Assessment of PURE LRIC FTRs in Ireland

Specifications and results

Ref: 2016-40-ML-ComReg-FTR modeling

Non-Confidential version

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March 2018

Summary

1 Context

1.1 Scope of the modelling

In the context of its analysis of the Market 1 (communications market for fixed voice call termination)[1], ComReg engaged TERA Consultants to develop a cost model to calculate the Fixed Termination Rates (FTR) following the 2009 European Commission recommendation on fixed and mobile termination rates (Termination Rates Recommendation or TRR)[2], and in respect of the draft pricing principles already defined[3] in a preliminary step of ComReg's review.

1.2 Overview of the current FTR regime in Ireland

The wholesale market for voice call termination on individual fixed networks ('the Fixed Voice Call termination (FVCT) Market') is currently regulated pursuant to ComReg Decision D06/07. In that Decision, ComReg defined seven separate relevant markets and stated that each of the fixed service providers providing fixed voice call termination services (i.e. eir and 6 other authorised operators) had SMP.

A price control obligation of cost orientation was imposed, with such costs calculated using a pricing model based on forward looking long run incremental costs 'FL-LRIC' or an alternative pricing model.

ComReg conducted a further market review of these markets in 2012. Currently the FTR is below 1 euro cent for all call configurations.

[1] EC Recommendation 2014/710/EU

[2] EC Recommendation 2009/396/EC : "The Regulatory Treatment For Fixed and Mobile Termination Rates in the EU"

[3] Analysis Mason draft report, "Pricing principles for future regulation of wholesale voice call termination services"

Table 1 – eir national termination rates (c€)

Table 1 open eir National Termination (Euro Cent)										
Charging Level	Cent Per Minute			Cent Per Call			Effective from	Effective to	Status
	Peak	Off Peak	Weekend	Peak	Off Peak	Weekend			
Primary	0.306	0.171	0.153	0.818	0.456	0.409	01/04/2004	30/06/2006	Final
Tandem	0.545	0.304	0.272	1.039	0.579	0.519	01/04/2004	30/06/2006	Final
Double Tandem	0.819	0.456	0.409	1.136	0.633	0.567	01/04/2004	30/06/2006	Final
Primary	0.319	0.174	0.155	0.804	0.438	0.391	01/07/2006	30/06/2007	Final
Tandem	0.548	0.298	0.265	1.012	0.550	0.491	01/07/2006	30/06/2007	Final
Double Tandem	0.794	0.431	0.385	1.147	0.622	0.554	01/07/2006	30/06/2007	Final
Primary	0.295	0.163	0.143	0.784	0.434	0.380	01/07/2007	31/03/2010	Final
Tandem	0.460	0.254	0.223	0.900	0.498	0.436	01/07/2007	31/03/2010	Final
Double Tandem	0.687	0.380	0.333	1.019	0.564	0.494	01/07/2007	31/03/2010	Final
Primary	0.2788	0.1541	0.1352	0.7409	0.4102	0.3591	01/04/2010	31/12/2010	Final
Tandem	0.4209	0.2325	0.2041	0.8370	0.4632	0.4055	01/04/2010	31/12/2010	Final
Double Tandem	0.6046	0.3344	0.2931	0.9171	0.5076	0.4446	01/04/2010	31/12/2010	Final
Primary	0.2626	0.1451	0.1273	0.6978	0.3863	0.3382	01/01/2011	30/06/2012	Final
Tandem	0.3818	0.2109	0.1851	0.7740	0.4283	0.3750	01/01/2011	30/06/2012	Final
Double Tandem	0.5222	0.2888	0.2531	0.8152	0.4512	0.3952	01/01/2011	30/06/2012	Final
Primary	0.2443	0.1350	0.1185	0.6772	0.3749	0.3282	01/07/2012	30/06/2013	Final
Tandem	0.3553	0.1962	0.1722	0.7512	0.4157	0.3639	01/07/2012	30/06/2013	Final
Double Tandem	0.4859	0.2687	0.2355	0.7912	0.4379	0.3835	01/07/2012	30/06/2013	Final
Primary	0.0700	0.0700	0.0700	0.0750	0.0750	0.0750	01/07/2013	30/06/2014	Final
Tandem	0.3553	0.1962	0.1722	0.7512	0.4157	0.3639	01/07/2013	30/06/2014	Final
Double Tandem	0.4859	0.2687	0.2355	0.7912	0.4379	0.3835	01/07/2013	30/06/2014	Final
Primary	0.0600	0.0600	0.0600	0.0680	0.0680	0.0680	01/07/2014	30/06/2015	Final
Tandem	0.3553	0.1962	0.1722	0.7512	0.4157	0.3639	01/07/2014	30/06/2015	Final
Double Tandem	0.4859	0.2687	0.2355	0.7912	0.4379	0.3835	01/07/2014	30/06/2015	Final
Primary	0.0490	0.0490	0.0490	0.0600	0.0600	0.0600	01/07/2015		Final
Tandem	0.3553	0.1962	0.1722	0.7512	0.4157	0.3639	01/07/2015		Final
Double Tandem	0.4859	0.2687	0.2355	0.7912	0.4379	0.3835	01/07/2015		Final

Source: Eir, extract of the RIO price list, April 2016 (v2.85)

1.3 Regulatory framework

1.3.1 General overview of the European framework for setting FTRs

Amongst the numerous Directives and Recommendations which compose the European regulatory framework, four specifically deal with the principles and objectives of cost orientation:

- The most important one, in the context of FTRs, is the "Access Directive" 2002/19/EC dealing with access to (and interconnection of) electronic communications networks and associated facilities.
- The second one deals with regulated access to Next Generation Access Networks ("Recommendation on NGA" 2010/572/EU). This document is

especially useful because it provides a practical application of the Access Directive for an access infrastructure.

- Two other documents deal with cost orientation but in the specific context of fixed and mobile termination rates ("Recommendation on termination rates" 2009/396/EC and "Explanatory note to the Recommendation 2009/396/EC on termination rates").

The last two documents, identified as the "Termination Rates Recommendation" or TRR in this document, are of major interest in the context of this modelling work, as they specify a number of key points for setting FTRs, and National Regulatory Authorities ("NRAs") are required to take "utmost account" of the Recommendation when deploying national regulatory policy. A focus on the TRR is therefore provided here below.

1.3.2 The Termination Rates Recommendation

In 2009, in order to harmonise termination rates calculation methodologies amongst member states, and in order to solve anti-competitive issues related to high Termination Rates, the European Commission issued a recommendation (reference 2009/396/EC) which specifies the principles to be followed by Regulatory Authorities for the setting of Fixed and Mobile Termination Rates.

According to this recommendation, NRAs shall adopt a specific cost standard when setting cost-based interconnection regulation: **the pure LRIC approach.**[4] The objective of the European Commission is clearly to avoid anti-competitive effects generated by high termination charges.[5]

In addition to the cost standard, the 2009 TRR further specifies how the bottom-up pure LRIC cost model should be developed. The main specifications of the TRR are presented hereafter:

- Fixed termination rates must be calculated on the basis of the cost of an efficient generic operator, which implies that termination rates would be also symmetric.

[4] "It is justified to apply the pure LRIC approach whereby the relevant increment is the wholesale call termination service and which includes only avoidable costs. […] In setting termination rates, any deviation from a single efficient cost level should be based on objective cost differences outside the control of operators. In fixed networks, no such objective cost differences outside the control of the operator have been identified. In mobile networks, uneven spectrum assignment may be considered an exogenous factor which results in per unit- cost differences between mobile operators."

[5] "High termination charges may be used to foreclose a new entrant network, where a large proportion of originated calls are off-net. High termination rates may also facilitate collusive behaviour between two or more terminating operators"

"Late entrants argue that due to large traffic imbalances and on-net/off-net price differentiation they cannot compete effectively at the retail level. A large proportion of calls originated on late entrant networks is terminated on other networks, i.e. off net. If new entrants pay a regulated termination charge in excess of actual costs they effectively give a transfer to the large network. As a result, their ability to offer retail rates comparable to the retail rates of an established operator, which terminates a majority of its calls on-net, is impeded."

  - *"When deciding on the appropriate single efficient scale of the modelled operator, NRAs should take into account the need to promote efficient entry, while also recognising that under certain conditions smaller operators can produce at low unit costs by operating in smaller geographic areas. Furthermore, smaller operators which cannot match the largest operators' scale advantages over broader geographic areas can be assumed to purchase the wholesale inputs rather than self-provide termination services"*

- The recommendation asks for the development of a BU-LRIC model, however top-down data can be used as a comparison:

  - *"NRAs may compare the results of the bottom-up modelling approach with those of a top-down model which uses audited data with a view to verifying and improving the robustness of the results and may make adjustments accordingly".*

- The Pure LRIC is the preferred approach:
  - *"[…] it is justified to apply* ***a pure LRIC approach whereby the relevant increment is the wholesale call termination service*** *and which includes only avoidable costs. The purpose of this is to send efficient cost signals to operators and end-users."*

- For fixed models, efficient technological choices have to be made:
  - *"The cost model should* ***be based on efficient technological choices, considering that those technologies should be available in the timeframe considered by the model****. Hence, a bottom-up model built today should assume that the core network for fixed networks is Next-Generation-Network (NGN)-based."*

- Non-traffic-related costs should be disregarded for the purpose of calculating wholesale termination rates within the LRIC model. The increment is the wholesale call termination (NB: this excludes on-net call termination). Only avoided costs are considered if wholesale termination is not provided. The BU-LRIC model is therefore run twice: first with the wholesale termination service, then without:
  - "*Within the LRIC model,* ***the relevant increment should be defined as the wholesale voice call termination service provided to third parties****. This implies that in evaluating the incremental costs NRAs should establish the difference between the total long-run cost of an operator providing its full range of services and the total long-run costs of this operator in the absence of the wholesale call termination service being provided to third parties. A distinction needs to be made between traffic-related costs and non-traffic related costs, whereby the latter costs should be disregarded for the purpose of calculating wholesale*

termination rates. The recommended approach to identifying the relevant incremental cost would be to ***attribute traffic-related costs firstly to services other than wholesale voice call termination, with finally only the residual traffic-related costs being allocated to the wholesale voice call termination service****. This implies that only those costs which would be avoided if a wholesale voice call termination service were no longer provided to third parties should be allocated to the regulated voice call termination services."*

- An economic depreciation has to be implemented:
  - *"The recommended approach for asset depreciation is* ***economic depreciation*** *wherever feasible."*

The European Commission indicated in the accompanying Staff Working Document[6] that such approach to costing principles in the call termination markets should promote a "*stable and effective regulatory environment for future investments and contribute to a more level playing field and enhanced competition between different operators and networks*".[7] The European Commission also highlights that the important consumer benefits from "*enhanced competition and investment through lower prices and innovative services*".

1.4 Implementation of the principles paper conclusions

Prior to the cost modelling workflow, ComReg engaged Analysis Mason to develop a principles paper on the most suitable approach to assess Fixed and Mobile Termination rates in the Irish context. This report summarizes the main conclusions from the European Commission recommendations presented above and defines further Ireland-specific features of the FTR and MTS models.

This section aims at summarizing the key identified principles that are relevant in the context of the FTR modelling and how they have been implemented in practice.

1.4.1 Price Control

The principles paper reaches the following conclusions:

- The current cost-oriented pricing is justified as a proportionate and suitable method of regulation for FVCT;

[6] Commission Staff Working Document accompanying the Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU – Implications for Industry, Competition and Consumers. SEC(2009)600 (Staff Working Document).

[7] Section 3.4, page 15 of the Staff Working Document.

- A 'pure' incremental costing should be adopted for FVCT services, considering (off-net) voice termination traffic as the last increment of the stack.

Following the conclusions of the principles paper, a cost model is developed following a 'Pure LRIC' traffic where voice termination traffic.

In line with the TRR, the increment is restricted to wholesale termination traffic.

1.4.2 Model structure

The principles paper reaches the following conclusions:

- A top-down validation of the modelling to be performed, "whereby the outputs of a bottom-up model are adjusted to reflect aspects of outputs from top down operator information";
- The cost model should calculate costs per minute for at least the years 2017-2022 in nominal currency.

The model developed by ComReg to determine the current FTRs was built as an add-on to ComReg's "NGN core cost model" used in the previous decision (D06/07).[8]

ComReg developed a new version of its BU-LRAIC+ "NGN Core Model" in 2016-17 in the context of market 3b and leased lines analyses. That is now used as a starting for the FTR modelling. The FTR add-on enables calculation of voice-specific costs and a macro is used to assess the incremental transmission costs (by comparing the network costs with and without the wholesale termination traffic).

During the development of the NGN model, a top-down validation has been performed by comparing the inventories (number of assets) modelled with the real number of assets in Eir's network. A comparison has been performed between eir's data and output from the NGN Core Model of the total number of exchanges, aggregation nodes, edge nodes and core nodes between and the number of DSLAMs/Chassis used.

The FTRs are assessed for the 2017-2022 period.

1.4.3 Costing approach

The principles paper reaches the following conclusions:

- The modelled operator should:
  - Be a hypothetical efficient operator;
  - Be assumed to have productively–efficient scale.

[8] https://www.comreg.ie/csv/downloads/ComReg12125.pdf

- Modern technologies for the future regulatory objective should be chosen (modelling for voice over IP platforms for example);
- Economic depreciation should be the starting point for cost recovery over time.

1.4.3.1 Choice of generic operator

An alternative operator can achieve high level of economies of scale deploying its network along routes of high densities and by buying wholesale products from the incumbent or other operators with significant coverage thanks to interconnection**:**

- If it buys termination charges from the incumbent, an alternative operator benefits from the same economies of scale as the incumbent because termination charges are cost oriented.
- The economies of scale of the incumbent can be achieved by alternative operators.

⇨ **Following the conclusions of the principles paper, the hypothetical efficient operator should have eir's scale.**

1.4.3.2 Choice of the modelled technology

In line with the European Commission recommendation and the principles paper, the model is based on an NGN core technology.

Another question to be addressed is whether a TDM[9] interconnection or a SIP[10] interconnection arrangement is to be modelled. In most European countries, the transition from TDM to SIP interconnection is at an early stage.

The modelling of SIP interconnection is only relevant if SIP interconnection is expected to significantly develop within the years to come.

In the context of this project, eir have been requested to provide their plans regarding the migration to SIP interconnection.[11] eir has underlined that the IP interconnection is unlikely to significantly develop in the years to come:

- IP interconnection will first be implemented by eir for the international traffic (early steps have been delayed for now);
- "Open eir has yet to implement an IP interconnection for voice with any of other operators";
- According to eir, no alternative operator has shown significant interest for a move to SIP interconnection with eir.

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[9] With TDM (Time Division Multiplexing) interconnects, the signalling may be (CCS) 7 or SS7.

[10] With IP interconnects, signalling may be SIP (Session Initiation Protocol), SIP-I.

[11] Open eir presentation : "ComReg briefing on Open eir VOIP and SIP interconnect plans", dated from 29 November 2016

⇨ **Taking into account the stage of development of IP interconnection, it appears reasonable to keep the current interconnection modelling based on TDM.**

1.4.3.3 Economic depreciation

Tilted annuities implemented in the model are a good proxy for economic depreciation in the context of a mature network and as demand is not forecasted to follow any significant take-up.

The annuity formula implemented in the model is the following:

$$A_1 = \frac{I}{(1+w)^{T+\frac{1}{2}}} \times \frac{w-P}{\left[1-\left(\frac{1+P}{1+w}\right)^N\right]}$$

Where:

- A1, the annual charge is year one (used for price calculation)
- I, the investment value of the asset
- w, the cost of capital (parameter)
- P, the real annual change in the price of the asset
- N, the useful life of the asset
- T, the average payment term

1.4.4 Consistency of treatment will be needed for both FVCT and MVCT:

The principles paper reaches the following conclusions:

- Symmetric pricing for the regulated service providers should be applied in both the FVCT and the MVCT models;
- Consistent forecast of the Irish voice market should be applied for the FVCT and the MVCT models;
- The model should also calculate the common costs not recovered if a pure-LRIC approach is applied to voice termination, in case this needs to be considered by ComReg in the context of other market analyses;
- The models should derive costs for individual twelve month periods.

The criteria listed in the principles paper have all been implemented with the exception of the consistency checks between the FCVT and the MCVT traffic. The consistency of fixed-to-mobile and mobile-to fixed traffic between these models could not be checked due to the unavailability of the traffic breakdown by traffic origin.

However, the traffic provided in the context of this project have been checked against ComReg's quarterly reports and so are sufficiently robust.

2 FTRs modelling

2.1 Presentation of the NGN model

For costing leased lines and market 3b costing, ComReg has been preparing a new version of the NGN model[12] that models the core network for a Hypothetical Efficient Operator with the scale of eir.

All core services are considered in the modelling and core network costs are modelled for the 2009-2022 period in a regional level taking in account:

- Active equipment at nodes, which depends on:
  - The number of subscribers connected at each node;
  - The traffic passing through the network depending on;
  - The architecture of the network;
- Routing factors for each service;
- Civil engineering assets;
- Top-down opex from eir regulatory accounts.

Specification of this NGN model is further detailed in ComReg's draft decision for the WCA/WLA market.[13]

It is used as the starting point for the FTR modelling as:

- The NGN model represents an appropriate efficient network topology.
- The NGN model has as input the likely demand for services.
- The NGN model calculates the efficient network and operating costs.
- The NGN model uses an appropriate allocation of costs to services

Fixed terminations rates can then be calculated following a pure LRIC approach using the NGN model and assessing the total costs with and without wholesale termination traffic.

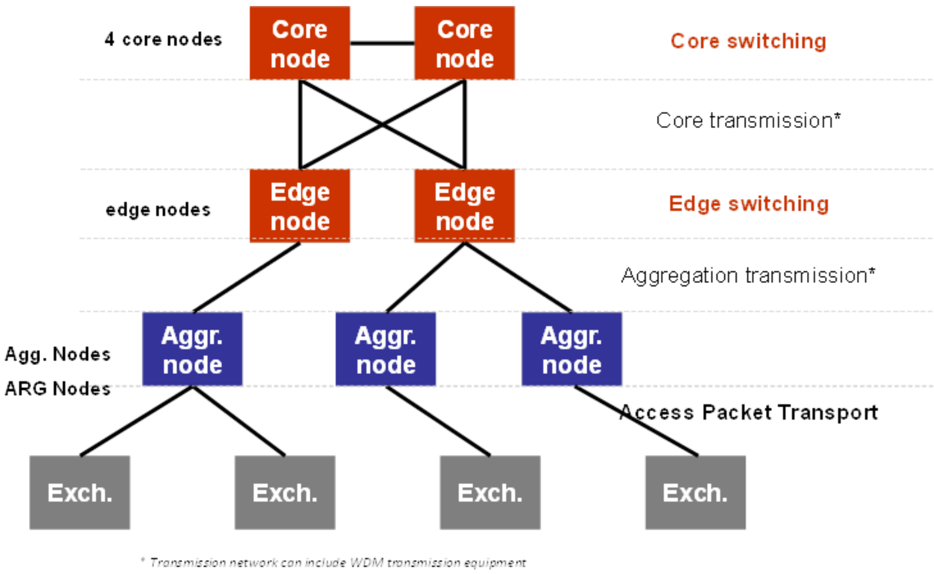
2.1.1 Appropriate efficient network topology

The model is based on a scorched node approach and modelled based upon eir's current deployment of NGN nodes as set out below. This is considered as representative of an efficient network topology over which fixed voice will be delivered over the next few years and beyond.

[12] This model is still being developed.

[13] ComReg D17/26: "Pricing of wholesale services in the Wholesale Local Access (WLA) market and in the Wholesale Central Access (WCA) markets: Further specification of price control obligations in Market 3a (WLA) and Market 3b (WCA)" dated from 07 April 2017

Figure 1 - Overview of Eir's NGN



Source: TERA Consultants

2.1.2 Likely demand for services

To determine the network capacity demands for voice services the NGN Core Model first calculates the number of voice channels active at the busiest hour of the year in erlang[14] as a percentage of the total customer base. The number of busy hour channels is augmented with a cell blocking probability formula before being converted to the number of equivalent links of STM-1 capacity. The network capacity demand due to voice services is then finalised for the various components in the network by adding an allowance for an overcapacity factor.

The model allows also the split of the overall voice capacity demand between the various call types (local, national, primary termination, etc.) as each call type can use the network assets in different ways. To do this the number of channels is allocated to the type of voice traffic proportionally to the number of minutes generated by each voice traffic category in the year under review.

In order to categorise the traffic between the different traffic topologies (voice, broadband and leased lines), the model uses a list of the exchanges (access nodes) based on information provided by eir with:

- The site code of the aggregation node to which it is connected;
- The region of the site (the NGN core network is divided in 17 regions);
- If the site is connected to an ATP.

[14] An Erlang is a unit of telecommunications traffic unit and represents the continuous use of one voice path.

2.1.3 Efficient network and operating costs

The model calculates the main network costs associated with the provision of voice services:

- Node costs;
- OLT and DSLAM costs;
- Trench, duct and poles costs;
- Dense wavelength division multiplexing ('DWDM') / Code or coarse wavelength division multiplexing ('CWDM') system costs / Access Packet Transport costs, and re-configurable optical add drop multiplexer ('ROADM') costs;
- Opex;
- Others (Material costs, Buildings and power cost, Network management systems).

2.1.3.1 Node costs

The NGN Core Model calculates the cost of all of the nodes in the network, including core nodes, edge nodes and aggregation nodes. Each node calculation is made separately and the costs are identified between fixed and variable elements.

The NGN Core Model calculates the cost per region for each of the following:

- Aggregation nodes;
- Edge nodes;
- Core nodes; and
- Reconfigurable optical add-drop multiplexer ('**ROADM**'), i.e., the equipment at the nodes.

Aggregation nodes:

The NGN Core Model calculates the number of links and ports required at each aggregation node. The objective is to assess the average number of gigabit ethernet ports for each aggregation node in the region. This is an important step as it determines the number of Input / Output multiplexer ('**IOMs**'), Media Dependent Adaptors ('**MDAs**') and small form pluggable devices ('**SFPs**') to deploy. These are in effect the variable cost components associated with aggregation routers. The traffic demands on the aggregation routers at the service ports facing primary service demands or indeed the demands on the ports which face links to the next layer of the network, the IP edge routers, are determined based on demand data and routing factor analysis. This in turn determines the capacity and the number of ports required at each aggregation site.

The following formulae are used to calculate the number of ports for fibre access, number of ports for DSLAMs (used for both broadband and voice services) and number of ports for backhaul (non-ROADM) respectively in the NGN Core Model. By determining the number of ports for each aggregation node we are able to determine the capital costs associated with aggregation node deployment at each location where they are placed. The first formula relates to leased lines traffic demands, the second relates to demands from broadband and voice services. Finally, the third formula relates to the onward connection of traffic demands for all services from the aggregation node layer of the network up the hierarchy to the IP edge or regional routers.

$$\textbf{Number of Ports for fibre access} = \frac{\textbf{Nb access term point}}{\textbf{Nb agg nodes}} \, x \, \frac{1}{\textbf{Max capacity agg nodes}}$$

$$\textbf{Number of Ports for DSLAM} = \frac{\textbf{Nb of ports linked to 1 Agg} + \textbf{Nb of DSLAM for cabinet per 1 Agg}}{\textbf{Max capacity agg nodes}}$$

$$\textbf{Number of Ports for BE backhaul (non ROAM)} = \frac{\textbf{PE backhaul requirement (traffic Agg to Edge)}}{\textbf{Nb of Agg}} \, x \, \frac{1}{10000}$$

The optical line termination ('**OLT**') is a device which serves as the service provider endpoint of a passive optical network for FTTH GPON solutions used to service such broadband end users. The dimensioning rule in the NGN Core Model is that at the aggregation node, 1 port is reserved for each 1 OLT. The chassis of the aggregation node in the NGN Core Model is generally an ESS-12, which is a multiple port switch for switching traffic between ports.

Finally, the cost for the aggregation node equipment is calculated per node and per region using the number of ports and the unit prices.

Edge nodes:

The NGN Core Model calculates the number of links and ports required at the edge node. This is based on traffic demands and routing factors.

Similar to the aggregation nodes, the objective is to derive the average number of gigabit Ethernet ports for each edge node in the region. This determines the number of IOMs, MDAs and XFPs. The selected chassis in the case of edge nodes is the SR12, which again is a multiple port device but in this case is a router rather than a switch, used to route traffic up and down the network hierarchy.

The cost for the edge node equipment is calculated per node and per region using the number of ports and the unit prices.

Core nodes:

Similar to the approach for determining the ports and links for the aggregation nodes and edge nodes, the NGN Core Model calculates the number of links and ports for the core node. Once again, and consistent with the objectives in the case of aggregation nodes and edge nodes, the aim is to assess the average number of gigabit ethernet ports for each core node in the region. This determines the number of XCM and SFPs to deploy.

In the case of failure, one core node may be dimensioned to handle traffic of other defect nodes. Therefore, in the NGN Core Model there are design rules in the case of node failure as follows:

- 2:1 node may carry its traffic and 1 additional failing node;
- 3:1 node may carry its traffic and 2 additional failing nodes;
- 4:1 node may carry its traffic and 3 additional failing nodes.

The selected chassis in the case of the core node is the Extensible Routing System (‘XRS’) which is a high capacity router solution which can be scaled to manage 32 T/B of data and interface with ROADM and other high speed optical multiplex solutions. This component is placed at the apex of the network and manages transit traffic between all 20 NGN network regions.

The cost for the core node equipment is calculated per node and per region using the number of ports and the unit prices.

ROADM for nodes:

The ROADM costs include fixed and variable costs. The rule in the NGN Core Model is to deploy ROADM for each and every edge node, core node and aggregation node that generates over 100Gbps of traffic.

The NGN Core Model calculates the variable cost for each ROADM depending on traffic. Note ROADM technology is only deployed between the edge and core routers where traffic demands are high.

For each site (with aggregation node, edge node and core nodes) the NGN Core Model counts how many other sites it is connected to in order to derive port counts:

- Edge node: each has 2 connections to a core router and there are two edge routers per region, which establishes ROADM node sites, and their capacity needs in each region;
- Core node: In addition to the ROADM port connections required to connect Core nodes and edge node in each region, there is also some port needed to connect Core router sites together, to form a secure traffic matrix with redundancy assurance. Thus again based on port and traffic needs, ROADM technology is deployed at the Core router sites, sufficient to address the calculated requirements.

The NGN Core Model then calculates the variable cost for each ROADM, depending on the traffic at the node.

There are three options in terms of variable costs, depending on traffic at the node:

- 100 Gbps capacity on a 100 Gbps system (traffic between 10 Gbps and 100 Gbps);
- 10 Gbps capacity on a 100 Gbps system (traffic <10 Gbps);
- 100 Gbps capacity on a 200 Gbps system (traffic < 200 Gbps).

For core nodes the NGN Core Model takes into account links with other core nodes and with the edge nodes of the region.

For each node the NGN Core Model calculates the cost for CMS (Cable Management systems), power and accommodation needs for the router type including core router nodes and all other equipment types. CMS equipment is used to connect fibre optic and power cable to/from the equipment types. In addition, the power demands for the core router is known from supplier specifications, and the model is informed by a cost of a kilowatt of power. Similar costs are calculated for all equipment types. Accommodation costs are calculated based on the physical footprint required by each equipment type and used in conjunction with eir wholesale tariffs for co-location facilities. This permits the model to calculate summary accommodation costs for all equipment types. The result of these processes is that ancillary costs for CMS, power and accommodation of all equipment types per region can be determined.

2.1.3.2 DSLAM costs

For DSLAMs, the NGN Core Model determines those sites where there is DSLAM or OLT equipment. For each site with DSLAM equipment the NGN Core Model calculates the number of cards for the DSLAMs at exchanges (eVDSL) and cabinets (FTTC) and the OLT for FTTH. For each site the number of cards required for DSLAM equipment is then calculated based on the number of end users as follows:

$$Nb\ of\ equip = \frac{INTEGER(Nb\ of\ customers)}{Max\ capacity} + 1$$

The annualised cost for DSLAMs at every site is calculated based on the unit cost for DSLAM equipment and taking into account the annualisation factor for the DSLAM equipment.

2.1.3.3 Trench / Pole costs

In the NGN Core Model trenches and poles are deployed in order to ensure core sites are connected together. The NGN Core Model assumes some of trench sharing calibrated to result in a similar length of trench in the core network as eir has in reality. This sharing component relates to the fact that inter-exchange routes between aggregation node and IP edge node sites share part of the trench with the aggregation to APT node.

In order to determine the overall trench costs, the NGN Core Model takes account of the results of the trench lengths, with additional dimensional aspects of trench required to finalise overall costs. These include the trench size (or the number of pipes in the trench) and the type of surface of the trench which needs to be excavated and reinstated.

The NGN Core Model can choose any of the three trench sizes used by eir in its core network as follows:

- 2 ways;
- 6 ways;
- 12 ways.

The assumptions in the NGN Core Model for the surface mix for trench are set out in figure below:

Figure 2 - Surface type assumptions in NGN Core Model (for illustrative purposes only)

Share for the length		
		Share
Dublin		
	Concrete	33%
	Carriageway	33%
	Verge	33%
Province		
	Concrete	33%
	Carriageway	33%
	Verge	33%

Source: 160415_Core Model Review_2015-34-DB-data request NGN model (2)

The trench costs associated with the surface mix are consistent with the costs in the Revised CAM. Price trends are applied to the trench costs.

For each region, the NGN Core Model calculates the total trench costs and then the share relevant to the access network is removed.

Costs of poles are assessed considering 1 pole every 50m and a sharing of half poles with the access network.

2.1.3.4 DWDM / CWDM / APT costs

Dense wavelength division multiplexing ('DWDM') is a technology that puts data from different sources together on an optical fibre, with each signal carried at the same time on its own separate light wavelength. Using DWDM technology means that a network operator can increase the capacity on a given route without having to deploy additional fibre cables on that route. In the NGN Core Model the value for DWDM equipment is based on the product of the volumes of DWDM systems required by the supplier costs for the equivalent CWDM system as outlined in the next paragraph.

Code / Coarse wavelength division multiplexing ('CWDM') is a method of combining multiple signals on laser beams at various wavelengths for transmission along fibre optic cables, such that the number of channels is fewer than in dense wavelength division multiplexing (DWDM) but more than in standard wavelength division multiplexing ('WDM'). In the NGN Core Model the unit cost for CWDM is based on the costs of an 8 channel passive WDM unit. Each system requires two of the 8 channel devices, one to service each end of the WDM route linking two network locations. This in turn permits the calculation of an approximate cost for each optical path or wavelength per region for the CWDM systems.

Access Packet Transport ('APT') is used to connect the remote sites to the aggregation nodes. eir has provided information on the cost and engineering rules associated with the deployment of APT.

The NGN Core Model parameters allows for exclusion of WDM technology costs as the cost model has deployed sufficient fibre optic cable capacity of up to 48 fibres so removing the need for optical multiplexing.

2.1.3.5 Operating costs

The NGN Core Model bases the operating costs on the operating costs of the core network contained in eir's accounts, but with a number of efficiency adjustments. The operating costs include pay costs, non-pay costs and indirect capital costs. The NGN Core Model allocates the operating costs from eir's accounts (e.g., repair and maintenance, data platforms, transmission link, transmission length, etc.) to each part of the NGN network by category (e.g., exchange to aggregation links, aggregation node, edge node, core node and all the relevant links connecting the locations of the routers).

In total the operating costs from eir's accounts relating to core network connectivity or transmission infrastructure, after efficiency adjustments, are summarised into seven cost classifications. These classifications include repair and maintenance, data platforms, transmission link, transmission length, etc.

The NGN Core Model then allocates the total operating cost for each network component to each of the NGN network regions using allocation keys based on the capital cost for equipment and trench length.

The allocation process is based on the application of a network allocation table which determines whether each of the seven operating cost classifications is relevant for allocation to each of the nine NGN network components, which are:

- Exchange (Remote) to Aggregation Node (Equipment);
- Exchange (Remote) to Aggregation Trench;
- IP Aggregation Router;
- IP Aggregation to IP Edge Router (Equipment);
- IP Aggregation to IP Edge Router (Trench);
- IP Edge Router;
- Core Network Equipment;
- Core Network Trench; and
- IP Core Router.

When the allocation rules permit the attribution of operating costs to a given infrastructure type, the next consideration is what share of each operating cost classification should be attributed to that infrastructure type in each of the 20 NGN network regions. This stage of the allocation process is determined by the relative capital values associated with the relevant infrastructure in each region. The scale of the capital values for infrastructure in each region would have already been established based on unit costs, network design rules and summary demands from the range of services supported. An example would be where the operating cost classification relates to the active electronics equipment, in which case the operating costs will be attributed to each of the regions based on the relative capital values for electronic equipment such as IP routers and WDM equipment in each of the 20 NGN network regions.

Finally, the NGN Core Model allocates the operating costs between the three services supported, including broadband, voice and leased lines. This is done in each NGN network region in line with the attribution of capital related costs of network infrastructure. In each NGN region, infrastructure costs are separated into fixed and variable cost classifications, e.g. trench costs would be regarded as a fixed cost classification as related costs do not readily increase with capacity demands, whereas port equipment costs on routers, are more immediately impacted by the growth in capacity demands and thus are regarded as variable in nature.

2.1.3.6 Other costs

Other costs include material costs, management system costs and building and power costs.

For material costs, the NGN Core Model includes the cost for cable management systems ('CMS'), power supply, optical distribution frames ('ODFs') and related fibre tie cables. CMS and power costs have been detailed earlier in this document. ODF costs relate to the termination of fibre cables connected to equipment at each site and also fibre cables connected to the access network, to provide a connection panel solution to link equipment optical ports with external fibre cables serving connectivity into the access network for FTTC or FTTH broadband, high speed or leased line access and also intra-core network connectivity (e.g., aggregation to edge node links).

The NGN Core Model also includes the costs for one-off management systems as well as the annualised costs of management of the network.

The one-off management system costs are calculated for each unit of traffic based on the following formula in the NGN Core Model:

$$\textit{Unit management CAPEX} = \frac{\textit{One} - \textit{off}}{\textit{Cumulated regional traffic}}$$

The annualised management costs for each unit of traffic are based on the following formula in the NGN Core Model:

$$\textit{Unit management cost} = \frac{\textit{Total annualised}}{\textit{Cumulated regional traffic}}$$

For building costs, the NGN Core Model takes the building rental cost per exchange (per square metre) from the Open eir ARO price list. The following costs are then added to derive a total cost per square metre:

- Base rental for building;
- Uplift for facilities, air conditioning and stand-by generator;
- Actual use of additional facilities of air conditioning and false flooring;
- Cost for power, assuming a maximum 1KW demand per year at the site with air conditioning provided.

The NGN Core Model then calculates the total number of square metres in order to derive the cost of buildings. There are two options in the NGN Core Model for calculating building costs as follows:

- Option 1: Bottom up
- Option 2: Use eir's accounts to calculate the building costs.

Currently, the NGN Core Model applies the bottom up approach, combining the Access Reference Offer ('**ARO**') tariffs in combination with the inventory of equipment and accommodation space needed (based on known dimensions of each equipment type). In addition, the power requirements at each location can be determined based on inventory and the equipment's power demands provided from supplier data. This approach also recognises the accommodation space used by legacy SDH infrastructure at some remote exchanges (access nodes) to service transmission capacity connectivity to aggregation node sites. Normally, APT nodes meet this requirement, and in recognition of this, additional accommodation capacity and consequent costs are included, at some network sites where APT nodes do not exist, but SDH equipment provides the same function.

2.1.4 Appropriate allocation of costs to services

One of the main challenges in the core network cost calculation is to allocate the shared network costs to each service.

Where costs are fixed, the traffic based cost allocation can raise issues, particularly when the traffic for one service is increasing at a faster rate compared to the other services. This is especially relevant in the case of broadband.

In the proceeding paragraphs we identify options to allocate traffic costs between the different telecoms services on the core network as well as the advantages and disadvantages of each. We also set out our preliminary views on the most appropriate option for sharing traffic costs across the core network going forward.

In terms of background, in order to provide eir's core network services, several types of costs are incurred as follows:

- **Network costs - fixed element:** These include all network costs that are not traffic-sensitive. This includes most of the costs of passive infrastructure (e.g., trenches, ducts, cables, buildings) as well as fixed cost elements associated with active equipment (e.g., DSLAMs or OLTs, common components of the aggregation router, etc.).
- **Network costs - variable element**: These include all of the variable cost elements of the active equipment (e.g., ports for each of the routers), including aggregation routers, edge routers and core routers.
- **Non-network costs**: These include corporate overhead costs (e.g., chief executive salary).

In the NGN Core Model, all specific costs that can be directly linked to services do not need a detailed allocation method (as direct allocation occurs). However, for joint network costs and non-network costs, allocation mechanisms are needed as follows:

- **Network cost: fixed element:** For fixed network cost, the traditional way to allocate costs (based on traffic) is less relevant as traffic is not the cost driver.
- **Network cost: variable element:** As the variable network costs are driven by traffic, the cost allocation method is to link it to traffic per service (traditional way to allocate costs).

- **Non-network costs:** The best practice to allocate non-network costs is on the basis of Equi-Proportional Mark up ('EPMU').

In order to allocate fixed network costs among services, we have considered the following options:

- Option 1: Capacity based allocation approach: For each asset, the cost is allocated to the services based on the peak hour traffic of each service making use of the asset.
- Option 2: Equi-repartition (1/3 1/3 1/3): For each asset, the cost is equally distributed between the services on the network making use of the asset.
- Option 3: Based on revenue per user: For this option, fixed costs of assets are allocated to each services based on the average income per user occurring in advance of the control period. This allocation key is calculated in the model by dividing the total revenue per service forecasted for each year by the total number of subscribers of that year.
- Option 4: Based on total revenue: This option is based on a snapshot of the revenues of the voice / broadband / IPTV / leased lines services taken at the beginning of the control period. For each asset, the fixed cost element is allocated to the services making use of the asset depending on the % of total revenue.

For Option 1 (capacity based approach), if the traffic per user for a service increases significantly, the costs allocated to that service increase significantly. In addition, if the traffic per user for a service doubles, the end user may not be willing to pay twice the price. The capacity based allocation is the traditional approach in the telecoms sector and it is the approach that has been adopted in the NGN Core Model to date. However, this approach fails to provide stable pricing signals over time and it may not be in line with end users' willingness to pay. As an example, broadband and leased lines services have increasing levels of traffic per end user but end users are generally not willing to pay a higher price for this better service.

For Option 2 (Equi-repartition), if the traffic per user for a service increases significantly, the cost allocated to the service remains stable. However, this can be problematic if the end users base evolves. If demand for any given one of the three services (voice, broadband and IPTV) grows and capacity and volumes related to that service classification increases, then costs attributable to each individual product associated with that service may fall to very low levels, due to economies of scale. This would arise as the model would not attribute incremental fixed costs driven by the emerging product demands in an appropriate manner, and would not link the cause and attribution of costs. In tandem with this outcome other services where demand volumes are static would absorb increasing fixed costs and so in some cases result in price increases, which might further disincentivise demand for a nascent service. Therefore, the share of fixed costs allocated to the growing service will not increase appropriately if the traffic per user increases but other services would bear a disproportionate share of the incremental fixed costs. The equi-repartition (option 2) provides more stable outputs and the allocation of costs to a given service is independent of the traffic evolution of other services. However, it may not be in line with the end users' willingness to pay if services driving more traffic are not those driving more revenues.

For Option 3 (total revenue per user), initially service revenues at a given point in time are used to apportion fixed costs to services. Subsequently, the allocation of fixed costs to each service is updated by forecast data, contained in the cost model. This is for each year in the control period. The forecast data includes product volumes and traffic levels, which in turn provide forecast revenues per service type. If the forecast traffic per user for a service increases significantly, or overall forecast end user volumes increase, the fixed costs allocated across each of the services will change. It will evolve with the end user base (and or with the traffic). Therefore, the share of costs allocated to the service will increase if the traffic per user increases and the allocation of costs should be in line with the end users' willingness to pay. This option takes the same revenues (as per Option 4 below) and divides it by the volumes to get ARPU/ end user type. As the volumes and mix changes between the three services over the years the drivers of fixed costs are updated to reflect the volume and product mix. This option provides more price stability and the allocation is based on what the end user has accepted to pay in the past.

Option 4 (total revenues approach), results in the apportionment of costs based on revenues per service at a point in time. So if the traffic per user for a given service increases significantly, the cost allocated to the service remains stable under this approach, as the cost drivers do not reflect more recent relativities of service revenues. However, this can be problematic if the end user base evolves, in which case actual revenues do increase and would normally result in higher costs being absorbed by that service. If volumes remain static or decline the share of costs allocated to the service will not increase or fall even if the traffic per user increases and the initial allocation would be in line with the end user's willingness to pay. This option takes revenues, split between voice, broadband, IPTV and Leased Lines (when included in the analysis), at a single point in time and is used to derive relative ratios as drivers for the fixed cost allocations. But this remains static and does not consider the changing mix of volumes over subsequent years, which are contained in the forecast data for product volumes and consequent traffic levels by service.

Option 4 is used in the base scenario.

2.2 Reference files for further changes to the NGN model required to calculate FTRs

The following table summarizes the main reference files for further changes to the NGN model required to calculate FTRs.

The NGN model input sheets: “Routing Factors”, “Voice Traffic” and the new “FTR plug-in” sheet have been updated accordingly using data from the following files.

Table 1 - Reference files

File name	Content
170223_NGN RF Review	- Updated Routing factors for existing voice services + proposed routing factors for the “inpayments service”
161230-FTRs Wholesale Input	- Wholesale services traffic volumes and forecasts for the period 2013-2019
170405_ComReg Data Request FTRs_Q#1	- Retail services traffic volumes and forecast for the period 2013-2022
170314_Call Ter_Updated voice platform calculation 2017	- Unit costs, support costs, asset lives, and price trends for voice specific switching and billing - Average call duration and busy hour minutes

Source: TERA Consultants

2.3 Main changes to the existing NGN model

The main changes to the existing BU-LRIC model include:

- Voice Traffic Volumes have been updated following new traffic figures received from eir for the period 2013-2016.
- Two options are proposed for forecasting voice traffic starting from 2017:
  - Using historical CAGR for the period 2014-2016.
  - Using forecasts submitted by eir.
- Routing factors for voice services were updated as per eir’s last submission

There are discrepancies between traffic volumes submitted by eir and historical trends.

- eir explains these discrepancies by the fact that they expect a significant share of the access line base to migrate from lines with voice and broadband to lines with only broadband.
- A sensitivity analysis on impact of these differences on FTRs is performed.

Figure 3 - Termination traffic evolution depending on forecast option (Mln mins, 2016-2019)

Source: NGN model – FTR update, "Voice Traffic"

2.4 Structure of the FTR add-on

"Voice services –Platform costs" worksheet included in the add-on to the FTR model enables to calculate:

- **Transmission costs:** As outputs from the BU-LRIC NGN model
- **Voice Platforms costs:** Based on eir's accounts
- **Billing costs:** Based on eir's accounts

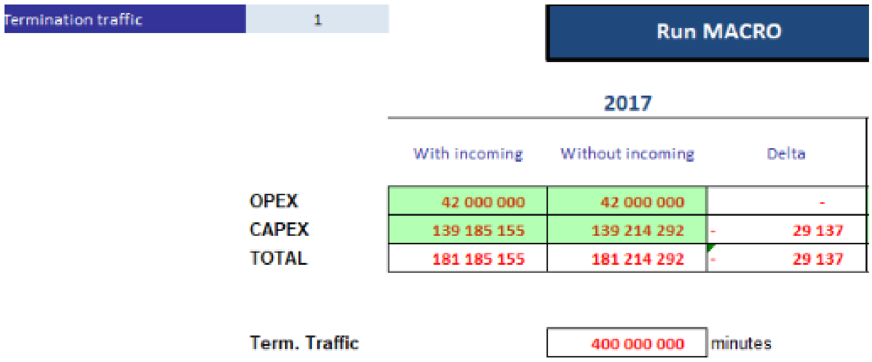
This sheet also summarizes Pure LRIC Fixed Termination Rates

2.4.1 Transmission costs calculation

Transmission costs are calculated as the difference of network cost when including and excluding wholesale termination traffic divided by the total wholesale termination traffic for year of calculation:

- The year of calculation can be chosen in the "Control" Sheet (here 2017)
- The model has to be set to the "eir" scenario in the context of FTR calculations
- To update the calculation, the "Run Macro" button has to be pushed.
    - The aim of the macro is to run twice the model for each year, once with the termination traffic and once without (in this scenario, the traffic is then deleted in the "Technical Peak Traffic" sheet).
    - Results of these scenarios for each year are then pasted in the sheet "Voice Services - Platform Costs".

Figure 4- Screenshot of the model for the functioning of the Macro for transmission cost calculation (for illustrative purposes only)



	With incoming	Without incoming	Delta
OPEX	42 000 000	42 000 000	-
CAPEX	139 185 155	139 214 292	- 29 137
TOTAL	181 185 155	181 214 292	- 29 137

Term. Traffic	400 000 000	minutes

Source: NGN model – FTR update, "Voice services –Platform costs"

Transmission costs are calculated as the difference in cost with or without the wholesale termination traffic. The change in costs between the two situations is more specifically due to the number of line cards to handle traffic between aggregation nodes and edge Nodes that is the more impacted by a change in voice traffic (the rest of installations can be considered as less variable with a change in traffic, as trenches, ducts and cables). Depending on the year, the number of line cards may or not vary (e.g. 2019 and 2020).

Therefore, a sensitivity analysis has been performed (see figure below) to assess the impact on FTRs of changes in traffic forecast depending on the option chosen:

- Eir's proposed forecasts (which is used for calculation);
- Historical traffic trends

This sensitivity analysis has shown that changing voice traffic forecast has an increasing impact on transmission cost. However, the 2 scenarios are closer for the earlier years

Nonetheless, transmission costs play a minor part in the total Fixed Termination Rates.

Figure 5 - Transmission costs evolution depending on forecast option (€c, 2017-2022)

Source: NGN model – FTR update, TERA Consultants analysis

2.4.2 Voice platform costs calculation

To model Voice specific costs, the plug-in follows the framework used in the previous version of the model that served for former FTR determination and the framework proposed by eir in their last submission:

- This modelling still appears relevant as the interconnection technical arrangement has not significantly evolved according to eir.
- Views from eir and Other Authorised Operators do not indicate that the move to SIP interconnection for national traffic is likely to be quick and significant in volume for the coming years.

To perform a pure LRIC approach for cost determination, only avoidable costs have to be taken into account.

eir proposes in their response to the data request[15] that as most material costs are fixed, only Voice-specific licenses of IMS Core/TAS, the SBC and MGC/MGW have to be taken into account as the variable part that depends on termination traffic volumes.

2.4.2.1 IMS Core / TAS

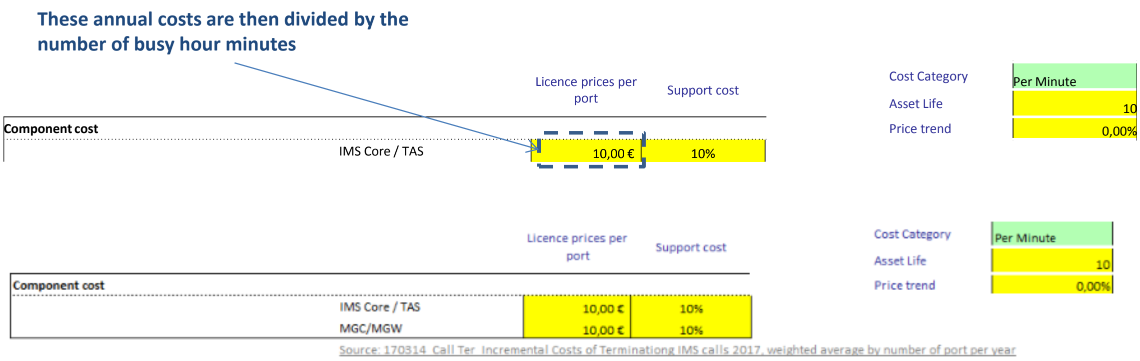
This Network Element is used for conveyance of packetized call minutes.

For this network element, the main costs are fixed:

- All physical platform costs are considered to be fixed.
- Fixed costs have not been assessed in the context of this pure LRIC calculation.

However, some licence costs are driven by call minute volumes as per figure below:

Figure 6 - IMS Core /TAS Licence specification (for illustrative purposes only)



Source: eir

These licence costs are dimensioned based on a required number of ports. Each port is assumed to handle ✂minutes over the year (250 busy days x ✂ busy hours x 60 minutes).

A Price trend for licences of ✂% is applied following Eir's assumption.

[15] Eir 's response in the file "170314_Call Ter_Incremental Costs of Terminating IMS calls 2017" received on 15 March 2017

A mark-up of ✂% of the 2017 licences GRC is added as support cost.

2.4.2.2 SBC and MGC/MGW

The SBC functions as a boundary between the access and core of IMS for signalling and media.

MGC/MGW provide functionality to break and out from IMS for signalling and media.

For these network elements, the main costs are fixed:

- All physical platform costs are considered to be fixed.
- Fixed costs have not been assessed in the context of this pure LRIC calculation.

However, some licence costs are driven by call volumes for traffic that requires TDM to IP, or IP to TDM, translation:

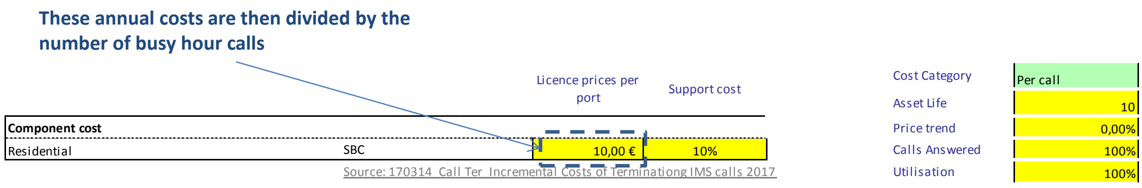
⇨ In the modelling, it is considered it is the case for all termination traffic as a IP core network is modelled with a TDM interconnection

These licence costs are dimensioned based on a required number of ports. Each port is assumed to handle ✂minutes over the year (250 busy days x✂ busy hours x 60 minutes).

A Price trend for licences of ✂% is applied following eir's assumption.

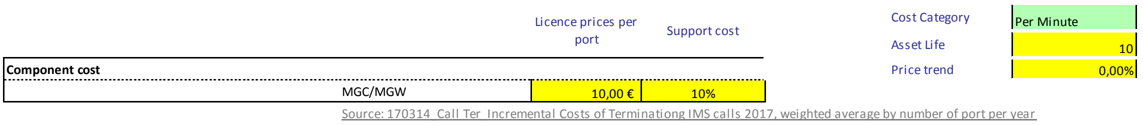
A mark-up of ✂% of the 2017 licences/component GRC is added as support cost.

Figure 7 – SBC Licence specification (for illustrative purposes only)



Source: eir

Figure 8 – MGC/MGW Licence specification (for illustrative purposes only)



Source: eir

SBC costs are then attributed to the "per call" component of the FTR.

2.4.2.3 Next generation intelligent network ('NGIN')

The costs of jNetx platform expansion have been provided by eir. These costs exclude base hardware & software (not relevant for Pure LRIC calculation).

Price trend for licences is ✂% according to eir.

A mark-up of ✂% of the 2017 licences GRC is added as support cost.

Figure 9 - jNetx platform expansion costs (for illustrative purposes only)

Component cost		JNetx platform expansion cost per call	Support cost
	NGIN	0,28 €	10%

Cost Category	Per call
Asset Life	10
Price trend	0,00%

10 Sessions per second capacity	10 000 €
Calls Answered	100%
Utilisation	100%
Calls per busy hour	36 000

Source: eir

NGIN costs are then attributed to the "per call" component of the FTR.

2.4.2.4 Voice specific costs calculation

Voice Specific costs are calculated in rows 39:121 of "Voice Services – Platform Costs" sheet. The total incremental cost for each cost category is then calculated using a titled annuity. Besides, support costs per year is calculated as mark-up of Material cost

Figure 10 - Example of voice specific cost calculation SBC (for illustrative purposes only)

Component cost		Licence prices per port	Support cost
Residential	SBC	10,00 €	10%

Source: 170314 Call Ter Incremental Costs of Terminationg IMS calls 2017

Cost Category	Per call
Asset Life	10
Price trend	0,00%
Calls Answered	100%
Utilisation	100%

Titled annuity as percentage of GRC	14,4%

		2017	2 018	2 019	2 020	2 021	2 022
Price Index	%	100%	100%	100%	100%	100%	100%
Index Adjusted Annuity	%	14,4%	14,4%	14,4%	14,4%	14,4%	14,4%
Total Incremental cost	€	1	1,4	1,4	1,4	1,4	1,4
Support as % of 2017 licences prices per port	€	1,0	1,0	1,0	1,0	1,0	1,0

Source: NGN model – FTR update, "Voice services –Platform costs"

2.4.3 Billing costs calculation

Billing costs are calculated in rows 122:143 of "Voice Services – Platform Costs" sheet. Billing Capex and Maintenance costs, Asset Life, Price Trends and usage come as input from eir.

Total Termination Minutes for the year come as forecast calculation in "Voice Traffic" sheet.

The total incremental cost of billing is then calculated using a titled annuity.

A similar price trend to the voice specific costs of ✂% is considered for this cost item.

Figure 11 -Screenshot of Billing costs calculation(for illustrative purposes only)

Billing (Per minute)

Capex	10 000 €	Asset Life	10
Annual Maintenance	10 000 €	Price trend	0,00%
		Calls Answered	100%
	Source: 170314_Call Ter_Incremental Costs of Terminationg IMS calls 2017	Utilisation	100%

Titled annuity as percentage of GRC: 15,0%

Total Termination Minutes: 400 000 000

		2017	2 018	2 019	2 020	2 021	2 022
Price Index	%	100%	100%	100%	100%	100%	100%
Index Adjusted Annuity	%	15,0%	15,0%	15,0%	15,0%	15,0%	15,0%
Total Incremental cost	€	1 502	1 502	1 502	1 502	1 502	1 502
Support	€	10 000	10 000	10 000	10 000	10 000	10 000
Cost per minute carried	€/min	0,000029	0,000029	0,000029	0,000029	0,000029	0,000029

Source: NGN model – FTR update, "Voice services –Platform costs"

3 FTRs calculation results

FTRs calculation results are summarized in rows 9:19 of “Voice Services – Platform Costs” sheet.

The FTRs are lower than the results of the former model (NGN Core Model 2012 version), this is to be accountable to:

- Change in WACC rates between the two calculations (passing from 10.21% prior to 2014 to 8.18%).
- Change in voice platform equipment price trends (from ✂% p.a to ✂% p.a)
- Transmission costs have also declined by around 0.010 €c. In the former version of the FTR model, there were 2 options to assess transmission costs, either by using the NGN model (this gives non-material costs, as in the current NGN model) or by using a "conservative scenario" with an hardcoded cost of 0.010 €c. The latter was the base case scenario.
- Average duration of a call moved from ✂ to ✂, which leads to a decrease of the 'per call' component when everything is charged on a per minute basis (as it is divided by the average call duration).

Table 2 - Former averaged results for 2013-2015 (as in former FTR calculation 2012 version)

€cent	Switching	Transmission	Billing	TOTAL
Per minute	**0.039**	**0.010**	**0.000**	**0.049**
Per call	**0.060**			**0.060**

Source: Former FTR calculation

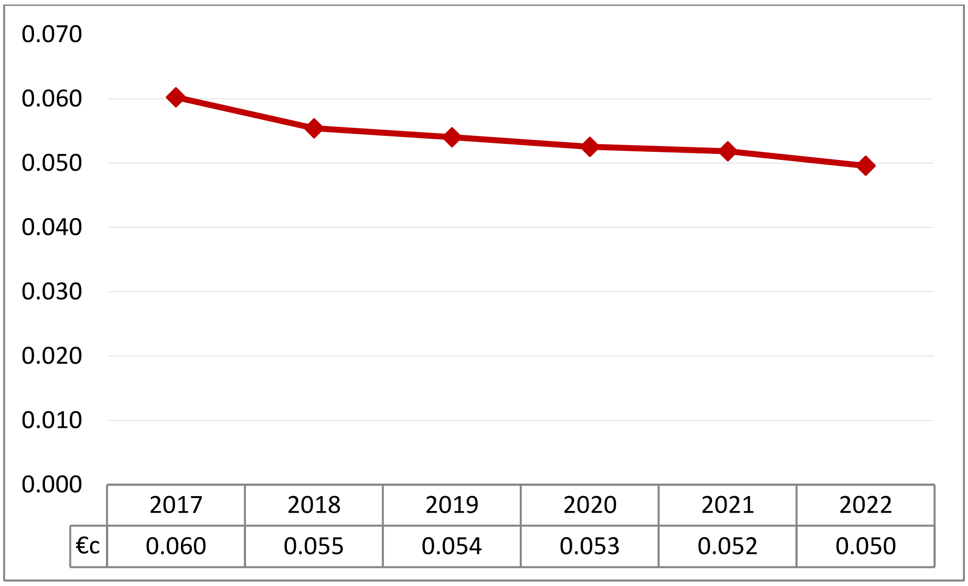
Table 3 - FTRs for 2018

€cent	Switching	Transmission	Billing	TOTAL
Per minute	**0.034**	**0.003**	**0.001**	**0.035**
Per call	**0.060**			**0.060**

Source: NGN model – FTR update

In 2018 the rate charged on a per minute basis, if using the new model (i.e. combining the per minute costs of 0.035 €c and the per call costs of 0.060 €c), would be 0.055 euro cent. This is based on an average call duration of ✂minutes, i.e., 0.035 euro cent per minute plus 0.060 / ✂for the per minute cost of the call component.FTR would then move from €0.072 cents per minute for the current pricing to €0.055 cents per minute in 2018 falling to €0.050 cents per minute in 2022. This downturn evolution is mainly due to price trends of voice platforms. The Figure 12 below summarizes the evolution of FTRs for the 2017-2022 period.

Figure 12 - Evolution of FTRs (€c, 2017-2022)



Source: NGN model – FTR update