DECISION

on the

specification of the price control obligation

on

WHOLESALE MARKETS FOR VOICE CALL TERMINATION ON INDIVIDUAL MOBILE NETWORKS

SPECIFICATION OF THE PRICE CONTROL OBLIGATION

– AUGUST 2015 –

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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], to declare companies with significant market power (SMP) and to determine suitable measures in respect of companies 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 30 April 2012, a final decision on the specification of the price control obligation on these markets, establishing that, as from 31 December 2012, price ceilings of voice call termination on mobile networks, to be applied by the three mobile operators with SMP, would be1.27 Euro cents per minute regardless of the origin of the call, on the basis of per-second billing throughout the call.

Given the time gap that elapsed in the meantime, ANACOM believes that, in the light of technological and market developments that took place in mobile communications in Portugal, it is appropriate to undertake the analysis of wholesale mobile termination markets and to update the cost model so as to reflect the most recent technological and commercial developments on termination rates of mobile networks voice calls.

To this end, ANACOM awarded the update and review of the mobile termination cost model, which is coherent and compatible with Commission Recommendation of 7 May 2009, to Analysys Mason Limited, the company responsible for the construction of the original model.

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[1] Law No 5/2004, of 10 February, as amended by Law No 51/2011, of 13 September, and subsequently amended by Law No 10/2013, of 28 January, Law No 42/2013, of 3 July and Decree-Law No 35/2014, of 7 March (ECL).

[2] Article 56 of Law No 5/2004, of 10 February, as amended by Law No 51/2011, of 13 September.

[3] Article 18 of Law No 5/2004, of 10 February, as amended by Law No 51/2011, of 13 September.

[4] According to Commission 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

ANACOM expects that the model now made available, for which mobile operators contributed with relevant information, supports the review of the price control obligation which falls on operators with SMP on 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 since the implementation and development of the original model. Given that this is an assessment of the cost model, a large proportion of concepts and assumptions used in the original model are maintained, although the Regulatory Authority always sought to use 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). A single albeit relevant structural change was introduced, concerning the inclusion of 4G networks, which had not been taken into consideration in the preceding model.

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

Further to the conclusion of the model update, ANACOM launched between 17/04/2015 and 25/05/2015, a public consultation both on the public version of the designed model and on new price ceilings for the wholesale service of voice call termination on national mobile networks.

As such, the cost model for mobile termination benefited from the analyses 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 on Market 2, according to the EC Recommendation, the public version of that model having been published in the Draft Decision (DD) that preceded the present Decision.

Still as regards the consultation previously carried out, it must be stressed that stakeholders may consult the respective report at ANACOM' website, together with ANACOM's position on comments to the various issues raised in the public consultation, as well as non-confidential contributions received.

ANACOM expects the model now provided, for which mobile operators contributed with relevant information, to support the implementation in 2015 and following years of the price control obligation which falls on operators with SMP on 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 deemed it to be the most appropriate instrument to define mobile termination price ceilings, in the scope of the price control obligation. At the same time, the document "*Bottom-up mobile cost model update - Model documentation*" (*vide* annex II) is also made available, to provide to mobile operators and stakeholders in general an adequate understanding of the various technical parameters that characterized the hypothetical efficient operator described in the model. In addition to the more technical component of the model, the consultant prepared a 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.

In addition, the consultant prepared the document "*Update of the mobile LRIC model: change report"* (*vide* annex IV) to enable stakeholders to understand the main changes introduced in the model, namely those that concern the introduction of 4G. 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" being provided, where appropriate.

In order to make this process more transparent and participated, ANACOM promoted a workshop during the consultation period, which was attended by the consultant, who provided clarification to stakeholders on issues under consultation, in more detail and in a more interactive way.

By determination of 1 July 2015, ANACOM approved draft decisions to be notified to the European Commission (EC), the Body of European Regulators for Electronic Communications (BEREC) and National Regulatory Authorities (NRA) of other Member States of the European Union (EU), which concerned (i) wholesale markets for voice call termination on individual mobile networks - definition of product markets and geographic markets, the assessment of SMP and the imposition, maintenance, amendment or withdrawal of regulatory obligations and (ii) the mobile termination cost model - specification of the price control obligation. On the same date, approval was given also to reports of the prior hearing and public consultation to which the corresponding draft decisions had been submitted, further to determination of 16 April 2015.

By letter dated 30.07.2015, the European Commission addressed the notified draft decisions, having made no comments on the cost model that supports the implementation of the price control obligation. As such, the final decision requires no amendment.

It is also stressed that the DD report made available is deemed to be an integral part of this Decision on the cost model for mobile termination - specification of the price control obligation, which includes non-confidential comments from the various participants and well as ANACOM's analysis thereon.

2. Concepts and assumptions of the cost model developed

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.

A modelling exercise aimed at assimilating the main features of above-mentioned characteristics must thus 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 and placed for public consultation 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 2012 a mobile termination cost model intended to implement Commission Recommendation[5] of 7 May 2009 on the regulatory treatment of fixed and mobile termination rates in the EU (hereinafter “EC Recommendation”) in the scope of the regulation of the price ceiling to be applied to the wholesale voice call termination on individual mobile networks. As referred

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

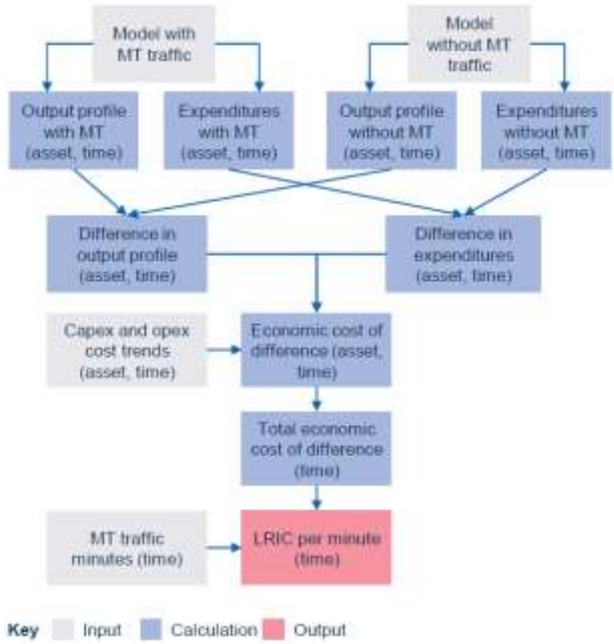
earlier, given the time gap elapsed in the meantime, and in the light of technological and market developments that took place in mobile communications in Portugal, it was deemed appropriate to update the cost model so as to reflect these developments on termination rates of voice calls to mobile networks, the review of which is articulated with a new analysis of the relevant market, with which this decision is intrinsically linked.

The EC Recommendation considers that the imposition of price control by National Regulatory Authorities (NRA), as far as the wholesale service of 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 must have the mobile termination service provided to third parties as 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 as well as total long-run costs of a hypothetical efficient operator that provides all services considered, without the termination service of voice calls to their 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 the provision of that service.

The model generally calculates the costs of an efficient operator in Portugal (*vide* Figure 1), 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



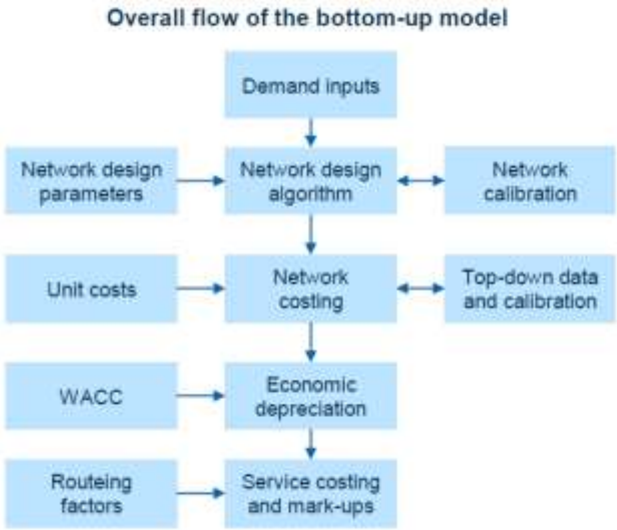
Source: "*Model documentation*" prepared by Analysys Mason

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, without 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 price 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 of 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*" prepared by Analysys Mason

Differences between the "updated model" and the "original model" result mainly from the update of certain assumptions and the inclusion of 4G. The availability of macroeconomic and market data that are new compared to the date of the "original model" led to the update of the estimate of demand for 2G, 3G and geotypes, which on their turn required the update of network parameters. In addition, all costs were recalculated, which were expressed in real terms for 2013, compared to 2011 in the "original model" and based on validated estimates of equipment costs and their evolution. As regards the 4G network, equivalent services to those supplied over 2G and 3G networks were taken into consideration, however the voice service ("Voice over LTE" - VoLTE) will only be possible after operators have implemented the platform that enables it to be provided.

As regards the inclusion of the 4G network in the model now updated (*vide* annex IV), this required a new set of assumptions and calculations in the model, concerning:

- 4G-capable spectrum and its cost
- 4G network population coverage
- Theoretical LTE network
- E-UTRAN radio access network
- Dimensioning of backhaul transmission
- Core network
- Features of LTE-specific assets

- Routeing factors[6]

It is important to stress that, with a few exceptions, it is not possible to examine thoroughly the impact of each of the technical characteristics implemented in the model in isolation, 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 able 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 decision:

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

Annex II - the document "Bottom-up mobile cost 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", prepared 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: change report", 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 various principles considered in the mobile termination cost model may be grouped in four different dimensions (Figure 3) which are related to:

[6] Routeing factors aim to reflect the average combination of network elements used in the production of a service.

- 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”, prepared by Analysys Mason

2.3.1. Operator

2.3.1.1. Type of Operator

The definition of the type of operator considered in 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 on 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 to provide 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 to provide 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 in 2013, 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 existing in 2013, which 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, prepared 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 to change the position taken on 2012, so as to take **Option 4 - Hypothetical existing operator** into consideration. 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 its network infrastructure.

ANACOM thus takes the view that **Option 4 - Hypothetical existing operator** - is the most appropriate for the definition of a regulatory instrument, 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)** which rolls out its network in 2005, and starts providing services in 2006. This operator uses the most efficient technology available at the time of entry, i.e. a combination of 2G, 3G and 4G networks and an NGN core.

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. 800MHz is the primary LTE coverage layer, and the 2600MHz and 1800MHz 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 complete 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 are always associated to a given level of investment, that is required to guarantee a certain geographical coverage, involving costs which are not directly related to the volume of network traffic.

The EC Recommendation 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 have almost ubiquitous 2G (GSM 900 MHz) and 3G (UMTS 2100 MHz) population coverage, as well as significant 4G coverage, and the developed cost model sought to reflect this.

Notwithstanding, good outdoor coverage does not directly translate into 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 level of coverage which all users of mobile services currently have access to. As such, for a hypothetical existing operator, the near-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 (2013). As far as coverage of 3G/4G is concerned, 100% coverage seems to be neither necessary nor realistic, even in light of the adoption of UMTS technology in the 900MHz, adopted by only one operator. Seeking to emulate current and expected coverage conditions, it is deemed reasonable to expect that 3G reaches 95% outdoor coverage of population in the 2.1GHz band by 2014 and then stabilises. 4G coverage is projected to reach 97% of population in the 800MHz band in 2019. The higher coverage reached by the LTE network is justified by the usage of lower-frequency spectrum (800MHz vs. 2100MHz) with better electromagnetic propagation properties.

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 considered coverage must correspond to that currently provided by mobile operators designated as having SMP, thus the model considers a near-ubiquitous 2G coverage (99.3% of population) on the basis primarily of the 900MHz band (coverage) and the 1800 MHz (for capacity increase purposes), mainly in urban areas[7]. The

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

coverage is complemented by 3G coverage (UMTS 2100 MHz), corresponding to 95% coverage of population by 2014 and then stabilising. 4G coverage is projected to reach 97% of population in the 800MHz band in 2016 (*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 refers in the respective Explanatory Note[8] 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 is referred that an operator with a lower market share will be able to achieve a 20% to 25% market share, insofar as it is efficient, and quoting the European Regulators Group (ERG), it is further referred 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 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 market for mobile communications shows that an operator obtains market share in a gradual way, 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 a four-year period for this purpose.

As regards the time horizon to obtain a minimum efficient scale, ANACOM deems that it is 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.

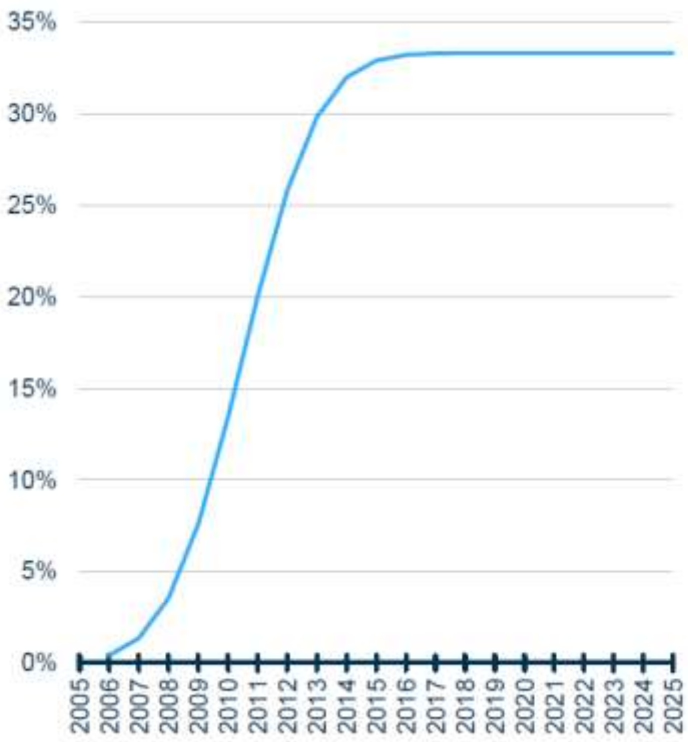
[8] Point 5.2.3. of the Explanatory Note accompanying Recommendation 2009/369/EC (SEC (2009) 600), which quotes UK's Competition Commission.

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 to 33.3% 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[9] years (2005–2011) and reaches a long-run market share of 33.3% (calculated as 1/n, where "n" represents the number of mobile networks throughout Portugal) by 2017, ensures methodological consistency with:

- EC Recommendation;
- the previous version of the mobile termination model;
- the recently developed fixed termination model.

Graph 1 – Market share of subscribers of the hypothetical existing operator



Source: "Model documentation" prepared by Analysys Mason

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

The developed model thus reflects an operator that achieves a minimum efficient scale (of 20%) in 2011, five years after services were made available to customers, growing to achieve a market share of 33.3.% in 2017, which will remain constant thereafter. This is consistent with a long-run market share in a competitive market with three 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 free of the competition concerns identified by ANACOM in the scope of previous market analyses. Under these conditions, ANACOM supports that a time period of six years (2005–2011) should be modelled, allowing an operator to achieve a market share of 20%, calculated by reference to the overall traffic volume, further development being pursued to reach in 2017 a market share by 33.3.%, this share remaining constant thereafter, for the purpose of this exercise.

A further issue related to the issue of minimum efficient scale is the time horizon required by this operator to achieve that share with appropriate network coverage. In this sense, a six-year time horizon was deemed appropriate for achieving a degree of network coverage similar to that of 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 frame considered, a position which has also been adopted in the EC Recommendation[10], and for this reason technologies available in the period from 2005 to 2013 were taken into consideration.

[10] Recital 12 of EC Recommendation: "*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*."

2.3.2.1. Radio network and spectrum assignment

The developed model corresponds to 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, a gradual expansion to include 3G, mainly driven by the emergence of new services associated to data traffic, and, recently, the development and commercial launch of 4G (namely LTE) networks and services.

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. The determination of this amount took account not only of the national reality, but also of the need 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 respective evolution. In the light of recent developments, namely the spectrum auction undertaken at the end of 2011 and 4G evolution on the national market, the model was updated to include the assignment of spectrum to the hypothetical operator and to ensure the provision of all services provided over 4G networks (*vide* section 4.1 of annex III).

Radio network and spectrum assignment

Since all operators have similar spectrum licenses, it is assumed that the future spectrum- and coverage-related costs are close. Taking into account the option taken when the model was developed, ANACOM takes the view 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:

- 2x10MHz of LTE 800MHz spectrum;
- 2x8MHz of GSM 900MHz spectrum;
- 2x20MHz of GSM and LTE 1800MHz spectrum;
- 2x20MHz of UMTS 2100MHz spectrum;
- 2x20MHz of LTE 2600MHz spectrum.

2.3.2.2. Value of spectrum

According to the EC Recommendation, the cost incurred with the initial acquisition of spectrum is not directly associated to the termination service, and as such should not be calculated as part of the incremental cost of the wholesale 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 wholesale mobile termination service.

Spectrum was assigned to mobile operators designated as having SMP through public tender and auction, intended for the provision of various mobile communication services and not only the wholesale mobile termination service. As such, costs incurred in their assignment are common costs (sunk or fixed costs) and not 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 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 for spectrum, 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 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 considers that only the assignment of spectrum directly associated to the provision of this service should contribute to costs of the provision of the mobile termination 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 cost of spectrum 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

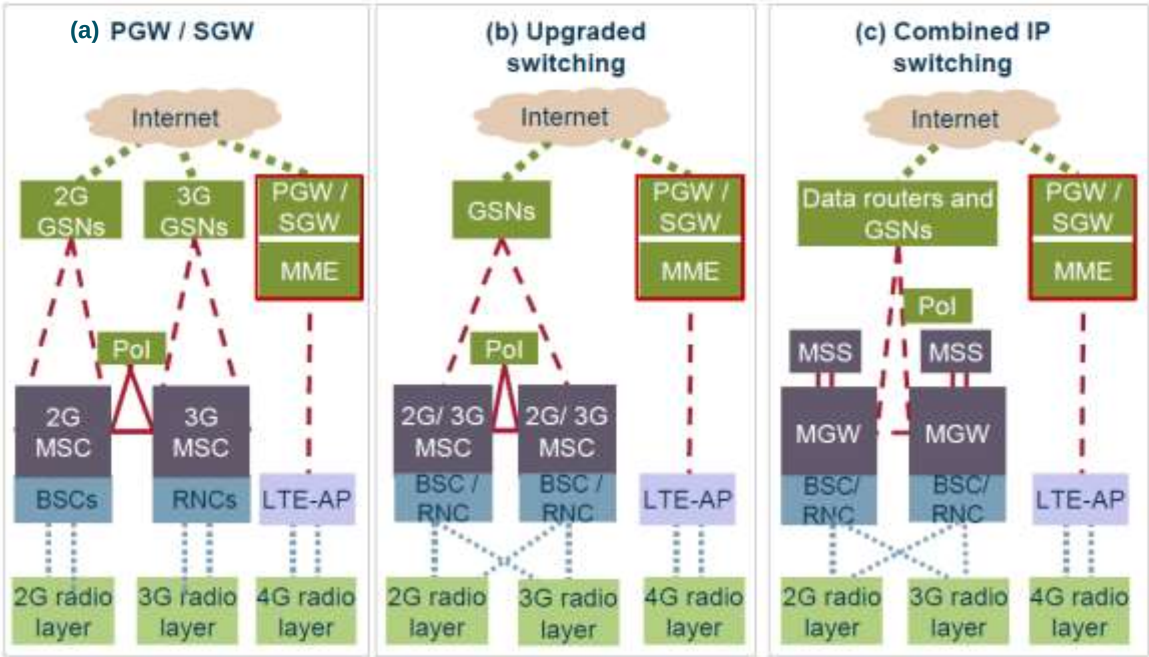
The EC Recommendation proposes that the cost model incorporates a switching network of an efficient hypothetical operator, where mobile communication services are based on the most efficient technology available in the considered time horizon. As such, the main options (Figure 4) considered when modelling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

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

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

Option 3 - a combined 2G+3G switching structure with a next-generation IP transmission network, linking pairs of MGWs with one or more MSSs, data routers and PoIs, separated into circuit-switched (CS) and packet-switched (PS) layers and a separate 4G structure (corresponds 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, 2015

In all these options, 4G, now introduced in the model, is 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, that **Option 1** on the switching network of the modelled hypothetical operator 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 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 also that this option should 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 follows 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 modelled operator.

As such, in order to reflect a modern switching network, able to be 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 – Capacity of switching equipment

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*" prepared by Analysys Mason

As 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 in which equipment still does not 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.

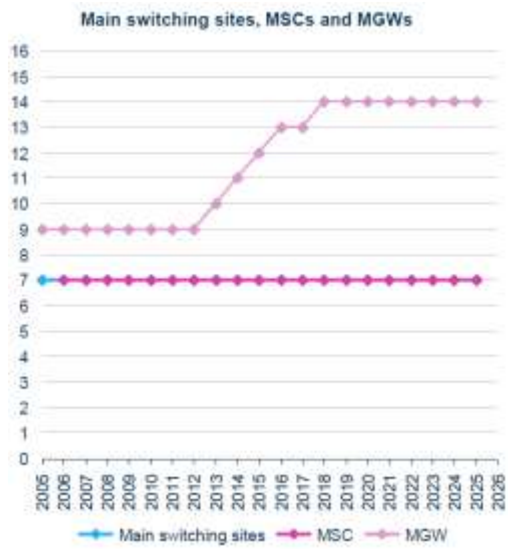
Given that the model incorporates certain evolution trends in the chosen time horizon, the aggregated effect of which results in the gradual increase of the volume of traffic to be carried (mainly as a result of the increase of market share, of average traffic per subscriber and the number of users of mobile high speed data services), the application of algorithms to calculate the need for equipment tends to result in increasing values of installed capacity (*vide* Graph 2, Graph 3 and Graph 4 on equipment evolution) throughout the modelled operator's lifetime. 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 number of items of equipment installed). Modelling a "stable state" 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 state” from that moment onwards is deemed to be a reasonable proxy for the underlying reality, thereby reducing the unpredictability of producing estimates for the period subsequent to 2025.

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

Unit: Number of items of equipment

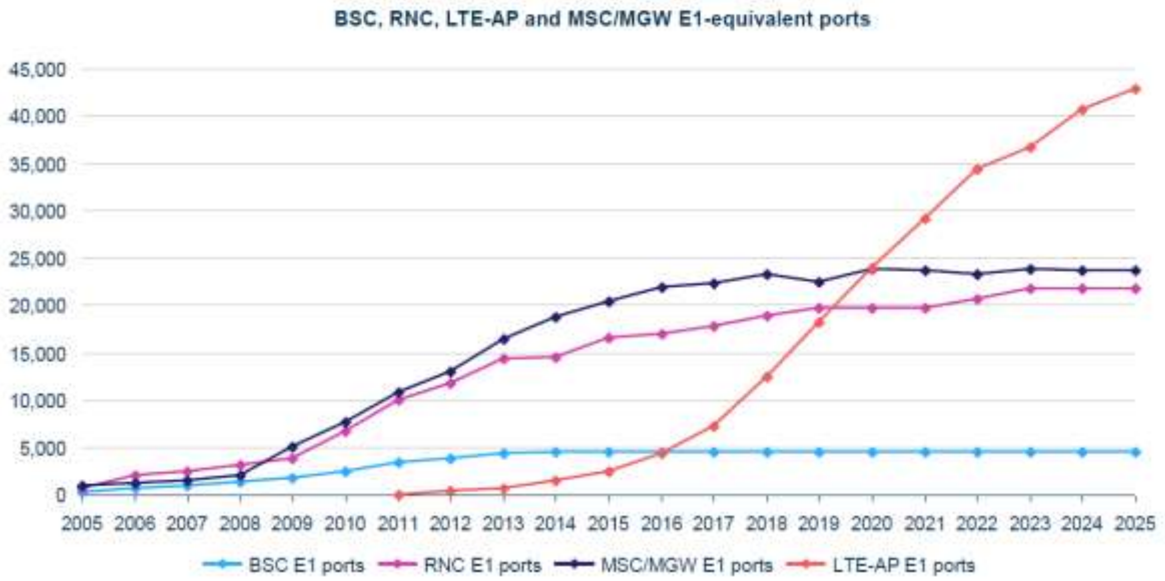
Source: “Model documentation” prepared by Analysys Mason

Graph 3 – Evolution of the number of sites, MSC and MGW



Source: “Model documentation” prepared by Analysys Mason

Graph 4 – Evolution of switching capacity



Source: “Model documentation” prepared by Analysys Mason

Annex II, prepared 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 which best represents the most modern switching network, implemented by a hypothetical existing and efficient operator who deployed its network in 2005 and who 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.

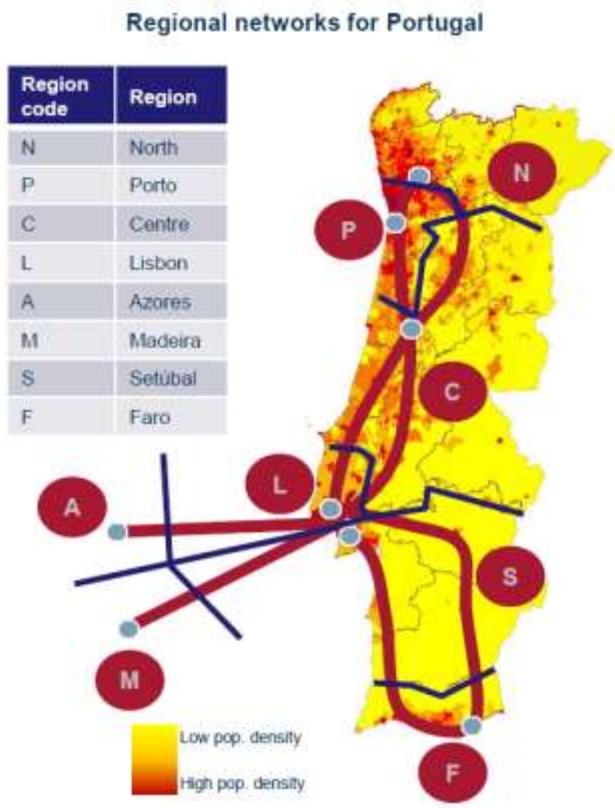
2.3.2.4. Transmission network

In the modelled hypothetical operator, the transmission network responsible for connectivity between mobile network nodes 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 ring architecture supported on fibre, constructed by the hypothetical operator (as opposed to the lease of infrastructures) which connect eight regional structures. It includes two submarine connections (Lisbon-Madeira and Lisbon-Azores), being assumed a total length (excluding Atlantic connections) of 1472 Km;

Figure 5 – Structure of the modelled national backbone



Source: “Model documentation” prepared 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" prepared by Analysys Mason

(iii) local (last-mile) access, 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 produced by the consultant.

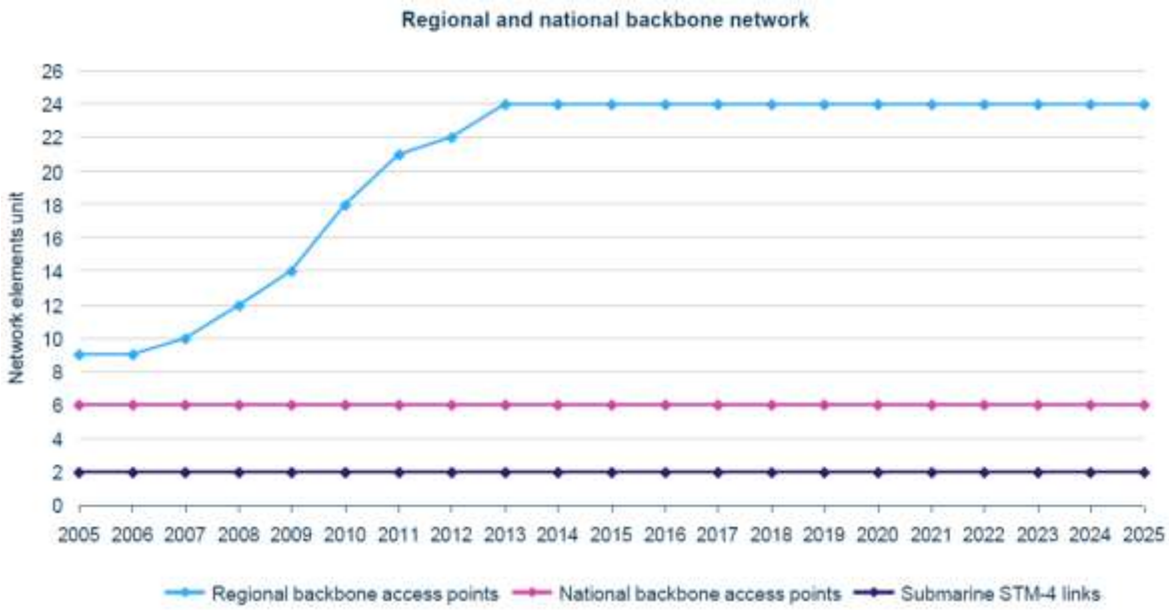
Table 3 – Types of transmission used according to 2G/3G and 4G technology

Technology	Geotype	Leased lines	Microwave	DSL	Fibre	Co-location
2G	Dense urban	15.0%	20.0%	-	65.0%	-
	Urban	20.0%	35.0%	-	45.0%	-
	Suburban	20.0%	60.0%	-	20.0%	-
	Rural	38.0%	60.0%	-	2.0%	-
	Indoor	100%	-	-	-	-
3G	Dense urban	15.0%	5.0%	-	80.0%	-
	Urban	15.0%	30.0%	-	55.0%	-
	Suburban	20.0%	40.0%	-	40.0%	-
	Rural	20.0%	60.0%	-	20.0%	-
	Indoor	100%	-	-	-	-
4G	Dense urban	3.0%	2.0%	-	95.0%	-
	Urban	5.0%	15.0%	-	80.0%	-
	Suburban	15.0%	30.0%	-	55.0%	-
	Rural	36.0%	60.0%	-	4.0%	-
	Indoor	100%	-	-	-	-

Source: "Conceptual approach for a mobile BU-LRIC model" prepared by Analysys Mason

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

Graph 5 – Evolution of the modelled national and regional backbone



Source: “Model documentation” prepared by Analysys Mason

Annex II, prepared 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 in order to develop a network based on actual and efficient technology. These options mainly concern three levels (national, regional and local) in 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). From a strictly conceptual perspective, the option remains unchanged from that implemented in the original model.

2.3.2.5. Network topology

The modelling of a hypothetical network of efficient mobile communications 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, 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, of 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 cost model for mobile termination is intended to represent national reality as much as possible, the various network components are quantified and qualified using optimization algorithms, which incorporate efficiency coefficients to produce the best possible approximation. In this regard *vide* also section 4.2 of annex III.

As regards this issue, that involves the definition of the topology of the modelled network, ANACOM considers that, in the light of the discussion that already took place during the development of the original model 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 continues to be the methodological option that best balances the need for efficiency parameters in the model with the concern not to make its practical development too complex. Moreover, this methodology allows the maintenance of a correspondence, as much as possible, with the national reality, taking into consideration several restrictions faced by mobile operators in the development of their networks.

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

Network topology

Having weighted the above-mentioned options, ANACOM takes the view that the approach described in **Option 3 - Modified scorched-node approach -** is the methodological option that best balances the need for efficiency parameters in the model with the concern not to make its practical development too complex. Moreover, this methodology allows the maintenance of a correspondence, as much as possible, with the national reality, taking into consideration several restrictions faced by mobile operators in the development of their networks (*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 loading during the busy hour. Traditionally, operators have considered as busy hours the period with highest level of voice traffic. The traffic volume which the network has to carry in the period with 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). Criteria were updated using available equivalent benchmarks, taking in consideration other regulation models that already use 4G, which were validated by sources from third parties to ensure that input levels used in the model are within the reference range (i.e. the benchmark).

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” prepared by Analysys Mason

The definition of geotypes resulted in a distribution of area and population 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, 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, we have: (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, as demonstrated by Table 5, it is distributed unevenly among geotypes. Dense urban and urban areas are likely to have a higher proportion of traffic than their population proportion, and conversely, suburban and rural areas are most likely to have a lower proportion of traffic than their population proportion. Some of the reasons that explain why higher-density areas carry more traffic in relative terms are: i) urban areas are characterised by higher data/voice consumption propensity and access to technology; ii) many companies, which have a high consumption of communication products, are located in these are areas; iii) the fastest networks – such as HSPA and LTE – are usually deployed first in more dense 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%**

Fonte: “*Model documentation*” preparado pela Analysys Mason

For each class of geotype, and for 800 MHz, 900 MHz and 2100 MHZ frequency bands, 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). This exercise was not performed for the 1800 MHz and 2600 MHz bands, as these bands were modelled to serve areas of high traffic.

Table 6: Calculations of radio network: theoretical and effective radii of cells

Theoretical cell radius (km)

Geotype	800MHz	900MHz	1800MHz	2100MHz	2600MHz
Dense urban	0.55	0.45	0.40	0.38	0.35
Urban	1.96	1.61	1.43	1.39	1.27
Suburban	5.42	4.46	3.95	3.84	3.50
Rural	6.01	4.95	4.38	4.31	3.89

The theoretical radii of 800MHz and 2600MHz cells are assumed to be 121% and 78% of the radius used for 900MHz

SNOCC

Geotype	800MHz	900MHz	1800MHz	2100MHz	2600MHz
Dense urban	0.540	0.564	-	0.604	-
Urban	0.589	0.615	-	0.659	-
Suburban	0.677	0.707	-	0.758	-
Rural	0.738	0.769	-	0.824	-

Effective cell radius (km)

Geotype	800MHz	900MHz	1800MHz	2100MHz	2600MHz
Dense urban	0.29	0.25	-	0.25	-
Urban	1.15	0.99	-	0.98	-
Suburban	3.67	3.16	-	3.11	-
Rural	4.43	3.81	-	3.79	-

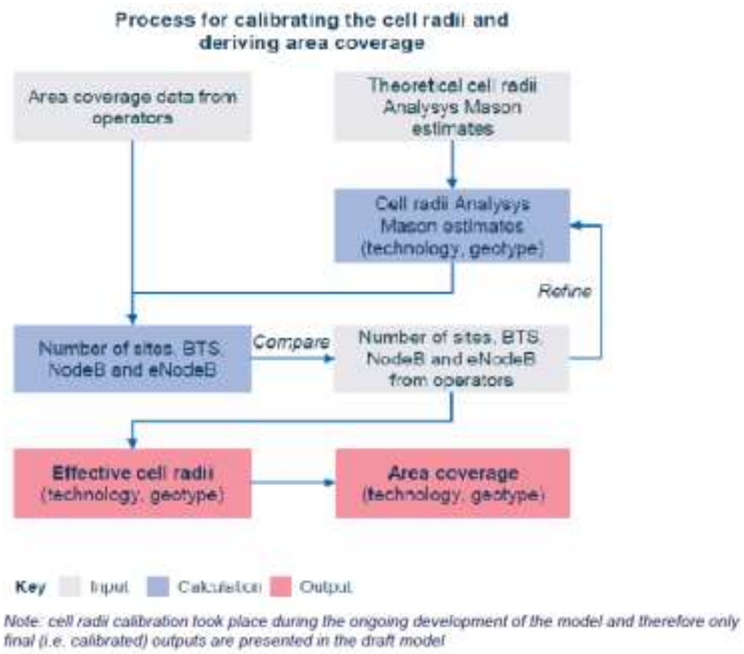
The 2100MHz effective cell radius also takes into account the cell-breathing effect illustrated on the following slides

Source: “Model documentation” prepared 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 in an optimal location (in terms of overlapping with adjacent cells) and that the propagation provided for radio signals suffers from interferences of 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 in theory. In more densely populated areas, the loss effect tends to be higher 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 following steps:

Figure 6 – Process for calibrating the modelled network



Source: “Model documentation” prepared by Analysys Mason

Having been determined the needs for cells by technology and by 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 sectorisation per site

Average sectorisation per site

	Dense urban	Urban	Suburban	Rural	Micro/indoor
LTE 800MHz	2.89	2.89	2.89	2.89	2.00
GSM 900MHz	2.54	2.54	2.54	2.54	2.00
GSM 1800MHz	2.62	2.62	2.62	2.62	2.00
LTE 1800MHz	2.47	2.47	2.47	2.47	2.00
UMTS 2100MHz	2.72	2.72	2.72	2.72	2.00
LTE 2600MHz	2.79	2.79	2.79	2.79	2.00

Source: “Model documentation” prepared by Analysys Mason

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

− share of 2G sites capable of hosting 3G

− share of 2G sites capable of hosting 4G

− share of 2G sites without 3G capable of hosting 4G

− share of 3G sites without 2G capable of hosting 4G

It was assumed that, as far as possible, mobile operators will reuse existing sites whenever they implement a new technology, 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.

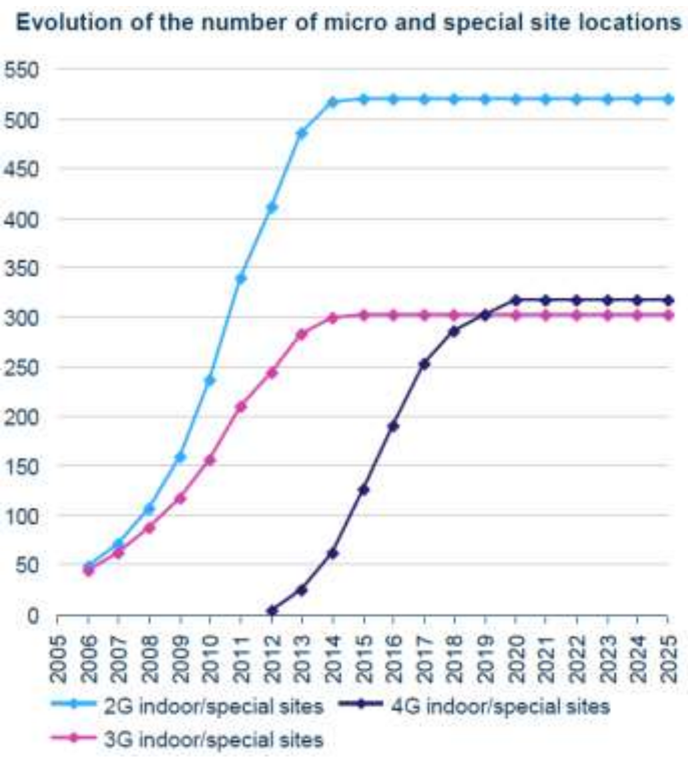
As regards the elements required to ensure indoor coverage, on the basis of data supplied by operators, taking into account the future evolution of traffic, and maintaining the consistency between the proportion of traffic served by micro-sites/special sites[11] and real data provided by national operators, 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” prepared 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.

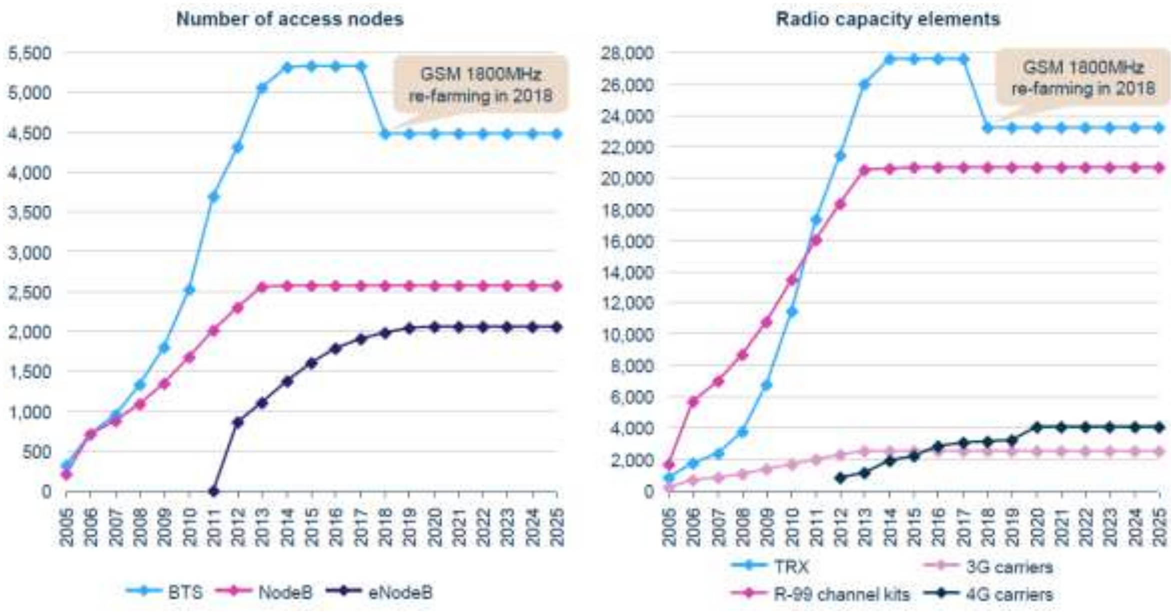
Graph 7 – Evolution of the number of special sites



Source: "Model documentation" prepared 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 number of items of radio network equipment



Source: “Model documentation” prepared by Analysys Mason

Annex III to this Decision 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, prepared 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 in the busy hour while reserving a GPRS channel per sector exclusively for data transportation. The 3G network is dimensioned by assigning a carrier for voice, SMS and data, and HSPA in the busy hour, while the rest of the carriers are exclusively used for data transportation. The 4G network is dimensioned based on Mbit/s of traffic (voice, SMS and data) in the data busy hour. In all of the three cases, it is ensured that the reserved spectrum has enough capacity to cope with the existing data traffic requirements for each geotype. In layers of the network 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 set 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 to third parties of the voice call termination service.

The EC Recommendation 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 retail and wholesale voice services 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", prepared 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 set of services provided by the hypothetical operator to be modelled must necessarily include all services currently provided by mobile operators designated with SMP. In particular, services listed in Figure 7 (*vide* section 5.1 of annex III) were modelled.

2.3.3.2. Traffic volume

The volume of traffic 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.

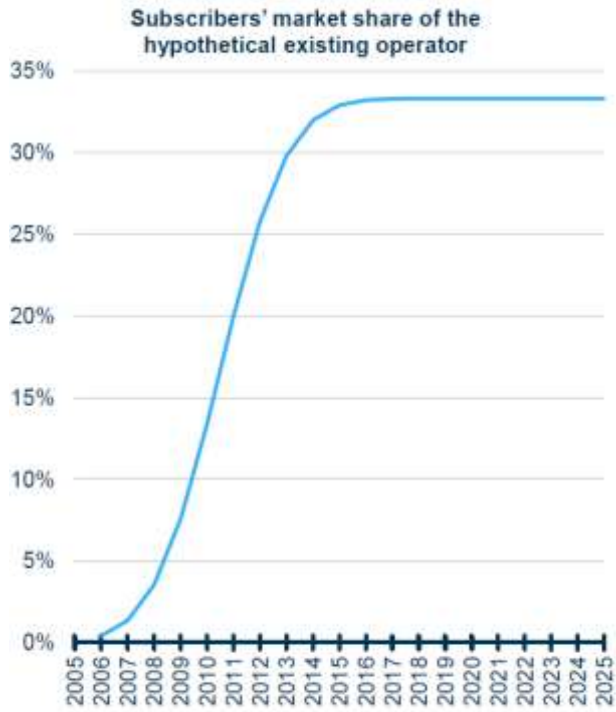
ANACOM acknowledges that there is necessarily some uncertainty as regards the future evolution of modelled services, particularly as this evolution is long-term designed. It is in fact for this reason that there was a deliberate choice for incorporating traffic estimates that are consistent with observations 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 termination traffic as a proportion of total traffic. The model estimates the proportion of off-net traffic for the hypothetical operator, on the basis of a slope that defines off-net traffic from the market share of the hypothetical existing operator. The relation between the market share and off-net traffic was calculated bearing in mind statistical data up to 2013 supplied by ANACOM and by mobile network operators (MNOs). The proportion of off-net traffic is not changed after the market share stabilises (33.3%) and remains at 20.7% as from 2025.

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 in point 2.3.1.3 - Minimum efficient scale - and recalled in the graph below (*vide* Graph 9).

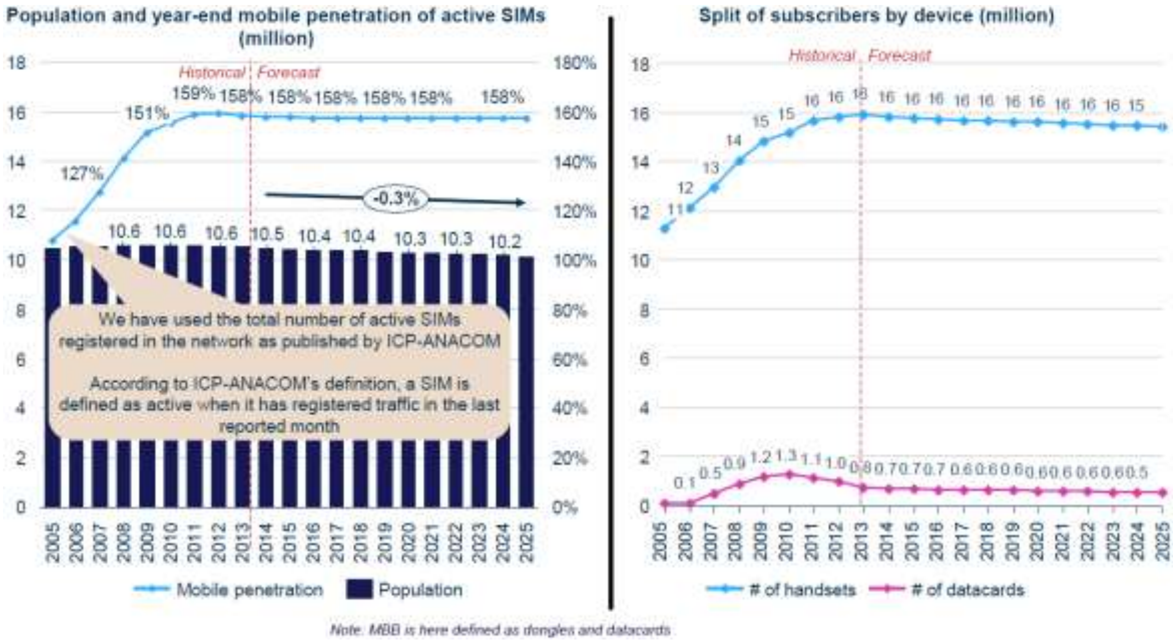
Graph 9 – Evolution of the modelled operator's market share



Source: "Model documentation" prepared by Analysys Mason

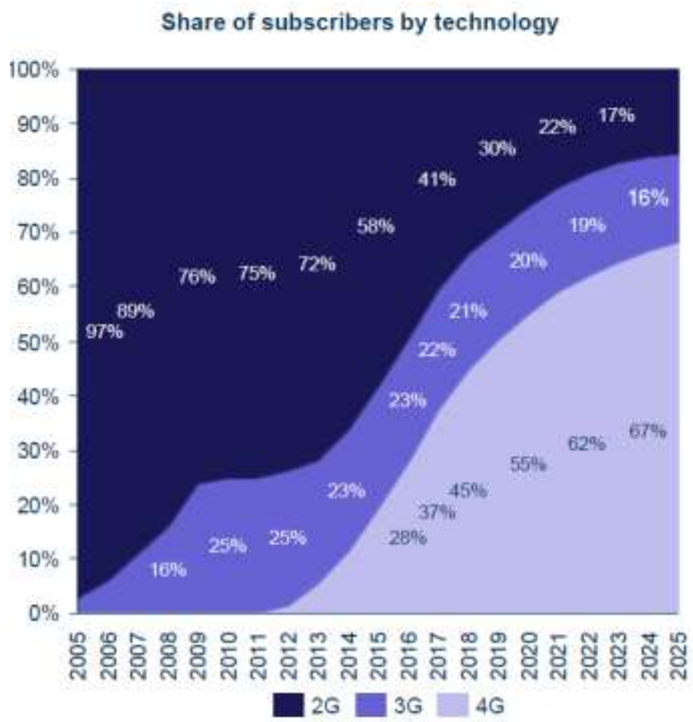
As regards values estimated for mobile penetration, an evolution based on current values was modelled, with a penetration of 158 subscribers (Subscriber Identity Module – SIM) per 100 persons from 2025 onwards (*vide* Graph 10). The model also considers the distribution of subscribers per device (handsets 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, 17% of subscribers using 2G, 4G starting to grow substantially as from 2013, representing in 2025 around 67% of the technology used for the data service. 3G technology will suffer a slight decrease, representing in 2013 around 25% ad in 2025 around 16% (*vide* Graph 11).

Graph 10: Evolution of the total number of subscribers and by device



Source: “Model documentation” prepared by Analysys Mason

Graph 11: Subscribers by technology



Source: “Model documentation” prepared by Analysys Mason

Voice consumption per SIM card was modelled using real market data and estimates for the period after 2014, having been assumed a constant growth of traffic (0.5%) per SIM card after 2013 (*vide* Graph 12). 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. Graph 11 concerns voice services only. Other services (SMS and data) are not represented in the graph.

Graph 12: Voice consumption per SIM card (minutes per month)

Source: "Model documentation" prepared 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 Mega Bytes (MB) per month in 2013, with an increase by 1.7% per year until 2025. Relatively to the use of high speed data services (*vide* Graph 13), 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

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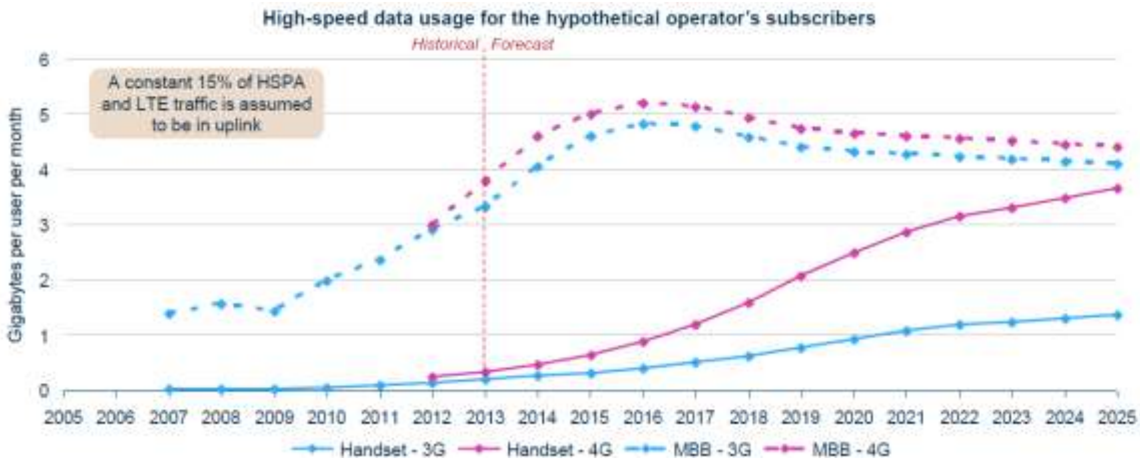
[12] Access to mobile broadband (MBB) through card/modem.

deployment. Moreover, as regards the voice service, it is also assumed that VoLTE will be launched commercially in 2016.

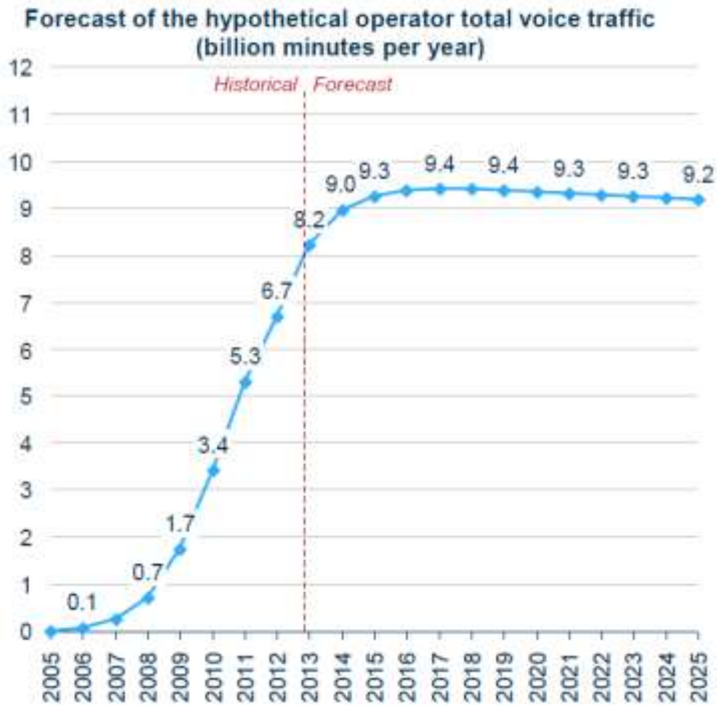
Graph 13: High-speed data usage for the hypothetical operator's subscribers



Source: "Model documentation" prepared by Analysys Mason

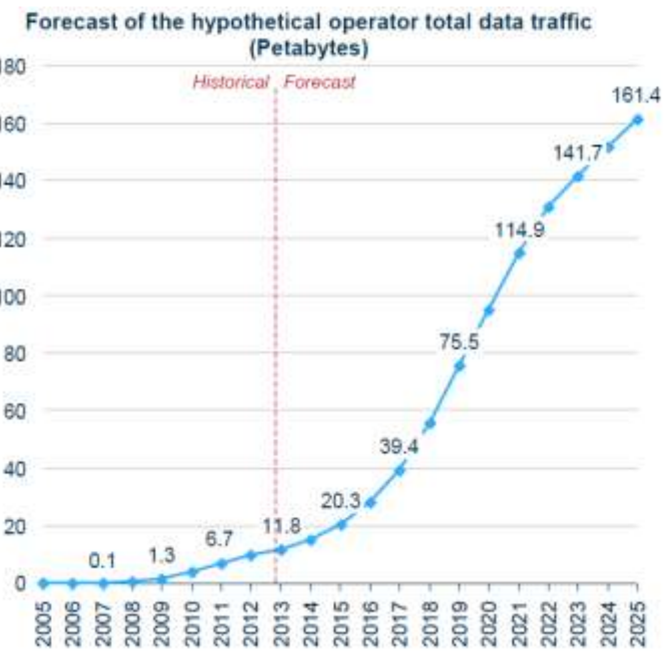
Usage data (voice traffic) are also based on observed data, where they exist, and on estimated data for the remaining modelled period. Voice traffic is expected to increase to around 9000 million minutes in 2014 and to gradually stabilise after that date (*vide* Graph 14). For data traffic, estimates point towards a drastic increase driven by the acceptance of high-speed data services in next generation mobile networks (*vide* Graph 15).

Graph 14: Forecast of the hypothetical operator total voice traffic



Source: "Model documentation" prepared by Analysys Mason

Graph 15: Forecast of the hypothetical operator total data traffic



Source: "Model documentation" prepared by Analysys Mason

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

Traffic volume

Taking into account contributions received in the scope of the DD, ANACOM took the view that the volume of overall traffic and, consequently, traffic of the hypothetical operator, 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 1396 minutes per customer/year in 2025, of which around 20.7% is termination traffic. The estimated data traffic is based on the current market-average usage, reaching 3252 MB per annum 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 higher 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 the 3G and also 4G networks has taken place, the latter still in a rudimentary way, in order to meet current needs of customers of mobile operators.

The former version of the mobile termination cost model already covered and modelled traffic migration from the 2G to 3G access networks. However, the relatively recent commercial launch of 4G services has added further complexity, as it requires a number of factors to be taken into account, including: i) the voice traffic migration occurring from 2G to 3G, from 3G to 4G and from 2G to 4G; ii) the fact that 4G technologies are IP-native, so voice traffic has to be routed throughout 4G networks as VoIP. On the other hand, traffic originated by customers of top level network may have to be carried over lower level networks, on grounds related to network coverage, the type of terminal used or capacity management.

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

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

Option 2 - to favour a rapid migration 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, no signs on a full migration from 2G to 3G and/or 4G, in the short-medium term, have been found.

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 the 4G network 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, this participation 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%

Source: "Conceptual approach for a mobile BU-LRIC model", Analysys Mason, 2015

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, 2015

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 2016, of the VoLTE platform, which is admitted to be able to follow the trend of other countries. This proportion is considered to increase over time, until it stabilizes by 2025. The level of ubiquity of the 4G network in 2018 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 progressive 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 state 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 around 50% of its subscriber database and 91% of total high-speed data traffic (i.e. HSPA and LTE) to 4G by 2019. It is assumed that the commercial launch of VoLTE occurs in 2016, having migration been modelled to reach 40% of the voice and messaging traffic generated by 4G subscribers in 2018 (two years later).

2.3.3.4. Retail and wholesale costs

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

Relevant increment

In this context, ANACOM considers that the model to be developed must follow the EC Recommendation on the increment to be used, that is, by establishing the avoidable costs of the wholesale mobile termination service 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 average utilisation levels that efficient operators may have 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 face the loss of value of fixed assets, which depreciate over time, which is aimed for the respective replacement 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 (*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 the call termination service 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 arose 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 long-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.

The original model included an appropriate and reasonable remuneration of investments made by the hypothetical efficient operator, taking associated risks into account, deemed 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 theoretically and technically is acknowledged to be apt to achieve objectives listed above (*vide* annex I, II and III).

[13] Paragraphs 1 and 2 of article 74 of Law No 5/2004, of 10 February, as amended by Law No 51/2011, of 13 September.

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 service of call termination on the mobile network, 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 (former PT Comunicações), 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 original model was developed. 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 that a rate of real cost-of-capital by 8.68% is deemed to be appropriate.

2.3.4.5. Calibration of the model

In order to ensure that the results produced by the model reasonably represent the underlying reality, the consultant carried out a network calibration exercise and an economic calibration, as described below (*vide* the section “Model Calibration” in annex II).

In brief, network calibration consisted in the comparison, for certain classes of network elements[15], of the number of network elements which according to each mobile operator is used with the values produced by the model, considering an operator with comparable characteristics, namely at the level of the 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 produced by the model and values reported by operators were analysed to make it clear why they emerged. Such differences, when deemed to be appropriate, resulted also in the modification of certain parameters of the model, in order

[14] Calculation of the rate of cost of capital of PTC, applicable to 2014, available at ANACOM’s website, Calculation of PTC's cost of capital, applicable in 2014

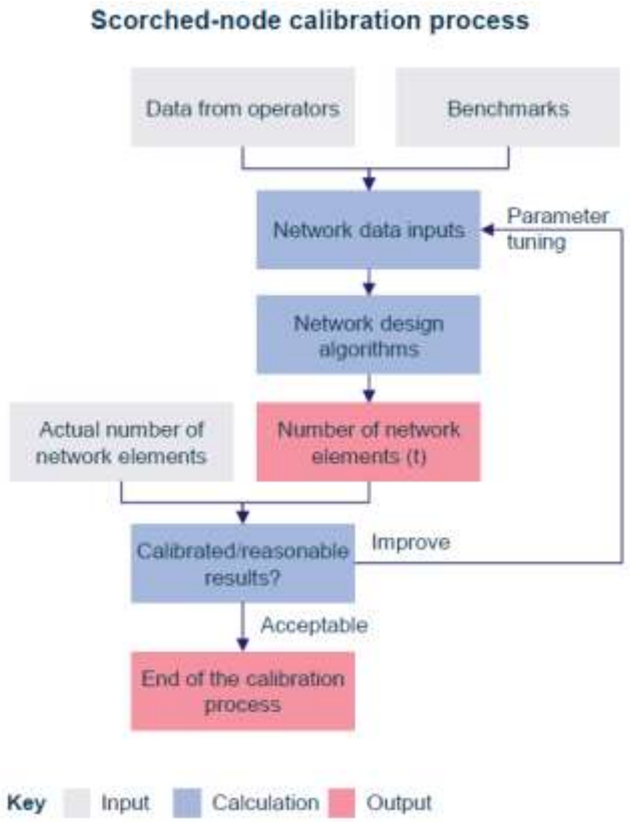
[15] For example, sites, BTS, TRX, NodeB, Channel Kits, Carriers, BSC, RNC, Switching sites, MSC and MGW.

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 until it replicates values reported by mobile operators, as their networks were gradually built (i) at a different and earlier time, 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.

Figure 10 – Model calibration process



Source: “Model documentation” prepared by Analysys Mason

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

[BCI – Beginning of Confidential Information]

Figure 11 – Calibration between model results and operator information

[redacted]

Source: “Model documentation” prepared by Analysys Mason

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

[redacted]

Source: “Model documentation” prepared 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 estimates prepared by the consultant.

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), produced 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 produced by the model and values reported by operators were analysed to make it clear why they emerged. 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 until 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.

Figure 13 illustrates results of the economic calibration.

[BCI]

Figure 13 – Economic calibration of the model (capex and opex)

[redacted]

Source: "Model documentation" prepared by Analysys Mason

[ECI]

ANACOM considers that there is a good correlation between data reported by mobile operators and equivalent data generated by the model, both at the level of main modelled network equipment, and at capex and opex levels.

2.4. Results of the model

Taking into consideration the description of modelled options and of mechanisms used to implement these options in practise, unit incremental costs (in 2013 terms) of the wholesale mobile termination service, calculated according to the "pure" LRIC methodology (*vide* Graph 16), are presented below.

As may be seen, 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, is, in 2015, around 0.83 cents per minute (in 2013 terms) or 0.83 cents per minute considering an inflation value close to -0.3% in 2014[16] and an expected inflation by 0.7%[17] in 2015, rounded to the closest one hundredth of a euro.

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[16] http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=211221946&DESTAQUEStema=00&DESTAQUESmodo=2

[17] According to the State Budget for 2015.

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 services, that is, 2016 and 2017, should be identified at this point, updated on the basis of existing and foreseen inflation data, as described below:

MTR (2015) = 0.83 €c * (1 - 0.3%) * (1 + 0.7%) = 0.83 €c

MTR (2016) = 0.80 €c * (1 - 0.3%) * (1 + CPI (2015)) * (1 + SB (2016))

MTR (2017) = 0.73 €c * (1 – 0.3%) * (1 + CPI (2015)) * (1 + CPI (2016)) * (1 + SB (2017))

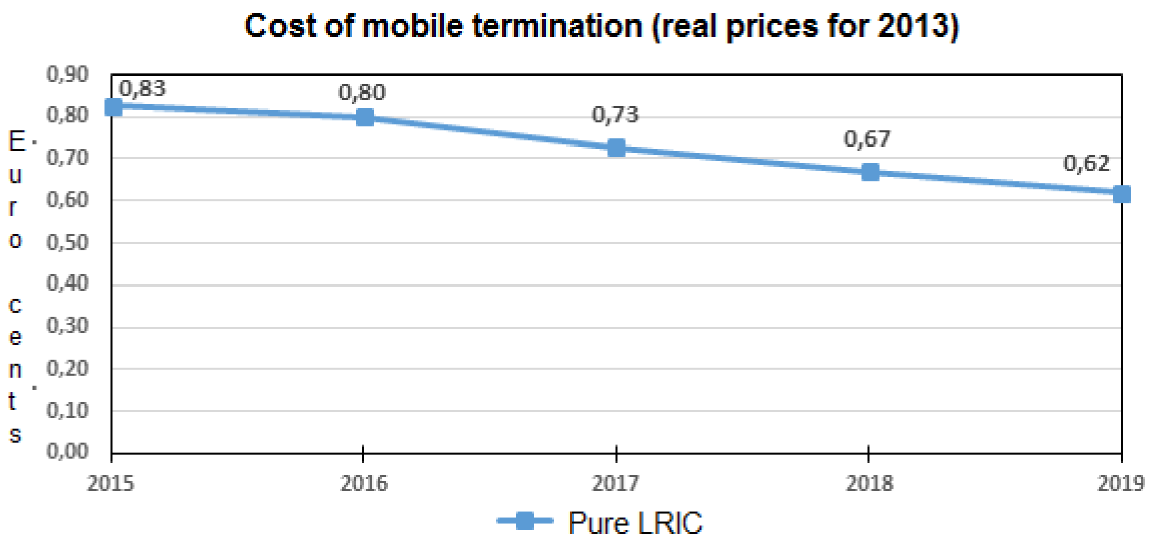
In this context:

- 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 approved, as far as 2015 prices are concerned, and on 1 July 2016 and 1 July 217, respectively, for prices concerning 2016 and 2017.

In order to make above-mentioned price update operational, ANACOM shall notify operators holding significant market power in these markets, by the end of the 1st third of the year, the resulting update for 2016 and 2017, and shall make this information available also at its website.

Graph 16 – Results produced by the model



Source: Cost model prepared by ANACOM and Analysys Mason

As referred earlier, in addition to this document, interested parties must take account of the report of the prior hearing of stakeholders and of the public consultation, documents in annex prepared 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 will not 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, as regards assumptions considered and the structure of calculation of algorithms used, having elements deemed to be confidential 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, will allow the various stakeholders to adequately understand the modelled hypothetical operator.

3. Decision

Taking into account the grounds given above, 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[18], ANACOM's Management Board, pursuant to articles 66 and 74 of the same Law, hereby determines:

1. To adopt the analysis of the mobile termination market together with the mobile termination cost model described in this document and respective annexes.

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 0.83 Euro cents per minute, ten working days after approval of the final decision on this subject, on the basis of per-second billing throughout the call.

3. To determine that the price ceiling of 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.

[18] As amended by Law No 51/2011, of 13 September.

Annex A: List of acronyms and abbreviations

2G	Second generation of mobile telephony (GSM)
3G	Third generation of mobile telephony (UMTS)
4G	Fourth generation of mobile telephony (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)
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
DD	Draft Decision
DNS	Domain name system
DSL	Digital subscriber line
DTM	Data traffic manager
E1	2Mbit/s unit of capacity
ECL	Electronic Communications Law
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
€c	Euro cents
FAC	Fully allocated cost
FDD	Frequency division duplex
FL-LRIC	Forward-looking long-run incremental cost
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
IMS	IP multimedia subsystem
IN	Intelligent network
IP	Internet protocol
IRU	Indefeasible right of use
LMA	Last-mile access
LRAIC	Long-run average incremental cost
LRAIC "+"	Long Run Average Incremental Costs, where "+" represents an increment intended for 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
Market 2	Wholesale voice call termination on individual mobile networks

Mbit/s	Mega bits per second
MB	Mega Bytes
MBB	Mobile broadband
MEA	Modern-equivalent asset
MGW	MediaGateway
MIMO	Multiple input, multiple output
MME	Mobility management entry
MMS	Multimedia messaging service
MMSC	MMS centre
MNO	Mobile Network Operator
MoU	Memorandum of Understanding
MSC	Mobile switching centre
MSS	Mobile switching centre server
MT	Mobile termination
MTR	Mobile termination rate
MVNO	Mobile Virtual Network Operator
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
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
SDCCH	Stand-alone dedicated control channel
SGSN	Serving GPRS support node
SGW	Serving gateway
SIM	Subscriber identity module
SMP	Significant Market Power
SMS	Short message service
SMSC	Short message service centre
SNOCC	Scorched-node coverage coefficient
STM	Synchronous transfer mode
SWG	Server gateway
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

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