PUBLIC VERSION

analysys mason

Final Report for Optus

Network cost analysis of the Telstra–TPG agreement – Model overview

Ian Streule, Audrey Bellis, Tom Upton, Vlad Kozynchenko

24 October 2022 CONFIDENTIAL (Optus information)

Ref: 8879808839-441

Contents

Analysys Mason Limited
St Giles Court
24 Castle Street
Cambridge
CB3 0AJ
UK

Tel: +44 (0)1223 460600
cambridge@analysysmason.com
www.analysysmason.com

Registered in England and Wales No. 5177472

1 Introduction

On 21 February 2022, Telstra and TPG announced a ten-year multi-operator core network (MOCN) commercial agreement involving regional and "urban fringe" areas in Australia. This agreement is expected to provide significant scale and cost benefits for Telstra and TPG within the Regional Coverage Zone (RCZ), covering between 81.4% and 98.8% of the population.

In the context of this agreement, Optus has commissioned Analysys Mason to build a simple network cost model to quantify the effects of the MOCN on all parties.

Telstra already benefits from economies of scale due to its high share of traffic within the RCZ. With the MOCN arrangement Telstra is expected to benefit from additional economies of scale due to the wholesale traffic from TPG. Telstra will also benefit from access to TPG's spectrum, which will further reduce network costs and allow Telstra to achieve capital and operating expenditure savings. These benefits are not replicable by Optus due to its lower traffic share in the RCZ and higher network costs (including mandatory swap-out costs of Huawei equipment).

Analysys Mason has built a network cost model to illustrate the effects and highlight the scale of the impact of the MOCN NaaS agreement between Telstra and TPG. Analysys Mason has modelled expenditure per GB in the RCZ for operators under different scenarios to highlight the impact of the MOCN NaaS agreement on market competitiveness in the RCZ. The model quantifies capital and operating expenditure requirements for maintaining, operating and expanding the network to support current and future traffic. We do not include depreciation ('spreading') of capital expenditure nor a return on capital employed or profit margin. In this document and the model we refer to the sum of expenditures as the 'cost', although it is recognised that this does not include all cost components in an economic sense.

This document presents a summary of inputs, parameters, results and a user guide to supplement the model. In addition, Analysys Mason has provided a report "Network cost analysis of the Telstra–TPG agreement – Results analysis" [REF: 798083498-424] on the interpretation of the results, which is included with the submission to the ACCC.

The remainder of this document is laid out as follows:

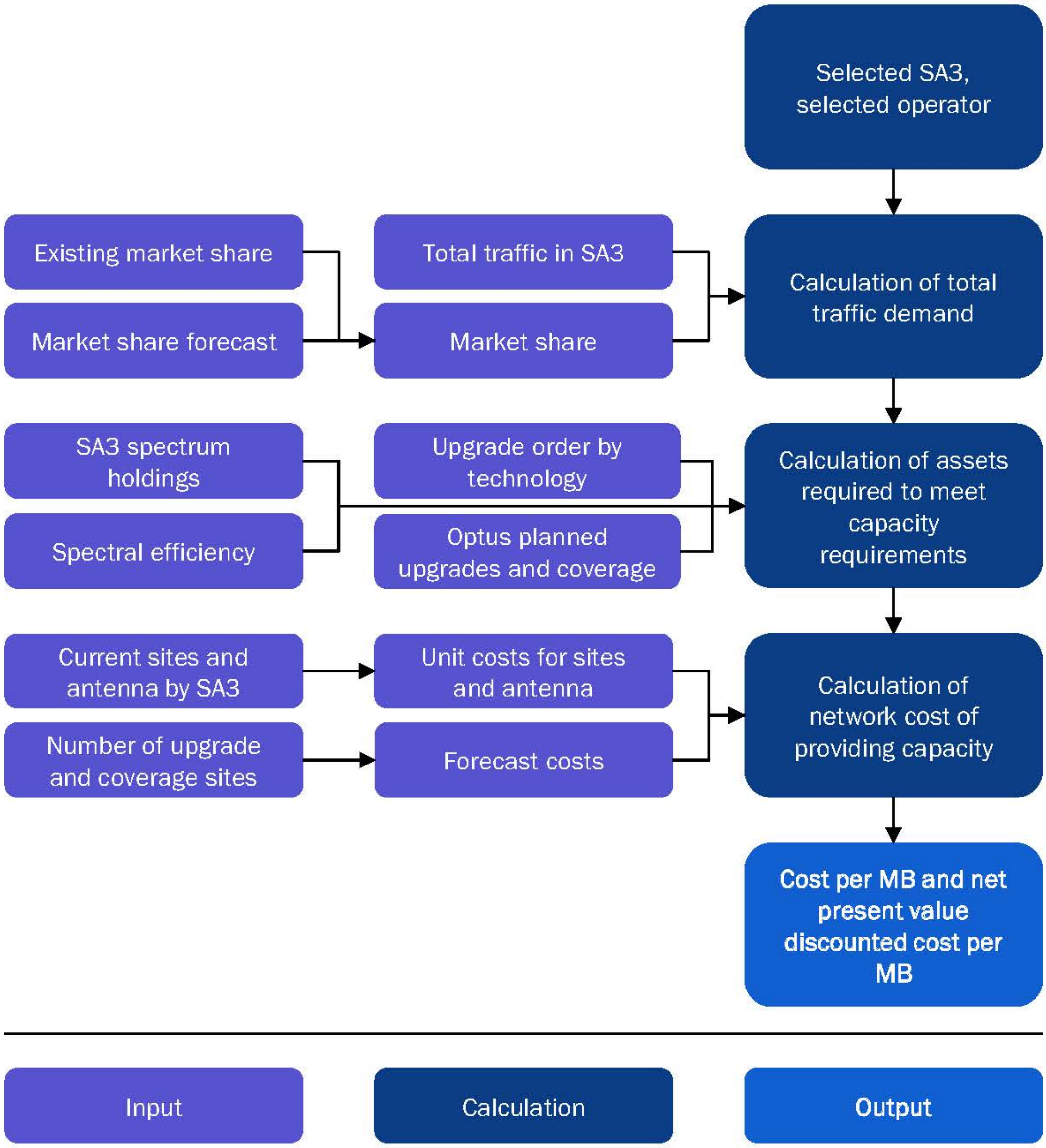
- Section 2 provides an overview of the model
- Section 3 describes key inputs to the model
- Section 4 provides an overview of the parameters used
- Section 5 describes the results of the model
- Section 6 provides a model user guide.

2 Model overview

In order to estimate the cost per GB of different operators in the RCZ, Analysys Mason has produced a model that uses data traffic forecasts and current spectrum holdings to calculate the number of sites and assets that each operator will require in each SA3 geographical area. The model is designed to accommodate six operators: Optus, Telstra, TPG, the Telstra-TPG MOCN, an alternative Optus-TPG MOCN and a spare.

An overview of the model is provided in Figure 1.

Figure 1: Overview of model [Source: Analysys Mason, 2022]



3 Key inputs

The *inputs* used in the model are real data points and these should only be changed if more accurate or alternative data is available.

The main model inputs are grouped into four categories:

- SA3 definition inputs
- site and spectrum inputs for each operator
- traffic inputs
- cost (expenditure) inputs.

The four types of inputs are summarised in the subsections below.

The model is set up to run for each of Australia's Statistical Area Level 3 (SA3) areas, which split the country into 358 spatial areas with no gaps or overlaps. The inputs of the model have therefore been collected at the SA3 level. 103 of the 358 SA3s are in scope for the MOCN NaaS agreement between Telstra and TPG.

3.1 SA3 definition inputs

SA3 definition inputs are used to define each SA3 region, its properties and characteristics. These inputs include population, regional status / geotype, and whether an SA3 falls into the MOCN arrangement area. Figure 2 below provides a summary of SA3 definition inputs, along with the sources used.

Figure 2: Summary of SA3 definition inputs [Source: Analysys Mason, 2022]

Inputs	Description	Source
Population	Population in each SA3 region has been obtained from the Australian Bureau of Statistics (ABS) for 2021	ABS (06.21)
Regional status/ geotype	Regional status has been assigned by Optus based on the proportion of population covered, which was mapped onto a geotype: • 0–67% => urban • 67–81.4% => suburban • 81.4–98.8% => rural	Optus
MOCN area	Of the 338[1] SA3s included in the model, 103 are within the scope of the MOCN NaaS agreement, as highlighted in the input sheet	Optus

1 18 SA3s are defined as non-spatial and include people with no fixed address and people working abroad; a further 2 SA3s (Norfolk Island and the Cocos (Keeling) Islands) were excluded due to lack of input data

3.2 Site and spectrum inputs

The Australian Competition and Consumer Commission (ACCC) publishes detailed information regarding the operations of mobile network operators as part of a commitment to use its Record Keeping Rules (RKRs) to provide more transparency and accountability in the market.

Most recently, in September 2022, ACCC published a 2022 Mobile Infrastructure Report[2] that contains details of operators' sites, the geolocation of those sites and spectrum deployed on a site-by-site basis; this information has been used to inform the model.

The spectrum holding of each operator by region is provided by Australian Communications and Media Authority (ACMA). ACMA uses the Hierarchical Cell Identification Scheme (HCIS), which is a naming system that splits the geographical areas of Australia into a Spectrum Map Grid.[3]

Figure 3 below provides insight on how the information obtained from ACCC and ACMA has been used to inform the model.

Figure 3: Summary of site and spectrum inputs [Source: Analysys Mason, 2022]

Inputs	Description	Source
Number of sites	Using site co-ordinates published in ACCC's Mobile Infrastructure Report, Analysys Mason has used the Alteryx geo-analysis tool to map site co-ordinates to SA3s, aggregating details of site locations at the SA3 level	ACCC (12.21)
Number of sites with each technology	As per above, the geospatial data provided by ACCC has been used to quantify the spectrum bands used at sites at the SA3 level	ACCC (12.21)
Spectrum by band	Using HCIS geospatial data, the Spectrum Map Grid co-ordinates have been mapped onto SA3 areas, and the total number of MHz available to operators in each band in each SA3 region has been aggregated to form an input to the model	ACMA (10.22)

3.3 Traffic inputs

Optus has provided a snapshot of its traffic, on a site-by-site basis, for an average week in the months of August 2021, February 2022 and August 2022. Using the rural (81.4–98.8% population coverage) market share as a proxy, Analysys Mason has estimated Telstra's and TPG's traffic.

2 https://www.accc.gov.au/regulated-infrastructure/telecommunications-and-internet/mobile-services-regulation/mobile-infrastructure-report/mobile-infrastructure-report-2022

3 https://web.acma.gov.au/rrl/spectrum_search.show_table?pSV_ID=85&pSS_ID=850

3.4 Cost inputs

Cost (expenditure) inputs have been informed primarily by Optus's Regional Planning Business Case SA3.[4] The primary drivers of capital expenditure (capex) are Huawei swap-out upgrades and greenfield sites. Upgrade refers to the replacement of active equipment on a site, driven by the requirement to swap out Huawei equipment to [redacted] equipment. A greenfield site refers to the deployment of a new site driven by coverage requirements. Operating expenditure (opex) is driven by the total number of sites in the network.

Unit cost elements used as inputs in the model were provided by Optus for the 2023 financial year. The model focuses on the radio access network (RAN) cost elements and hence items not directly related to the RAN have not been taken into account. The following subsections summarise unit costs inputs in the model, categorised as capex and opex.

3.4.1 Capex

Service costs and TXM costs

Service costs are associated with passive equipment (e.g. shelters, towers, generators) and planning costs, whilst TXM are software-related costs that are incurred during a site upgrade or site deployment. Summary of service and TXM costs can be found in Figure 4.

Figure 4: Summary of unit service and TXM costs [Source: Optus, 2022]

Item	Upgrade	Greenfield
Service cost[5]	[redacted]	[redacted]
TXM costs	[redacted]	[redacted]

Greenfield unit service costs have varying inputs depending on whether a site is a ground-based tower (GBT) or a rooftop tower (RTT). Difference between GBT and RTT greenfield service costs is driven by planning and permission costs. RTT deployment predominantly occurs in urban areas requiring more resources for approval of construction, whereas GBTs are principally deployed in rural areas with less planning restrictions. As the Telstra–TPG MOCN arrangement will only target rural areas, a blended value of greenfield site service costs has been applied to reflect the predominance of GBT sites. The weightings used to derive the blended value are model parameters and so can be adjusted to meet users' requirements (see Section 4.4 for more details on the cost parameters).

4 [redacted]

5 Based on the current agreements with service providers; the service cost for an upgrade is higher than for a greenfield site due to ATN (Optus's towerco) incurring the majority of deployment capex for a greenfield site

When upgrading a site, service costs are uniform for all tower types. Costs associated with the Huawei swap-out are significantly higher than those for greenfield sites. It is expected that Optus will renegotiate its contracts, and so the model assumes a more-conservative upgrade service cost, which equates to the blended cost of greenfield sites. The upgrade service cost is also a model parameter which can be varied by the user.

Active equipment costs

Both upgrade and greenfield sites have identical active equipment costs. However, these costs do vary depending on the site architecture and vendor [redacted] as can be seen from. Figure 5.

Figure 5: Summary of active equipment costs [Source: Analysys Mason, 2022]

Site architecture	Equipment only	Software cost (5 years)	Equipment and software
[redacted]			

Figure 6 shows frequency layers allocation depending on site architecture.

Figure 6: Site architecture in frequency layers [Source: Analysys Mason, 2022]

Frequency layer	Low	Medium	High	Ultra
700/900MHz	Yes	Yes	Yes	Yes
1800/21000MHz	–	Yes	Yes	Yes
2600MHz	–	–	Yes	Yes
3500MHz	–	–	–	Yes

► *Upgrade hierarchy*

ACCC's Mobile Infrastructure Report 2022 provides details of the different technologies used by operators that can be noted from Figure 7. An upgrade hierarchy has been assumed to account for varying starting points in terms of active equipment available at sites. The frequency bands and the cellular technologies have formed the basis for the upgrade hierarchy.

Figure 7: Upgrade hierarchy by technology and frequency band[6] [Source: Analysys Mason, 2022]

Frequency band	5G	4G	3G	IoT
700MHz	NR	LTE	–	NB-IoT; IoT
850MHz	NR	LTE	W-CDMA	–
900MHz	NR	LTE	UMTS	NB-IoT
1800MHz	–	LTE	–	–
2100MHz	NR	LTE	UMTS; W-CDMA	–
2300MHz	NR	LTE	–	–
2600MHz	NR	LTE	–	–
3500MHz	NR	–	–	–
3600MHz	NR	–	–	–

The upgrade hierarchy follows frequency layering for active equipment, with sub-1GHz spectrum deployed first to ensure adequate coverage, followed by mid-band spectrum and finally the 3.5GHz band to address capacity requirements. The upgrade hierarchy also takes into account the cellular technology on a site with upgrades starting at 5G followed by 4G, 3G and IoT cellular technologies.

3.4.2 Opex

Unlike capex, opex is treated uniformly across all sites, including sites that have been upgraded and greenfield sites. Opex includes rent, electricity, preventative maintenance, etc. Opex inputs are summarised in Figure 8 below.

Figure 8: Summary of unit opex cost elements [Source: Optus, 2022]

Item	Unit opex cost elements for upgrade and greenfield
Opex	
Rent	[redacted]
Electricity	[redacted]
Preventative maintenance	[redacted]
ACMA fee	[redacted]

3.4.3 Summary of unit costs

Figure 9 below provides a summary of the unit capex and opex costs described in Section 3.4.

Figure 9: Summary of unit cost elements in FY2023 [Source: Optus, 2022]

Item	Upgrade	Greenfield
Capex		
Active equipment cost	[redacted]	

6 New Radio (NR); Long-Term Evolution (LTE); Universal Mobile Telecommunications System (UMTS); Wideband Code Division Multiple Access (W-CDMA); Narrowband Internet of Things (NB-IoT)

Item	Upgrade	Greenfield
	[redacted]	
Service cost	[redacted]	[redacted]
TXM cost	[redacted]	[redacted]
Opex		
Total opex	[redacted]	

In addition to unit costs, Optus's Regional Planning Business Case SA3 also provides planning information on the number of upgrade and greenfield sites from 2023–27, as well as proposed vendors for different SA3 regions, which has enabled Analysys Mason to model the total capex and opex associated with upgrades and greenfield sites.

Optus's regional planning is taken into account in the model before supplementary capacity-driven sites are added (if required).

4 Key parameters

Key *parameters* to the model can be changed to permit the analysis of model results under different conditions. The parameters are set out below, grouped into four categories: model-specific and general; site and spectrum; traffic; and cost parameters.

4.1 Model-specific and general parameters

The model-specific and general parameters outlined in Figure 10 below represent inputs that are either very specific to the model such as SA3 areas that the model should run for, or general parameters such as inflation.

Figure 10: Summary of model-specific and general parameters [Source: Analysys Mason, 2022]

Parameter	Description
Iteration number	Each iteration represents one SA3, with the total number of available iterations being 338
Iteration number operator	Allows the user to select which operator the model will be run for
Number of years modelled	Allows the users to select the number of years the model will run for
Market share change period	This parameter includes an option to change the market share of operators in the market following the introduction of a MOCN NaaS agreement, on the assumption that an operator will lose market share to the MOCN entity
Inflation	Allows the user to select a percentage value, which will be applied uniformly to all relevant costs throughout the modelled period

4.2 Site and spectrum parameters

Certain site and spectrum inputs have been included as easily changeable parameters, to enable users to select different inputs as more information becomes available.

Site parameters

Site parameters include the shutdown of 3G and 4G technology, site and equipment lifetime, as shown in Figure 11.

Figure 11: Summary of site parameters [Source: Analysys Mason, 2022]

Parameter	Description
3G/4G shutdown	Allows the user to select the year in which 3G and 4G networks will be switched off
Site lifetime	Gives the user an option to change the lifetime of passive equipment on a site (e.g. the tower)

Parameter	Description
Site lifetime on/off switch	Allows the site lifetime parameter to be turned on or off, in case the user wishes to run the model without this parameter
Equipment lifetime	Allows the user to select the number of years that active equipment is anticipated to last before requiring replacement

Spectrum parameters

Spectrum parameters include the ability to specify when new spectrum will become available, the type of 5G technology used by an operator (i.e. with or without mMIMO[7]), spectral efficiencies to reflect the evolution of cellular technology, and a MIMO multiplier, as summarised in Figure 12 below.

Figure 12: Summary of spectrum parameters [Source: Analysys Mason, 2022]

Parameter	Description
New spectrum available	Allows the user to select the year in which new spectrum will become available in the next auction
5G technology	Allows the user to specify whether the operator has mMIMO (which drives spectral efficiencies in the model)
MIMO multiplier	Due to increase spectral efficiency we assume that 5G technology in the 3.5GHz band will be four times more efficient when using MIMO technology over standard antennas

► *Spectral efficiency*

In addition to the input parameters described above, the model also considers spectral efficiency, by means of the three inputs summarised in Figure 13.

Figure 13: Summary of spectral efficiency parameters [Source: Analysys Mason, 2022]

Parameter	Description
Sector non-homogeneity factor	This parameter is assumed to be [redacted] throughout the modelled period, yet the user is able to change the value
Maximum utilisation of carriers	This parameter is assumed to be [redacted] throughout the modelled period; the value that can be changed by the user
Sectors per site	This represents the number of carriers facing in different directions on a site. The default value for this parameter is three, representing the industry standard, although the value can be changed by the user

7 mMIMO stands for massive multiple-input and multiple-output which is a method of multiplying the capacity of a radio link

4.3 Traffic parameters

The model includes traffic parameters which enable the capacity of each operator's network to be adjusted depending on user requirements and knowledge about traffic distribution between operators.

Figure 14: Summary of key traffic parameters [Source: Analysys Mason, 2022]

Parameter	Description
Traffic distribution	Traffic distribution is driven by a high-level assumption that an operator's market share in the rural area (81.4–98.8% population coverage) drives a comparable share of traffic. However, if the user has better information regarding traffic distribution between operators this parameter can be flexed to represent a more accurate view of traffic distribution between operators.
Traffic multiplier	This multiplier allows the user to take into account any differences in traffic usage per subscriber between different operators. The traffic multiplier is currently set to 1, due to a lack of information regarding differences in traffic usage per subscriber between different operators

The model allows traffic growth to be changed on a yearly basis and for different traffic growth profiles to be tested. The default base-, low- and high-case values are shown in Figure 15.

Figure 15: Traffic growth sensitivities used in the model [Source: Analysys Mason, 2022]

Sensitivity	2023	2024	2025	2026	2027	2028	2029+
Base case	30%	30%	30%	30%	30%	30%	30%
Low	13%	13%	13%	13%	13%	13%	13%
High	40%	40%	40%	40%	40%	40%	40%

4.4 Cost parameters

Greenfield cost

As outlined in Section 3.4.1, the model assumes that the majority of sites deployed in RCZs are GBTs (rather than RTTs). The relative proportions of GBTs and RTTs are model parameters, which by default are set at 90% for GBTs and 10% for RTTs, giving a blended service cost of [redacted]

Huawei swap-out upgrade costs

Huawei swap-out service costs have been made into a parameter. The model contains a switch which enables the user to model upgrade costs as a share of greenfield unit costs or as the initial Huawei swap-out costs provided by Optus. These parameters then drive the inputs on unit costs per site. In the base case, the Huawei service swap-out costs are assumed to be 100% of the greenfield site costs.

Spectrum rental fee

Due to the unavailability of data on spectrum lease costs that Telstra will be expected to pay TPG, spectrum auction data (including date of the auction, frequency bands auctioned, spectrum won, areas covered, licence duration and price paid) was obtained from ACCC's website.

This data from ACCC's website was then used to estimate the price paid per MHz per head of population. Due to variations in licence duration the figures were normalised to provide a comparable view of price paid per MHz per head of population.[8] The figures were then inflated using the inflation rates in Australia over representative time periods to estimate the value of the spectrum in 2022 terms by band.

By multiplying the value of 1MHz per head of population in each band by 17% of the Australian population (share of population in RCZ out of Australia's total) and the total frequency blocks TPG will lease to Telstra split by frequency bands enabled us to produce a rough estimate of the spectrum lease cost for the MOCN arrangement.

By normalising the licence duration to ten years (the initial timeframe of the Telstra-TPG MOCN arrangement) we have estimated the cost of the spectrum lease to the MOCN to be around [redacted] per year. This figure was made into a parameter that can be changed by the user.

MOCN cost

It has been assumed that if the MOCN arrangement goes ahead, the venture will incur additional software costs associated with activating TPG's spectrum on Telstra's sites. Since the current spectrum holdings of TPG and Telstra are similar we have assumed that existing Telstra sites will not incur an equipment cost for upgrading to other frequency bands; instead, the MOCN cost will only consist of software costs associated with additional spectrum provided by TPG, which we have estimated at [redacted] per 10MHz.

8 To make the results comparable for regional licences, the results were derived using regional populations

5 Results

5.1 Base-case scenario – factual and counterfactual

In the base case, it is assumed that Optus has a market share of ~25%, whilst Telstra and TPG have ~70% and ~4% respectively in the RCZ. These market shares are assumed to remain stable over the time period modelled, with operators only using their current spectrum holdings.

For the MOCN entity, the market shares and spectrum holdings of Telstra and TPG are added together, and 170 TPG sites are added to Telstra's network. TPG's spectrum holdings in this scenario include 700MHz, 850MHz, 2100MHz and 3.5GHz bands.

For this scenario the model assumes that no coverage sites are added for Telstra and TPG during the modelled period; additional sites are only built to address capacity requirements. For Optus, the number of coverage and upgrade sites is taken from the Regional Planning Business Case SA3 provided by Optus, which includes [redacted] upgrades and [redacted] coverage sites by 2027. Additional sites are deployed to meet Optus's capacity requirements.

Traffic is assumed to grow at a year-on-year rate of 30% for all operators until 2030.

Figure 16 summarises the net present value (NPV) of the cost that each operator is forecast to incur for every GB of data that it carries. Whilst Figure 17 displays how these costs change over the time frame.

Operator	AUD cent/GB
Optus	[redacted]
Telstra	[redacted]
MOCN	[redacted]

Figure 16: Base-case NPV results, 2023–30 [Source: Analysys Mason, 2022]

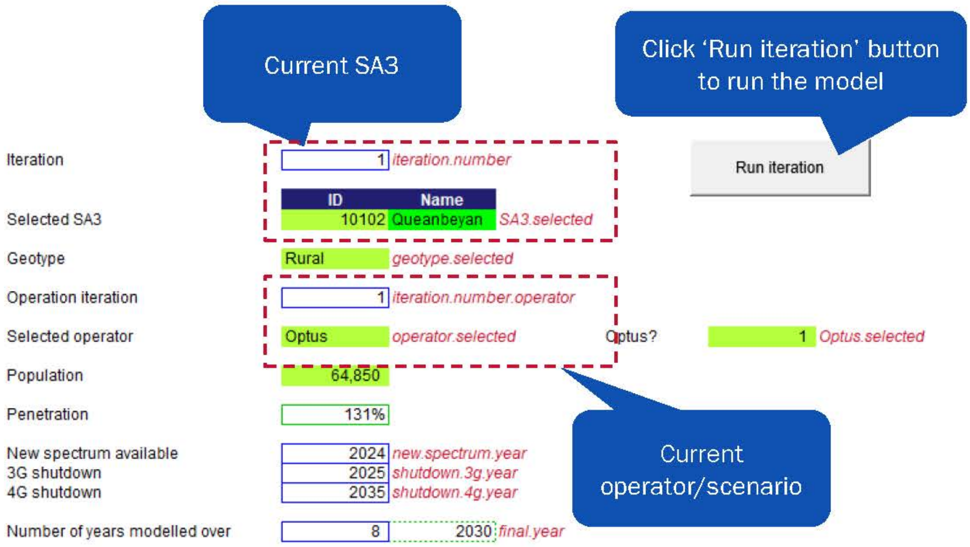
[redacted]

6 Model user guide

6.1 The Control worksheet

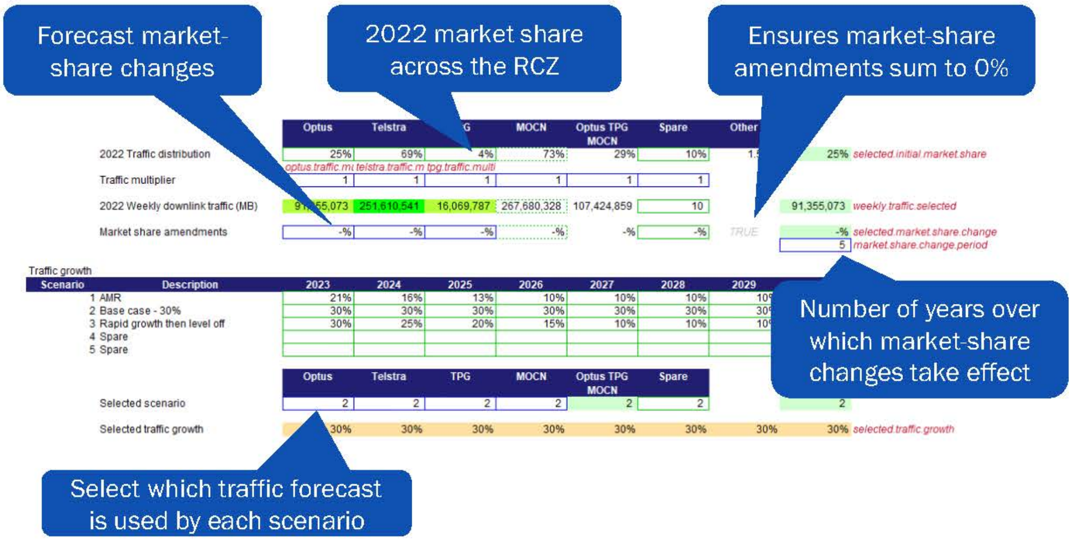
Figure 18 shows a screenshot from the top of the Control sheet. This sheet allows the user to assess the current status of the model. From here it is possible to change which SA3 area and which operator/scenario are being modelled, by changing the cells named iteration.number and iteration.number.operator respectively. When the 'Run iteration' button is pressed, both iteration numbers will be initially set to 1 and for each operator the model is run before moving on to the next SA3.

Figure 18: Control worksheet, showing current status of model [Source: Analysys Mason, 2022]



The other main inputs that can be changed in the Control worksheet relate to market share and traffic growth (see Figure 19). The model enables market shares to be changed by a specified number of percentage points linearly over a prescribed number of years. This allows the user to investigate the effects on the cost of the MOCN if RCZ market shares change.

Figure 19: Market share and traffic growth [Source: Analysys Mason, 2022]



Opex and capex costs can be varied for all inputs and are set out as shown in Figure 20.

[redacted]

6.2 Outputs

The outputs from the model over the selected period of years are presented on the Outputs worksheet. The sheet also provides, for each SA3 and scenario, the full costs and cost per MB over the selected time period.

An RCZ-wide output can be found at the top of the worksheet, as shown in Figure 21.

[redacted]

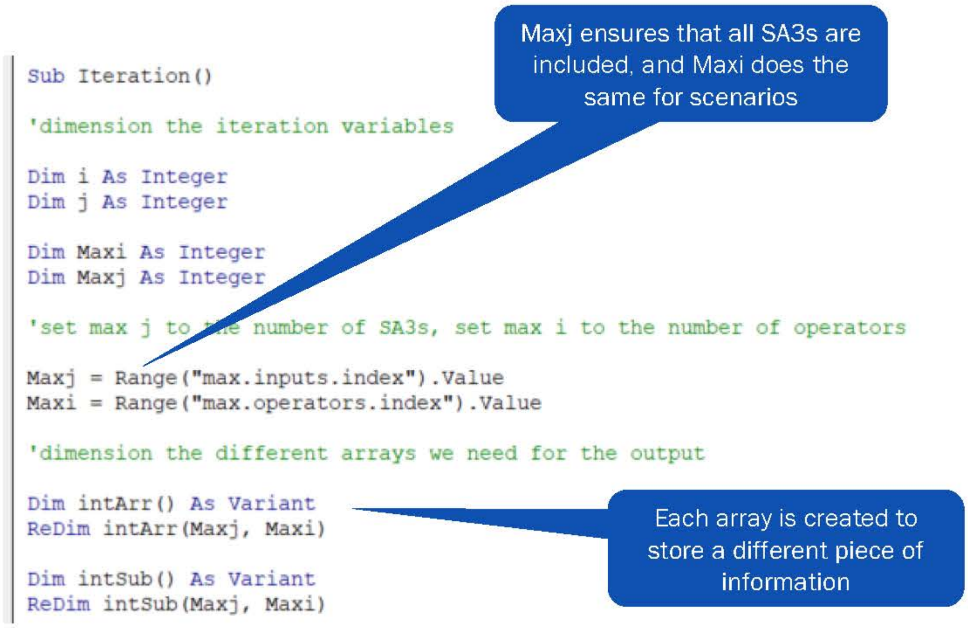
In addition to the Outputs sheet there is also a Fulloutput list worksheet which provides annual figures for total cost and data usage per SA3 and operator.

6.3 Iteration macro

The macro that is used to run the model is a two-level iteration macro. The first level iterates through the SA3 areas by changing the value in the iteration.number cell on the control worksheet. The second level then iterates through the scenarios using the iteration.number.operator cell. This means that the model is run six times for each SA3, before moving on to the next SA3.

The first thing the macro does is to find the number of iterations required by inputting the number of SA3s and the number of scenarios. It then sets up a variety of arrays in which to store the results. This initialising step can be seen in Figure 22.

Figure 22: Initialising the iteration macro [Source: Analysys Mason, 2022]



Once the arrays are set up, the iteration phase of the model can be run. For each unique SA3–scenario combination the Excel worksheets are calculated in order to produce the outputs and then the macro stores the values of these outputs in the arrays. This can be seen in Figure 23.

Figure 23: The iteration stage [Source: Analysys Mason, 2022]

For each SA3 the model is run six times

```
'iterate

For j = 1 To Maxj

    Range("iteration.number").Value = j


    For i = 1 To Maxi

        Range("Iteration.Number.Operator").Value = i

        Worksheets("Control").Calculate           'recalculate the required sheets just to ensure it does the new calculation
        Worksheets("L").Calculate
        Worksheets("Model").Calculate

        intArr(j - 1, i - 1) = Range("output.generated").Value      'record the values calculated
        intSub(j - 1, i - 1) = Range("output.cost.sub").Value
        intCost(j - 1, i - 1) = Range("total.cost").Value
        intMB(j - 1, i - 1) = Range("total.data").Value
        intTotSubs(j - 1, i - 1) = Range("total.subs").Value
        intNPV(j - 1, i - 1) = Range("output.npv").Value
        intsites(j - 1, i - 1) = Range("output.sites.delta").Value
```

VBA starts counting from 0 whilst the SA3 and operator indexes start at 1. Hence the -1s

Finally, as shown in Figure 24, the results are pasted into the output worksheets.

Figure 24: The results are presented in the output sheets [Source: Analysys Mason, 2022]

```
    Next i

Next j

Range("outputs.test.output").Value = intArr                  'output all our arrays
Range("output.array.sub").Value = intSub
Range("output.array.cost").Value = intCost
Range("output.array.mb").Value = intMB
Range("output.array.total.subs").Value = intTotSubs
Range("output.array.NPV").Value = intNPV
Range("annual.output.array").Value = intAnnual
Range("output.array.site.delta").Value = intsites

Range("iteration.number").Value = 1                          'set these back to one
Range("Iteration.Number.Operator").Value = 1

End Sub
```

The macro arrays are pasted back into the output worksheets