Model documentation" drawn up by Analysys Mason*

[11]Special sites are indoor sites intended for additional indoor coverage (also known as in-building cells). Micro-sites, also designated micro-cells, are sites placed in high traffic areas, which are used to increase the capacity of the network, without requiring the installation of macro-sites.

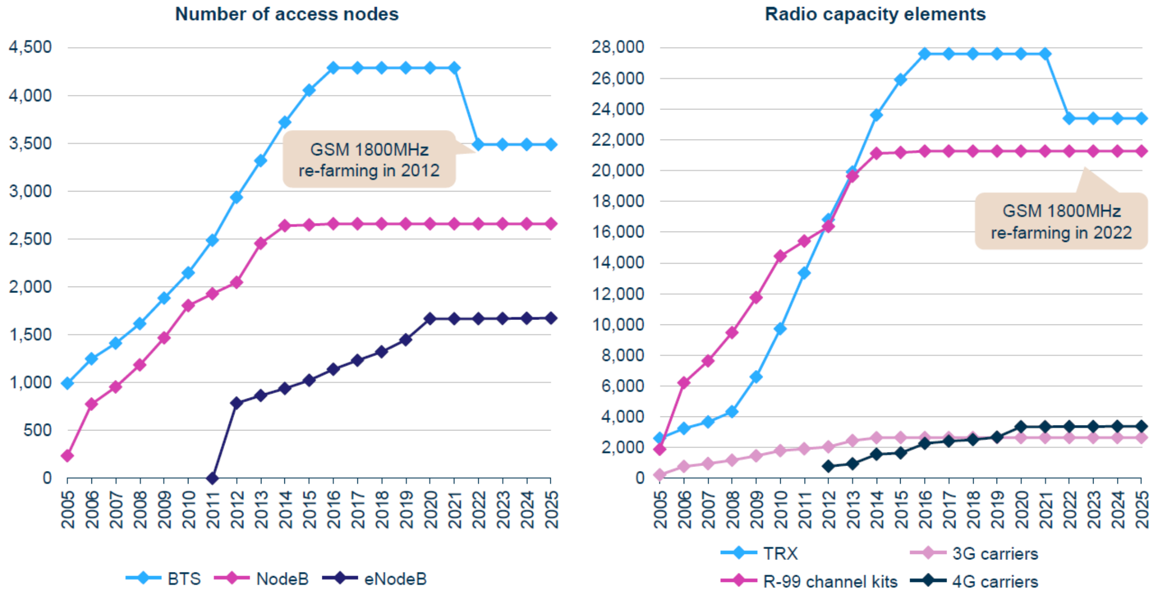
**Graph 7 – Evolution of the number of special sites**




*Source: "Model documentation" drawn up by Analysys Mason*

In relation to results incorporated in the model, Graph 8 reflects the evolution over time of the need for access network equipment (BTS, Node B and eNode B), being deemed that, for the purpose of this exercise, all variables in the model remain constant from 2025 onwards.

**Graph 8 – Evolution of the amount of radio network equipment**




*Source: "Model documentation" drawn up by Analysys Mason*

Annex III hereto presents in its annex B a detailed description of the methodology used to model the network of the hypothetical operator, in the scope of the model to be implemented, covering, among others, the methodological aspects to be considered in its dimensioning taking into account the volume of voice and data traffic.

In addition, annex II, drawn up by the consultant, shows in detail the algorithms and assumptions used in the determination of equipment operated by the network of the hypothetical operator.

> **Dimensioning of the network**
>
> The network to be modelled for the hypothetical operator in the scope of this model is dimensioned on the basis of both voice traffic and data traffic. The 2G network is dimensioned based on voice traffic during peak time while reserving a GPRS channel per sector exclusively for carrying data. The 3G network is dimensioned by assigning a carrier for voice, SMS and data, and HSPA during peak time, while the rest of carriers are exclusively used for carrying data. The 4G network is dimensioned based on Mbit/s of traffic (voice, SMS and data) during peak time. In all of the three cases considered, it is ensured that the reserved spectrum has enough capacity to cope with the existing data traffic requirements for each geotype. In network layers where serving aggregate

traffic is critical (e.g. in the core network), it is likely that the driver of network capacity is the combined voice plus data traffic peak load (*vide* section 4.3 of annex III).

### 2.3.3. Services provided

#### 2.3.3.1. Modelled services

The definition of the range of services to be considered in the model to be developed is directly related to the way how the model will determine the incremental cost of the provision of the voice call termination service to third parties.

The EC Recommendation on termination rates refers that the cost of the mobile termination service should be calculated in an incremental way, corresponding to the difference between the total long-run costs of an operator providing its full range of services and the total long-run costs borne by this operator if the wholesale call termination service was not provided to third parties.

In the light of the above, a full list of services was included in the model, and a proportion of network costs must be allocated to these services. This implies that both voice services, retail and wholesale, need to be modelled, so that the network is correctly dimensioned. Costs are fully recovered from traffic volumes applicable to each service. Figure 7 contains a detailed list of the services that are included in the model.

**Figure 7 – List of services included in the model**

| Mobile services |
|---|
| 2G, 3G and 4G: Outgoing to on-net, international, fixed and other mobile operators |
| 2G, 3G and 4G: Incoming from on-net, international, fixed and other mobile operators |
| 2G, 3G and 4G: Roaming in origination and termination |
| 2G, 3G and 4G: SMS on-net, outgoing and incoming |
| MMS |
| 2G packet data (GPRS / EDGE) |
| 3G packet data (Release-99) |
| 3G packet data (HSDPA, HSUPA) |
| 4G packet data (LTE) |

*Source: "Conceptual approach for a mobile BU-LRIC model" drawn up by Analysys Mason*

**Modelled services**

Given that the purpose of the developed model is to simulate a hypothetical operator, ANACOM takes the view that the range of services provided by the hypothetical operator to be modelled must necessarily include all services currently provided by mobile operators designated with SMP. Services listed in Figure 7 (*vide* section 5.1 of annex III) were specifically modelled.

#### 2.3.3.2. Traffic volume

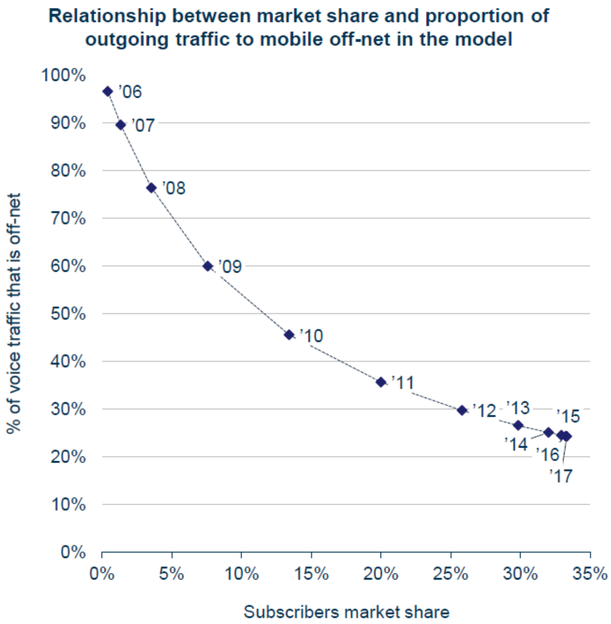
The traffic volume of services to be modelled is of particular importance as far as the development of the model is concerned, as it has a decisive influence on the dimensioning of the modelled network and, consequently, on unit costs of services, and for this reason it is one of the main criteria used in the distribution of costs of the modelled network.

The estimate of overall traffic volume is based on the effective evolution registered for mobile communications, and a growth rate is estimated to obtain its future evolution, traffic of call termination on mobile networks being a proportion of overall volume.

ANACOM acknowledges that there is necessarily some uncertainty as regards the future evolution of modelled services, particularly as this evolution is long-term designed. It is in fact for this reason that there was a deliberate choice for incorporating traffic estimates that are consistent with observations from the past.

As regards the evolution of mobile termination traffic, it was assumed that the proportion of off-net traffic evolves on the basis of the market share of the hypothetical existing operator. Off-net traffic is in general not constant among operators with different market shares, as a result, among other aspects, of different customer behaviour and operator strategy. In Portugal, differences between operators are relatively small, however they make it hard to foresee the evolution of the proportion of termination traffic compared to total traffic. The model estimates the proportion of off-net traffic for the hypothetical operator, based on a slope that defines off-net traffic on the basis of the market share of the hypothetical existing operator (Graph 9). The relation between the market share and off-net traffic was calculated bearing in mind statistical data up to 2016 supplied by ANACOM and by mobile network operators (MNOs). The proportion of off-net traffic does not change after the market share stabilises (33.3%) and remains by 24.3% as from 2025.

**Graph 9 – Relation between off-net traffic and the market share**

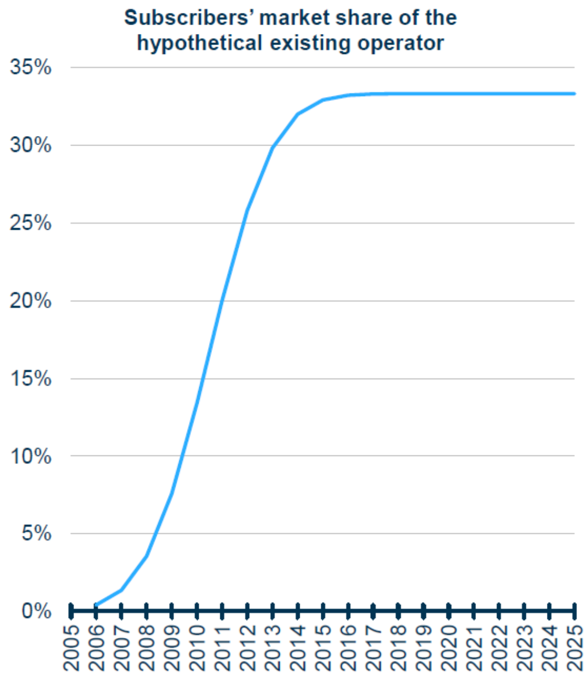



*Source: "Model documentation" drawn up by Analysys Mason*

In general terms, the model considers that the traffic to be carried in each period is obtained according to the market share of the hypothetical operator, mobile penetration and the considered average consumption profile (*vide* annex II).

The model considers that the hypothetical operator reaches the 20% minimum scale five years after deployment, to grow up to 33% in 2017 (and stabilising thereafter), as referred above in point 2.3.1.3 - Minimum efficient scale - and recalled in the graph below (*vide* Graph 10).

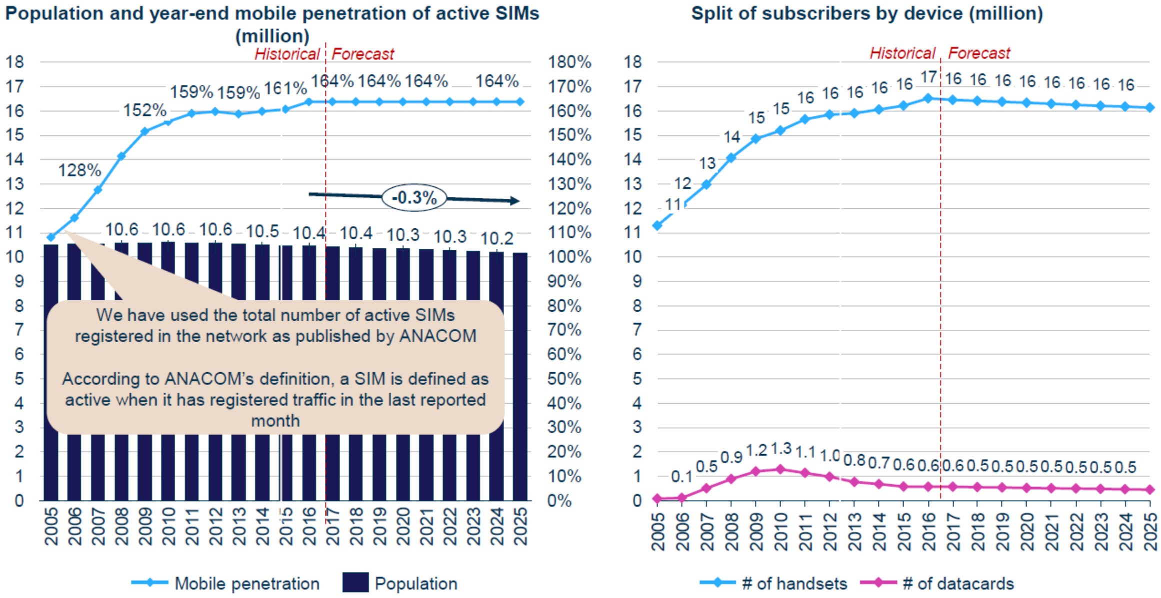
**Graph 10 – Evolution of the modelled operator's market share**




*Source: "Model documentation" drawn up by Analysys Mason*

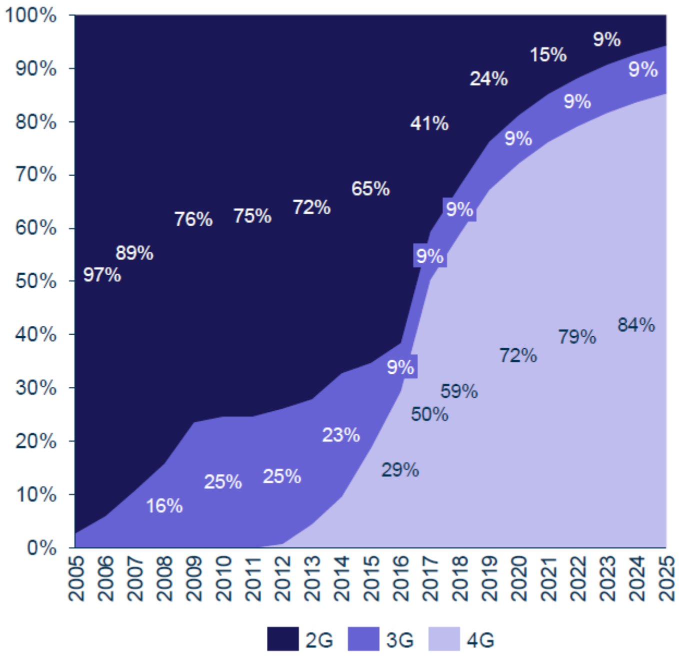
As regards values estimated for mobile penetration, an evolution based on current values was modelled with a penetration of 164 subscribers (Subscriber Identity Module – SIM) per 100 persons from 2025 onwards (*vide* Graph 11). The model also considers the distribution of subscribers per device (handsets or datacards). As regards the distribution of subscribers of the data service according to existing technologies (2G, 3G and 4G), the model assumes, for 2025, 9% of subscribers using 2G, 4G starting to grow substantially as from 2013, representing in 2025 around 84% of the technology used for the data service. 3G technology will suffer a slight decrease, representing in 2013 around 25% ad in 2025 around 9% (*vide* Graph 12).

**Graph 11 – Evolution of the total number of subscribers and by device**




*Source: "Model documentation" drawn up by Analysys Mason*

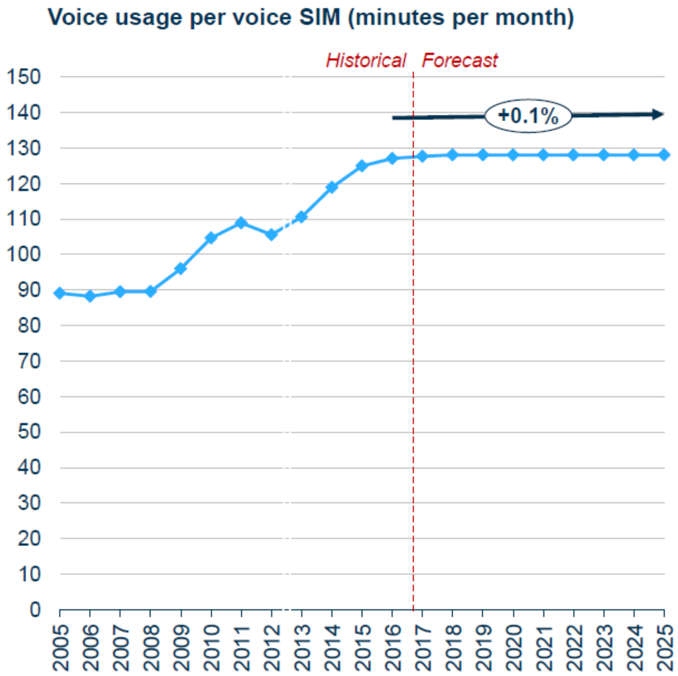
**Graph 12 – Subscribers according to technology**




*Source: "Model documentation" drawn up by Analysys Mason*

Voice consumption per SIM card was modelled using real market data and estimates for the period after 2016, having been assumed a constant growth of traffic (0.1%) per SIM card after 2016. It was assumed that, in the short term, SMS will be quickly replaced by alternative over-the-top services (OTT), while the use of low speed data will increase moderately (*vide* Graph 13). It is stressed that Graph 12 concerns voice services only, other services (SMS and data) not being represented in the graph.

**Graph 13 – Voice consumption per SIM card (minutes per month)**

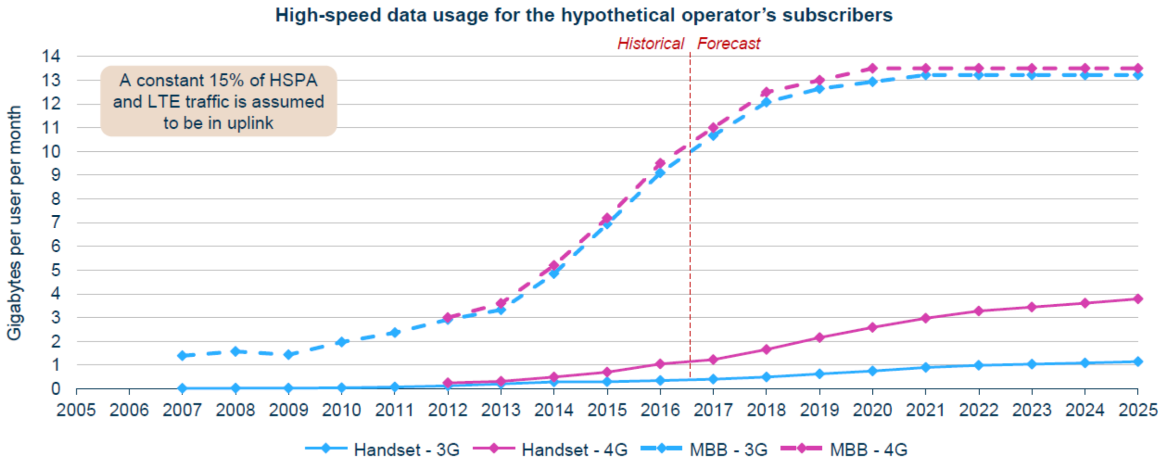



*Source: "Model documentation" drawn up by Analysys Mason*

As regards data consumption, it is assumed that all mobile users (SIM cards) are potential consumers of low speed services, having been incorporated an average consumption of around 0.22 megabytes (MB) per month in 2016, with an increase by 0.9% per year until 2025. Relatively to the use of high speed data services (*vide* Graph 14), the model estimates the evolution of the use of data separately for access devices (handsets or mobile broadband (MBB[12]) and for technology (HSPA or LTE). However, traffic generated by a 4G subscriber may not be necessarily carried over a 4G network. In fact, it could be carried over a 3G or 2G network taking into account technical and/or commercial issues of the operator. As such, it was assumed that a given percentage of 4G data traffic will continue to be carried over legacy networks, especially in the starting years of 4G deployment. Moreover, as regards the voice service, it is also assumed that VoLTE will be launched commercially in 2020.

[12] Access to mobile broadband (MBB) through card/modem.

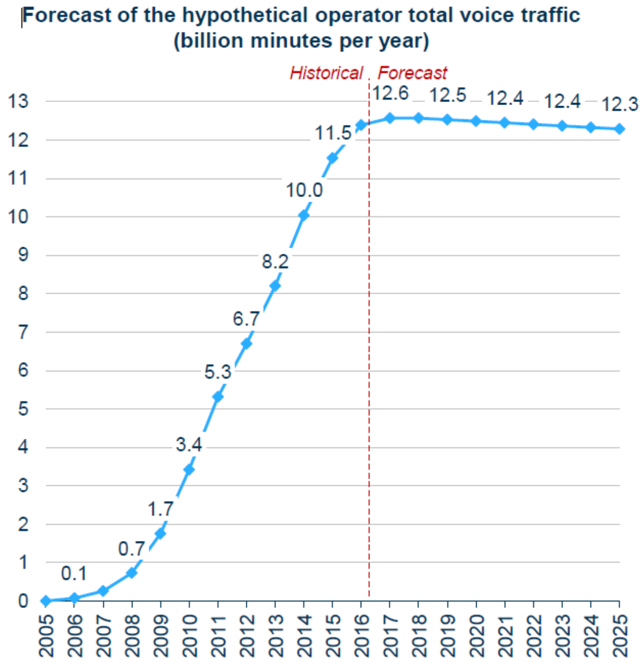
**Graph 14 – High-speed data usage for the hypothetical operator's subscribers**




*Source: "Model documentation" drawn up by Analysys Mason*

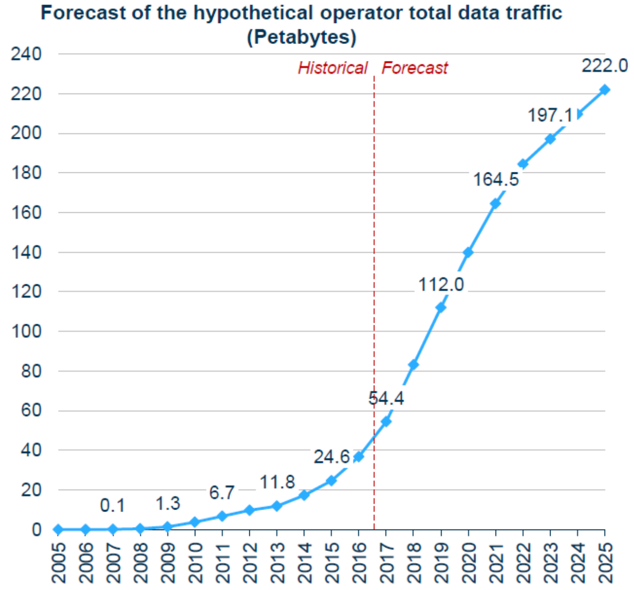
Usage data (voice traffic) are also based on observed data, where they exist, and on estimated data for the remaining modelled period. Voice traffic is expected to increase to around 12.500  million minutes in 2016 and to gradually stabilise after that date (*vide* Graph 15). For data traffic, estimates point towards a drastic increase driven by the acceptance of high-speed data services by next generation mobile networks (*vide* Graph 16).

**Graph 15 – Forecast of the hypothetical operator total voice traffic**




*Source: "Model documentation" drawn up by Analysys Mason*

**Graph 16 – Forecast of the hypothetical operator total data traffic**




*Source: "Model documentation" drawn up by Analysys Mason*

It must be stressed that these variables, just like all others in the model, remain constant as from 2025.

**Traffic volume**

ANACOM believes that the overall traffic volume and, consequently, the hypothetical operator's traffic, to be considered for the purpose of the model, must be estimated taking into consideration current average volumes and traffic profiles, as described above, voice traffic reaching 1537 minutes per customer/year in 2025, around 19.3% of which corresponds to termination traffic. The estimated data traffic is based on the current market-average usage, reaching 3547 MB per year in 2025 for users of mobile equipment (*vide* section 5.2 of annex III).

#### 2.3.3.3. Migration of traffic from the legacy mobile network to more modern access networks

The increasing provision of data services that require larger bandwidth has fostered the growing use of handsets with 3G and more recently 4G technology. As a consequence, an increasing migration of customers of the 2G access network to 3G and 4G has taken place, in order to meet current needs of customers of mobile operators.

As such, three possibilities for modelling migration of services between 2G, 3G and 4G technologies were identified:

**Option 1** - to maximise past investments in 2G (and 3G) networks, delaying expansion of the 3G (and 4G) networks for as long as possible;

**Option 2** - to favour a rapid migration from 2G to 3G and 4G networks, to seek refarming of 2G spectrum at an earlier date;

**Option 3** - to migrate progressively from the 2G (and 3G) networks to the 3G (and 4G) networks, allowing the recovery of investment in the former technology coupled with the development of new services based on the 3G (and 4G) network, to the extent required by needs prompted by the emergence and growth of new services.

Moreover, it must be stressed that, in the scope of the development of this model, there were no signs of a full migration from 2G to 3G and/or 4G, in the short-medium term.

The network traffic modelling used for dimensioning purposes was performed taking into account the forecast of subscriber migration from 2G to 3G and 4G, assuming that each category of subscriber generates a percentage of voice, messages and data traffic to be carried over 2G, 3G and 4G networks, as shown in Figure 8. The option to migrate voice traffic over 4G also depends on the implementation of a VoLTE platform (which the network requires to manage native IP voice traffic). The share of data traffic generated by 4G subscribers, carried over the 4G network, increases over time, consistently with the increase of coverage and availability of LTE equipment. As Figure 9 shows, the use of the 4G network is not expected to reach 100% in the modelled time horizon, whereby around 5% of data traffic generated by 4G subscribers will be carried over 3G in 2025. On the contrary, all traffic generated by 2G and 3G subscribers will be carried over the respective networks.

**Figure 8 – Percentage of voice and messaging traffic assumed to be carried by each network (2G, 3G and 4G) in 2025**

| | Voice | | | Messages | | |
|---|---|---|---|---|---|---|
| | 2G network | 3G network | 4G network | 2G network | 3G network | 4G network |
| 2G subs | 100.0% | - | - | 100.0% | - | - |
| 3G subs | 10.0% | 90.0% | - | 10.0% | 90.0% | - |
| 4G subs | 13.8% | 11.3% | 74.9% | 13.8% | 11.3% | 74.9% |

*Fonte: "Conceptual approach for a mobile BU-LRIC model", Analysys Mason, 2017*

**Figure 9 – Percentage of data traffic carried by the network assumed in the model in 2025**

| | Low-speed data | | | High-speed data | | |
|---|---|---|---|---|---|---|
| | 2G network | 3G network | 4G network | 2G network | 3G network | 4G network |
| 2G subs | 100% | - | - | - | - | - |
| 3G subs | - | 100% | - | - | 100% | - |
| 4G subs | - | - | - | | 5% | 95% |

*Source: "Conceptual approach for a mobile BU-LRIC model", Analysys Mason, 2017*

In the light of the above, it is assumed that 40% of voice and messaging traffic of 4G subscribers is carried over the LTE network two years after the commercial launch, in 2020, of the VoLTE platform, which is admitted to follow the trend of other countries. This proportion is considered to increase over time, until it stabilizes in 2025. The level of ubiquity of the 4G network in 2022 is thus estimated to be lower than for 3G and specially 2G, and for this reason part of 4G traffic will have to be carried over 2G and 3G networks.

**Migration from 2G to 3G**

ANACOM believes that the model should contemplate a gradual migration from 2G to 3G/4G, on the basis of **Option 3** described above. This view results from the fact that, several years after the deployment of the 3G network and in the present status of development of 4G networks, current 2G networks continue to be prominent in the provision of mobile services, especially as far as voice is concerned, thus it is considered that the model to be developed should reflect, as much as possible, the strategic and commercial options of mobile operators designated as having SMP (*vide* section 5.3 of annex III).

As such, the modelling of the hypothetical operator incorporates a gradual 2G/3G/4G migration, where the operator migrates to 4G around 50% of its subscriber database and 91% of total high-speed data traffic (i.e. HSPA and LTE) by 2019. It is assumed that the commercial launch of VoLTE occurs in 2020, being deemed in the migration modelling that 40% of the voice and messaging traffic generated by 4G subscribers in 2022 is carried over the LTE network (two years after VoLTE has been launched).

#### 2.3.3.4. Retail and wholesale costs

The EC Recommendation on termination rates refers that the cost of the mobile termination service should be calculated in an incremental way, corresponding to the difference between the total long-run cost of an operator providing its full range of services and the total long-run costs borne by this operator if the wholesale call termination service was not provided to third parties.

In this scope, it must be stressed that this model review includes the regulatory fees borne by operators on an annual basis, consistently with determinations for the fixed interconnection model.

**Retail and wholesale costs**

In this context, ANACOM believes that costs related to retail activities must necessarily be excluded from the calculation of mobile termination costs. In particular, only incremental costs that are associated to the provision of wholesale mobile termination services have been considered. As such, all costs which do not vary with the increment of traffic considered are not taken into account for the purpose of the determination of the "pure" LRIC value (*vide* section 5.4 of annex III).

### 2.3.4. Implementation of the model

#### 2.3.4.1. Relevant increment

According to the EC Recommendation on termination rates, NRA are required to establish incremental costs incurred in the provision of the wholesale mobile termination service, distinguishing costs that are sensitive to termination traffic and costs which do not depend on this traffic. ANACOM agrees with this interpretation, as referred in the past, the Regulatory Authority's position not having changed on this issue.

**Relevant increment**

ANACOM considers that the model to be developed must follow the EC Recommendation on termination rates as regards the increment to be used, that is, by establishing the avoidable costs of wholesale mobile termination of calls to third parties. As such, costs which do not vary with the increment of traffic considered are not taken into account for the purpose of the determination of the "pure" LRIC value.

To determine the likely average utilisation levels achieved by efficient operators in their networks in order to supply current and foreseeable services, the implementation of the model provides for a time gap, which varies according to the type of equipment, between the initial deployment of a new network element and its effective activation (*vide* section 6.1 of annex III).

#### 2.3.4.2. Asset depreciation methodology

Asset depreciation represents a financial reserve set up to address the loss of value of fixed assets, which depreciate over time, with the main objective of replacing such assets at the end of the estimated lifetime.

This issue was discussed at length at the time of the development of the original model, and ANACOM maintains its view that the depreciation of assets of the hypothetical operator to be considered in the model to be developed must be based on the economic depreciation method.

**Asset depreciation methodology**

ANACOM believes that the depreciation of assets of the hypothetical operator to be considered in the model to be developed must be based on the economic depreciation method, which best reflects the economic value of modelled assets, as supported in the EC Recommendation on termination rates (*vide* section 6.2 of annex III).

#### 2.3.4.3. Time horizon

The time horizon of the model to be developed is an important input, as it must allow for the recovery of efficient costs associated to the provision of call termination on mobile networks, which is only possible by using long time frames. One of the possibilities as regards the definition of the time horizon could be the lifetime of the operator, the value of which is debatable.

Taking into account the discussion which was held when the original model was developed, ANACOM believes that it should maintain its position, according to which a 45-year time horizon should be considered for the purpose of the model to be developed, so that longer-lived assets may be covered.

**Time horizon**

Given that the determination of the lifetime of the operator is a subjective exercise, and in the light of the need to ensure that the time horizon covers longer-lived assets, ANACOM takes the view that a 45-year time horizon should remain as parameter for the model, this value having already been the subject of a long discussion. It is also consistent with most LRIC models developed by the various European Regulatory Authorities, as well as with similar models recently developed by ANACOM (*vide* section 6.2 of annex III).

#### 2.3.4.4. Remuneration of the cost-of-capital

According to ECL, the imposition by the NRA of obligations on operators identified as having SMP, namely the obligation for cost-orientation of prices and for adoption of a cost accounting system, must take into consideration the investment made by the operator, allowing it to earn a reasonable rate of return on the capital employed, taking into account the associated risks[13].

The concept of “cost-of-capital” is associated in general to the return that a given investment must provide, in the light of the risk involved in the business.

[13] Paragraphs 1 and 2 of article 74 of ECL.

The original model included an appropriate and reasonable remuneration of investments that the hypothetical efficient operator would likely make, taking associated risks into account, considered to be able to stimulate investments required for an appropriate provision of services. In this context, the update of the model incorporates a review of the cost-of-capital rate, so as to reflect the current market conditions, determined on the basis of the Weighted Average Cost-of-Capital (WACC) methodology, which is acknowledged, at theoretical and technical levels, to be able to achieve objectives listed above (*vide* annex I, II and III).

**Remuneration of the cost-of-capital**

ANACOM takes the view that the model update must take into consideration an appropriate remuneration of investments that the hypothetical operator would be required to make in order to provide the mobile network call termination service, taking into account the associated business risks.

As such, the calculation of the cost-of-capital for the purpose of the model to be developed must be based on the adjustment of the methodology[14] applied to MEO in the scope of the fixed communications business to the mobile communications business, using a specific benchmark of operators with similar characteristics, according to the procedure followed when the model was updated in 2014. In addition, it is considered that WACC must be determined in pre-tax and real terms, to eliminate the need for long-term inflation estimates (*vide* section 6.3 of annex III). For the purpose of the developed model, ANACOM considers a real cost-of-capital rate by 6.09% to be appropriate (vide "Network costing" section of annex II and section 6.3 of annex III).

### 2.3.4.5. Calibration of the model

In order to ensure that the results generated by the model reasonably represent the underlying reality, the consultant carried out network calibration and economic calibration exercises, as described below (*vide* the section "Model Calibration" of annex II).

[14] Calculation of MEO's cost-of-capital rate for 2017, available at ANACOM's website, https://www.anacom.pt/render.jsp?contentId=1414305.

In brief, the network calibration exercise consisted in the comparison, for certain classes of network elements[15], of the number of network elements which each mobile operator reported to use with the values generated by the model, considering an operator with comparable characteristics, namely at the levels of market share and GSM, UMTS and LTE coverage. As referred by the consultant, this comparison uses not only data supplied by mobile operators, but also values that result from international benchmarks.

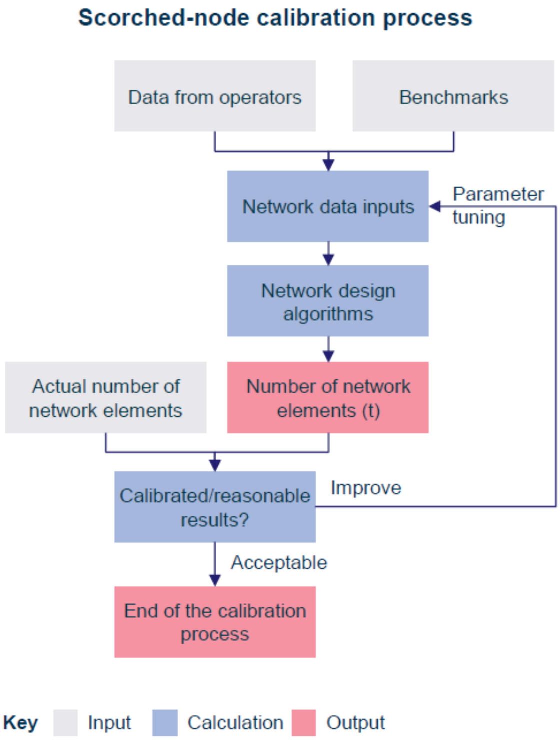
Differences between data generated by the model and values reported by operators were analysed so that grounds for such differences could be understood, and when deemed to be appropriate, these differences resulted also in the modification of certain parameters of the model, in order to bring model results closer to individual values provided by operators, in a recursive approach, and bearing in mind, where appropriate, the judgment and technical experience of the consultant. It must be noted that the result of this iterative process is already reflected in the model now updated and made available.

It is stressed that the purpose of this exercise is not to adjust parameters of the model up to the point where it replicates values reported by mobile operators, given that networks of the latter were gradually built (i) at a different and earlier time compared to when the model is being prepared, and (ii) subject to restrictions and constrains other than those incorporated in the model - otherwise the purpose of the model would be totally distorted - but only to ensure that the underlying reality is reasonably represented.

By way of example, it should be referred that, over time, technological progress led certain network elements to be provided with increased individual capacity, which requires that the model broadly provides for the installation of fewer network elements than what values reported by national operators suggested. Figure 10 schematically represents the calibration process developed by the consultant.

[15] For example, sites, BTS, TRX, NodeB, Channel Kits, Carriers, BSC, RNC, switching sites, MSC and MGW.

**Figure 10 – Model calibration process**




*Source: "Model documentation" drawn up by Analysys Mason*

Figure 11 and Figure 12 illustrate results of the network calibration exercise.

**[BCI – Beginning of confidential Information]**

**Figure 11 – Calibration between model results and operator information**

[redacted]

*Source: "Model documentation" drawn up by Analysys Mason*

**Figure 12 – Calibration of the model with information from operators (core network)**

[redacted]

*Source: "Model documentation" drawn up by Analysys Mason*

**[ECI - End of confidential information]**

As regards the economic calibration exercise, the model was initially fed with values of equipment prices supplied by mobile operators, or based on the consultant's estimates.

Subsequently, the model considered a hypothetical operator with a constant market share of 33.3% so as to compare with accumulated capex and opex values for the three large cost groups (transmission, core network and 2G, 3G and 4G radio access network), generated by the model with values corresponding to an "average" national operator, which was built by the consultant on the basis of elements supplied by mobile operators.

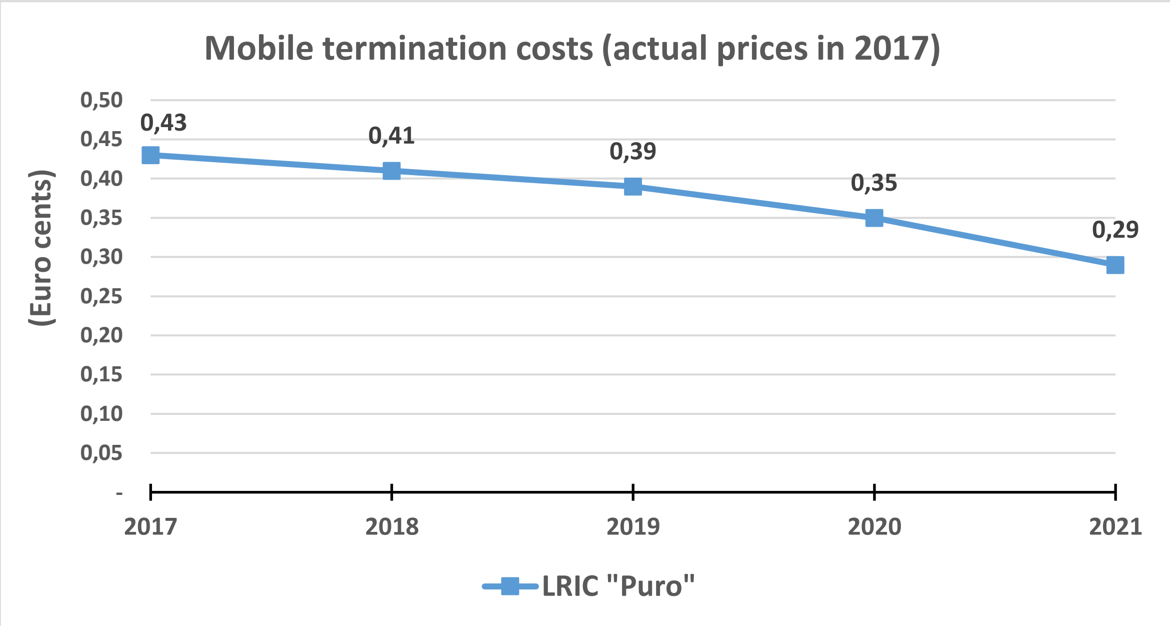
Just like with the network calibration process, differences between data generated by the model and values reported by operators were analysed so that the grounds for their existence could be understood. Such differences, when deemed to be appropriate, resulted also in the modification of certain parameters of the model, in order to bring model results closer to the national reality, in a recursive approach strongly dependant on the judgment and technical experience of the consultant. It must be noted that the result of this iterative process is already reflected in the model now updated and made available.

It must be stressed again that the purpose of the calibration is not to adjust parameters of the model up to the point where it replicates values reported by mobile operators - otherwise the purpose of the model would be totally distorted - but only to ensure that the underlying reality is reasonably represented.

### 2.4. Model results

Taking into consideration the description of modelled options and of mechanisms used to implement these options in practise, unit incremental costs (at values for 2017) of the wholesale mobile termination service, calculated according to the "pure" LRIC methodology, are presented below (*vide* Graph 17).

**Graph 17 – Results generated by the model**




*Source: Cost model developed by ANACOM and Analysys Mason*

As may be observed, according to the cost model developed by ANACOM on the basis of the "pure" LRIC option, the cost of the wholesale mobile termination service, calculated according to the EC Recommendation on termination rates, is, in 2018, around 0.41 cents per minute (at values for 2017) or 0.42 cents per minute considering an inflation value close to -1.4% in 2018[16], rounded to the closest one hundredth of an Euro cent.

[16] According to the State Budget for 2018, available at https://www.oe2018.gov.pt/orcamento-estado/.

Moreover, in order to promote regulatory certainty, ANACOM takes the view that the price ceiling of the wholesale mobile termination service for the next two financial years, that is, 2019 and 2020, should be identified at this point, updated on the basis of existing and foreseen inflation data, as described below:

MTR (2018) = 0.41 €c * (1 + 1.4%) = 0.42 €c

MTR (2019) = 0.39 €c * (1 + CPI(2018)) * (1 + SB(2019))

MTR (2020) = 0.35 €c * (1 + CPI (2018)) * (1 + CPI (2019)) * (1 + SB(2020))

In this context:

- MTR(x) corresponds to the mobile termination price ceiling, per minute and on the basis of per-second billing throughout the call, to be applied in financial year x.
- CPI(x) corresponds to the average variation rate of the Consumer Price Index in financial year x, as calculated and published by Instituto Nacional de Estatística (the National Statistics Institute).
- SB(x) corresponds to the inflation value foreseen in the State Budget for financial year x.

Values above must take effect ten working days after the final decision on this process is published, as far as 2018 prices are concerned, and on 1 July 2019 and 1 July 2020, respectively, for prices concerning 2019 and 2020.

In order to make above-mentioned price update operational, ANACOM shall notify operators holding SMP in these markets, by the end of the 1st third of the year, of the resulting update for 2019 and 2020, making this information available also at its website.

As referred earlier, in addition to this document, stakeholders must take account of the documents in annex drawn up by the consultant as well as the public version of the developed cost model.

### 2.5. Presentation of the model

The update of the “pure” LRIC cost model for mobile termination was based, among other data, on elements that could be deemed to be confidential, and for this reason ANACOM chooses not to make such elements publicly available, in order to safeguard bodies concerned by these data. Nevertheless, a cost model is provided to stakeholders, which stems from the original model referred above and is equal in all that concerns assumptions considered and the structure of calculation of algorithms used, elements deemed to be confidential having, however, been deleted and masked.

ANACOM thus opts to publish a model that differs from the confidential model only as regards the input parameters deemed to be confidential, which were modified relatively to original parameters in a random proportion between -15% and +15%, to protect their confidential nature. In any case, ANACOM believes that the assumptions, structure of the calculation model and algorithms used by the model, as well as remaining documents published, allow the various stakeholders to adequately understand the modelled hypothetical operator.

## 3. Decision

Bearing in mind the above-mentioned grounds, and in pursuit of regulatory objectives, especially the provisions set out in paragraph 1a) and 2b) of article 5 of Law No. 5/2004, of 10 February, as it stands, ANACOM's Management Board, pursuant to articles 66 and 74 of the same Law, hereby determines:

1. To adopt the mobile termination cost model described herein and respective annexes, together with the assessment of the mobile termination market.

2. To determine that the price ceiling for voice call termination on mobile networks to be applied in the scope of the final decision on wholesale markets for voice call termination on individual mobile networks - definition of product markets and geographic markets, assessment of SMP and the imposition, maintenance, amendment or withdrawal of regulatory obligations - by mobile operators notified with SMP, is 0.42 Euro cents per minute, ten working days after the final decision on this process is published, as far as 2018 prices are concerned, on the basis of per-second billing throughout the call.

3. To determine that the price ceiling for voice call termination on mobile networks to be applied in the scope of the final decision on wholesale markets for voice call termination on individual mobile networks - definition of product markets and geographic markets, assessment of SMP and the imposition, maintenance, amendment or withdrawal of

regulatory obligations - by mobile operators notified with SMP, is updated according to the description in point 2.4 hereto.

## Annex A: List of acronyms and abbreviations

| | |
|---|---|
| **2G** | *Second generation of mobile communication systems (GSM)* |
| **3G** | *Third generation of mobile communication systems (UMTS)* |
| **4G** | *Fourth generation of mobile communication systems (LTE)* |
| **AMR** | *Adaptive multi-rate* |
| **AMR-HR** | *Adaptive multi-rate half rate* |
| **AMR-WB** | *Adaptive multi-rate wideband* |
| **AP** | *Aggregation point* |
| **AUC** | *Authentication centre* |
| **BH** | *Busy hour* |
| **BHCA** | *Busy-hour call attempts* |
| **BHE** | *Busy-hour Erlangs* |
| **BHSMS** | *Busy-hour SMS* |
| **BSC** | *Base-station controller* |
| **BTS** | *Base transmitter station or base station* |
| **BU** | *Bottom-up* |
| **BU-LRIC** | *Bottom-up – Long Run Incremental Costs (LRIC)* |
| **€c** | *Euro cents* |
| **CAPEX** | *Capital expenditure* |
| **CCA** | *Current Cost Accounting* |
| **CDMA** | *Code-division multiple access* |
| **CDR** | *Call data record* |
| **CE** | *Channel element* |
| **CK** | *Channel kit* |
| **CPU** | *Central processing unit* |
| **CS** | *Circuit-switched* |
| **CS** | *Call server* |
| **CSCF** | *Call session control function* |
| **DCS** | *Digital Cellular System* |
| **DNS** | *Domain name system* |
| **DSL** | *Digital subscriber line* |
| **DTM** | *Data traffic manager* |
| **E1** | *2Mbit/s unit of capacity* |
| **E1** | *2.048 Mbps dedicated digital circuit* |
| **ED** | *Economic depreciation* |
| **EDGE** | *Enhanced data rate for GSM evolution* |
| **EIR** | *Equipment identity register* |
| **eNodeB** | *Evolved Node B* |
| **ENUM** | *Enumeration* |
| **EPC** | *Enhanced packet core* |
| **EPMU** | *Equi-proportional mark-up* |
| **E-UTRAN** | *Evolved universal terrestrial radio access network* |
| **FAC** | *Fully allocated cost* |
| **FDD** | *Frequency division duplex* |
| **FL-LRIC** ***or*** **LRIC** | *Long Run Incremental Costs* |
| **GGSN** | *Service GPRS support node* |
| **GPRS** | *General Packet Radio Service* |
| **GSM** | *Global system for mobile communications* |
| **GSN** | *GPRS Serving Node* |
| **HCA** | *Historical Cost Accounting* |
| **HLR** | *Home location register* |
| **HSDPA** | *High-speed downlink packet access* |
| **HSPA** | *High Speed Packet Access* |
| **HSS** | *Home subscriber server* |
| **HSUPA** | *High-speed uplink packet access* |
| **HW** | *hardware* |
| **IMS** | *IP multimedia subsystem* |
| **IN** | *Intelligent network* |
| **IP** | *Internet protocol* |
| **IRU** | *Indefeasible right of use* |
| **ECL** | *Electronic Communications Law* |
| **LL** | *Leased Lines* |
| **LMA** | *Last-mile access* |

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|---|---|
| **LRAIC** | *Long-run average incremental cost* |
| **LRAIC "+"** | *Long Run Average Incremental Costs, where "+" represents an increment aimed at the recovery of part of joint and/or common costs* |
| **LRIC** | *Long-run incremental cost* |
| **LTE** | *Long Term Evolution, also known as 4G* |
| **LTE-AP** | *LTE aggregation point* |
| **MB** | *Mega Bytes* |
| **MBB** | *Mobile broadband (*Access to mobile broadband via cards/modem) |
| **Mbit/s** | *Megabits per second* |
| **MEA** | *Modern-equivalent asset* |
| **Market 2** | *Wholesale voice call termination on individual mobile networks* |
| **MGW** | *Media Gateway* |
| **MIMO** | *Multiple input, multiple output* |
| **MME** | *Mobility management entry* |
| **MMS** | *Multimedia messaging service* |
| **MMSC** | *MMS centre* |
| **MNO** | *Mobile Network Operator* |
| **MoU** | *Minutes of use* |
| **MRC** | *monthly rental cost* |
| **MSC** | *Mobile switching centre* |
| **MSS** | *Mobile switching centre server* |
| **MT** | *Mobile termination* |
| **MTR** | *Mobile termination rate* |
| **MVNO** | *Mobile Virtual Network Operator* |
| **MW** | *Microwave* |
| **NDA** | *Non-disclosure agreement* |
| **NGN** | *Next Generation Networks* |
| **NMS** | *Network management system* |
| **Node B** | *UMTS equivalent of a BTS* |
| **NPV** | *Net present value* |
| **NRA** | *National regulatory authority* |
| **ODF** | *Optical distribution frame* |
| **OFDM** | *Orthogonal frequency division multiplexing* |
| **OPEX** | *Operational Expenditure* |
| **OTT** | *over-the-top service* |
| **PCRF** | *Policy and charging rules function* |
| **PCU** | *Packet control unit* |
| **PDN-G** | *Packet data network gateway* |
| **PDP** | *Packet data protocol* |
| **PGW** | *PDN Gateway* |
| **SMP** | *Significant market power* |
| **PoI** | *Point of interconnection* |
| **PoP** | *Point of presence* |
| **PS** | *Packet switched* |
| **PV** | *Present value* |
| **QAM** | *Quadrature amplitude modulation* |
| **QPSK** | *Quadrature phase-shift keying* |
| **R99** | *Release-99* |
| **RAN** | *Radio access network* |
| **RNC** | *Radio network controller* |
| **SAU** | *Simultaneous active users* |
| **SBC** | *Session border controller* |
| **SCC-AS** | *Service Centralisation and Continuity Application Server* |
| **SDCCH** | *Stand-alone dedicated control channel* |
| **SGSN** | *Serving GPRS support node* |
| **SGW** | *Serving gateway* |
| **SIM** | *Subscriber identity module* |
| **SMS** | *Short message service* |
| **SMSC** | *Short message service centre* |
| **SNOCC** | *Scorched-node coverage coefficient* |
| **DD** | *Draft Decision* |
| **SPR** | *Subscriber Profile Repository* |
| **SR-VCC** | *Single Radio Voice Call Continuity* |
| **STM** | *Synchronous transfer mode* |
| **SW** | *Software* |
| **SWG** | *Server gateway* |

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|---|---|
| **TAS** | *Telephony application servers* |
| **TCH** | *Traffic channel* |
| **TDD** | *Time division duplex* |
| **TRX** | *Transceiver Unit* |
| **UMTS** | *Universal mobile telecoms system* |
| **UTRAN** | *UMTS terrestrial radio access network* |
| **VAS** | *Value-added services* |
| **VLR** | *Visitor location register* |
| **VMS** | *Voice mail system* |
| **VoIP** | *Voice over Internet Protocol* |
| **VoLTE** | *Voice over LTE* |
| **WACC** | *Weighted Average Cost of Capital* |
| **WAP** | *Wireless application protocol* |

## Annex B: List of other bodies/organizations

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|---|---|
| Analysys Mason | Analysys Mason Limited |
| EC | European Commission |
| ERG | European Regulators Group (currently BEREC) |
| ANACOM | Autoridade Nacional de Comunicações (the Portuguese National Regulatory Authority for Communications) |
| BEREC | Body of European Regulators for Electronic Communications |
| PwC | PricewaterhouseCoopers Portugal |
| EU | European Union |