CONSULTING

Report for the ACCC

Benchmarking the cost of providing MTAS in Australia

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Contents

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1 Introduction

The mobile terminating access service (MTAS) is a service provided by a mobile network operator (MNO) to other MNOs and to fixed network operators to terminate voice calls on the infrastructure operated by that MNO. It is a wholesale service that is declared under Section 152AL of the Competition and Consumer Act 2010 (CCA) in Australia.

The Australian Competition and Consumer Commission (ACCC) requires an estimate of the cost of providing MTAS in Australia. The approach chosen for the inquiry requires an international benchmark of the costs of providing the equivalent service in other jurisdictions where this has been calculated using a bottom-up model of hypothetical mobile operators.

This exercise involves first the selection of an appropriate group of countries from which to obtain benchmark values (implicitly, those with available suitable cost models), and second the compilation of a list of appropriate adjustments to the models/benchmark values to reflect the required cost standard and the specificities of providing MTAS in Australia.

The exercise is being undertaken in two phases. In Phase 1, Analysys Mason and the ACCC developed the methodology for the benchmark, which was described in a draft document released for consultation in December 2019. This document contains the draft benchmark for industry parties for consultation and is laid out as follows:

- Section 2 lists the candidate published cost models and the subset that have been used in the benchmark peer group
- Section 3 describes the methodology that Analysys Mason has used to develop the cost benchmarks for MTAS
- Section 4 describes the forecast of demand
- Section 5 summarises the results of our modelling
- Annex A summarises the data required for the benchmarking exercise
- Annex B sets out the adjustments made to each cost model in the peer group
- Annex C describes the feedback on our proposed methodology
- Annex D provides the numerical results from the models, both excluding and including the PPP adjustment.

2 Candidate cost models

Figure 1 below sets out the list of models that Analysys Mason has identified as having been published by national regulatory authorities (NRAs) or similar bodies. The models listed below have all been published with few or no inputs anonymised and therefore closely reflect the cost results that have been used for pricing purposes by the NRA.

Figure 1: Overview of candidate public models for this study [Source: Analysys Mason, 2020]

No.	Country	Years modelled	Year of last update	Comments
1	Denmark	1992–2041	2018	4G technologies are not modelled
2	East Caribbean	2015–2020	2017	
3	France	1992–2040	2017	A LR(A)IC+ calculation is not included in the published model
4	Greece	1990–2039	2019	The definition of geotypes is not included in the published materials
5	Mexico	2005–2056	2019	A LR(A)IC+ calculation is not included in the published model
6	Netherlands	2004–2053	2016	
7	Norway	1992–2041	2017	4G technologies are not modelled
8	Peru	Single-year	2018	
9	Portugal	2001–2060	2015	
10	Romania	2006–2020	2013	4G technologies are not modelled and the model is no longer published on the NRA website
11	Spain	2000–2049	2016	
12	Sweden	2008–2058	2016	
13	UK	1990–2040	2018	

There are other examples of published models, such as that recently published by the European Commission, or published by the regulator in Bulgaria, where the model is public but the inputs have been heavily anonymised. Such models are not suitable for this benchmark, since the model itself as published is not reflective of any specific country or operator.

Of the models shown above, we propose to exclude the three models that do not consider the costs of 4G technologies (Denmark, Norway and Romania), given that 4G is a relevant and efficient technology in widespread use in Australia today. We also propose to exclude the model developed in Greece given that the definition of the geotypes in the model is not available and therefore our proposed approach to capturing the effects of the different geography of Australia (described in Section 3.3) cannot be undertaken for that model.

The models for France and Mexico are the only two cases in where no LRAIC+ calculation is implemented. We will therefore construct our own estimates of LRAIC+ for these models. In the case of the model for Mexico, we can use calculations implemented in an earlier version of the model.[1] In the case of the model for France, we have implemented our standard LRAIC+ calculation structure (since no version of this published model includes a LRAIC+ calculation). The inclusion of these LRAIC+ calculations will enable both models to provide suitable LRAIC+ outputs for MTAS.[2]

Each of the nine remaining models that we propose to include in the benchmark (i.e. excluding models 1, 4, 7 and 10 in the table above) will be included in the benchmark set only if it is possible to obtain any necessary permissions from the appropriate parties for this use by the ACCC prior to the consultation on the draft benchmark. Figure 2 below sets out the sources for the cost models Analysys Mason has used in the benchmark.

Figure 2: Weblinks to relevant cost models [Source: Analysys Mason, 2020]

Country	Webpage
Eastern Caribbean	https://www.ectel.int/regulatory-framework/access-and-interconnection
France	https://www.arcep.fr/uploads/tx_gspublication/modele-TA-mobile-consultation_publique-avril17.rar
Mexico	http://www.ift.org.mx/politica-regulatoria/modelos-de-costos/condiciones_tecnicas_minimas_y_modelos_de_costo_2020
Netherlands	https://www.acm.nl/nl/publicaties/publicatie/17159/Annex-B2-Final-BULRIC-Models-bij-notificatiebesluit
Peru	http://www.osiptel.gob.pe/articulo/res021-2018-cd
Portugal	https://www.anacom.pt/render.jsp?contentId=1363106#.VcOBX_mqqko
Spain	https://www.cnmc.es/en/ambitos-de-actuacion/telecomunicaciones/concrecion-desarrollo-obligaciones
Sweden	https://www.pts.se/sv/bransch/telefoni/konkurrensreglering-smp/prisreglering/kalkylarbete-mobilnat/gallande-prisreglering
UK	https://www.ofcom.org.uk/consultations-and-statements/category-1/mobile-call-termination-market-review (labelled as "2018 MCT market review cost model")

It should be emphasised that the central calculation engines within these models do differ considerably. Many key features have been developed in a bespoke fashion tailored for each model, including:

- Determination of the coverage area of a site in a given geotype based on the assumed cell radius
- Transformation annual demand volumes into traffic drivers for the network design
- Derivation of the traffic-driven radio network requirements

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1 This is available at http://www.ift.org.mx/politica-regulatoria/condiciones-tecnicas-minimas-y-modelo-de-costos-utilizado-para-determinar-las-tarifas-de. The plusLRAIC worksheet from this old version can be copied and reintegrated back into the new version (and the formulae/structure can be updated to also capture 4G networks/services).

2 In the East Caribbean and Spain models, there are multiple results, including one labelled as a fully allocated cost (FAC) and another labelled as a LRIC+. We use the FAC in both cases since its derivation more closely resembles the LRAIC+ calculated in the other models (i.e. the allocation of total network costs across all services using routeing factors).

- Dimensioning of the last-mile access backhaul (for example, some calculate it at the level of to each base station and others to at the level of to each site)
- Redistribution of traffic based on the coverage of the deployed networks (this is undertaken in the Portugal and UK models in particular)
- Calculation of sites based on the modelled base stations
- Treatment of the modelled coverage network as a network common cost (and allocated using an equi-proportionate mark-up)
- Years in which the resource requirements of the modelled operator are calculated
- Use of real-terms currency or nominal-terms currency
- Annualisation of costs (some models use economic depreciation, others use annuities. Moreover, even if two models both apply economic depreciation, they can differ in their specific implementation)
- Allocation of costs based on routeing factors.

It must therefore be emphasised that even though the same inputs can be used in each calculation engine, the resulting network design and allocation of costs can differ across the models. These effects are on top of the different unit cost assumptions within each model. Therefore, the calculation engines can lead to different cost results even with a set of common input assumptions.

3 Methodology to derive the benchmark cost values

In this section we set out our proposed methodology to derive the benchmark cost value for mobile termination services from a set of published cost models.

Our approach to deriving the benchmarks is to adjust key inputs within each model to more closely reflect the conditions of mobile network deployments and services in Australia. These adjustments are as follows:

- levels of market demand
- assumed market share
- geography
- cell coverage radii
- mobile radio technologies in use
- spectrum holdings
- spectrum costs
- weighted-average cost of capital (WACC)
- currency
- backhaul.

Each is described in more detail in this section.

3.1 Levels of market demand

The levels of demand for mobile services (by which we mean traffic and subscribers) vary from country to country. Most cost models of mobile networks contain a time series of demand volumes by service for the duration of the modelling period. This time series will usually reflect the market totals, with the modelled operator serving an assumed “market share” of the demand (as described below in Section 3.2). We have used inputs from: the operators, the ACCC and the Australian Bureau of Statistics (ABS) to produce “actual” information for the years 2013–2019. The trends found in these results, along with research from Analysys Mason, has been used to estimate the trends both forward to 2030 and back to 1990. From 2030 to 2060 (the last year modelled by any of the peer group models), we assume that usage per subscriber will remain the same.

Our standard approach to demand forecasting is to derive relevant metrics for historical years that can be forecast (e.g. mobile penetration, outgoing voice minutes per subscriber per month, etc.) and then to develop forecasts for these metrics over a specific number of years. For example, we have calculated mobile SIM penetration as a percentage of population in past years, forecast this penetration and then multiplied by a forecast of population (from the ABS). This allowed us to derive a forecast of mobile SIMs. This forecasting is described in more detail in Section 4.

The information used for developing suitable forecasts for all the models (which each have their own variants of modelled demand services) in the peer group is set out in Annex A.

Using these forecasts and operator data on the split of data traffic by technology used, we then created migration profiles to show the split of voice/SMS and data across the different technologies for the entire time series. The starting point was operator data about the split of voice and data between the years 2015 and 2019; trends were then used to model the years before and after this range.

3.2 Assumed market share of demand

In the benchmark models, the assumed market share determines the proportion of total market demand (traffic and subscribers) that is assumed to be carried by the modelled network. Therefore, this is invariably a "network-level" market share rather than a "retail-level" market share.

On the basis that there are three network operators with extensive mobile network coverage (all covering at least 97% of the population[3]) in Australia, we have assumed a network market share of 33.3% to use in all of the benchmark models.

3.3 Geography

A key input to a cost model of mobile networks is the way in which areas with different geo-demographic characteristics are handled. Areas are commonly grouped into one of a number of classes of area with "similar" geo-demographics, referred to as 'geotypes'. Each of the benchmark models has a classification for the country in question, based on a specific definition (usually using population density).

Geotypes are often defined based on a set of sub-regions of the country, ordered by population density.

We have used a single national geo-demographic dataset (i.e. a tiling of Australian land). The model developed by Analysys Mason for the Australian Communications and Media Authority (ACMA) was based on approximately 2200 statistical local areas level 2 (SA2).[4]

We have used SA2 areas as the starting point for the geotypes to use in each of the benchmark models. Since the ACMA model was developed, a 2016 definition of SA2 areas has been released by ABS, which we have used as the most recent definition of SA2 areas available.[5] We have applied the geotype definition (e.g. the population density boundaries) for the geotypes in each benchmark

3 See https://www.accc.gov.au/system/files/Communications%20Sector%20Market%20Study%20Final%20Report%20April%202018_0.pdf, page 35

4 See the GEO worksheet of the Excel file (the 'mobile network infrastructure forecasting model') available at https://www.acma.gov.au/publications/2015-06/report/mobile-network-infrastructure-forecasting-model.

5 The population and area for each SA2 area is available from https://www.abs.gov.au/AUSSTATS/subscriber.nsf/log?openagent&32180ds0006_2016-17.xls&3218.0&Data%20Cubes&798BAFC7B3A9BAE1CA2582FA0017AFEF&0&2016-17&31.08.2018&Latest. The four SA2 area in for the Other Territories, as well as the "Migratory - Offshore - Shipping"/"No usual address" codes have not been included in our geotypes.

model to these SA2 areas. In other words, for a given model, each of the SA2 areas has been classified into one of the geotype definitions for that model.

Therefore, for each of the benchmark models, we have maintained the geotype definitions in terms of population density ranges within a geotype and we use the SA2 areas to estimate the different fractions of the Australian population and area within each of these geotypes.

The sources for limits to population density for each geotype in each country are set out below in Figure 3.

Figure 3: Population density limits by geotype sources [Source: Analysys Mason, 2020]

Country	Source	Note
East Caribbean	Model documentation[6]	Since the absolute population criteria used for the East Caribbean model are not consistent with the Australian population, we have removed them, so only population density is used. The “mountainous” and “spread” geotypes have also not been used
France	Regulator’s website[7]	The “mountainous” geotypes have not been used
Mexico	Published model, Geotypes worksheet, cells C13:C15	
Netherlands	Published model, Geotypes worksheet, cells C11:C13	
Peru	Model documentation[8]	
Portugal	Model documentation[9]	
Spain	Model documentation[10]	Since the absolute population criteria used for the Spanish model are not consistent with the Australian population, we have removed them, so only population density is used. The “mountainous” and “spread” geotypes have also not been used
Sweden	Published model, AreaToPop worksheet, cells F5:F7	

6 See https://www.ectel.int/wp-content/uploads/2017/05/Description-BULRIC-Model-Mobile-Networks.pdf, page 23

7 See https://www.arcep.fr/fileadmin/cru-1582218129/reprise/dossiers/modeles-couts/consult-model-opmobile-fev07.pdf, page 8

8 See www.osiptel.gob.pe/repositorioaps/data/1/1/1/PAR/res021-2018-cd/05-Res021-2017-CD_Inf016-GPRC-2018.pdf, page 146

9 See https://www.anacom.pt/streaming/AnexoII+Anexo8.pdf?contentId=1363129&field=ATTACHED_FILE page 36

10 See https://www.cnmc.es/sites/default/files/editor_contenidos/Telecomunicaciones/Modelos%20de%20coste/20160603%20-%20Axon%20Consulting%20-%20Documento%20Metodológico%20Modelo%20BULRIC.PDF page 20

Country	Source	Note
UK	Published model, Traffic workbook, Geotypes worksheet, cells K4:K10	

This has allowed the Australian land area to be captured in the model and the number of sites modelled reflects this[11].

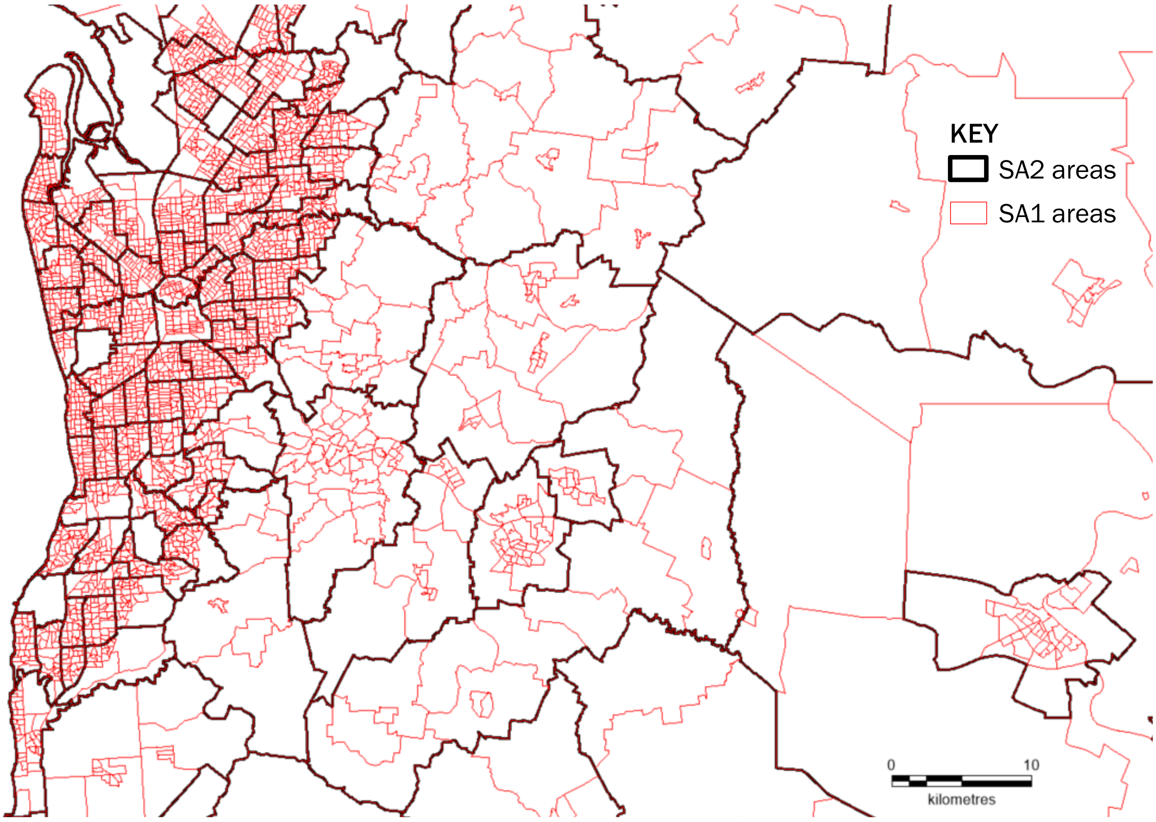
The most rural geotype in each benchmark model is effectively a ‘catch-all’ category i.e. represents all areas below a certain population density.

It is well known that using too large an aggregated area scale for geotyping can lead to anomalous results because it will miss the impact of localised areas of higher density. Mobile coverage is planned at the scale of coverage of individual base stations, so smaller towns in rural areas may in some cases be small “islands” of mobile coverage within a larger area that is not covered. A more granular (level 1, ‘SA1’) set of areas is also available from the ABS.[12] However, we believe that the SA2 areas are an appropriate choice for the geotype definition since their scale is more appropriate to the coverage of individual base stations. This is illustrated in Figure 4 below for the Adelaide area.

11 For example, in the Netherlands model, the assumed area in the original published model was approximately 30 000km^2, which has now increased to almost 7.7 million km^2. The number of rural sites in the published model is approximately 2000 in 2019, but the adjusted model deploys 5500.

12 See https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.001July%202011 for the 2011 release and https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.001July%202016?OpenDocument for the 2016 release

Figure 4: Illustration of SA1/SA2 areas for the Adelaide region [Source: Analysys Mason/ABS, 2020]



As can be seen above, the SA2 areas illustrated in the Adelaide area are usually several kilometres across, whilst many SA1 areas are much less than 1km across. Typical base stations will therefore cover many SA1 areas (which could be assigned to different geotypes), whilst several base stations will be required to cover SA2 areas. Since base stations and sites are calculated separately by geotype in the benchmark models, the SA2 areas are therefore more appropriate (and also consistent with the approach taken to geography in the modelling by ACMA).

3.4 Cell coverage radii

The benchmark models usually calculate the number of base stations required in a given geotype to provide both the necessary coverage and the necessary busy-hour traffic capacity, and then take the larger of the two. The number of base stations required for coverage in a particular geotype is usually calculated as:

$$\frac{\textit{Area assumed to be covered in that geotype}}{\textit{Area covered by a typical base station in that geotype}}$$

One issue arising from our proposed approach to capturing geography is that the assumed cell radius in the most rural geotype (a key input to the mobile network design that will determine the number of rural sites required) will have been set in each of the benchmark models based on calibration to the actual coverage in the most rural areas covered within that country.

The most rural geotype in each of the benchmark models is effectively defined with no lower bound of population density, but the actual lowest covered population density in the modelled geotype could still vary significantly. For example, the areas with the lowest population density in the Dutch model will still likely have a far higher population density than most of the SA2 areas in Australia. The real network design does in each case respond to this actual population density: the towers used in the Netherlands' most rural areas may be shorter than those in the remote areas of Australia, for example.

Since Australia is likely to have coverage in far more sparse areas than these other models, the calculation will likely overestimate the number of coverage sites required in rural areas when Australian geo-demographic information is used in each of the benchmark models.

We have therefore adjusted (i.e. increased) the cell radii assumed for mobile coverage in the most rural geotype in each of the benchmark models to address this issue. This adjustment needed to be made for each spectrum band used. We note that the model published by ACMA assumes a cell radius by band in the modelled rural and remote geotypes (14km and 22km for 900MHz coverage in the two geotypes respectively), which provides useful starting points for this adjustment.[13] We have assumed that a site in the most rural geotype can cover 585km^2 in each model: equivalent to a cell radius of approximately 15km.

If the area assumed to be covered in a geotype is large when using the Australian areas, the benchmark models will (to first order) respond in the required way. The change to the cell radius discussed above will also account for second-order effects e.g. Australian networks might tolerate worse performance at the cell edge in rural areas.

3.5 Mobile radio technologies in use

The benchmark models consider a mixed deployment of 2G, 3G and 4G technologies. However, in Australia, 2G technologies have been completely shut down since 2019, meaning that only 3G and 4G technologies are relevant to the forward-looking costs of mobile termination in Australia.

Therefore, in each benchmark model, any modelled 2G network has been assumed to be switched off from 2019 onwards (or reduced to a negligible deployment[14]) and all traffic has been assumed to be carried on 3G or 4G technologies from 2019 onwards. Therefore, all 2G-related network costs have been assumed to be recovered before 2019.

We have requested from the Australian mobile network operators the proportion of traffic carried on each network technology (2G, 3G and 4G) over time, as described in Annex A. Based on the

13 See rows 314 and 315 of the *IN* worksheet of ACMA's mobile network infrastructure forecasting model, as published on its website.

14 It may be that the benchmark models return formula errors if the 2G network is completely switched off, in which case we ensure that a negligible network, such as 1 site per geotype, will be kept running.

historical information received, we forecast the proportion of traffic on 3G and 4G networks for future years. This forms part of our demand forecast, which is described in Section 4.

In terms of assumed coverage, we have developed a profile for how Optus' coverage has increased up to its current level using datapoints from Optus annual reports and data provided by Optus itself. We have assumed the 2G network has always covered almost 99% of the population and that in 2019 the network was switched off. We consider that using a level of coverage as provided by Optus is reasonable since, based on the information provided, Optus carry more than one third of the mobile data traffic in Australia and therefore their level of coverage can support the assumed market share of traffic.

For 3G networks, we have assumed deployment begins in 2004, based on the average of the three MNOs launch dates for 3G networks.[15]. We have assumed deployment of 4G networks commenced in 2014, corresponding to the first year that 700MHz spectrum was available for use in Australia. The assumed demand is assumed to be carried on 2G/3G networks prior to 2014.

3.6 Spectrum holdings

Since the benchmark models largely consider only frequency division duplex (FDD) bands rather than time division duplex (TDD) bands, TDD spectrum has not been considered in this benchmark. We consider this to be a reasonable simplification since TDD technologies are not in widespread use in Australia for the conveyance of mobile voice traffic.

Another simplification that was required for this exercise was the assumption of nationwide licences. Many of the benchmark models cannot model regionally varying spectrum allocations, which are in place for several bands in Australia. Therefore, a conservative (i.e. smaller) assumption of nationwide spectrum holdings in each band will be assumed in each of the benchmark models. The impact of the modelled operator having smaller spectrum holdings has been more pronounced for traffic-driven geotypes (usually the more urban geotypes), where more sites have been needed to serve the assumed traffic.

The spectrum bands that have been considered and the assumed nationwide allocation for the modelled operator are summarised in Figure 5 below. The year shown is derived from the first year in which the spectrum licence is active.[16]

15 VHA launched in 3G services in 2003. Telstra launched 3G services (using Evolution-Data Optimized (EVDO) technology) using in 2004. Optus launched 3G services in 2005. Sources are hyperlinked to the year.

16 This information can be found at https://www.acma.gov.au/spectrum-auctions

Figure 5: Spectrum bands to be considered in the calculation [Source: Analysys Mason, 2020]

Band	Spectrum frequencies (MHz)	Spectrum allocation (MHz)	First year
700MHz	703–748 paired with 758–803	2×10	2014
800MHz/ 900MHz	825–845 paired with 870–890[17] and 890–915 paired with 935–960	2×5 of 900MHz 2×5 of 850MHz	Beginning of model[18]
1800MHz	1710–1785 paired with 1805–1880	2×15	2000
2100MHz	1920–1980 paired with 2110–2170	2×10	2002
2.5GHz	2500–2570 paired with 2620–2690	2×20	2014

Figure 6 then shows how the assumed frequencies are used by the modelled technologies.

Figure 6: Assumed spectrum holdings (MHz) [Source: Analysys Mason, 2020]

	Before 2004	2004–2013	2014–2016	2017–2018	2019 onward
2G coverage	900: 2×5 850: 2×5	900: 2×5	900: 2×5	900: 2×5	
2G capacity	1800:2×15[19]	1800: 2×15	1800: 2×15		
3G coverage		850: 2×5	850: 2×5	850: 2×5	850: 2×5 900: 2×5
3G capacity		2100: 2×10	2100: 2×10	2100: 2×10	2100: 2×10
4G coverage			700: 2×10	700: 2×10	700: 2×10
4G capacity			2500: 2×20	1800: 2×15 2500: 2×20	1800: 2×15 2500: 2×20

The assumed spectrum holdings have been tested as part of the benchmarking exercise to determine how sensitive the cost results are to these assumptions. The assumed quantity of spectrum will also have a knock-on effect on the contribution to the overall cost from spectrum costs, as described in Section 3.7 below.

3.7 Spectrum costs

We have chosen to adopt the following approach to considering spectrum costs: we de-activate spectrum costs within all the models and consider Australian-specific spectrum costs externally to the models as an additional cost component. This approach has been chosen because the structure of spectrum costs varies from country to country, with different relative mixes of one-off auction fees and recurring fees in each case.

Within our separate calculation of the MTAS spectrum-related costs, we therefore have started with the spectrum auction fees and recurring fees in Australia, based on the actual licence durations. The

17 Based on the reports published at https://www.acma.gov.au/consultations/2019-08/800-900-mhz-band-implementation-arrangements-support-milestone-1-consultation-212018

18 This spectrum will be assumed to be available for 2G deployments in the early modelled years, if required.

19 From 1999.

costs have been allocated across a time series of traffic volumes using a routeing factor approach. The resulting spectrum cost per minute can then be added to the benchmark MTAS values (coming from the benchmark models each of which has been adjusted to exclude spectrum costs).

Our approach has been to calculate spectrum costs for the modelled operator based on the assumed spectrum holdings in Figure 6. These have been derived as separate time series of one-off fees to be capitalised (e.g. auction payments and renewal fees) and recurring opex.

We have then allocated these costs to the assumed traffic of the modelled operator, based on the demand forecasts developed according to Section 4. Only the auction fees for active spectrum licences have been considered, with costs recovered by their expiry date (i.e. the auction fees for licences that have expired in or before 2019 will be assumed to already be fully recovered).[20]

This approach avoids the diverse nature of spectrum costs in other countries and has automatically reflected the specifics of Australia's spectrum costs in the estimate of the costs of MTAS.

For the one-off fees to be capitalised, we have used the information on ACMA's website. When fee information (e.g. annual fees) was not publicly available, we requested the information from ACMA.

Our sources for the one-off fees by band are summarised below in Figure 7.

Figure 7: Assumption of one-off fees by band [Source: Analysys Mason, 2020]

Band	Assumption	Source
700MHz	Derived from the spectrum auctions of the band in 2017 and 2013, excluding an assumed cost of the 2.5GHz band	See entry for 2.5GHz band
900MHz	No one-off fees, use renewal fees indicated by ACMA	Reflects situation in Australia
850MHz, 1800MHz and 2100MHz	Weighted average of renewal fees based on cost per MHz per capita issued by the Australian government, and fees for auctioned spectrum in these bands in 2016 and 2017 (weighted by the coverage of the auctioned spectrum, expressed in terms of cost per MHz per capita)[21]	Government directive of 2012[22] for renewal fees, auction fees from ACMA website[23]
2.5GHz	Derived from TPG's spectrum auction payment for a standalone allocation of 2.5GHz spectrum in 2013	ACMA website[24]

20 This cost allocation uses an economic depreciation calculation implemented in a simple side model. Spectrum costs have been allocated to the traffic of the network technologies that use the spectrum. For example, if a spectrum band is assumed to be used only for 3G traffic, then it is allocated only to 3G traffic. 900MHz recurring spectrum fees for spectrum holdings used for the 2G network are assumed to have been recovered prior to 2020: only fees for spectrum used for the 4G network are considered.

21 For 850MHz, this is purely based on the cost per MHz per capita value issued by the Australian government, since this spectrum has not been recently auctioned

22 See https://www.communications.gov.au/sites/default/files/Direction-to-the-ACMA-under-subsection-294-2-of-the-Radiocommunications-Act-1992.pdf, page 2

23 See https://www.acma.gov.au/auction-summary-multiband-residual-lots-1800-mhz-2-ghz-23-ghz-and-34-ghz-band-2017 and https://www.acma.gov.au/auction-summary-1800-mhz-regional-2016

24 See https://www.acma.gov.au/auction-summary-700-mhz-digital-dividendand-25-ghz-band-reallocation-2013 and https://www.acma.gov.au/auction-summary-700-mhz-residual-lots-2017

3.8 WACC

The benchmark models all require a pre-tax WACC as an input. The ACCC has calculated a pre-tax WACC for this purpose. The ACCC has provided both a real-terms pre-tax WACC (2.53%) and a nominal-terms pre-tax WACC (4.98%), since different models in the peer group require a different format of WACC input.

3.9 Currency

The relevant outputs are the cost per minute for voice termination, for the years 2020–2024. Each of the benchmark models produces results for a given year in local currency (except Peru which uses USD); some models express the results in real-terms currency (according to a currency value in a fixed year, which excludes subsequent inflation effects), whilst other models express results in nominal-terms currency (the currency value of the given year).

We have taken the cost results from the benchmark models and we first converted them to nominal currency (if this is not already undertaken in the model). For each model where required, we have sourced forecasts of domestic inflation for the period 2020–2024 from appropriate sources (such as the government Treasury organisation or government bank).[25]

We have also converted the values to Australian dollars using the most recent foreign exchange rates and also estimated the proportion of costs that relate to non-tradeable items (e.g. site installations, operating expenses)[26] using the asset-by-asset cost breakdowns available in each cost model. For each model, we then adjusted this proportion of the cost result for purchasing power parity (PPP). The datapoints required for both conversions (foreign exchange rate and PPP) have been sourced from the World Bank.[27]

3.10 Backhaul

The benchmark models use a combination of leased lines, owned/dark fibre and microwave technology to provide backhaul to the radio network. In order to better reflect the situation in Australia, the backhaul could be split according to mix of backhaul options used by the MNOs in Australia. This information has been requested from the MNOs. For now, this has not been adjusted in the basecase results, but a sensitivity test has considered the impact of assuming a common split of backhaul deployments. This test considers a 25%:50%:25% split for leased lines, owned/dark fibre and microwave technology as an example that can be refined once the MNOs have been able to provide this information.

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25 This data has been gathered for the models for France, Mexico, Portugal, Sweden and the UK. The Netherlands model assumes 2% inflation in all years, whilst the East Caribbean, Peru and Spain models are in nominal-terms currency and so no such time series is required. Weblinks to the relevant inflation data are provided in Annex B.

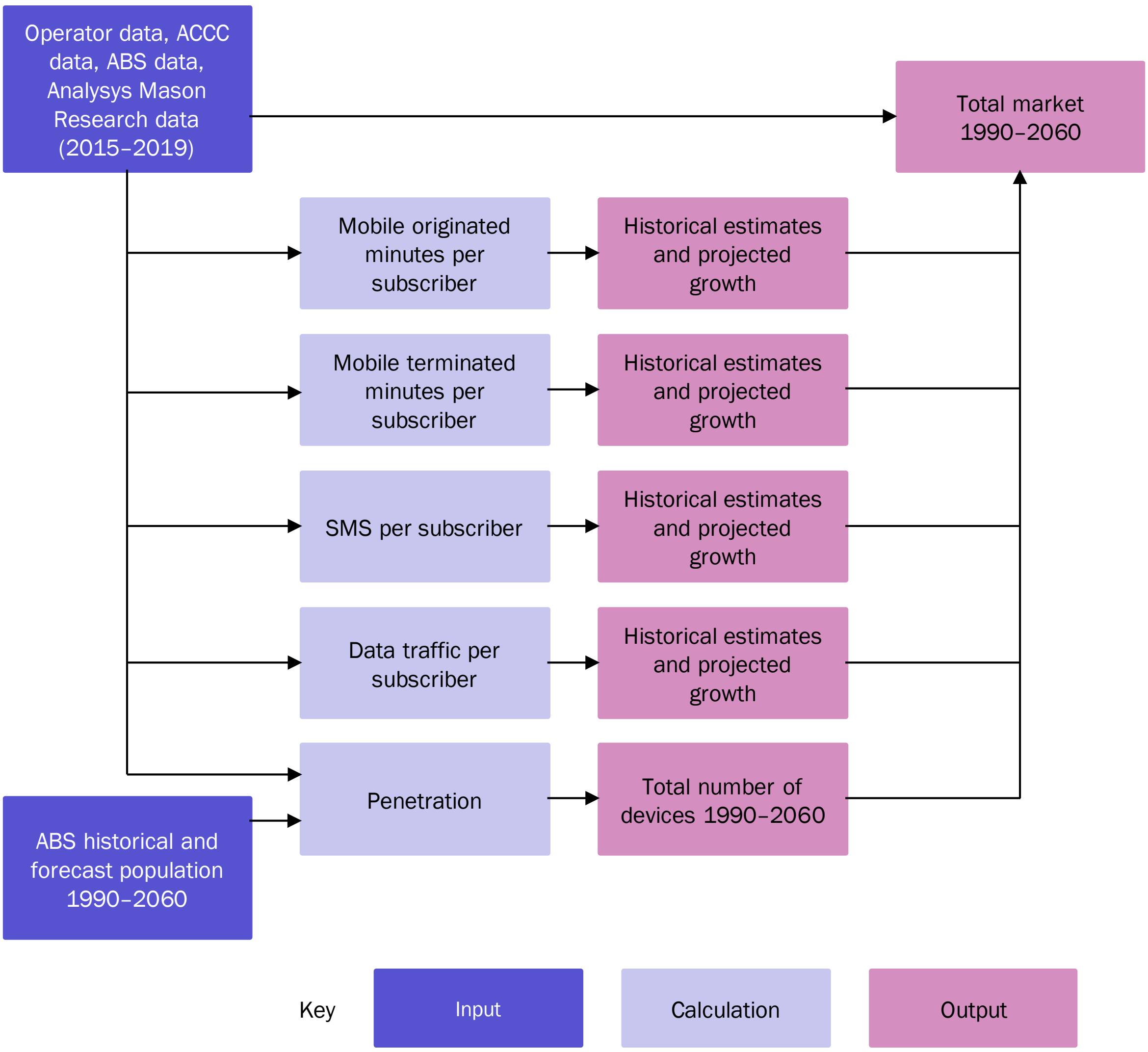
26 We assume that electronic capital assets are tradeable and therefore that these capital costs will not require an adjustment for PPP.

27 See https://data.worldbank.org/indicator

4 Demand forecast

The benchmarking process requires demand values from 1990 and forecasts to 2060. Voice, SMS and data traffic time series have been produced from market information provided by the operators and supplementary information from the ACCC, ABS and Analysys Mason Research. All three types of traffic have been treated separately and have been split into further categories in order to be tailored for each of the benchmark models. For voice and data traffic, migration profiles were also derived for the migration of traffic from 2G to 3G to 4G. SMS are split using the voice migration profile. An outline of the market calculation is shown below in Figure 8.

Figure 8: Demand forecast framework [Source: Analysys Mason 2020]



The main sources of information used to develop these forecasts are set out below.

Figure 9: Overview of sources used to develop the forecasts [Source: Analysys Mason, 2020]

Source	Input updated
Operator data	Data from Optus, Telstra and VHA for 2009–2019 (not all operators provided full data for all of these years) detailing: • subscribers • outgoing minutes (including splits to on-net, off-net mobile, off-net fixed, off-net international and off-net other) • incoming minutes (split over the same categories) • SMS messages (on-net, off-net outgoing, off-net incoming) • data megabytes (sent/received) Statistics were also provided for voice/data traffic on each radio technology
ACCC	Subscribers and voice minutes from FY 2011/12 to FY 2018/19
ABS	• Subscriber and data usage from 2007 Q1 to 2019 Q2[28] • Historical population data (1990–2018)[29] • Forecast population (2019–2060)[30]
Analysys Mason Research	• Historical data for penetration, outgoing minutes, outgoing messages and data megabytes (2006–2018) • Forecasts for the same metrics (2018–2024)[31]

The rest of this section describes the components of the forecasts, namely:

- population and penetration in Section 4.1
- voice traffic in Section 4.2
- messages in Section 4.3
- data traffic in Section 4.4
- migration profile in Section 4.5.

4.1 Population and mobile penetration

The historical population from ABS details the estimated population in Australia as of the beginning of December every year from 1990 to 2018. We have used the ABS forecast series B (the middle of its three series) up to 2060. We have averaged the mid-year forecast values to get year-end forecasts. The population forecast is shown in Figure 10.

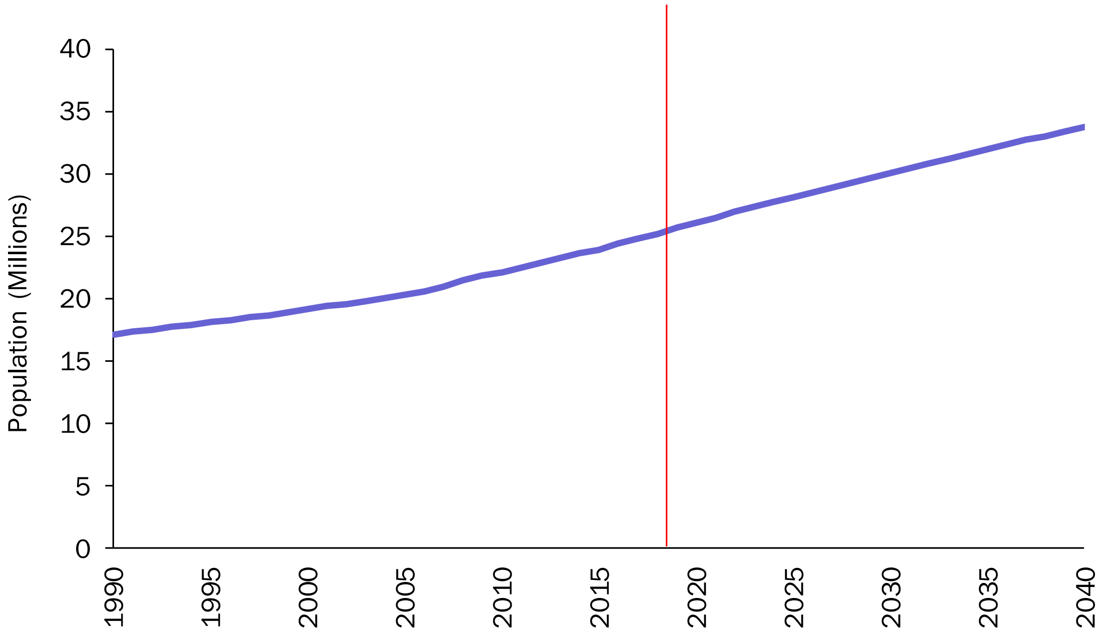
28 See the most recent Annual communications market report, https://www.accc.gov.au/system/files/Communications%20Market%20Report%202018-19%20-%20December%202019_D07.pdf, pages 44 and 46.

29 See https://www.abs.gov.au/AUSSTATS/ABS@Archive.nsf/log?openagent&310104.xls&3101.0&Time Series Spreadsheet&002114231FCBA18CCA2584D4001C2B85&0&Jun 2019&19.12.2019&Latest series A2060842F

30 See https://www.abs.gov.au/AUSSTATS/abs@.nsf/mf/3222.0 series B

31 See https://www.analysysmason.com/services/Research/DataHub/

Figure 10: Projected Australian population [Source: Analysys Mason, 2020]



To calculate the mobile penetration rate, the values from different sources have been used over time, depending on the availability of information.[32] Since in the latter years of this dataset, penetration was largely flat (in particular, from 2013 to 2018 penetration only increased from 133.69% to 137.95%), projected future penetration was forecast to remain at the same level as in 2019. The number of subscribers still increases due to increasing population. To estimate historical penetration, the annual growth rate from 2006 to 2007 was assumed to also apply between all prior years. The penetration forecast is shown in Figure 11 and the subsequent subscriber forecast in Figure 12.

32 Specifically, we have used Analysys Mason Research for 2006–2012, the ACCC for 2013–2017 and the ABS for 2018.

Figure 11: Projected penetration [Source: Analysys Mason, 2020]

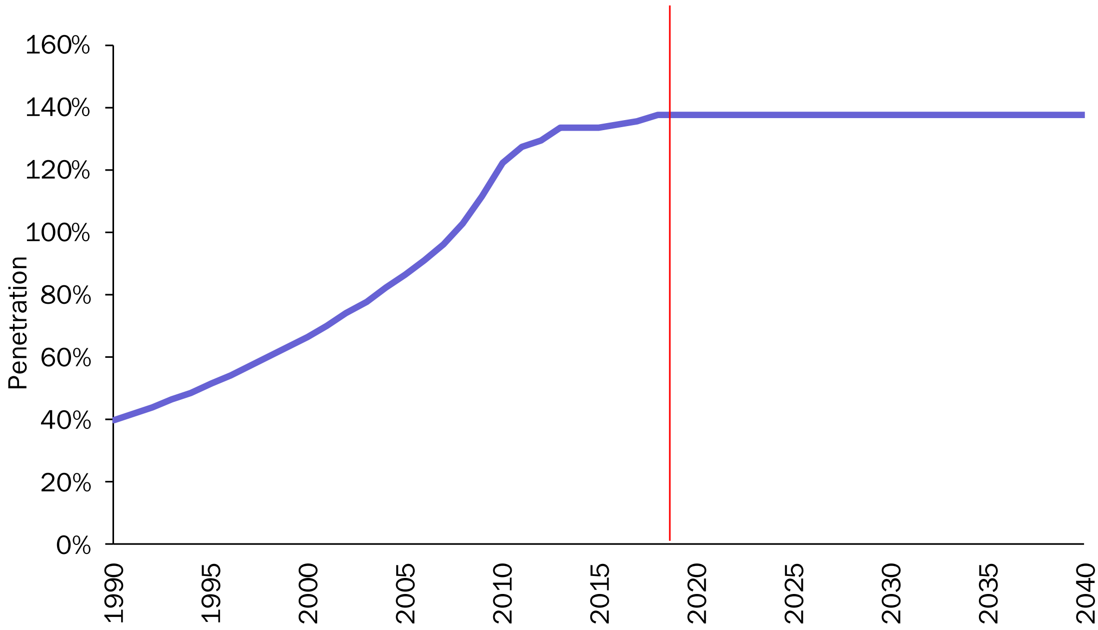
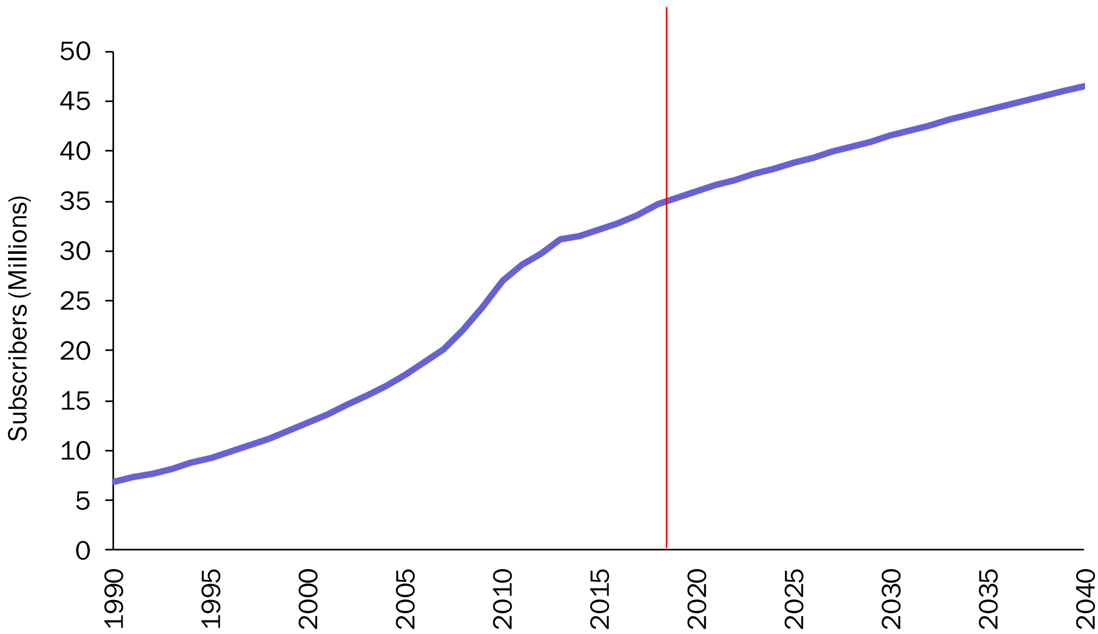


Figure 12: Projected number of subscribers [Source: Analysys Mason, 2020]



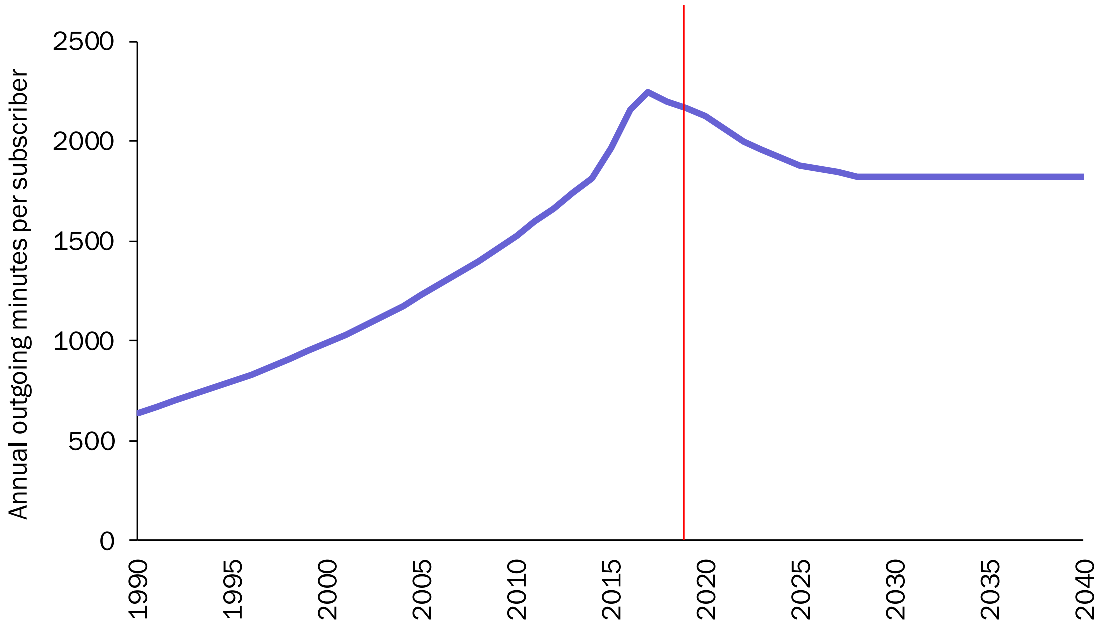
4.2 Voice traffic

4.2.1 Outgoing minutes

In order to calculate the total outgoing minutes per subscriber, the starting point selected was the ACCC information from 2013 to 2018. This was preferred to the data from the operators since outgoing minutes were not given by all operators and therefore only an incomplete picture was available from this source. To calculate historical values, the annual growth rate between 2013 and 2014 was assumed to also apply in all prior years.

For the years 2019-2025, forecasts from Analysys Mason Research were used to calculate the year-on-year change in in usage per subscriber (between a 2% and 3% decrease). This year-on-year decrease in usage per subscriber is assumed to reduce to a 1% decrease in 2026-2028 and from 2029 onwards the number of outgoing minutes per subscriber is assumed to remain constant (i.e. a 0% year-on-year percentage change). This forecast can be seen in Figure 13.

Figure 13: Projected outgoing minutes per subscriber [Source: Analysys Mason, 2020]



This forecast decline is consistent with what information was provided by operators, which does indicate a consistent year-on-year decline in usage per subscriber since 2016

To split the outgoing voice between on-net, off-net to mobile, off-net to fixed, off-net to international and other off-net (as required for some models), the percentage distribution from the operator data was used for the years 2016 to 2019. Prior to 2016, the 2016 percentage distribution is used and from 2020 onwards, the 2019 percentage distribution is used.

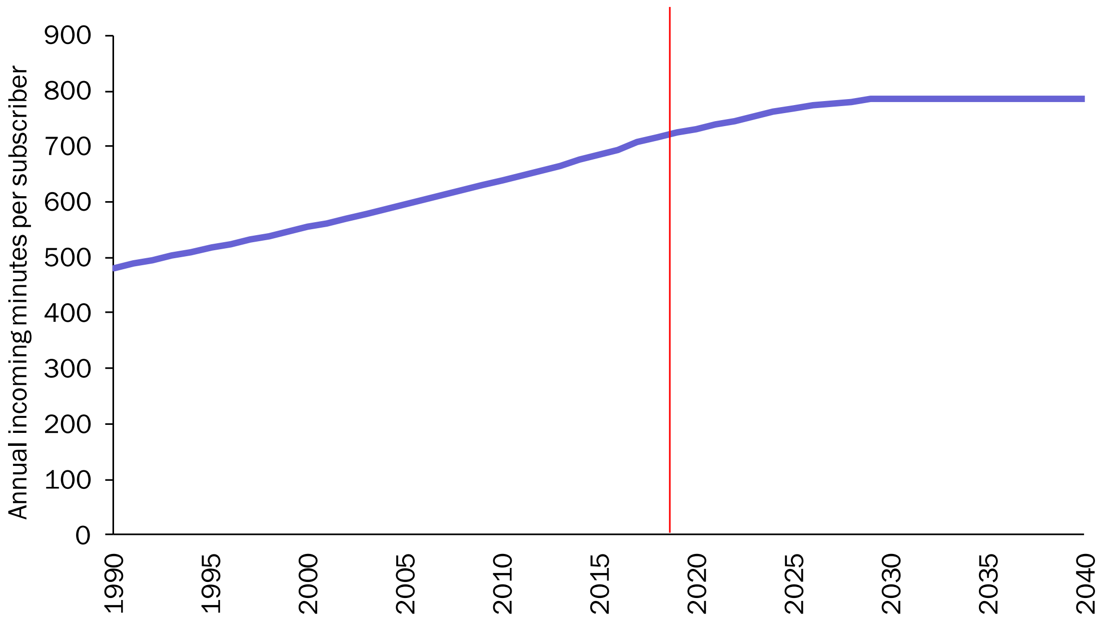
4.2.2 Incoming minutes

Operator data was used to calculate incoming minutes per subscriber between 2016 and 2019. The trend in this usage per subscriber was then extrapolated back to 1990. Between 2018 and 2019, a 1.05% increase in usage per subscriber was recorded. The year-on-year increase in usage per subscriber from 2016 onwards has been slowing from 2016 onwards.

From 2020 to 2025, a 1% year-on-year increase in usage per subscriber was assumed i.e. the slight growth observed in previous years has been assumed to continue. From 2026 to 2029, a 0.5%

increase in usage per subscriber was assumed with no further increases in usage per subscriber assumed thereafter. This can be seen in Figure 14.

Figure 14: Projected incoming minutes per subscriber [Source: Analysys Mason, 2020]



Total incoming minutes per subscriber were then broken down by source into: fixed, mobile off-net, international and other. These were calculated using the distribution implied by the data received from operators for 2015 to 2019. Prior to 2015, the 2015 distribution is used and the 2019 distribution is used from 2019 onwards.

We note that the forecast of both the decline in outgoing voice per subscriber coupled with a very slight increase in incoming voice per subscriber are the continuation of trends that have been observed in voice usage in Australia based on the data submitted by operators.

Based on the operator information, total outgoing minutes per subscriber has slightly decreased since 2016, but outgoing off-net to mobile minutes per subscriber has slightly increased, which would correspond to the slightly increase in incoming off-net minutes per subscriber. The overall decrease in outgoing voice is due to a rapid decline in outgoing to international minutes.

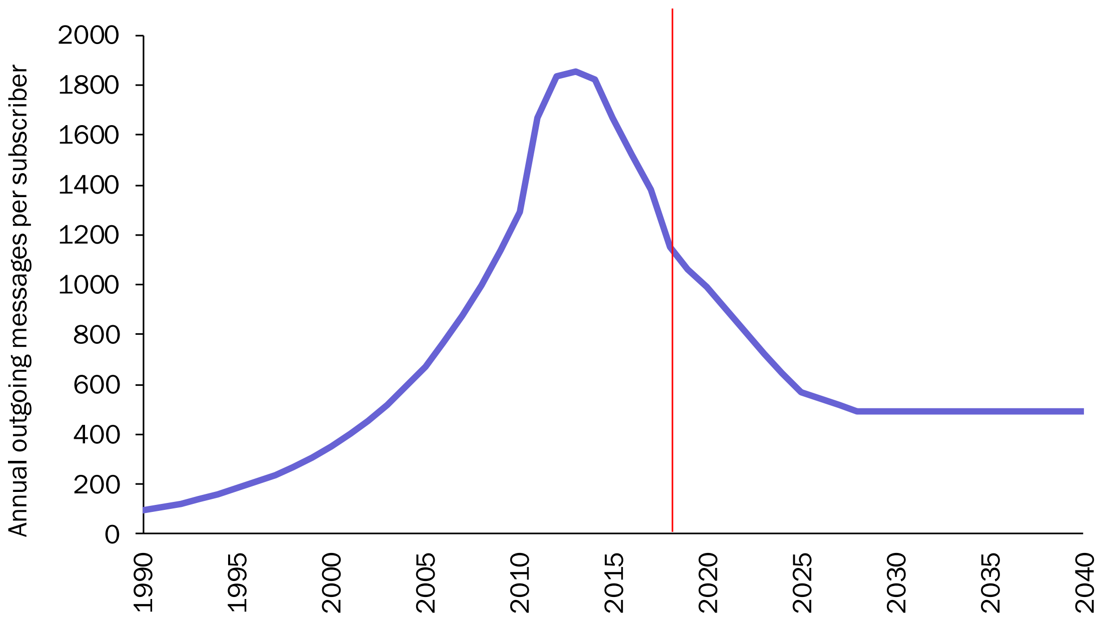
4.3 Messages

4.3.1 Outgoing messages

From 2009 to 2019 the number of outgoing messages per subscriber was calculated based on operator data. To attain values from 1990 to 2008, the annual growth rate between 2009 and 2010 was assumed to also apply between all prior years. From 2020 to 2025, data from Analysys Mason Research was used to inform the year-on-year decrease in usage. This forecast was consistent with the trends observed in the operator data provided. This was between 7% and 11% in these years:

from 2026 to 2028, a further 5% year-on-year decrease in usage was assumed. From 2028, outgoing messages per subscriber are assumed to remain constant. This forecast is shown in Figure 15.

Figure 15: Projected outgoing messages per subscriber [Source: Analysys Mason, 2020]

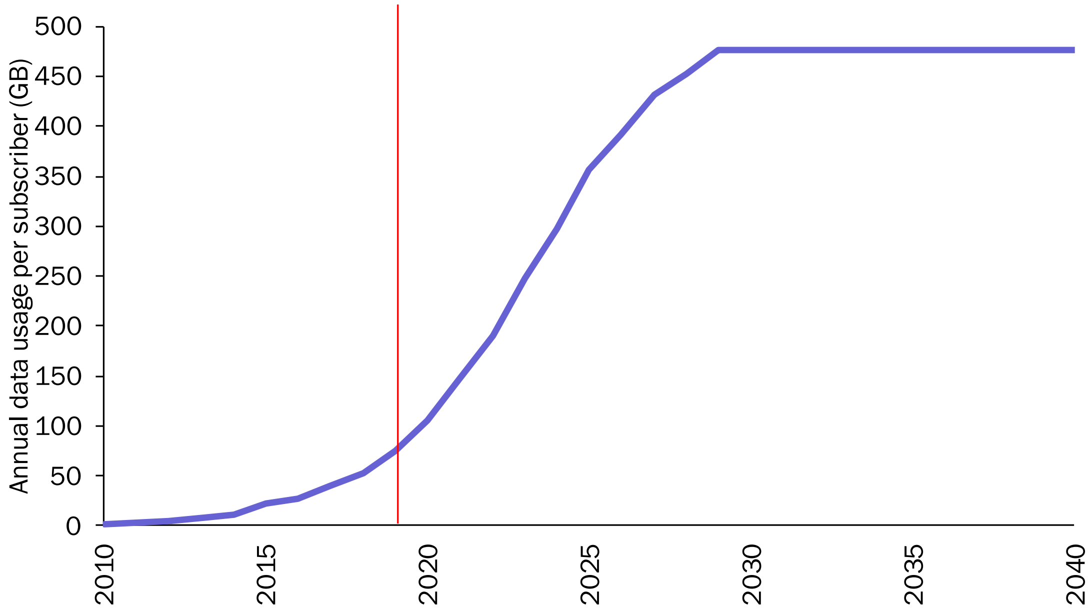


Outgoing messages were then broken down into outgoing on-net and outgoing off-net using the distribution implied from data provided in the period 2016-2019. The forecast changes for 2020–2025 are broadly consistent with the trend observed in this 2016–2019 period. Incoming messages are calculated using operator data in a similar fashion.

4.4 Data traffic

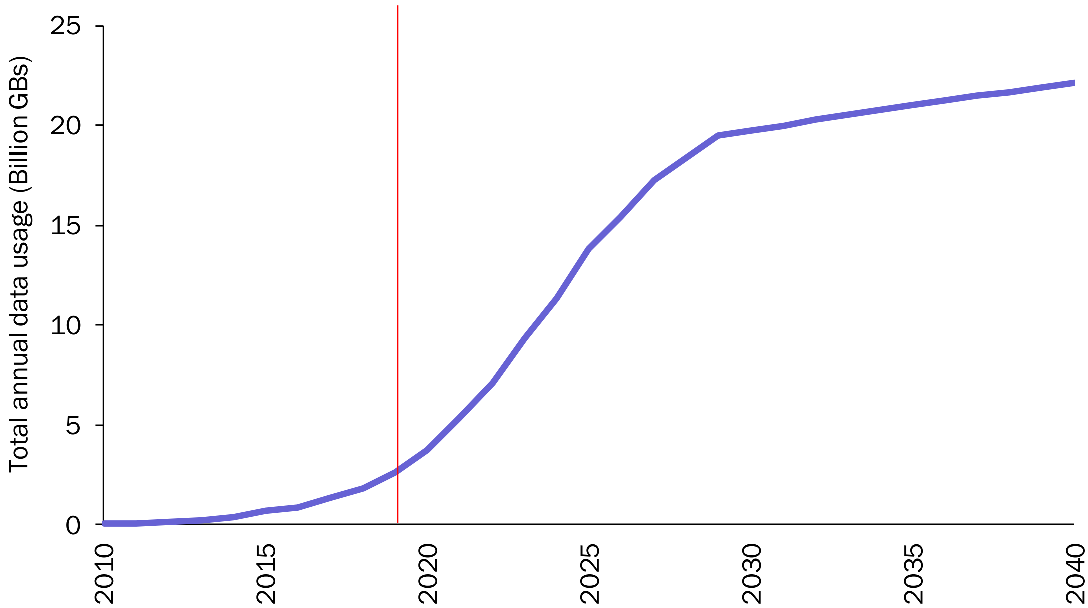
Operator data was provided from 2010 to 2019 and showed a clear exponential trend in data usage per subscriber. The exponential curve was extrapolated back to 2000. To forecast from 2020 to 2029, the assumed year-on-year percentage increase in usage per mobile subscriber was 40% for 2020 and 2021, 30% for 2022 and 2023, 20% for 2024 and 2025, 10% for 2026 and 2027, and 5% for the remaining two years. The year-on-year percentage increases assumed in usage per subscriber for the period 2020–2025 are consistent with Analysys Mason Research's own forecasts. From 2029 onwards, usage per subscriber has been assumed to remain constant, so we reduce the year-on-year percentage increase in usage per subscriber from 20% in 2025 to 0% in 2029. This can be seen in Figure 16.

Figure 16 Projected annual data usage per mobile subscriber [Source: Analysys Mason, 2020]



To attain a split of data between upload and download, the data submitted by operators was used to calculate the breakdown between 2015 and 2019 with the 2015 and 2019 splits being used backward and forward in time respectively. The projected total data usage is shown in Figure 17.

Figure 17: Projected total data usage [Source: Analysys Mason, 2020]

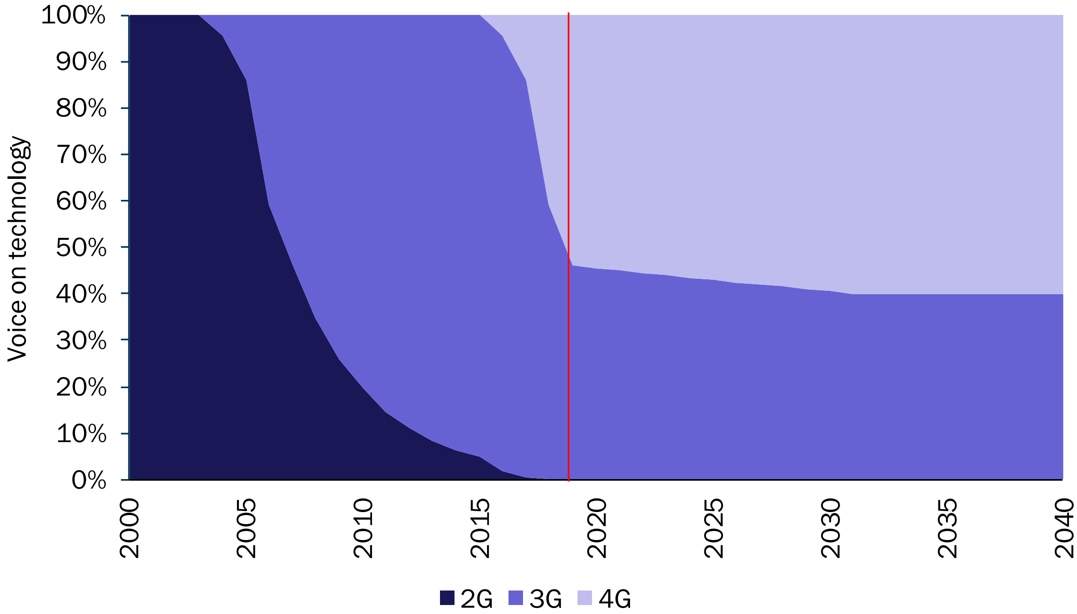


4.5 Migration profiles

4.5.1 Voice migration profile

Using data provided by all three operators, the split of total minutes on 2G/3G/4G networks was calculated from 2015 to 2019. We have assumed that 3G was introduced in 2004 and 4G in 2014. Therefore, from 1990 to 2003, 100% of voice traffic was carried by the 2G network. Between 2015 and 2019 the proportion of voice traffic carried on the 4G network went from 0% to 54%; we have used the same growth profile for 3G traffic from the first year of 3G to calculate the minutes carried by 3G from 2004 to 2007 (with the remainder being carried by the 2G network). To generate the split from 2008 to 2014, the 2G network was assumed to carry 25% less of the total minutes every year, with 3G picking up the remaining voice minutes. From 2019, the 2G network was switched off with remaining traffic split between 3G and 4G. From 2020 to 2030, we have aimed to keep the number of total minutes on the 3G network roughly constant. Since over these years there is an increase in total minutes, this means that the percentage of voice traffic carried on the 3G network does slightly decrease from 46% to 40% over these 10 years. The resulting voice migration profile can be seen in Figure 18.

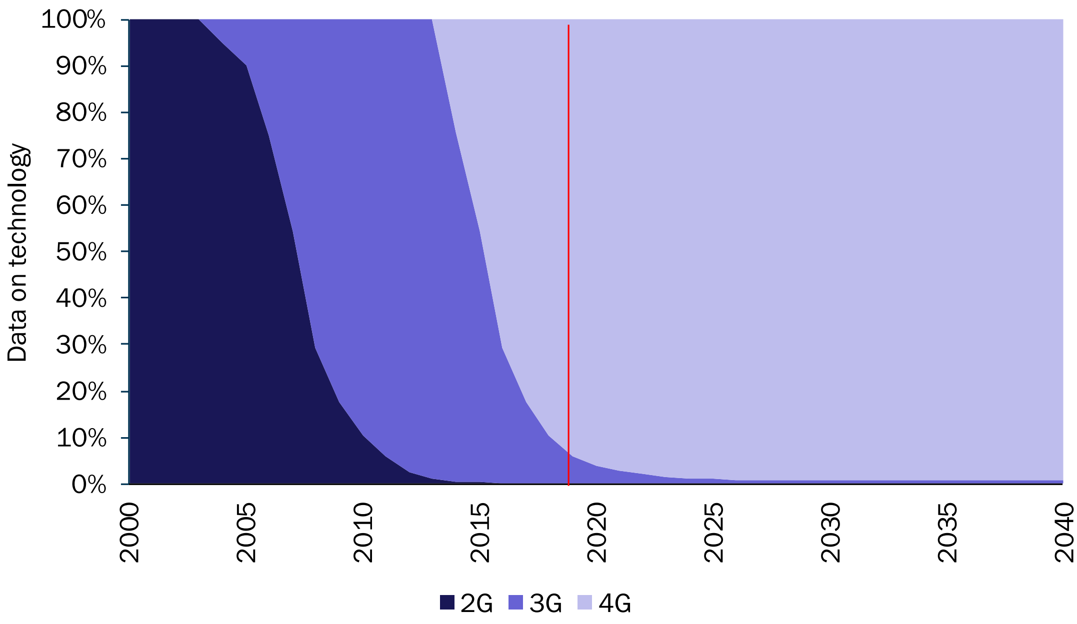
Figure 18: Voice migration profile [Source, Analysys Mason 2020]



4.5.2 Data migration profile

Information provided by the operators gave a split by mobile technology for data traffic from 2015 to 2019. We have used this information and the assumed start dates for 3G data in 2004 and 4G data in 2014 to estimate how the migration from 2G to 3G to 4G occurred. From 2020 to 2030, the 3G network is assumed to carry a roughly constant number of megabytes. However, since the total number of megabytes is still increasing, the proportion of data traffic carried on the 3G network decreases from 4% of total megabytes in 2020 to 0.65% in 2030. This can be seen in Figure 19.

Figure 19: Projection data migration profile [Source Analysys Mason, 2020]



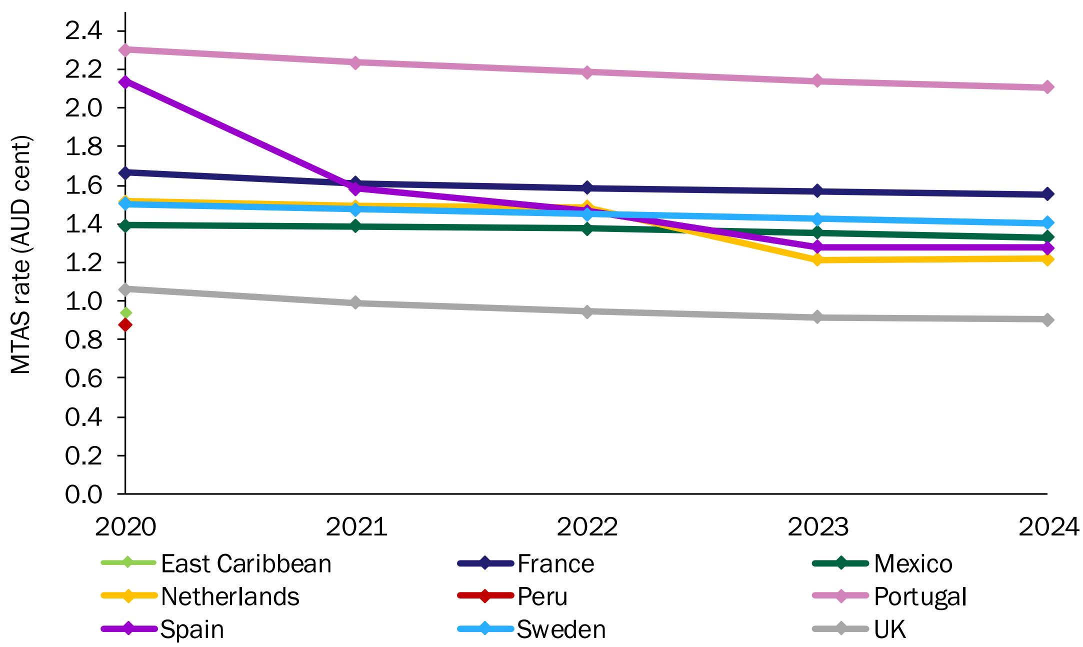
5 Benchmark results

Our findings from the adjusted cost models are provided in this section. We use the same colour for each of the peer group models when presenting our results. Where average values are indicated, they only include the models shown on the same chart.

5.1 Initial results

Figure 20 expresses the unit cost results per minute for terminated voice for the years 2020–2024 from the published models, where applicable.[33] These results include none of our adjustments, other than removing local country-specific spectrum costs.

Figure 20: Output results for 2020–2024 (nominal AUD cents, no adjustment for PPP, excluding spectrum costs) [Source: Analysys Mason, 2020]



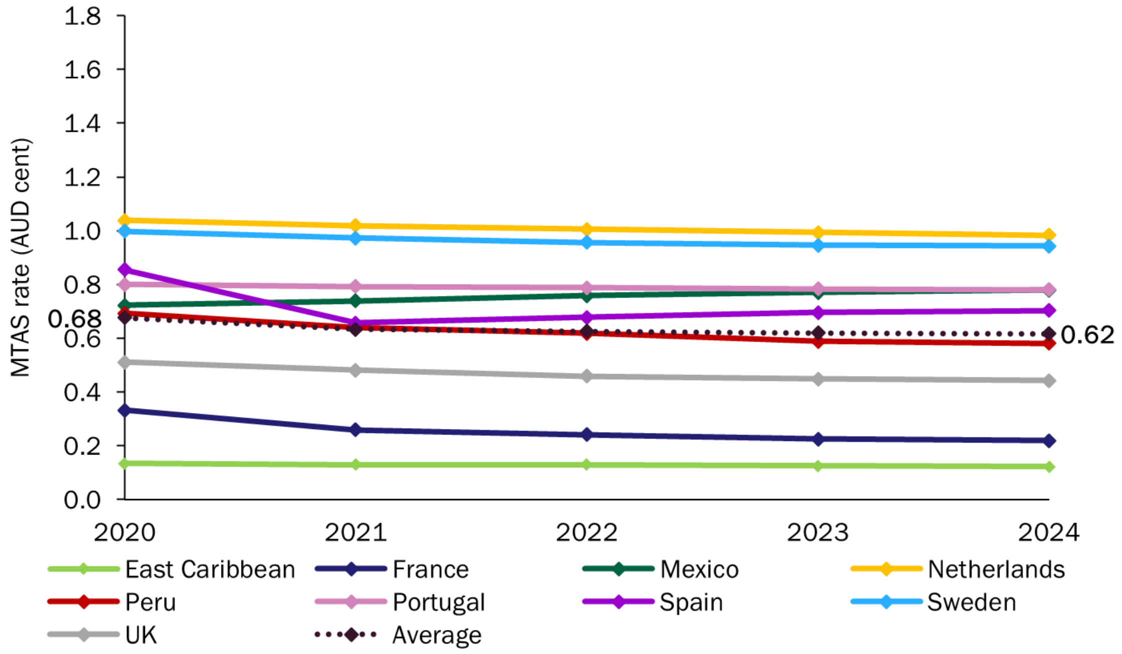
The costs per minute for terminated voice from each cost model, after implementing the adjustments described earlier in this report, for the period 2020–2024 are shown in Figure 21 below.

All results are expressed in nominal AUD cents. The average across all nine models reduces from AUD0.0069 (0.69 AUD cents) in 2020 to AUD0.0063 (0.63 AUD cents) in 2024. As can be seen by comparing the two charts, the adjustments caused considerable changes to both the absolute

33 The East Caribbean model only calculates results for the years 2015–2020, meaning that only the 2020 result is shown in the chart. The Peru model only calculates a result for a single year (2015/2016), which we show as being a 2020 result in the chart. The France and Mexico results are derived using our own LRAIC+ calculations, since neither published model includes a LRAIC+ calculation. These modifications are outlined in Annex B

model results and the relative values between the models. The range in results across the nine models has also reduced. The results shown also exclude Australia-specific spectrum costs, which are described separately below.

Figure 21: MTAS calculation for 2020–2024 (nominal AUD cents, no adjustment for PPP, excluding spectrum costs) [Source: Analysys Mason, 2020]



Key reasons for the overall reduction in the outputs of the model include the assumed WACC (which is lower than the value assumed in the original models) and the fact that many of the original models still have active 2G network carrying voice traffic in the period 2020–2025 (and contributing to the overall average voice cost), whilst in the adjusted models 2G has been deactivated by 2019.

As can be seen above, there are three cost models generating lower results (East Caribbean, France and the UK) and a group of six cost models generating higher results.

We have determined that the additional contribution arising from the assumed spectrum fees equals AUD0.0013 (0.13 AUD cents) per terminated minute in 2020, increasing to AUD0.0014 per terminated minute by 2024. This is not included in any of the results shown from the benchmark models in this report, since it is calculated using a separate side-model. It would therefore need to be added to any final cost results derived by the ACCC.

We have collated the purchasing power parity (PPP) factors from the World Bank[34] and used the cost models to calculate the proportion of total annualised cost that arises from equipment capex and

34 Specifically, we use two series available from https://data.worldbank.org. These are "PPP conversion factor, GDP (LCU per international $)" (Series 1) and "Official exchange rate (LCU per US$, period average)" (Series 2). We calculate the ratio for a given country as

(Series 1 for Australia/Series 1 for country)/(Series 2 for Australia/Series 2 for country).

We calculate this ratio for the years 2016–2018 and derive the average ratio over those three years.

therefore can be considered tradable (Tradable proportion, T). The values of these factors for the countries in the peer group are shown in Figure 22. The tradable proportions typically range across the models from 20%–40% (although the proportion in the East Caribbean model is significantly lower).

Country	Proportion of cost assumed to be tradable	Multiplier for PPP to non-tradable costs
East Caribbean	5%	1.60
France	25%	1.22
Mexico	35%[35]	2.28
Netherlands	25%	1.19
Peru	40%	2.28
Portugal	20%	1.63
Spain	25%	1.47
Sweden	20%	1.05
UK	20%	1.18

Figure 22: Factors related to the PPP adjustment [Source: Analysys Mason, 2020]

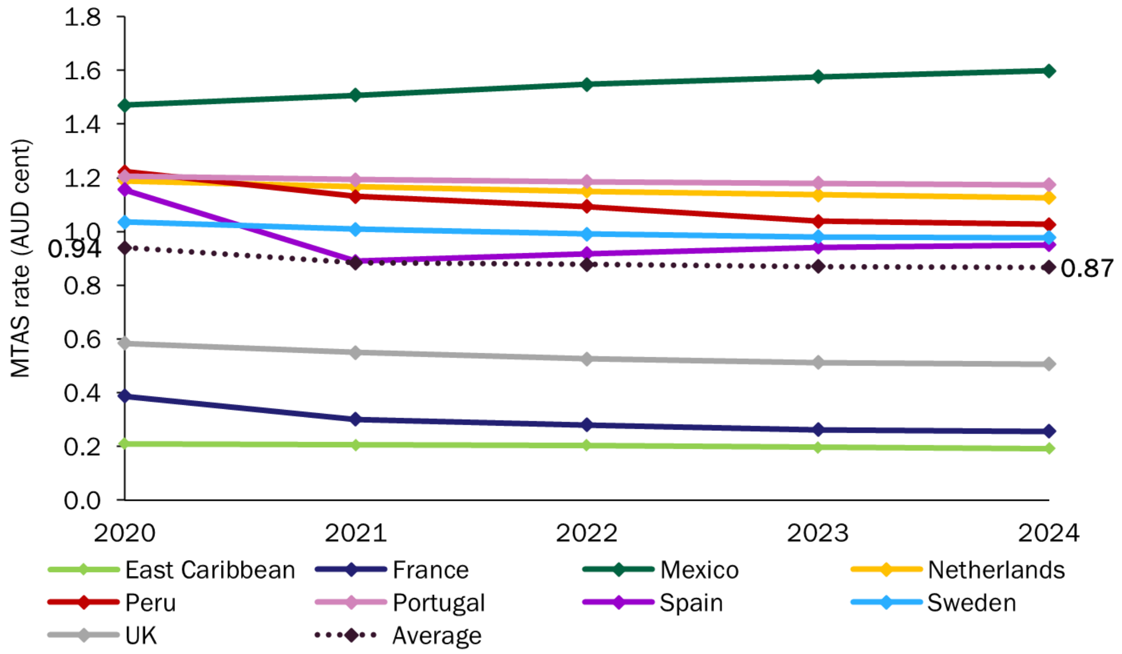
We then adjust the calculated MTAS rate to reflect PPP using the formula:

$$[\textit{PPP factor} \times (1–T) \times \textit{MTAS rate}] + [T \times \textit{MTAS rate}]$$

The MTAS rates adjusted for PPP are shown below in Figure 23.

[35] The Mexico model expresses capex per unit output in USD and opex per unit output in MXN. This allows the capex cost per terminated minute and opex cost per terminated minute to be derived separately. The PPP adjustment is only applied to the opex component (converted from MXN to AUD) and the proportion of the capex component from tradable assets (converted from USD to AUD).

Figure 23: MTAS cost results from the benchmark models for 2020–2024 (nominal AUD cents, adjusted for PPP, spectrum costs excluded) [Source: Analysys Mason, 2020]



As can be seen above, this adjustment does create a definite cluster of five model results in the range 1.0–1.2 AUD cents (Netherlands, Peru, Portugal, Spain and Sweden). The net effect of the PPP adjustment is an increase in the overall average of the MTAS rate.

The Mexico results are significantly higher than the other models and are unusual in that they increase over time. The increase over time is due to the assumed forecast of inflation. The high cost results are partially due to the unit capex assumptions for fibre backhaul that comprise 30% of the total modelled capex (that is further compounded by having the PPP adjustment applied since fibre backhaul is not be assumed to be tradable).

We observe that the UK, French and East Caribbean models still have significantly lower results when the PPP adjustment is included.

We have used the adjusted models to derive the total calculated economic cost in 2022 to better understand if the differences are arising from a different cost base or a different internal cost allocation mechanism, or both. A scatter plot of these values compared to the calculated MTAS rate (all expressed in Australian currency) are shown in the two charts below.

Figure 24 shows the results excluding the PPP adjustment.

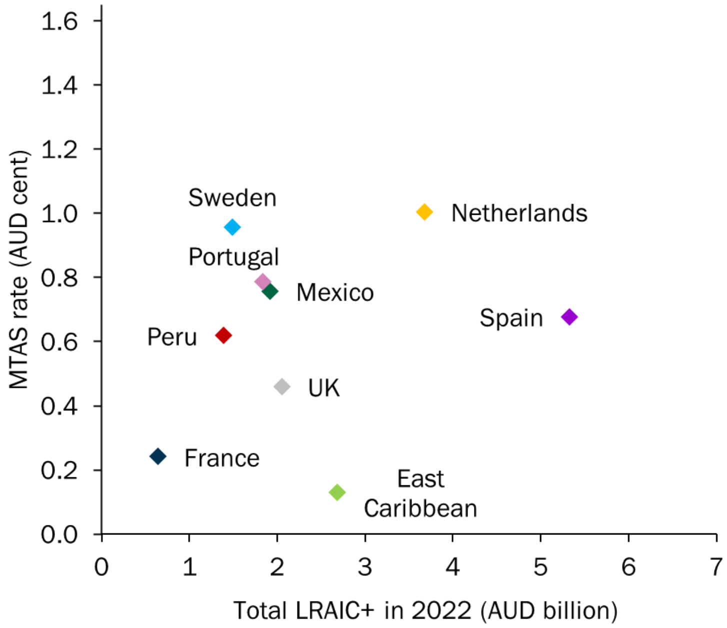


Figure 24: Total economic cost versus MTAS rate per minute in 2022, excluding PPP adjustment [Source: Analysys Mason, 2020]

Figure 25 shows the results after the PPP adjustment.

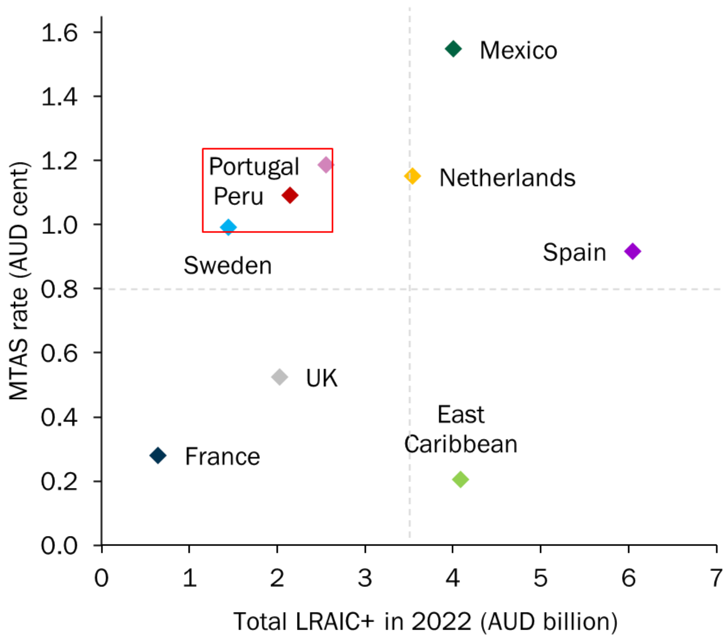


Figure 25: Total economic cost versus MTAS rate per minute in 2022, including PPP adjustment [Source: Analysys Mason, 2020]

Three of the model results are in close proximity to each other in both dimensions in Figure 25 (ringed in red above). With regard to the other models:

- The France model is a low-cost model overall with our adjustments i.e. in terms of both total cost and unit costs of MTAS
- The UK model is generating similar total economic costs to the cluster, but derives a low unit cost of MTAS. We believe that this may be due to its rather different approaches to both economic depreciation and cost allocation. The cost allocation is based on Mbit/s rather than

voice-equivalent minutes, and the way in which it converts between voice minutes and data megabytes[36]

- The Mexico model is a high-cost model overall following our adjustments
- The Spain model is a high-cost model overall with our adjustments,[37] but allocates less of this cost to voice, meaning that the final unit cost of MTAS is similar to several of the other models
- The East Caribbean model appears to be both high cost and allocating proportionately significantly less cost to MTAS. It is an outlier in both dimensions.

We have also compared the radio sites calculated in each model. We have first identified the SA2 area of each Optus site location in 2019 and then calculated how many site locations are assigned to the most rural geotype in each model.[38] For each model, we have also extracted the total number of modelled sites in this most rural geotype. Figure 26 shows the ratio of these modelled site locations to the actual site locations in the most rural geotype.

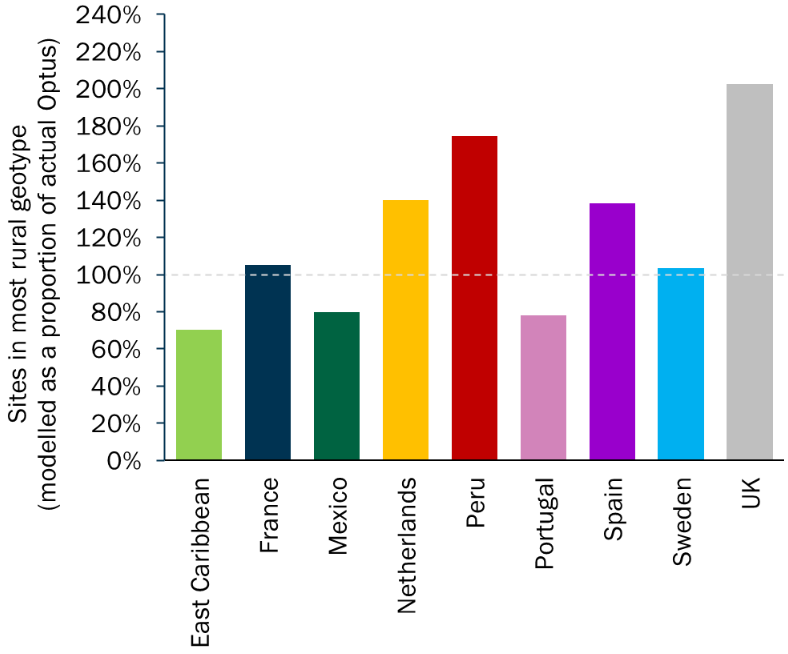


Figure 26: Modelled sites in the most rural geotype in 2019[39], as a proportion of the actual Optus sites located in SA2 areas assigned to the most rural geotype for that model [Source: Analysys Mason, 2020]

36 As an example, we have compared the ratio of the LRAIC for a 4G MTAS minute and the LRAIC for a 4G megabyte in 2019/2020 in the UK, Peru and Portugal models (which both calculate comparable total economic costs to the UK model as can be seen from Figure 24 and Figure 25). The ratio is approximately 1 in the UK model but is 9–10 in the other two models. There is therefore clearly a difference in how the UK model is allocating costs between voice and data services compared to the other two models.

37 One of the reasons for the Spain model having a high total cost result is the assumed fibre backhaul capex/opex assumptions (similar to the Mexico model). These costs comprise more than a third of the total modelled economic costs and are further inflated when the PPP adjustment is applied.

38 It is important to note that the total number of Optus site locations in the most rural geotype in the model will vary for each model, since the geotyping definition applied is different in each case (e.g. a SA2 area containing Optus sites allocated to the Rural geotype in Sweden may not be allocated to the Rural 4 geotype in the UK model, and vice versa).

39 A comparison of site counts as of the end of 2019/start of 2020 is made since that is the year for which the most reliable data is available.

Some models deploy fewer rural site locations than the Optus actuals (i.e. the ratio is less than 100%) but others deploy more than actuals (i.e. the ratio exceeds 100%). Four of the models have significantly higher calculated site counts. We have investigated the reason for this excess in these models and have identified different reasons for the high ratio. These are set out below.

Figure 27: Reasons for high ratios of modelled sites to actual sites in the most rural geotype [Source: Analysys Mason, 2020]

Model	Outline of reason	Explanation
Netherlands	High numerator in ratio	This is due to the lower assumed traffic capacity of 4G eNodeBs when compared to the other models, which is leading to the deployment of more eNodeBs and therefore more sites.
Peru	Low denominator in ratio	Based on the rural population density assumed in the Peru model, the Optus base station count in SA2 areas allocated to the most rural geotype is significantly lower (less than half) than that in the most rural geotype in the other models. However, the total area in the most rural geotype in the Peru model is not significantly lower than the other models. The total area of the most rural geotype in the Peru model is 7.3 million km^2, whilst the other models range from 7.6 million–7.7 million km^2, so it is only about 5% lower. Therefore, this ratio just appears to be artificially high in this one case due to the particular geotyping definition used in the Peru model and how this interacts with the SA2 areas.
Spain	High numerator in ratio	This is due to the 4G network design on the '7C CALC DIM LTE' worksheet, which is deploying significant numbers of eNodeBs for capacity purposes
UK	High numerator in ratio	The sum of total NodeBs and total eNodeBs modelled in the most rural geotype is almost the same as the total number of modelled sites (one would expect that many would be co-sited and therefore the total number of sites would be smaller). This is due to the evolution of site deployment from the past 2G network that, although it has been turned off by 2019, the modelled sites after 2019 have not been rationalised to account for this. The UK model does not usually consider 2G shutdown and we therefore think that this effect is an anomaly arising when a 2G shutdown is attempted within the model.[40]

40 One of the inputs controlling the number of sites deployed by this model is the site sharing inputs specified on the 'InputRevisions' worksheet of the Network model. These inputs were originally set by Ofcom in the context of an 1800MHz-only 2G operator deploying a 3G overlay using 2100MHz spectrum. Since the adjustments across the various models in this study assume the modelled operator has access to 900MHz spectrum for both 2G and 3G networks, we considered that these site sharing inputs could (and should) be set to 100% for greater consistency with the modelled operator in this study. This issue is specific to the UK model only

The average ratio, derived as a straight average in 2019 across all the most rural geotypes of all nine models, is 121%. Our assumed 900MHz radius is already close to the lower bound of that used in the ACMA model (14km and 22km in the two most rural geotypes). Therefore, we do not believe that that the cell radius should be reduced further, since this will cause the average ratio across all models to increase further beyond 100%.

The equivalent average ratio for total sites, derived as a straight average in 2019 across all nine models, is a similar value at **[✂].**

Based on the charts above, the Netherlands and Spain models overstate the number of sites required both in the most rural geotype and in total across the remaining geotypes. We consider this evidence to exclude these two models from consideration.

5.2 Sensitivity testing

We have undertaken several sensitivity tests on the models, defined as follows:

1. implementing the PPP adjustment
2. increasing the nominal-terms WACC to 5.07% and real-terms WACC to 2.62%: these are alternative WACC values provided by the ACCC
3. reducing the spectrum allocation by 2×5MHz of 1800MHz spectrum (used for 2G and 4G) and 2×10MHz of 2500MHz spectrum
4. reducing the market share to 25%
5. assuming a greater level of network coverage for the operator (closer to that of Telstra)
6. assuming a mix of radio site backhaul more similar to that used in Australia (assumed to be 25% microwave, 25% leased lines and 50% dark/owned fibre backhaul).

The percentage change in 2022 MTAS unit cost is shown below for each sensitivity test and country.

Figure 28: Results of sensitivity tests (using the 2022 unit costs of MTAS, expressed in nominal AUD cents with no PPP adjustment [Source: Analysys Mason, 2020][41]

Country	Unadjusted MTAS cost in 2022	[1] PPP adjustment	[2] WACC	[3] Reduced spectrum allocation	[4] 25% market share	[5] Increased coverage	[6] Adjusted mix of backhaul
East Caribbean	0.13	+57%	+0.2%	–25%	+12%	+19%	–%[42]
France	0.24	+16%	+0.5%	+7%	+16%	+16%	+0.1%
Mexico	0.76	+104%	+0.0%	–[43]	+8%	+4%	+13%
Netherlands	1.01	+14%	+0.1%	+3%	+8%	+11%	–0.6%
Peru	0.62	+77%	+0.2%	–2%[44]	+10%	+11%	+0.1%
Portugal	0.79	+50%	+0.1%	+0.0%	+7%	–0.2%[45]	+1%
Spain	0.68	+35%	+0.2%	+21%	+33%	+8%	+7%
Sweden	0.96	+4%	+0.1%	+10%	+4%	+2%	–0.4%
UK	0.46	+14%	+0.7%	+1%	+16%	–2%[46]	–0.0%

As can be seen above, the models usually respond as expected in response to the changes. For example, marginally increasing the WACC always marginally increases the MTAS unit cost, reducing the market share increases the MTAS unit cost. There are exceptions in relation to the other tests (especially the reduced spectrum allocation), which we describe via footnotes.

5.3 Recommendation

With regards to the PPP adjustment, we recommend including the adjustment.

We recommend that less weight be attributed to the results from the East Caribbean and Mexico models, which according to the cost results in Figure 28 do not respond in the expected way in the

41 In the table, "+0.0%" and "–0.0%" indicates that minimal changes occur in the sensitivity test rather than no change (which are shown as –%).

42 This model calculates backhaul requirements differently to the other models. It does not split the backhaul according to a predefined split, but derives a split of backhaul based on an assumed availability of backhaul options and their underlying unit costs. Changing the assumed availability (based on our assumed split of backhaul options) does not lead to a change in the model results.

43 This value is unchanged since the model assumes that only a maximum of 2×20MHz of spectrum can be used for 4G capacity on base stations. Therefore, since the maximum spectrum allocation is available in both cases, the same network is deployed.

44 This reduction in value is due to the single-RAN network design used in this model. The cost increase in single-RAN baseband cards and sites arising from a reduced spectrum allocation is offset by the decreased requirements in single-RAN base stations.

45 This marginal change in value is due to the compensating effects of a larger network (and therefore network cost) with increased coverage, but a larger common cost arising from the larger coverage network, that then leads to a different set of mark-ups for network common costs on smaller incremental costs.

46 This reduction in value is due despite the network cost increasing with increased coverage. It appears to be due to the economic depreciation of the network costs.

sensitivity test where the spectrum allocations are reduced (the results in the Mexico model do not change at all, whilst the results in the East Caribbean model significantly reduce).

Whilst some of the sensitivity test results in Figure 28 indicate changes that are either smaller than (or in the opposite direction to) what would be expected, based on our inspection these are due to specificities in the network design. However, in these two models, their response to the reduction in spectrum allocation is a more material concern in our view. With the Mexico model, the trend in calculated MTAS rate over time also appears to be in contrast to all the other models.

The results from the Netherlands and Spain models should also be treated with some caution, since they appear to be significantly overstating radio network requirements in both the most rural geotype and in total over all remaining geotypes, as can be seen in Section 5.1.

We consider that whilst all the remaining adjusted model results could merit consideration by the ACCC, the overlap of the clusters shown in Figure 23 and Figure 25 could be considered with the greatest weight, corresponding to the adjusted models from Portugal, Peru and Sweden. This is because all three models, given their common inputs, are each calculating comparable total economic costs for the modelled network and also allocating a similar proportion of cost to voice.

The UK could also be included in this group, on the basis that its total modelled economic cost is comparable to Portugal, Peru and Sweden, with the difference in its unit cost of MTAS being primarily due to its allocation of costs between the modelled services.

Figure 29 sets out different averages for the cost of MTAS (excluding the spectrum costs) using different subsets of the models based on the above considerations. The first is the average from all nine models. The second average excludes the East Caribbean and Mexico models. The third average excludes Netherlands and Spain as well, the fourth average also excludes France, whilst the final average includes only the three models whose total economic costs and MTAS cost per minute are in close proximity in 2022.

Figure 29: Average costs per minute for MTAS across different subsets of the models, in nominal AUD cents and including the PPP adjustment [Source: Analysys Mason, 2020]

Subset for averaging purposes (number of models)	2020	2021	2022	2023	2024
All (9)	0.94	0.88	0.88	0.87	0.87
All except East Caribbean and Mexico (7)	0.97	0.89	0.88	0.86	0.86
Also exclude Netherlands and Spain (5)	0.89	0.84	0.82	0.79	0.79
Portugal, Peru, Sweden and UK (4)	1.01	0.97	0.95	0.93	0.92
Portugal, Peru and Sweden only (3)	1.15	1.11	1.09	1.07	1.06

Annex A Data requested for the benchmarking exercise

In order to modify the input data and parameters in the benchmark models, Analysys Mason required several datapoints, including demand volumes, distribution of traffic by radio technology, mobile network area coverage by technology and base station deployments.

The ACCC requested the information set out below from the MNOs for the years requested in Figure A.1, Figure A.2, Figure A.3 and Figure A.4.

A.1 Demand volumes

Figure A.1 and Figure A.2 outline the traffic/subscriber volumes required to develop the demand forecasts. The volumes required are those carried on each MNO's network (i.e. both retail and wholesale), rather than just the volumes of the MNO's retail subscriber base.

Figure A.1 sets out the high-level total market information we requested for as many years as were available. A long time series of information is most useful since the majority of the benchmark models are multi-year models that consider network deployments in the 2000s, or even earlier.

Figure A.1: High-level demand for the period 2000–2019 [Source: Analysys Mason, 2020]

Data to request	Description
Subscriptions	Year-end total active mobile SIMs, including mobile broadband and machine-to-machine (M2M)
Outgoing voice	Annual mobile-originated minutes
Incoming voice	Annual mobile-terminated minutes
Messages	Annual mobile-originated SMS/MMS
Messages	Annual mobile-terminated SMS/MMS
Data megabytes	Annual mobile data megabytes sent and received

Figure A.2 indicates the more detailed demand volumes that we requested. For this detailed data we sought data for the last five years. To the extent that this data was not provided by the MNOs, Analysys Mason has made its own assumptions when developing forecasts for these more specific services considered within the benchmark models.

Figure A.2: Detailed demand for the period 2015–2019 [Source: Analysys Mason, 2020]

Data to request	Description
Subscriptions	Year-end active mobile broadband SIMs, excluding M2M
Subscriptions	Year-end active M2M SIMs
Outgoing voice	Annual mobile-originated minutes (on-net)
Outgoing voice	Annual mobile-originated minutes (off-net to mobile)
Outgoing voice	Annual mobile-originated minutes (off-net to fixed)

Data to request	Description
Outgoing voice	Annual mobile-originated minutes (off-net to international)
Outgoing voice	Annual mobile-originated minutes (off-net to non-geographic numbers)
Outgoing voice	Annual mobile-originated minutes (other off-net)
Incoming voice	Annual mobile-terminated minutes (from mobile)
Incoming voice	Annual mobile-terminated minutes (from fixed)
Incoming voice	Annual mobile-terminated minutes (from international)
Incoming voice	Annual mobile-terminated minutes (from other)
Outgoing messages	Annual mobile-originated messages (on-net)
Outgoing messages	Annual mobile-originated messages (off-net to mobile)
Outgoing messages	Annual mobile-originated messages (off-net to international)
Outgoing messages	Annual mobile-originated messages (other off-net)
Incoming messages	Annual mobile-terminated messages (off-net from mobile)
Incoming messages	Annual mobile-terminated messages (from international)
Incoming messages	Annual mobile-terminated messages (from other)
Data megabytes	Annual data megabytes sent
Data megabytes	Annual data megabytes received

A.2 Distribution of traffic by radio technology

Analysys Mason also required the information in Figure A.3 on the distribution of traffic by technology for each of the last ten calendar years (2010–2019). This informed how traffic has migrated between technologies over time (and, in particular, at the recent point of 2G shutdown).

Figure A.3: Traffic distribution information for the period 2010–2019 [Source: Analysys Mason, 2020]

Description
Proportion of all voice minutes carried on own 2G radio networks
Proportion of all voice minutes carried on own 3G radio networks
Proportion of all voice minutes carried on own 4G radio networks
Proportion of all data megabytes carried on own 2G radio networks
Proportion of all data megabytes carried on own 3G radio networks
Proportion of all data megabytes carried on own 4G radio networks

A.3 Mobile network area coverage

Analysys Mason requested the information in Figure A.4 on the geographical area coverage of each network technology. The signal strength assumed for the coverage value was also required (dBm).

Figure A.4: Coverage data for the period 2015–2019 [Source: Analysys Mason, 2020]

Description
Geographical land area outdoor voice coverage of 2G networks, in square kilometres, year-end
Geographical land area outdoor voice coverage of 3G networks, in square kilometres, year-end
Geographical land area outdoor voice coverage of 4G networks, in square kilometres, year-end
Geographical land area indoor voice coverage of 2G networks, in square kilometres, year-end
Geographical land area indoor voice coverage of 3G networks, in square kilometres, year-end
Geographical land area indoor voice coverage of 4G networks, in square kilometres, year-end

A.4 Base station deployments

Analysys Mason also required the information in Figure A.5 on site locations. Analysys Mason used this information to calculate the number of sites by geotype for high-level comparisons with the benchmark models. A separate calculation was undertaken of the Australian MNO site counts by geotype for the geotype definition in each model.

Figure A.5: Radio site locations [Source: Analysys Mason, 2020]

Site identifier	Longitude	Latitude	3G is active (Y/N)	4G is active (Y/N)

Annex B Adjustments made to the cost models

In this annex, we describe the changes made to each cost model:

- Annex B.1 sets out the changes made to the East Caribbean model
- Annex B.2 sets out the changes made to the French model
- Annex B.3 sets out the changes made to the Mexican model
- Annex B.4 sets out the changes made to the Dutch model
- Annex B.5 sets out the changes made to the Peruvian model
- Annex B.6 sets out the changes made to the Portuguese model
- Annex B.7 sets out the changes made to the Spanish model
- Annex B.8 sets out the changes made to the Swedish model
- Annex B.9 sets out the changes made to the UK model.

We have provided the ACCC with an Excel file containing time series to be linked into the various published cost models. This includes forecasts of subscribers, traffic, migration profiles and network coverage in the format required for each published cost model. Named ranges in this Excel file to be linked into the published cost model are shown in blue text (e.g. named.range) in the tables below.

B.1 East Caribbean

Figure B.1 below summarises the adjustments that we have made in this model. Only the input cells for Dominica have been adjusted for the Australia case and only the Dominica model is recalculated.

Figure B.1: Indication of adjustments to the East Caribbean model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	1A INP DEMAND worksheet, *input.demand.scenario1.1*	Link in the named range EC.Demand.Inputs
	1H INP Technology DIS worksheet, rows 18–20, 58–60, 68–70, 78–80, 321–323, 326–328, 331–333 and 336–338	Link in the named range EC.Input.Voice.Migration
	1H INP Technology DIS worksheet, cells K28:028, K39:039, K50:050, K89:089 and K342:0342	Set to 100%
	1B INP NW STATISTICS worksheet, cells F24:F26	Set to 90%
Assumed market share	CONTROL worksheet, *selection.demand.percentage*	Set to assumed market share
Geography	'2C INP GEO' worksheet, cells E20:F27	Replaced input data for Dominica with Australian SA2 areas. Allocated SA2 areas to the geotypes defined in the

Adjustment required	Location in model	Description of adjustment(s)
		model based on population density ("URBAN_DENSE" areas have more than 900 people per km^2; "URBAN" areas have more than 750 people per km^2, "SUBURBAN_DENSE" areas have more than 600 people per km^2, "SUBURBAN" areas have more than 375 people per km^2, and all other SA2 regions are "RURAL-NON MOUNTAINOUS"). All other geotypes are not used
	'2C INP GEO' worksheet, rows G20:H27	Set both columns to the count of SA2 areas by geotype
	'2C INP GEO' worksheet, cells I20:I27	Include formulas to calculate the average density rather than being hardcoded
	'2C INP GEO' worksheet, cells D26, K20:K27, P20:P27, Z20, Z26 and T20:T27	Set to 1.1, 1, 100%, 6, 2 and NO respectively
Coverage of the hypothetical operator	'1C INP COVERAGE' worksheet, cells F29:P36, F49:P56 and F69:P76	Link in the named ranges EC.2G.Input.Coverage, EC.3G.Input.Coverage and EC.4G.Input.Coverage
Adjustments to cell radii	'2C INP GEO' worksheet, cells L20:N20	Increased the assumed rural cell radii on the basis that the rural areas in Australia, on average, will have a lower population density than in Dominica. Specifically, set these factors to 162.5%, 144.4% and 173.3% respectively
Spectrum holdings of MNOs	'1D INP SPECTRUM' worksheet, rows 18–24	Set spectrum holdings by band/ technology over time out to 2025, as set out in Figure 6 (use 1900MHz in the model for 2100MHz holdings)
	CONTROL worksheet, D30	Set to 100%
	0F PAR TECHNOLOGIES worksheet, cell E12	Overwrite as 10 (i.e. a carrier size of 2×5MHz)
Remove country-specific spectrum costs	'1E INP UNITARY COSTS' worksheet, cells I240:AG256	Set to zero to deactivate spectrum fees
WACC	CONTROL worksheet *input.wacc*	Set to the nominal-terms, pre-tax WACC for Australia
Extend time series to 2025	3A MAP EXT.SERV 2 INT.SERV worksheet, cells J15:N23	Set to 100%
	0G PAR TIME worksheet, *year.final*	Set to 2025
	2L INP TX TECH AVAIL worksheet, columns J to O	Copied 2020 values into subsequent years
Other adjustments	6D CALC DIM SITES worksheet, cells M340:AC340	Copied formula from cell L340 into subsequent cells
	CONTROL worksheet, cell D11	Set to Dominica

Adjustment required	Location in model	Description of adjustment(s)
Calculate results	CONTROL worksheet	Click RUN button
Technology used for backhaul	'2L INP TX TECH AVAIL' worksheet, cells E15:O30	Set to the assumed proportion of microwave backhaul in the backhaul sensitivity test
	'2L INP TX TECH AVAIL' worksheet, cells E31:O46	Set to the assumed proportion of leased line backhaul in the backhaul sensitivity test
	'2L INP TX TECH AVAIL' worksheet, cells E47:O62	Set to the assumed proportion of optical fibre backhaul in the backhaul sensitivity test

B.2 France

Figure B.2 below summarises the adjustments that we have made in this model.

Figure B.2: Indication of adjustments to the French model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	Op.Generic.metro worksheet, cells H9:BF26	Link in the named range France.Demand.Inputs
	Op.selected worksheet, cells J132:BF149 and J218:BF235	Set to array formula =INDIRECT(op.wksht.selected & "$J$9:$BF$26")*J42:BF42
	Op.selected worksheet, cells H260:BF262 and H264:BF266	Link in the named range France.Voice.Migration.Profile
	Op.selected worksheet, cells H268:BF270	Link in the named range France.Data.Migration.Profile
	Op.selected worksheet, cells J272:BF272 and J273:BF273	Set to 0% and 100% respectively
	Op.selected worksheet, cells J274:BF274 and J275:BF275	Set to 0% and 100% respectively
	Op.selected worksheet, cells E276 and E277	Adjust the proportion of data received and sent to 90% and 10% respectively
	NetworkLoad worksheet, H458 and H464	Adjust the proportion of data to 90% in both cells
	Zone.Metropole worksheet, cells H16:BF16	Input the actual and forecast Australian population from ABS (link in the relevant years from the named range population.by.year)
Assumed market share	Op.Generic.Metro worksheet, cells J30:BF34 and J38:BF42	Set to assumed market share
Geography	Geotypes worksheet, cells F32:G44	Replaced input data for France with Australian SA2 areas. Allocated SA2 areas to the geotypes defined in the model based on population density

Adjustment required	Location in model	Description of adjustment(s)
		("Dense urban" areas have more than 7000 people per km², "Urban" areas have more than 300 people per km², "Suburban" areas have more than 50 people per km², and all other regions are "Rural"). All other geotypes are not utilised
	Op.Generic.metro worksheet, cells H65:I80	Set the traffic split by geotype to be equal to the population split by geotype (set equal to Geotypes!F32:F47)
Coverage of the hypothetical operator	Op.Generic.metro worksheet, cells H88:BF103	Link in the named range France.2G.Input.Coverage. 2G coverage has been held at a constant level until 2019, at which point it has been set to a negligible level in the "Dense Urban" geotype and zero otherwise to avoid errors
	Op.Generic.metro worksheet, cells H111:BF126	Link in the named range France.3G.Input.Coverage
	Op.Generic.metro worksheet, cells H134:BF149	Link in the named range France.4G.Input.Coverage
Adjustments to cell radii	Op.Generic.metro worksheet, cells J245 and J265	Increased the assumed rural cell radii to 15km for 900MHz on the basis that the rural areas in Australia, on average, will have a lower population density than in France
	Op.Generic.metro worksheet, cells H236:M236 and H256:M256	Ensured that the radii for every frequency is dependent on the 900MHz radius in the same ratio as the ACMA model (the six cells in the range should be set to 1.20, 1.10, 1.00, 0.68, 0.60 and 0.55 respectively)
	Op.Generic.metro worksheet, cells H238:I252, K238:M252, H258:I272 and K258:M272	Included formulae to calculate the radius for each geotype and band using the 900MHz radii
Spectrum holdings of MNOs	Op.Generic.metro worksheet, cells H505:BF520, H522:BF537, H539:BF554, H556:BF571, H573:BF588, H590:BF605 and H607:BF622	The spectrum holdings of the hypothetical operator have been set based on Figure 6. Values should be the same for each geotype in a given year
	Op.Generic.metro worksheet, cells H452:BF467 and H469:BF484	Set to 900
	Op.Generic.metro worksheet, cells H486:BF501	Set to 700
	Op.Generic.metro worksheet, cells H280:BF295, H339:BF354, H361:BF376 and H420:BF435	Set to zero

Adjustment required	Location in model	Description of adjustment(s)
	Op.Generic.metro worksheet, cells H299:BF314, H319:BF334, H380:BF395 and H400:BF415	Set to FALSE
Remove country-specific spectrum costs	Op.Generic.metro worksheet, cells H1536:BF1537, H1541:BF1542 and H1546:BF1547	Set to one to deactivate spectrum fees within the model (setting to zero creates errors)
WACC	DF worksheet, cells E8:BC8	Set to the real-terms, pre-tax WACC for Australia
	DF worksheet, cells E9:BC9	Set to =(1+E8:BC8)*(1+E18:BC18)-1
LRAIC+ calculation	Not applicable	A separate workbook undertaking a LRAIC+ calculation for France has been constructed
Technology used for backhaul	Op.Generic.metro worksheet, cells H849:BF864	Set to the assumed proportion of microwave backhaul in the backhaul sensitivity test
	Op.Generic.metro worksheet, cells H868:BF883	Set to the assumed proportion of wireline backhaul in the backhaul sensitivity test
	Op.Generic.metro worksheet, cells H886	Set to zero to ensure owned fibre is used and not leased lines in the backhaul sensitivity test

Inflation data is sourced from https://www.insee.fr/en/statistiques/serie/001761313.

B.3 Mexico

Figure B.3 below summarises the adjustments that we have made in this model.

Throughout the model, we only use the inputs for the Norte (North) region i.e. all of Australia is modelled to occur in one of the two modelled regions.

Figure B.3: Indication of adjustments to the Mexican model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	Demanda worksheet, cells G55:BD74	Link in the named range Mexico.Demand.Inputs This model has an operator-level forecast, so the market share is applied prior to injecting the demand forecast into the model
	Demanda worksheet, cells G7:BD8	Link in the named range Mexico.Input.Subscribers to both (i.e. assume 100% are data subscribers)
	Control worksheet, cells G415:X415	Link in the named range Mexico.Input.3G.Voice.Migration
	Control worksheet, cells G424:X424	Link in the named range Mexico.Input.4G.Voice.Migration

Adjustment required	Location in model	Description of adjustment(s)
	Demanda worksheet, cells G12:BD12	Link in the named range Mexico.Input.4G.Data.Migration
Assumed market share	No adjustment required	All inputs are on an operator basis, meaning operator-level demand is injected into the model
Geography	Geotypes worksheet, rows 2342–7034	Remove rows and formulae, so that table extends only from row 54 to row 2341
	Geotypes worksheet, cells B54:D2341 and E54:F2341	Replaced input data for Mexican municipalities with Australian SA2 areas. Allocated SA2 areas to the geotypes defined in the model based on population density ("Urbano" areas have more than 4500 people per km^2; "Rural" areas have fewer than 500 people per km^2; all areas in between are "Suburbano")
	Network_design_inputs worksheet, cells D377:F377	Set to 100%
Coverage of the hypothetical operator	Control worksheet, cells G122:BD125	Link in the named range Mexico.Input.Coverage. 2G has been held at a constant level until 2019, at which point it has been set to zero
Adjustments to cell radii	Control worksheet, cell G309	Increased the assumed rural cell radii to 19km
	Control worksheet, cells J346:J348	Set equal to G346:G348
	Network_design_inputs worksheet, cells G340:G344	Adjusted 4G radius (estimated as being 700MHz band) Set equal to D340:D344*1.2
	Network_design_inputs worksheet, cells F340:F344	Set 3G radius equal to 2G radius (based on 900MHz band) Set equal to D340:D344
	Control worksheet, cells I346:J348	Set 3G/4G coefficients equal to 2G coefficients (based on 900MHz band) Set equal to G346:G348
Spectrum holdings of MNOs	Control worksheet, cells G187:BD191	Set to 2G 900MHz assumptions, based on Figure 6. Set uniform across geotypes and use paired MHz rather than total MHz
	Control worksheet, cells G194:BD198	Set to 2G 1800MHz assumptions, based on Figure 6. Set uniform across geotypes and use paired MHz rather than total MHz
	Control worksheet, cells G201:BD204	Set to 3G assumptions, based on Figure 6. Set uniform across geotypes and use paired MHz rather than total MHz
	Control worksheet, cells G207:BD210	Set to 4G assumptions, based on Figure 6. Set uniform across geotypes

Adjustment required	Location in model	Description of adjustment(s)
		and use paired MHz rather than total MHz
	Control worksheet, cells G221:G223	Set to 20, 30 and 90 respectively
Remove country-specific spectrum costs	Network_design_inputs worksheet, cells D967:D968, D972:D973, D977:D978 and D981	Set to zero to deactivate spectrum fees within the model
WACC	Control worksheet, *input_wacc*	Set to the real-terms, pre-tax WACC for Australia
Produce a LRAIC output	LRAIC+CapUSD and LRAIC+OpMXN worksheets Costos económicos totals Costo incremental por unidad producida	Move a copy of the plusLRAIC worksheet from the previous published version of the model into the more recent version[47]. Then create two further copies of this worksheet within the more recent version. Rename these two copies to LRAIC+CapUSD and LRAIC+OpMXN respectively. Use Name Manager to delete all instances of named ranges defined to look at the original workbook from where the plusLRAIC worksheet was copied: this will force the worksheet copies to look within the more recent version of the model. For both worksheets, adjust the calculations to reflect 4G networks and services, analogously to how 2G and 3G networks are captured in the worksheet. In particular: • all instances of the service list and accompanying formulae need to be extended from 40 entries to 59 entries • The adjustments to capture mark-ups for 4G-only assets need to be included in the sections "Calculo de márgenes", "Calculo de costos unitarios CITLP" and "Costos unitarios con EPMU" For the LRAIC+CapUSD worksheet, adjust the array formula in the "Costos económicos totals" and "Costo incremental por unidad producida" sections to be Capex_cost_per_unit_output* Network_Element_Output and Capex_cost_per_unit_output*(1-Common_cost_proportions) respectively. Adjust the LRAIC+OpMXN worksheet in an analogous fashion to use Opex_cost_per_unit_output

47 See the Excel file "Modelo Móvil 2017" available at http://www.ift.org.mx/politica-regulatoria/condiciones-tecnicas-minimas-y-modelo-de-costos-utilizado-para-determinar-las-tarifas-de

Adjustment required	Location in model	Description of adjustment(s)
		These worksheets allow the calculation of the capex contribution in USD and the opex contribution in MXN respectively
Technology used for backhaul	Control worksheet, cells I438:K442, I446:K450 and I454:K458	Set to the assumed proportions of backhaul that are microwave/ fibre/ leased line respectively in the backhaul sensitivity test

Inflation and forex data is sourced from https://www.inegi.org.mx/temas/inpc/, https://www.banxico.org.mx/publicaciones-y-prensa/encuestas-sobre-las-expectativas-de-los-especialis/%7BA3A1A5FD-227F-E474-C65B-AE19E9155414%7D.pdf and https://www.banxico.org.mx/publicaciones-y-prensa/encuestas-sobre-las-expectativas-de-los-especialis/%7B3E054A21-B4A4-28E8-5793-A0D2F005AD52%7D.pdf.

B.4 Netherlands

Figure B.4 below summarises the adjustments that we have made in this model.

Figure B.4: Indication of adjustments to the Dutch model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	Market workbook, Market worksheet, cells L559:BM591	Link in the named range Netherlands.Demand.Inputs
	Market workbook, Control worksheet, cells C119:AZ119	Link in the named range NED.Input.Voice.Migration
	Market workbook, Market worksheet, cells L13:BM13	Paste the original population per household values
	Market workbook, Market worksheet, cells L7:BM7	Input the Australian population data (link in the relevant years from the named range population.by.year)
	Market workbook, Market worksheet, cells L10:BM10	Set equal to L7:BM7/L13:BM13
	Mobile workbook, Network_Design_Inputs worksheet, cells D306:F306	Set to one
	Mobile workbook, Coverage worksheet, cells I64:BF66, I69:BE71 and I74:BF76	Set equal to $M$6:$M$8
Assumed market share	Market workbook, Control worksheet, cells C52:C53	Set to 1/assumed market share
Geography	Market workbook, Geotypes worksheet, rows 2309–3988	Delete rows entirely
	Market workbook, Geotypes worksheet, cells B21:D2308	Replaced input data for the Netherlands municipalities with Australian SA2 areas.

Adjustment required	Location in model	Description of adjustment(s)
		Allocated SA2 areas to the geotypes defined in the model based on population density ("Urban" areas have more than 5825 people per km^2; "Rural" areas have fewer than 720 people per km^2; all areas in between are "Suburban")
Coverage of the hypothetical operator	Mobile workbook, Controls worksheet, cells E37:BB40	Link in the named range Netherlands.Input.Coverage 2G has been held at a constant level until 2019, at which point it has been set to zero
Adjustments to cell radii	Mobile workbook, Network_design_inputs worksheet, cell D247	Increased the assumed rural cell radii to 21.5km
	Mobile workbook, Network_design_inputs worksheet, cells F245:F247	Set 3G radius equal to 900MHz radius. Set equal to D245:D247
Mobile radio technologies	Market workbook, Control worksheet, *switch.off.2G*	St to 2019
Spectrum holdings of MNOs	Mobile workbook, Controls worksheet, cells C9:H9	The spectrum holdings of the hypothetical operator for 2G/3G have been set based on Figure 6 (5, 15, 10, 0, 0, 0)
	Mobile workbook, Design_Inputs_4G worksheet, cells P67:BC67, S68:BC68 and P69:BC69	The spectrum holdings of the hypothetical operator for 4G have been set based on Figure 6 (set to 10, 15 and 20 respectively; with zero otherwise in cells F67:BC70)
Remove country-specific spectrum costs	Mobile workbook, Network_design_inputs worksheet, cells C642:C644, F622 and C650	Set to zero to deactivate spectrum fees within the model
WACC	Market workbook, Control worksheet, *mobile_input_wacc*	Set to the real-terms, pre-tax WACC for Australia
Changes to macro	Macros stored in the model workbooks	If the workbook names are not changed, then no edits are needed. If they are changed, then any reference to the old workbook names in the Visual Basic macros need to be updated accordingly
Error fixes	Mobile workbook, Network_design worksheet, cells BG1651:FG1665	The reference table needs to be extended to 200 entries. All the formulas in the table can simply be extended all the way to the 200th entry
	Mobile workbook, Network_design worksheet, cells I1668:BF1680	Since the reference table has just been extended, the reference range also needs to have its scope increased
	Mobile workbook, Network_design_inputs worksheet, cells F332:U333	The table below it needs a column for when it searches for zero. Insert cells to the right of F332:F333. Copy F332:F333 into G332:G333. Set F332 equal to 0 and F333 equal to 1

Adjustment required	Location in model	Description of adjustment(s)
	Mobile workbook, Network_design_inputs worksheet, *channels_2100_HSPA*	Set to one so that the resulting calculation does not have a negative output
	Mobile workbook, Demand_Calcs worksheet, cells X187:BF187 and X201:BF201	Set to 0%
Settings	Mobile workbook, Control worksheet, *coverage_scenario*	Set to outdoor
	Market workbook, Control worksheet, *migration_scenario_selected*	Set to the word "perpetual"
Technology used for backhaul	Mobile workbook, Network_design_inputs worksheet, cells I489:I492, I495:Y498, I501:I504, I517:I520, I523:Y526, I529:I532, I545:I548 and I557:I560, as well as cell H550	Set to the assumed proportions of backhaul that are microwave/fibre/collocation for 2G/3G/4G deployments respectively in the backhaul sensitivity test. Set cell H550 to be 2/3

B.5 Peru

Figure B.5 below summarises the adjustments that we have made in this model.

Figure B.5: Indication of adjustments to the Peruvian model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	Trafico worksheet, cells G10:G46	Link in the named range Peru.Demand.Inputs
	Demand worksheet, cell F23	Set to 100%
	Demand worksheet, cell F24	Linked in the named range Peru.subscribers
	Control worksheet, cells K1089:K1091	Linked in the named range Peru.voice.migration.profile
	Control worksheet, cells K1094:K1096	Linked in the named range Peru.data.migration.profile
Assumed market share	Control worksheet, cells K750:K756, K759:K761, K764 and K766:K767	Set to assumed market share
Geography	Lists worksheet, cells C6:C9 and E6:E9	Replaced input data for Peru with Australian SA2 areas. Allocated SA2 areas to the geotypes defined in the model based on population density ("Muy denso" areas have more than 400 people per km^2, "Denso" areas have more than 30 people per km^2, "Poco denso" areas

Adjustment required	Location in model	Description of adjustment(s)
		have more than 2 people per km^2, and any other areas are "Otro")
	Control worksheet, cells K1100:K1103, K1112:K1115 and K1124:K1127	Set the voice traffic in each geotype to be equal to the percentage of population in each geotype
	Control worksheet, cells K1137:K1141, K1149:K1153 and K1161:K1165	Set the data traffic in each geotype to be equal to the percentage of population in each geotype, with 2% of traffic transferred from "Muy denso" to "Micoceldas"
Coverage of the hypothetical operator	Control worksheet, cells K1044:K1048	Link in the named range Peru.2G.Input.Coverage. 2G has been held at a constant level until 2019, at which point it has been set to a negligible level to avoid errors
	Control worksheet, cells K1056:K1060	Link in the named range Peru.3G.Input.Coverage
	Control worksheet, cells K1068:K1072	Link in the named range Peru.4G.Input.Coverage
Adjustments to cell radii	NWDesignInputs worksheet, cell J29	Increased the assumed rural cell radii to 15km on the basis that the rural areas in Australia, on average, will have a lower population density than in Peru
	NWDesignInputs worksheet, cell R28	Set to 1.2
Spectrum holdings of MNOs	Control worksheet, cells K899, K911, K923 and K938	Set to 10, 0, 0 and 10 respectively We have assumed the element labelled "850" is used for 700MHz, "1900" is used for 1800MHz and have added the holdings in the 2.5GHz band into the 1900MHz band
	Control worksheet, cells K962	Set equal to "=K938-K950"
	Control worksheet, cells K977, K989, K1001 and K1016	Set to 35, 0, 0 and 10 respectively
	Control worksheet, cells K779:K783, K790:K794, K801:K805, K806:K810, K828:K832 and K840:K844	Set to 900, 900, 850, "Spare", "1700/2100 (AWS)" and 1900 respectively
Remove country-specific spectrum costs	Not applicable	There are no spectrum fees in the Peruvian model
WACC	Control worksheet, cell G12	Set to the nominal-terms, pre-tax WACC for Australia
Error fix	Control worksheet, cells K404:K413	Changed the array formula so that it refers to K$20 and not M$20
Multi-year Results	Results worksheet, cells F28:L30 Add a TABLE() function to calculate the cost result per MTAS minute and the total	Set F28 to be 2019/2020. Set F29 to be "=Result.LRAIC.termination .and.origination"

Adjustment required	Location in model	Description of adjustment(s)
	LRAIC+ for 2019/2020 – 2024/2025.	Set F30 to be "=SUM('LRAIC+'!E683:E685)/million" Set cells G28:L28 to be the years "2019/2020" to "2024/2025" Define a TABLE function of the form "{=TABLE(F28,)}"
	Control worksheet, G22	Set to "=Results!F28" Set the named range Peru.year.of.data to be equal to cell Control!G22
Technology used for backhaul	Control worksheet, cells K1196, K1197 and K1198	Set to the assumed proportions of backhaul that are leased line/ microwave/ fibre respectively in the backhaul sensitivity test

B.6 Portugal

Figure B.6 below summarises the adjustments that we have made in this model.

Figure B.6: Indication of adjustments to the Portuguese model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	Operator_Demand worksheet, cells K582:BR609	Link in the named range Portugal.Demand.Input.Final
	Load_inputs worksheet, cells G105, K109:BR109 and V148:W148	Set to zero (to deactivate rebalancing of traffic by network due to coverage fallback)
	SubsCalc worksheet, cells K13:BR15	Link in the named range Portugal.Data.Migration.Profile
Assumed market share	Control worksheet, *market_share_selected*	Set to '33.3% in 2006'
	Control worksheet, cells P125:BR125	Set to assumed market share
Geography	Geotypes worksheet, row 2294 onwards	Delete rows entirely. Rebuild array formulas where required to consider only rows 6–2293 e.g. in cells Z6:AC2293 and AO6:AR2293
	Geotypes worksheet, columns A, B, C, E and K, rows 6–2293	Replaced input data for the Portuguese municipalities with Australian SA2 areas. Allocated SA2 areas to the geotypes defined in the model based on population density ("Dense urban" areas have more than 14 000 people per km^2; "Urban" areas have more than 1100 people per km^2; "Suburban" areas have more than 100 people per km^2; and "Rural" areas are any left). For Portugal, the geotype tag by area has to be hardcoded

Adjustment required	Location in model	Description of adjustment(s)
	Geotypes worksheet, cells F6:G2293	Delete contents
Coverage of the hypothetical operator	NwDes_Inputs worksheet, cells K252:BR252 and K260:BR260	Link to Portugal.2G.Input.Coverage. 2G has been held at a constant level until 2019, at which point it has been set to zero
	NwDes_Inputs worksheet, cells K279:BR279 and K282:BR282	Link to Portugal.3G.Input.Coverage
	NwDes_Inputs worksheet, cells K239:BR239	Link to Portugal.4G.Input.Coverage
	NwDes_Inputs worksheet, cells K269:BR269 and K290:BR290	Set to zero
Adjustments to cell radii	NwDes_Inputs worksheet, cell L158	Increase the assumed cell radii to 19km
	Nw_Des worksheet, cells H809:H812	Refer to Cell_radius_900 rather than Cell_radius_2100
Spectrum holdings of MNOs	NwDes_Inputs worksheet, cells K12:P12	The spectrum holdings of the hypothetical operator have been set based on Figure 6 (10.0, 5.0, 15.0, 0.0, 15.0 and 20.0)
	NwDes_Inputs worksheet, cells S12:X12	Revise all instances of 2012 to 2014
	NwDes_Inputs worksheet, cell K109	Set to 900MHz
	NwDes_Inputs worksheet, cells K110:K113	Set equal to L155:L158
	NwDes_Inputs worksheet, cells K147:K150	Set to 1/1.2, 1/0.68, 1/0.6 and 1/0.55 respectively
	Control worksheet, cell K102	Set to 2017
Remove country-specific spectrum costs	Control worksheet, cells K143:BR145	Set to zero to deactivate spectrum fees within the model
	NwDes_Inputs worksheet, cells K1588:BR1588, K1601:BR1601, K1614:AI1614, K1628:Q1633, K1635:Q1635, K1665:AE1665, S1673, V1673 and X1673	Set to zero to deactivate spectrum fees within the model
WACC	Control worksheet, cell K112	Set to the real-terms, pre-tax WACC for Australia
Error fixes	Nw_Des worksheet, rows 2097–2112	The reference table needs to be extended to sufficient entries for the maximum number of sites. All the formulae can be extended
	Nw_Des worksheet, rows 2115–2128	The table looking at the previous reference table needs to have its index range increased

Adjustment required	Location in model	Description of adjustment(s)
	Nw_Des worksheet, cells AC239:BR243 and AC430:BR434	Set to one
Technology used for backhaul	NwDes_Inputs worksheet, cells K1027:O1027, K1039:O1039, K1051:O1051, K1063:O1063, K1075:O1075, K1121:O1121, K1133:O1133, K1145:O1145, K1157:O1157, K1169:O1169, K1211:O1211, K1220:O1220, K1229:O1229, K1238:O1238, K1247:O1247	Set to the assumed proportions of backhaul that are leased lines/ microwave/ DSL/ fibre/ co-location respectively in the backhaul sensitivity test

Inflation data is sourced from https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&contecto=pi&indOcorrCod=0002386&selTab=tab0 and https://ec.europa.eu/info/business-economy-euro/economic-performance-and-forecasts/economic-performance-country/portugal/economic-forecast-portugal_en. Cells Operator_Demand!W23:AE23 are updated

B.7 Spain

Figure B.7 below summarises the adjustments that we have made in this model.

Figure B.7: Indication of adjustments to the Spanish model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	1A INP DEMAND worksheet, cells C5:AZ204	Link in the named range Spain.Demand.Inputs
Assumed market share	Control worksheet, *selection.demand.percentage* Control worksheet, *selection.spectrum.percentage*	Set to be the assumed share of the total market served by the modelled operator
Geography	‘2C INP GEO’ worksheet, cells E8:T9	Set to zero
	‘2C INP GEO’ worksheet, rows 15–17	Set these unused geotypes to each have 1km² of area, zero population, one population centre and one municipality, plus zero values in columns I-L
	‘2C INP GEO’ worksheet, cells V8:V17	Set to NO
	‘2C INP GEO’ worksheet, cells E10:G14	Replaced input data for Spain with Australian SA2 areas. Allocated SA2 population and areas to the geotypes defined in the model based on population density (“URBAN_DENSE” areas have more than 3000 people per km², “URBAN” areas have more than 500 people per km², “SUBURBAN_DENSE”

Adjustment required	Location in model	Description of adjustment(s)
		areas have more than 200 people per km^2,"SUBURBAN" areas have more than 100 people per km^2, and any other areas are "RURAL-NON MOUNTAINOUS)
	'2C INP GEO' worksheet, cells H10:H14 and I10:I14	Set equal to cells G10:G14 and F10:F14 respectively
	'2C INP GEO' worksheet, cells J10:J14	Set equal to F10:F14/E10:E14
	'2C INP GEO' worksheet, cells K10:K14 and L10:L14	Set both equal to F10:F14/F20
Coverage of the hypothetical operator	'1B INP COVERAGE' worksheet, cells D10:AG15	Link to Spain.Input.Coverage. 2G has been held at a constant level until 2019, at which point it has been set to zero
Adjustments to cell radii	2C INP GEO worksheet, cells: M14:O14	Set to 130%, 130% and 156% respectively
	2A INP NW worksheet, cell D89	Set to 10
Spectrum holdings of full market	'1C INP SPECTRUM' worksheet, cells F10:AI16	The spectrum holdings have been set so that they reconcile to the assumed paired holdings for the hypothetical operator (equivalent to be the holdings in Figure 6 multiplied by six). GSM900 spectrum should be set to 1 after 2018. Any other holdings should be set to zero
Remove country-specific spectrum costs	'1D INP UNITARY COSTS' worksheet, cells H805:V834	Set to zero to deactivate spectrum fees within the model
WACC	CONTROL worksheet, *input.wacc*	Set to the nominal, pre-tax WACC for Australia
Settings	Whole workbook	The entire workbook needs to be fully updated (Ctrl+Alt+F9). This makes it less likely to crash
Calculate results	CONTROL worksheet	Click RUN button
Technology used for backhaul	'2D INP BACKHAUL' worksheet, cells D10:AG39 and D44:AG73	Set to the assumed proportions of backhaul that are optical fibre/ leased lines/ microwave in the backhaul sensitivity test

B.8 Sweden

Figure B. below summarises the adjustments that we have made in this model.

Figure B.8: Indication of adjustments to the Swedish model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	MarketDemand worksheet, cells H157:BF166	Link in the named range Sweden.Demand.Inputs
	MarketDemand worksheet, *Voice.split.by.technology*	Link in the named range Sweden.Voice.Migration.Profile
	MarketDemand worksheet, cells H182:BF183	Link in the first two rows of the named range Sweden.Voice.Migration.Profile
	MarketDemand worksheet, cells H185:BF185 and H186:BF186	Set to 100% and 0% respectively
	MarketDemand worksheet, cells H188:BF193	Link in the named range Sweden.Data.Split.Input
Assumed market share	Inputs_Generic_integrated worksheet, cells H13:H17	Revised to be the assumed share of the total market served by the modelled operator
Geography	AreaToPop worksheet, rows 17 onwards, plus cells G5:G7 and D16:I16	Extend table and all formulae to row 2304. Some formulas need to be checked carefully e.g. in columns Y/Z/AA/AK/AL/AM
	AreaToPop worksheet, cells C17:E2304	Replaced input data for Swedish municipalities with Australian SA2 areas. Allocated SA2 areas to the geotypes defined in the model based on population density ("urban" areas have more than 260 people per km^2; "rural" areas have fewer than 15.8 people per km^2; all areas in between are "suburban").
	AreaToPop worksheet, cells F17:H2304	Set all inland water/lake/sea to zero area
Coverage of the hypothetical operator	Inputs_Generic_integrated worksheet, cells H32:BF35	Link in the named range Sweden.Input.Coverage. 2G has been held at a constant level until 2019, at which point it has been set to zero
Adjustments to cell radii	NetworkDesignInputs worksheet, cell J15	Increased the assumed rural cell radii to 15km
	NetworkDesignInputs worksheet, cell I11[48]	Set to 1.2
Spectrum holdings of MNOs	Inputs_Generic_integrated worksheet, cells H47:BF50, H52:BF55, H57:BF60 and H62:BF65	Set to 900, 900, 2100 and 800 respectively

48 This adjustment factor for 700MHz spectrum can be found in each of cells IN!J307/IN!R307/IN!Z307 of ACMA's mobile network infrastructure forecasting model, as published on its website.

Adjustment required	Location in model	Description of adjustment(s)
	Inputs_Generic_integrated worksheet, cells H69:BF97	The spectrum holdings of the hypothetical operator by band have been set based on Figure 6
Remove country-specific spectrum costs	NetworkDesignInputs worksheet, cell range *weighted.MHz.for.licensing.fee*	Set to zero to deactivate spectrum fees within the model
WACC	Ctrl worksheet, cell *input.wacc*	Set to the real-terms, pre-tax WACC derived by the ACCC
Change selected operator	Control worksheet, *op.selected*	Set value to Generic_integrated
Formula revisions	RF worksheet, cells R42	Set to =MAX(NwDesLoad!S503:S506)
	RF worksheet, cells U42	Set to =MAX(NwDesLoad!S833:S836)
Technology used for backhaul	Inputs_Generic_integrated worksheet, cells H117:H120	Set to the assumed proportions of backhaul that are leased lines in the backhaul sensitivity test. The values should be uniform across all geotypes

Inflation data is sourced from http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START__PR__PR0101__PR0101A/KPI12MNy and https://ec.europa.eu/info/business-economy-euro/economic-performance-and-forecasts/economic-performance-country/sweden/economic-forecast-sweden_en.

B.9 UK

Figure B.9 below summarises the adjustments that we have made in this model.

Figure B.9: Indication of adjustments to the UK model [Source: Analysys Mason, 2020]

Adjustment required	Location in model	Description of adjustment(s)
Forecasts of total market demand	Traffic workbook, TrafficForecast worksheet, cells F162:GW184	Link in the named range UK.Demand.Inputs.Final This model requires a quarter-by-quarter forecast. In order to avoid errors, a negligible volume of minutes, messages and data is assumed to stay on the 2G network. Since this model uses a quarterly time series, quarterly traffic = calendar year traffic ÷ 4
	Traffic workbook, Inputs worksheet, cells E45:GV47	Overwrite as zero
	Traffic workbook, Subscribers worksheet, cells D59:GU61	Set equal to UK.Demand.Subscribers * UK.Input.Voice.Migration.Profile
	Traffic workbook, Inputs worksheet, cells E379:GV379	Overwrite as zero

Adjustment required	Location in model	Description of adjustment(s)
	Traffic workbook, TrafficForecast worksheet, cells F1874:GW2173, F2177:GW2476 and F4030:GW4329	Overwrite as zero (to deactivate rebalancing of traffic by network due to coverage fallback)
Assumed market share	Traffic workbook, Inputs worksheet, cells E129:P129	Set to zero
	Traffic workbook, Inputs worksheet, cells Q129:GV129	Set to assumed market share
	Traffic workbook, Subscribers worksheet, cells D141:O141	Set to zero
	Traffic workbook, Subscribers worksheet, cells P141:GU141	Set to assumed market share
Geography	Traffic workbook, Geotypes worksheet, cells C4:D10	Replaced input data for UK with Australian SA2 areas. Allocated SA2 areas to the geotypes defined in the model based on population density ("Urban" areas have more than 7959 people per km^2, "Suburban 1" areas have more than 3119 people per km^2, "Suburban 2" areas have more than 782 people per km^2,"Rural 1" areas have more than 112 people per km^2, "Rural 2" areas have more than 47 people per km^2, "Rural 3" areas have more than 25 people per km^2, and any other areas are "Rural 4")
	Traffic workbook, Geotypes worksheet, cells H4:H10	Set equal to D4:D10
	Traffic workbook, Geotypes worksheet, cells H10:H12	Set cells H11:H12 to 0.05% and subtract 0.1% from cell H10
	Traffic workbook, Geotypes worksheet, cells C11:C12	Set to zero
	Network workbook, Params-4G worksheet, cells J62:BG63, J65:BG66 and J68:BG69	Set to zero
	Scenario Control workbook, Parameters worksheet, cells AI6:AL6	Set to zero
Coverage of the hypothetical operator	Scenario Control workbook, Parameters worksheet, cells G53:G58, G59 and G60:G62	Set to 100%, 32% and 0% respectively
	Traffic workbook, Inputs worksheet, cells E134:GV143	Link in the named range UK.4G.Input.Coverage
	Traffic workbook, Inputs worksheet, cells E150:GV159	Link in the named range UK.2G.Input.Coverage
	Traffic workbook, Inputs worksheet, cells E166:GV175	Link in the named range UK.3G.Input.Coverage

Adjustment required	Location in model	Description of adjustment(s)
	Network workbook, Params – 4G worksheet, cells H191:H192	Set to 800 and 1800
Adjustments to cell radii	Network workbook, Params – 2G worksheet, cell F61	Set to 10.2km
	Scenario Control workbook, Parameters worksheet, cells C109:D117	Set equal to 'Params - 2G'!G55:G63 from Network workbook
	Network workbook, Params – 2G worksheet, cell G67	Set equal to 1/0.68
	Network workbook, Params – 4G worksheet, cell J145	Set to 1.2/0.68
	Traffic workbook, Inputs worksheet, cells CR207:DD207	Copy formula from cell CQ207 and paste into cells CR207:DD207
Spectrum holdings of MNOs	Network workbook, Scenarios worksheet, cells D74:D76	The 4G spectrum holdings of the hypothetical operator have been set based on Figure 6 i.e. 10, 15 and 20 respectively (700MHz allocations is included in the 800MHz slot)
	Network workbook, Spectrum-3G worksheet, cell D37	Set to one
	Network workbook, Params-4G worksheet, cells AF139:AJ139	Set to zero
	Network workbook, Params-2G worksheet, cells G106:BD107	Set equal to assumed total 2G spectrum allocations (25 until 2002/03, 20 until 2015/16, 5 from 2016/17 onwards to prevent errors)
	Scenario Control workbook, Parameters worksheet, cells C153:C162	Set to 2003/04 respectively
	Scenario Control workbook, Parameters worksheet, cells D153:D162	Set to 2018/19 respectively
	Scenario Control workbook, Scenarios worksheet, cells G117:BA117	Set to TRUE
	Scenario Control workbook, Scenarios worksheet, cells G83:BA83	Set to three
Remove country-specific spectrum costs	Network workbook, Scenarios worksheet, cells G12:H14, G16:H16 and D20	Set to one
	Cost workbook, 'Unit expenses' worksheet, cells H4958:BE4958	Set to zero
	Scenario Control workbook, Scenarios worksheet, cells G31:BA31	Set to TRUE

Adjustment required	Location in model	Description of adjustment(s)
WACC	Scenario Control workbook, Scenarios worksheet, cells G22:BA22	Set to the real-terms, pre-tax WACC derived by the ACCC
Infrastructure sharing	Scenario Control workbook, Scenarios worksheet, G64:BA64	Switched off infrastructure sharing (set to FALSE)
	Network workbook, 'InputRevisions' worksheet, cells Y72/Y76/Y80:BF80/AJ88	Set to 100%
LRAIC+ calculation	Scenario Control workbook, Scenarios worksheet, cell D13	Set to "LRIC Plus"
Changes to macro	Macros stored in the model workbooks	If the workbook names are not changed, then no edits are needed. If they are changed, then any reference to the old workbook names in the Visual Basic macros need to be updated accordingly
Calculation of LRAIC+	Scenario Control workbook	Run sensitivities
Technology used for backhaul	Network workbook, 'Params – other' worksheet, *Params.Shared.High.Speed.BH. Using.Owned.MW*	Set to the assumed proportions of backhaul that use microwave in the backhaul sensitivity test

Inflation data is sourced from https://obr.uk/download/historical-official-forecasts-database.

Annex C Responses to the consultation on the draft methodology

The ACCC launched a consultation on the proposed approach for the MTAS benchmark in December 2019.[49]

Responses to the proposed approach were received from three industry parties (Optus, Telstra and VHA). In this annex, we respond to the issues raised by these stakeholders rand describe any changes made to the approach, which have been reflected in the final approach set out in Section 3.

C.1 Benchmark peer group

Comment (page 2, Telstra)

> We believe the majority of countries selected for benchmarking are appropriate. However, we are concerned with the inclusion of the East Caribbean due to the vastly different geographic nature of these islands compared to Australia and because it is an aggregate of multiple countries. It may be that the adjustments will compensate for these differences. However, should it, or any of the countries included, be an outlier from the majority of the results of the benchmarking process, we believe they should be excluded from the benchmark set of countries.

Comment (pages 18 and 19, Optus)

> However, there remain some deviations from the modelled output and the final regulated MTR value in the benchmark countries. For example, where a final model has not been published, it is difficult to align the modelled output with the regulatory determination – the Dutch modelled output based on pure BULRIC shows the weighted outcome for 2017-20 to be 0.00599 EUR per minute, while the final decision shows the 2017-20 MTR rate has been set at 0.581 EUR cents per minute. The French and UK models have also been similarly acknowledged to be Draft Models, while the ECTEL model clearly does not replicate the final modelled output referred to in the final regulatory decision, given that each of the member countries captured each have different input parameters (which are not all publicly available) applied in the determination of their regulated rates.
>
> Even where a cost model can be configured for 4G/LTE, these fields may not have been applied in the determination of the model outputs (e.g. none of the five member states in the ECTEL mobile model have been configured to utilise 4G technologies, i.e. the LTE network coverage is set to zero in all cases)
>
> Irrespective, there remains no robust discussion on the suitability of the selected benchmark countries as a comparator for the Australian market.

49 https://www.accc.gov.au/regulated-infrastructure/communications/mobile-services/mobile-terminating-access-service-access-determination-inquiry-2019/position-and-consultation-paper

Comment (page 11, VHA)

The benchmark pool is small, consisting of only nine countries. We recognise there are a limited set of available countries to benchmark and this has driven the decision to use a small dataset. To that end, the methodology reflects an "opportunity sample" and, while we do not have any specific objections to the models chosen, the ACCC should be cognisant that opportunity sampling could lead to biased estimates of the cost of the MTAS.

Response by Analysys Mason

We have considered what results to include/exclude when deriving the cost range from the benchmarks in Section 5. For the avoidance of doubt, we have only used one of the island slots in the East Caribbean model.

To correct an observation above, the East Caribbean model does in fact consider 4G technologies. The redacted inputs are also not very significant: they are only call durations and overhead mark-ups. Although other inputs are redacted, they have been overwritten by our adjustments.

The concerns regarding the final versions of several models above are unfounded. We have read the accompanying documentation of the French model from April 2017 (in French) and were able to ascertain that the version we have identified for use is the final model released with the draft pricing decision, rather than a draft version. Moreover, the Dutch[50] and UK[51] models are definitely final versions.

We do not agree with the comment on the small size of the benchmark pool. This benchmark is not considering a range of results from other countries, but rather using a set of calculation engines using common inputs for multiple key aspects including geography/coverage, demand, spectrum and cost of capital. We would consider that nine calculation engines offers a sufficient number of benchmark results for the ACCC to consider.

50 The Dutch model available at https://www.acm.nl/nl/publicaties/publicatie/17159/Annex-B2-Final-BULRIC-Models-bij-notificatiebesluit is the final version. The reason for the slight difference is that the published model indicates a final result in cell [Service_costing.xlsx]Results_mobile!R114= EUR0.00599 for the period April 2017–March 2020 (with cells [Service_costing.xlsx]Results_mobile!S111:V111 set to 2/3, 1, 1 and 1/3). The final pricing decision is for the period July 2017–June 2020. By changing cells [Service_costing.xlsx]Results_mobile!S111:V111 set to ½, 1, 1 and ½ in the published model, the final result cell states EUR0.00581, as indicated as the final MTR in the final pricing decision document (https://www.acm.nl/sites/default/files/old_publication/publicaties/17143_notificatie-ontwerpbesluit-marktanalyse-voor-vaste-en-mobiele-gespreksafgifte.pdf, page 5).

51 The 2018 MCT model available at http://static.ofcom.org.uk/static/models/2018%20MCT%20model.zip accompanies the final statement and is the final model.

C.2 Levels of market demand

Comment (pages 21, Optus)

> It is unclear how this is to be reconciled, particularly given the confidential nature of the underlying data, as well as the treatment in cost models which only rely on a single year input.

Comment (page 18, VHA)

> We recognise that the level of market demand is a significant driver of the mobile network costs. There is insufficient information in Analysys Mason's Methodology Report for the ACCC to determine how it will forecast the level of market demand to 2060. Greater transparency is required on the forecasting methods to determine if they are consistent with MNOs demand expectations over the medium term (or have been produced in a reasonable manner in the event they are not consistent with expectations).

Response by Analysys Mason

Regarding the first comment, the Peruvian model is the only member of the peer group that calculates on a single-year basis. We have run the model for each year in the period 2020–2024 with appropriate inputs for each year.

demand forecasts have been developed based on the (limited) data we have been provided by operators in response to the data request and have been documented in Section 4 of this report.

The outputs of the demand forecasting are time series of national demand by service. We believe these national totals can be shared with operators, with the confidential underlying operator data redacted.

C.3 Assumed market share

Comment (pages 21, Optus)

> There are significant regional variances in market share. It is unclear how this is to be reconciled given the diference (sic) in spectrum holdings and network coverage given the disparate differences in regional market share

Response by Analysys Mason

We do not think this is a significant issue in the context of a hypothetical operator, particularly since the key result of each model is a national-average cost of mobile termination, rather than a regional cost of mobile termination.

C.4 Geography

Comment (pages 21, Optus)

It is unclear how this is to be reconciled, despite the acknowledgement that this approach will cause an increase in the number sites modelled to take into account the Australian land mass.

Comment (page 13, VHA)

It is not clear that scaling the benchmark models for Australia's area and implementing the benchmark models' geotypes using our population density data will provide a reasonable proxy for the differences in costs associated with geography for all aspects of the network. The geotypes used in some of the benchmark models are different from Australia. For instance, the Swedish and Dutch models have three geotypes – Urban, Suburban and Rural and does not consider differences in spectrum allocations across geography. The different density threshold used in the Swedish and Dutch are noteworthy for the magnitude of the difference in the thresholds used. These differences may impact the credibility of the classifications produced from these models when scaled to reflect Australia's population and area.

Traffic demand in dense urban areas and urban areas should include people travelling to work. Often cost models the allocate traffic to geotypes on the basis of the population of each geotype but adjustments should be made to account for the flow of commuters. For instance, the ACMA's network infrastructure model made an adjustment to the SA2 population data to reflect the increased number of users in the suburban, urban and dense urban geotypes due to commuters. These impacts can be significant – for instance, the uplift from commuting to dense urban areas in the ACMA model was 154% of the demand based solely on population estimates. Analysys Mason did not make a corresponding reduction in the number of suburban and rural users since it assumed that commuters used "mobile services in their commuting destination during the day and in their home location in the evenings, so the busy hours in different geotypes may well occur at different times".23 It is unclear whether and how models with fewer geotypes accurately capture the impacts of commuting on network dimensioning and costs.

At this stage, we are unclear on the proposed assumption for the size of the network for the hypothetical operator. Analysys Mason has indicated that it will determine the size during implementation. Given the differences in the geographic area of existing MNOs' networks, interested stakeholders should be consulted on this design choice prior to its adoption and implementation

Response by Analysys Mason

Since we model a level of area coverage comparable to Optus (as described in Section 3.5), we have compared the modelled sites to the actual site deployments of Optus and VHA (whereas Telstra's site counts correspond to a much higher level of area coverage). This comparison is outlined in Section 5.1. The modelled sites are in the range of Optus'/VHA's deployments for most of the benchmark models. The Netherlands and Spain models are the only two cases where the modelled sites could be considered excessive in both the most rural geotype (which would be expected to be coverage-driven) and the remaining geotypes (which would be expected to be at least somewhat traffic-driven).

The VHA text refers to values being "scaled" to reflect Australia's population and area. We are not using scaling: the Australian population and area are actually being injected into each models calculation engine.

In the ACMA model (cells CTRL!B520:H547), there are inputs setting out how commuters affect the distribution of traffic by geotype. These inputs are specific to the geotypes defined in ACMA's model and cannot be replicated in all the other cost models. However, if during the consultation on the draft benchmark, operators can provide information on how the distribution of traffic is skewed away from the distribution of population due to commuting, then we can consider if there may be a way to capture this.

C.5 Cell coverage radii

Comment (pages 21, Optus)

> AM proposal = to adjust the cell radii used for mobile coverage in the most rural geotype in each model to address overestimation in the number of coverage sites due to Australia having coverage in far more sparse areas than the benchmark models.
>
> Cell radii is acknowledged as being calibrated to the coverage that exists within that country, however the inclusion of an adjustment is only being considered for the most rural geotype in each model.

Response by Analysys Mason

We consider that the cell radii from the original models should still be sufficiently representative in the geotypes other than the most rural geotype.

The most rural geotype is different (and a special case) since it catches all remaining areas and will likely have a far lower average population density in Australia than in the original model (and therefore is likely to require a far larger cell radius). This most rural geotype will also almost certainly be coverage-driven rather than traffic-driven, meaning that the cell radius is the single most important input to the site calculation in that geotype.

In contrast, more urban geotypes may be traffic driven rather than coverage driven, meaning that numerous other inputs (such as those related to site traffic capacity) affect the site requirements in those geotypes.

C.6 Mobile radio technologies in use

Comment (pages 22, Optus)

> technologies in use

• AM proposal = all benchmark models will consider a mixed deployment of 2G, 3G and 4G technologies. Given Australia has shutdown 2G since 2019, adjustment will be made that any modelled 2G network will be assumed to be switched off from 2019 onwards. Forecast for proportion of traffic on 3G and 4G networks for future years to be based on historical information received

The assumption being applied are two-fold, first to accommodate 2G switch off and second to forecast future traffic distribution, and risks entrenching potential model errors. Given the arbitiriary shutdown of 2G allocations, the natural assumption would be that all 2G voice traffic will need to move to 3G voice in the first instance.

Response by Analysys Mason

It is not clear what is being objected to. For the avoidance of doubt, there will be no 2G traffic (voice, messages or data) assumed from 2019 onwards, except for a negligible volume to preserve calculation integrity if required.

C.7 Spectrum holdings

Comment (pages 20 and 22, Optus)

It is not clear why smaller spectrum holdings for a modelled operator would be considered, given that total spectrum bandwidth in most bands are the same on a nationwide basis, and that almost all other input factors are based on total market assumptions. The assumed spectrum holding will also have flow though implications on the contribution of spectrum costs.

It remains unclear how the benchmark models are able to accommodate many of the Australian specific adjustments. For example, it is unclear how a number of the models will be able to reflect the use of different frequencies by different operators, and in different geographic areas. Comments set out in AM's worked example also suggest that the same Australian assumptions will be applied consistently across all benchmark models, but it is difficult to envisage how this would be applied.

Comment (pages 16 and 17, VHA)

The proposed simplification to assume nationwide licences does not reflect the acute differences in spectrum holdings between metropolitan areas and, regional and remote parts of Australia. Lack of spectrum is a major cost driver for some MNOs in regional and remote areas as it means more sites are required to meet capacity requirements. Hence it is important to reflect the nuances of Australia's geographically-based spectrum licensing regime in the benchmarking exercise as it will materially affect the cost estimates derived from the models.

The ACCC has suggested that its hypothetical operator will obtain 33.3% market share. Given this premise, it is not reasonable to assume a disproportionate allocation of spectrum for the hypothetical operator in any given spectrum band nor do we consider it reasonable to assume a reallocation of spectrum. That is, at least three operators should have access to the spectrum holdings assumed for the hypothetical operator.

spectrum use is dynamic in nature as bands are re-farmed from use by one technology to use by newer technologies. These challenges will increase with respect to spectrum identified for 4G use. This will likely have a material impact on 4G spectrum availability as we expect it to decrease in line with users switching to 5G. However, we are unclear whether this is material to Analysys Mason's proposed consideration of spectrum holdings and how Analysys Mason intends to treat past 're-farming' of spectrum for use by newer technologies

Response by Analysys Mason

A smaller spectrum holding should be a conservative assumption, since it should trigger additional site deployments in the models (any savings in spectrum costs are counterbalanced by increases in network costs). The spectrum holding assumed is also less than one-third of the available spectrum in each band.

The issue remains that most of the models in the benchmark cannot handle geographical differences in spectrum, so we must proceed with national licences. The assumed spectrum holdings will have been sensitivity tested, as described in Section 5.2.

C.8 Spectrum costs

Comment (page 2, Telstra)

The proposed use of the 2012 Government Directive on renewal fees is significantly below the value of recent auctions. Telstra considers it is more appropriate to use actual auction results. Specifically, we believe the auction results from the regional 1800MHz auction, which concluded in February 2016, and the Multiband 'residual lots' auction, which concluded in December 2017, should inform the spectrum allocation costs used in the modelling.

Comment (pages 22, Optus)

As noted the assumed spectrum holding will have implications for the cost allocation approach. The total spectrum costs should be considered for each band, including all one-off spectrum costs and recurring apparatus licence fees. Depending on the relevant time series, this is currently not all captured in the table set out Figure 2.4 in the AM report.

Response by Analysys Mason

Regarding the 1800MHz and 2.1GHz spectrum auctions in 2016/2017, we recognise that a proportion of the country's population is covered by these licences. The ACCC has calculated that 22.4% of the population was covered by the 1800Hz licences and 3.3% of the population was covered by the 2.1GHz licences (in each case, licence renewals are excluded).

We have then calculated the cost per paired MHz per capita for both bands from the auction fees[52] and then derived a weighted-average cost per paired MHz per capita separately for the two bands using the renewal fees from the 2012 Government Directive.

For example, for the 1800MHz band, we calculate a cost per paired MHz per capita from the auction fees of AUD2.00. The cost per paired MHz per capita used in our spectrum cost calculation for this band is then derived as *(22.4%×2.00)+(77.6%×0.23) = AUD0.625*.

We understand that the recurring fees mentioned here are those for the 900MHz spectrum. The ACCC has provided information on these fees and these are included in the spectrum cost calculation.

C.9 Currency

Comment (page 2, Telstra)

Telstra notes that the intent is to use a combination of market exchange rates and purchasing power parity (PPP) rates when converting models to Australian dollars. If the group of countries selected are broadly comparable to Australia, then we would not expect material differences in the outcome of the benchmarking due to the use of PPP or exchange rates. If any countries have materially different PPP and exchange rates, then we recommend that Analysys Mason analyse the cause of the difference, and then an appropriate decision can be made as to whether to include that country in the benchmarking or not. However, if the choice between PPPs and exchange rates does materially affect the benchmark outcomes, then that could be a reason to not change current MTAS pricing.

Comment (pages 14-16, VHA)

There are four areas where Analysys Mason should consider specific adjustments to reflect Australia's unique circumstances: Transmission costs; Site deployment costs; Network costs associated with natural disasters; and National security arrangements.

The transmission cost assumption used in the benchmark models is unlikely to reflect the true cost of transmission incurred by MNOs in Australia. The cost of delivering transmission to mobile sites varies significantly across the country, with the distance between the site and the nearest aggregation point is often the key cost driver. The mix of transmission solutions is also likely to be different for the reasons set out in the section on Geography and cell coverage radii and this will impact transmission cost estimates as it will require further adjustments to the data used in the benchmarking models

Our analysis of a selection of models suggest that PPP adjustments may not adequately reflect the difference in costs associated with differences in site deployment costs. For instance, the unit cost of site acquisition and preparation in the Swedish and UK models are far below the cost incurred in Australia for deploying a site. Given the scale of the discrepancy and the materiality of site costs to the TSLRIC+ cost estimate, it is not appropriate to rely on a generalised PPP-adjustment for site acquisition and preparation costs – a specific adjustment is required.

52 These values are adjusted where required to reflect a 15-year licence duration.

Mobile telecommunications infrastructure is vulnerable to many types of natural disasters including bushfires, floods and cyclones. The recent Australian bushfire crisis has highlighted the community's need and desire for continuous mobile telecommunications before, during and after natural disasters. Australian telecommunications companies implement numerous measures to improve the resilience of their telecommunications infrastructure and incur costs to ensure the recovery of services in areas impacted by natural disasters.24 The ACCC and Analysys Mason must determine if Australian telecommunications companies have a different approach to hardening mobile infrastructure against natural disasters and developing network redundancy options compared to countries in the benchmark pool. The findings would mean a higher cost profile compared to telecommunications companies in other countries.

Australia has a fundamentally different approach to its national security arrangements compared with the countries in the benchmark set. Most notably, the Australian Government's Telecommunications Sector Security Reforms (TSSR) introduced and clarified security obligations requiring carriers to protect their networks and facilitate against threats to national security from unauthorised access or interference. Some vendors that are likely to operate in countries from the benchmark pool are not permitted to be involved in the deployment of networks in Australia. Some aspects of these rules are solely targeted at the access layer of 5G networks and other parts restrict the use of certain vendors in the core network regardless of the underlying technology.

Response by Analysys Mason

As described in Section 5, we have considered PPP when looking at the benchmark results.

Regarding the modelling of transmission costs, we have considered an adjustment to derive a common split of backhaul links that are fibre/microwave/leased lines to reflect the mix observed in Australia as a sensitivity test in Section 5.3. This adjustment is not currently captured in the basecase results, but could be revisited once the MNOs have been able to provide information on their split of backhaul links.

Regarding site deployment costs, if operators can provide an indication of the average capex per site for their networks (specifically, across *all* sites, not just limited to recent/new deployments), and this is found to be both consistently higher and materially higher than in the cost models, then an uplift of the assumed site costs could be considered in the models.

Regarding the increased network costs due to natural disasters, operators should provide evidence demonstrating the cost uplift effect that this additional resilience brings to the network (or the amount they spend on suitable insurance). This evidence can then be considered in the finalisation of the benchmark.

Regarding the increased costs of national security arrangements, operators should provide evidence of the upward impact this has on their network costs, such as how much more expensive previous network investments would have been if the now unavailable vendors had not participated. This evidence can then be considered in the finalisation of the benchmark.

Annex D Numerical results of the models

The cost per minute for MTAS from each of the models, in nominal AUD and excluding the PPP adjustment, is presented below in Figure D.1.

Figure D.1: Cost per minute for MTAS from each of the models, in nominal AUD cents and excluding the PPP adjustment [Source: Analysys Mason, 2020]

Country	2020	2021	2022	2023	2024
East Caribbean	0.13	0.13	0.13	0.13	0.12
France	0.33	0.26	0.24	0.23	0.22
Mexico	0.72	0.74	0.76	0.77	0.78
Netherlands	1.04	1.02	1.01	0.99	0.98
Peru	0.69	0.64	0.62	0.59	0.58
Portugal	0.80	0.79	0.79	0.78	0.78
Spain	0.85	0.66	0.68	0.70	0.70
Sweden	1.00	0.97	0.96	0.95	0.94
UK	0.51	0.48	0.46	0.45	0.44

The cost per minute for MTAS from each of the models, in nominal AUD and including the PPP adjustment, is presented below in Figure D.2.

Figure D.2: Cost per minute for MTAS from each of the models, in nominal AUD cents and including the PPP adjustment [Source: Analysys Mason, 2020]

Country	2020	2021	2022	2023	2024
East Caribbean	0.21	0.21	0.20	0.20	0.19
France	0.39	0.30	0.28	0.26	0.26
Mexico	1.47	1.51	1.55	1.58	1.60
Netherlands	1.19	1.17	1.15	1.14	1.13
Peru	1.22	1.13	1.09	1.04	1.03
Portugal	1.20	1.19	1.19	1.18	1.17
Spain	1.16	0.89	0.92	0.94	0.95
Sweden	1.04	1.01	0.99	0.98	0.98
UK	0.58	0.55	0.53	0.51	0.51

The total modelled economic cost by year, in nominal AUD and excluding the PPP adjustment, is presented below in Figure D.3.

Figure D.3: Total economic cost from each of the models, in nominal AUD billion and excluding the PPP adjustment [Source: Analysys Mason, 2020]

Country	2020	2021	2022	2023	2024
East Caribbean	1.60	2.07	2.69	2.72	3.28
France	0.54	0.56	0.62	0.69	0.76
Mexico	1.44	1.67	1.92	2.27	2.62
Netherlands	2.35	2.99	3.68	4.62	5.48
Peru	1.12	1.21	1.39	1.54	1.81
Portugal	1.21	1.50	1.84	2.30	2.70
Spain	3.43	4.09	5.33	6.95	8.52
Sweden	1.14	1.31	1.49	1.75	2.00
UK	1.24	1.55	2.06	2.60	3.22

The total modelled economic cost by year, in nominal AUD and including the PPP adjustment, is presented below in Figure D.4.

Figure D.4: Total economic cost from each of the models, in nominal AUD billion and including the PPP adjustment [Source: Analysys Mason, 2020]

Country	2020	2021	2022	2023	2024
East Caribbean	2.44	3.16	4.09	4.15	4.99
France	0.59	0.60	0.65	0.72	0.78
Mexico	2.98	3.47	4.01	4.75	5.49
Netherlands	2.36	2.93	3.54	4.38	5.15
Peru	1.81	1.91	2.15	2.33	2.70
Portugal	1.74	2.11	2.56	3.15	3.68
Spain	4.00	4.68	6.05	7.84	9.58
Sweden	1.16	1.29	1.44	1.66	1.86
UK	1.27	1.56	2.03	2.54	3.12