Report for ANACOM

Update of the mobile LRIC model: proposal of changes – PUBLIC VERSION

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Ref: [2011000-371]

www.analysysmason.com

Contents

Analysys Mason Limited Sucursal en España
José Abascal 57, 7ºD
28003 Madrid
Spain
Tel: +34 91 399 5016
madrid@analysysmason.com
www.analysysmason.com

Registered in England: Analysys Mason Limited
North West Wing, Bush House
Aldwych
London WC2B 4PJ
UK
No. 5177472, C.I.F. W0066133J

1 Update and revision of the mobile termination cost model

This document describes the main aspects that we propose to update in the mobile termination cost model that we have developed on behalf of ANACOM. The updates to the model reflect the evolutions of the Portuguese mobile market since the last model update was made in 2014. Those evolutions include changes in network coverage, cost inputs, or updated technical characteristics of the network. Additionally, the main conceptual aspects, definitions and parameters of the model have been reviewed and assessed, including updating the data collection and demand forecast.

Analysys Mason prepared a data request that was sent by ANACOM to all Portuguese mobile network operators (MNOs) and mobile virtual network operators (MVNOs). Analysys Mason received data responses from MEO, NOS and Vodafone. This data was used to populate and calibrate the model.

This is the public version of the document. Confidential inputs have been removed and replaced by the following symbol: [✂].

1.1 Update of macro-economic input parameters

We propose to update the macro-economic input parameters so that the model reflects the most up-to-date macroeconomic data.

It should be noted that the macro-economic data for years 2014 to 2016 in the 2014 model were assumptions or forecasts. In the 2017 model, we propose to use the updated figures both for future years but also retrospectively for years 2014 to 2016.

Similarly, we propose to also update the 2000–2013 historical figures, if these figures have been revised. This will ensure that the model is run with the most reliable sources of information on the Portuguese market that are currently available. For instance, GSMA slightly changed the data for total mobile subscribers and 3G/4G shares (see Figure 1.1).

Figure 1.1: Data comparison for minor historical changes [Source: Analysys Mason, 2017]

Metric	2008	2009	2010	2011	2012	2013
GSMA subs; 2017 data	-	-	17.668.316	17.545.564	17.779.600	17.105.991
GSMA subs; 2014 data	-	-	17.778.913	18.005.540	18.223.562	17.584.517
GSMA 4G share; 2017 data	-	-	-	-	0.8%	4.5%
GSMA 4G share; 2014 data	-	-	-	-	1.0%	5.8%

In the “Operator_Demand” worksheet we propose to update the following macroeconomic indicators to reflect the latest data available:

National population

We propose to update the national population data and forecasts based on updated projections from third-party sources (namely the EIU, Euromonitor, ITU and Analysys Mason Research). To assure consistency across the models (and consideration of the different views of all sources) we propose to use the average of the forecasts from the various third-party analysts for the national population.

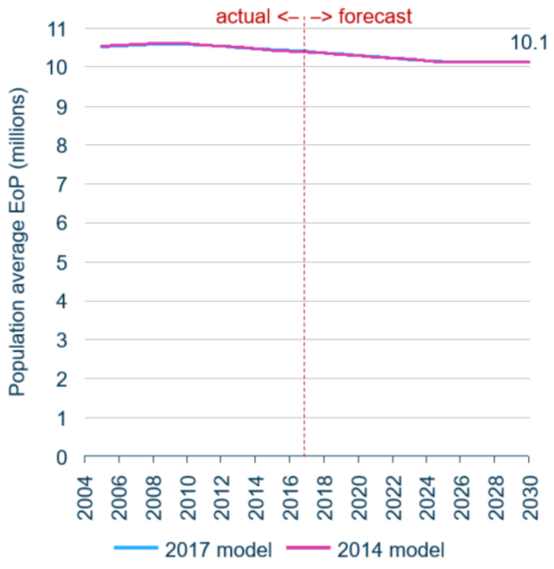
Regarding the population data by *freguesia* (parish) in the "Geotypes" worksheet, the data is already up to date with the latest census[1] figures from 2011. We therefore propose to maintain the figures, as there is no accurate information to perform an informed forecast at *freguesia* level. We also propose to maintain the use of the number of individuals present in each *freguesia* as the population metric, since it better reflects the number of users generating traffic in a given area.

Proposed Update 1:

- Update national population based on updated projections from third-party sources and use the average of those figures

Figure 1.2 shows that the updated national population figures are slightly higher than the previous forecast used in the 2014 model, but that the difference is marginal:

Figure 1.2: Comparison of forecast for national population in 2014 and 2017 model [Source: Analysys Mason, 2017]



1 Instituto nacional de Estatistica, Censos 2011, available at http://mapas.ine.pt/download/index2011.phtml.

Figure 1.3: Comparison of population proposed in the 2017 model and used in the 2014 model [Source: Analysys Mason, 2017]

Population	2014	2015	2016	2017	2018	2019	2020
2017 model	10.469.839	10.448.016	10.430.670	10.394.604	10.358.943	10.328.260	10.292.144
2014 model	10.469.339	10.420.625	10.395.450	10.373.450	10.349.500	10.320.975	10.290.300

Inflation

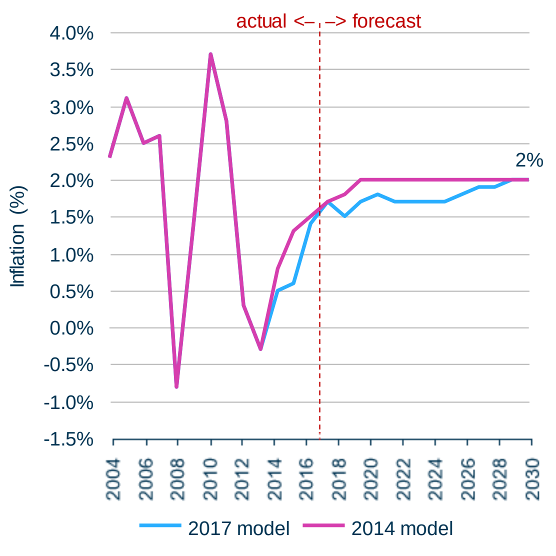
We propose to update inflation on the basis of third-party sources (namely the EIU and Euromonitor). To be consistent with the previous model, we propose to use Euromonitor's data for the forecast and assume constant 2% inflation after 2029, which is in line with forecasts, the previous model and in line with the inflation target of the ECB.

Proposed Update 2:

- Update inflation from third-party sources and assume constant 2% inflation after 2029

Figure 1.4 shows the comparison between inflation used in the 2014 model and the one proposed in 2017:

Figure 1.4: Comparison of forecast for national inflation [Source: Analysys Mason, 2017]



1.2 Update of 2G, 3G and 4G coverage

We have used operator data [✂] to inform our proposed updates on the 2G/3G/4G outdoor population coverage.

900MHz outdoor coverage

900MHz is the primary coverage layer for GSM. [✂]. Based on the data presented, we propose to:

- update the hypothetical efficient operator coverage to [✂].

Figure 1.5: Comparison of hypothetical efficient operator 900MHz outdoor population coverage: 2014 model vs. proposed 2017 model [Source: Analysys Mason, 2017]

Operator	Model	2013	2014–2060
Hypothetical efficient operator	2014	99.3%	99.34%
Hypothetical efficient operator	2017	99.4%	99.75%

Proposed Update 3:

- Update 900MHz outdoor coverage for the hypothetical efficient operator

2100MHz outdoor coverage

[✂]. Based on the data presented, we propose to:

- update the hypothetical efficient operator coverage to [✂].

Figure 1.6: Comparison of hypothetical efficient operator 2100MHz outdoor population coverage: 2014 model vs. proposed 2017 model [Source: Analysys Mason, 2017]

Operator	Model	2013	2014-2060
Hypothetical efficient operator	2014	95%	95%
Hypothetical efficient operator	2017	95.6%	96.9%

Proposed Update 4:

- Update 2100MHz outdoor coverage for the hypothetical efficient operator

800MHz outdoor coverage

In the 2014 model, 4G coverage was expected to exceed that for 3G in 2016, given the use of a lower-frequency band as the primary layer (800MHz for 4G, versus 2100MHz for 3G). However, based on the data provided, the coverage achieved is lower than was expected in the development of the 2014 model.

One factor that could explain the difference is that neither MEO or NOS has yet launched VoLTE, and voice services would require more ubiquitous coverage.

The spectrum in the 800MHz band is assumed to provide the primary coverage layer for LTE, whereas the 2.6GHz and the 1.8GHz bands are assumed to provide primary and secondary capacity overlays respectively. Additionally, [✂].

Based on the data presented, we propose to:

- update the hypothetical efficient operator coverage to be [✂] in 2012, to achieve a coverage of 90% by 2020 (VoLTE launch year) and 97% by 2030.

In the long run, we still expect 4G outdoor coverage to achieve 97% of the population, however, this will take longer to occur than what was forecast in the 2014 model.

Figure 1.7: Comparison of hypothetical efficient operator 800MHz outdoor population coverage: 2014 model vs. proposed 2017 model [Source: Analysys Mason, 2017]

Operator	Model	2013	2014	2015	2016	2017	2018	2019	2020
Hypothetical efficient operator	2014	88%	93%	95%	96%	96.5%	96.8%	97%	97%
Hypothetical efficient operator	2017	67.9%	71.0%	74.2%	77.4%	80.5%	83.7%	86.8%	90.0%

Proposed Update 5:

- Update 800MHz outdoor coverage for the hypothetical efficient operator

1800MHz outdoor coverage

Network deployment using 1800MHz is considered to be a secondary capacity layer in the model.

[✂].

In line with the 2014 model, we do not include 1800MHz outdoor coverage for the hypothetical efficient operator since we assume that 1800MHz is a capacity layer.

1.3 Update of the modelled services

The definition of the range of services to be considered in the model is directly related to how the model in question will determine the incremental cost of providing the call termination service.

Based on the responses provided in the data requests, we have not identified a need to update the list of services. Additionally, this list of services has not been contested by the stakeholders in the previous iteration of the model so we expect this list to remain uncontroversial.

Therefore, Analysys Mason proposes that the list of network services included in the model remains as presented in Figure 1.8:

Figure 1.8: Network services included in the model [Source: Analysys Mason, 2017]

Network service costing list
2G Roaming in origination
2G Roaming in termination
2G On-net SMS
2G Outgoing SMS to other networks
2G Incoming SMS from other networks
2G low speed mobile data
3G On-net calls
3G Outgoing calls to other national fixed networks
3G Outgoing calls to other national mobile networks
3G Outgoing calls to international
3G Incoming calls from other national fixed networks
3G Incoming calls from other national mobile networks
3G Incoming calls from international
3G Roaming in origination
3G Roaming in termination
3G On-net SMS
3G Outgoing SMS to other networks
3G Incoming SMS from other networks
3G low speed mobile data
3G HSDPA
3G HSUPA
MMS
4G On-net calls
4G Outgoing calls to other national fixed networks
4G Outgoing calls to other national mobile networks
4G Outgoing calls to international
4G Incoming calls from other national fixed networks
4G Incoming calls from other national mobile networks
4G Incoming calls from international
4G Roaming in origination
4G Roaming in termination
4G On-net SMS
4G Outgoing SMS to other networks
4G Incoming SMS from other networks

Network service costing list
4G data (LTE)

1.4 Network traffic and loading parameters

The traffic volume of modelled services is particularly important in the development of the model, influencing the design of the modelled network and consequently the unit costs of services. Thus, we propose to update the previous assumptions in the model, particularly the evolution of traffic.

1.4.1 Connections

We propose to update the market module in the "Operator_Demand" worksheet. For consistency reasons, we have continued using the same sources we used in the previous model, namely:

- ANACOM for actual data
- third-party analyst forecasts (e.g. GSMA Intelligence, ITU and Analysys Mason Research) to inform our projections.

The latest data shows that mobile penetration is slightly higher than what was forecast in 2014 (given the economic recovery of the country). We propose to slightly adjust our forecast of mobile penetration upwards, versus the 2014 model.

Figure 1.9 compares mobile penetration in the 2014 model and the mobile penetration proposed for the updated 2017 model. Figure 1.10 compares mobile subscribers in both models.

Figure 1.9: Comparison of forecast for mobile penetration [Source: Analysys Mason, 2017]

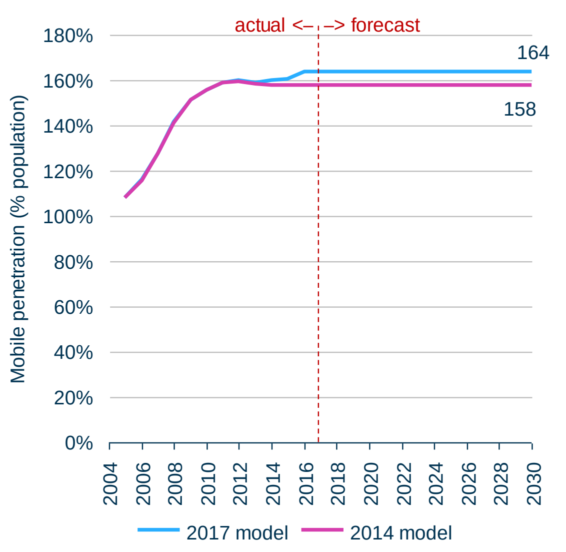
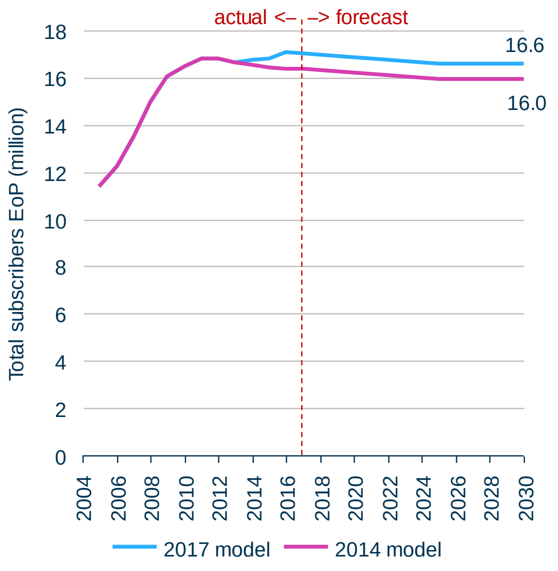


Figure 1.10: Comparison of forecast for total mobile subscribers [Source: Analysys Mason, 2017]



Proposed Update 6:

Ref: [2011000-371]

- Update historical figures based on ANACOM data
- Revise upwards the forecasts of mobile penetration based on recent trends and third-party forecasts

1.4.2 Traffic (voice, SMS, and data)

We propose to update the service demand module in the "Operator_Demand" worksheet. For consistency reasons, we have continued using the same sources we used in the 2014 model, namely:

- ANACOM for actual data
- Analysys Mason for projections.

From the data gathered, we can see that there has been an increase in minutes of usage (MoU), a drastic reduction in SMS (in line with what was projected in 2014) and that data traffic continues to grow significantly.

In addition to the increased number of subscribers, there has been higher MoU, which could be due to flat rates from operators (in fact, the main growth in minutes comes from mobile-off-net-mobile).

We propose to update MoU based on historical figures and forecast a slight growth in MoU in the short term and flat usage in the long run, based on the historical evolution of the voice traffic in the Portuguese market and consistent with forecasts in comparable countries (from third-party sources).

We also propose to forecast SMS usage falling significantly over the forecast period. The negative yearly growth rate will be based on the negative usage trend reported by ANACOM's reports. The root cause of this reduction in SMS usage lies in the rapid adoption of instant messaging services from over-the-top (OTT) players (e.g. WhatsApp, iMessage) among Portuguese subscribers.

We propose to forecast the data traffic using the same methodology as in the last iteration of the model, namely:

- defining a migration of subscribers from 2G to 3G and 4G[2]
- segmenting the market by mobile device type (i.e. handsets, datacards/dongles)
- forecasting the rate of adoption of data services by device type and technology
- assuming a profile of data consumption of data users by device type and technology, and forecasting its evolution according to European benchmarks.

Additionally, in order to better reflect the characteristics of each Portuguese MNO, we have included in the model a traffic (voice, SMS and data) multiplier per operator in order to better take into consideration the actual traffic profile of each operator. The multiplier allows for the calibration of traffic for the real MNOs in order to increase the accuracy of the network calibration performed. This does not affect the hypothetical efficient operator, as that is assumed to have a standard profile.

2 A user is defined as a 4G subscriber if he/she owns a 4G-capable device and SIM and subscribes to 4G services.

The charts below present a comparison of MoU, SMS and data forecasts between the 2017 model and the 2014 model.

Figure 1.11: Comparison of forecast for MoU (per month) [Source: Analysys Mason, 2017]

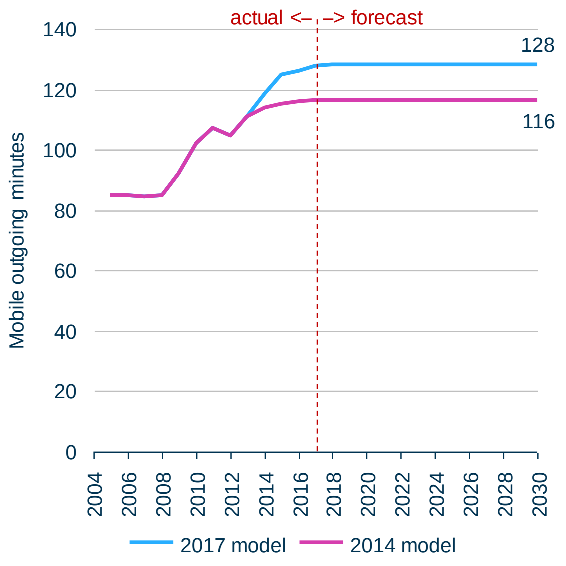


Figure 1.12: Comparison of forecast for SMS [Source: Analysys Mason, 2017]

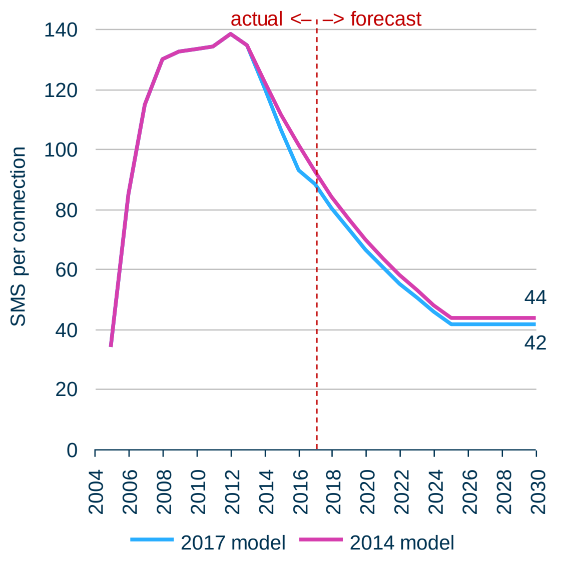
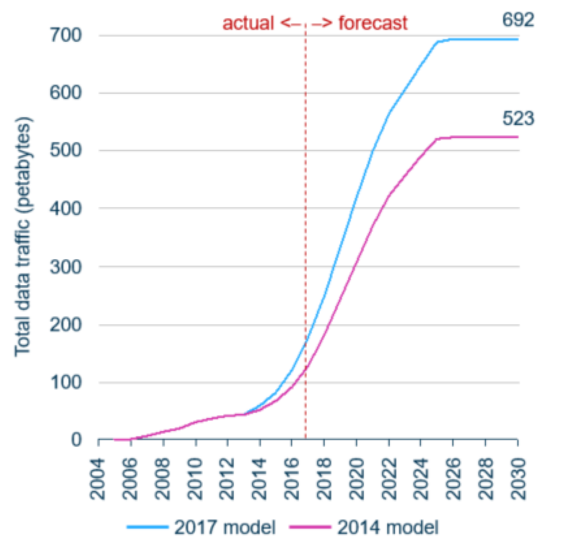


Figure 1.13: Comparison of forecast for total data [Source: Analysys Mason, 2017]



Proposed Update 7:

- Update historical figures based on ANACOM data

- Revise upwards the forecasts of MoU and data per subscriber based on recent trends and Analysys Mason Research forecasts. For SMS per connection, slightly revise downwards the forecast based on the same assumptions

1.4.3 Calculation of traffic carried by the networks

The model enables the calculation of the total traffic generated by 2G, 3G and 4G subscribers separately. However, the traffic generated by a 4G subscriber is not necessarily always carried over the 4G network: instead, it may fall back onto 3G or 2G networks. There are a number of reasons why traffic might fall back onto lower-generation networks:

- **Coverage gaps** – There are coverage differences among the networks, with 2G able to provide an almost ubiquitous coverage layer to ensure the provision of basic voice services. For instance, whenever the signal reception is weak or absent, a 4G subscriber will automatically connect to a 3G or 2G signal if they are available.

- **Device availability** – Mobile users may not have a handset which is capable of supporting a particular technology, despite having an enabled SIM installed; for instance, there still is a large share of 2G handsets in the market that cannot connect to the 3G network, and some of the handsets that are sold today are not VoLTE capable. There is still a considerable amount of handset sold that are basic phones without smartphone capabilities (around 20% of total handsets sold for 2017).

Figure 1.14: Smartphone connections and sales in Portugal [Source: Analysys Mason Research, 2017]

Metric	2014	2015	2016	2017e	2018e	2019e	2020e
Smartphone share (% connections)	51.6%	60.6%	67.5%	73.9%	80.2%	86.0%	90.8%
Smartphone share (% sales)	70.3%	77.0%	79.0%	80.4%	81.4%	82.0%	83.5%

- **User experience / capex efficiency** – Mobile operators are interested in maximising the user experience offered to their customers. On the basis of their network loading, operators might decide that a certain share of traffic needs to fall back on other networks in order to avoid overloading capacity-constrained cells. This also allows operators to limit the capex required to increase capacity on the constrained network by better utilising the capacity already installed for other technologies.

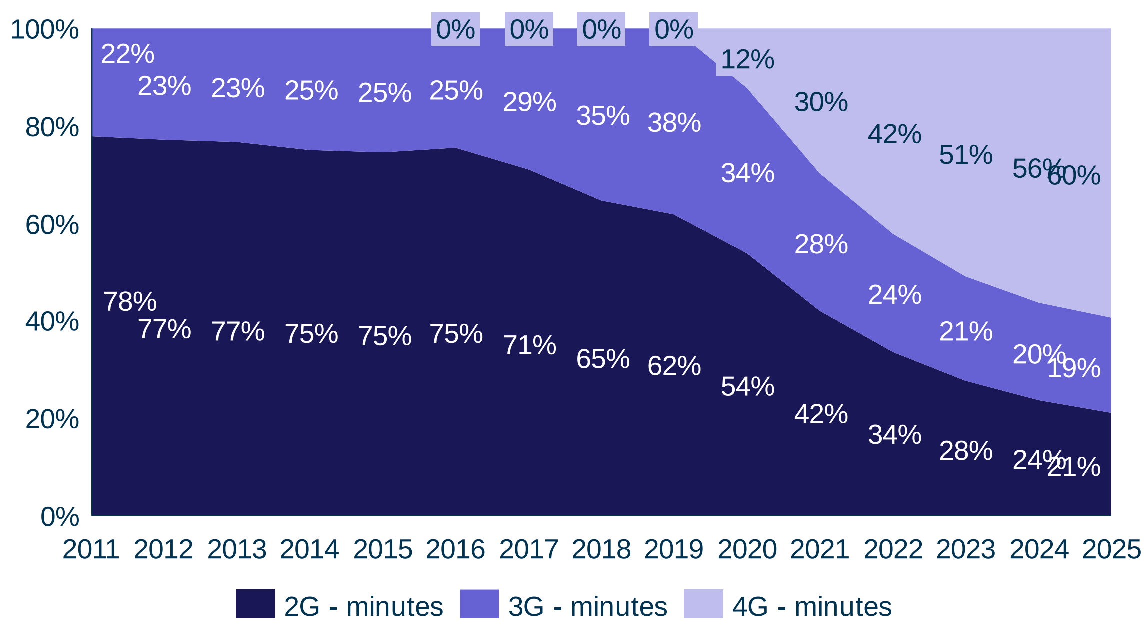
The model therefore allows traffic routeing over different networks with a migration profile that is set in the “Load_inputs” worksheet. The migration is separately set for the different traffic types:

- voice traffic
- messages (including SMS and MMS)
- low-speed data traffic (GPRS, EDGE, UMTS R99)

- high-speed data traffic (e.g. HSPA, LTE).

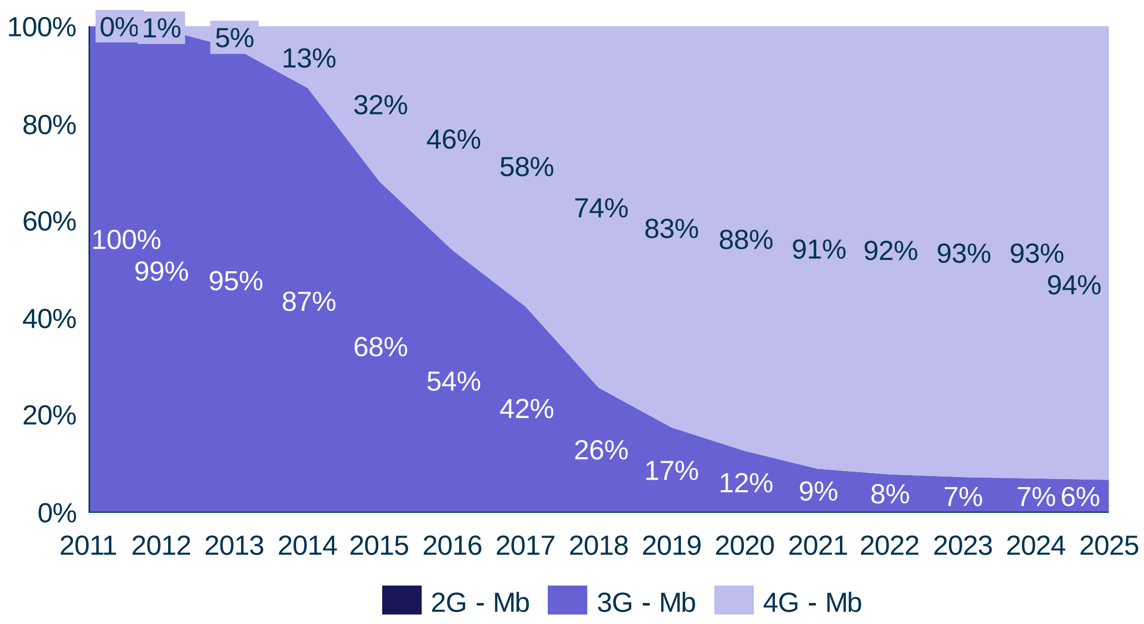
In the 2017 model, we propose to change the share of voice traffic carried by each network generation. In the 2014 model, we had assumed that 100% of the voice traffic generated by 4G subscribers was carried by 2G and by 3G networks (respectively 55% and 45% of the total) until the launch of VoLTE, which was set to occur in 2016 in the base case. Since we are proposing to postpone the launch of VoLTE in the 2017 model, the percentage of traffic carried in the 4G network will also need to be postponed.

Figure 1.15: Proposed share of voice traffic carried by each network generation [Source: Analysys Mason, 2017]



Additionally, we propose to maintain the assumption that a certain percentage of the data traffic generated by 4G subscribers (30% in 2012, decreasing to 5% in 2021) falls back on to the existing 3G network, which serves as an additional capacity layer. This is caused by the fact that mobile operators will try to re-use capacity on their 3G networks once subscribers have begun migrating to 4G, in order to optimise capital expenditure.

Figure 1.16: Proposed share of data traffic carried by each network generation [Source: Analysys Mason, 2017]



Proposed Update 8:

- Postpone the percentage of traffic carried in the 4G network by four years, in line with the proposed delay for the launch of VoLTE (2016 in the 2014 model vs. 2020 in the 2017 model)

1.4.4 Traffic and call profiles

We have included the values of network loading parameters using data provided by [✂] (in the "Load_inputs" worksheet). We propose to use the values provided in the 2017 data request to ensure the model is updated with the latest parameters of the network.

For the hypothetical efficient operator, we propose to use the same methodology as in 2014 (the average of operator's data).

Figure 1.17: Busy-hour loading parameters proposed for the hypothetical efficient operator in the 2017 model [Source: Analysys Mason based on operator data, 2017]

	Voice		SMS		Data	
Model	**2017**	**2014**	**2017**	**2014**	**2017**	**2014**
% traffic in the weekday	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
% traffic in the peak hour	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]

Figure 1.18: Average call duration proposed for the hypothetical efficient operator in the 2017 model, minutes [Source: Analysys Mason based on operator data, 2017]

Voice services	2017 model	2014 model
On-net calls	[✂]	[✂]
Outgoing calls to other national fixed networks	[✂]	[✂]
Outgoing calls to other national mobile networks	[✂]	[✂]
Outgoing calls to international networks	[✂]	[✂]
Incoming calls from other national fixed networks	[✂]	[✂]
Incoming calls from other national mobile networks	[✂]	[✂]
Incoming calls from international	[✂]	[✂]
Roaming in origination	[✂]	[✂]
Roaming in termination	[✂]	[✂]

Figure 1.19: Call attempts per successful call proposed for the hypothetical efficient operator in the 2017 model [Source: Analysys Mason based on operator data, 2017]

Voice services	2017 model	2014 model
On-net calls	[✂]	[✂]
Outgoing calls to other national fixed networks	[✂]	[✂]
Outgoing calls to other national mobile networks	[✂]	[✂]
Outgoing calls to international networks	[✂]	[✂]
Incoming calls from other national fixed networks	[✂]	[✂]
Incoming calls from other national mobile networks	[✂]	[✂]
Incoming calls from international	[✂]	[✂]
Roaming in origination	[✂]	[✂]
Roaming in termination	[✂]	[✂]

Proposed Update 9:

- Update MNO's traffic profile based on the data request and calculate the average of the values for the hypothetical efficient operator

1.4.5 Definition of the geotypes and theoretical cell radii

In the 2014 model, the population density thresholds for the definition of the geotypes were updated according to available benchmarks. The definition of the geotypes is based on a number of factors, including conformation of the territory, availability of locations suitable for mobile sites, etc., which are approximated with the population density (which is an indirect proxy for the expected traffic in the area). Additionally, the theoretical cell radii for each spectrum band was also updated in the 2014 model because the used cell radii had to be consistent with the definition of the geotypes to allow calibration of the model.

In general, it is best to avoid modifying the definitions of geotypes between model versions unless one has compelling evidence that this is necessary. The reason to be consistent is twofold:

- First, a significant amount of data collected in the past was based on given geotype definitions. Changing the definitions may make that data obsolete or difficult to compare with results from the updated model.
- Second, operators have become used to given geotype definitions, and changing the definitions could confuse the operators.

In the current update, we did not receive any indication that the population density thresholds should be altered. Since the operators did not make any comments regarding this issue, we propose to maintain the definition of geotypes.

Regarding the theoretical cell radii, we propose to maintain the same theoretical cell radii in the dense urban, urban and suburban geotypes. For the cell radius in the rural geotype, we propose to increase the cell radius of the 900MHz band from 4.95km (as in the 2014 model) to 6.24km (as in the 2011 model). The cell radius of the other bands in the rural geotype will be calculated using the same methodology (ratio) as in the 2014 model. We propose to make this change based on [✂].

Proposed Update 10:

- Update the theoretical cell radius in the rural geotype based on the calibration performed for the MNOs

1.4.6 VoLTE

In the 2014 model, we had assumed the re-farming of the GSM 1800MHz spectrum to LTE in 2018; 1800MHz has already been used to provide LTE services by Portuguese MNOs (some on selected sites, others on all sites). However, the re-farming of GSM 1800MHz spectrum to LTE is subject to the migration of voice traffic from 2G to other networks. The capacity provided by the GSM 900MHz coverage layer alone is insufficient to carry the modelled operator's 2G traffic, and so the operator would need to make additional investments to increase the capacity installed (i.e. by deploying additional sites). As a consequence, the launch of VoLTE is assumed to be a key enabler of spectrum re-farming and further expansion of the LTE coverage.

VoLTE is still somehow a nascent technology, and as a general rule, since it is a new technology, a conservative deployment should be considered. To date, only Vodafone has deployed the technology in Portugal, and so most voice traffic generated by LTE subscribers is carried over 2G and 3G. However, it appears reasonable to assume that VoLTE will be launched by the Portuguese mobile operators in the next few years in light of a number of factors:

- Comparatively early launch and take-up of LTE (with respect to comparable countries, e.g. Western European countries)
- Commercial reasons (e.g. HD voice service offerings)

- Higher spectral efficiency of VoLTE with respect to traditional voice, allowing additional spectrum to be freed up for data[3]
- Based on a 2Q 2017 benchmark, in most Western European countries more than one operator has already launched VoLTE services (see Figure 1.20 below):

Figure 1.20: Status of VoLTE in selected Western European countries [Source: Analysys Mason Research, 2017]

Operator	Country	Status	Launch date
A1	Austria	Launched	November 2015
Proximus	Belgium	Launched	November 2016
TDC	Denmark	Launched	December 2014
Telenor	Denmark	Launched	November 2015
Elisa	Finland	Launched	Nov 2016
DNA	Finland	Launched	Mar 2015
Bouygues	France	Launched	Nov 2015
Orange	France	Launched	Jan 2016
T-Mobile	Germany	Launched	Jan 2016
Telefónica (O2)	Germany	Launched	Apr 2015
Vodafone	Germany	Launched	May 2015
T-Mobile	Hungary	Launched	Apr 2017
TIM	Italy	Launched	Dec 2015
Vodafone	Italy	Launched	Jul 2015
KPN	Netherlands	Launched	Nov 2016
T-Mobile	Netherlands	Planned for 2H 2017	
Tele2	Netherlands	Launched	Mar 2016
Vodafone	Netherlands	Launched	Nov 2016
Telia	Norway	Launched	Oct 2016
Telenor	Norway	Launched	Nov 2015
T-Mobile	Poland	Launched	Nov 2016
Vodafone	**Portugal**	**Launched**	**Sep 2015**
Orange	Spain	Launched	Nov 2016
Telefónica (Movistar)	Spain	Launched	Mar 2017
Vodafone	Spain	Launched	Jul 2015
Tele2	Sweden	Planned 2H 2017	
TeliaSonera	Sweden	Launched	Apr 2017
Swisscom	Switzerland	Launched	Jun 2015
EE(BT)	UK	Launched	Feb 2016
Telefónica (O2)	UK	Launched	Mar 2017
Vodafone	UK	Launched	Soft launch May 2017

[3] This step implies 1800MHz spectrum re-farming (from GSM to LTE).

Based on the above, we recommend that VoLTE be included in the updated version of the model, and we propose that the hypothetical existing operator will roll out the technology at the beginning of 2020, since an imminent (i.e. 2018) launch seems unlikely, [✂].

In the 2017 model we will therefore assume that an operator will be able to migrate 40% of the voice (and messaging) traffic generated by its 4G subscribers to VoLTE two years after the commercial launch (i.e. in 2022). This share is projected to continue increasing over time.

Proposed Update 11:

- Postpone the launch of VoLTE to 2020 (based on current state of VoLTE deployment in Portugal)

1.4.7 Other model network parameters

We reviewed and compared the network parameters between MNO responses and the model. We propose to update the model when differences are found, in order to correctly represent the network state of operators in Portugal. Additionally, based on the assets counts provided by [✂], we calibrated the network parameters of these operators so that the model would be a better representation of their networks.

The parameters that we propose to change include the following:

Sectorisation

We compared the data for sectorisation in the model and the data provided from operators and propose to update the model accordingly. We propose to use the average of the responses of [✂] for the hypothetical efficient operator, in line with the methodology of the 2014 model.

Figure 1.21 shows the elements we revised:

Figure 1.21: Comparison of the sectorisation by technology in both models for the hypothetical efficient operator [Source: Analysys Mason based on operator data, 2017]

Technology	1 sector	2 sectors	3+ sectors
GSM 900MHz			
2017 model	[✂]	[✂]	[✂]
2014 model	[✂]	[✂]	[✂]
GSM 1800MHz			
2017 model	[✂]	[✂]	[✂]
2014 model	[✂]	[✂]	[✂]
UMTS 2100MHz			
2017 model	[✂]	[✂]	[✂]
2014 model	[✂]	[✂]	[✂]

LTE 800MHz			
2017 model	[✂]	[✂]	[✂]
2014 model	[✂]	[✂]	[✂]
LTE 1800MHz			
2017 model	[✂]	[✂]	[✂]
2014 model	[✂]	[✂]	[✂]
LTE 2600MHz			
2017 model	[✂]	[✂]	[✂]
2014 model	[✂]	[✂]	[✂]

Proposed Update 12:

- Update the sectorisation by technology based on the 2017 data request responses

Proportions of owned and third-party sites

We have updated the percentage of sites that are not owned by the hypothetical existing operator on the basis of new data provided by the operators, and propose to update the hypothetical efficient operator with the following figures ([✂]): (see Figure 1.22).

Figure 1.22: Comparison of the shares of owned and third-party sites for the hypothetical efficient operator in the 2017 and 2014 models [Source: Analysys Mason based on operator data, 2017]

Site ownership	2017	2014
Operator	[✂]	[✂]
Third party	[✂]	[✂]

This update can be found in the 'Radio access network elements and inputs' section of the "NwDes_Inputs" worksheet.

Proposed Update 13:

- Update the proportion of owned vs. third-party sites based on the 2017 data request responses

Backhaul and transmission

We have calibrated the model in order to capture the new data received from operators regarding the technologies used for their last-mile access (LMA). Data from operators shows that fibre backhaul has been deployed to an extent that exceeds forecast assumptions from the 2014 model. The revised data is shown in Figure 1.23:

Figure 1.23: Share of sites connected by radio technology, backhaul technology and by geotype for the hypothetical efficient operator [Source: Analysys Mason based on operators' data, 2017]

Geotype	Leased lines	Microwave	DSL	Fibre
Proposed update for the 2017 model				
2G				
Dense urban	-	-	10.0%	90.0%
Urban	-	12.5%	1.0%	86.5%
Suburban	2.5%	13.5%	2.0%	82.0%
Rural	2.5%	32.5%	2.5%	62.5%
Indoor / micro	20.0%	-	-	80.0%
3G				
Dense urban	-	-	10.0%	90.0%
Urban	2.5%	12.5%	1.0%	84.0%
Suburban	2.5%	18.5%	2.0%	77.0%
Rural	2.5%	25.0%	2.5%	70.0%
Indoor / micro	20.0%	-	-	80.0%
4G				
Dense urban	-	10.0%	-	90.0%
Urban	2.0%	15.0%	-	83.0%
Suburban	2.5%	17.5%	-	80.0%
Rural	5.0%	25.0%	-	70.0%
Indoor / micro	20.0%	-	-	80.0%
2014 model				
2G				
Dense urban	15.0%	20.0%	-	65.0%
Urban	20.0%	35.0%	-	45.0%
Suburban	20.0%	60.0%	-	20.0%
Rural	38.0%	60.0%	-	2.0%
Indoor / micro	100.0%	-	-	-
3G				
Dense urban	15.0%	5.0%	-	80.0%
Urban	15.0%	30.0%	-	55.0%
Suburban	20.0%	40.0%	-	40.0%
Rural	20.0%	60.0%	-	20.0%
Indoor / micro	100.0%	-	-	-
4G				
Dense urban	3.0%	2.0%	-	95.0%
Urban	5.0%	15.0%	-	80.0%
Suburban	15.0%	30.0%	-	55.0%

Geotype	Leased lines	Microwave	DSL	Fibre
Rural	36.0%	60.0%	-	4.0%
Indoor / micro	100.0%	-	-	-

Proposed Update 14:

- Update the share of sites connected by radio or backhaul technology by geotype based on the 2017 data request responses

Equipment lifetimes

For the financial calibration, we reviewed the lifetime of the equipment of the network. [✂].

We therefore conclude that no update is required regarding equipment lifetime and we propose to retain the values of the 2014 model, [✂].

Deployment of new sites on existing sites

[✂] we propose to maintain the 2014 model figures as the hypothetical existing operator is assumed to have launched GSM, UMTS and LTE more or less simultaneously [✂].

Figure 1.24: Proposed deployment of new sites on existing sites for the hypothetical efficient operator by geotype (similar to the 2014 model) [Source: Analysys Mason, 2017]

	Dense urban	Urban	Suburban	Rural
Deployment of UMTS sites on GSM sites	95%	99%	100%	100%
Deployment of LTE sites on GSM sites	95%	99%	100%	100%
Deployment of LTE sites on UMTS-only sites	95%	99%	100%	100%

SNOCC

In line with what was mentioned in the theoretical cell radii section, we also propose to update the SNOCC figures to ensure that the model better represents the actual network of the mobile operators.

[✂].

We propose to update the dense urban geotype SNOCC, maintaining the same ratio (vs. dense urban geotype) for the SNOCC of the urban, suburban and and rural geotypes.

Figure 1.25: SNOCC multiplier – dense urban geotype – 2017 model [Source: Analysys Mason, 2017]

Operator	800MHz	900MHz	GSM1800MHz	LTE1800MHz	2100MHz	2600MHz
Hypothetical efficient operator	0.475	0.573	0.579	0.519	0.585	0.650

Proposed Update 15:

- Update the SNOCC multiplier based on the calibration performed for the MNOs

Utilisation inputs

[✂].

Based on the calibration performed on the MNOs, we therefore propose to update the utilisation inputs of the hypothetical existing operator for the following parameters:

Figure 1.26: Utilisation input parameters for the hypothetical existing operator [Source: Analysys Mason, 2017]

Utilisation input	HEO 2017	HEO 2014
TRX, in terms of Erlangs	[✂]	[✂]
2G or 3G MSC, in terms of BHE, BHCA	[✂]	[✂]
2G or 3G MSC, in terms of ports	[✂]	[✂]
VMS, subscriber capacity	[✂]	[✂]
HLR and HSS, subscriber capacity	[✂]	[✂]

Proposed Update 16:

- Update utilisation inputs based on the calibration performed for the MNOs

Core network elements

Based on the data request from the operators [✂].

Proposed Update 17:

- Update SGW minimum number of systems for the hypothetical efficient operator based on [✂]

BSC and MSC

[✂]

Based on the values provided by the operators, we propose to update the maximum number of main switching sites for the hypothetical efficient operator to [✂], resulting in a decrease to [✂] MSC sites (from [✂] MSC sites in the 2014 model), while increasing the BHCA capacity for 2G/3G combined MSC Servers to [✂] (from [✂]).

Proposed Update 18:

- Update the max number of main switching sites and MSC Servers' BHCA capacity for the hypothetical efficient operator based on [✂].

Other proposed changes

We have reviewed the calculations of the model and propose to update the following calculations to add robustness to the model:

- spectral capacity of TRX, in 900MHz (rounded to decimals instead of numerical)
- number of E1 core-facing ports required (included the value for voice only)
- number of STM1 core-facing ports required (included the value for voice only)
- capacity provided by 900MHz and 1800MHz (included micro / indoor sites)
- MGWs to support port requirements (2G MSC E1 ports, 3G MSC STM1 ports) (considered the port requirements for voice only).

Proposed Update 19:

- Update model calculations on some network parameters to add robustness to the model

1.5 Spectrum holding

Spectrum holding and re-farming of the 1800MHz spectrum band

There has not been a spectrum auction since the last model update. We therefore propose to maintain the 2014 model values.

The 2011 spectrum auction assigned LTE-capable spectrum in three bands, i.e. 800MHz, 1800MHz and 2600MHz.[4]

4 ICP-ANACOM, "Information on multi-band spectrum auction", available at http://www.anacom.pt/render.jsp?contentId=1106646#.VIr2UzHF_pV.

As shown in Figure 1.27, in 2011 the three MNOs were awarded similar spectrum lots, with Vodafone obtaining the largest amount of spectrum in total, thanks to additional lots in the 900MHz and 2600MHz bands (the latter including an unpaired TDD lot).

Spectrum bands	MEO	Vodafone	NOS
800MHz	2×10MHz	2×10MHz	2×10MHz
900MHz	-	2×5MHz	-
1800MHz	2×14MHz	2×14MHz	2×14MHz
2600MHz	2×20MHz	2×20MHz 25MHz TDD	2×20MHz

Figure 1.27: Outcome of the 2011 spectrum auction in Portugal [Source: ICP-ANACOM, 2014]

In light of these results we have assumed a spectrum holding for the modelled operator as shown in Figure 1.28, with an amount of LTE-capable spectrum similar to that actually awarded to existing Portuguese MNOs.

Figure 1.28: Paired spectrum holding assumed for the hypothetical efficient operator [Source: Analysys Mason, 2017]

	800MHz	900MHz	1800MHz	2100MHz	2600MHz
New spectrum assigned in 2011	2×10MHz	-	2×14MHz	-	2×20MHz
Spectrum holding from 2012	2×10MHz	2×8MHz	2×20MHz	2×20MHz	2×20MHz

The spectrum in the 800MHz band is modelled to provide the primary coverage layer for LTE, whereas the 2.6GHz and the 1.8GHz bands are modelled to provide primary and secondary capacity overlays respectively.

We propose to postpone the re-farming of the GSM 1800MHz spectrum to LTE in 2022, as we also propose to postpone the launch of VoLTE by four years.

This spectrum has already been used to provide LTE services by Portuguese MNOs (some on selected sites, others on all sites). However, the re-farming of GSM spectrum to LTE is subject to the migration of voice traffic from 2G to other networks. The capacity provided by the GSM 900MHz coverage layer alone is insufficient to carry the modelled operator’s 2G traffic, and so the operator would need to make additional investments to increase the capacity installed (i.e. by deploying additional sites).

Therefore, we consider the launch of VoLTE as a key enabler of spectrum re-farming. The spectrum is re-farmed at the beginning of 2022 because this is the first year in which the share of total voice traffic carried on the 2G network falls below 50%.

Proposed Update 20:

- Postpone the re-farming of the GSM 1800MHz spectrum to LTE to 2022, ensuring consistency with the launch year of VoLTE

1.6 Update of unit cost inputs

Technological developments in recent years have increased the capacity of the equipment, resulting in an increased amount of traffic that can be served from a single base station. Consequently, unit costs need to be reviewed.

Cost trends

The results in the updated model will be shown in real 2017 value and so the unit costs will be updated accordingly.

Additionally, we propose to maintain the same cost trends as in the 2014 model, as there is no evidence of changes in cost trends.

Proposed Update 21:

- Update the model to real 2017 terms

Capex and opex costs

Based on the data provided in the data request and following a financial calibration of the model, we propose to [✂]

We propose to base the values for the hypothetical efficient operator on the [✂]

Figure 1.29 presents the proposed updated capex and opex unit costs.

Figure 1.29: Proposed updates for unit costs for the hypothetical existing operator [Source: Analysys Mason, 2017]

	2017 model		2014 model		% change	
Asset	**Capex**	**Opex**	**Capex**	**Opex**	**Capex**	**Opex**
Own macro-site location (acquisition, ancill, tower)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Third-party macro-site location (acquisition, ancill)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Third-party indoor site location (acquisition, ancill)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Macro BTS 1-sector	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Macro BTS 2-sector	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Macro BTS 3-sector	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Micro BTS	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
TRX	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]

Asset	2017 model Capex	2017 model Opex	2014 model Capex	2014 model Opex	% change Capex	% change Opex
Macro Node B 3-sector (excluding carrier equipment)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Node B R99 carriers (excluding channel kit)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Node B R99 channel kit (16 CE)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Macro eNodeB (LTE)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Indoor special BTS+distributed antenna	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Indoor special NodeB+distributed antenna	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Indoor special eNodeB+distributed antenna	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Site upgrade – 2G site upgrade facilities for 3G	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Site upgrade – 2G/3G site upgrade facilities for 4G	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Fibre LMA	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased E1 LMA Dense Urban	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased E1 LMA Urban	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased E1 LMA Suburban	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased E1 LMA Rural	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased E1 LMA Indoor	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Self provided ULL E1	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Microwave link (up to 32 Mb/s)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Microwave E1 activated	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased E1 – Remote BSC/PCU to MSC/SGSN	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased STM1 – Remote BSC/PCU to MSC/SGSN	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased E1 – MSC to MSC/VMS	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Leased STM1 – MSC to MSC/VMS	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Regional backbone access points STM1	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Regional backbone access points STM4	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Regional backbone access points STM16	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Regional backbone access points STM64	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]

	2017 model		2014 model		% change	
Asset	**Capex**	**Opex**	**Capex**	**Opex**	**Capex**	**Opex**
Regional backbone distance (km)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone access points STM1	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone access points STM4	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone access points STM16	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone access points STM64	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone distance (km)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
LTE-AP	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
BSC base unit	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Remote BSC sites	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
BSC E1 ports (facing BTS)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
BSC E1 ports (facing MSC)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
RNC base unit	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
RNC E1 ports (facing Node B)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
RNC E1 ports (facing core)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
RNC STM1 ports (facing core)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Regional backbone access points 1GbE	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Regional backbone distance 1GbE (km)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone access points 10GbE	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone access distance 10GbE (km)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
National backbone access submarine STM-4 connection	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Main switching sites	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
2G MSC	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
2G MSC software	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MSC E1 ports (facing RAN)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MSC STM1 ports (facing RAN)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MSC E1 ports (facing other MSC)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MSC STM1 ports (facing other MSC)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MSC E1 ports (facing POI)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MSC E1 ports (facing VMS, etc.)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
2G/3G MSC combined	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
2G/3G MSC combined software	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]

	2017 model		2014 model		% change	
Asset	**Capex**	**Opex**	**Capex**	**Opex**	**Capex**	**Opex**
MGW	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MSC remote BSC facing E1 transcoders 16-64kbit/s	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Data traffic manager (DTM)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Mobility Management Entity-HW (MME)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Mobility Management Entity-SW (MME)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Serving GateWay (SGW)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Home Subscriber Server (HSS)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Call server hardware	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Call server software	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
TAS	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
SBC hardware	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
SBC software	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
VoLTE upgrades to HLR	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
VoLTE upgrades to MSC-S	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
VoLTE upgrades to NMS	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
IN (SCP + SMP)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Voice Mail System (VMS + IVR)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
HLR	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
AUC	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
EIR	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
SMSC HW	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
SMSC SW units	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
GPRS/EDGE-PCU	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
GPRS/EDGE/UMTS-GGSN	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
GPRS/EDGE/UMTS-SGSN (small capacity)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
GPRS/EDGE/UMTS-SGSN (large capacity)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Billing system (wholesale)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Network management system (HW)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
Network management system (SW)	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
VAS/Content platforms	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
MMSC	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
HDSPA step for: 1.8	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
HDSPA step for: 3.6 & 42.2 & 84.4	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
HDSPA step for: 7.2	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
HDSPA step for: 10.1	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
HDSPA step for: 14.4	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]

	2017 model		2014 model		% change	
Asset	Capex	Opex	Capex	Opex	Capex	Opex
HDSPA step for: 21.1	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
HSUPA upgrade HW per Node B	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
LTE step for: upgrade 1	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
LTE step for: upgrade 2	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
LTE step for: upgrade 3	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
LTE step for: upgrade 4	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
LTE step for: upgrade 5	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]
LTE step for: upgrade 6	[✂]	[✂]	[✂]	[✂]	[✂]	[✂]

Proposed Update 21:

- Update opex and capex costs based on the data request from operators and the financial calibration

Leased lines

We verified leased-line pricing according to the latest available Reference Offer from Portugal Telecom, following the recent amendments to the LLRO (Leased Lines) and RELLO (Ethernet Leased Lines) drafts approved by ANACOM on 31 August 2017.[5] We have concluded that the prices did not change, so we propose to maintain the same unit costs.

1.7 WACC and regulatory fees

WACC

We propose to update the WACC using the same methodology used in the 2014 model (more details can be found in the model concept paper). Figure 1.30 compares the WACC components between the 2017 model and 2014 model.

Figure 1.30: Comparison of WACC components [Source: Analysys Mason, 2017]

WACC	2017 model	2014 model	Source (2017 model)
Risk-free rate, nominal	2.8%	3.91%	ANACOM
Equity premium	7%	5.75%	ANACOM
Beta (re-levered for gearing and tax)	1.89	1.57	Calculation
Unlevered beta	0.8	0.69	Average of mobile operators' beta

[5] https://www.anacom.pt/render.jsp?contentId=1417001
PT Reference Offer for Leased Lines, "ORCA_Anexo2_Preços_v20"
http://ptwholesale.pt/en/servicos-nacionais/capacidade/Pages/orca.aspx

WACC	2017 model	2014 model	Source (2017 model)
			(Mobistar, Telenor ASA, TeliaSonera AB, Vodafone, Mobile Telesystems) extracted from Reuters[6] and Financial Times[7] websites
Nominal cost of equity (post-tax)	15.96%	12.92%	Calculation
Nominal cost of equity (pre-tax)	22.63%	17.82%	Calculation
Nominal cost of debt (pre-tax)	4.32%	4.84%	Calculation
Debt premium over risk-free rate	1.5%	0.93%	Benchmark of debt premiums adopted by other Western European telecoms regulators
Gearing D/(D+E)	57.6%	56.19%	Average 2012–2016 gearing of Western European mobile operators (Mobistar, Telenor ASA, TeliaSonera AB, Vodafone, Mobile Telesystems) sourced from Financial Times and Morningstar
Debt over equity (D/E)	135.67%	128.28%	Calculation
Marginal tax rate	29.5%	27.50%	ANACOM
Nominal WACC (pre-tax)	12.09%	10.52%	Calculation
Inflation rate	1.45%	1.70%	2015–2025 average based on Euromonitor
Real pre-tax WACC	**10.48%**	**8.68%**	**Calculation**

We therefore propose to increase the WACC of the model to 10.48% (from 8.68% in the 2014 model).

Proposed Update 22:

- Update the WACC of the model based on the latest calculations by ANACOM and by Analysys Mason

6 See http://www.reuters.com/finance/stocks/.

7 See http://markets.ft.com/research/Markets/Overview.

Regulatory fees

The mobile model includes a cost for regulatory fees. We propose to adopt the same methodology followed in the fixed model and in the 2014 model, which is in line with ANACOM's calculation of the regulatory fees charged to the major telecoms operators (by revenue).

Tier-2 operators (with revenue higher than EUR1.5 million) pay a variable regulatory fee T_2, which is a percentage of their revenue; i.e. $T_2 = t_2 \times R_2$, where t_2 is the fee rate (expressed as a percentage of revenue) and R_2 is the relevant revenue, which excludes VAT, sales of terminals (equipment), transactions between entities of the same group and revenue from the universal service. t_2 is calculated by ICP-ANACOM and is worth 0.6213% for 2015 and 0.6884% for the year 2016.

In light of the actual values, we propose to update the long-term value of regulatory fees to 0.7% for t_2 (from 0.6% in the 2014 model).

The mobile termination cost calculated by the new model is marked up by t_2 to also take into account the regulatory fees, i.e. $Termination\ cost_{with\ regulatory\ fees} = Termination\ cost \times (1 + t_2)$.

Proposed Update 23:

- Update the historical regulatory fee rate and update the long-term fee rate based on recent values

Annex A List of input data updated from third-party sources

The table below describes the input data from third-party analysts that was updated in the 2017 model:

Figure A.1: List of macroeconomic / mobile market metrics that were updated in the model [Source: Analysys Mason, 2017]

Source	Metrics
ANACOM (data up to 2Q 2017)	Total SIMs M2M SIMs SIMs registered in the network Active SIMs Datacards Mobile internet users 3G/4G subscribers (handsets and datacards) Total mobile outgoing minutes Total mobile income minutes Total roaming traffic Total SMS Total MMS Total data traffic (split datacard/handset)
Analysys Mason Research	Population to 2016 Total subscribers to 2021 M2M subscribers to 2021 Datacards to 2021 Share of 3G subscribers to 2021 Share of 4G subscribers 2021
GSMA	Total subscribers to 2020 M2M subscribers to 2020 Share of 2G subscribers to 2020 Share of 3G subscribers to 2020
Euromonitor	Population to 2030 Inflation to 2030
EIU	Population to 2050 Inflation to 2050
ITU	Population to 2016 Total subscribers to 2016

Annex B Information received in 2017 and comparison to information received in 2014

To guarantee consistency in the information received we [✂].

Annex C List of acronyms

2G	Second-generation mobile telephony
3G	Third-generation mobile telephony
4G	Fourth-generation mobile telephony
AMR	Adaptive multi-rate
AMR-HR	Adaptive multi-rate half rate
AMR-WB	Adaptive multi-rate wideband
ANACOM	Autoridade Nacional de Comunicaçoes (National Communication Authority)
AP	Aggregation point
BH	Busy hour
BHCA	Busy-hour call attempts
BHE	Busy-hour Erlangs
BSC	Base-station controller
BTS	Base transceiver station
BU	Bottom-up
CCA	Current cost accounting
CDR	Call data record
CDMA	Code-division multiple access
CE	Channel element
CPU	Central processing unit
CS	Circuit-switched
CSCF	Call session control function
DNS	Domain name system
DSL	Digital subscriber line
DTM	Data traffic manager
E1	2Mbit/s unit of capacity
EC	European Commission
EDGE	Enhanced Data Rates for GSM Evolution
EIU	Economist Intelligence Unit
EPC	Enhanced packet core
EU	European Union
FAC	Fully allocated cost
FDD	Frequency division duplex
GGSN	Service GPRS support node
GPRS	General packet radio system
GSM	Global system for mobile communications
GSN	GPRS serving node
HCA	Historical cost accounting
HD	High definition
HLR	Home location register
HSDPA	High-speed downlink packet access
HSPA	High-speed packet access
HSS	Home subscriber server
HSUPA	High-speed uplink packet access
IMS	IP multimedia subsystem
IP	Internet protocol
IRU	Indefeasible right of use
ITU	International Telecommunication Union
LLRO	Leased Lines Reference Offer
LMA	Last-mile access
LRAIC	Long-run average incremental cost
LRIC	Long-run incremental cost
LTE	Long-term evolution
LTE-AP	LTE aggregation point
M2M	Machine to Machine
MEA	Modern equivalent asset
MGW	Media gateway
MIMO	Multiple input, multiple output
MME	Mobility management entity
MMS	Multimedia messaging service
MMSC	Multimedia messaging service
MNO	Mobile network operator
MoU	Minutes of use
MSC	Mobile switching centre
MSS	Mobile switching centre server
MTR	Mobile termination rate
MVNO	Mobile Virtual Network Operator
NGN	Next-generation network
NMS	Network management system
NPV	Net present value
NRA	National regulatory authority
ODF	Optical distribution frame
OFDM	Orthogonal frequency division multiplexing
OTT	Over the top
PCRF	Policy and charging rules function
PCU	Packet control unit
PDN-G	Packet data network gateway
PDP	Packet data protocol
PGW	PDN Gateway
PoI	Point of interconnect
PoP	Point of presence
PS	Packet switched
PV	Present value
QAM	Quadrature amplitude modulation
RAN	Radio access network
RELLO	Reference Ethernet Leased Lines Offer
RNC	Radio network controller
SAU	Simultaneous active users
SBC	Session border controller
SGSN	Serving GPRS support node
SGW	Serving gateway
SIM	Subscriber identity module
SMS	Short message service
SMSC	Short message service center

SNOCC	Scorched-node coverage coefficient
STM	Synchronous transport module
SWG	Server gateway
TAS	Telephony application servers
TDD	Time division duplex
UMTS	Universal mobile telecoms system
VMS	Voice mail system
VoLTE	Voice over LTE
WACC	Weighted average cost of capital