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Report for ICP – Autoridade Nacional de Comunicações (ICP-ANACOM)

Conceptual approach for the fixed BU-LRIC model

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Contents

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1 Introduction

ICP − Autoridade Nacional de Comunicações (ICP-ANACOM) has commissioned Analysys Mason Limited (Analysys Mason) to develop a bottom-up long-run incremental cost (BU-LRIC) model for the purpose of understanding the costs of fixed voice termination services in Portugal. This wholesale service falls under the designation of Market 3 of the European Commission (EC) Recommendation on relevant product and service markets within the electronic communications sector susceptible to *ex ante* regulation.[1]

This document describes the key concepts underlying the development of the fixed BU-LRIC model, which was issued for public consultation by ICP-ANACOM on 20 November 2013 ('the Concept Paper'). It also summarises the comments received from the stakeholders and sets out Analysys Mason's response to the stakeholder comments on each of the proposed concepts.

The BU-LRIC model will be issued for public consultation, to invite industry stakeholders within the electronic communications sector in Portugal to provide input on the development of the model.

Modelling approach

In May 2009, the EC published its Recommendation on the regulatory treatment of fixed and mobile termination rates in the European Union (EU) ('the Recommendation').[2] The Recommendation adopts a more specific approach to costing and regulation than previous guidelines. It recommends that National Regulatory Authorities (NRAs) calculate the costs of termination services on the basis of 'pure BU-LRIC models'. In particular, the Recommendation sets out the following guidelines:

- the relevant increment is the wholesale call termination service only (as opposed to all traffic as in total service long-run incremental cost (TS-LRIC) or long-run average incremental cost plus (LRAIC+) models)
- common costs and mark-ups are excluded.

ICP-ANACOM intends to build a bottom-up model in line with the EC Recommendation regarding the application of a pure LRIC approach. This document describes the modelling approach we have taken for the BU-LRIC model.

The conceptual issues to be addressed throughout this document are classified in terms of four dimensions: operator, technology, service and implementation, as shown in Figure 1.1 below.

1 COMMISSION RECOMMENDATION of 17 December 2007 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/LexUriServ/LexUriServ.do?uri=OJ:L:2007:344:0065:0069:en:PDF

2 COMMISSION RECOMMENDATION of 7 May 2009 on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU (2009/396/EC). Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:124:0067:0074:EN:PDF

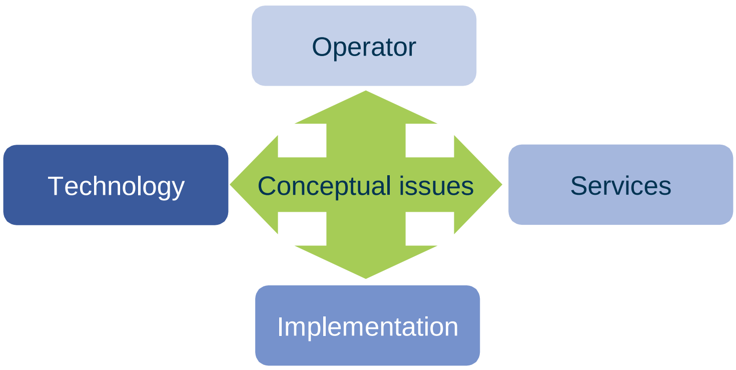


Figure 1.1: Framework for classifying conceptual issues [Source: Analysys Mason, 2013]

Operator

The characteristics of the operator used as the basis for the model represent a significant conceptual decision with major costing implications:

- What **structural implementation** of the model should be applied? Typically, this question aims to resolve whether top-down models built from operator accounts should be used, or whether a more transparent bottom-up network design model should be applied. This issue is not debated further herein as ICP-ANACOM requires that a bottom-up approach be applied to calculate the costs of fixed voice termination.
- What **type of operator** should be modelled – actual operators, average operators, a hypothetical existing operator, or some kind of hypothetical entrant to the market?
- What is the **footprint** of the operator being modelled – is the modelled operator required to provide national service (or at least to 99%+ of the population), or some specified sub-national coverage?
- What is the **scale** of the operator in terms of market share?

Technology

The type of network to be modelled depends on the following conceptual choices:

- What **technology and network architecture** should be deployed in the modelled networks? This concept encompasses a wide range of technological issues which aim to define the modern and efficient standard for delivering the voice termination services.
- What is the appropriate way to define the **network nodes**? When building models of operator networks in a bottom-up manner using modern technology, it is necessary to determine which functionality should exist at the various layers of nodes in the network. Here we can use either a *scorched-node* or a *scorched-earth* approach, although more complex node adjustments may be carried out in the fixed network.

Service Within the service dimension, we define the scope of the services being examined:

- What **service set** does the modelled operator support?
- How should **traffic volumes** be determined?
- Are costs calculated at the **wholesale** or **retail** level?

Implementation A number of implementation issues must be defined to produce a final cost model result. They are:

- What **increments** should be costed?
- What **depreciation** method should be applied to annual expenditures?
- What is the **weighted average cost of capital** (WACC) for the modelled operator?

Structure of the document

The remainder of this document is structured as follows:

- Section 2 introduces the principles of long-run incremental costing
- Section 3 deals with operator-specific issues
- Section 0.0.0 discusses technology-related conceptual issues
- Section 0.0.0 examines service-related issues
- Section 0.0.0 explores implementation-related issues.

For each concept, we summarise the comments received from the stakeholders during the public consultation and set out Analysys Mason's response to each of the stakeholder comments.

The report includes several annexes containing the following supplementary materials:

- Annex A introduces aspects of the implementation of the economic depreciation
- Annex B includes a list of the fixed core next-generation network (NGN) assets
- Annex C includes a list of acronyms used throughout this document.

2 Principles of long-run incremental costing

This section discusses the main concepts and principles underlying the long-run incremental costing methodology for fixed voice termination. It is structured as follows:

- concepts of competitiveness and contestability (Section 2.1)
- long-run costing (Section 2.2)
- incremental costing (Section 2.3)
- efficiently incurred costs (Section 2.4)
- costs of supply using modern technology (Section 2.5).

2.1 Competitiveness and contestability

The 13th Recital[3] of the EC Recommendation is in line with the principle that LRIC reflects the level of costs that would occur in a competitive or contestable market. Competition ensures that operators achieve a normal profit and normal return over the lifetime of their investment (i.e. the long run). Contestability ensures existing providers charge prices that reflect the costs of supply in a market that can be entered by new players using modern technology. Both of these market criteria ensure that inefficiently incurred costs are not recoverable.

2.2 Long-run costs

Costs are incurred in an operator's business in response to the existence of, or change in, service demand, captured by the various cost drivers. Long-run costs include all the costs that will ever be incurred in supporting the relevant service demand, including the ongoing replacement of assets used. As such, the duration 'long run' can be considered at least as long as the network asset with the longest lifetime. Long-run costing also means that the size of the network deployed is reasonably matched to the level of demand it supports, and any over- or under-provisioning would be levelled out in the long run.

Consideration of costs over the long run can be seen to result in a reliable and inclusive representation of cost, since all the cost elements would be included for the service demand supported over the long-run duration, and averaged over time in some way. On the other hand, short-run costs are those which are incurred at the time of the service output, and are typically characterised by large variations: for example, at a particular point in time, the launch or increase in a service demand may cause the installation of a new capacity unit, giving rise to a high short-run unit cost, which then declines as the capacity unit becomes better utilised with growing demand.

Therefore, in a LRIC method, it is necessary to identify incremental costs as all cost elements, which are incurred over the long run to support the service demand of the increment.

This is in agreement with the 13th Recital of the EC Recommendation, which recognises that all costs may vary over the long run.

3 L 124/69 of the Official Journal of the European Union (20 May 2009).

2.3 Incremental costs

Incremental costs are incurred in the support of the increment of demand, assuming that other increments of demand remain unchanged. Put another way, the incremental cost can also be calculated as the avoidable costs of not supporting the increment.

There is considerable flexibility in the definition of the increment, or increments, to apply in a costing model, and the choice should be suitable for the specific application. Possible increment definitions include:

- the marginal unit of demand for a service
- the total demand for a service (e.g. voice service termination, which is the option favoured by the EC Recommendation)
- the total demand for a group of services
- the total demand for all services in aggregate.

In Figure 2.1, we illustrate where the possible increment definitions interact with the costs that are incurred in a five-service business.

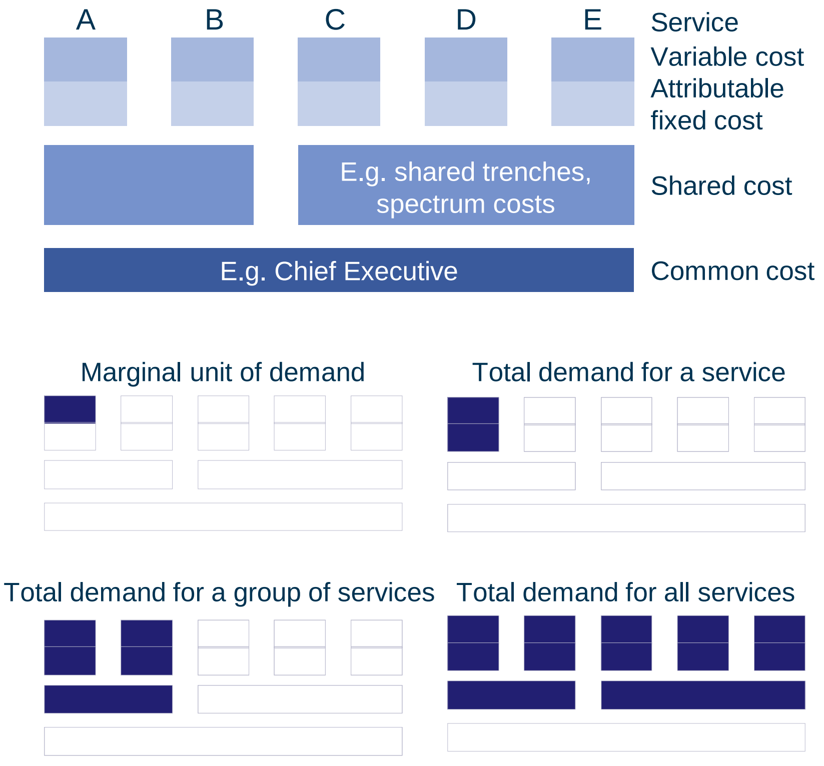


Figure 2.1: Possible increment definitions [Source: Analysys Mason, 2013]

Section 6.1 discusses the definition of the increments that are proposed to be used in the BU-LRIC model in more detail.

2.4 Efficiently incurred costs

In order to set the correct investment and operational incentives for regulated operators, it is necessary to allow only efficiently incurred expenditures in cost-based regulated prices. The specific application of this principle to a set of cost models depends significantly on a range of aspects:

- detail and comparability of information provided by individual operators
- detail of modelling performed
- the ability to uniquely identify inefficient expenditures
- the stringency in the benchmark of efficiency which is being applied[4]
- whether efficiency can be distinguished from below-standard quality.

The Portuguese operators are active in a competitive market, which includes both the competitive supply of services to end users, and the competitive supply of infrastructure and services to those operators. Therefore, the *a priori* expectation of inefficiencies in the market may be limited. However, it is still necessary to ensure that there is a robust assessment of efficiently incurred costs.

2.5 Costs of supply using modern technology

In a market, a new entrant that competes for the supply of a service would deploy modern technology to meet its needs – since this should be the efficient network choice. This implies four 'modern' aspects: (i) the choice of network technology (e.g. TDM, IP); (ii) the capacity of the equipment; (iii) the price of purchasing that capacity; (iv) and the costs of operating and maintaining the equipment. Therefore, a LRIC model should be capable of capturing these aspects:

- *The choice of technology should be efficient* – Legacy technologies which are being phased out should not be considered modern.

- *Equipment capacity should reflect the modern standard* – For instance, switches become larger in absolute capacity over time; new-generation switches may be optimised to have improved capacity.

- *The modern price for equipment represents the price at which the modern asset can be purchased over time* – It should represent the outcome of a reasonably competitive tender for a typical supply contract in Portugal. It is expected that operators in Portugal should be able to acquire their equipment at typical European prices given that they are part of large international groups with centralised sourcing, or they should have a comparable purchasing power to that of their European peers. A data request has been sent to the Portuguese fixed operators in order to obtain their estimate of the unit costs for the different network elements. We expect to complement the Portuguese data points with European benchmarks in order to come to a final view of the equipment costs in the model.

4 For example: most efficient in Portugal, most efficient in Europe, most efficient in the world.

- *Operation and maintenance costs should correspond to the modern standard of equipment*, and represent all the various facility, hardware and software maintenance costs relevant to the efficient operation of a modern standard network.

The definition of modern equipment is a complex issue. Fixed operators around the world are at different stages of deploying fixed next-generation IP-based core networks: from initial plans to fully deployed.

The EC Recommendation states that for a fixed network the efficient technological choice on which the cost models should be based in principle is a next-generation-based core network. This appears to be the current efficient technology applicable to Portugal. (Please see Section 4.1 for a discussion about the choice of network architecture for the BU-LRIC model.)

3 Operator issues

This section discusses the following aspects of the modelled operator:

- type of operator (Section 3.1)
- network footprint of the operator (Section 3.2)
- efficient scale of the operator (Section 3.3).

3.1 Type of operator

The type of operator to be designed in the model is the primary conceptual issue which determines the subsequent structure and parameters of the model. The full range of operator choices is:

- **Actual operators**: in which the costs of all actual market players are calculated.
- **Average operator**: in which the players in the fixed market are averaged together to define a 'typical' operator.
- **Hypothetical existing operator**: in which an operator is defined with characteristics similar to, or derived from, the actual operators in the market, except for specific hypothetical aspects that are adjusted (e.g. the date of entry).
- **Hypothetical new entrant**: in which a hypothetical new entrant to the market is defined as an operator entering in 2013 with today's modern network architecture, which acquires an incumbent's share of the market.

At this stage, we exclude the option to apply actual operators. This is because:

- It would reduce costing and pricing transparency and increase the risk/complexity of ensuring identical/consistent principles are applied if the method were to be applied to individual operator models for all fixed players.
- The EC recommends costing an operator with an efficient scale – by implication, not an actual operator.
- It would be inconsistent with the previous mobile BU-LRIC approach, which adopted a hypothetical operator launching services in 2006 and reached a minimum efficient scale in 2010.

Therefore, we consider three options for the type of operator to be modelled. The characteristics of these options are outlined in the table below.

Figure 3.1: Operator choices [Source: Analysys Mason, 2013]

Characteristics	Option 1: Average operator	Option 2: Hypothetical existing operator	Option 3: Hypothetical new entrant
Date of entry	Different for all operators, therefore an average date of entry is not meaningful	Can be set to a consistent date of entry, taking account of key milestones in the real networks (e.g. migration from next-generation SDH to Ethernet)	In this case, the date of entry is inferred from the EC Recommendation, which sets a relation between time and the acquisition of market share
Technology	Different for all fixed operators (e.g. level of roll-out of all IP core), therefore an average fixed technology is not appropriate, most advanced operators would bear the costs of less-efficient ones (see 'efficiency' section below)	The technology of a hypothetical operator can be specifically defined, taking into account relevant technology components of existing networks. In the case where the hypothetical existing operator is modelled as an operator entering the market in recent years, the EC Recommendation specifies the appropriate technology mix	By definition, a hypothetical new entrant would employ today's modern technology choice. The EC specifies a next-generation all-IP fixed core network
Evolution and migration to modern technology	The main fixed operators have evolved and migrated in significantly different ways – the average evolution is not straightforward to define	The evolution and migration of a hypothetical operator can be specifically defined, taking into account the existing networks. Legacy network deployments can be ignored if migration to next-generation technology is expected in the short-to-medium term or has already been observed in real networks	By definition, a hypothetical new entrant would start with the modern technology. Therefore evolutionary or migratory aspects are not relevant. However, the rate of network roll-out and subscriber evolution will be a key input to the model
Efficiency	May include inefficient costs through the average	Efficient aspects can be defined	Efficient choices can be made throughout the model
Comparability and transparency of bottom-up network modelling with real operators	The network model of an average operator would only be comparable with an average across the real network operators. However, it would be possible to illustrate this average comparison in a reasonably transparent way	In order to compare a hypothetical operator network model with real operators, it would be necessary to transform the actual operator information in some way (e.g. averaging, or re-scaling to reflect the characteristics of the hypothetical operator). While the hypothetical operator model would be transparent to industry	In principle, the hypothetical new entrant approach is fully transparent in design. However, since none of the real operators is a new entrant, it would not be possible to do a like-for-like comparison against real operator network information

Characteristics	Option 1: Average operator	Option 2: Hypothetical existing operator	Option 3: Hypothetical new entrant
		parties, the comparison against real operator information might include additional steps which need to be explained	
Practicality of reconciliation with top-down accounting data	It is not possible to directly compare an average operator with actual top-down accounts. Only indirect comparison (e.g. overall expenditure levels and opex mark-ups) is possible	It is not possible to directly compare a hypothetical existing operator with actual top-down accounts. Only indirect comparison (e.g. overall expenditure levels and opex mark-ups) is possible	It is not possible to directly or indirectly compare a hypothetical new entrant model to real top-down accounts without additional transformations in the top-down domain (e.g. current cost revaluation)

There are four key issues in deciding the type of operator to be modelled:

Is the choice appropriate for setting cost-based regulation?

All three options presented above could be considered a reasonable basis on which to set cost-based regulation of wholesale fixed termination services. However in the case of Option 1, inefficient costs would need to be excluded.

What modifications and transformations are necessary to adapt real information to the modelled case?

The table above summarises the various transformations which will be required in the modelling approach (e.g. migration from next-generation SDH to Ethernet).

Are there guidelines which should be accommodated (e.g. the EC Recommendation)?

The EC Recommendation suggests that an efficient-scale operator should be modelled. However, the precise characteristics of this type of operator are not defined. In principle, all three of the above options can satisfy the efficient-scale requirement.

Flexibility

A model constructed for Option 3 would be designed in such a way as to exclude historical technology migrations. It would also be mechanically designed to start its costing calculations in 2013. Therefore, the model for Option 3 can be considered linked to the type of operator modelled.

A model constructed for Option 2 can, if known at the outset, also be used to calculate costs for Option 3 by assuming a modern equivalent asset (MEA) deployment from the beginning of the period of operation and adjusting the subscriber demand and take-up.

Proposed concept 1: We do not recommend Option 1 (average operator) as it is dominated by historical issues rather than modern and efficient network aspects.

We propose that the cost model be based on Option 2 (hypothetical existing operator) since this enables the model to determine a cost consistent with the existing suppliers of fixed termination in Portugal, such that actual network characteristics in recent years can be taken into account. This way, it will also be consistent with the type of operator modelled in the mobile BU-LRIC model built by ICP-ANACOM.

The operator modelled would therefore be:

A fixed operator rolling out a national NGN IP core network in 2009, and launching voice services in 2010. The core network design would be linked to a specific choice of next-generation access technology. The NGN IP core would be operated for the long term, at least 25 years, and thus migration off the NGN IP core would not be modelled.

Stakeholders' comments

Four parties [**PT, DECO, OniTelecom and Cabovisão**] mostly agree that the cost model should be based on Option 2 (hypothetical existing operator), while one party believes that Option 3 (hypothetical new entrant) would be more appropriate.

One party [**DECO**] agrees without any caveat.

One party [**PT**] suggests that while agreeing with the recommended option, a longer horizon is required to reach a minimum efficient scale.

Two parties [**OniTelecom and Cabovisão**] argue that although they do not oppose the choice of a hypothetical operator, it should be noted that there are operators in the market far from the level of efficiency of the hypothetical operator, namely those which have less than 10% of originated traffic. They argue that these operators certainly have different costs from those of operators with a traffic market share of above 30%, so in the event of a reduction in fixed termination rates, they argue that differentiated termination prices should be set for the operators with less than 10%. Therefore, in order to provide a smooth transition to termination rates based on efficient cost models, a glide path should be applied to those operators with less than 10% of traffic.

One party [**ZON OPTIMUS**] mentions that the option of a hypothetical operator is appropriate, as it minimises the inconsistencies associated with calculation of the costs of the average operator. However, it considers that the choice should have been a hypothetical new entrant, as this would avoid the limitations associated with the modelling of a hypothetical existing operator.

Analysys Mason response

Although numerous parties agree with the proposed concept, one party has indicated that it prefers a hypothetical new-entrant model. We consider that a hypothetical new-entrant cost model would need, in some way, to be grounded in the reality of the Portuguese fixed operators. In our view, without having a full existing operator model which can be compared with existing operations, a hypothetical new-entrant model would be more speculative and difficult to populate. It would therefore suffer from more disadvantages than advantages compared to the hypothetical existing operator approach: for example, it would not reflect real-world technology evolution in recent years, it would only model the future and it would be harder to justify use of any existing nodes in the fixed networks. Provided that the hypothetical existing operator is modelled using an efficient mix of technologies and deployments available today (which is our proposal, e.g. as in concepts 5, 6 and 7), we do not think that it would set an unduly lenient benchmark of costs.

One party has suggested considering a longer time horizon for reaching the minimum efficient scale. We comment on this issue later, under Concept 4.

Finally, two parties have asked for a glide path of the termination rates to take into account the smaller scale (and then the lower efficiency level) of the operators with less than 10% of traffic share. This is actually a pricing issue and not a cost modelling one, and then it cannot be addressed in this context.

Conclusions

Concept 1: The cost model will be based on Option 2 (hypothetical existing operator), since this enables the model to determine a cost consistent with the existing suppliers of fixed termination in Portugal, such that actual network characteristics in recent years can be taken into account. In this way, it will also be consistent with the type of operator modelled in the mobile BU-LRIC model built by ICP-ANACOM.

The operator modelled would therefore be:

A fixed operator rolling out a national NGN IP core network in 2009, and launching voice services in 2010. The core network design would be linked to a specific choice of next-generation access technology. The NGN IP core would be operated for the long term, at least 25 years, and thus migration off the NGN IP core would not be modelled.

3.2 Network footprint of operator

Coverage is a central aspect of network deployment. The question of what coverage to apply to the modelled operator can be understood as follows:

- What is the current level of coverage applicable to the market today?
- Is the future level of coverage different from today’s level?

- Over how many years does the coverage roll-out take place?
- What quality[5] of coverage should be provided, at each point in time?

The coverage offered by an operator is a key input to the costing model. The definitions of coverage parameters have two important implications for the cost calculation:

Level of unit costs due to the present value (PV) of expenditures

The rate, extent and quality of coverage achieved over time determine the PV of associated network investments and operating costs. The degree to which these costs are incurred prior to demand materialising represents the size of the 'cost overhang'. The larger this overhang, the higher the eventual unit costs of traffic will be. The concept of a cost overhang is shown below in Figure 3.2.

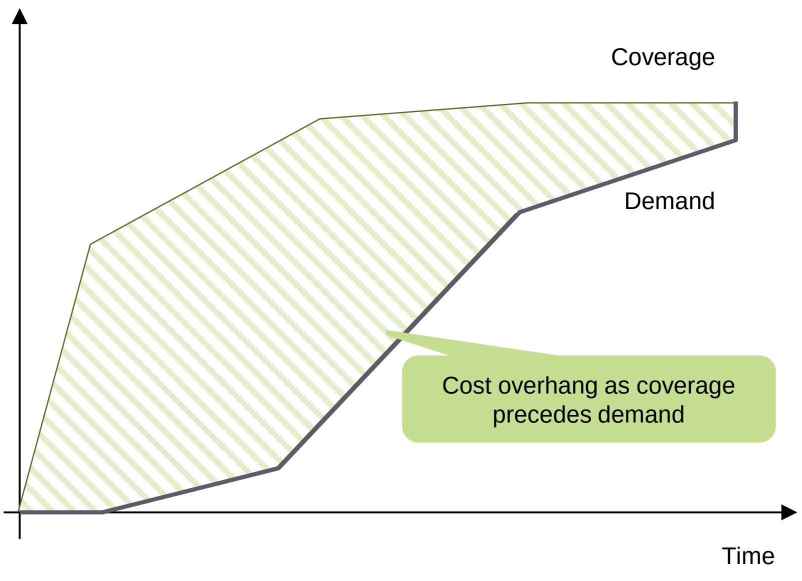


Figure 3.2: Cost overhang [Source: Analysys Mason, 2013]

Identification of network elements that are driven by traffic

In a situation where the coverage deployment is significant, fewer network elements are likely to be dependent on traffic. This has particular implications during the application of a small traffic-related increment (see Section 6.1 on *Choice of Increment*).

Using actual fixed network coverage is a pragmatic choice for the principle of fixed network footprint; PT's network coverage is national, and therefore it appears a reasonable choice. If regional coverage would lead to significant and exogenous cost differences, a case could be made for modelling regional coverage. However, cable operators are not limited by exogenous factors in expanding their coverage. They have the possibility to do so by their own deployment, leasing capacity outside their own coverage area, or by joining with other sub-national operators (as is already achieved by the main cable operators). Different cost prices due to lower economies of geographical scale are therefore not to be reflected in the costs of an efficient operator providing termination services.

5 In the case of fixed networks, the quality is related to the availability, access sharing, etc.

> **Proposed concept 2**: National levels of geographical coverage represented in the model will be comparable to that offered by current national fixed operators in Portugal.

Stakeholders' comments

Two parties **[PT]** and **[ZON OPTIMUS]** agree with the proposed concept.

Analysys Mason response

Since all the parties that commented on this concept are in agreement, the proposed concept will be maintained.

Conclusions

> **Concept 2**: National levels of geographical coverage represented in the model will be comparable to that offered by current national fixed operators in Portugal.

3.3 Efficient scale of operator

One of the main parameters that defines the cost (per unit) of the modelled operator is its market share: it is therefore important to determine the evolution of the market share of the operator and the period over which this evolution takes place.

The parameters chosen for defining the operator's market share over time influence the overall level of economic costs calculated by the model. The quicker the operator grows,[6] the lower the eventual unit cost of traffic should be.

The scale of the modelled operator is primarily determined by the number of actual players in the fixed market. In Portugal, there are five major competing providers: PT, Vodafone, Sonaecom and the cable operators ZON Optimus and Cabovisão; they all use different access technologies: copper, cable and/or fibre.[7]

Consistent with ICP-ANACOM's desire to reflect a competitive, efficient, cost-based market for the regulated supply of wholesale voice termination, the BU-LRIC model will take into account the costs of an operator in a fully competitive market:

- in a fully competitive market with *n* operators, each operator will have a *1/n* share of the market in the long term, i.e. *1/n* share of all standard retail and wholesale services in Portugal.

6 E.g. the net present value of demand – therefore reflecting the discounted combination of eventual share and rate of acquiring share.

7 Consolidation is occurring in the telecoms market: the merger between Sonaecom and ZON Multimedia was approved in July 2013.

However, it should be noted that the main fixed operators do not cover the same areas of Portugal. For example, all of them are present in Greater Lisbon and Porto; however, some areas are only covered by PT and the cable operators, while in others PT is the only service provider:

- The combined network of the cable operators covers most of the households in 167 municipalities, with little overlap between the different networks. This implies that a two-player market in areas not covered by the fibre-to-the-home (FTTH) network of alternative operators seems reasonable.
- Both PT and the alternative operators are building their own FTTH networks. PT already covers about half of the households in Portugal with fibre, while the alternative operators have entered into agreements to roll out FTTH networks in the main cities of Portugal (e.g. the joint venture between Vodafone and Sonaecom to roll out fibre in different areas of Portugal). This implies that a three-player market in areas where both PT and cable operators are present together with the alternative operators that have rolled out fibre seems reasonable.

Another issue related to the *scale* of the modelled operator is the time taken by the operator to achieve a steady market share. The model needs to specify the rate at which the modern network is rolled out, and the corresponding rate at which that modern network carries the volumes of the operator (up to the market share in the long term). There are a number of options in terms of modelling a hypothetical existing operator:

- **Option 1: Immediate scale** – In this option, the modelled operator immediately achieves its market share, and rolls out its network just in time to serve this demand at launch. This approach does not reflect real technology transitions.
- **Option 2: Matching the modern technology transition during the modelled years** – In this option, the utilisation of the modern technology during the specific recent years is observed for the actual networks and used to define an efficient profile for the hypothetical existing operator.
- **Option 3: Assuming a hypothetical roll-out and market share profile** – In this option, a time period to achieve a target network coverage (footprint) roll-out would be specified (e.g. three years), as well as a time period to achieve full scale (e.g. four years).
- **Option 4: Roll-out and growth based on history** – It is possible to apply roll-out and volume growth profiles which have been obtained directly from (the average of) the actual fixed operators. This approach would require looking back at networks *a long time ago*, and therefore would be complex to carry out, with numerous assumptions based on historical information.

Proposed concept 3: We suggest a long-run market share of 1/*n* for the modelled operator, with the value of 'n' defined to take into account the number of networks with a significant penetration operating in each geotype:

- In Greater Lisbon and Porto, there are primarily three competing providers: PT, the cable operators and the alternative operators that have built a FTTH network. Based on this, we suggest a long-run market share of 33% in these areas.
- In the rest of mainland Portugal where cable operators are present, there are primarily two competing providers: PT and the cable operators. Based on this, we suggest a long-run market share of 50% in these areas.
- In the rest of mainland Portugal where cable operators are not present, there is primarily only one service provider: PT. In addition to PT's network, a neutral operator is rolling out a new FTTx network in these municipalities. Based on this, we suggest a long-run market share of 100% in 2013, decreasing to reach 50% in the long run.
- In the Portuguese islands, there are primarily two competing providers: PT and the cable operators. Based on this, we suggest a long-run market share of 50% in these areas.

Proposed concept 4: We suggest considering Option 3, which is a time period to achieve a target network coverage (footprint) roll-out of two to three years and a time period to achieve full scale of three to four years. Coverage deployments are, in many cases, dictated by the strategic choice of the operator in order to compete and achieve a minimum market share nationwide.

Stakeholders' comments

To take more detailed account of all the comments received from stakeholders, we consider two aspects of this concept:

Fixed operators' share

While four parties [**PT, ZON OPTIMUS, Vodafone and DECO**] agree with the long-run market share, they have provided some comments.

Two parties [**ZON OPTIMUS** and **DECO**] agree without caveat.

One party [**PT**] agrees with the use of a long-run market share of 1/*n* for the modelled operator per geotype. However, this party argues that *n* should represent the number of *operators* operating in each geotype, rather than the number of *networks* per geotype. This party claims that it is not possible to have a market share of 100% in geotype 3 in 2013, since if there is an access network that provides call termination services, including wholesale services, the incumbent operator will also provide access to its network to third parties, so, by definition, the market share of the modelled operator could not be 100%.

One party [**Vodafone**] comments that the geotype of Greater Lisbon and Porto is too broad and it should be broken down at a municipal or parish level.

Rate of roll-out

One party [**ZON OPTIMUS**] agrees without any caveat.

Two parties [**PT** and **DECO**] agree with the methodology proposed but have provided comments. These parties argue that the timetable for achieving full scale (four years) is too short. One of these parties argues that, historically, roll-out of the access network took much longer than the proposed four years. Also, this operator mentions that the period required for the roll-out should include the time needed to build both the core network and the access network.

Finally, one party [**PT]** favours Option 2 ('Matching the modern technology transition during the modelled years').

Analysys Mason response

Fixed operators' market share

The scale of the operator is a reflection of the subscribers and traffic that it serves: this can be described through its market share. In order to define the long-run market share of the modelled operator we have considered the number of operators that have a significant penetration in the market, rather than the existing number of networks. We do not consider that local loop unbundlers or the indirect access providers have a significant market share in geotype 3, as the market share of these operators in the regions covered by geotype 3 was below 5% in 2013.

Thus, we consider it reasonable to assume that a hypothetical existing operator in geotype 3 would have 100% market share until the neutral operator has completed its network roll-out. When this happens, the hypothetical existing operator's market share will be consistently reduced to 50%.

One stakeholder points out that the definition of geotype 1, including Greater Lisbon and Porto, is too broad. We want to note that the geographical analysis (in terms of number lines, node co-ordinates, etc.) has been done at smaller level, municipality level; however, all the municipalities belonging to the same geotype have the same market share of subscribers by geotype. We consider that this approach allows the complexity of the model to be reduced, while still capturing the geographical diversity of Portugal.

Rate of roll-out

Two parties deem a timeframe of four years too short for achieving efficient scale. In line with the comments received, we propose to consider a roll-out period of ten years for the access layer. However, it is worth noting that the focus of the modelling exercise is the core network (for which the roll-out period is significantly shorter) and that the roll-out period for the access network has no impact on the pure LRIC result of the model because the access network is not incremental with respect to termination.

One party has argued that the most suitable option for setting market share is Option 2 ('Matching the modern technology transition during the modelled years'). We do not consider that use of Option 2 will lead to a consistent treatment of fixed network costs in an efficient, modern, forward-looking context. The actual evolution of copper, cable and fibre networks is related to events and expectations 10, 15 or even more years in the past. This option could lead to costs that are heavily dependent on historical developments of different operators, rather than the costs which today's modern, forward-looking operators should achieve through the operation of efficient networks. Consequently, we believe that it would be most consistent and competitively neutral to adopt the principle for the rate of roll-out of fixed networks represented by Option 3 ('hypothetical roll-out and market share profile').

Conclusions

Concept 3: The modelled operator will have a long-run market share of 1/*n*, with the value of 'n' defined to take into account the number of networks with a significant penetration operating in each geotype:

- In Greater Lisbon and Porto, there are primarily three competing providers: PT, the cable operators and the alternative operators that have built an FTTH network. Based on this, the modelled operator will have a long-run market share of 33% in these areas.
- In the rest of mainland Portugal where cable operators *are* present, there are primarily two competing providers: PT and the cable operators. Based on this, the modelled operator will have a long-run market share of 50% in these areas.
- In the rest of mainland Portugal where cable operators *are not* present, there is primarily only one service provider: PT. In addition to PT's network, a neutral operator is rolling out a new FTTx network in these municipalities, and is expected to launch its services in 2014. Based on this, the modelled operator will have a long-run market share of 50% by 2014.
- In the Portuguese islands, there are primarily two competing providers: PT and the cable operators. Based on this, the modelled operator will have a long-run market share of 50% in these areas.

Concept 4: We will consider Option 3, which is a time period to achieve a target network coverage (footprint) roll-out of three years and a time period to achieve full scale of four years. Coverage deployments are, in many cases, dictated by the strategic choice of the operator in order to compete and achieve a minimum market share nationwide.

4 Technology issues

This section describes the most important conceptual issues with regard to technology in the fixed BU-LRIC model. These are:

- the choice of modern network architecture (Section 4.1)
- the demarcation of networks layers (Section 4.2)
- the treatment of network nodes (Section 4.3).

4.1 Network design

The fixed BU-LRIC model will require a network architecture design based on a specific choice of modern technology. From the perspective of termination regulation, modern equivalent technologies should be reflected in this model: that is, proven and available technologies with the lowest cost expected over their lifetimes.

Fixed networks tend to comprise two layers of assets, both of which can be deployed using several technologies. These are typically referred to as the access layer and the core layer (incorporating the transmission network), although the precise boundary between the two layers is technology dependent and must be carefully defined. These layers are described below.

4.1.1 Access layer

The access layer connects end users to the network, allowing them to use fixed services. The architectural options for this layer are either copper, fibre or coax cable from the network termination point (NTP) in the end-user premises back to aggregation nodes within the network tree structure:

- a **traditional copper** architecture, with copper cable deployed back to nodes (street cabinets), and then back to exchanges
- a **cable** architecture, with coax cable deployed back to a hierarchy of fibre and metro aggregation nodes
- next-generation access (NGA) architecture using fibre cable, either through
  - **fibre-to-the-node (FTTN) VDSL**, which employs almost the same structure as traditional copper, except that fibre is deployed between the street cabinet and a smaller number of exchanges (metro core locations), with VDSL electronics installed in the cabinet
  - **fibre-to-the-home (FTTH) Gigabit passive optical network (GPON)**, which deploys fibre from the exchange in a tree structure using a hierarchy of splitters
  - **FTTH point-to-point (PTP)**, which deploys fibre from the exchange to the premises.

These options are shown below in Figure 4.1.

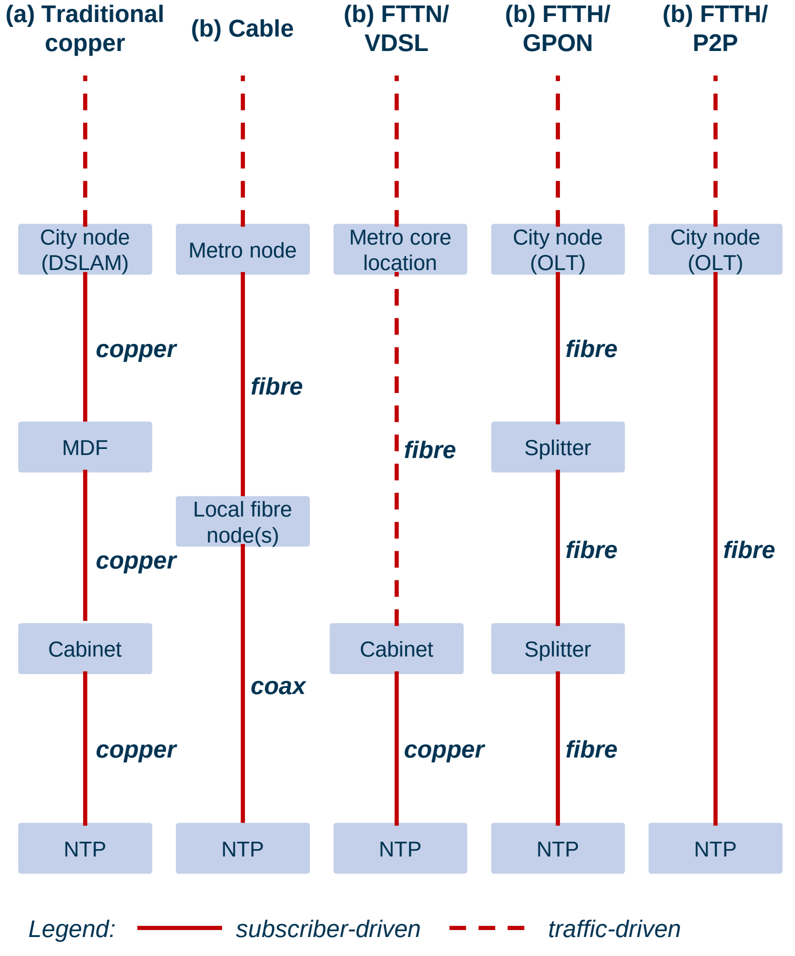


Figure 4.1: Options for the access layer in the fixed BU-LRIC model [Source: Analysys Mason, 2013][8]

As can be seen in Figure 4.1 above, there are a number of choices for the access architecture. The EC Recommendation provides no guidance on a suitable access technology for the fixed model. All five options are proven and available technologies and can be used to provide voice services: this includes cable – all the cable operators in Portugal have upgraded their networks to offer voice and high-speed broadband services. A mix of technologies may be appropriate: for example, fibre deployment in urban areas with traditional copper retained in the most remote areas of Portugal.

As the purpose of the BU-LRIC model is to understand the costs of fixed voice termination services in Portugal, we are not modelling the access network. These resources are located before the first point of traffic concentration, and, in line with the EC Recommendation, they should be excluded from the calculation of the costs of termination. However, the technology used in the access network will influence the design of the backbone and core network.

The model considers that the modern equivalent technology to provide voice services on a fixed network is voice-over-Internet-Protocol (VoIP) over a fibre access network (or at least, in most of

8 This figure has been updated according to one party's comment on Concept 8.

the network).[9] Therefore, the model considers a copper and fibre access network, without explicitly considering alternative technologies such as cable, wireless or other access technologies.

> **Proposed concept 5**: The modelled fixed access layer will be based on copper/fibre technology. Migration from copper to fibre will be modelled taking into account the NGA roll-outs of the fixed operators in Portugal.

Stakeholders' comments

One party [**ZON OPTIMUS**] agrees with the proposed concept without any caveat.

One party [**PT**] agrees with the concept; however, it wishes to highlight the fact that the model does not consider fixed–mobile convergence, which would lead to radio access technologies also being considered for the fixed termination rates.

Analysys Mason response

In our opinion a mobile access network cannot be considered to be a modern, efficient, forward-looking fixed technology. It can be argued that it could be more cost efficient to deploy certain wireless technologies (such as WiMAX/CDMA) in some specific rural areas. However, in the case of Portugal, most households are currently covered by fixed operators with wired technologies. Therefore, we have assumed that the modern-equivalent access technology that the hypothetical modelled operator would choose to roll out is fibre given the migration from copper to fibre that is already underway in Portugal.

Conclusions

> **Concept 5**: The modelled fixed access layer will be based on copper/fibre technology. Migration from copper to fibre will be modelled taking into account the NGA roll-outs of the fixed operators in Portugal.

4.1.2 Core layer

As in the access layer, there are both traditional and NGN core architectures. An NGN core is defined as a converged IP-based platform which will carry all services on the same platform. Certain deployment options are upgrades to the public switched telephone network (PSTN), while others use transport based on Ethernet and IP/MPLS switches and routers. However, the choice of NGN control layer is heavily influenced by the access network architecture. These options are summarised below:

- Traditional **time division multiplexing (TDM) core**, where the voice and data platforms are both carried and switched separately, but are conveyed on the same transmission

[9] It might be the case that in certain rural areas it could be more cost efficient to deploy a wireless network.

network.Cable **head-ends**, which contain several assets for distributing cable services, including:
  - antennas to receive incoming TV programming for distribution
  - a voice switch
  - the computer system and databases needed to provide Internet access, including the cable-modem termination system (CMTS).

- NGN **access gateways** (AGWs), which can be co-located in the PSTN concentrators or local switches (LS) to adapt the TDM backhaul links, retaining the separation of voice and data.

- NGN **3G digital loop carriers** (DLCs), which combine a traditional TDM cross-connect for legacy services with a broadband switch with asynchronous transfer mode (ATM) and Ethernet uplinks (i.e. voice and data can be controlled using this unit). These incorporate IP multicast capabilities for video delivery and a VoIP server gateway for PSTN emulation on a converged network. These are also commonly known as multi-service access nodes (MSANs).

- NGN **IP/Ethernet broadband access platforms** (IP BAP), which aggregate all varieties of service lines, including legacy interfaces, from IP-enabled line cards aggregated at a Gigabit Ethernet core.

The mix of access layer technologies determines the assets required in the NGN control layer. If deployments are oriented towards a copper access network, then a core with NGN DLCs would be appropriate. However, if the access layer contains extensive fibre deployments (i.e. FTTH/PTP or FTTH/GPON), then an IP BAP approach is more reasonable. The use of AGWs may be appropriate for the most remote customers, who are not assumed to be connected with fibre.

In addition, the EC Recommendation states that "*the core part could be assumed to be NGN-based*" [Clause 12]. Therefore, given that a copper/fibre access layer is deployed, we conclude that an IP BAP architecture is most appropriate (if a cable network were to be modelled, then a cable head-end would be appropriate).

Proposed concept 6: Given that a copper/fibre access layer is modelled, we will deploy an IP BAP NGN core architecture. In this architecture, traffic is transported as IP from the customer premises; voice services are enabled by applications using IP multimedia subsystems (IMS); and trunk media gateways (TGWs) are deployed at TDM interconnection points.

Stakeholders' comments

One party [**PT Portugal**] agrees with the proposed concept.

One party [**ZON OPTIMUS**] disagrees, stating that TDM should not be mandatory as a hypothetical operator should deploy its core network in the most efficient way.

Analysys Mason response

Two parties have commented on this concept, one agreeing and the other one arguing that TDM should not be considered as mandatory in the context of an efficient operator.

We would like to note that TDM technology is considered only for interconnection purposes, and not for traffic routeing or switching within the network. The model supports both interconnection technologies, i.e. TDM and IP, and considers a migration of interconnected traffic from the former to the latter. We do not consider that we can ignore TDM interconnection, because we cannot disregard the fact that a significant share of Portuguese traffic is still TDM-interconnected (e.g. international calls from/to Latin America and Africa). Therefore, even if the modern efficient interconnection technology is IP, the modelled operator must be able to interconnect with TDM-based systems.

Conclusions

> **Concept 6**: Given that a copper/fibre access layer is modelled, we will deploy an IP BAP NGN core architecture. In this architecture, traffic is transported as IP from the customer premises; voice services are enabled by applications using IP multimedia subsystems (IMS); and trunk media gateways (TGWs) are deployed at TDM interconnection points.

Please see Annex B to this document for a list of assets to be modelled under this architecture.

4.1.3 Transmission layer

Fixed network transmission may be accomplished by a number of alternative methods:

- ATM over SDH
- point-to-point STM microwave
- IP/MPLS over SDH
- IP/MPLS over native Ethernet.

> **Proposed concept 7**: IP/MPLS over native Ethernet seems to be the most appropriate technology. However, we understand that most Portuguese fixed operators still use SDH, at least in the access layer.

Stakeholders' comments

One party [**PT Portugal**] suggests that the transmission technology should include IP/MPLS over Ethernet (FO/WDM) and IP/MPLS over SDH.

One party [**ZON OPTIMUS**] states that SDH should not be considered, as the model should reflect the options that a hypothetical operator would adopt, considering an up-to-date and efficient technology.

Analysys Mason response

There is broad consensus on the relevant future fixed transmission technology; of the two parties providing comments on this concept, both agree on the use of IP/MPLS over Ethernet, and one suggests excluding IP/MPLS over SDH while the other recommends including it.

We understand the perspectives of both parties, as although the modern efficient transmission technology is IP/MPLS over Ethernet, our understanding is that most Portuguese fixed operators still use SDH. For this reason, the model is capable of managing a migration at the access layer away from SDH towards IP/MPLS transmission technology.

Conclusions

> **Concept 7**: IP/MPLS over native Ethernet seems to be the most appropriate technology. However, we understand that most Portuguese fixed operators still use SDH, at least in the access layer.

4.2 Demarcation of network layers

The EC Recommendation defines the principles for the calculation of wholesale termination rates in fixed networks, including:

> "*The default demarcation point between traffic- and non-traffic-related costs is typically where the first point of traffic concentration occurs*." [p.7]

In fixed cost models, cost recovery has historically been segregated, with:

- costs related to the access layer being predominantly subscriber-sensitive, recovered through subscription charges
- costs related to the core layer being predominantly traffic-sensitive, recovered through traffic charges.

The key concept here is that costs related to the provision of end-user 'access' should be clearly identifiable in the fixed BU-LRIC model, mainly because subscriber-driven access-related costs are excluded from the cost calculation for fixed termination services.

Fixed networks use a tree structure, as having dedicated paths between all possible combinations of end users is not feasible. As a result, traffic is concentrated as it passes up the network. The assets related to the provision of end-user *access* are those dedicated to connecting the end user to the telecoms network, allowing it to use available services. This layer conveys traffic and does not have the capability to *concentrate it according to traffic load*. This layer of the network ends at the first asset that has this specific capability. The assets used for the provision of access are only used for the purposes of connecting end users to the network and are hence subscriber-driven. The remaining assets are driven by the traffic volumes that they concentrate.

Proposed concept 8: The demarcation point between traffic- and access-related costs will be where the first point of traffic concentration occurs, such that resources are allocated according to the offered traffic load.

In the network architecture defined above, the first traffic point of concentration is the digital subscriber line access multiplexer (DSLAM) for copper subscribers, and the optical line termination (OLT) for fibre subscribers. More specifically, the last subscriber-driven assets are the access-facing DSLAM/OLT line cards and ports, and the first traffic-driven assets are the core-facing line cards and ports of the DSLAM/OLT. The demarcation point in the network is shown below in Figure 4.2.

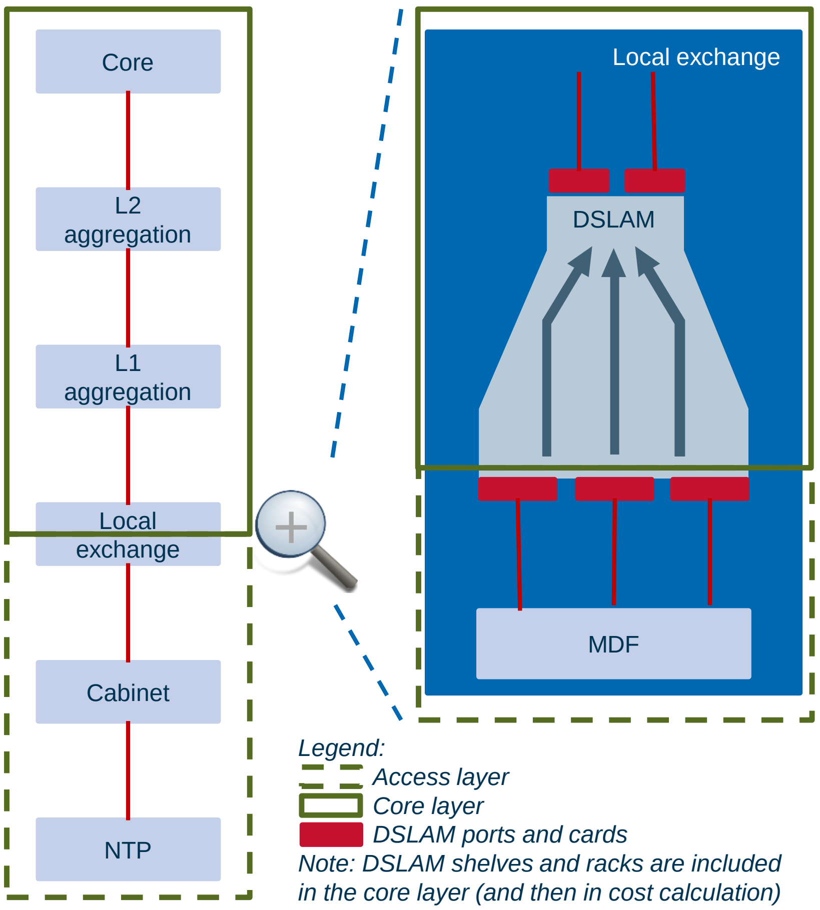


Figure 4.2: Fixed network demarcation point in a network with a copper access layer [Source: Analysys Mason, 2013]

As shown above, using this principle means that the *cost of access* for a fixed end user, where concentration first occurs at the line card in either the DSLAM or the OLT, corresponds to:

- the dedicated costs of the final drop to the end user
- a share of the costs of getting the traffic-insensitive cabling from the NTP back to the line card (trench and cabling in this link).

Stakeholders' comments

Two parties [**PT** and **ZON OPTIMUS**] agree with the proposed concept.

One party [**PT**] has also requested some modifications to Figure 4.3 below. In particular, it believes that in the traditional copper architecture (a) the segment between the MDF and the city node is also essentially subscriber-driven. In the cable architecture (b) it requests that the segment between the local fibre node(s) and the metro nodes should be labelled as 'fibre', and that in the FTTH/GPON architecture (d) all the segments up to the city node should be subscriber-driven.

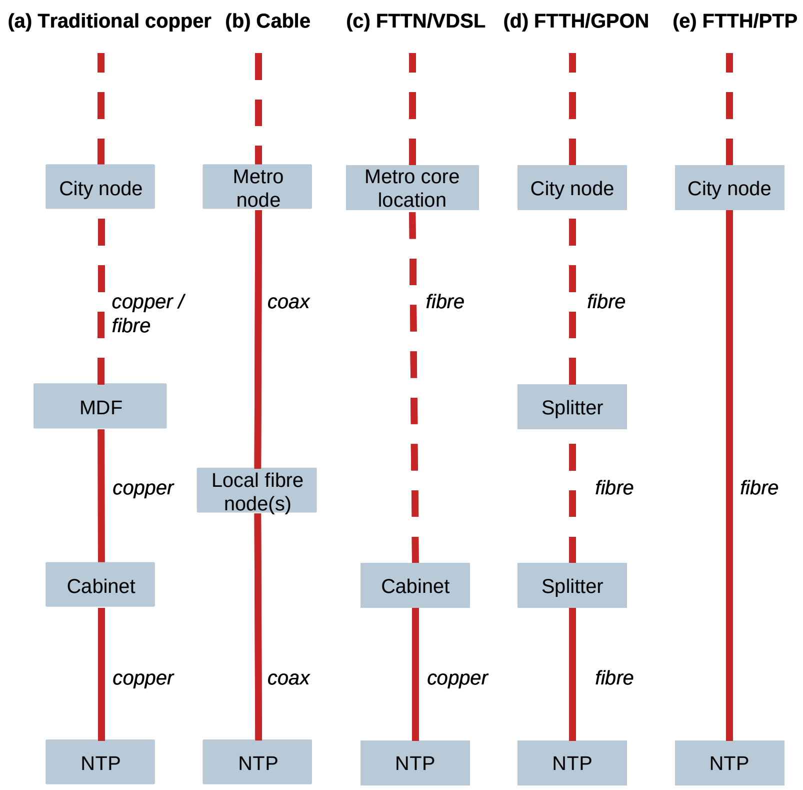


Figure 4.3: Options for the access layer in the fixed BU-LRIC model [Source: Analysys Mason, 2014]

Analysys Mason response

Both the parties that have replied to this concept agree on what is proposed. Figure 4.4 below is our modified version of Figure 4.3. We have:

- added the legend
- highlighted that the DSLAM is at the same local exchange as the MDF in the traditional copper architecture (thus making the upwards link effectively subscriber-driven)
- replaced the 'coax' link with a fibre one between the local fibre node(s) and the metro nodes in the cable architecture
- changed all of the FTTH/GPON local loop (i.e. from the NTP to the OLT in the city node) to be subscriber-driven.

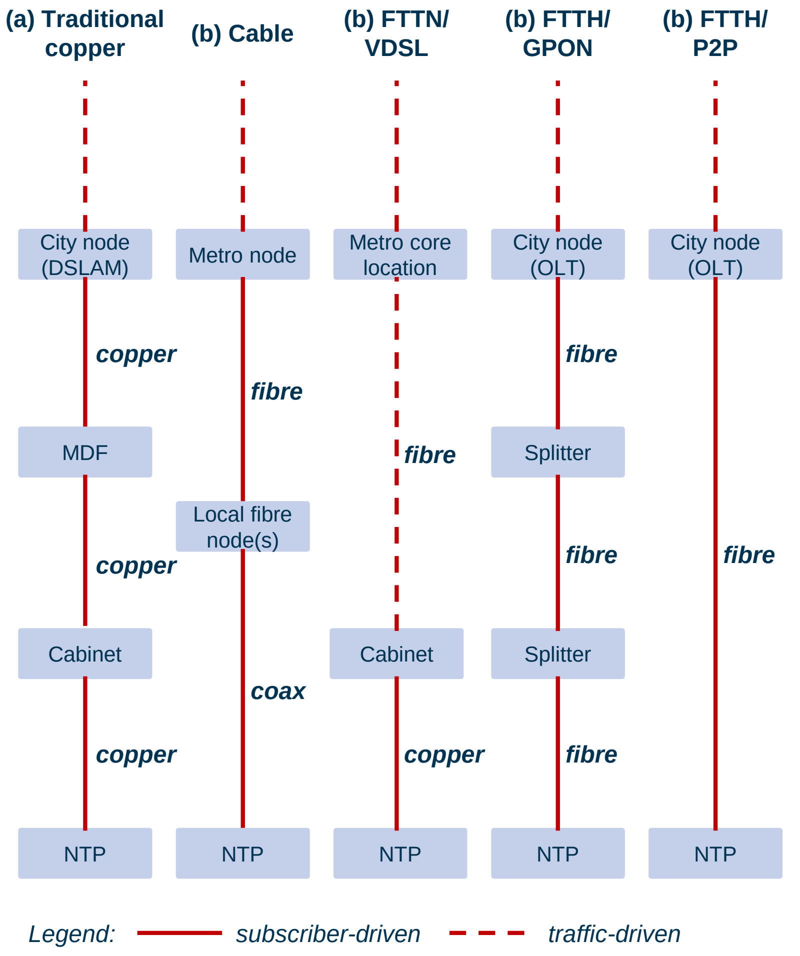


Figure 4.4: Options for the access layer in the fixed BU-LRIC model [Source: Analysys Mason, 2014]

Conclusion

Concept 8: The demarcation point between traffic- and access-related costs will be where the first point of traffic concentration occurs, such that resources are allocated according to the offered traffic load.

4.3 Network nodes

Fixed networks can be considered as series of nodes (with different functions) and links between them. In developing deployment algorithms for these nodes, it is necessary to consider whether the algorithm accurately reflects the actual number of nodes deployed. Allowing the model to deviate from the operators' actual number of nodes may be allowed in the instance where the operators' network is not viewed as efficient or modern in design.

Specification of the degree of network efficiency is an important costing issue. When modelling an efficient network using a bottom-up approach, there are several options available as to the level of detail used from actual networks. The greater the level of granularity/detail that is used directly in the calculation, the lower the extent of network 'scorching' that is being used.

Actual network This approach implements the exact deployment of the real operator without any adjustment to the number, location or performance of network nodes.

Scorched-node approach This assumes that the historical locations of the actual network node buildings are fixed, and that the operator can choose the best technology to configure the network at and in between these nodes to meet the optimised demand of a forward-looking efficient operator. For example, this could mean the replacement of legacy equipment with best-in-service equipment.

The scorched-node approach, therefore, determines the efficient cost of a network that provides the same services as the incumbent network, taking as given the current location and function of the incumbent's nodes.

Modified scorched-node approach The scorched-node principle can be reasonably modified in order to replicate a more efficient network topology than is currently in place. Consequently, this approach takes the existing topology and eliminates inefficiencies. In particular, using this principle can mean:

- simplifying the switching hierarchy (e.g. reducing the number of switching nodes, or replacing a number of small switches with a larger modern switch)
- changing the functionality of a node (for instance, reducing a small exchange to the equivalent of a remote multiplexer).

Scorched-earth approach The scorched-earth approach determines the efficient cost of a network that provides the same services as actual networks, without placing any constraints on its network configuration, such as the location of the network nodes. This approach models what an entrant would build if no network existed, based on a known location of customers and forecasts of demand for services.

This approach would give the lowest estimate of cost, because it removes all inefficiencies due to the historical development of the network, and assumes that the network can be perfectly redesigned to meet current criteria.

We propose to apply a modified version of the scorched-node principle, with the scope extended to all nodes which contain traffic-sensitive components. Therefore, the implication is that scorching will occur through all levels of traffic-concentration nodes (i.e. from local exchanges upwards to the core nodes).

We will utilise the actual node counts of the existing operators, but the functionality or capacity of the nodes may be revised, meaning the number of nodes by sub-type may change.

Proposed concept 9: We will apply a modified scorched-node principle, with scorching applied to all nodes containing traffic-sensitive assets.

Stakeholders' comments

Two parties [**PT** and **ZON OPTIMUS**] agree with the proposed concept.

One party [**DECO**] states that it cannot assess how Options 3 and 4 (Modified scorched-node approach vs. Scorched-earth approach) will vary, in terms of their impact on the model.

Analysys Mason response

Our modified scorched-node approach is consistent with the views of most industry stakeholders: we do not intend to implement unrealistic efficiency improvements, and we accept that it is not possible to continuously redesign a network.

The scorched-earth approach provides the most efficient (i.e. the lowest-cost) network layout in light of the current and forecast values of the key inputs that influence the network design (location of customers, service demand, etc.). The modified scorched-node approach maintains the current location of the network nodes and can at most change the functionality of some of them; it removes some inefficiencies but not all of them, and leads to a cost level higher than that provided by the scorched-earth approach (which is a floor). In particular, use of the modified scorched-node approach can mean simplifying the switching hierarchy (e.g. reducing the number of switching nodes, or replacing a number of small switches with a larger modern switch).

The actual difference between the modified scorched-node and the scorched-earth cost levels therefore depends on the actual level of inefficiency of the existing network nodes and on the efficiency increases that are introduced; in order to evaluate this difference, it would be necessary to re-build the model with the scorched-earth approach. However, by maintaining the same number of nodes when modelling the scorched-earth approach a certain level of inefficiency would remain in the model, due to the steep reduction in transmission costs over the last year and the increased switching capacity of the switching equipment, which are leading to networks characterised by a smaller number of nodes and hierarchy levels, at least at the core levels.

Conclusion

Concept 9: We will apply a modified scorched-node principle, with scorching applied to all nodes containing traffic-sensitive assets.

5 Service issues

The primary aim of the model is to understand the costs of services related to Market 3 (fixed voice termination). However, fixed networks typically convey a wide range of services. The extent to which the modelled network can offer services to locations within its network footprint determines the treatment of economies of scope, and therefore needs to be considered. This section subsequently discusses the following aspects:

- set of services that need to be included in the model (Section 5.1)
- evolution of traffic volumes (Section 5.2)
- scope of wholesale/retail services (Section 5.30.0.0).

5.1 Service set

Economies of scope, arising from the provision of both voice and data services across a single infrastructure, will result in a lower unit cost for voice and data services. This is particularly true for NGNs, where voice and data services can be delivered via a single platform.

As a result, a full list of services must be included within the model, as a proportion of network costs will need to be allocated to these services. This also implies that both end-user and wholesale voice services will need to be modelled so that the voice platform is correctly dimensioned and costs are fully recovered from the applicable traffic volumes.

Assessing both voice and data services in the model increases the complexity of the calculation and the supporting data required. Conversely, however, excluding costs relevant to non-voice services (and developing a standalone voice cost model) can also be complex.[10]

Some of the non-voice services are proven services (particularly services like fixed broadband Internet access). However, other non-voice services, such as over-the-top (OTT) traffic, can give rise to forecast uncertainty when included in the regulated prices for voice. It will be necessary to understand the implications for voice costs of the forecast made for such uncertain non-voice services – and as a result, a range of forecast scenarios would be considered sensible to maximise understanding in such areas.

10 For example, actual top-down costs representing voice and data operation would need to be divided into standalone voice relevant costs, and additional data costs. Voice-only networks do not commonly exist in practice, meaning that the modelled network cannot be compared to any real-world operator.

Proposed concept 10: The modelled operator should provide all the non-voice services (broadband access, leased lines, IPTV, etc.) currently available (and planned) in Portugal, alongside voice services (originating and terminating voice, VoIP and transit traffic). The associated economies of scope will be shared across all services, although care ought to be taken where uncertain growth forecasts significantly influence the economic cost of voice (and therefore forecast sensitivities will be explored).

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] agree with the proposed concept.

Analysys Mason response

Since all the parties commenting on this concept are in agreement, the proposed concept will be maintained.

Conclusion

Concept 10: The modelled operator will provide all the non-voice services (broadband access, leased lines, IPTV, etc.) currently available (and planned) in Portugal, alongside voice services (originating and terminating voice, VoIP and transit traffic). The associated economies of scope will be shared across all services, although care ought to be taken where uncertain growth forecasts significantly influence the economic cost of voice (and therefore forecast sensitivities will be explored).

Fixed network traffic services to be modelled

The table in Figure 5.1 below shows the list of fixed services which would contribute to the deployment of the core network.

Figure 5.1: Fixed market services in Portugal [Source: Analysys Mason, 2013]

Service	Description
Local on-net calls (retail)	Voice calls between two retail subscribers of the modelled fixed operator located within the same regional node
National on-net calls (retail)	Voice calls between two retail subscribers of the modelled fixed operator that are not located within the same regional node
Non-geographic on-net calls (retail)	Voice calls from a retail subscriber of the modelled fixed operator to non-geographic numbers, including 08xx numbers, directory enquiries, and emergency services located in the network of the modelled operator
Outgoing calls to mobile (retail)	Voice calls from a retail subscriber of the modelled fixed operator to a domestic mobile operator
Outgoing calls to other fixed operators (retail)	Voice calls from a retail subscriber of the modelled fixed operator to a domestic fixed operator

Service	Description
Outgoing calls to international numbers (retail)	Voice calls from a retail subscriber of the modelled fixed operator to an international destination
Incoming calls to non-geographic numbers	Voice calls received from another mobile or fixed operator and terminated on a non-geographic numbers of the modelled operator
Other outgoing calls (retail)	Remaining outgoing voice calls
Local incoming calls (wholesale)	Voice calls received from another mobile or fixed operator and terminated on a retail subscriber of the modelled fixed operator, with no transit on another core node of the modelled fixed operator
Simple tandem incoming calls (wholesale)	Voice calls received from another mobile or fixed operator and terminated on a retail subscriber of the modelled fixed operator, after transiting on one core node of the modelled fixed operator
Double tandem incoming calls (wholesale)	Voice calls received from another mobile or fixed operator and terminated on a retail subscriber of the modelled fixed operator, after transiting on two core nodes of the modelled fixed operator
International incoming calls (wholesale)	Voice calls received from another international operator and terminated on a retail subscriber of the modelled fixed operator
Other incoming calls (wholesale)	Remaining incoming voice calls
Local outgoing calls (wholesale)	Voice calls originated by a wholesale subscriber of the modelled fixed operator and terminated on-net or off-net, with no transit on another core node of the modelled fixed operator
Simple tandem outgoing calls (wholesale)	Voice calls originated by a wholesale subscriber of the modelled fixed operator and terminated on-net or off-net, after transiting on another core node of the modelled fixed operator
Double tandem outgoing calls (wholesale)	Voice calls originated by a wholesale subscriber of the modelled fixed operator and terminated on-net or off-net, after transiting on two core nodes of the modelled fixed operator
Other outgoing calls (wholesale)	Remaining wholesale outgoing voice calls
Local outgoing calls to non-geographic numbers (wholesale)	Voice calls originated by a wholesale subscriber of the modelled fixed operator and terminated on a non-geographic number, with no transit on another core node of the modelled fixed operator
Simple tandem outgoing calls to non-geographic numbers (wholesale)	Voice calls originated by a wholesale subscriber of the modelled fixed operator and terminated on a non-geographic number, after transiting on another core node of the modelled fixed operator
Double tandem outgoing calls to non-geographic numbers (wholesale)	Voice calls originated by a wholesale subscriber of the modelled fixed operator and terminated on a non-geographic number, after transiting on two core nodes of the modelled fixed operator
Local transit calls (wholesale)	Voice calls received from another mobile or fixed operator and terminated on another mobile or fixed operator, with no transit on another core node of the modelled fixed operator
Simple transit calls (wholesale)	Voice calls received from another mobile or fixed operator and terminated on another mobile or fixed operator, after transiting on another core node of the modelled fixed operator
Double transit calls (wholesale)	Voice calls received from another mobile or fixed operator and terminated on another mobile or fixed operator, after transiting on two core nodes of the modelled fixed operator
National to International or International to National transit calls (wholesale)	Voice calls received from another international operator and terminated on another international operator, after transiting on a core node of the modelled operator

Service	Description
International transit calls (wholesale)	Voice calls received from another mobile or fixed operator and terminated on another international operator, and voice calls received from another international operator and terminated on another mobile or fixed operator after transiting on the network of the modelled operator
Other transit calls (wholesale)	Remaining transit calls
Dial-up Internet	Circuit-switched calls made by customers for Internet access
Broadband (direct access)	Provision of a broadband subscriber line (NGA or xDSL) Internet service, sold through the modelled operator's retail arm
Bitstream (indirect access)	Provision of an Internet service, resold by other operators
Leased lines	Includes leased line services provisioned for either retail customers, other operators, or internal use
TV (IPTV)	Linear broadcast television with the same channel offering for all of the TV subscribers
TV (VoD)	Broadcast television content allowing TV subscriber to select the content on demand
OTT traffic	Provision of a high-quality Internet service in order to deliver video and audio on demand

Proposed concept 11: We will model the service set included in the table in Figure 5.1 above.

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] agree with the proposed concept.

Analysys Mason response

Since all the parties commenting on this concept are in agreement, the proposed concept will be maintained.

Conclusion

Concept 11: We will model the service set included in the table in Figure 5.1 above.

5.2 Traffic volumes

In defining the modelled operator, it is necessary to define the volume and profile[11] of traffic that the operator is carrying on its network. Since the definition of the modelled operator incorporates a view of its market share, it is proposed to define traffic volumes and usage profiles for an average subscriber. This traffic profile will need to take into account the balance of traffic among the various competing services within the market. A holistic approach to forecast traffic evolution will therefore be required, for both voice and data traffic.

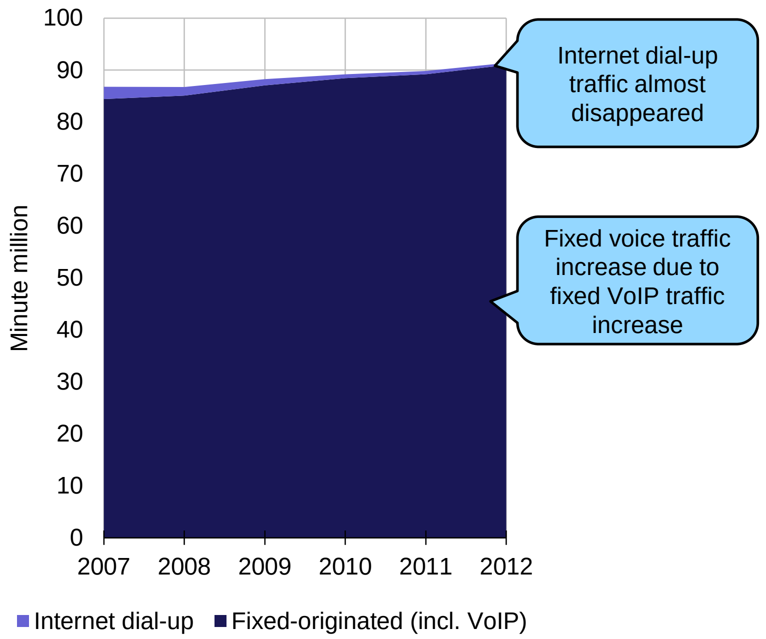


Figure 5.2: Indication of the historical evolution of voice traffic. Traffic data is based on actual historical data [Source: Analysys Mason, 2013]

The volume of traffic associated with the subscribers acquired by the modelled operator is the main driver of costs in the core network, and the measure by which economies of scale will be exploited.

In the hypothetical competitive market being modelled, the subscriber base of each operator will have the same profile of usage. Therefore, the traffic profile of the modelled operator should be the market average, calculated to be consistent with the scale of that operator.[12]

Proposed concept 12: The forecast traffic profile for the modelled operator should be based on a market-average profile.

11 By 'profile', we mean proportions of calls to/from various mobile and fixed destinations, by time of day, and usage of other services.

12 E.g. the proportion of originated calls that are on-net can be expected, all other factors being equal, to be related to the size of the operator's subscriber base. Clearly, as the size of the modelled operator changes over time, a dynamically changing proportion of traffic would be estimated as on-net.

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] agree with the proposed concept. However, one party claims that the connections published in the public consultation do not match the data published by ICP-ANACOM. This party also states that the volume of traffic originating on Portuguese fixed networks in 2012 was 8.35 billion minutes instead of 9.13 billion minutes (as reported in the public consultation).

Analysys Mason response

One party argues that there are discrepancies between the data published by ICP-ANACOM and the data used in the public consultation. In order to overcome this issue, we will update the model with the latest data available from ICP-ANACOM before the model is made public.

We also note that in order to calculate the traffic originating on fixed networks in Portugal, it is necessary to include traffic under the categories "*Tráfego de Calling cards*", "*Tráfego para números não geográficos*", "*Tráfego para números curtos*" and "*Outro tráfego*", as published by ICP-ANACOM (in the calculation provided by one of the operators this traffic does not seem to have been included).

Indeed, for the modelled operator all of the traffic routeing through the fixed network has to be included, not only calls to fixed (both on-net and off-net) and mobile but also other traffic types, e.g. calls to non-geographic numbers, calls from calling cards, etc.

Conclusion

Concept 12: The forecast traffic profile for the modelled operator will be based on a market-average profile.

5.3 Wholesale or retail costs

The BU-LRIC model is intended to be applied in a wholesale market. As such, we intend to consider only those costs that are relevant to the provision of the wholesale network termination service.

Proposed concept 13: Only wholesale network costs will be included; retail costs will be excluded. We will consider all incremental costs that are associated with the provision of wholesale termination traffic services and that are incremental to wholesale traffic at the margin (i.e. avoidable). Common business overheads costs are not added to the cost of termination in a pure LRIC approach, because they are common costs which do not vary with the last increment of wholesale termination.

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] agree with the proposed concept.

Analysys Mason response

Since all the parties commenting on this concept are in agreement, the proposed concept will be maintained.

Conclusion

Proposed concept 13: Only wholesale network costs will be included; retail costs will be excluded. We will consider all incremental costs that are associated with the provision of wholesale termination traffic services and that are incremental to wholesale traffic at the margin (i.e. avoidable). Common business overheads costs are not added to the cost of termination in a pure LRIC approach, because they are common costs which do not vary with the last increment of wholesale termination.

6 Implementation issues

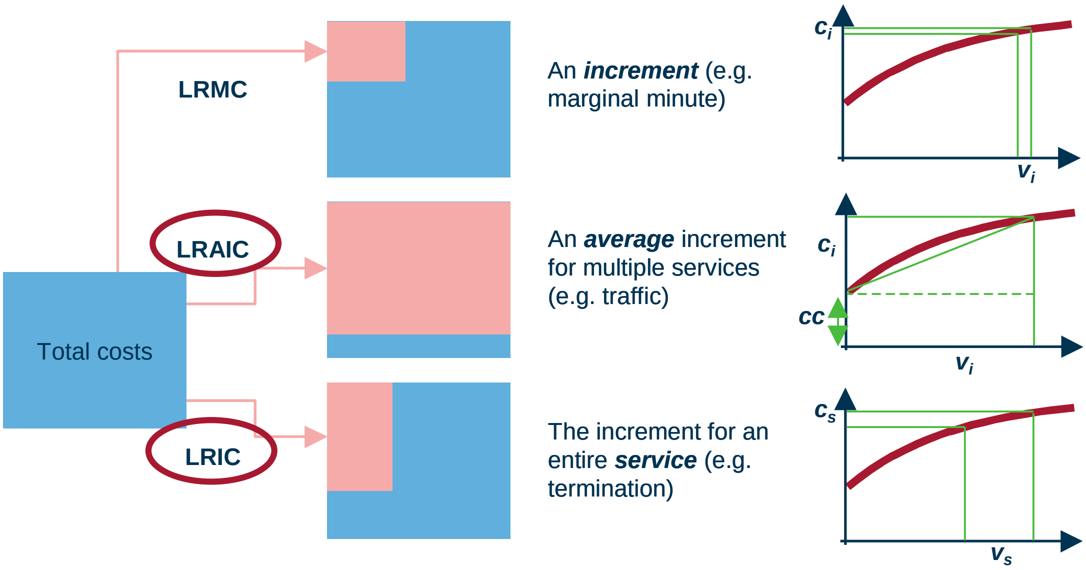
Careful consideration will need to be given to the following issues relating to the implementation of the BU-LRIC model:

- choice of service increment (Section 6.1)
- depreciation method to be applied (Section 6.2)
- WACC to be applied (Section 6.3)

6.1 Choice of increment

The LRIC of an 'increment' of demand is the difference in the total long-run cost of a network which provides all service demand including the increment, and a network which provides all service demand except the demand of the specified increment. The figure below shows three incremental cost approaches commonly used to calculate the LRIC of an increment of demand.

Figure 6.1: Increment approaches [Source: Analysys Mason, 2013]



Long-run incremental costing (LRIC, which we describe as 'pure' LRIC in the case recommended by the EC where common costs are not included) is consistent with the EC Recommendation of May 2009, which considers the increment to be all traffic associated with a single service. Based on the avoidable cost principle, incremental costs are defined as the costs avoided when not offering the service. By building a bottom-up cost model containing network design algorithms, it is possible to use the model to calculate the incremental cost: by running it *with* and *without* the increment in question, and thus determine the cost increment.

The unit cost of voice termination is then determined by dividing that cost increment by the total service volume.

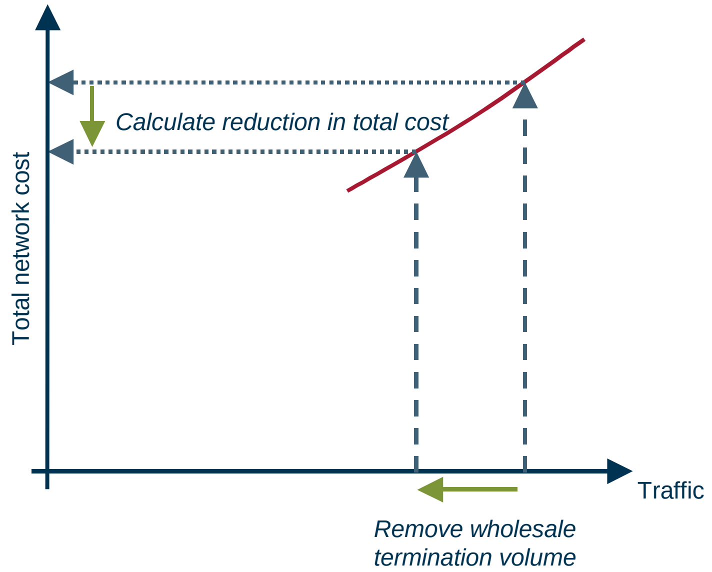


Figure 6.2: Calculation of the incremental cost of termination traffic [Source: Analysys Mason, 2013]

In the working document accompanying its Recommendation of May 2009, the EC notes (at page 14) the following: "*In practice, the majority of NRAs have implemented LRIC models which are akin to LRIC+ or a fully allocated cost (FAC) approach, resulting in an allocation of the whole of a mobile operator's cost to the different services*". The EC goes on to argue that ('pure') LRIC is a more appropriate approach for termination services.

The *pure BU-LRIC* approach will be consistent with the EC Recommendation, which specifies the following approach for the calculation of the incremental costs of the wholesale termination service:

- The relevant increment is the wholesale termination service, which includes only avoidable costs. Its costs are determined by calculating the difference between the total long-run costs of an operator providing full services and the total long-run costs of an operator providing full services except voice termination.
- Non traffic-related costs, such as subscriber-related costs, should be disregarded.
- Costs that are common and do not increase in response to voice termination traffic, such as network common costs and business overheads, should not be allocated to the wholesale terminating increment.

The colour-filled box in Figure 6.3 below indicates the costs included in the unit cost of terminated traffic for this method.

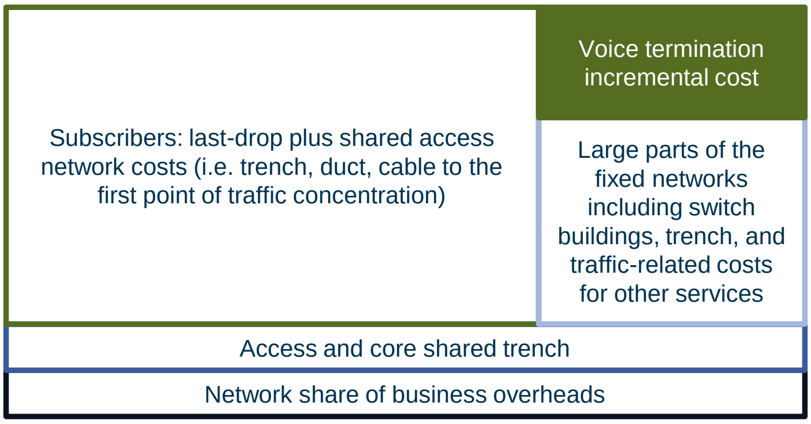


Figure 6.3: Pure BU-LRIC cost allocation [Source: Analysys Mason, 2013]

This *pure BU-LRIC* approach is consistent with the prevailing approach used for the costing of fixed voice termination in Europe, and in line with the methodology used in the mobile cost model built by ICP-ANACOM.

Proposed concept 14: The BU-LRIC model will use a pure LRIC approach, in line with the EC Recommendation. LRAIC+ costs will also be modelled for information purposes.

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] have provided comments on this concept; two of them agree with it while one [**PT]** disagrees with the proposed implementation.

One party [**PT**] does not think that the methodology described in the Concept Paper and the EC Recommendation can be implemented, as it considers that the costs directly associated with the traffic should be allocated to all services in proportion to their consumption, including the call termination service. It indicates that, for an operator, not only does the call termination service have costs associated with the traffic, but it also includes other costs incurred in the provision of the service, such as billing platform, invoicing and service to operators, etc. The party submits that all costs associated with the call termination service should be considered as incremental and avoidable, regardless of whether they are traffic-related or not, and thus the eligibility criteria should be oriented to the *service* and not just its associated *traffic*.

Two parties [**ZON OPTIMUS** and **DECO**] agree with the proposed concept. One party [**ZON OPTIMUS**] states that it will be important to know in greater detail and rigour how it will be implemented, and the reach and definition of incremental costs, to the extent that possible common costs allocated to several services can lead to non-negligible impacts on the calculation of the incremental cost.

Analysys Mason response

We consider that pure LRIC is the most appropriate cost measure, because it maintains consistency with the two key references that must be considered for this type of exercise, that is:

- the EC Recommendation, which proposes that NRAs calculate the costs of termination services on the basis of 'pure BU-LRIC models'[13]
- the methodology for the calculation of mobile termination rates applied in Portugal.

In addition, as well as pure LRIC, the model will also calculate LRAIC+ results (for information only).

Regarding the costs to consider for the development of the model, as explained in Concept 13 we will consider all incremental costs that are associated with the provision of wholesale termination traffic services and that are incremental to wholesale traffic at the margin (i.e. avoidable).

Indeed, as argued by one of the operators, the avoidable costs also include other costs, such as for wholesale billing systems. While this is correct, the volume of wholesale termination traffic will determine whether the modelled operator will require further capacity to manage the wholesale termination traffic, compared to the case without termination traffic – and therefore whether these *other costs* (e.g. wholesale billing systems) contribute to the pure LRIC costs.

The model will be made public and so the stakeholders will be able to see in greater detail how it has been implemented.

Conclusion

Concept 14: The BU-LRIC model will use a pure LRIC approach, in line with the EC Recommendation. LRAIC+ costs will also be modelled for information purposes.

6.2 Depreciation method

6.2.1 Options

Before the EC Recommendation of May 2009 was published, it was possible to consider four main potential depreciation methods for defining cost recovery:

- historical cost accounting (HCA) depreciation
- current cost accounting (CCA) depreciation
- tilted annuities
- economic depreciation (ED).

13 COMMISSION RECOMMENDATION of 7 May 2009 on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU (2009/396/EC). Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:124:0067:0074:EN:PDF

Economic depreciation is the recommended approach for regulatory costing. The table in Figure 6.4 below shows that only economic depreciation considers all potentially relevant depreciation factors.

Figure 6.4: Factors considered by depreciation method [Source: Analysys Mason, 2013]

	HCA	CCA	Tilted annuity	ED
MEA cost today		✓	✓	✓
Forecast MEA cost			✓	✓
Output of network over time			[14]	✓
Financial asset lifetime	✓	✓	✓	✓[15]
Economic asset lifetime			✓	✓

The primary factor in the choice of the depreciation method is whether the network output is changing over time. The situation in fixed networks is quite complicated. Historically, fixed network traffic was voice-dominated and volumes were fairly stable. In recent years, however:

- voice volumes have been falling and dial-up has almost disappeared
- broadband and other data traffic volumes are currently growing strongly.

Therefore, using tilted annuities in the fixed costing may differ significantly from economic depreciation. Furthermore, the EC recommends that economic depreciation be used wherever feasible, and this approach would be consistent with the cost recovery methodology used by ICP-ANACOM in its mobile BU-LRIC model.

Proposed concept 15: The fixed BU-LRIC model will use economic depreciation.

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] agree with the proposed concept.

Analysys Mason response

Since all the parties commenting on this concept are in agreement, the proposed concept will be maintained.

Conclusion

Concept 15: The fixed BU-LRIC model will use economic depreciation.

[14] An approximation for output changes over time can be applied in a tilted annuity by assuming an additional output tilt factor of x% per annum.

[15] Economic depreciation can use financial asset lifetimes, although strictly it should use economic lifetimes (which may be shorter, longer or equal to financial lifetimes).

6.2.2 Time series

The time series, namely the period of time across which demand and asset volumes are calculated in the model, is an important input. A long time series:

- allows the consideration of all costs over time, providing the greatest clarity within the model as to the implications of adopting economic depreciation
- provides greater clarity as to the recovery of all costs incurred from services
- provides a wide range of information with which to understand how the costs of the modelled operator varies over time and in response to changes in demand or network evolution
- can also include additional forms of depreciation (such as accounting depreciation) with minimal effort.

The time series itself should be equal to the lifetime of the operator, allowing full cost recovery over the entire lifetime of the business. However, the lifetime of an operator is impractical to identify. Hence, we would propose that the time series should be at least as long as the longest asset lifetime used in the model.

Using our proxy, for a fixed BU-LRIC model, the longest-lived assets are normally set to 40 years (for trenches and ducts), so a modelling time series in excess of 40 years is often used. As a result, it may be necessary to develop a model which is capable of calculating the costs of an asset with a lifetime of 40 years at minimum.

Proposed concept 16: The length of the fixed BU-LRIC model time series must be at least as long as the longest asset lifetime used in the model, and a period of 45 years is suggested in order to reasonably calculate the costs of long-lived assets.

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] provided comments.

One party [**PT]** does not agree with the proposed implementation. PT believes that 45 years is too long a period of time. It states that estimates at such a long term can be useless and far from reality, especially in a sector subject to constant evolution such as the fixed telecoms market and considering that traffic demand estimations will not be credible in a time horizon of 45 years. However, the party [**PT**] also mentions that understands the use of long time horizon in order to accommodate the longest asset lifetime used in the model.

Two parties [**ZON OPTIMUS** and **DECO**] agree with the proposed concept.

Analysys Mason response

Three parties commented on this concept, two agreeing and one disagreeing. The disagreeing party highlighted that a 45-year time horizon seems unreasonably long, in terms of:

- assessing the likely technological changes in an evolving sector such as fixed telecoms
- deriving reliable forecasts of service demand.

In relation to concerns of technology evolution and forecasting over a very long period, we note that a 45-year LRIC model is not intended to forecast accurately and precisely over such a long period of time. This, as it has been pointed out by one of the parties, will be an uncertain exercise due to new technology developments, the introduction of new services, changing consumer behaviour, etc.

We model a 'steady state' for the market from 2025 onwards, which ensures that cost recovery can continue in perpetuity, subject to ongoing modern equivalent asset (MEA) equipment price declines and the WACC.

The extended time period allows for the full recovery of all investments, as well as negating the need for a terminal value of the business (which would also require assumptions on revenue and cost growth rates). A modelling time frame of 45 years ensures that at least one full period of a long-lived asset is considered in the model. It also ensures that any terminal value becomes negligible and can be ignored.

In effect, there may be few assets that are considered to have a lifetime of 45 years (according to operator data, there are just a small number of assets with an accounting lifetime of 40 years or over). However, it is our expectation that the majority of assets in the cost model will be based on shorter-lived assets such as hardware electronics and network software (which have a typical lifetime of between 5 and 8 years).

If we were to assume a zero terminal value after a much shorter period, e.g. 20 years, this would:

- allow the operators to effect a cost-free exit from the market at that point (all expenditures having been fully recovered)
- imply that the value of the business was zero beyond 20 years.

As such, the modelling of full cost recovery within a relatively short (e.g. 20-year) period would in our view involve an overly conservative assessment of the risk of obsolescence, and would not reflect the shareholder value and investment incentives for long-term presence in the market.

We therefore believe that a model with a time frame of 45 years, which forecasts the development of the Portuguese market up to 2025 and assumes a steady state thereafter, and adopts an economic depreciation methodology is reasonable for the next regulatory review period and reduces the potential effect of unforeseeable market evolution post-2025.

Conclusion

Concept 16: The length of the fixed BU-LRIC model time series must be at least as long as the longest asset lifetime used in the model, and we will use a period of 45 years in order to reasonably calculate the costs of long-lived assets.

6.3 WACC

The cost model will require a cost of capital (WACC) to be specified.

The generic formula of the pre-tax WACC is $WACC_{pre-tax} = k_D * \frac{D}{D+E} + \frac{1}{1-t} * k_E * \frac{E}{D+E}$, where:

- k_D is the pre-tax cost of debt
- k_E is the post-tax cost of equity
- D is the stock of debt
- E is the stock of equity
- t is the corporate tax rate.

Moreover, we usually refer to the company gearing, defined as $G = \frac{D}{D+E}$.

While k_D is calculated/benchmarked with the typical corporate bond yields, k_E is usually calculated with the capital asset pricing model (CAPM), whose formula is $k_E = \beta * (r_M - r_f) + r_f$, where:

- β is the (de-)amplification coefficient of the spread between the average market risk and risk-free risk associated to the examined investment/share
- r_M represents the average market risk
- r_f is the market risk-free rate.

It holds the following relation between pre- and post-tax WACC: $WACC_{pre-tax} = \frac{WACC_{post-tax}}{(1-t)}$. The model will work in real terms, and then any 'nominal' WACC would need to be converted in its corresponding real one through the formula $WACC_{real} = \frac{1+WACC_{nominal}}{(1+i)} - 1$, where i is the inflation rate in a given year.

ICP-ANACOM has recently calculated the cost of capital rate for Portugal Telecom for the year 2013.[16] Even if the fixed BU-LRIC model is not considering an actual operator (like Portugal Telecom), we propose to adopt an approach which is consistent with the methodology used by ICP-ANACOM for calculating the cost of capital rate of Portugal Telecom. This same approach was also used to calculate the WACC for mobile operators in the mobile LRIC model developed by Analysys Mason on behalf of ICP-ANACOM.

16 ANACOM (2013). Decisão final sobre a definição da metodologia de cálculo da taxa de custo de capital da PTC, aplicável a partir do exercício de 2012. Available at: http://www.anacom.pt/render.jsp?contentId=1183361

A benchmark of the WACC of real operators 'comparable' to the modelled hypothetical operator could provide useful insight. In this task, the key issue is the choice of the benchmark sample, as the degree of similarity can be evaluated from several points of view (operations in place, years from launch, market share, reference market, etc.).

The model will work in real, pre-tax terms (as opposed to nominal, post-tax terms, which is the convention employed for statutory financial statements).

The ICP-ANACOM methodology referred to above, adapted as suggested, is suitable for determining a single pre-tax WACC for a hypothetical Portuguese fixed operator.

Proposed concept 18: The model will remove the effect of inflation by expressing costs and revenues in real terms and using the corresponding 'real-terms' WACC.

Proposed concept 19: The model will simulate the effect of corporate tax by applying a 'pre-tax' WACC to pre-tax cashflows.

Proposed concept 20: The 'pre-tax' WACC will be determined using an analogous methodology to that already defined by ICP-ANACOM for Portugal Telecom, but using different input values for some key parameters (mainly β and G); useful insight will also be derived through *ad-hoc* benchmarking exercises.

Stakeholders' comments

Three parties [**PT**, **ZON OPTIMUS** and **DECO**] provided comments.

One party [**PT]** agrees with the calculation of a 'pre-tax' WACC based on the capital asset pricing model (CAPM). Nevertheless, given the time horizon of the model, it considers that it is unrealistic to use a fixed WACC for the whole period, and believes that it is necessary to estimate the evolution of the different parameters leading to the calculation of the WACC.

One party [**DECO**] states that while the option of a 'pre-tax' WACC is acceptable, the market risk-free rate and the average market risk calculated by regulators has been beneficial to operators. As an example, it says that the indexation of the risk-free rate to the Portuguese government treasury bonds is not acceptable.

One party [**ZON OPTIMUS**] has provided detailed comments on the different options for calculating the WACC and states that the WACC should be adopted based on a simulation methodology.

Analysys Mason response

All three parties that responded on these concepts provided comments, broadly accepting the use of a 'pre-tax' WACC discount rate for the model.

Two parties provided comments on a single topic each: one party focused on the fact that it does not seem realistic to assume a fixed WACC for the whole period; the second party claimed that indexing some key inputs of the WACC formula is beneficial to the operators.

While a constant WACC for 45 years is indeed not realistic, it cannot be reasonably expected to calculate the WACC for each of the 45 years. As explained in other parts of this document (e.g. under Concept 16), the model must ensure that it produces coherent and consistent results for the next regulatory period. This means that the calculation of the WACC will need to take into account information available about this period, typically two to three years. To avoid additional errors and complexity, we will aim to implement simple WACC calculations that combine a rigorous approach with a simple methodology that takes into account the economic reality of the country and allows a transparent verification of calculations.

With respect to the WACC methodology calculation, we would like to note the following points:

- ICP-ANACOM has recently calculated the cost of capital rate for Portugal Telecom for 2012 and 2013.[17]
- The value calculated by ICP-ANACOM has been validated by third parties through a public consultation process and by the European Commission.
- This calculation used a methodology which was published in 2009[18], updated in 2013[19] and has been implemented, thus providing a reference for all the market players.
- The whole methodology and the input values provided for WACC calculation have been compared with best practices and figures from approaches used by comparable countries (Western European/other developed nations) and operators, etc. through a comprehensive benchmarking exercise.

Conclusion

Concept 18: The model will remove the effect of inflation by expressing costs and revenues in real terms and using the corresponding 'real-terms' WACC.

Concept 19: The model will simulate the effect of corporate tax by applying a 'pre-tax' WACC to pre-tax cashflows.

17 ANACOM (2013). Decisão final sobre a definição da metodologia de cálculo da taxa de custo de capital da PTC, aplicável a partir do exercício de 2012. Available at: http://www.anacom.pt/render.jsp?contentId=1183361

18 Report 'Assessment of the cost of capital analysis of Portugal Telecom Comunicações', July 2009. Available at: http://www.anacom.pt/streaming/PWC_report_costofcapital.pdf?contentId=994447&field=ATTACHED_FILE

19 ANACOM (2013). Decisão final sobre a definição da metodologia de cálculo da taxa de custo de capital da PTC, aplicável a partir do exercício de 2012. Available at: http://www.anacom.pt/render.jsp?contentId=1183361

Concept 20: Since the modelled operator has a similar scale and coverage to the ones of Portugal Telecom, the model will use a 'pre-tax' WACC based on the one calculated by ICP-ANACOM for Portugal Telecom for 2013; this value is maintained flat across the whole time horizon of the model as this is considered the most reasonable proxy of the average cost of capital for the years included in the model.

Annex A Implementation of the economic depreciation

This annex describes certain key aspects and principles of the implementation of the economic depreciation. These aspects are not intended to be under consultation until the draft model has been produced. These descriptions are provided to operators to give an indication of the issues that will be dealt with during the construction of the BU-LRIC models. Operators are nonetheless welcome to provide comment on these aspects if they wish.

An economic depreciation algorithm recovers all efficiently incurred costs in an economically rational way by ensuring that the total of the revenues[20] generated across the lifetime of the business are equal to the efficiently incurred costs, including cost of capital, in present value terms: the (net) present value (NPV) of a series of (expected) future cash flows is equal to $NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}$, where:

- CF_t is the cash flow at the instant t
- r is the discount rate (the WACC in the model).

This calculation is carried out for each individual asset class, rather than in aggregate. Therefore, asset-class specific price trends and element outputs are reflected in the components of total cost.

Present value calculation

The calculation of the cost recovered through revenues generated needs to reflect the value associated with the opportunity cost of deferring expenditure or revenue to a later period. This is accounted for by the application of a discount factor on future cash flow, which is equal to the WACC of the modelled operator.

The business is assumed to be operating in perpetuity, and investment decisions are made on this basis. This means that it is not necessary to recover specific investments within a particular time horizon (for example, the lifetime of a particular asset), but rather throughout the lifetime of the business. In the model, this situation is approximated by explicitly modelling a period of 45 years., the present value of the cash flows in the last years of the model (i.e. when the discount rate is applied) is fractional and thus any perpetuity value beyond 45 years is regarded as immaterial to the final result (it holds $\lim_{t\to\infty} \frac{1}{(1+r)^t} = 0$).

20 Strictly cost-oriented revenues, rather than actual received revenues.

Cost recovery profile

The $NPV = 0$ constraint on cost recovery can be satisfied by (an infinite) number of possible cost recovery trends. However, it would be impractical and undesirable from a regulatory pricing perspective to choose an arbitrary or highly fluctuating recovery profile[21]. Therefore, the costs incurred over the lifetime of the network are recovered in line with revenues generated by the business. The revenues generated by an asset class are a product of the demand (or output) supported by that asset class and the price per unit demand.

In the modelled environment of a competitive market, the price that will be charged per unit demand is a function of the lowest prevailing cost of supporting that unit of demand, thus the price will change in accordance with the costs of the MEA for providing the same service function[22]. The shape of the revenue line (or cost recovery profile) for each asset class is thus a product of the demand supported (or output) of the asset and the profile of replacement cost (or MEA price trend) for that asset class.

Capital and operating expenditure

The efficient expenditure of the operator comprises of all the operator's efficient cash outflows over the lifetime of the business, meaning that capital and operating expenditures are not differentiated for the purposes of cost recovery. As stated previously, the model considers costs incurred across the lifetime of the business to be recovered by revenues across the lifetime of the business. Applying this principle to the treatment of capital and operating expenditure leads to the conclusion that they should both be treated in the same way since they both contribute to supporting the revenues generated across the lifetime of the operator.

Details of implementation

The proposed depreciation method implemented has the following characteristics:

- it explicitly calculates the recovery of all costs incurred across the specified time horizon in present value terms
- the cost recovery schedule is computed for each asset along the output profile of the asset
- cost recovery is computed separately for capital and operating expenditures (allowing for potentially different MEA price trends of capex and opex)
- costs are calculated with reference to network element output: the routeing factor weighted sum of service demand produced by the network element in each year.

21 For example, because it would be difficult to send efficient pricing signals to interconnecting operators and their consumers with an irrational (but $NPV = 0$) recovery profile.

22 In a competitive and contestable market, if incumbents were to charge a price in excess of that which reflected the modern equivalent asset prices for supplying the same service, then competing entry would occur and demand would migrate to the entrant which offered the cost-oriented price. The rate of demand migration is determined by the contestability of the market under consideration.

Annex B List of fixed core NGN assets

A list of assets that would be modelled under the assumed fixed core NGN architecture is shown below in Figure B.1.

Figure B.1: NGN assets required for IP broadband access platform approach [Source: Analysys Mason, 2013]

Network asset	Asset description
OLT	This is where the first point of concentration of traffic occurs in a fibre access network
DSLAM	This is where the first point of concentration of traffic occurs in a copper access network
Ethernet switch	It is used to aggregate the traffic
Edge router	It is used for routeing the traffic from the access layer to the core nodes or to another DSLAM/OLT located within the same aggregation node, and vice versa
Core router	A core router is used for routeing the traffic between aggregation and core nodes, and between core nodes
Core switch	Core switches are used to aggregate the traffic
TGW	The TGW translates the TDM-based voice coming from other networks to IP for transit over the next-generation core network
Session border controller (SBC)	The SBC monitors the IP interconnection traffic and manages the QoS of the interconnection traffic; it controls the per-call (or per-session) bandwidth allocation at the borders of the network. It also provides security between the different network domains (e.g. network address translation, stopping denial of service attacks, etc.)
Call server/softswitch (CS)	The softswitch oversees the voice traffic
Broadband remote access server (BRAS)	Among other functions, the BRAS manages the QoS requirements for the broadband subscribers
RADIUS	Server that performs authentication and authorization functions
Domain name server (DNS)	Server that translates the domain names into its corresponding IP address
Clock	The clock performs the synchronization functions

Annex C Glossary of acronyms

AGW	Access gateways
ICP-ANACOM	ICP – Autoridade Nacional de Comunicações
ATM	Asynchronous transfer mode
BAP	Broadband access platforms
BRAS	Broadband remote access server
CAPM	Capital asset pricing model
CCA	Current cost accounting
CDMA	Code division multiple access
CMTS	Cable modem termination system
CS	Circuit switched
DECO	Portuguese Association for Consumer Protection
DLCS	Digital loop carriers
DNS	Domain name system
DSL	Digital subscriber line
DSLAM	Digital subscriber line access multiplexer
EC	European Commission
ED	Economic depreciation
EU	European Union
FAC	Fully allocated cost
FTR	Fixed termination rate
FTTH	Fibre to the home
FTTN	Fibre to the node
GPON	Gigabit passive optical network
HCA	Historical cost accounting
IMS	IP multimedia subsystems
IP	Internet protocol
IPTV	Internet protocol television
LRAIC	Long run average incremental cost
LRIC	Long run incremental cost
MDF	Main distribution frame
MEA	Modern equivalent asset
MPLS	Multi-protocol label switching
MSAN	Multi-service access nodes
NGA	Next generation access
NGN	Next generation network
NPV	Net present value
NRA	National regulatory agency

NTP	Network termination point
OLT	Optical line terminal
OTT	Over the top
PSTN	Public switched telephone network
PT	Portugal Telecom
PTP	Point to point
PV	Present value
QOS	Quality of service
SBC	Session border controller
SDH	Synchronous digital hierarchy
STM	Synchronous transfer mode
TDM	Time division multiplexing
TGW	Trunk gateway
TV	Television
UK	United Kingdom
VDSL	Very-high-bitrate DSL
VOD	Video on demand
VOIP	Voice over Internet protocol
WACC	Weighted average cost of capital
WDM	Wave division multiplexing