Model documentation for the Australian Competition and Consumer Commission

Fixed LRIC model user guide – Version 2.0

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1 Introduction

This document is to be used in conjunction with the LRIC model in order to gain a full understanding of the calculations that take place.

1.1 LRIC model workbooks

The LRIC model is a series of workbooks and databases containing multiple interlinks. The structure is summarised below in Figure 1.1:

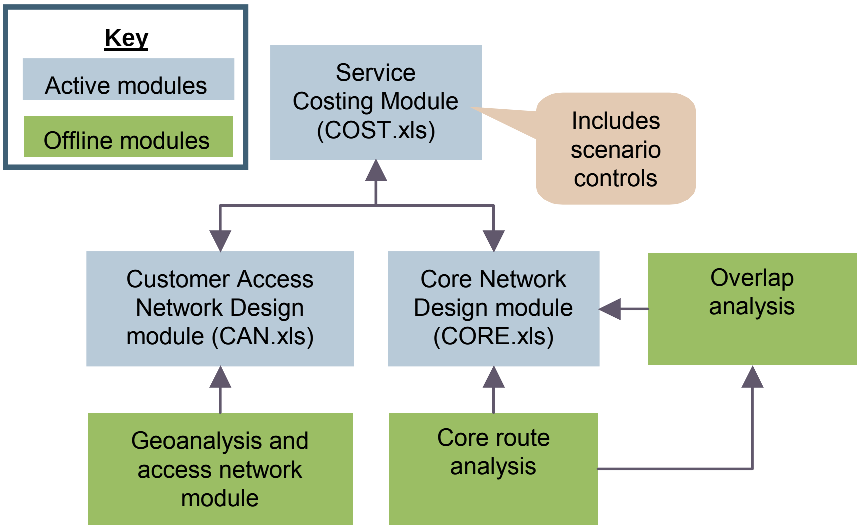


Figure 1.1: Structure of the model [Source: Analysys]

As shown above, the LRIC model splits into two parts: offline modules and active modules.

The active modules comprise two network design modules which calculate the number of assets for the customer access network (CAN) and the core network respectively. The serving costing (Cost) module ties the active modules together, performing several key functions. Specifically, it:

- defines the calculation scenarios
- presents demand drivers, over time, to the network design modules
- costs the dimensioned network
- calculates unit costs of services
- passes costs of network elements between the access and traffic increments.

The offline modules, which perform analysis of issues believed to be relatively stable, comprise the following:

- Core route analysis – defining the routes between core nodes from the local exchanges (LE), and points of confluence (PoCs) to the local access switch (LAS), and calculating the total and incremental distances

- Overlap analysis – an analysis of actual routes based on road distances to inform the core module
- Geoanalysis and access network module – estimating the access network.

A demand module, discussed in previous versions of the LRIC model, has been removed. Demand forecasts are now controlled in the cost module ('Inputs.Demand' worksheet).

The active modules and Geoanalysis and access network module, as well as their system requirements, are described below. The core route analysis is described in Annex B. The overlap analysis is described in the main report.

1.1.1 Active modules: access and core network design and service costing calculations

The active modules, whilst being large files, are logically structured and an experienced MS Excel modeller, following the provided documentation, should be able to navigate and operate the models. In Annex A, a structure is proposed for working through the model in a logical manner. The following section explains how to calculate results and maintain links between files.

Single-year result

To produce a fixed long run incremental cost (FLRIC) model result, all three active modules needs to be open. To run the model, press **F9** to calculate (the modules are provided with Manual calculation enabled). When the model has completed a calculation, 'calculate' is no longer displayed in the Excel status bar – if 'calculate' does not disappear, perform a full calculation (**Ctrl-Alt-F9**).

The main model scenarios are controlled in the Cost module (on the 'Scenario' worksheet). Importantly, the model can be run for each of the years 2007–2012. To run the model for a particular year, select the appropriate year from the year modelled scenario. Once selected, re-calculating feeds the appropriate year's service demand into the CAN and Core modules.

Multi-year result

To produce a set of results for all years, a macro in the Cost module ('Paste_results') has been developed to cycle through each year and paste results. To run the macro:

- ensure all three active modules are open (Cost.xls, Core.xls, CAN.xls), with macros enabled on opening the Cost module
- go to the *Results.Pasted* worksheet of the Cost module
- click the grey button in cell C1 labelled "paste results"

The files will take several minutes to calculate. Macros must have been enabled when opening the workbooks originally.

Saving files

If changes are to be made in any of the active modules, the modules should be recalculated and saved (using the same filenames) – this means that the links in the Cost module are automatically maintained. All active modules should be kept in the same directory.

1.1.2 Offline modules: geoanalysis and access network module

The geoanalysis and access network module is the key input to the CAN module. The structure of the workbooks and database supporting this module are presented in Figure 1.2:

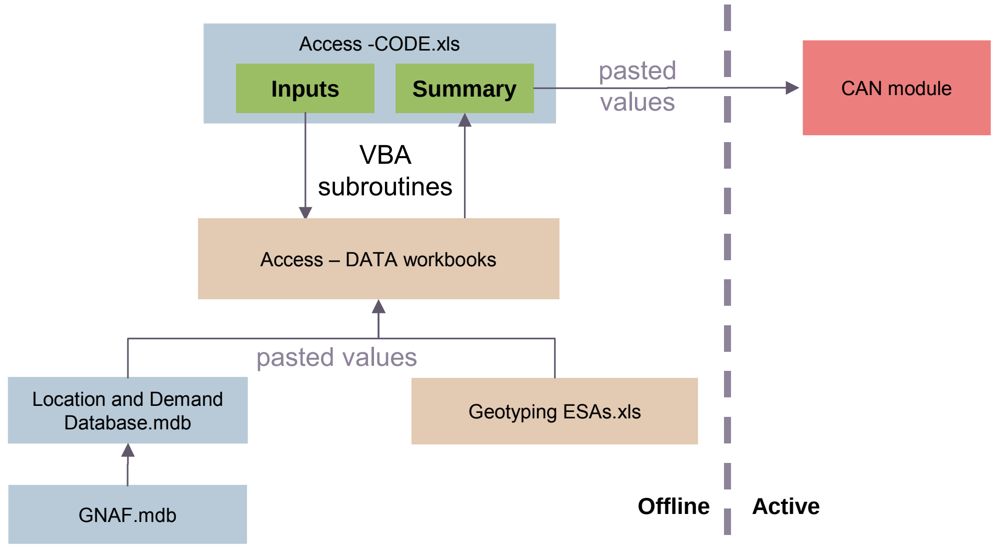


Figure 1.2: Structure of offline and active modules of the access network [Source: Analysys]

The *geoanalysis and access network* module calculates access network asset volumes for a sample set of exchange service areas (ESAs) and then determines parameters to drive the access network element volumes by geotype. Along with the 'Location and Demand database' and associated analysis, two sets of workbooks are important:

- *Access – CODE.xls*
- *Access – DATA – Gy.xls*, with *y* including the index of the geotype.

Access – CODE.xls contains Visual Basic subroutines which are the basis of the access network deployment algorithms.

The active component is the CAN module, involving Excel-based calculations dimensioning the access network, nationally, and the subsequent allocation of costs to services. These dimensioning calculations are dependent on the parameters determined in the offline component.

Running the geoanalysis and access network module

The workbooks that make up the *geoanalysis and access network* module can be re-run to feed the active module with new parameters to dimension the access network. All of these workbooks should be kept in one directory in order to preserve the workbook interlinks. All of the inputs that feed into the offline calculation lie within the ‘Inputs’ worksheet of *Access – Code.xls*. The ‘Summary’ worksheet contains a numerical index of the ESAs within the sample.

The calculation can be re-run for all or a contiguous selection of ESAs. In order to do this, all of the data workbooks must be closed, with *Access – Code.xls* open. Enter the indices of the first and last ESAs to be re-run in the cells called *first.ESA* and *last.ESA* respectively on the ‘Inputs’ worksheet, as shown below.

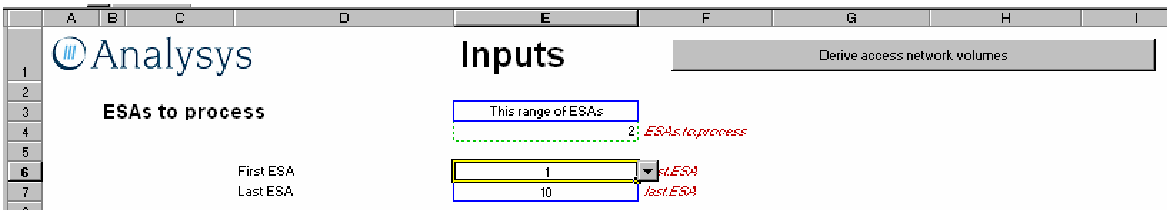


Figure 1.3: Running the algorithms in Access – CODE.xls [Source: Analysys]

Clicking on the button “Derive access network volumes” will then re-run the calculations for these ESAs using the inputs specified on the ‘Inputs’ worksheet. More details on the underlying Visual Basic in the offline modules of the model can be found in the accompanying *Description of the Visual Basic used in the fixed LRIC model*.

There are 200 ESAs in the sample. A number of these ESAs contain more than one copper centre, so we have split these ESAs into sub-areas, each containing one copper centre. As a result, there are 219 areas to run in all. The calculation time varies depending on the number of locations and whether the urban or rural deployment is used. Indicative times are given below.

	Approximate running time (minutes)	
Number of locations	*Urban deployment*	*Rural deployment*
100	0.1	5
1000	0.5	150
5 000	5	225
20 000	125	

Table 1.1: Approximate run-times for ESAs, using Excel 2003 [Source: Analysys]

Several of the sampled ESAs using the urban deployment algorithm contain over 10 000 locations, whilst a number of those using the rural deployment algorithm contain several thousand locations. Our experience is that a desktop computer can run all 219 ESAs in 3–4 days.

The load can be split by using a central directory with several computers accessing the directory. Copies of *Access – CODE.xls* can be taken and left in this directory. Provided each computer is working on a separate data workbook, each copy of the code workbook can be run on a separate computer. It is recommended that one set of results and the associated code workbook are saved in a separate folder to allow checking of input parameters at a later date.

To set up and run the geoanalysis and access network module, as described in Sections 4 and 5 of the *Fixed LRIC model documentation*, the following minimum specifications are recommended:

- MS Excel (2003 edition)
- MS Access (2000 edition)
- MapInfo (v8.0)
- MapBasic (v4.5 is required for the geocoding algorithms).

1.2 Document roadmap

The calculations performed in each of the modules are explained in the following sections, on a worksheet-by-worksheet basis.

The remainder of this document is set out as follows:

- Section 2 outlines the key parameters and calculations for each worksheet in the *geoanalysis and access network module: Part I (CODE)*.
- Section 3 outlines the key parameters and calculations for each worksheet in the *geoanalysis and access network module: Part II (DATA)*.
- Section 4 outlines the key parameters and calculations for each worksheet in the *CAN module*.
- Section 5 outlines the key parameters and calculations for each worksheet in the *Core module*.
- Section 6 outlines the key parameters and calculations for each worksheet in the *Cost module*.

2 Geoanalysis and access network module: Part I (CODE)

The geoanalysis and access network module is used to derive, store and post-process the modelled asset volumes of an actual deployment in a sample of ESAs in Australia. It has two main components: a code sub-module and a data sub-module. The data sub-module, which comprises several workbooks, is explained in Section 3.

The code sub-module is a single workbook called *Access – CODE.xls*, which contains the following elements:

- Main inputs and calculations used to generate asset volumes to construct an access network within a sample of ESAs in Australia.
- Subroutines of Visual Basic code used for the access network deployment algorithms: a description of these appears in *Description of the Visual Basic used in the fixed LRIC model*.
- A summary of the derived access network for each sampled ESA.

The complexity of this sub-module is contained within the Visual Basic subroutines, rather than the Excel worksheets, which contain very few calculations. *Access – CODE.xls* must be placed within the same directory as the workbooks within the data sub-module in order for the access network volumes to be re-calculated. The worksheets contained in *Access – CODE.xls* are explained in the rest of this section.

The remainder of this section is set out as follows:

- Section 2.1 outlines the key labels in the 'Names' worksheet
- Section 2.2 outlines the key parameters and calculations in the 'Inputs' worksheet
- Section 2.3 outlines the key labels and links in the 'Summary' worksheet.

2.1 'Names' worksheet

Note: it is highly unlikely that any cell will need to be modified in this worksheet. It is in fact recommended that no changes are made to this worksheet.

The 'Names' worksheet contains the named ranges for labels that are used to describe particular assumptions within the geoanalysis and access network module. These assumptions are stored on the 'Inputs' worksheet.

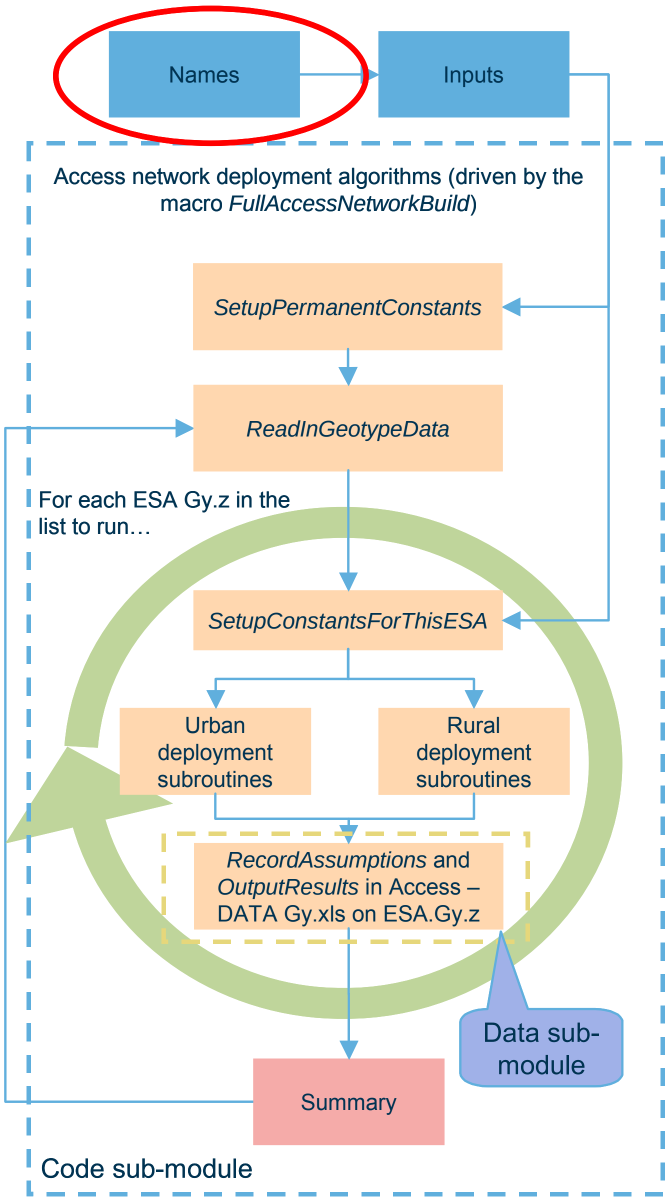


Figure 2.1: Location of the 'Names' worksheet within the overall structure of the geoanalysis and access network module [Source: Analysys]

2.1.1 Key parameters

This worksheet outlines the main labels used throughout the geoanalysis and access network module, such as the labels for assumptions stored in the data sub-module whenever the network volumes for an ESA are calculated using the Visual Basic. Other named ranges are used for drop-down boxes in the 'Inputs' worksheet to list the options available. For instance, the named range *ESA.methodology* is used for the list of options stored in the range *ESA.calculation.methodology* for each geotype.

Parameter	*Location*	*Impact*
Geotype names	Rows 5-18	Lists the labels given to each of the geotypes used within the model
Methodology to use when calculating for an ESA	Rows 23-26	These are the two labels currently used for the deployment algorithms within the geoanalysis and access network module
Nature of fibre connections	Rows 30-32	These are the labels used to denote the three different means of deploying fibre within an ESA
Nature of distribution network	Rows 37-38	These allow the ESAs having their access network calculated to have either tapered or non-tapered copper cabling back to the pillar
Options for calculating for ESAs	Rows 43-44	These are the two options with which the code sub-module can recalculate the asset volumes for the ESAs in the data sub-module
Labels	Rows 49-56	These are the labels for the possible clusters derived by the access network deployment algorithms

Table 2.1: Key parameters on the 'Names' worksheet [Source: Analysys]

2.1.2 Calculation description

The main named parameters stored on this worksheet are summarised below.

Cell reference	*Description and details of spreadsheet calculations*
Rows 5-18	Geotype names
Rows 23-26	Methodology to use when calculating for an ESA
Rows 30-32	Nature of fibre connections
Rows 37-38	Nature of distribution network
Rows 43-44	Options for calculating for ESAs
Rows 49-56	Labels

Table 2.2: Calculations performed on the 'Inputs' worksheet [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 5- 18	Geotype names

These are the labelling used for the geotypes that are included within the geoanalysis and access network module. It should be noted that the CAN module also contains a 15th and a 16th geotype. However, these ESAs are not included within the sample of ESAs processed by the network design algorithms. The 15th geotype contains ESAs we assume are served by satellite, whilst the 16th geotype contains ESAs with neither location data nor demand at all. The labels here are those relevant to the sampled ESAs.

It is not expected that the number of geotypes to be analysed will be increased.

Geotype
1
2
3
4
5
6
7
8
9
10
11
12
13
14

geotypes

Figure 2.2: Excel parameters for geotype names [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 23-26	Methodology to use when calculating for an ESA

These are the two labels currently used for the deployment algorithms within the model: "URBAN" denotes a copper and fibre CAN and is intended for at least all of Bands 1 and 2, whereas "RURAL" can also deploy wireless and satellite within an ESA.

Methodology to use when calculating for an ESA

URBAN	
RURAL	
ESA.methodology	
2	*num.ESA.methodologies*

Figure 2.3: Excel parameters for methodology to use when performing calculation for an ESA [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 30-32	Nature of fibre connections

These are the labels used to denote the three different means of deploying fibre within an ESA. The first two options cause all (respectively some) pillars to be joined together in a fibre ring, with locations fed by fibre then linked by spurs to their parent pillar. The third option simply connects all locations fed by fibre directly to the remote access unit (RAU) via their parent pillar.

Nature of fibre connections

Include all pillars in a fibre ring
Include all pillars with existing fibre demand into a ring
Connect fibre demand locations directly to pillar
nature.of.fibre.connections

Figure 2.4: Excel parameters for the nature of fibre connections [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 37-38	Nature of distribution network

These are the labels used to denote the two different means encoded within the geoanalysis and access network module for deploying copper cable within the distribution network of an ESA. This part of the network can either be tapered or (partially) non-tapered.

The default assumption used in the model is to use a non-tapered deployment in all geotypes.

Nature of distribution network

Fully tapered
Primarily non-tapered
distribution.network.assumptions

Figure 2.5: Excel parameters for the nature of the distribution network [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 43-44	Options for calculating for ESAs

These are the two options with which the code sub-module can recalculate the asset volumes for the ESAs in the data sub-module. The option “This range of ESAs” means that all ESAs within the range specified on the ‘Inputs’ worksheet are re-calculated. The option “All” means that all ESAs are re-calculated, regardless of this range.

It is recommended that *ranges of ESAs* are calculated in batches when re-running the whole of the sample. See section 1.1.2 for further details.

Options for calculating for ESAs

All
This range of ESAs
ESAs.to.calculate.options

Figure 2.6: Excel parameters for the options available for the calculation of ESAs [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 49-56	Labels

These are the labels for the possible clusters derived by the access network deployment algorithms and are used in the summary tables for each ESA in the data sub-module. Copper clusters are denoted by either

- *RAU* (if served by the RAU)
- *Pillars* (if served by a pillar)
- *LPGS–fibre/wireless/satellite backhaul* (if served by an large pair gains system (LPGS), with its means of backhaul to the RAU also specified).[1]

Other clusters are labelled as either base transceiver system (BTS) or *satellite*, if they are either served by wireless technology or satellite respectively.

Labels

LPGS	*label.LPGS*
satellite	*label.satellite*
RAU	*label.RAU*
BTS	*label.BTS*
Pillar	*label.pillar*
LPGS - fibre backhaul	*label.LPGS.fibre.backhaul*
LPGS - wireless backh	*label.LPGS.wireless.backhaul*
LPGS - satellite backha	*label.LPGS.satellite.backhaul*

Figure 2.7: Excel labels [Source: Analysys]

2.2 'Inputs' worksheet

This worksheet contains the key inputs dimensioning the equipment and network topology used in the access network. Whenever a particular ESA is calculated within the geoanalysis and access network module, the assumptions for the ESA, which are determined by its geotype, are read into the design algorithms from this worksheet using subroutines such as *SetUpPermanentConstants* and *ReadInGeotypeData*.

[1] A copper cluster served by LPGS is not labelled as "LPGS": its means of backhaul is always specified as well. *LPGS.label* is used to aid the summation of asset volumes in LPGS clusters of all types within an ESA.

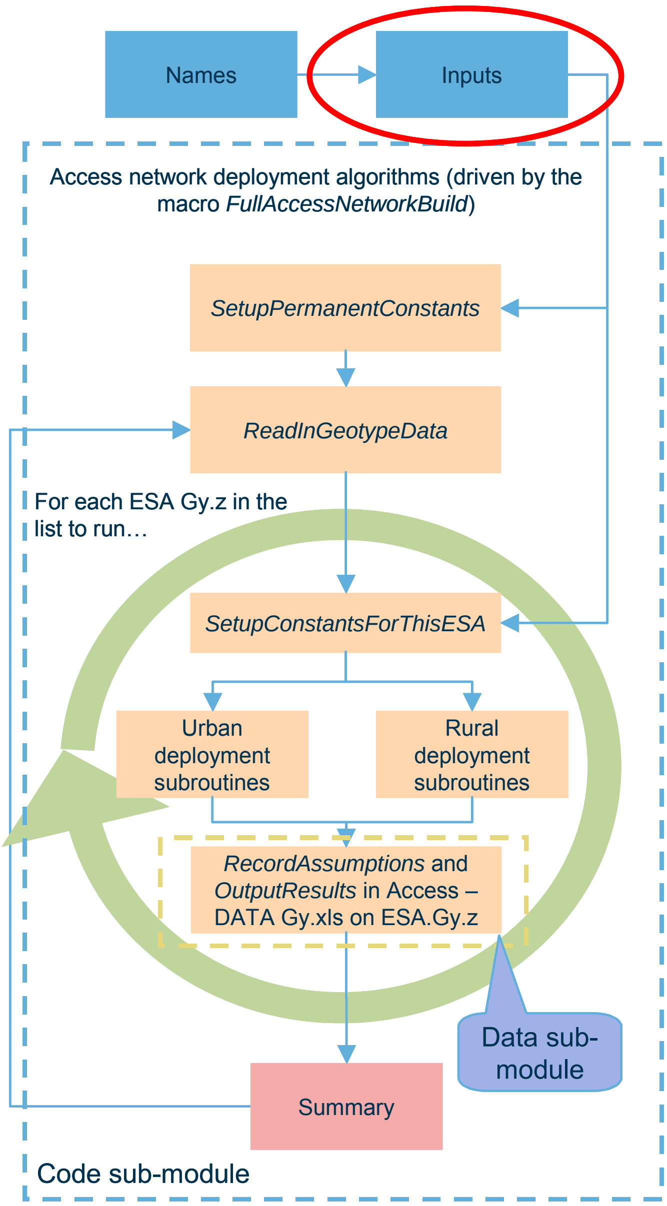


Figure 2.8: Location of the 'Inputs' worksheet within the overall structure of the geoanalysis and access network module [Source: Analysys]

The worksheet also specifies which ESAs will be re-calculated if the 'Derive access network volumes' button is pressed and the option "This range of ESAs" is selected.

2.2.1 Key parameters

This worksheet contains all the important assumptions used to derive the access network volumes.

Parameter	*Location*	*Impact*
ESAs to process	Rows 3–7	Controls which ESAs are processed by the access algorithms: see section 1.1.2 for further details
Utilisation basic inputs	Rows 12–14	Determines how much spare capacity is employed within the cabling deployed in the distribution network, distribution points (DPs) and pillars. A lower utilisation implies more spare capacity is provisioned in the network, so more assets will be deployed.

Parameter	*Location*	*Impact*
DP definitions	Rows 17–18	The DP capacity determines how much demand can be accommodated by a single DP during clustering. The maximum distance between pits in the distribution network is used to determine whether and how many additional pits are required along the trench network within a pillar cluster.
Pit and manhole definitions	Rows 21–52	States the labels for the pits that can be deployed in the network. The other inputs are driven off of this list and specify the • number of ducts that can be provisioned in the trench network and the corresponding pit required • minimum pits requirements given the number of links at the pit, based on engineering rules. • minimum pit size at a pillar location.
Duct capacity definitions	Rows 55–59	These specify the maximum number of cables a single length of each type of duct can accommodate. Reducing these can increase the amount of duct deployed.
Copper basic inputs	Rows 62–133	There are a fixed number of different copper cable sizes that can be used within the network, which are listed here. In addition, two of these cable sizes can be specified for a non-tapered network as the main and minor cable sizes (the latter will be used at the extremities). The final table describes which cables to use between the location and the DP in the URBAN deployment.
Pillars basic inputs	Row 137	This is the pillar capacity and changes will clearly affect the number of pillars deployed in an ESA.
Fibre basic inputs	Rows 141–152	The demand threshold determines which locations are served by fibre. Reducing this threshold means more locations are served by fibre. The second input limits the number of pillars on any one ring in a fibre ring deployment. The main fibre cable sizes are those most commonly used in fibre deployments. These are used here to connect the pillars within the fibre ring.
Backhaul basic inputs	Rows 155–166	The wireline inputs are limits for pulling cable through duct without jointing and for determining how many additional manholes are required in the network for access purposes. The wireless inputs are • the maximum distance a wireless link can be used without a relay station en route • a set of coefficients which capture the cost of different backhaul links relative to the smallest link of 2 × 2Mbit/s, which are used for wireless backhaul links deployed in the RURAL deployment.
Satellite basic inputs	Rows 169–172	These are the component costs assumed for serving a single location with satellite in the RURAL deployment. Decreasing the these costs makes it more likely for a wireless cluster to be served by satellite.
Copper inputs by geotype	Rows 180–193	These allow the copper clustering constraints to be varied on a geotype basis and affect the number of DPs and pillars

Parameter	*Location*	*Impact*
		deployed in an ESA. The cable size to link pillars back to the RAU is also included here.
Fibre inputs by geotype	Rows 198–211	These determine the fibre lengths deployed in an ESA given the number of fibres included within each cable.
Copper versus wireless decision data by geotype	Rows 218-231	These are used for a cost-based decision in the RURAL deployment as to whether locations are served by copper of wireless. Changing these inputs will affect the balance of locations served by copper and wireless within the ESA.
Other data by geotype	Rows 236-249	These drop-down boxes allow the user to specify the deployment methodologies on a geotype basis.
Proxy cost function coefficients	Rows 258-303	These are used in the minimum spanning tree algorithms to determine the copper (and wireless backhaul) networks. Changing these may give rise to sub-optimal trench and cable networks.
Cost function coefficients	Rows 309-317	These allow a cost comparison for linking an LPGS to its RAU by either fibre or wireless.
Distance function	Rows 324-355	These coefficients determine a street-distance function for each geotype in the geoanalysis and access network module. The coefficients for straight-line "Euclidean" distance are also included within the model as the default distance measure. Wherever a distance measure is used in the subroutines, it will always use exactly one of these two options.
Trench sharing coefficient	Rows 361-374	In order to capture trench sharing within the model, all aggregated totals of trench within the model are scaled by this coefficient, which can vary by geotype.

Table 2.3: Key parameters on the 'Inputs' worksheet [Source: Analysys]

2.2.2 Description of parameters and associated calculations

There are few calculations within this worksheet. The most important are those in rows 180–193, which determine the capacity constraints for DP clusters and pillar clusters. The DP cluster capacity uses the utilisation assumption for a DP. The pillar cluster capacity is driven by the

- number of pairs (900) that a pillar can accommodate
- utilisation factor for the pillar
- number of pairs back from the pillar to the RAU: the capacity cannot exceed this value.

The following table outlines the parameters and calculations that lie on the 'Inputs' worksheet, which are discussed in more detail below:

Cell reference	*Description and details of spreadsheet calculations*
Rows 3-7	ESAs to process

Rows 12-14	Utilisation basic inputs
Rows 17-18	DP basic inputs
Rows 21–52	Pit and duct basic inputs
Rows 55–59	Duct capacity definitions
Rows 62–133	Copper basic inputs
Rows 137	Pillars basic inputs
Rows 141–152	Fibre basic inputs
Rows 155–166	Backhaul basic inputs
Rows 169–172	Satellite basic inputs
Rows 180–193	Copper inputs by geotype
Rows 198–211	Fibre inputs by geotype
Rows 218–231	Copper versus wireless decision data by geotype
Rows 236–249	Other data by geotype
Rows 258–303	Proxy cost function coefficients
Rows 309–317	Cost function coefficients
Rows 324–355	Distance function
Rows 361–374	Trench sharing coefficient

Table 2.4: Calculations performed on the 'Inputs' worksheet [Source: Analysys]

ESAs to process

Cell reference	*Description and details of spreadsheet calculations*
Rows 3–7	ESAs to process

Specifies which ESAs are processed by the access algorithms. See Section 1.1.1 for further details.

Basic inputs

Cell reference	*Description and details of spreadsheet calculations*
Rows 12-14	Utilisation basic inputs

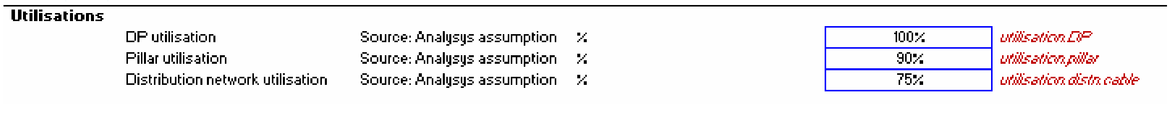


Figure 2.9: Excel parameters for asset utilisation [Source: Analysys]

The above parameters determine the assumed utilisation level of:

- DPs
- pillars
- distribution network cabling.

The first two are used in the capacity calculations for DPs and pillars (see 'Inputs by geotype' section below). These inputs are not read into the Visual Basic directly: it is the outputs of the calculations that are read in and used by the clustering subroutines in the deployment algorithm.

The utilisation of the distribution network cabling is read into the algorithms. This is used both when this part of the network is assumed to be tapered and non-tapered. Specifically, this cabling joins demand back to its parent pillar / LPGS / RAU and is dimensioned on the basis of "downstream demand" i.e. how much demand passes through the link en route back to the node. The utilisation factor defines the minimum level of spare capacity in this cabling.

Suppose, for example, that the network was fully non-tapered, only used 100-pair cable and assumed 100% utilisation of that cable. Then, wherever the downstream demand was 100 or less, one 100-pair cable would be deployed. If the downstream capacity was exactly 100, then there would be no spare capacity dimensioned in that part of the network. A utilisation factor of 80% would increase the cabling to two 100 pair sheaths as soon as the downstream demand exceeded 80.

Cell reference	*Description and details of spreadsheet calculations*
Rows 17-18	DP basic inputs

Figure 2.10: Excel parameters for distribution points [Source: Analysys]

There are two parameters associated with DPs, as shown above:

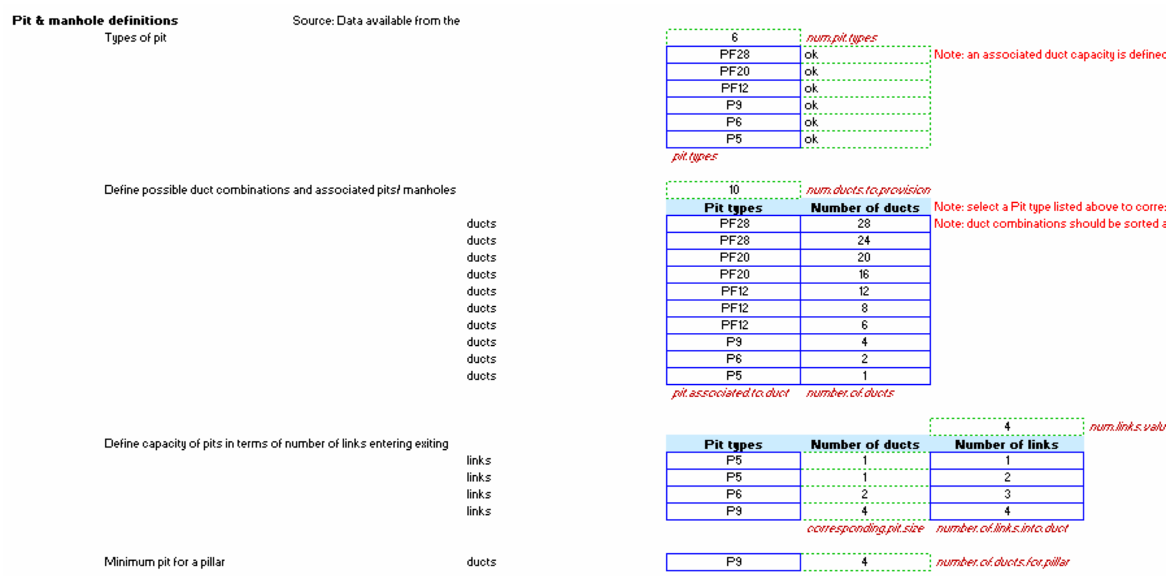
DP capacity — This defines the maximum demand accommodated by a DP cluster, which can serve one or more locations by connecting to final distribution points (FDPs). The maximum capacity is multiplied by the utilisation (defined above) in rows 180–193 to determine the practical capacity (see below for further details). It is only used in the URBAN deployment.

A DP can serve *individual* locations with copper demand higher than this capacity.

Maximum distance between pits — If a single DP–DP trench link exceeds this defined distance, then an additional pit will be deployed. It is only used in the URBAN deployment.

These additional DPs for an ESA are recorded in the DATA workbooks files under the column "Extra DPs required along trench within pillars."

Cell reference	*Description and details of spreadsheet calculations*
Rows 21–52	Pit and manhole definitions



Pit & manhole definitions — Source: Data available from the

Types of pit — 6 *num.pit.types*

Pit type	Check
PF28	ok
PF20	ok
PF12	ok
P9	ok
P6	ok
P5	ok

pit.types — Note: an associated duct capacity is definec

Define possible duct combinations and associated pits/ manholes — 10 *num.ducts.to.provision*

	Pit types	Number of ducts
ducts	PF28	28
ducts	PF28	24
ducts	PF20	20
ducts	PF20	16
ducts	PF12	12
ducts	PF12	8
ducts	PF12	6
ducts	P9	4
ducts	P6	2
ducts	P5	1

pit.associated.to.duct — *number.of.ducts*

Note: select a Pit type listed above to corre:
Note: duct combinations should be sorted a

Define capacity of pits in terms of number of links entering exiting — 4 *num.links.valu*

	Pit types	Number of ducts	Number of links
links	P5	1	1
links	P5	1	2
links	P6	2	3
links	P9	4	4

corresponding.pit.size — *number.of.links.into.duct*

Minimum pit for a pillar	ducts	P9	4

number.of.ducts.for.pillar

Figure 2.11: Excel parameters for pit and duct [Source: Analysys]

The above parameters drive the pit and duct calculations. The first three sets of inputs define the labels of the pits and manholes which can be used. Six types have been defined and it is not expected that they will change. The next three sets of inputs relate to determining the minimum pit size that should be deployed at a cluster node:

Number of ducts entering the node — Combinations of the number of ducts which can be deployed are listed, in decreasing order. A pit name is associated with each duct combination. Each listed pit should tie in with at least one duct combination.

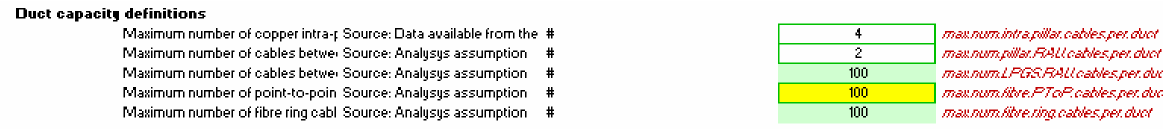
Number of links intersecting at a node — Pits are limited by the number of diverse routes they can accommodate. The pit type associated with 1, 2, 3 or '4 and above' routes entering from one side of the pit is defined.

Is the cluster node a pillar — The minimum pit requirement for a pillar location is defined separately.

Each node is allocated the smallest pit that satisfies the pit requirements of these three criteria.

It is likely that only fairly significant changes to these inputs will change the mix of pits deployed. The mix of pits may be more sensitive to changes in the amount of duct deployed which are driven by the duct capacity definitions, as shown below:

Cell reference	*Description and details of spreadsheet calculations*
Rows 55–59	Duct capacity definitions



Duct capacity definitions

Maximum number of copper intra-p	Source: Data available from the	#	4	max.num.intra.pillar.cables.per.duct
Maximum number of cables betwe	Source: Analysys assumption	#	2	max.num.pillar.RAU.cables.per.duct
Maximum number of cables betwe	Source: Analysys assumption	#	100	max.num.LPGS.RAU.cables.per.duc
Maximum number of point-to-poin	Source: Analysys assumption	#	100	max.num.fibre.PToP.cables.per.duc
Maximum number of fibre ring cabl	Source: Analysys assumption	#	100	max.num.fibre.ring.cables.per.duct

Figure 2.12: Excel parameters for duct capacity [Source: Analysys]

Maximum number of copper intra-pillar cables in a duct	Deploys a duct for every *n* intra-pillar copper sheaths within a single trench link.
Maximum number of cables between pillar and RAU in a duct	Deploys a duct for every *n* pillar–RAU copper sheaths within a single trench link. Note: this assumes that separate ducts are used to backhaul copper to the RAU even if the trench is shared with other copper links.
Maximum number of cables between LPGS and RAU in a duct	Deploys a duct for every *n* LPGS-RAU fibre sheaths within a single trench link. Note: this allows the calculation of the LPGS–RAU ducts relative to the total number of ducts and is important in the allocation of CAN cost to the core network.
Maximum number of point-to-point fibre cables between DP and pillar in a duct	Deploys a duct for every *n* intra-pillar fibre sheaths within a single trench link.
Maximum number of fibre ring cables in a duct	Deploys a duct for every *n* pillar-RAU fibre sheaths within a single trench link. Note: this assumes that separate ducts are used to backhaul fibre to the RAU even if the trench is shared with other fibre links.

Decreasing these capacities may increase the amount of duct deployed in the network, and subsequently the size of pits deployed.

Cell reference	*Description and details of spreadsheet calculations*
Rows 62–133	Copper basic inputs

					Lead-in demand served by these cables Minimum	Maximum
Copper cable employed for distribution network in a primarily non-tapered network						
Minor non-tapered cable size used	Source: Analysys assumption	copper pairs	0	smaller.non.tapered.cable.size		
Main non-tapered cable size used i	Source: Data available from the	copper pairs	100	main.non.tapered.cable.size		
Copper cable employed for lead-in cable (and a tapered distribution network)				copper.lead.in.cable.sizes.employed		
	Source: Data available from the	copper pairs	2		-	4
	Source: Data available from the	copper pairs	10		5	20
	Source: Data available from the	copper pairs	30		21	30
	Source: Data available from the	copper pairs	50		31	50
	Source: Data available from the	copper pairs	100		51	1.00E+06
	Source: Data available from the	copper pairs	200	Only used for rural areas served by copper	min.demand.by.lead.in.cab	max.demand.by.lead.in.cable.size
	Source: Data available from the	copper pairs	400	Only used for rural areas served by copper		
	Source: Data available from the	copper pairs	800	Only used for rural areas served by copper		
	Source: Data available from the	copper pairs	1200	Only used for rural areas served by copper		
			max.rural.cable.size			
			5	num.copper.urban.lead.in.cable.sizes		
			9	num.copper.rural.lead.in.cable.sizes		

Figure 2.13: Excel parameters for copper cabling [Source: Analysys]

The above parameters determine the number of copper pairs employed for either a primarily non-tapered or a fully tapered network.

The primarily non-tapered case has two sizes: a "main size" and a "smaller size." For the assumptions above, DPs in the main chain would have 100 copper pairs whereas those at the end of a chain (e.g. in a cul-de-sac) might have only 10 copper pairs. To deploy a fully non-tapered network, the parameter for the minor non-tapered cable size should be set to zero. This is the default assumption.

The tapered network can use the full range of sizes specified above. The larger cable sizes can be deployed in RURAL deployments, and are excluded from urban deployments due to the comments in column H to the right.

Units of demand	2	10	30	50	100	Total sheath lengths	Total copper pairs
1	1	-	-	-	-	1	2
2	1	-	-	-	-	1	2
3	2	-	-	-	-	2	4
4	2	-	-	-	-	2	4
5	-	1	-	-	-	1	10
6	-	1	-	-	-	1	10
7	-	1	-	-	-	1	10
8	-	1	-	-	-	1	10
9	-	1	-	-	-	1	10
10	-	1	-	-	-	1	10
11	1	1	-	-	-	2	12
12	1	1	-	-	-	2	12
13	2	1	-	-	-	3	14
14	2	1	-	-	-	3	14
15	-	2	-	-	-	2	20
16	-	2	-	-	-	2	20
17	-	2	-	-	-	2	20
18	-	2	-	-	-	2	20
19	-	2	-	-	-	2	20
20	-	2	-	-	-	2	20
21	-	-	1	-	-	1	30
22	-	-	1	-	-	1	30

Figure 2.14: Excel parameters to determine combinations of copper cable deployed for varying levels of demand in urban areas [Source: Analysys]

The parameters in G84:K133 are used when determining the copper pairs need to link a location to its parent DP in an urban deployment. For example, we assume that 4 units of demand are served by two 2-pair cables, whereas 6 units of demand are assumed to use one 10-pair cable. This table must be kept updated given changes in the minimum demand threshold for locations to be fed by fibre. If this threshold exceeds the largest capacity in the table, then the subroutines will not work.

This table should also only use one cable size to supply each level of demand. This is because it also defines a summary table of boundaries of demand in Rows 66–73. These boundaries are used in the data sub-module to define how much demand / how many locations are served by each cable size in the final drop.

Cell reference	*Description and details of spreadsheet calculations*
Row 137	Pillars basic inputs

Pillars				
	Pillar capacity	#	900	std.pillar.capacity

Figure 2.15: Excel parameters for the pillar capacity [Source: Analysys]

The pillar capacity feeds into the pillar capacity calculations in the 'Inputs by geotype' section, as described below.

Cell reference	*Description and details of spreadsheet calculations*
Rows 141–152	Fibre basic inputs

Fibre				
	Minimum demand at a location for it to be served by fibre	#	40	minimum.location.demand.for.fibre
	Maximum number of nodes in a fibre ring	#	20	maximum.nodes.in.fibre.ring
	Main fibre cable sizes employed	fibres in cable	18	
	Must be written in ascending order of size	fibres in cable	24	
		fibres in cable	36	
		fibres in cable	60	
		fibres in cable	120	
		fibres in cable	312	
			fibre.cable.sizes.employed	
			6	num.fibre.cable.sizes

Figure 2.16: Excel parameters for the fibre ring demand and capacity and cable sizes deployed in the fibre ring [Source: Analysys]

Minimum demand at a location for it to be served by fibre	The parameter used to determine the minimum demand at a location before fibre is deployed is important, particularly for the concentrated demand within ULLS Band 1. A higher threshold leads to fewer fibre-fed locations and a larger volume of copper deployed in an ESA.
Maximum number of nodes in a fibre	A fibre node is a pillar with fibre demand in its cluster or a LPGS with fibre backhaul. This parameters defines the upper limit for clustering of fibre

ring	nodes. The default assumption is that fibre rings are deployed in Band 1 (geotypes 1 and 2).
Main fibre cable sizes employed	This defines the different fibre bundle sizes that can be used on a the fibre ring. The cables deployed for the fibre ring are chosen from this list of options and dimensioned on the number of fibres per location (see 'Inputs by geotype').

Cell reference	*Description and details of spreadsheet calculations*
Rows 155–166	Backhaul basic inputs
Rows 169–172	Satellite basic inputs

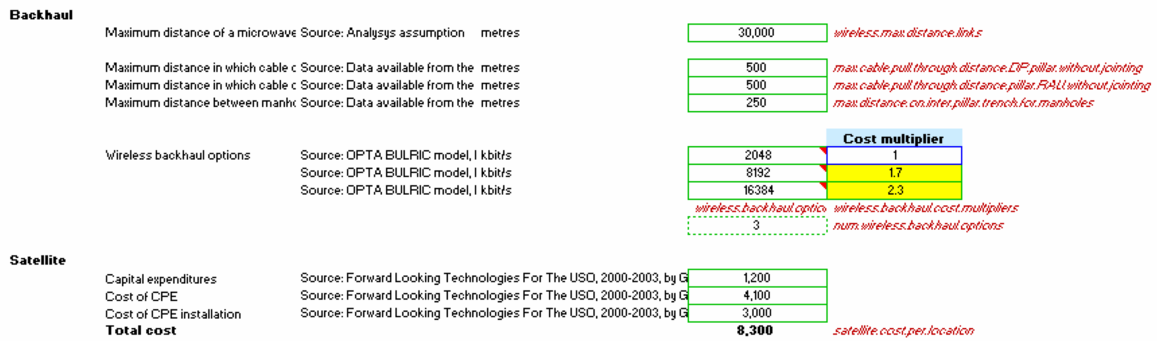


Figure 2.17: Excel inputs to determine backhaul and satellite dimensioning [Source: Analysys]

There are inputs for both copper and wireless backhaul deployments. For copper deployments, the maximum distances for DP–pillar and pillar–RAU cables without jointing lead to additional full joints (of the entire cable) being included in the distribution and feeder networks respectively.

The maximum distance between manholes is only employed on the incremental trench joining the pillar clusters back to the RAU to ensure that there are sufficient access points along this trench. The wireless backhaul options are used in determining the capacity of wireless links between base stations and wireless-fed LPGS required deployed to serve rural ESAs.

The satellite inputs are used for a cost-based decision for installing satellite compared with wireless within rural ESAs. Clusters served by a wireless BTS are checked individually to see if they can be served by satellite more cheaply. Decreasing this satellite cost will mean that wireless clusters are more inclined to be served by satellite rather than a BTS.

Inputs by geotype

All parameters driving the clustering algorithms which deploy copper and fibre in an ESA can be varied by geotype. However, most quantities are currently set to be equal across all geotypes.

Cell reference	*Description and details of spreadsheet calculations*
Rows 180–193	Copper inputs by geotype

- *Copper node capacities*

Copper

Geotype	Maximum practical DP capacity	Maximum practical pillar capacity	Absolute maximum DP capacity	Absolute maximum pillar capacity
1	4	360	4	400
2	4	360	4	400
3	4	360	4	400
4	4	360	4	400
5	4	360	4	400
6	4	360	4	400
7	4	360	4	400
8	4	360	4	400
9	4	360	4	400
10	4	360	4	400
11	4	360	4	400
12	4	360	4	400
13	4	360	4	400
14	4	360	4	400
	max.DP.capacity	max.pillar.capacity	max.absolute.DP.cap	max.absolute.pillar.capacity

Figure 2.18: Excel parameters to dimension copper node capacities by geotype [Source: Analysys]

Absolute maximum DP capacity Linked in directly from DP definitions

Maximum practical DP capacity Defined as the absolute maximum DP capacity multiplied by its utilisation. It is used in the DP clustering algorithm, which only occurs in the URBAN deployment.

Absolute maximum pillar capacity Defined as the minimum of the cable capacity from pillar to RAU and the pillar capacity in pairs excluding that reserved for the cable from pillar to RAU

Maximum practical pillar capacity Defined as the absolute pillar capacity multiplied by its corresponding utilisation parameter. This is the effective capacity limit on pillar clusters, though the absolute limit is used for certain optimisation algorithms which may merge small pillar clusters into other clusters.

- *Copper cable capacities and distance constraints*

	600	URBAN			
	4500	RURAL			
Maximum permitted distance from DP centre (m)	**Maximum permitted distance from pillar centre (m)**		**Required capacity from DP to pillar**	**Cable capacity between pillar and RAU**	**Distance constraint for LPGS rather than a pillar**
40	600		4	400	10000
40	600		4	400	10000
40	600		4	400	10000
40	600		4	400	10000
60	600		4	400	10000
60	600		4	400	10000
100	600		4	400	10000
100	4500		4	400	10000
100	4500		4	400	10000
100	600		4	400	10000
100	4500		4	400	10000
100	4500		4	400	10000
100	4500		4	400	10000
100	4500		4	400	10000
maximum.distance.from.	*maximum.distance.from.pillar.centre*		*DP.pillar.cable.capa*	*pillar.RAU.cable.capacity*	*cable.dist.threshold.for.LPGS*

Figure 2.19: Excel parameters to dimension copper distances and cable capacities / constraints by geotype [Source: Analysys]

Maximum permitted distance from DP / pillar centre — These distances are the constraints used in the clustering algorithms and are varied by geotype in order to control the effectiveness of these algorithms. It should be emphasised that these distance constraints are *controls* rather than *technical constraints*.

Required capacity from DP to pillar — This is only used in the tapered deployment for the purpose of the spanning tree algorithm, in order to estimate the cable size for linking DPs back to their pillars when calculating the proxy cost of linking any two DPs.

Cable capacity between pillar and RAU — Defines the cable size used to link pillars to the RAU and therefore impacts the cluster size of a pillar. This is always modelled as a single sheath non-tapered deployment.

Distance constraint for LPGS — Determines the maximum acceptable length for a copper loop, which is used as a test to deploy a LPGS rather than a pillar. If a cluster in an ESA has any loops exceeding this length, then an LPGS is deployed. Decreasing this distance increases the propensity to deploy LPGS

Cell reference	*Description and details of spreadsheet calculations*
Rows 198–211	Fibre inputs by geotype

Fibre

Geotype	Fibres linking location to DP	Fibres linking DP to pillar
1	6	6
2	6	6
3	6	6
4	6	6
5	6	6
6	6	6
7	6	6
8	6	6
9	6	6
10	6	6
11	6	6
12	6	6
13	6	6
14	6	6
	location.DP.fibre.pairs	DP.pillar.fibre.pairs

Figure 2.20: Excel parameters to determine fibre dimensioning [Source: Analysys]

These parameters are used to dimension the fibre cables for point-to-point links up to the DP and between the DP and pillar respectively.

Cell reference	*Description and details of spreadsheet calculations*
Rows 218–231	Copper versus wireless decision data by geotype

The rural deployment uses a cost-based decision to determine whether each location should be served by a wireless or copper solution. These coefficients comprise the terms in the cost-based decision. Increasing the coefficients for copper will decrease the propensity of the algorithm to deploy it, so fewer locations are likely to be served by copper.

Copper versus wireless decision

Geotype	Coverage radius	Maximum capacity of base station (in terms of units of	Set-up cost for a pillar	Set-up cost for a LPGS	Incremental set-up cost for copper per unit	Set-up cost for wireless	Incremental cost for radio	Incremental capacity per unit of demand	Incremental capacity per unit of high-demand
1	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
2	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
3	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
4	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
5	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
6	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
7	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
8	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
9	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
10	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
11	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
12	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
13	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
14	25,000	250	2,000	80,000	11	200,000	825	1.00	1.00
	wireless.BTS.coverage.radius	wireless.BTS.capacity	comparison.copper.pillar..	comparison.copper.LPG	comparison.copp	comparison.wirel	comparison.wireless.incre	incremental.residen	incremental.business.wireless.demand

Figure 2.21: Parameters used to determine whether a copper or wireless solution is used for a location [Source: Analysys]

Coverage radius This is the distance constraint used when clustering locations to be fed by wireless BTS

Analysys

Maximum capacity of base station This is the capacity constraint used when clustering locations to be fed by wireless BTS, having scaled the copper demand of the locations in order to derive a measure of the wireless demand (see 'Incremental capacity per unit of (high)-demand' below)

Costs for copper deployment The trench cost of a copper cluster is calculated incrementally, with each location that is attempted to be added to the cluster, using the formula:

New cost = Old cost + (Incremental set-up cost for copper per unit distance × distance between location and nearest other location in cluster)

The total cost of a copper cluster is calculated by

Total cost = Set-up cost for a pillar / LPGS + total trench cost

Costs for wireless deployment The total cost of a wireless cluster is calculated by

Total cost = Set-up cost for wireless + (number of wireless locations in cluster × incremental cost for wireless CPE)

Incremental capacity per unit of (high)-demand The demand by location stored in the workbooks reflect copper demand (i.e. lines required). This mapping of demand may not be suitable dimensioning for a wireless solution, as these will be driven more heavily by the Erlangs of traffic passing onto the network. When calculating the demand served by a BTS, different scaling factors can be applied to demand at locations depending on whether it is one or several units of demand. However, the model currently has identical scaling factors i.e. it is assumed that this difference is not material.

Maximum number of relay stations in backhaul link If an LPGS served by wireless require more than this number of relay stations in the link, then the LPGS is served by satellite.

Backhaul capacity per subscriber The backhaul requirements at each wireless node is derived from the demand at each location. A location with one unit of demand uses the residential value of backhaul capacity: otherwise the demand is multiplied by the business value of backhaul capacity.

Critical capacity This is the minimum demand (~20 units) that we assume a pillar is ever deployed to serve. At certain points in the copper-wireless decision, copper clusters which are smaller than this level of demand are converted to wireless. This input is also used in the URBAN deployment: clusters that serve less than this demand can be merged with the nearest pillar cluster regardless of the distance constraint.

Cell reference	*Description and details of spreadsheet calculations*
Rows 236–249	Other data by geotype

These selections determine whether the deployment for a geotype

- is URBAN or RURAL
- uses rings or a point-to-point topology to deploy fibre to high-demand location
- uses a fully tapered or partially non-tapered distribution network to connect DPs (resp. locations) to the pillar in URBAN (resp. RURAL) deployments.

Other

Geotype	Calculation branch	Methodology to connect fibre demand	Nature of distribution network	Calculation branch index	Fibre methodology index	Distribution network index
1	URBAN	Include all pillars in a fi	Primarily non-tapered	1	1	2
2	URBAN	Include all pillars in a fi	Primarily non-tapered	1	1	2
3	URBAN	Connect fibre demand	Primarily non-tapered	1	3	2
4	URBAN	Connect fibre demand	Primarily non-tapered	1	3	2
5	URBAN	Connect fibre demand	Primarily non-tapered	1	3	2
6	URBAN	Connect fibre demand	Primarily non-tapered	1	3	2
7	URBAN	Connect fibre demand	Primarily non-tapered	1	3	2
8	RURAL	Connect fibre demand	Primarily non-tapered	2	3	2
9	RURAL	Connect fibre demand	Primarily non-tapered	2	3	2
10	URBAN	Connect fibre demand	Primarily non-tapered	1	3	2
11	RURAL	Connect fibre demand	Primarily non-tapered	2	3	2
12	RURAL	Connect fibre demand	Primarily non-tapered	2	3	2
13	RURAL	Connect fibre demand	Primarily non-tapered	2	3	2
14	RURAL	Connect fibre demand	Primarily non-tapered	2	3	2
	ESA.calculation.methodology	fibre.methodology.na	distn.network.methodolo	ESA.calculation.methoo	fibre.methodolog	distn.network.methodology

Figure 2.22: *Excel inputs used to determine urban/rural deployment, how fibre is deployed and the type of distribution network [Source: Analysys]*

There are three fibre deployment choices available: two implement ring structures and the third implements point-to-point links. The two ring deployments either join all pillars into a fibre ring (or rings) going through the RAU, or alternatively only those pillars with fibre-fed locations. Point-to-point links use fibre to connect fibre-fed locations directly back to the RAU via their parent pillar.

Function coefficients

Cell reference	*Description and details of spreadsheet calculations*
Rows 258–303	Proxy cost function coefficients

Proxy cost function coefficients

URBAN deployment - Within DP clusters

Proxy cost function is of the form $k_1*d+k_2*c+k_3*d*c+k_4*d*\sqrt{c}$, where d is the length of the link and c is the total number of pairs in the lir

	URBAN	
k_1	1	*prx.fn.within.DP.area.k1*
k_2	0	*prx.fn.within.DP.area.k2*
k_3	0	*prx.fn.within.DP.area.k3*
k_4	0	*prx.fn.within.DP.area.k4*

RURAL deployment - Within pillar clusters

Proxy cost function is of the form $k_1*d+k_2*c+k_3*d*c+k_4*d*\sqrt{c}$, where d is the length of the link and c is the total number of pairs in the lir

	Fully tapered	Primarily non-tapered	
k_1	1	1	*prx.fn.within.pillar.area.k1*
k_2	0.1	0.01	*prx.fn.within.pillar.area.k2*
k_3	0.001	0.002	*prx.fn.within.pillar.area.k3*
k_4	0	0	*prx.fn.within.pillar.area.k4*

URBAN deployment - DP-pillar connections

Proxy cost function is of the form $k_1*d+k_2*c+k_3*d*c+k_4*d*\sqrt{c}$, where d is the length of the link and c is the total number of pairs in the lir

	Fully tapered	Primarily non-tapered	
k_1	1	1	*prx.fn.DP.pillar.k1*
k_2	0.1	0.01	*prx.fn.DP.pillar.k2*
k_3	0.001	0.002	*prx.fn.DP.pillar.k3*
k_4	0	0	*prx.fn.DP.pillar.k4*

Pillar-RAU connections

Proxy cost function is of the form $k_1*d+k_2*c+k_3*d*c+k_4*d*\sqrt{c}$, where d is the length of the link and c is the total number of pairs in the lir

k_1	1	*prx.fn.pillar.RAU.k1*
k_2	0.01	*prx.fn.pillar.RAU.k2*
k_3	0.0005	*prx.fn.pillar.RAU.k3*
k_4	0	*prx.fn.pillar.RAU.k4*

Node-node connections (for constructing a fibre ring)

Proxy cost function for determining the full mesh of pillar-pillar linkages is of the form $k1*d+k2*c+k3*d*c+k4*d*\sqrt{c}$, where d is the lengtl

Proxy cost function for determining the manner in which the pillars link together in the actual fibre ring is of the form $k_1*D_T+k_3*D_C$, whe

k_1	1	*prx.fn.pillar.pillar.k1*
k_2	0	*prx.fn.pillar.pillar.k2*
k_3	0.0005	*prx.fn.pillar.pillar.k3*
k_4	0	*prx.fn.pillar.pillar.k4*

BTS-BTS connections

Cost function for identifying a wireless backhaul link for copper-fed areas is of the form $k1*d+k2*M+k3*n$

where n is the number of relay stations required for the link and M is the cost multiplier for the relevant capacity needed

1.00	*prx.fn.BTS.BTS.k1*
0.00	*prx.fn.BTS.BTS.k2*
0.00	*prx.fn.BTS.BTS.k3*

Figure 2.23: Excel proxy cost function coefficients [Source: Analysys]

These proxy cost functions are used in the minimum spanning tree algorithms to determine the linkages between locations in copper, fibre and wireless networks. For the wireline cases, separately calibrated functions are used to build the trench and cable networks

- within urban DP clusters
- within rural pillar clusters
- between urban DPs and their parent pillar
- between pillars and their parent RAU
- between pillars on a fibre ring.

There is also a function to construct the wireless backhaul network wireless LPGS and BTS back to the RAU in the RURAL deployment.

Currently, the copper functions have a fourth term using the square root of the capacity, although it is always set to be zero.

$$k_1 * d + k_2 * c + k_3 * d * c + k_4 * d * \sqrt{c}$$
$$Where:$$
$$d = the\ length\ of\ the\ link$$
$$c = the\ total\ number\ of\ pairs\ in\ the\ link$$
$$k_{1-4} = cost\ coefficients\ determined\ in\ Excel$$

Figure 2.24: Form of proxy cost function for DP area, DP-pillar connections and pllar-RAU connections [Source: Analysys]

$$k_1 * D_T + k_3 * D_c$$
$$Where:$$
$$D_T = the\ length\ of\ new\ trench\ required$$
$$D_c = the\ length\ of\ cabling\ required\ for\ the\ link$$
$$k_{1-4} = cost\ coefficients\ determined\ in\ Excel$$

Figure 2.25: Form of proxy cost function for determining the linking of pillars in the fibre ring [Source: Analysys]

$$k_1 * d + k_2 * M + k_3 * n$$
$$Where:$$
$$d = the\ crow-flies\ distance\ between\ the\ nodes$$
$$n = the\ number\ of\ relay\ stations\ required\ for\ the\ link$$
$$M = \text{cost}\ multiplier\ for\ the\ relevant\ capacity\ needed$$
$$k_{1-4} = \text{cost coefficients determined}\ in\ \text{Excel}$$

Figure 2.26: Form of proxy cost function for identifying a wireless backhaul link for copper-fed areas [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 309–317	Cost function coefficients

These two cost functions are not proxy cost functions, but are rather a (normalised) comparison of cost between fibre and wireless backhaul. These will choose the lowest cost solution for linking an LPGS back to the RAU. Changing these inputs will not change the number of LPGS, but they may change how they are connected to the RAU.

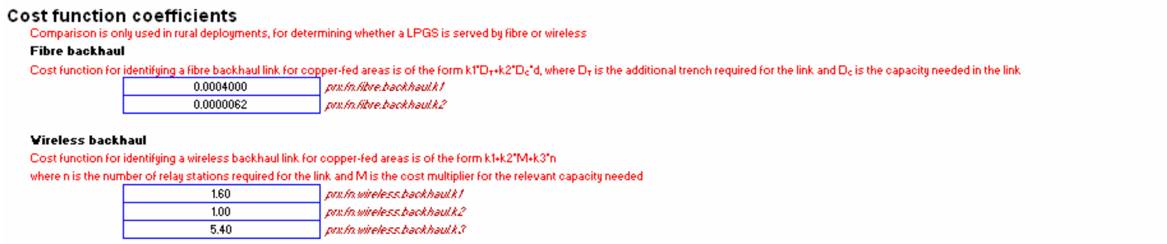


Figure 2.27: Cost function coefficients [Source: Analysys]

$$
\begin{aligned}
& k_1 * D_T + k_3 * D_c \\
& \textit{Where}: \\
& D_T = \textit{the length of new trench required} \\
& D_c = \textit{the length of cabling required for the link} \\
& k_{1-4} = \text{cost } \textit{coefficients} \text{ determined in excel}
\end{aligned}
$$

Figure 2.28: Form of cost function for identifying a fibre backhaul link for copper-fed areas [Source: Analysys]

$$
\begin{aligned}
& k_1 * d + k_2 * M + k_3 * n \\
& \textit{Where}: \\
& d = \textit{the crow-flies distance between the nodes} \\
& n = \textit{the number of relay stations required for the link} \\
& M = \text{cost multiplier } \textit{for the relevant capacity needed} \\
& k_{1-4} = \text{cost coefficients determined } \textit{in} \text{ Excel}
\end{aligned}
$$

Figure 2.29: Form of proxy cost function for identifying a wireless backhaul link for copper-fed areas [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 324–355	Distance function
Rows 361–374	Trench sharing coefficient

The distance function, or p-function, has been calibrated separately for each geotype using the street network of Australia. For any two points, it estimates the road distance between them. This has been used in calculating the trench cable distances of individual links at certain points in the network. However, there are occasions when straight-line distance is used (e.g. to measure distances between locations within a DP cluster).

The trench sharing coefficient varies by geotype and is used to scale aggregated totals of trench for the outputs of an ESA in order to capture trench sharing that occurs in the network.

The function to estimate the road distance between two points given by (x_1,y_1) and (x_2,y_2) takes the form $k([x_1-x_2]^p+[y_1-y_2]^p)^{1/p}$

Value of k

Geotype	Default (Euclidean)	Non-Euclidean
1	1	1.16
2	1	1.27
3	1	1.01
4	1	1.01
5	1	1.22
6	1	1.13
7	1	1.19
8	1	1.04
9	1	1.01
10	1	1.32
11	1	1.10
12	1	1.16
13	1	1.18
14	1	1.37
	Default.p.fn.k	*Non.default.p.fn.k*

Value of p

Geotype	Default (Euclidean)	Non-Euclidean
1	2	1.34
2	2	1.85
3	2	1.26
4	2	1.09
5	2	1.97
6	2	1.67
7	2	1.59
8	2	1.37
9	2	1.15
10	2	3.02
11	2	1.52
12	2	1.66
13	2	1.38
14	2	8.23
	Default.p.fn.p	*Non.default.p.fn.p*

Trench sharing coefficient

The distance function is scaled by j when aggregating trench/duct within an ESA: this accounts for overlap of trench/duct within the ESA

Geotype	Trench sharing coefficient
1	82%
2	86%
3	93%
4	90%
5	87%
6	88%
7	85%
8	86%
9	92%
10	85%
11	88%
12	86%
13	87%
14	83%
	Non.default.p.fn.j

Figure 2.30: Excel distance function coefficients [Source: Analysys]

$$k\left(\left[x_1 - x_2\right]^p\right) + \left(\left[y_1 - y_2\right]^p\right)^{1/p}$$
$$\begin{aligned}&Where:\\&x_{1,2}, y_{1,2} = road\ coordinates\ used\ to\ measure\ distance\\&p = coefficient\ determined\ in\ excel\\&k = coefficient\ determined\ in\ excel\end{aligned}$$

Figure 2.31: Form of distance function [Source: Analysys]

2.3 'Summary' worksheet

This worksheet gives a summary of the volumes calculated for each ESA within our sample, summarised by geotype. These volumes are then analysed within each geotype to derive average measures to be applied on a geotype basis within the CAN module.

2.3.1 Key parameters

The only parameters contained on this worksheet are indices related to the ESAs contained within the sample. These should not be changed. No other parameters are manually inputted into this worksheet, but numerous data and outputs are linked in from the DATA workbooks.

It is crucial that the code workbook links to the correct data workbooks: linking to old versions will lead to incorrect outputs being extrapolated for the active part of the model. Keeping the links valid is best achieved by always keeping the code and data workbooks in the same directory and by taking copies of the whole directory to create new versions.

Parameter	*Location*	*Impact*
Directory locations; number of geotypes and ESAs sampled	Rows 9-17	The formulae in these cells determine where the Visual Basic will look for the DATA workbooks. The whole geoanalysis and access network module must lie in the same directory for the Visual Basic to work
ESA index and corresponding demand input from the data sub-module	Rows 21-239	These volumes are linked in and their values are post-processed to be fed into the CAN module. These should only be changed by re-calculating the ESAs under different assumptions selected in the 'Inputs' worksheet

Table 2.5: Key parameters on the 'Summary' worksheet [Source: Analysys]

2.3.2 Flow diagram

The 'Summary' worksheet plays a role in both the input and output of the geoanalysis and access network module. The ESA indices are used to identify which ESAs are to be processed by the

Visual Basic, whilst the main table on the worksheet, linked to all the workbooks in the data sub-module, display the total volumes derived by the calculations.

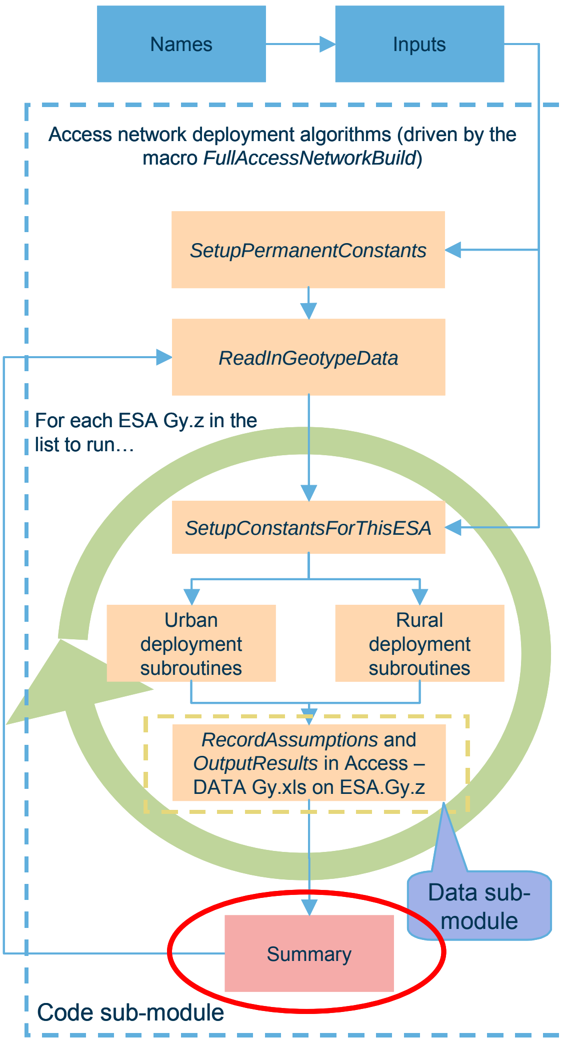


Figure 2.32: Location of the 'Inputs' worksheet within the overall structure of the geoanalysis and access network module [Source: Analysys]

2.3.3 Calculation description

Below the main table linking in volumes from the DATA workbooks, a summary of volumes and ratios for each geotype is calculated. Then a series of calculations that derive average volumes on a geotype basis to be fed into the CAN module are performed. These measures are used to derive geo-demographic and technical inputs for the CAN module.

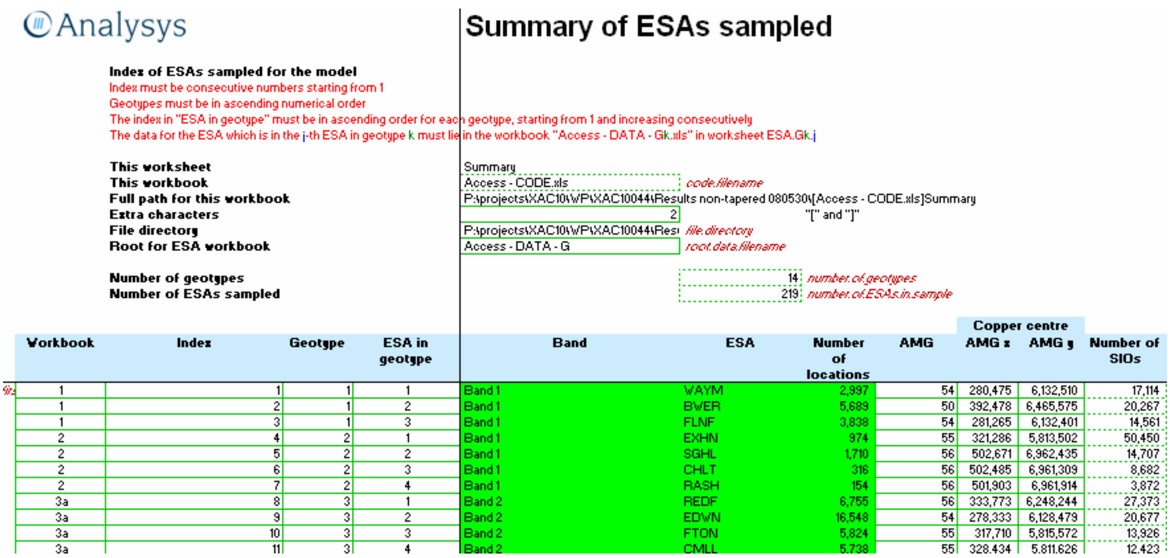
The following table outlines the calculations that take place on the 'Summary' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 21–239	Summary of volumes for each calculated ESA
Rows 243–264	Summary of volumes by geotype and then by band
Rows 282–286	Demand density by geotype
Rows 289–292	Access technology by geotype
Rows 296–301	Wired connections by geotype
Rows 305–458	Assets by geotype

Table 2.6: Calculations performed on the 'Summary' worksheet [Source: Analysys]

Summary of volumes for each calculated ESA

Cell reference	*Description and details of spreadsheet calculations*
Rows 21–239	Summary of volumes for each calculated ESA


Analysys

Summary of ESAs sampled

Index of ESAs sampled for the model
Index must be consecutive numbers starting from 1
Geotypes must be in ascending numerical order
The index in "ESA in geotype" must be in ascending order for each geotype, starting from 1 and increasing consecutively
The data for the ESA which is in the j-th ESA in geotype k must lie in the workbook "Access - DATA - Gk.xls" in worksheet ESA.Gk.j

This worksheet	Summary	
This workbook	Access - CODE.xls	code.filename
Full path for this workbook	P:\projects\XAC10\WP\XAC10044\Results non-tapered 080530\[Access - CODE.xls]Summary	
Extra characters	2	"[" and "]"
File directory	P:\projects\XAC10\WP\XAC10044\Res	file.directory
Root for ESA workbook	Access - DATA - G	root.data.filename
Number of geotypes	14	number.of.geotypes
Number of ESAs sampled	219	number.of.ESAs.in.sample

Workbook	Index	Geotype	ESA in geotype	Band	ESA	Number of locations	AMG	Copper centre AMG x	Copper centre AMG y	Number of SIOs
1	1	1	1	Band 1	WAYM	2,997	54	280,475	6,132,510	17,114
1	2	1	2	Band 1	BWER	5,689	50	392,478	6,465,575	20,267
1	3	1	3	Band 1	FLNF	3,838	54	281,265	6,132,401	14,561
2	4	2	1	Band 1	EXHN	974	55	321,286	5,813,502	50,450
2	5	2	2	Band 1	SGHL	1,710	56	502,671	6,962,435	14,707
2	6	2	3	Band 1	CHLT	316	56	502,485	6,961,309	8,682
2	7	2	4	Band 1	RASH	154	56	501,903	6,961,914	3,872
3a	8	3	1	Band 2	REDF	6,755	56	333,773	6,248,244	27,373
3a	9	3	2	Band 2	EDWN	16,548	54	278,333	6,128,479	20,677
3a	10	3	3	Band 2	FTON	5,824	55	317,710	5,815,572	13,926
3a	11	3	4	Band 2	CMLL	5,738	55	328,434	5,811,626	12,423

Figure 2.33: Excel sample of summary of volumes for each ESA [Source: Analysys]

Data in Columns F–H and M–DO is linked in from the relevant workbook from the data sub-module.

We also note that we have split certain ESAs due to them having multiple copper centres. Hence, one ESA can be in the table several times. A dash and a numerical identifier are used on the end of the four-letter ESA code to differentiate these. For example, ESAs 25 and 26 are the two parts to the Tuart Hill ESA and are labelled as TUTT-1 and TUTT-2 respectively.

Cell reference	*Description and details of spreadsheet calculations*
Rows 243–258	Summary of volumes by geotype and by band

The volumes in the main table are also aggregated by geotype and then further by band, as shown below.

Summary of volumes by geotype

Geotype summary		Count ESAs	862,386	1,334,615	196	217
Geotype 1	1	3	12,524	51,942	3	3
Geotype 2	2	4	3,154	77,711	4	4
Geotype 3	3	16	169,264	262,603	16	16
Geotype 4	4	28	256,381	345,420	27	27
Geotype 5	5	40	236,840	369,112	40	40
Geotype 6	6	9	35,347	52,556	9	9
Geotype 7	7	8	15,023	17,947	8	8
Geotype 8	8	6	8,178	10,203	6	6
Geotype 9	9	3	1,158	1,382	3	3
Geotype 10	10	21	75,202	86,695	21	21
Geotype 11	11	8	15,640	20,309	8	8
Geotype 12	12	24	23,690	27,781	19	23
Geotype 13	13	37	8,890	9,710	26	37
Geotype 14	14	12	1,095	1,244	6	12
Geotype 15	15	-	-	-	-	-
Geotype 16	16	-	-	-	-	-
Band summary			862,386	1,334,615	196	217
Band 1			15,678	129,653	7	7
Band 2			697,832	1,029,691	92	92
Band 3/4			148,876	175,271	97	118

Figure 2.34: Excel data for summary of volumes and calculation of their standard deviation by geotype and by band [Source: Analysys]

Output by geotype

This data is outputted into the CAN module, by the user copying and pasting the range H282:W458 into the CAN module using the “paste values” and “skip blanks” options of the advanced paste function (‘Alt-E’, ’S’, ‘V’, ‘B’, ‘OK’).

Cell reference	*Description and details of spreadsheet calculations*
Rows 282–286	Demand density by geotype
Rows 289–292	Access technology by geotype
Rows 295–301	Wired connections by geotype

Note: copy outlined area to CAN module	Total	Geotype 1	Geotype 2	Geotype 3	Geotype 4	Geotype 5	Geotype 6	Geotype 7
		1	2	3	4	5	6	7
Demand density								
Average number of SIOs per location	1.55	4.15	24.64	1.55	1.35	1.56	1.49	1.19
Average number of copper SIOs per location	1.32	2.69	3.15	1.35	1.27	1.34	1.39	1.16
Average number of fibre SIOs per location	140.62	104.90	314.11	108.83	109.87	118.42	84.12	64.86
Average number of wireless SIOs per location	1.12	-	-	-	-	-	-	-
Average number of satellite SIOs per location	1.17	-	-	-	-	-	-	-
Access technology								
Average proportion of SIOs addressed directly by copper	84.16%	64.05%	11.88%	86.95%	92.11%	86.01%	93.44%	97.47%
Average proportion of SIOs addressed directly by fibre	15.44%	35.95%	88.12%	13.05%	7.89%	13.99%	6.56%	2.53%
Average proportion of SIOs addressed directly by wireless	0.35%	-%	-%	-%	-%	-%	-%	-%
Average proportion of SIOs addressed directly by satellite	0.05%	-%	-%	-%	-%	-%	-%	-%
Wired connections								
Copper parameters								
Average proportion of copper SIOs directly connected to LE		3.13%	13.99%	2.46%	2.51%	3.74%	4.66%	8.92%
Average proportion of copper SIOs served by LPGS		0.94%	3.12%	22.87%	36.94%	29.56%	34.07%	20.93%
Average proportion of copper SIOs served by pillars		95.92%	82.89%	74.67%	60.55%	66.69%	61.28%	70.15%
Fibre parameters								
Average proportion of fibre SIOs directly connected to LE		1.31%	12.65%	2.09%	9.03%	14.26%	24.50%	-%
Average proportion of fibre SIOs served by pillars		98.69%	87.35%	97.91%	90.97%	85.74%	75.50%	100.00%

Figure 2.35: Excel data for calculation of geographical and technological factors by geotype [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 305–458	Assets by geotype

Figure 2.36 below shows examples of the parameters that are the ultimate outputs from the geoanalysis and access network module. These are a combination of average proportions and average lengths for various elements of the access network.

Assets						
Average number of LE per ESA	1.00	1.00	1.00	0.96	1.00	1.00
Average number of LE serving copper per ESA	1.00	1.00	1.00	0.96	1.00	1.00
Copper parameters						
Copper deployment type (1=URBAN, 2=RURAL)	1.00	1.00	1.00	1.00	1.00	1.00
Average number of SIO per DP	5.12	5.19	4.23	3.84	4.14	3.92
Average number of SIO per LE cluster	347.33	323.00	351.50	295.22	297.13	254.00
Average number of SIO per pillar	329.00	294.42	343.71	301.51	266.67	218.05
Average number of SIOs per LPGS	314.00	288.00	320.36	276.55	197.18	117.82
LPGS backhaul parameters						
% fibre	100%	100%	100%	100%	100%	100%
% wireless	-%	-%	-%	-%	-%	-%
% satellite	-%	-%	-%	-%	-%	-%
Fibre parameters						
Fibre demand connected directly	0	0	1	1	1	1
Percentage of copper pillars on fibre ring	100%	100%	-%	-%	-%	-%
Average number of pillars on a ring	14.00	6.75	-	-	-	-
Wireless parameters						
Average number of locations per BTS	-	-	-	-	-	-
Relay stations per BTS	-	-	-	-	-	-
Trench network parameters						
GNAF >> FDP						
Property boundary >> FDP						
FDP >> DP	3.57	4.40	5.85	6.82	9.16	8.34
DP >> next node	17.14	31.39	20.17	26.62	35.30	44.23
Pillar/ LPGS >> LE	63.02	69.44	101.08	145.25	193.68	265.85
Link on fibre rings (pillar to pillar)	22.56	65.68	-	-	-	-
DISTRIBUTION: trench by duct size						
28	-%	-%	-%	-%	0%	-%
24	-%	-%	-%	-%	-%	-%
20	-%	-%	-%	-%	0%	-%
16	-%	-%	-%	-%	0%	-%
12	0%	-%	0%	0%	0%	0%
8	0%	0%	0%	0%	1%	0%
6	5%	3%	3%	3%	2%	2%
4	23%	27%	16%	15%	11%	14%
2	26%	31%	34%	34%	26%	34%
1	46%	38%	46%	48%	59%	50%
DISTRIBUTION: pits by size						
PF28	-%	-%	-%	-%	0%	-%
PF20	-%	-%	-%	-%	0%	-%
PF12	9%	7%	6%	5%	5%	4%
P9	26%	32%	21%	21%	17%	26%
P6	32%	32%	49%	56%	40%	50%
P5	34%	29%	24%	18%	38%	21%

Figure 2.36: Excel data for calculation of assets by geotype [Source: Analysys]

3 Geoanalysis and access network module: Part II (DATA)

Section 2 described the code sub-module of the geoanalysis and access network module. The workbooks that form the accompanying data sub-module are described here. They store the results of all calculations for each ESA in a stratified sample. Each workbook's name takes the form *Access – DATA – Gy.xls*, with *y* being based on the index of the geotype. Due to file size, certain geotypes have been split across several workbooks (with the geotype index number suffixed with a letter). The 15th and 16th geotypes are not included within the sample and hence have no associated workbooks.

The remainder of this section is set out as follows:

- Section 3.1 outlines the information displayed in the 'FR.data' worksheet
- Section 3.2 outlines the information displayed in the 'Links' worksheet
- Section 3.3 outlines the information displayed in the 'ESA.Gy.z' worksheet.

3.1 'FR.data' worksheet

The 'FR.data' worksheet is intended to allow the user to select a particular ESA and view its fibre ring deployment (if it has been used), without having to construct the chart from scratch.

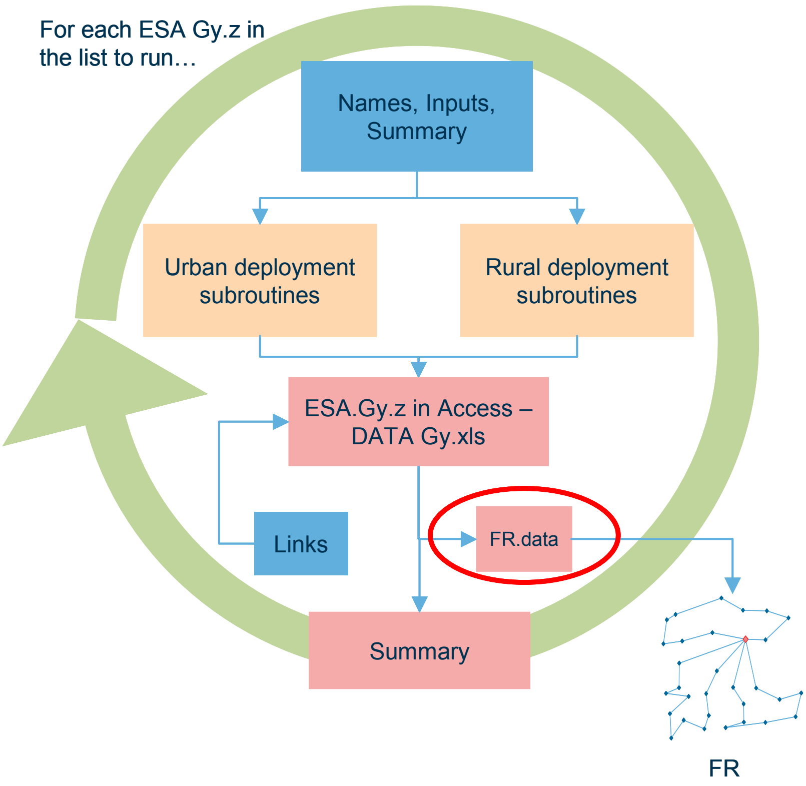


Figure 3.1: Location of the 'FR.data' worksheet within the overall structure of the geoanalysis and access network module [Source: Analysys]

The chart FR is currently limited to displaying the edges corresponding to the first thirty rows in the table in 'FR.data'. If there are more pillars, then the rings will appear incomplete, as not all edges can be displayed. The chart will then require additional series as appropriate.

3.1.1 Key parameters

The only parameter is in cell D3 and is the index of the ESA in the workbook for which the user would like to plot the fibre ring(s). The relevant co-ordinates are then linked into this worksheet in cells BA37:BD286 from the worksheet of the corresponding ESA.

3.1.2 Calculation description

The 'FR data' worksheet is used to generate the co-ordinates for plotting the fibre rings. This is used to plot the chart 'FR,' an example of which is shown in the figure below.

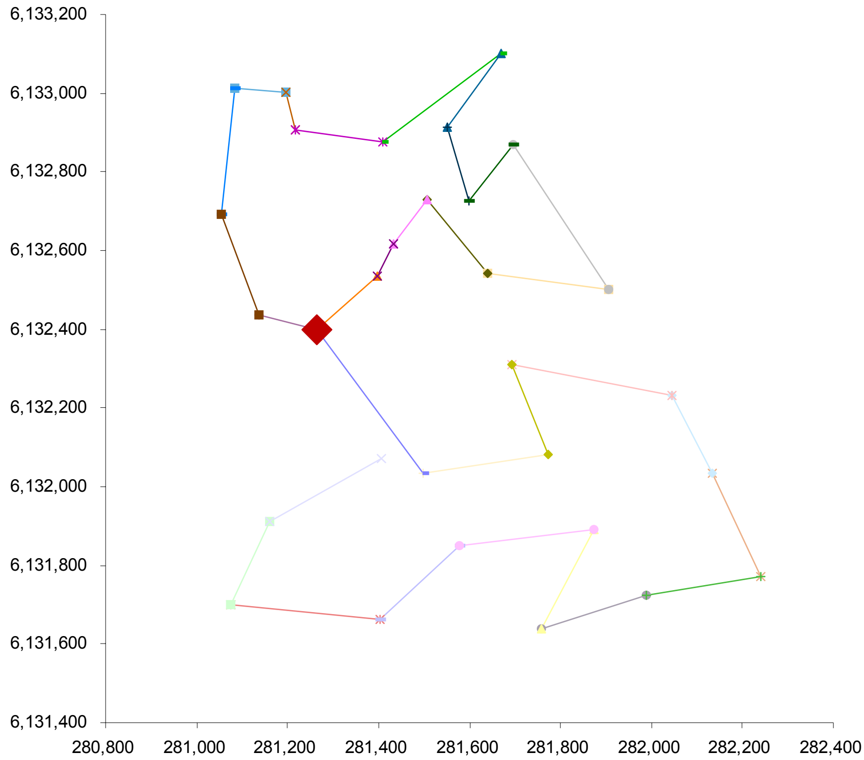


Figure 3.2: *Excel plot of fibre ring for a selected ESA [Source: Analysys]*

3.2 'Links' worksheet

This worksheet contains linked labels and inputs from the *Access – CODE.xls* workbook which are used for the consistent display of asset volumes in the output worksheets.

3.2.1 Key parameters

This worksheet does not require any inputs or user interactions.

Parameter	*Location*	*Impact*
Sizes of copper cable employed in the network	Rows 5–13	List of copper cable sizes used in the network: linked to a table breaking down the cable lengths by size for the processed ESA. There is also a separate table with the boundaries of demand to be served by each cable size in the final drop.
Labels	Rows 16–23	Labels used to identify the pillar clusters (and pillar equivalents) in the ESA
Duct combinations	Rows 27–36	Tables linked into the final output tables for each ESA to display the trench deployed with each number of ducts
Pit types	Rows 40–45	Labels used to identify the pit types deployed in the ESA
Distribution network options	Rows 49–50	Labels used to identify the options for the deployment of the cable in the distribution network

Table 3.1: Labels on the 'Links' worksheet [Source: Analysys]

3.2.2 Calculation description

These ranges are linked in from *Access – CODE.xls* and themselves link into the output tables of each ESA worksheet.

The cluster labels (LPGS, satellite, RAU etc.) are used for the summing of output volumes by cluster into totals for the whole ESA, but are also written within the Visual Basic. It is recommended that these are not changed without extreme care and should also be changed within the Visual Basic.

3.3 'ESA.Gy.z' worksheets

Each data workbook contains one worksheet for every ESA sampled. For example, the first geotype (used in the figures below) has three ESAs. Therefore, there are three worksheets in this module storing the outputs of the calculations. These are labelled 'ESA.G1.1', 'ESA.G1.2' and 'ESA.G1.3' respectively. The worksheet summarises the following data and outputs:

- basic information for the ESA, including ULLS Band, geotype, ESA code and number of locations
- assumptions used the last time that the ESA was calculated and the total time required

- co-ordinates of locations within the ESA and the assumed demand at each location, derived using the geocoded national address file (G-NAF)
- edges, if any, contained within the minimum spanning trees for any copper/fibre deployment
- locations of any DPs from the urban copper deployment
- edges, if any, contained within the minimum spanning trees for any wireless backhaul deployment
- volumes of trench and cable for each pillar cluster, or pillar equivalent
- edges, if any, contained within the fibre ring deployment in the ESA.

3.3.1 Key data and inputs

This workbook contains outputs for the ESA and assumptions used in the last calculation of its access network. The only input parameters on each worksheet are the co-ordinates and associated demand for each location. The remaining items are either recorded assumptions, information on the ESA or outputs from the network design algorithms.

The recorded assumptions are read in from the ‘Inputs’ worksheet within *Access – CODE.xls*. Output volumes are on a cluster basis, which are then re-calculated to arrive at single volumes on an ESA basis. In order to modify assumptions for an ESA(s) and view the changes, the necessary inputs must be modified in *Access – CODE.xls* and the relevant ESA(s) re-calculated.

The outputs stored are explained below. The worksheet is assumed to be for ESA *z* in geotype *y* (i.e. the worksheet ‘ESA.Gy.z’ in *Access – DATA Gy.xls*).

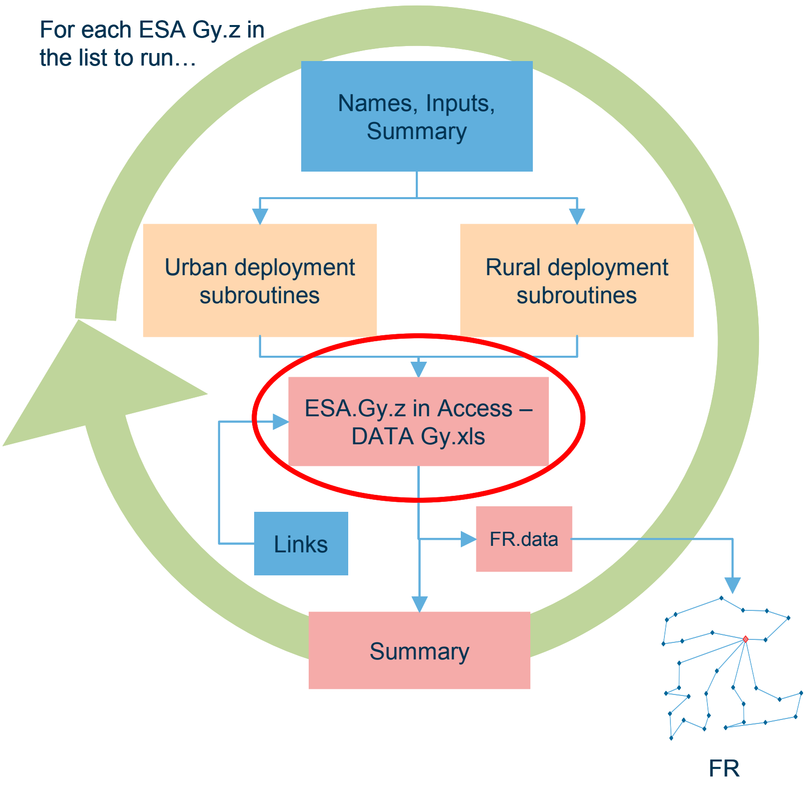


Figure 3.3: Location of the 'ESA.Gy.z' worksheet within the overall structure of the geoanalysis and access network module [Source: Analysys]

Parameter	*Location*	*Impact*
ESA data and acronyms	Cells B6–C28	Derived from several sources and specific to the ESA. A key to the acronyms used on the worksheet is also included.
Timings for calculation stages during last run	Cells G5–I29	An approximate breakdown for the time spent at each stage of the last calculation and the total time taken to process the ESA.
Capacity inputs and distance constraints	Cells K5–N28	These are the assumptions used within the latest calculation of the ESA. The code reads in data from the 'Inputs' worksheet even if it does not use it.
Other inputs used in the last calculation	Cells R5–U27	As far as possible, only the values actually used in the calculation are printed. These values are for archiving only: changing them will not affect the printed output volumes.
Final total volumes for ESA	Cells Y27–DZ27	Approximately 100 quantities are calculated for the whole ESA based on the outputs for the last calculation. These are linked into the 'Summary' worksheet in *Access – CODE.xls* to be extrapolated for the purposes of the CAN module.
Duct combinations	Cells Z7–AB16	Length of trench by ducts provisioned for the last calculation, up to a maximum of 28 duct.
Proxy cost functions	Cells AF7–AM22	Coefficients for the relevant proxy cost and distance functions used in the last calculation. Some of their column headings vary with the deployment used (URBAN / RURAL), so as to make their description more explicit.
Sheath by cable size within DP / pillar clusters and in the urban distribution network	Cells AS7–AU15	Approximate breakdown of the copper cable length by cable size. The left-hand column is the intra-DP linkages in URBAN deployments. The right-hand column is for DP–pillar (distribution network) cabling in URBAN deployments or for that within pillar clusters for RURAL deployments.
Total demand served by each final drop cable size	Cells AX7–BB11	This table separately aggregates both the demand and number of locations whose final drop is served by each cable size (up to 100-pair).
Other outputs	Cells AU18–AU20	Number of fibre rings, wireless relay stations and additional manholes for the last calculation
Location data and DP cluster (uses co-ordinates in Map Grid of Australia (AMG))	Cells B37–K	Co-ordinates of every location in the ESA, including the copper centre, as well as their associated demand and node classification data from the last calculation.
Assets volume by pillar	Cells M37–AY286	Printed values of asset volumes including trench and sheath on a pillar cluster basis
List of edges in fibre ring	Cells BA37–BD286	List of edges (in terms of the endpoints) that link pillars into a fibre ring(s)
Data on spanning trees connecting address locations	Cells BF37–BV	Co-ordinates of the endpoints of every edge in the trench network, printed from deployment algorithms. Also indicates duct requirements for each link.
Data on DP clusters	Cells BX37–CJ	Location and capacity data on the DP clusters for an URBAN deployment, printed from deployment

	algorithms. Also shows the derivation for the pit deployed at the node.

Table 3.2: Data and outputs displayed on the 'ESA.Gy.z' worksheet [Source: Analysys]

3.3.2 Description of information displayed

The following table summarises the information that is displayed on the 'ESA.Gy.z' worksheets:

Cell reference	*Description*
Cells B6–C28	ESA data and acronyms
Cells G5–I29	
Cells K5–N28	
Cells R5–U27	
Cells Y25–DZ27	
Cells Z7–AB16	See Table 3.2 above
Cells AF7–AM22	
Cells AS7–AU15	
Cells AX7–BB11	
Cells AU18–AU20	
Cells B37–K	Location data and DP cluster (uses co-ordinates in AMG)
Cells M37–AY286	Assets volume by pillar
Cells BA37–BD286	List of edges in fibre ring
Cells BF37–BV	Data on spanning trees connecting address locations
Cells BX37–CJ	Data on DP clusters

Table 3.3: Information displayed on the 'ESA.Gy.z' worksheets [Source: Analysys]

Parameters used for previous calculation

Cell reference	*Description and details of spreadsheet calculations*
Cells B6–C28	ESA data and acronyms

The ESA data provided in C6-C13 is fixed within the model. It has been written, along with the co-ordinates, when the workbook was created. The ESA code, ULLS Band and state for each ESA have been identified for each ESA. The geotype is a direct result of our geoanalysis, as is the AMG zone. This zone identifies the variant of the Map Grid of Australia co-ordinate system required to plot the co-ordinates accurately. The number of locations is calculated directly from the data currently included for the ESA.

ESA data

ESA	1.1	
ESA Code	WAYM	Code.ESA.G1.1
Geotype	1	Geotype.ESA.G1.1
Band	Band 1	Band.ESA.G1.1
AMG co-ordinate zon	54	AMG.Zone.ESA.G1.1
RAU location	1	RAU.node.ESA.G1.1
State	SA	State.ESA.G1.1
Deployment method	URBAN	calculation.branch.used.ESA.G1.1
Number of locations	2997	number.of.locations.ESA.G1.1

Acronyms

AMG	Map Grid of Australia 1994 co-ordinate system
BTS	Base Tranceiver Station
DP	Distribution pit
ESA	Exchange Service Area
FD	Final drop
FDP	Final drop point: where the cable leaves the street ne
GNAF	Geocoded National Address File
LE	Local exchange
LPGS	Large-pair gain system
RAU	Remote access unit

Figure 3.4: Excel sample of ESA data and acronyms [Source: Analysys]

Input data from the location and demand database

Cell reference	*Description and details of spreadsheet calculations*
Cells B37–K	Location data and DP cluster (uses co-ordinates in AMG)

The Location and Demand Database, which has been constructed using the G-NAF, contains a list of co-ordinates of addresses for the whole of Australia and associates a demand to each address entry. The addresses and demand for the sampled ESAs have been aggregated into locations and pasted into the relevant worksheets in the data sub-module.

There are two pairs of co-ordinates required for each location used. The first is derived directly from G-NAF. The second is derived from mapping the first co-ordinates directly onto their nearest street using MapInfo: this second point is referred to as the FDP. Both sets of co-ordinates are derived in the relevant zone. Changing the location data is an intrusive adjustment for an ESAs and will certainly change the network deployments.

The DP cluster index for URBAN deployments is printed during the calculation. The pillar cluster index is identified using the INDEX() function on the table of DP clusters. Whether the location is served by copper / fibre / wireless / satellite, as well as the exact nature of the location, is also printed.

Location data and DP cluster

Point index	FDP x (AMG)	FDP y (AMG)	GNAF x (AMG)	GNAF y (AMG)	Point capacity	Cluster index	Pillar index	Served by copper or fibre	Location type
	first.FDP.x.ESA	first.FDP.y.ESA	first.GNAF.x.ES	first.GNAF.y.ES	first.point.cap.E	first.cluster.ID.ESA.GI.I		first.technology.serv	first.location.type
1	280,475.04	6,132,509.97	280,475.04	6,132,509.97	1	1802	1	Copper	RAU
2	279524.18	6133709.66	279432.49	6133584.47	2	3	2	Copper	DP
3	279588.19	6130523.02	279591.31	6130272.91	2	2	3	Copper	FDP
4	279586.60	6130554.83	279703.17	6130560.65	2	2	3	Copper	DP
5	279653.98	6132509.18	279679.07	6132511.01	2	1186	8	Copper	FDP
6	279653.15	6132520.70	279678.16	6132522.52	75	1189	10	Fibre	FDP
7	279652.36	6132530.89	279677.18	6132532.71	2	1184	10	Copper	DP
8	279682.80	6132466.37	279681.01	6132487.63	2	1213	8	Copper	FDP
9	279654.90	6132497.66	279679.99	6132499.48	2	1186	8	Copper	DP
10	279670.33	6132828.12	279672.34	6132805.20	6	77	2	Copper	DP
11	279652.62	6132527.45	279684.29	6132529.77	3	1189	10	Copper	DP
12	279705.89	6132430.29	279687.46	6132428.73	11	1230	8	Copper	DP
13	279682.41	6132702.22	279679.48	6132736.55	3	1234	2	Copper	DP
14	279710.23	6132378.78	279691.71	6132377.22	2	1210	8	Copper	FDP
15	279708.95	6132393.85	279690.53	6132392.29	2	1216	8	Copper	FDP
16	279689.73	6132466.98	279687.32	6132495.00	6	1220	8	Copper	DP
17	279711.39	6132365.05	279692.87	6132363.50	2	1198	8	Copper	DP
18	279682.50	6132702.22	279685.16	6132671.75	2	1235	2	Copper	DP
19	279713.18	6132343.78	279694.66	6132342.22	2	1192	8	Copper	FDP
20	279684.65	6132829.35	279683.50	6132842.87	3	100	2	Copper	DP
21	279707.48	6132576.28	279693.25	6132575.05	2	1518	10	Copper	DP
22	279730.09	6132890.06	279690.60	6132885.88	2	68	2	Copper	FDP
23	279725.41	6131984.56	279723.75	6132004.17	2	841	27	Copper	FDP
24	279694.99	6132021.69	279724.09	6132024.17	3	842	27	Copper	DP
25	279694.10	6132032.20	279723.20	6132034.68	2	851	27	Copper	DP

Figure 3.5: Excel co-ordinates in AMG [Source: Analysys]

Outputs from the last calculation

Cell reference	*Description and details of spreadsheet calculations*
Cells M37–AY286	Assets volume by pillar

The asset volumes are listed individually for each pillar or equivalent cluster (e.g. BTS, LPGS) within the ESA, with the type of each such cluster clearly labelled. Certain measures cannot be split by cluster and their totals are printed directly into Row 35. For example, the incremental trench between the pillars and the RAU may be used by the links for several pillars, so it cannot be attributed to an individual pillar.

This table can store the asset volumes for up to 250 clusters, which is highly unlikely to be exceeded based on current settings. However, if alternative settings lead to the creation of more than 250 clusters in any one ESA[2], then the volumes from the algorithms will be printed but calculations within the worksheet would need to be extended as SUMIF() function on the columns in this table.

[2] For example a maximum pillar cluster size of only 100 SIOs would create more than 250 clusters in ESA with more than 25 000 SIOs.

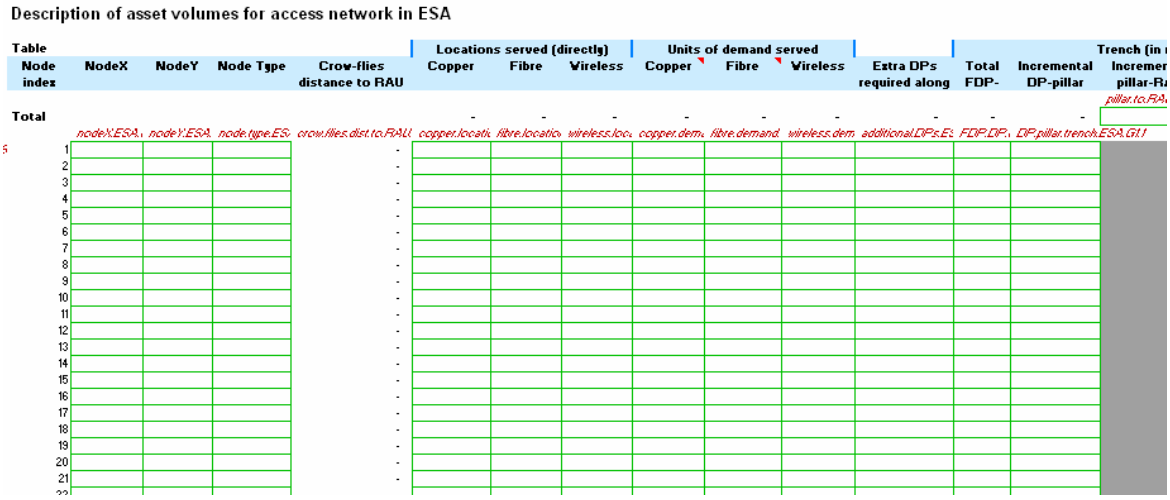


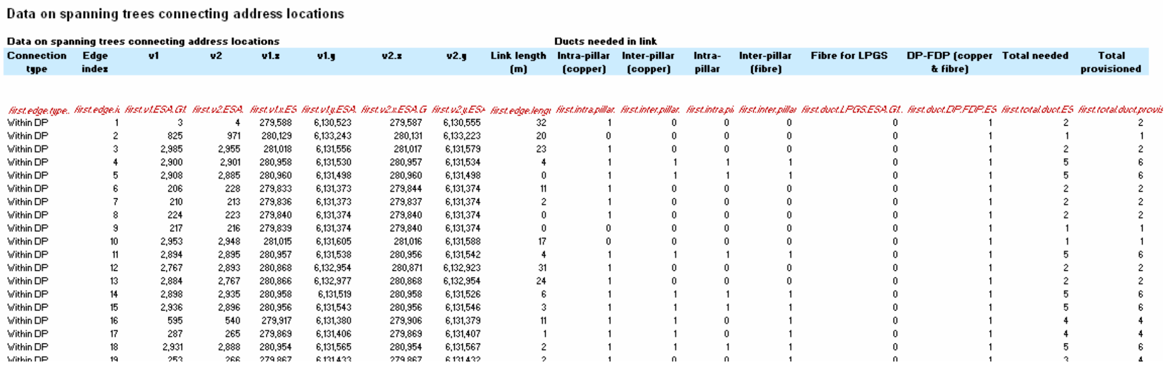
Figure 3.6: Excel outputs on asset volumes by pillar [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Cells BA37–BD286	List of edges in fibre ring

This table lists the co-ordinates of the endpoints of pillar-pillar links formed by the fibre rings. These co-ordinate pairs can be linked through to the chart 'FR' by selecting the ESA in the 'FR.data' worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Cells BF37–BV	Data on spanning trees connecting address locations

This table lists the co-ordinates of the endpoints of every edge within the trench network formed by the minimum spanning tree. These co-ordinate pairs can be plotted using MapInfo to inspect the resulting trees. The number of ducts, by use, is also printed for each link.



Data on spanning trees connecting address locations

Connection type	Edge index	v1	v2	v1.x	v1.y	v2.x	v2.y	Link length (m)	Ducts needed in link: Intra-pillar (copper)	Inter-pillar (copper)	Intra-pillar	Inter-pillar (fibre)	Fibre for LPGS	DP-FDP (copper & fibre)	Total needed	Total provisioned
Within DP	1	3	4	279,588	6,130,523	279,587	6,130,555	32	1	0	0	0	0	1	2	2
Within DP	2	825	971	280,129	6,133,243	280,131	6,133,223	20	0	0	0	0	0	1	1	1
Within DP	3	2,985	2,955	281,018	6,131,556	281,017	6,131,579	23	1	0	0	0	0	1	2	2
Within DP	4	2,900	2,901	280,958	6,131,530	280,957	6,131,534	4	1	1	1	1	0	1	5	6
Within DP	5	2,908	2,885	280,960	6,131,498	280,960	6,131,498	0	1	1	1	1	0	1	5	6
Within DP	6	206	228	279,833	6,131,373	279,844	6,131,374	11	1	0	0	0	0	1	2	2
Within DP	7	210	213	279,836	6,131,373	279,837	6,131,374	2	1	0	0	0	0	1	2	2
Within DP	8	224	223	279,840	6,131,374	279,840	6,131,374	0	1	0	0	0	0	1	2	2
Within DP	9	217	216	279,839	6,131,374	279,840	6,131,374	0	0	0	0	0	0	1	1	1
Within DP	10	2,953	2,948	281,015	6,131,605	281,016	6,131,588	17	0	0	0	0	0	1	1	1
Within DP	11	2,894	2,895	280,957	6,131,538	280,956	6,131,542	4	1	1	1	1	0	1	5	6
Within DP	12	2,767	2,893	280,868	6,132,954	280,871	6,132,923	31	1	0	0	0	0	1	2	2
Within DP	13	2,884	2,767	280,866	6,132,977	280,868	6,132,954	24	1	0	0	0	0	1	2	2
Within DP	14	2,898	2,935	280,958	6,131,519	280,958	6,131,526	6	1	1	1	1	0	1	5	6
Within DP	15	2,936	2,896	280,956	6,131,543	280,956	6,131,546	3	1	1	1	1	0	1	5	6
Within DP	16	595	540	279,917	6,131,380	279,906	6,131,379	11	1	1	0	1	0	1	4	4
Within DP	17	287	265	279,869	6,131,406	279,869	6,131,407	1	1	1	0	1	0	1	4	4
Within DP	18	2,931	2,888	280,954	6,131,565	280,954	6,131,567	2	1	1	1	1	0	1	5	6
Within DP	19	253	266	279,867	6,131,433	279,867	6,131,432	2	1	0	0	1	0	1	3	4

Figure 3.7: Excel outputs for edges in spanning tree [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Cells BX37–CJ	Data on DP clusters

This table lists the locations of every DP for ESAs processed with an urban deployment. For the rural deployment, every point that is served by copper is printed. In both cases, the derivation of the pit type deployed at the point is printed in stages.

Data on DP clusters

								Pit/ manhole calculations					
	Node index (RAU, pillar, LPGS)	Cluster index	DP x coord	DP y coord	Point representing DP	Number of vertices in cluster	Capacities in cluster	Ducts out of node	Max in one link	Count of links in to node	Pit - based on most ducts	Pit - based on links	Final pit size
													A pillar will b
d.E	first.node.idx.ESA.L	first.cluste	first.DP.	first.DP.;	first.cluster.centre.po	first.num.vertices.ESA.Gl	first.cluster.capacity.E	first.ducts.int	first.max.du	first.num.links.into.n	first.pit.by.ducts.ES	first.pit.by.link.	first.final.pit.
	3	1	279413	6129965	45	1	2	1	1	1	P5	P5	P5
	3	2	279587	6130555	4	2	4	3	2	2	P5	P5	P6
	2	3	279524	6133710	2	1	2	1	1	1	P5	P5	P5
	23	4	280379	6133413	1891	1	2	1	1	1	P5	P5	P5
	16	5	280684	6133245	2206	1	3	1	1	1	P5	P5	P5
	25	6	281154	6131487	2997	1	2	1	1	1	P5	P5	P5
	22	7	280131	6133223	971	2	4	2	1	2	P5	P5	P5
	7	8	280934	6133014	2906	1	2	1	1	1	P5	P5	P5
	22	9	280146	6133190	1465	1	2	1	1	1	P5	P5	P5
	22	10	280146	6133190	1467	1	20	3	1	3	P6	P6	P6
	7	11	280863	6133007	2848	1	3	2	1	2	P5	P5	P5
	3	12	279795	6131370	111	1	3	2	1	2	P5	P5	P5
	25	13	281017	6131579	2955	2	4	4	2	3	P6	P6	P6
	25	14	280957	6131534	2901	2	4	9	5	2	P9	P5	PF12
	25	15	280960	6131498	2885	2	4	9	5	2	P9	P5	PF12
	25	16	281018	6131562	2954	1	3	1	1	1	P5	P5	P5
	25	17	280918	6131467	2843	1	4	8	4	2	P9	P5	P9
	3	18	279844	6131374	228	2	4	6	2	5	P9	P9	P9
	3	19	279834	6131373	209	1	5	1	1	1	P5	P5	P5
	3	20	279837	6131374	213	2	4	2	2	1	P6	P5	P6
	3	21	279840	6131374	223	2	4	3	2	2	P5	P5	P6

Figure 3.8: Excel outputs on location of distribution points [Source: Analysys]

4 CAN module

The CAN module contains the calculations for the dimensioning of the network assets required from the customer location back to the local exchange (LE), extrapolating for all customer locations in Australia.

This module is structured as follows:

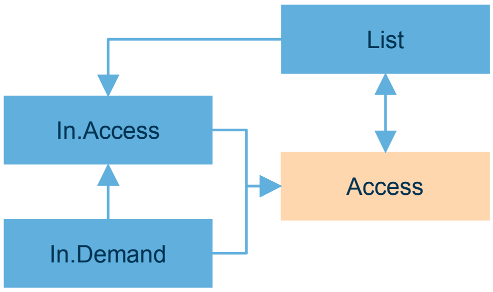


Figure 4.1: Structure of the CAN module [Source: Analysys]

- The 'List' worksheet links in defined names from the Cost module and defines names used within the workbook.
- The 'In.Demand' worksheet contains the demand mapped to geotypes from the Core module and location data derived via geoanalysis using MapInfo.
- The 'In.Access' worksheet contains the output data pasted in from the CODE workbook.
- The 'Access' worksheet contains the main calculations extrapolating the data derived from the geoanalysis of the sampled ESAs up to all ESAs.

In terms of the CAN architecture, it is important to establish the terminology used regarding the component elements of the path forming the access network:

Element	*Description*
NTP >> Property boundary (PB)	The distance from the network termination point (NTP) of a customer to the property boundary. It is normally assumed that the trench is provided by the customer.
PB >> serving pit (S.P)	The distance from the property boundary to the S.P on the same side of the road as the property, at the terminus of the road crossing passing underneath the road towards the customer's property. The distance from the NTP to this S.P is the customer lead-in.
Road crossing >> DP	The trench that passes underneath the road between the serving pits either side of the road, with one S.P. located at the actual DP location
FDP >> DP	The trench between FDPs and their parent DP in a DP cluster. This aggregation of demand corresponds to the first level of clustering within the URBAN deployment algorithm.
DP >> pillar/LE	DPs are linked back to a local pillar (or for those DPs near the exchange to the pillar at exchange). The pillar is a point in the access network at which sets of cables from DPs are aggregated for backhaul to the LE
Pillar >> LE	Represents the link from pillars, remote from the LE, back to the LE.
LPGS >> LE (non-ring deployment)	Represents the links from a LPGS (large pair gain system) back to the LE. An LPGS is a multiplexer unit deployed remotely from the LE in order to provide a telephony service to households that would otherwise be too distant from the LE to receive a telephony service using only copper.
Link on fibre rings (pillar-to-pillar)	Under the URBAN deployment algorithm, a parameter can be set that will link pillars and LPGS together on a fibre ring structure. The fibre serves LPGS and locations requiring fibre within each pillar cluster.
LE	The local network exchange building, which contains the MDF at which the individual lines are terminated

Table 4.1: Elements in the CAN [Source: Analysys]

The remainder of this section is set out as follows:

- Section 4.1 outlines the 'C', 'V' and 'S' worksheets
- Section 4.2 outlines the labels defined in the 'List' worksheet
- Section 4.3 outlines the key parameters and calculations in the 'In.Demand' worksheet
- Section 4.4 outlines the key parameters and calculations in the 'In.Access' worksheet
- Section 4.5 outlines the key calculations in the 'Access' worksheet.

4.1 Contents, version history and style guidelines

The Contents ('C'), Version History ('V') and Style Guidelines ('S') worksheets are standard across all modules. The first two of these worksheets simply contain the reference details of the worksheets that the workbook contains and its history of generation. The third worksheet identifies the Excel cell formatting styles implemented by Analysys in the LRIC model in order to provide clarity as to the contents of the individual cells.

The model uses a number of input parameters and is designed so that these can easily be changed. These are detailed in the ‘S’ worksheet.

The inputs themselves are separated into three types:

- inputs based on data (identified in the model using a dark green box outline)
- inputs based on estimates (a yellow cell within a dark green box outline)
- inputs which are parameters in the model (a dark blue box outline).

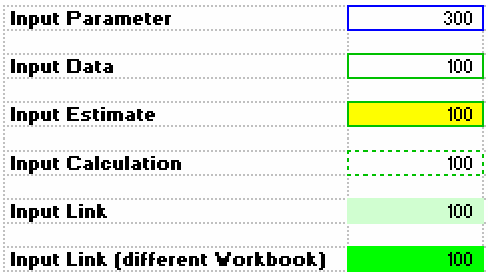


Figure 4.2: Cell formatting used in the LRIC model [Source: Analysys]

The inputs into the various modules are located on the worksheets whose names begin with ‘*In*’.

4.2 ‘List’ worksheet

This worksheet defines the list of assets for the CAN as well as the category, or level, for each asset. It also contains named ranges linked in from the Cost module.

4.2.1 Key labels

The names of each asset are defined in column L. As this list feeds into the ‘Access’ worksheet and summarises the calculated volumes of assets, it is critical that consistency is maintained. The units of volume for each asset is defined in column M.

The category type for each asset is defined in column O. This list should be only changed in conjunction with the ‘Recon’ worksheet within the Cost module, as these two worksheets interact to determine opex mark-ups by category type. Assets are given a category type in column K. It should be noted that a data validation check has been implemented on these inputs.

4.3 ‘In.Demand’ worksheet

This worksheet performs five main functions:

- stores data from the geoanalysis
- scales the number of locations based on known data regarding the services in operation (SIO) distribution
- links in demand by geotype, from the Core module
- captures the geoanalysis of the various distances from the NTP to the serving pits
- Calculates the length of trench for distribution points to the property boundary.

4.3.1 Key parameters

The specific locations for each of the line types is outlined below:

Location	*Description*
Rows 10–25	Captures the location data by geotype, specifically: • Identified locations (from the Location and Demand Database) • Locations in the sampled ESAs • Count of ESAs • Count of copper centres • Count of subdivided ESAs (where multiple or no copper centres exist) • Measured road distance (based on the processed StreetPro data)
Rows 29–30	The total number of SIOs used to dimension the CAN is linked in from the Cost module.
Rows 30–50	The total number of SIOs used to dimension the CAN is distributed by geotype The forecast ULLS and LSS SIOs by geotype are linked in from the core module.
Cells E58–H73	Captures distances from the geoanalysis, specifically: • 'Average distance: GNAF >> Road centre' • 'Average distance: Property boundary >> road centre' Captures assumption for 'NTP >> PB as % of GNAF >> PB' Calculates 'Average distance: NTP >> PB'
Cells K58–K73	Input the assumption for the distance of the serving pit from the property boundary. If required, change input by geotype.
N55	Define the Serving pit architecture Option 1: Serving pits placed at DP moved towards pillar by geo-analysis Option 2: Serving pits placed at location closest to demand-weighted centre of cluster
N76: Q76	Input proportion of property boundary width built to (λ)
N81:R81	Input proportion of DPs where road crossing deployed
N82:Q82	Defines additional serving pits required per road crossing
R83	Defines proportion of isolated FDPs requiring an additional serving pit
L58: V73	Calculation of distances for serving pit to property boundary

Table 4.2: Key parameters on the 'In.Demand' worksheet [Source: Analysys]

4.3.2 Calculation description

One significant calculation is performed on this worksheet to derive the distances between the NTP, property boundary (PB) and serving pit (SP) within DP clusters.

A number of calculations were performed in the geoanalysis to understand the magnitude of the distance for the path from the NTP to the serving pits. Using the G–NAF locations for the sampled ESAs, the land parcel boundaries from CadastralPlus and the road network from StreetPro, we calculate the average distance of the G–NAF >> FDP (represented as being situated in the middle of the road) and the PB >> FDP. The difference in the two distances is the 'G–NAF >>PB,' as illustrated in Figure 4.3.

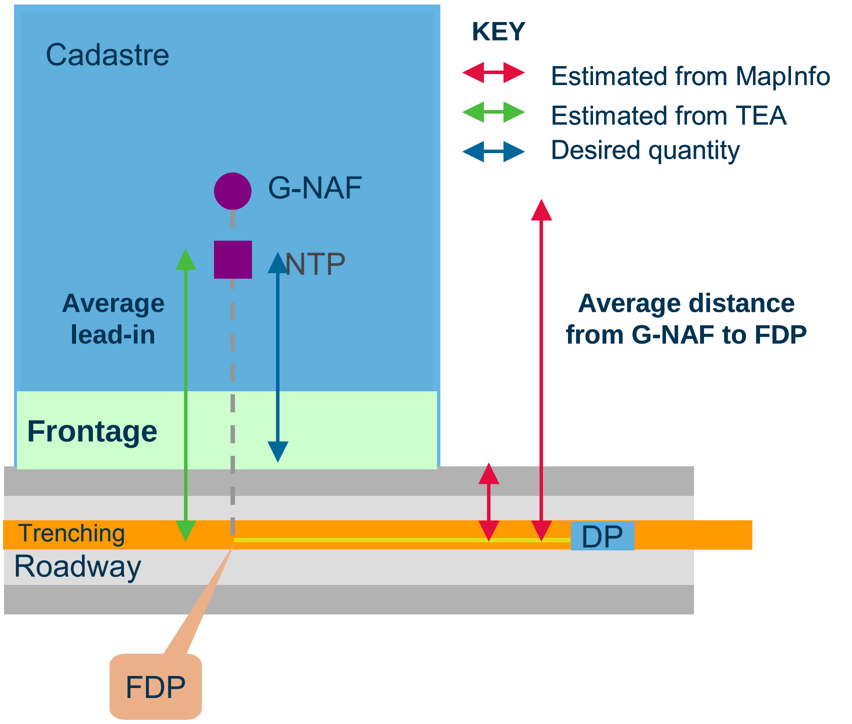


Figure 4.3: Final drop distances estimated from the MapInfo data sets [Source: Analysys]

It is believed that the distance from the NTP to the property boundary can be defined as a portion of the 'G–NAF >> PB' distance. We also calculate the average lengths of road crossings and the PB >> SP link, as described in the *Fixed LRIC model documentation*.

The results of this analysis is captured on rows 58–73. This data feeds into the 'In.Access' worksheet, as shown in Figure 4.4. The assumed proportion of 'G–NAF >> PB' distance for the 'NTP–PB' (column H) can be adjusted as a scenario.

Note: these parameters are taken from the geo-analysis (see Geo-analysis user guide)

		Deployment algorithm	Average distance: GNAF >> Road centre	Average distance: Property boundary >> road centre	Average distance: NTP >> PB	NTP >> PB as % of GNAF >> PB	Average road width (PB >>PB)	Distance of pits from property boundary	Average distance between locations in DP cluster	Road crossing distance
Geotype 1	Band 1	1	22.98	6.51	3.06	19%	13.02	1.00	9.01	11
Geotype 2	Band 1	1	19.66	6.12	2.52	19%	12.24	1.00	11.52	10
Geotype 3	Band 2	1	24.90	8.51	3.25	20%	17.02	1.00	9.58	15
Geotype 4	Band 2	1	27.91	8.54	4.05	21%	17.09	1.00	10.93	15
Geotype 5	Band 2	1	30.45	9.63	3.33	16%	19.26	1.00	13.96	17
Geotype 6	Band 2	1	36.50	9.13	5.22	19%	18.26	1.00	14.90	16
Geotype 7	Band 3/4 (clust	1	29.80	9.81	3.72	19%	19.61	1.00	18.03	18
Geotype 8	Band 3/4 (clust	2	47.01	10.80	6.73	19%	21.60	1.00	-	20
Geotype 9	Band 3/4 (clust	2	34.77	14.60	3.75	19%	29.20	1.00	-	27
Geotype 10	Band 3/4 (sprea	1	55.59	12.44	8.03	19%	24.88	1.00	17.91	23
Geotype 11	Band 3/4 (sprea	2	55.70	10.00	8.50	19%	20.00	1.00	-	18
Geotype 12	Band 3/4 (sprea	2	78.03	13.80	11.95	19%	27.60	1.00	-	26
Geotype 13	Band 3/4 (sprea	2	136.22	13.37	22.85	19%	26.73	1.00	-	25
Geotype 14	Band 3/4 (sprea	2	87.18	10.03	14.35	19%	20.07	1.00	-	18
Geotype 15	Band 3/4 (satell	-	-	-	-	19%	-	1.00	-	-
Geotype 16	No demand	-	-	-	-	19%	-	1.00	-	-
			33.93	9.43	4.59	19%				
			ave.dist.GNAF.FL	ave.dist.PB.FDP_	ave.dist.NTP.PB.g					ave.dist.road.cro

Proportion of property boundary width built to (λ):

100% = build to cent

Figure 4.4: *Inputs for NTP >> serving pit [Source: Analysys]*

4.4 'In.Access' worksheet

This worksheet holds the outputs of the CODE workbook of the geoanalysis and access network module.

4.4.1 Key parameters

The parameters in this worksheet should be updated if the CODE workbook is re-run, using the following procedure:

- On the 'Summary' worksheet of the CODE workbook, select the highlighted outputs (H282:W458) and copy
- On the 'In.Access' worksheet, go to the first parameter cell (E7)
- Using the Paste-Special function, paste "values" and "skip blanks" ('Alt–E', 'S', 'V', 'B', 'OK')

Note that it is vital that blanks are skipped so as to ensure that data on this worksheet linked in from elsewhere in the CAN module is not over-written.

4.5 'Access' worksheet

The 'Access' worksheet use the parameters from the offline modules to extrapolate volumes for all access network assets. The extrapolation needs to reflect the choice of access technologies in the offline module (fibre, copper, wireless, satellite) and changes in demand over time. Extrapolations are performed by geotype.

4.5.1 Key parameters

No parameters are stored on this worksheet. All parameters are taken from the ‘List’, ‘In.Demand’ and ‘In.Access’ worksheets.

4.5.2 Calculation description

Calculations on the ‘Access’ worksheet are summarised in the table below. Assets are calculate for the current modelled year.

Cell reference	*Description and details of spreadsheet calculations*
Rows 7–29	Number of SIOs and locations by both technology and by geotype. This is driven by the number of SIOs in the year and parameters from the geoanalysis.
Rows 34–40	Number of exchange areas and those that are wireless and satellite only. “Exchange areas” account for ESAs with multiple copper centres..
Rows 43–64	Number of copper clusters, and whether they are served by the pillar at the LE, by other pillars or by LPGS. The number of LPGS, by backhaul technology (fibre, wireless, satellite) is also calculated.
Rows 66–102	Number of DPs, including the distribution of DPs by the size of the main DP cluster. Number of isolated FDPs.
Rows 105–109	Number of fibre rings, which are used to connect pillars in dense urban exchange areas.
Rows 114–172	Length of trench, segmented by the number of ducts deployed, is calculated by geotype.
Rows 175–198	Number of pits and manholes, calculated by size. Pits deployed for DPs, as well as additional pits due to parameters related to maximum cable haulage, isolated FDPs and road crossings are also calculated.
Rows 202–273	Length of copper sheath deployed is calculated by geotype and by cable size (in terms of number of pairs). We make the distinction between the main network (from LE to pillar) and the distribution network – this is relevant for the next-generation access scenario, where pillars and main cable are replaced respectively with MSANs and fibre. The lead-in cable volumes are separately identified for cases where cost is not recovered through an annual rental due to be recovery through connection costs. The jointing required for the copper network is also calculated.
Rows 278–297	Distance of fibre sheath and number of fibre NTPs.
Rows 301–306	Number of wireless BTS and relay stations.
Rows 310–311	Number of satellite access nodes.
Rows 315–394	Summary table of assets. This feeds into the Cost module.
Rows 397–398	Calculation to inform the Core module of the number of pillars and fibre-fed LPGS by ESA. This is relevant to the next-generation access scenario.

Table 4.3: Calculations performed on the ‘’Access’ worksheet [Source: Analysys]

5 Core module

The Core module generates calculations for the dimensioning of the network from the MDF in the local exchange[3] (or the large pair gain system) into the core network.

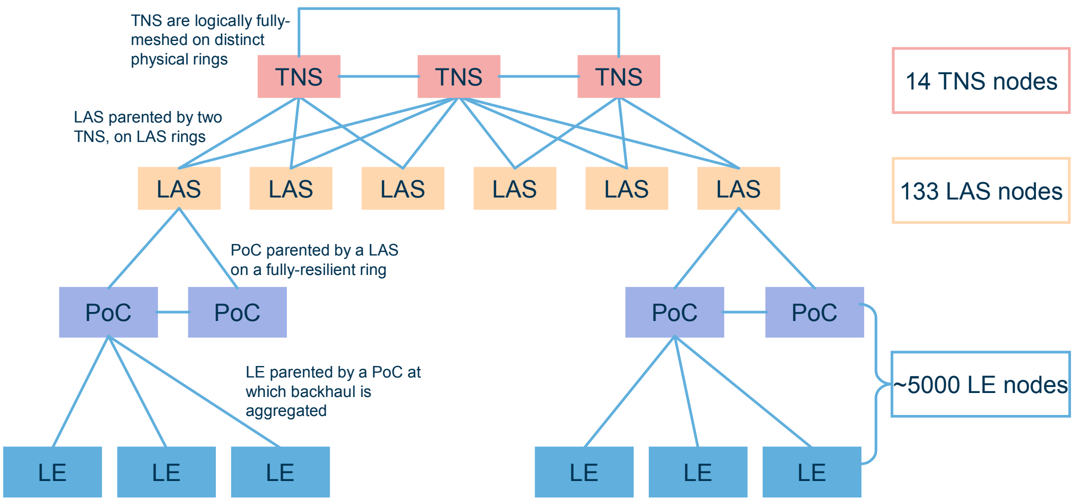
The Core module contains the calculations for both the modern and next generation network (NGN) architectures. A similar structure is used for the modern and NGN architectures, with the calculations at the corresponding levels of the two architectures taking place on the same set of worksheets:

Network Design worksheet	*Modern network level calculations*	*NGN level calculations*
NwDes.1.Access	Local exchange (LE)	Access Tier 1 and 2 (AT1 & AT2)
NwDes.2.PoC	Point of confluence (PoC)	Point of confluence (PoC)
NwDes.3.RegNodes	Local access switch (LAS)	Regional node
NwDes.4.CoreNodes	Transit network switch (TNS)	Core node
NwDes.5.Islands	Special island solutions	Special island solutions

Table 5.1: Network design worksheet content summary [Source: Analysys]

The levels of the core modern network and core NGN networks as modelled are shown below in Figure 5.1 and Figure 5.2 respectively.

3 The designated network physical boundary between the access and core network.

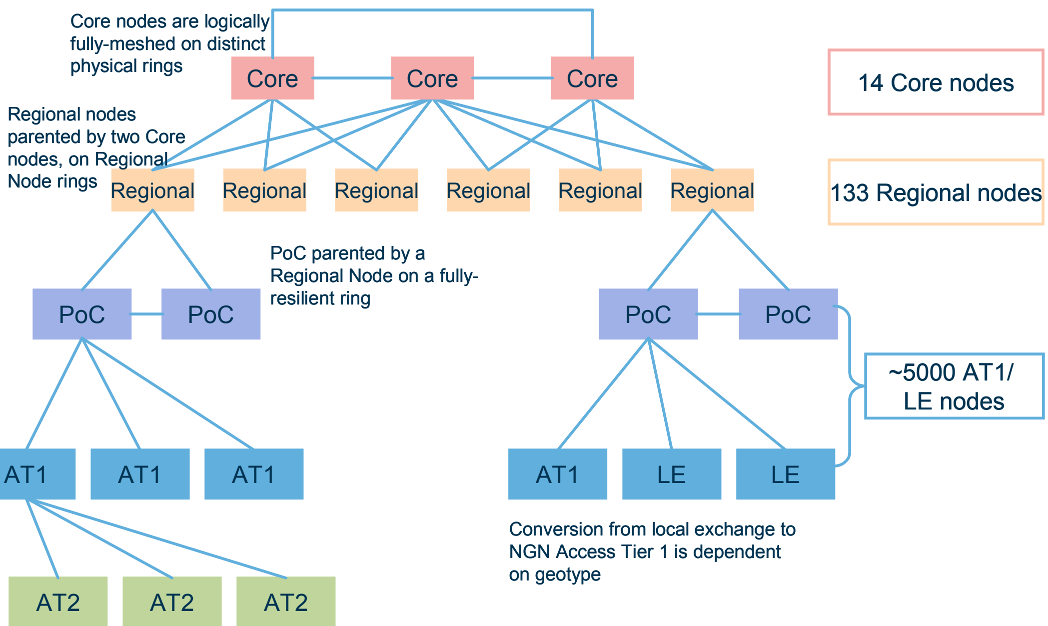


Note: LE: Local exchange; PoC: Point of confluence; LAS: Local access switch; TNS: Transit network switch

Note: A PoC is a local exchange on an SDH ring

Note: Although the Large Pair Gain Systems (LPGS), such as CMUX equipment, are costed as part of the core network, the deployment of these assets is actually calculated in the CAN module as it is modelled as an access decision.

Figure 5.1: Modern core network structure [Source: Analysys]



Note: AT2: Access Tier 2; AT1: Access Tier 1; LE: Local Exchange; PoC: Point of confluence; Regional: Regional nodes; Core: Core nodes

Note: A PoC is a AT1 on a resilient ring

Figure 5.2: NGN core network structure [Source: Analysys]

As indicated in Table 5.1, the network design algorithms for each network level are modelled in separate worksheets.

The modelling follows the scorched-node principle – the current locations of each of the main network nodes (LE, LAS, TNS) is retained, although the equipment modelled at each node location is efficiently determined by the busy-hour traffic carried on the network. The calculations are performed on a node-by-node basis in order to take into account equipment and transmission thresholds at each point in the network.

The remainder of this section is set out as follows:

- Section 5.1 outlines the ‘C’, ‘V’ and ‘S’ worksheets
- Section 5.2 outlines the ‘In.Control’ worksheet
- Section 5.3 outlines the key parameters and calculations in the ‘In.Demand’ worksheet
- Section 5.4 outlines the key parameters and calculations in the ‘In.Subs’ worksheet
- Section 5.5 outlines the key parameters and calculations in the ‘Dem.Calc’ worksheet
- Section 5.6 outlines the key parameters and calculations in the ‘In.Nodes’ worksheet
- Section 5.7 outlines the key parameters and calculations in the ‘Input.LAS.distances’ worksheet
- Section 5.8 outlines the key parameters and calculations in the ‘Input.TNS.Gravity’ worksheet
- Section 5.9 outlines the key parameters and calculations in the ‘In.Network’ worksheet
- Section 5.10 outlines the key parameters and calculations in the ‘NwDes.1.Access’ worksheet – this worksheet contains the asset and transmission calculations for both the modern LE level and the NGN AT1 level
- Section 5.11 outlines the key parameters and calculations in the ‘NwDes.2. PoC’ worksheet
- Section 5.12 outlines the key parameters and calculations in the ‘NwDes.3.Reg.Nodes’ worksheet – this worksheet contains the asset and transmission calculations for both the modern LAS level and the NGN Regional Nodes level
- Section 5.13 outlines the key parameters and calculations in the ‘NwDes.4.Core.Nodes’ worksheet – this worksheet contains the asset and transmission calculations for both the modern TNS level and the NGN Core Nodes level
- Section 5.14 outlines the key parameters and calculations in the ‘NwDes.5.Islands’ worksheet
- Section 5.15 outlines the calculations that take place on the ‘Out.Assets’ worksheet.

5.1 ‘C’, ‘V’ and ‘S’ worksheets

The Contents (‘C’), Version (‘V’) and Style Guidelines (‘S’) worksheets are standard across all modules. The first two of these worksheets contain the reference details of what the file contains and its history of generation. The latter worksheet identifies the Excel cell formatting styles implemented by Analysys in the model.

The model uses a number of input parameters, and is designed so that these can easily be changed. The type of changes that can be undertaken for input parameters are detailed in the ‘S’ worksheet. Specifically, the inputs themselves are separated into three types:

- inputs based on data (identified in the model using a dark green box outline)
- inputs based on estimates (a yellow cell within a dark green box)
- inputs which are parameters in the model (a dark blue box outline).

Input Parameter	300
Input Data	100
Input Estimate	100
Input Calculation	100
Input Link	100
Input Link (different Workbook)	100

Figure 5.3: Cell formatting used in the LRIC model [Source: Analysys]

The inputs into the various modules are contained within the worksheets preceded with the naming convention '*In.*'

5.2 'In.Control' worksheet

The 'In.Control' worksheet provides the primary interface for a user of the Core module wishing to run different pre-defined scenarios.

It contains several input parameters, which can easily be adjusted by a user of the model.

set contains major scenario parameters, which are linked directly from the Cost.xls module

Year modelled	2008	Scenario.year.modelled					
	='C:\Documents and Settings\dl\My Documents\wac10\2009 post consultation\WIP\Cost.xls'!Geotype.served.by.MSAN.(						
Geotype	1	2	3	4	5	6	7
MSANs deployed in geo-type (0=no, 1=yes)	0	0	0	0	0	0	0
Full TDM core deployed	1						
Force deployment of IP core	FALSE	Scenario.force.core.IP.deployment			Note: this parameter should only be set to TRUE in order to ge		
Deploy TDM core	1	Legacy.core.required			DEFAULT is FALSE		
Implement DWDM on transit links	TRUE	Scenario.DWDM.transit			Note: This switch set to TRUE forces TNS traffic to be carried		
Implement DWDM on LAS links	TRUE	Scenario.DWDM.LAS			Note: This switch set to TRUE allows LAS traffic to be carried		
# STM-64 links before DWDM equipment req	2				note: DWDM only deployed if number of STM-64 exceeds thi		
Distance uplift for slope effect	0%	Input.distance.uplift.slope			Note: this parameter is controlled in the Cost.xls module. It upli		
Select overlap level between core and access	4km buffer	Scenario.overlap.access.core			Note: this parameter is controlled in the Cost.xls module. It sele		

Note: This screenshot graphic shows only the inputs for geotypes 1–7, rather than for all of geotypes 1–16

Figure 5.4: Excel parameters used to set up user-defined scenarios [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*	*Impact*
Row 3	Year modelled	Changes which year's service demand levels are used to dimension the core model. Note: this parameter is controlled from the Cost module. To change this parameter, the user should go to the 'Scenario' worksheet in the Cost module.
Row 6	Determines if any traffic in each of the 16 geotypes requires an MSAN.	If any of the geotypes requires the deployment of MSAN equipment for its traffic, then a NGN core is required – this assumes IP transport and SIP signalling. Note, this parameter is controlled from the Cost module. To change this parameter, the user should go to the 'Scenario' worksheet in the Cost module. As soon as a single geotype is selected as having MSAN equipment deployed, then an IP core network is modelled. Deploying MSN equipment in a geotype results in the NGN core network algorithms being implemented. Furthermore, costs from the access network are transferred to the core network, as the core network boundary is pushed out further into the access network. The transfer of costs from the access to the core networks is calculated on the 'TA.Access' worksheet (cells M94:N96) in the Cost module
Row 8	Force deployment of IP core	This should only be set to TRUE in order to deploy an IP core when the access network is using TDM equipment
Row 11–12	Parameters determine whether DWDM is implemented on transit links and LAS links	If set to TRUE for the core, then DWDM equipment is deployed instead of SDH ADMs at the TNS/core node locations for the transport of transit traffic. If set to TRUE for the LAS/ regional network, DWDM is deployed if demand is sufficient and SDH if demand is lower. If FALSE, only SDH is deployed. This affects the calculation on the 'NwDes.3.Reg.Nodes' worksheet and on the 'NwDes.4.Core.Nodes' worksheet Rather than carrying traffic on multiple fibres, traffic is carried on individual wavelengths within a single strand of fibre. This effectively reduces the number of fibre metres deployed in the core network
Row 20	Distance uplift for slope effect	This parameter is linked from the Cost module and uplifts core transmission distances to account for them possibly being longer due to slope
Row 22	Overlap level between core and access	This parameter is linked from the Cost module. It selects the level of IEN-CAN overlap to calculate trench sharing

Table 5.2: Description of main scenario parameters [Source: Analysys]

5.3 'In.Demand' worksheet

The 'In.Demand' worksheet presents the appropriate year's service demand, for the traditional (non multi-service access node (MSAN)) and NGN (MSAN) parts of the network, for use in the Core module algorithms.

The 'In.Demand' worksheet links in the forecast service demand data from the Cost module (from the 'Inputs.Demand' worksheet). The outputs of this worksheet feed into the 'Dem.Calc' worksheet, which are used to calculate the service demand per subscriber. These per subscriber demands are then used at each level in the network deployment algorithm. These linkages are shown in the diagram below:

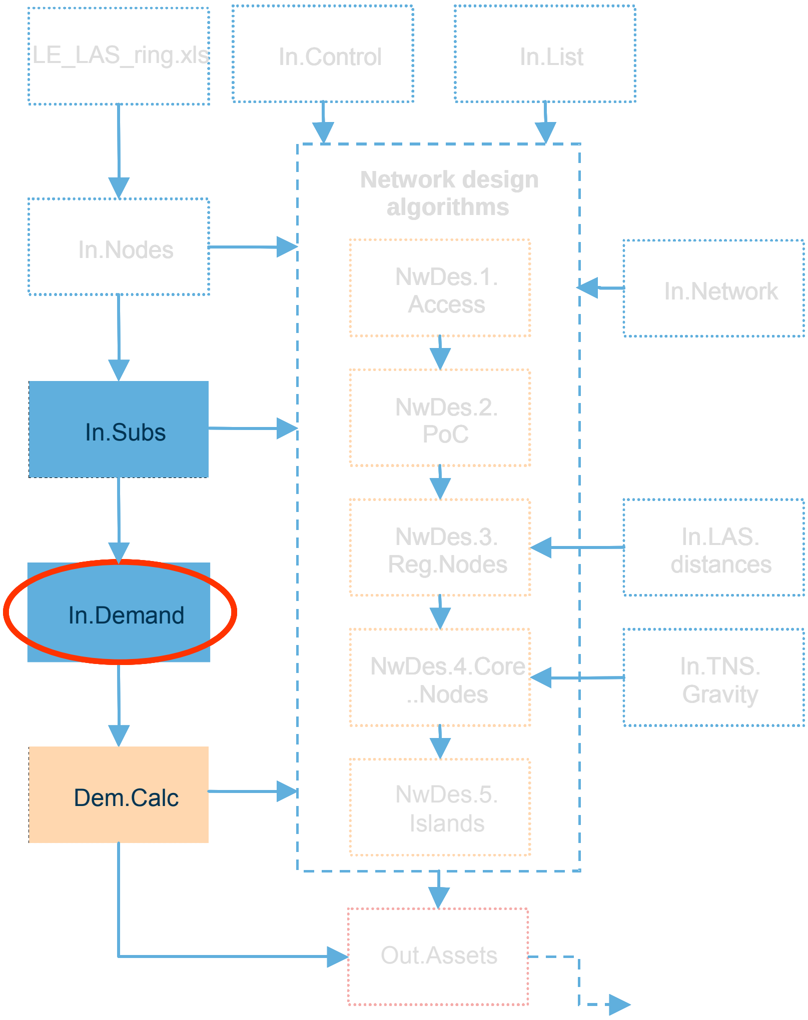


Figure 5.5: Location of the 'In.Demand' worksheet in the overall Core module structure [Source: Analysys]

5.3.1 Key parameters

There are no key parameters that can be manipulated directly on this worksheet. Manipulation of the subscriber numbers should be done in the Cost modules and on the In.Subs worksheet of the Core module.

5.3.2 Calculation description

The table below details the specific calculations that are performed in the 'In.Demand' worksheet

Cell reference	*Description of spreadsheet calculations*	*Details of spreadsheet calculations*
Row 4	Modelled year	Linked from the 'In.Control' worksheet, in turn linked from the Cost module ('Scenario' worksheet)
Rows 6–7	Flag of whether any traffic in each of the 16 geotypes requires an MSAN.	Linked from the 'In.Control' worksheet, in turn linked from the Cost module ('Scenario' worksheet)
Rows 10–15	Calculation of subscribers by geotype	Calculated using the subscriber data from the 'In.Subs' worksheet
Rows 19–22	Percentage of traffic carried using MSAN equipment	These determine the split of demand for the year modelled between modern (non-MSAN) and NGN (MSAN) traffic
Row 26	Local exchanges enabled for xDSL	Linked in from the Cost module and used to distribute xDSL subscribers
Rows 29–58	Demand array for modelled services	Linked in from the Cost module ('Inputs.Demand' worksheet)
Rows 61–90	Demand sensitivity array - adjusts the volume of demand used to calculate network equipment requirements and thus can be used to set up demand scenarios e.g. setting all of these demand multipliers to zero would make the model non-traffic driven and could be used to calculate common costs	Linked in from the Cost module ('Inputs.Demand' worksheet)
Rows 94–123	Call data for modelled services	Linked in from the Cost module ('Inputs.Demand' worksheet)

Table 5.3: Calculations performed on the 'In.Demand' worksheet [Source: Analysys]

The demand inputs are listed by year and selected on the basis of the year chosen in the 'Scenario' worksheet of the Cost module. Traffic is split into MSAN and non-MSAN traffic on a geotype basis, determined also in the 'Scenario' worksheet. .

Access line data, distributed by ESA in the access module, can change slightly due to rounding errors. The volumes that flow through the model are adjusted in this worksheet.

Traffic data is linked from the Cost module, so cannot be adjusted directly in this worksheet. Under the NGN scenarios, dial-up traffic is removed in proportion to the number of subscribers in geotypes with MSAN deployment enabled.

5.4 'In.Subs' worksheet

This worksheet calculates the subscribers that are controlled by each node at each level in the network (i.e. at the LE, LAS, and TNS levels). The layout of this worksheet is shown below:

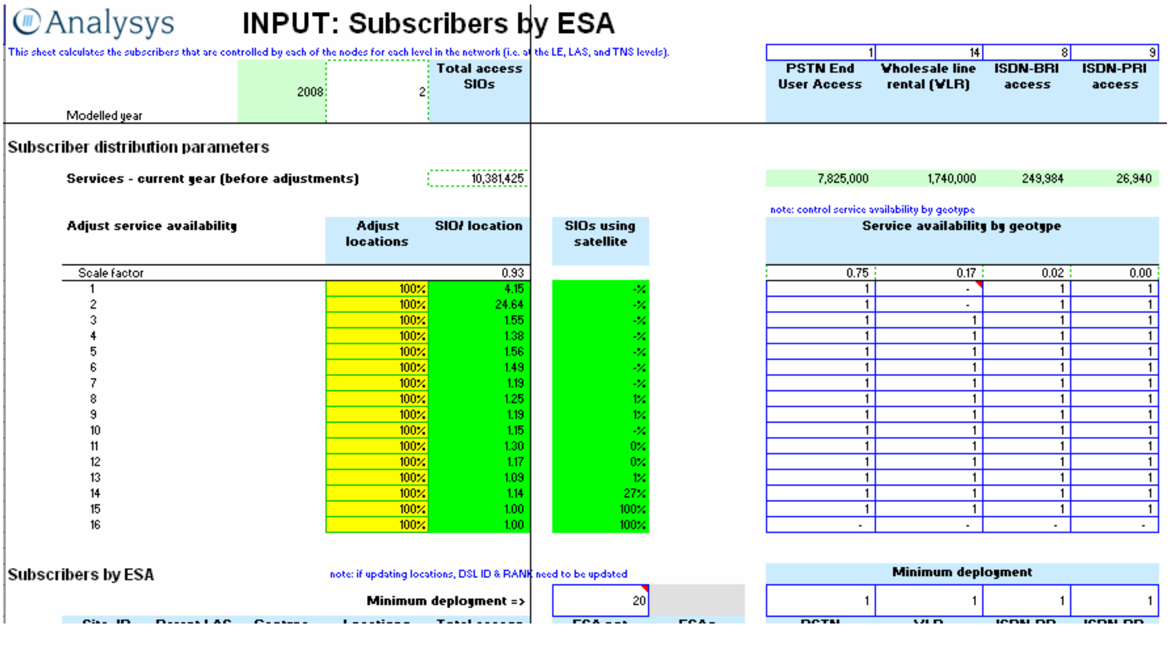


Figure 5.6: 'In.Subs' worksheet: output node data [Source: Analysys]

This worksheet links distributes access subscriber demand across ESAs for Public Switched Telephony Network (PSTN), Wholesale Line Rental (WLR), Integrated Services Digital Network (ISDN)-BR, ISDN-PR, Asynchronous Digital Subscriber Line (ADSL) retail, ADSL wholesale, Symmetric Digital Subscriber Line (SDSL) retail and SDSL wholesale subscribers. Subscriber demand by geotype feeds into the Access module for PSTN, WLR, ISDN-BR, ISDN-PR, Unconditioned Local Loop Service (ULLS) and Line Sharing Service (LSS).

The calculated subscribers numbers feed into the appropriate network design algorithm worksheet, i.e. the calculated LE subscribers are linked into the 'NwDes.1.Access' worksheet; the calculated LAS subscribers are linked into the 'NwDes.3.Reg.Nodes' worksheet; and the calculated TNS subscribers are linked into the 'NwDes.4.Core' worksheet.

Due to rounding effects, subscribers by geotype do not quite total the input value, therefore the resultant values replace the projections in the Core module. The calculated subscriber numbers are used on the 'In.Demand' worksheet (specifically in cells C10:R15, K29, K36, K37, K40:K42 and K50), and subsequently into the 'Dem.Calc' worksheet where they are used to calculate the demand per subscriber. These values of demand per subscriber are then used at each level in the network deployment algorithm. These linkages are shown in the diagram below:

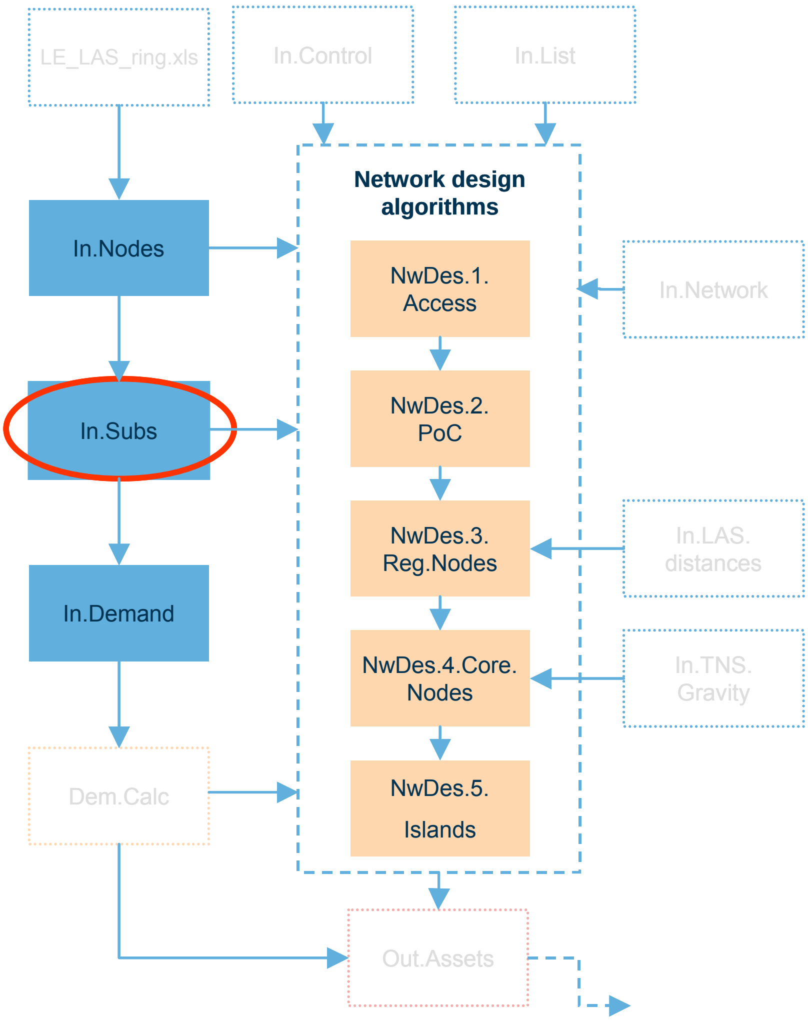


Figure 5.7: Location of the 'In.Subs' worksheet in the overall Core module structure [Source: Analysys]

5.4.1 Key parameters

The key parameters on the 'In.Subs' worksheet impact the distribution of subscribers by geotype.

Location	*Description*
E12–E27	‘Adjust locations’ is a set of parameters can modify the identified locations from the location and demand database to reflect the known number of total SIOs by geotype. However, these inputs have been set to a default of 100%, replicating the potential demand across Australia before competition.
H31	Defines a threshold where small ESAs will be served by satellite
K12–S27	Defines the geotype in which a service is available for PSTN, WLR, ISDN BR, ISDN PR, ULLS, Lines in the CAN, LSS.
K31–Y31	Defines the minimum threshold for a service to be recognised in an ESA. Without this, there is the potential for small values of a service (less than 1) to be extrapolated in an ESA which would not be reasonable.
AA33–AB5286	ESAs need to be ranked in an order that reflects the likely order in which they may be enabled with xDSL services. This allows a subset of exchanges to be enabled in a logical manner. ESAs are currently ordered by descending number of locations in a geotype, then subsequent ESAs are ordered
AD12–AH27	Defines the geotype in which a service is available for ADSL retail, ADSL wholesale, SDSL retail and SDSL wholesale services.
AK12–AL27	Average number of copper SIOs per pillar and per LPGS. Linked in from the CAN module
AD31–AH31	Defines the minimum threshold for an xDSL service to be recognised in an ESA. Without this, there is the potential for small values of a service (less than 1) to be extrapolated in an ESA which would not be reasonable. xDSL service availability is also limited by whether an exchange is enabled.

Table 5.4: Key parameters on the ‘In.Subs worksheet [Source: Analysys]

5.4.2 Calculation Description

The table below outlines the calculations that take place on the ‘In.Subs’ worksheet:

Cell reference	*Description of spreadsheet calculations*	*Details of spreadsheet calculations*
Rows 33–5286	Line data by ESA	Calculated based on availability of service in geotype, scaled for current year demand
Rows 5292–5424	Line data by LAS	Calculated using a SUMIF() formula according to the parent LAS of each LE
Rows 5429–5442	Line data by TNS parent 1	Calculated using a SUMIF() formula according to the TNS parent 1 of each LAS
Rows 5447–5460	Line data by TNS parent 2 – each LAS has 2 parents defined for redundancy	Calculated using a SUMIF() formula according to the TNS parent 2 of each LAS
Rows 5465–5480	Summary: Subscribers by geotype	Calculated using a SUMIF() formula using the LE geotypes
AK33–AL5286	Derives MSAN-equivalent assets using pillars / fibre-fed LPGS by ESA	Based on data linked from CAN module
AM33–AM5286	NGA copper SIOs	Maximum of ‘PSTN & WLR SIOs’ or xDSL SIOs

Table 5.5: Calculations performed on the ‘In.Subs’ worksheet [Source: Analysys]

5.5 ‘Dem.Calc’ worksheet

The ‘Dem.Calc’ worksheet is used to calculate service routed busy-hour Erlang or busy-hour kbit/s load on each of the different parts of the network.

Input parameters defining the busy hour demand on the network are linked from the ‘In.Network’ worksheet. The appropriate level of demand data is linked from the ‘In.Demand’ worksheet.

The calculated busy hour demand is converted into a per-subscriber demand measure for the modern and NGN deployments and are subsequently used to dimension the network elements at each network level – the calculations for which take place on the separate network deployment algorithm worksheets.

These linkages are shown in the diagram below:

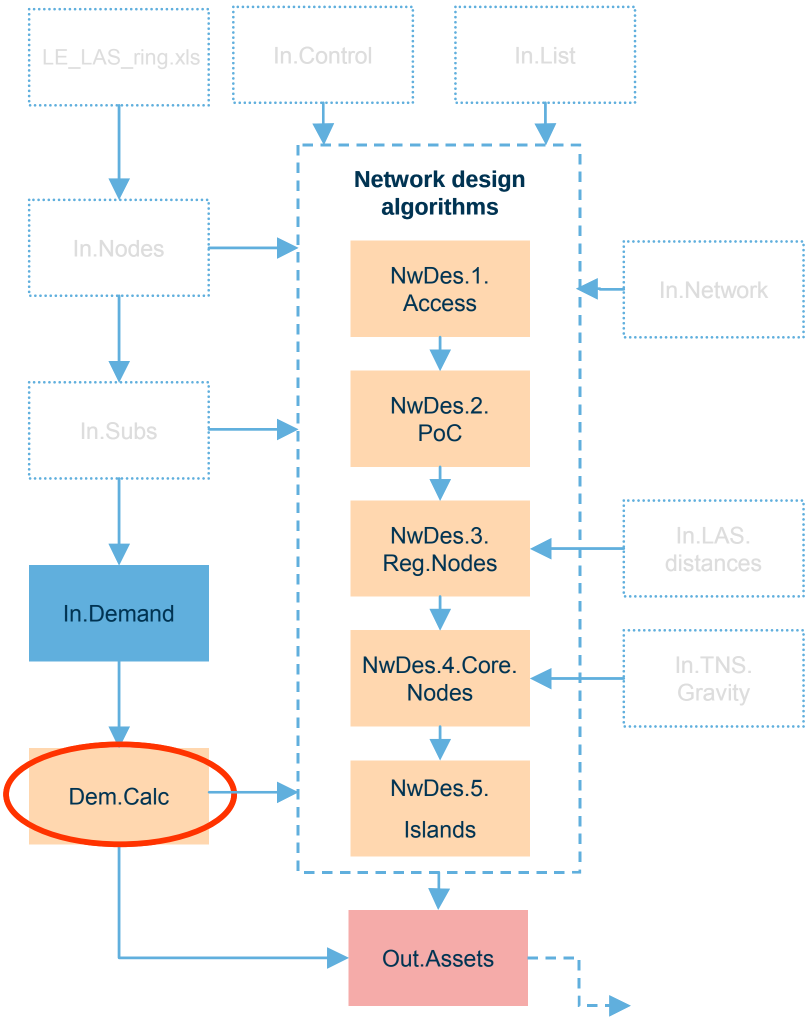


Figure 5.8: Location of the 'Dem.Calc' worksheet in the overall Core module structure [Source: Analysys]

5.5.1 Key parameters

There are two main sets of parameters on the 'Dem.Calc' worksheet that can be directly manipulated by the user:

Parameter	*Location*	*Impact*
Weighting of traffic routes through the network	Rows 134–227 for PSTN & NGN Rows 316–331 for NGN ISDN only	The weighting of the different traffic routes through the network determines the intensity to which the traffic interacts with certain network elements
Non-inclusion of LTH-LTH links for ISDN routeing	C213 and C216	Determines whether routes including an LTH–LTH link are included in the calculation of network asset utilisation for ISDN

Table 5.6: Key parameters in the 'Dem.Calc' worksheet [Source: Analysys]

Analysys

5.5.2 Calculation description

The table below lists specific data inputs and calculations by row number.

Cell reference	*Description and details of spreadsheet calculations*
Rows 5–21	Demand parameters used to calculate the busy hour load on the network
Rows 25–88	Demand calculation of service busy hour Erlang load and busy hour call attempts – modern and NGN
Rows 98–127	Input & calculation of modern network service routeing factors
Rows 134–230	Input and calculation of the modern and NGN service routeing factors according to weighted network call-paths through the network by traffic type
Rows 234–264	Calculation of the busy hour load for each part of the modern network according to the routed service demand
Rows 267–271	Calculation of the busy hour load for each part of the network on a per PSTN SIO and per ISDN SIO basis - modern network
Rows 280-309	Calculation of NGN service routeing factors
Rows 316–334	Calculation of the NGN service routeing factors according to the weighted network call paths through the network by traffic type
Rows 338–370	Calculation of the busy hour load for each part of the NGN according to the routed service demand
Rows 372–377	Calculation of the busy hour load for each part of the NGN on a per PSTN SIO and per ISDN SIO basis

Table 5.7: Calculations performed on the 'Dem.Calc' worksheet [Source: Analysys]

The remainder of this section details the calculations that take place on the 'Dem.Calc' worksheet.

Calculation of busy hour demand

Cell reference	*Description and details of spreadsheet calculations*
Rows 25–88	Demand calculation of service busy hour Erlang load and busy hour call attempts

The calculation of the busy-hour Erlangs/kbit/s is shown below, and explained in detail below:

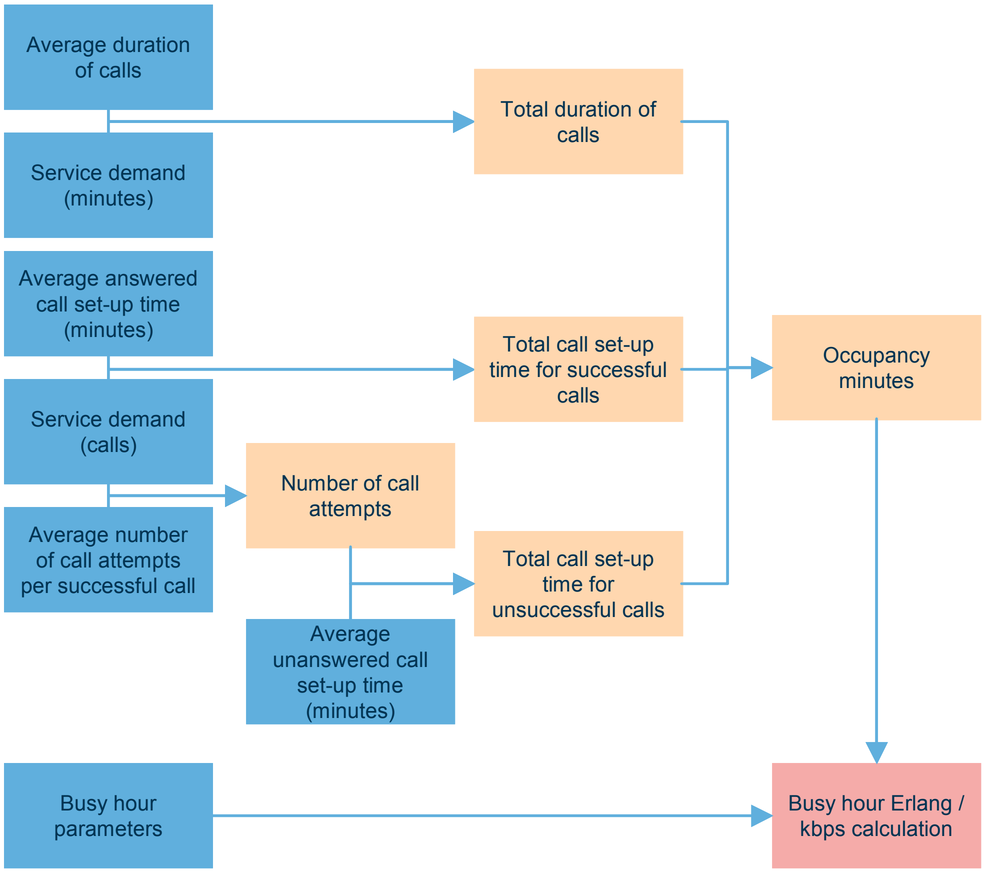


Figure 5.9: Calculation of demand loading on each part of the core network [Source: Analysys]

Demand is calculated separately for the MSAN and non-MSAN equipment.

- Columns E–F link in the level of demand and number of calls, by service, for the selected year from the 'In.Demand' worksheet.
- Column G calculates the average duration of calls for those services that are measured in terms of minutes.
- Columns H–I calculate the average number of call attempts per successful call.
- Columns J–K link in the average ringing time for successful and unsuccessful calls.
- Column L calculates the number of occupancy minutes by service. This calculation is based upon the average duration of successful calls, plus ringing time for successful and unsuccessful calls.
- Columns M–N calculate the busy hour volume in terms of Erlangs, kbit/s and call attempts.
- Column Q calculates the average call duration blended across both MSAN and non-MSAN.

The calculated Excel output of the service demand for the non-MSAN equipment is shown below in Figure 5.10 and Figure 5.11.

Demand calculation - MSAN traffic

Note: These calculations determine the busy hour load on the NGN network, including call set-up times

Services	Units	Type	Demand	Calls	Average duration of calls
PSTN End User Access	Lines	Lines	-	-	-
PSTN local traffic (onnet traffic)	Minutes	Voice	-	-	-
PSTN national long distance traffic (onnet calls)	Minutes	Voice	-	-	-
PSTN outgoing traffic to international destinations	Minutes	Voice	-	-	-
PSTN outgoing to mobile traffic (mobile terminating)	Minutes	Voice	-	-	-
PSTN terminating traffic (from international, mobile, other	Minutes	Voice	-	-	-
Local carriage service (LCS)	Minutes	Voice	-	-	-
ISDN-BRI access	Lines	Lines	-	-	-
ISDN-PRI access	Lines	Lines	-	-	-
Service 10	none	Data	-	-	-
ISDN - voice traffic	Minutes	Voice	-	-	-
Unconditioned local loop service (ULLS)	Lines	Lines	-	-	-
Line sharing service (LSS).	Lines	Lines	-	-	-
Wholesale line rental (WLR)	Lines	Lines	-	-	-
Service 15	none	Voice	-	-	-
Dial-up Internet Traffic	Minutes	Voice	-	-	-
ADSL retail lines	Lines	Lines	-	-	-
ADSL wholesale lines	Lines	Lines	-	-	-
SDSL retail lines	Lines	Lines	-	-	-
SDSL wholesale lines	Lines	Lines	-	-	-
Other services on ATM	Mbit/s	Lines	-	-	-
Lines in CAN	Lines	Lines	-	-	-
Service 23	none	Lines	-	-	-
Mbit/s in LE-LTH	Mbit/s	Transmission	-	-	-
Mbit/s in LTH-MTH	Mbit/s	Transmission	-	-	-
Mbit/s in MTH-MTH	Mbit/s	Transmission	-	-	-
Service 27	none	None	-	-	-
Service 28	none	None	-	-	-
Service 29	none	None	-	-	-
Service 30	none	Overheads	-	-	-

Service.demand.MSAN.traffic

Figure 5.10: Calculation to determine demand for non-MSAN traffic [Source: Analysys]

Number of call attempts	Average number of call attempts per	Average answered call set-up time (minutes)	Average unanswered call duration (minutes)	Occupancy minutes	Busy hour kbit/s calculation	Busy hour call attempts in year	Average duration of calls (MSAN + non-MSAN)
-	-	-	-	-	-	-	-
-	-	0.17	0.47	-	-	-	5.00
-	-	0.17	0.47	-	-	-	5.82
-	-	0.17	0.47	-	-	-	7.91
-	-	0.17	0.47	-	-	-	2.00
-	-	0.17	0.47	-	-	-	2.79
-	-	0.17	0.47	-	-	-	5.36
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	0.17	0.47	-	-	-	8.01
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	0.17	0.47	-	-	-	62.34
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

BHkbps.Dema BH.Call.Attempts.MSAN.traffic Service.demand.Ave.C

Figure 5.11: Calculation to determine demand for non-MSAN traffic [Source: Analysys]

The following subsections discuss the calculation of the busy-hour voice traffic; the calculation for the inclusion of ringing time in addition to the previously calculated conveyed minutes, and the calculation of the average bandwidth provisioning for broadband services in the core network.

Voice services

In the modern network, the number of E1s required to carry the network traffic needs to be dimensioned. To do this, the number of voice minutes is converted into a year-average busy-hour Erlang (BHE) load *(Sheet Dem.Calc, Cells M59:M88)* using the following inputs:

Demand parameters

Voice busy hour %	9%
ISDN busy hour %	9%
% calls occuring in weekdays	
PSTN Local calls	85%
PSTN National calls	85%
PSTN International calls	75%
PSTN Fixed to mobile calls	85%
PSTN Terminating traffic	85%
ISDN	95%
Annual busy days	250
Minutes per hour	60
Assumed call attempts per call	1.10
Average answered call set-up time (minutes)	0.17
Average unanswered call duration (minutes)	0.47
Bandwidth occupied per voice call	95
Extreme busy hour factor	1

Figure 5.12: Excel key demand parameters [Source: Analysys]

- proportion of annual traffic during 250 normal[4] weekdays
- proportion of weekday traffic occurring in the normal busy hour
- the average proportion of daily calls that occur in the busy hour.

$$BHE = annualtraffic \times \frac{P_d \times P_w}{B_d \times 60}$$

Where:
P_d = *Proportion of daily traffic in the busy hour*
P_w = *Proportion of annual traffic in the busy week days*
B_d = *Number of busy (week) days*

Figure 5.13: Calculation of the busy-hour Erlang voice demand [Source: Analysys]

The number of voice busy hour erlangs (BHE) is converted into a further measure of demand, namely the number of busy-hour call attempts (BHCA) *(Sheet Dem.Calc, Cells N59:N88)* using the following inputs:

- average call duration.

[4] Normal being defined as a day which is not a public holiday.

- number of call attempts per successful call (e.g. due to unanswered calls).

$$BHCA = \frac{BHE \times C}{D_{ave}}$$

Where:
C = *Call attempts per successful call*
D_{ave} = *Average duration of a successful call*

Figure 5.14: Calculation of the number of busy-hour call attempts [Source: Analysys]

Ringing time

Voice services explicitly include the additional Erlang load presented by the ringing time associated with calling. Ringing time occurs for calls to a land line where there is network occupancy until the call is answered, diverted or not answered. A ringing time of 10 seconds for answered calls and 28 seconds for unanswered calls to an end-user is applied to the various call types and is based on submitted industry average data.

For each service, the model calculates the occupancy minutes in the network:

$$Occupancy\ minutes = C \times (D_{ave} + R_{suc}) + (CA - C) \times R_{unsuc}$$

Where:
C = *Successful calls*
D_{ave} = *Average duration of a successful call*
R_{suc} = *Average ringing and call set-up time for successful calls*
CA = *Total call attempts (successful calls + unsuccessful calls)*
R_{unsuc} = *Average ringing and call set-up time for unsuccessful calls*

Figure 5.15: Calculation of the total occupancy minutes [Source: Analysys]

Routeing factors

Cell reference	*Description and details of spreadsheet calculations*
Rows 134–230	Input and calculation of the modern and NGN service routeing factors according to the weighted network call paths through the network by traffic type
Rows 234–264	Calculation of the busy hour load for each part of the network according to the routed service demand
Rows 267–271	Calculation of the busy hour load for each part of the network on a per PSTN SIO and per ISDN SIO basis

An input table of routeing factors determines the factor applied to each service volume when calculating the load on the various parts of the network *(Sheet Dem.Calc, Rows 134–230)*. An example of these routeing tables is shown in the figure below for PSTN local traffic.

PSTN local traffic (onnet traffic)

Note: the percentage of these routes determine the routeing of traffic across the core network for the different types of traffic. These routeing factors d

	%	LE1	LAS1	LAS2	TNS1	TNS2	LE2
CPE>>LE>>LAS>>LE>>CPE	25%	2	1	-	-	-	-
CPE>>LE>>LAS>>LAS>>LE>>CPE	5%	1	1	1	-	-	1
CPE>>LE>>LAS>>TNS>>LAS>>LE>>CPE	65%	1	1	1	1	-	1
CPE>>LE>>LAS>>TNS>>TNS>>LAS>>LE>>CPE	5%	1	1	1	1	1	1
PSTN local traffic call paths	*PSTN local traffic call path percentages*						

Figure 5.16: Excel screenshot displaying sample of routeing factor input tables for PSTN local traffic [Source: Analysys]

The routeing factors for a particular traffic service are calculated on the basis of the number of times/loading a particular network element is used to deliver the service being modelled. Different combinations of network elements may be used depending on the path taken in the network. For example, PSTN local traffic may be switched by only one LAS, or may be switched by two LAS, or may indeed involve switching at the transit layer. The proportion of traffic utilising a specific route is inserted into the cells outlined in blue in the screenshot above. The proportion of calls that utilise a particular combination of network assets is used to ascertain the average routeing factors for that particular type of traffic. An example of this calculation is shown in the figure below.

	%	LE-LAS	LAS-LAS	LAS-TNS	TNS-TNS	LAS Interconnect	TNS Interconnect
CPE>>LE>>LAS>>LE>>CPE	25%	2	-	-	-	-	-
CPE>>LE>>LAS>>LAS>>LE>>CPE	5%	2	1	-	-	-	-
CPE>>LE>>LAS>>TNS>>LAS>>LE>>CPE	65%	2	-	2	-	-	-
CPE>>LE>>LAS>>TNS>>TNS>>LAS>>LE>>CPE	5%	2	-	2	1	-	-

Figure 5.17: Excel screenshot displaying sample of calculations to determine the proportion of traffic utilising a specific network route [Source: Analysys]

For ISDN voice traffic, the model currently assumes all traffic routes via TNS locations. Several call-routing options are set up to accommodate the different call types (on-net local, on-net national, off-net domestic, off-net international), as unlike PSTN, only one service is defined to capture all ISDN call-types. The figure below shows this calculation, with the adjustable parameters outlined in green and blue input boxes.

ISDN - voice traffic

	%	LE1	LTH1	LTH2	MTH1	MTH2	LE2
CPE>>LE>>LTH>>LE>>CPE	5.10%	2	1	0	0	0	0
CPE>>LE>>LTH>>LTH>>LE>>CPE	0.00%	1	1	1	0	0	1
CPE>>LE>>LTH>>MTH>>LTH>>LE>>CPE	62.24%	1	1	1	1	0	1
CPE>>LE>>LTH>>MTH>>MTH>>LTH>>LE>>CPE	13.27%	1	1	1	1	1	1
CPE>>LE>>LTH>>Int	0.00%	1	1	0	0	0	0
CPE>>LE>>LTH>>MTH>>Int	15.31%	1	1	0	1	0	0
CPE>>LE>>LTH>>MTH>>TNS>>Int	4.08%	1	1	0	1	1	0

Distribution of ISDN voice traffic between traffic types		20%	60%	10%	10%		
	Note: Select	PSTN on-net	PSTN on-net	PSTN off-net	PSTN off-	Total	Normalised
CPE>>LE>>LAS>>LE>>CPE		5.00%	0.00%	0.00%	0.00%	5%	5.10%
CPE>>LE>>LAS>>LAS>>LE>>CPE	0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CPE>>LE>>LAS>>TNS>>LAS>>LE>>CPE		13.00%	48.00%	0.00%	0.00%	61.00%	62.24%
CPE>>LE>>LAS>>TNS>>TNS>>LAS>>LE>>CPE		1.00%	12.00%	0.00%	0.00%	13.00%	13.27%
CPE>>LE>>LAS>>Int	0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CPE>>LE>>LAS>>TNS>>Int		0.00%	0.00%	8.00%	7.00%	15.00%	15.31%
CPE>>LE>>LAS>>TNS>>TNS>>Int		0.00%	0.00%	2.00%	2.00%	4.00%	4.08%

Figure 5.18: Excel screenshot displaying sample of calculations to determine the proportion of ISDN traffic utilising a specific network route [Source: Analysys]

The calculated routeing factors for each of the traffic types are multiplied by the calculated busy hour traffic to generate the traffic loading with which to dimension the core network. This traffic is divided by subscribers to calculate the per-subscriber demand loading on the network for each part of the network.

5.6 'In.Nodes' worksheet

The 'In.Nodes' worksheet contains node data for each level in the network, for use in the core network design algorithms. The top of the worksheet (rows 9–34) contains the outputs from the overlap analysis of the core and access network routes. These specify the fibre sheath requirements for the core network and the trench distance required, split by that within the CAN and incremental to the CAN.

The parent nodes (parent LAS and parent TNSs) have been pre-calculated on the basis of the nearest LAS/TNS to each LE. The data relating to the PoC transmission is pasted in from an external workbook ('*LE_LAS_ring.xls*'). The calculations for the LE–PoC links are based on a minimum spanning tree calculation, whilst the PoC rings are based on a multi-ring travelling salesman algorithm. Both of these outputs come from *LE_LAS_ring.xls*.

The layout of the nodes data on the 'In.Nodes' worksheet is shown below:

LE/AT1 node data

Note: This sheet collates the outputs from the TS Note: The PoC data, brought in from the external workbook, is used to define the parent PoC for each LE in the 'NwDes.1.Access' worksheet, as well

Note: Parent LAS Note: check LE list in output of TSP matches LE list here

Note: Do not change the order of LE site names in this

Access Tier 1 (LE) site name	Access Tier 1 (LE) site	Geotype	Parent LAS	Parent PoC	Distance (km) to parent PoC: Trench distance	Distance (km) to parent PoC: Fibre distance	LE remote to POC
ACACIA RIDGE	AARE	4	SSBU	AARE	-	-	0
LORD HOWE IS	LORI	11	SKTB	KNST	1	1	1
LE.name	LE.ID	LE.Geotype	LE.Parent.LAS	LE.Parent.POC	91,979	257,082	4,035
					LE.POC.trench	LE.POC.fibre	LE.remote.PoC

PoC node data

Note: The data regarding the specific PoC rings is linked to the 'NwDes.2.PoC' worksheet in cells B13:J1512.

Note: this is built for 1500 rows

POC Name	LAS	Ring	Number Of POCs in	Is a LAS?	Bridging Node	Dist To Next Node	Ring Joined To	Is in LAS Ring
ADLE-1	ADLJ	1	9	Y		5	1	Y
WYNG	WYGJ	216	9	Y	Y	7	216	Y
POC.Name	POC.LAS	POC.Ring	POC.Ring.Cou	POC.Ring.Is.L	POC.Bridge	POC.Dist.Next	POC.Ring.Join	POC.Is.LAS.Ring

LAS/TNS nodes

Note: LAS nodes are co-parented by a pair of TNS nodes

Regional Node (LAS) site name	Regional Node (LAS) (node code)	Regional Node (LAS) (ESA code)	Co-sited Regional Node - Core Node	TNS parent 1	TNS parent 2	Geotype
ALBURY	ALBG	ALBY	-	METC	CDTA	6
ALICE SPRINGS A	ALSG	ALSS	-	PPTA	AWTA	11
ARMIDALE	ADLJ	ADLE-1	-	SPTF	SCTC	11
BALGOWLAH S12	BALJ	BALG	-	SPTF	SCTC	4
BALLARAT S12	BRAJ	BRAT	-	MLTB	METC	5
BANKSTOWN 1 S1	BAKN	BANK-1	-	SKTB	SPTF	3
BANORA POINT	BRPT	BRPT	-	SCTC	BWTB	5
BATHURST AXE	BATJ	BATH	-	SPTF	SCTC	10
BEGA AXE	BEGX	BEGA	-	MWTB	CDTA	12
BENDIGO LAS	BENV	BEND-2	-	MLTB	METC	5
BLACKTOWN AXE	BLAP	BLAC-2	-	SKTB	SPTF	4
BLAKEHURST AX	BLHJ	BLAK	-	SKTB	SPTF	3
BOX HILL	BHLX	BOXL	-	MWTB	MLTB	3
BROKEN HILL	BNHJ	BNHL-1	-	AWTA	AFTA	8
BROOME AXE	BMEX	BRMK-1	-	PWTA	PPTA	11
WYONG S12	WYGJ	WYNG	-	SCTC	SPTF	10
LAS.name	LAS.ID	LAS.ID.ESA.code		LAS.parent.TN	LAS.parent.TNS.2	

Core Node (TNS) site name	Core Node (TNS)
ADELAIDE TN	AFTA
ADELAIDE TN	AWTA
BRISBANE TN	BWTB
BRISBANE TN	BCTB
CANBERRA T	CCTA
CANBERRA T	CDTA
MELBOURNE	MLTB
MELBOURNE	MWTB
MELBOURNE	METC
PERTH TNS1	PPTA
PERTH TNS2	PWTA
SYDNEY TNS2	SKTB
SYDNEY TNS4	SCTC
SYDNEY TNS5	SPTF
Site.name.TNS	TNS.ID

Figure 5.19: 'In.Nodes' worksheet: output node data [Source: Analysys]

Analysys

The data in the 'In.Nodes' worksheet is used in each of the network design algorithm worksheets.

The PoC data is used to define the parent PoC for each LE in the 'NwDes.1.Access' worksheet, as well as the trench and fibre distances used in the minimum spanning tree calculations. This information is linked to the 'NwDes.1.Access' worksheet in cells C10538:D15791 and C15806: D21059.

The data regarding the specific PoC rings is linked to the 'NwDes.2.PoC' worksheet in cells B13:J1512.

The parent PoC/LAS/TNS data is used in the calculation of the appropriate number of lines at the PoC/LAS/TNS level on the 'In.Subs' worksheet.

These linkages are shown in the diagram below:

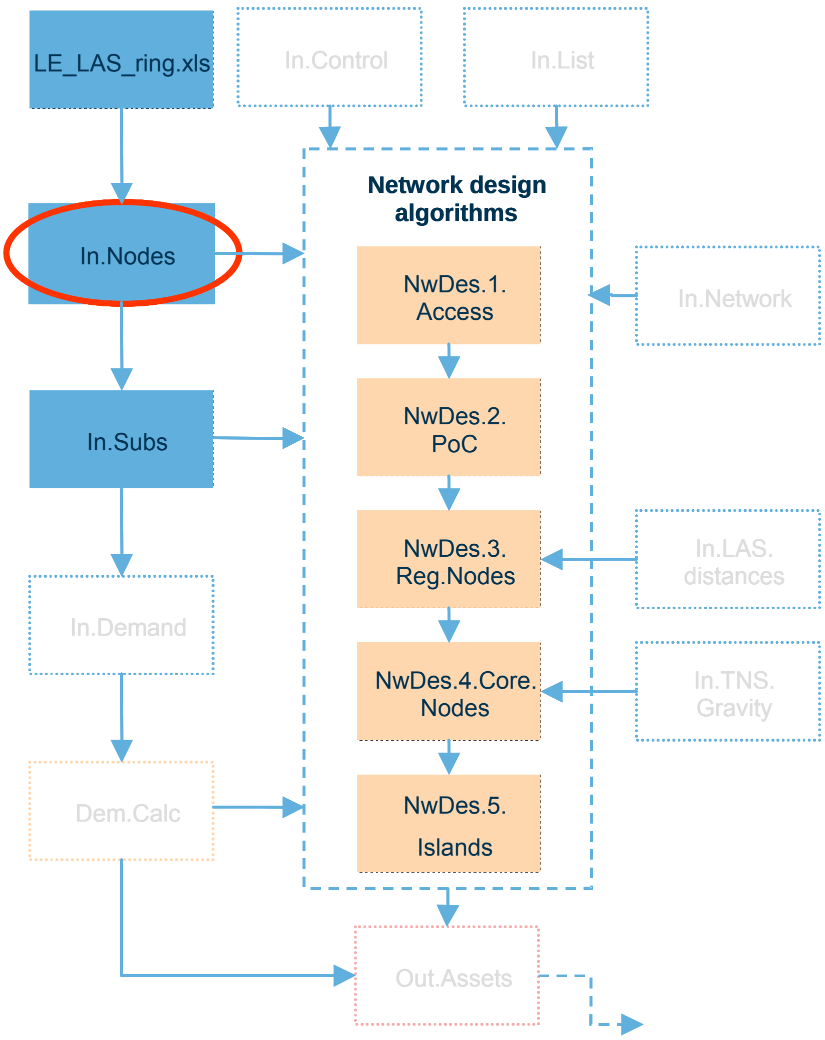


Figure 5.20: Location of the 'In.Nodes' worksheet in the overall Core module structure [Source: Analysys]

5.6.1 Key parameters

This worksheet contains contains data pasted in from an external workbook (*LE_LAS_ring.xls*). In this external workbook, there are several important parameters which control PoC ring generation:

Parameter	*Impact*
Clustering To PoCs	
Maximum Local Exchanges per PoC	Controls the cluster number of LEs into PoCs
Automatically assign as a PoC if number of SIOs exceeds [3000]	Designates an LE as a PoC if it has more SIOs than the defined threshold number
Trench cost per metre Fibre cost per metre	Controls the minimum spanning tree shape based on a least cost function between trench and fibre costs
Generating Rings algorithm parameters	
Maximum number of PoCs per ring	Controls the number of PoCs that dimension a PoC ring
Number of PoCs before using Generic Algorithm	Defines whether a Genetic Algorithm is required, otherwise an exact solution is determined (an exact solution may take an extremely long time if many (>12) PoCs are modelled
Number of generations to use in Generic Algorithm	The more generations that are used, the more likely the optimum solution is determined

Table 5.8: Parameters in LE_LAS_ring.xls [Source: Analysys]

The structure of the external *LE_LAS_ring.xls* workbook is outlined in Annex B.

This external data is pasted into this worksheet in the blue bordered cells (cells F41:H5294 for the LE/AT1 node data, and cells B5300:J6799 for the PoC node data)

The inputs related to the overlap analysis in cells C11:D15, D21:D24 and O20:U24 are the result of the MapInfo calculations as described in section 7.11 of the *Fixed LRIC model documentation*. The can be changed by users should alternative data be available.

5.6.2 Calculation description

The table below outlines the calculations that take place on the 'In.Nodes' worksheet:

Cell reference	*Description and details of worksheet calculations*
Rows 11–34	Derives the proportional overlap of the inter-exchange (IEN) network trench within the IEN and with the access network
Rows 41–5294	Input data defining the parent PoC for each LE, and trench, duct and fibre cable distances for the LE–PoC links. Also contains the number of locations by ESA from the Location and Demand database.
Rows 5300–6799	PoC node data describing the PoC-LAS transmission rings
Rows 6805–6937	Input data describing the parent LAS and TNS nodes
Rows 6943–6957	Calculation deriving LAS and TNS by geotype

Table 5.9: Calculations performed on the 'In.Nodes' worksheet [Source: Analysys]

5.7 'In.LAS.distances' worksheet

The 'In.LAS.distances' worksheet contains a pre-calculated matrix of the straight-line distance between each LAS or regional node. This data is used to inform the network design distance calculations in the 'NwDes.3.RegNodes' worksheet:

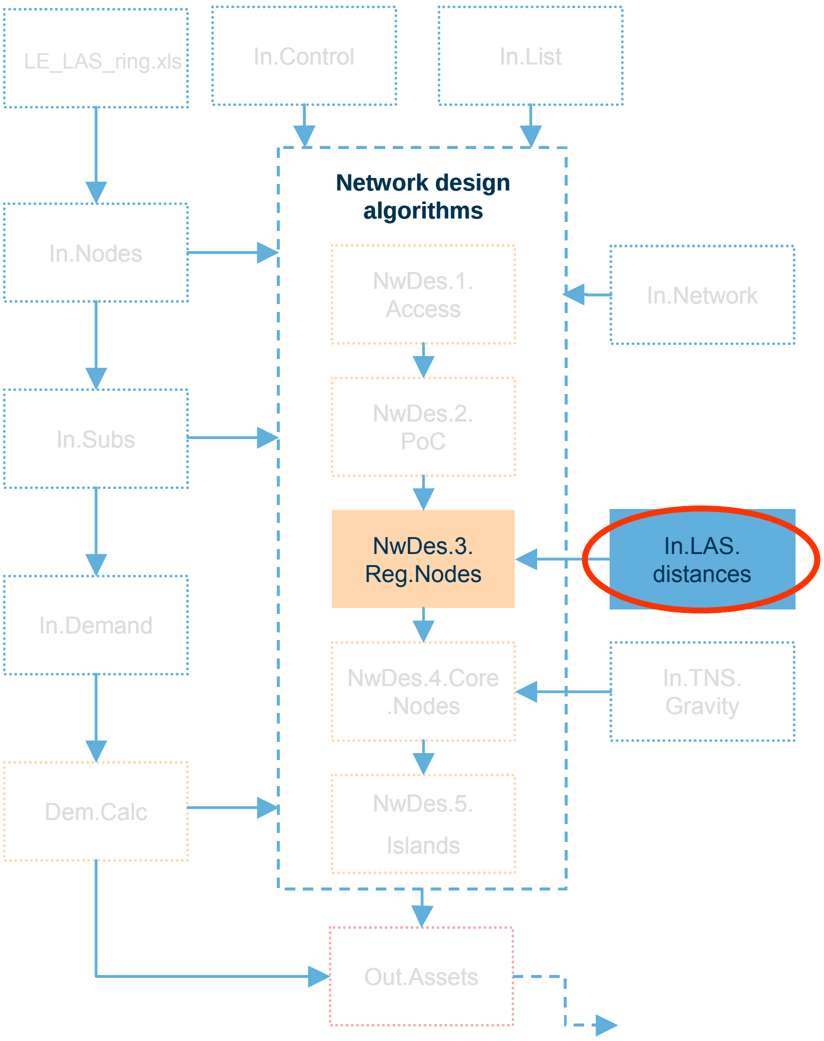


Figure 5.21: Location of the 'In.LAS.distances' worksheet in the overall Core module structure [Source: Analysys]

The layout of the matrix is shown in the figure below (the full matrix is 133 × 133 cells). This data feeds directly into the 'NwDes.3.Reg.Nodes' worksheet, and informs the LAS-ring distances.

	ALBG	ALSG	ADLJ	BALJ	BRAJ	BAKN	BRPT	BATJ
ALBG		1,859	760	471	318	445	1,073	383
ALSG	1,859		1,913	2,027	1,810	2,015	2,025	1,871
ADLJ	760	1,913		367	1,063	383	314	378
BALJ	471	2,027	367		789	25	657	161
BRAJ	318	1,810	1,063	789		763	1,376	693
BAKN	445	2,015	383	25	763		677	145
BRPT	1,073	2,025	314	657	1,376	677		691
BATJ	383	1,871	378	161	693	145	691	

Figure 5.22: Excel screenshot displaying sample of the matrix of the straight-line distances between each LAS [Source: Analysys]

5.7.1 Key parameters

Whilst there are no key parameters on this worksheet, it should be highlighted that this matrix contains straight line distances as opposed to road length distances. The straight line distances have been calculated using a formula that takes into account the curvature of the Earth.

An uplift parameter[5] is implemented later in the model to account for the fact that road length is greater than straight line length. As an alternative, a matrix of actual road length distances may be entered in place of the existing straight-line distance matrix.

5.7.2 Calculation description

The table below lists specific data inputs and calculations that take place on the 'In.LAS.distances' worksheet, by row number.

Cell reference	*Description and details of spreadsheet calculations*
Rows 4–136	Matrix of the distance (straight-line distance) between each LAS. This matrix may be updated with the road/railway distances between each LAS

Table 5.10: Calculations performed on the 'In.LAS.distances' worksheet [Source: Analysys]

5.8 'In.TNS.Gravity' worksheet

This worksheet estimates the proportion of the national calls that goes to each individual TNS node, by using a gravity model. In the base case, the gravity model ignores the effect of distance. The gravity model is required as Analysys has not been provided with national-level call distribution data.

The inputs in the 'In.TNS.Gravity' worksheet inform the network design traffic destination percentages on the 'NwDes.4.Core.Nodes' worksheet:

5 Located on 'In.Nodes' worksheet, and informed by the IEN route and overlap analysis

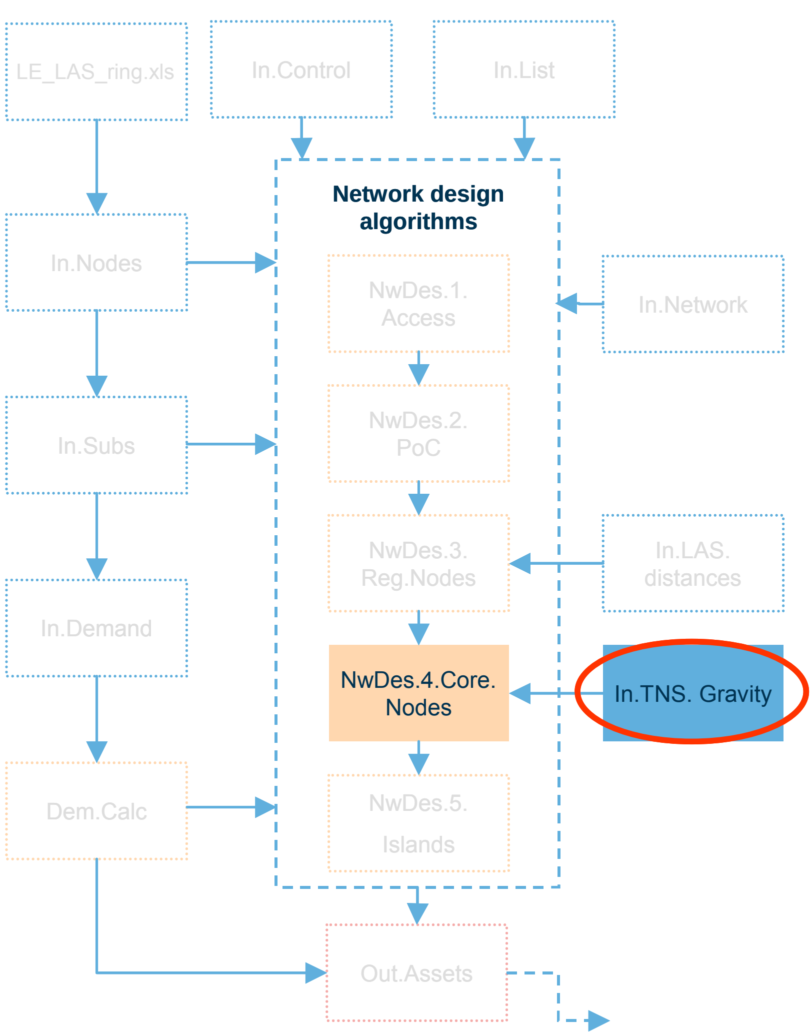


Figure 5.23: Location of the 'In.TNS.Gravity' worksheet in the overall Core module structure [Source: Analysys]

5.8.1 Key parameters

The gravity model output may be directly adjusted by means of a single parameter.

- The distance parameter (cell C6) controls the degree to which distance affects the call destination distribution using the gravity model formula. Note: when it is set to 0, distance is not taken into account.

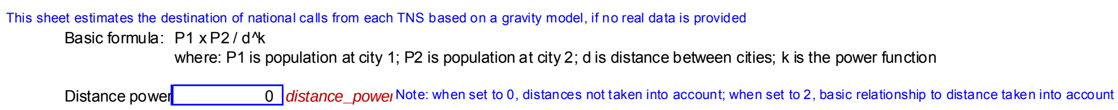


Figure 5.24: Excel screenshot displaying the distance parameter [Source: Analysys]

5.8.2 Calculation description

The table below lists specific data inputs and calculations that take place on the 'In.TNS.Gravity' worksheet, by row number.

Cell reference	*Description and details of spreadsheet calculations*
Row 6	Distance power for the gravity model formula. When set to 0, distances are not taken into account. When set to 2, a basic relationship to distance is included
Rows 10–24	PSTN SIOs parented by each transit network switch. Note, each SIO is parented by two transit network switches for resilience purposes in the network
Rows 28–41	Road length distance matrix to and from each TNS
Rows 46–59	Calculation of the traffic flowing to each TNS on the basis of the gravity model formula
Rows 65–78	Destination of the national traffic to each TNS on a percentage basis of traffic from a particular TNS

Table 5.11: Calculations performed on the 'In.TNS.Gravity' worksheet [Source: Analysys]

The TNS gravity model is based on the following formula:

$$\frac{P_1 * P_2}{d^k}$$

Where:
P_1 = *Subscribers at TNS1*
P_2 = *Subscribers at TNS2*
D = Distance between TNS1 and TNS2
k = Distance power, when set equal to 0,
the routeing of traffic is not affected by distance

Figure 5.25: Formula for TNS gravity model [Source: Analysys]

The calculations that take place on the specified sets of rows in the 'In.Subs' worksheet are set out in the remainder of this sub-section.

This worksheet uses as its inputs:

- the number of PSTN and WLR lines parented by each TNS (this is linked in from the 'In.Subs' worksheet):

Cell reference	*Description and details of spreadsheet calculations*
Rows 10–24	PSTN SIOs parented by each TNS. Note, each SIO is parented by two TNSs for resilience purposes in the network

SIOs at each TNS		PSTN & WLR subs
	AFTA	1,100,898
	AWTA	875,186
	BWTB	1,565,144
	BCTB	1,684,732
	CCTA	306,651
	CDTA	586,736
	MLTB	2,305,912
	MWTB	1,275,060
	METC	1,427,177
	PPTA	1,059,080
	PWTA	930,573
	SKTB	1,167,897
	SCTC	1,528,349
	SPTF	2,143,780
		17,957,174 *TNS.population*

Figure 5.26: The number of SIOs at each TNS [Source: Analysys]

- the road length distance between each TNS location:

Cell reference	*Description and details of spreadsheet calculations*
Rows 28–41	Road length distance matrix to and from each TNS

Road length distances (km) Note: road length distances have been calculated using MapInfo and StreetPro Australia

	AFTA	AWTA	BWTB	BCTB	CCTA	CDTA
AFTA	-	1	1,599	1,599	957	954
AWTA	1	-	1,600	1,600	958	955
BWTB	1,599	1,600	-	2	941	948
BCTB	1,599	1,600	2	-	942	949
CCTA	957	958	941	942	-	7
CDTA	954	955	948	949	7	-
MLTB	653	653	1,373	1,374	468	461
MWTB	656	657	1,375	1,376	468	462
METC	653	654	1,372	1,373	466	460
PPTA	2,130	2,129	3,604	3,604	3,087	3,083
PWTA	2,131	2,130	3,605	3,605	3,088	3,084
SKTB	1,161	1,161	731	732	246	252
SCTC	1,160	1,160	724	725	249	255
SPTF	1,143	1,144	730	731	236	242

Figure 5.27: Excel screenshot showing sample of parameters used to determine the road length distance in km between TNSs [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 46–59	Calculation of the traffic flowing to each TNS on the basis of the gravity model formula

The gravity model calculates the absolute weighting for traffic by destination:

Gravity model absolute calcu

		From:						
		AFTA	AWTA	BWTB	BCTB	CCTA	CDTA	MLTB
To:	*Population (mn)*	1.10	0.88	1.57	1.68	0.31	0.59	2.31
AFTA	1.10	-	1	2	2	0	1	3
AWTA	0.88	1	-	1	1	0	1	2
BWTB	1.57	2	1	-	3	0	1	4
BCTB	1.68	2	1	3	-	1	1	4
CCTA	0.31	0	0	0	1	-	0	1
CDTA	0.59	1	1	1	1	0	-	1
MLTB	2.31	3	2	4	4	1	1	-
MWTB	1.28	1	1	2	2	0	1	3
METC	1.43	2	1	2	2	0	1	3
PPTA	1.06	1	1	2	2	0	1	2
PWTA	0.93	1	1	1	2	0	1	2
SKTB	1.17	1	1	2	2	0	1	3
SCTC	1.53	2	1	2	3	0	1	4
SPTF	2.14	2	2	3	4	1	1	5

Figure 5.28: Excel screenshot showing sample of the gravity model calculation of distances [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 65–78	Destination of the national traffic to each TNS on a percentage basis of traffic from a particular TNS

These absolute numbers are converted into a normalised percentage number, resulting in a matrix of the percentage of national traffic that flows from each TNS to every other TNS:

RESULT: Destination of transit traffic

		From:						
		AFTA	AWTA	BWTB	BCTB	CCTA	CDTA	MLTB
To:	AFTA	-%	6%	7%	7%	6%	6%	7%
	AWTA	5%	-%	5%	5%	5%	5%	6%
	BWTB	9%	9%	-%	10%	9%	9%	10%
	BCTB	10%	10%	10%	-%	10%	10%	11%
	CCTA	2%	2%	2%	2%	-%	2%	2%
	CDTA	3%	3%	4%	4%	3%	-%	4%
	MLTB	14%	13%	14%	14%	13%	13%	-%
	MWTB	8%	7%	8%	8%	7%	7%	8%
	METC	8%	8%	9%	9%	8%	8%	9%
	PPTA	6%	6%	6%	7%	6%	6%	7%
	PWTA	6%	5%	6%	6%	5%	5%	6%
	SKTB	7%	7%	7%	7%	7%	7%	7%
	SCTC	9%	9%	9%	9%	9%	9%	10%
	SPTF	13%	13%	13%	13%	12%	12%	14%

Figure 5.29: Excel screenshot showing sample of the output of destination of transit traffic [Source: Analysys]

The output of the gravity model is the percentage of the traffic at each particular TNS that flows to each of the other TNS units. This is used in the dimensioning of the TNS–TNS links (cells E218:R231 on the 'NwDes.4.CoreNodes' worksheet.

5.9 'In.Network' worksheet

This worksheet contains the network parameters used within each of the demand and network design algorithm worksheet in the Core module. These linkages are shown in the diagram below:

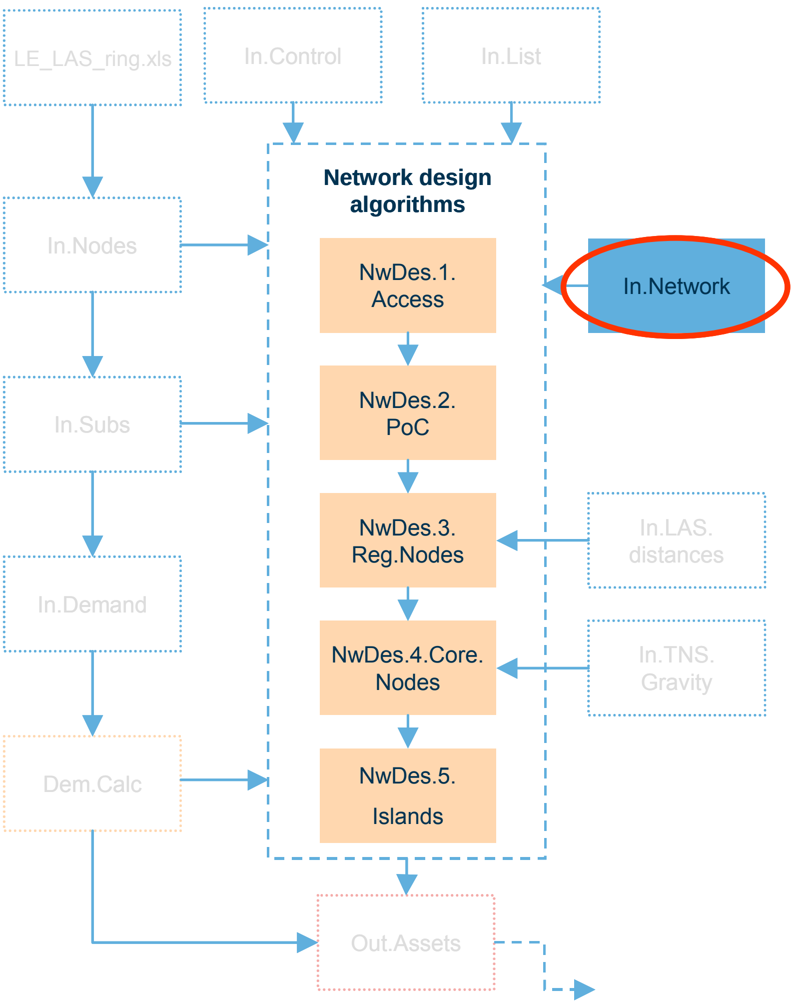


Figure 5.30: Location of the 'In.Network' worksheet in the overall Core module structure [Source: Analysys]

5.9.1 Key parameters

This worksheet contains the network design parameters, including equipment and transmission link capacities, and asset utilisation parameters, used within the demand and network design algorithms in the Core module. Many of the parameters are based on either industry standards or are based on operator/industry submissions – Analysys recommends that users do not readily change these parameters.

The table below identifies the parameters that may be readily altered by users:

Parameter	*Location*	*Impact*
Busy hour data	Rows 11–26	Affects the amount of traffic dimensioned in the busy hour on the ‘Dem.Calc’ worksheet
Exchange equipment parameters	Rows 31–77	These determine the physical capacity of the exchange based equipment. These physical capacities have been where possible based on industry data. It is recommended that only the provisioning and utilisation parameters be manipulated by users.
Grade of service	Cell H179	Affects the provisioning of transmission links
Cost threshold for transmission equipment	Cells L82–L88, L99–L102	Affects the provisioning of transmission links
Equipment capacities and utilisations	Row 176–219	Affects the actual capacity of equipment
Percentage of trench that is ducted	Rows 128–141	Affects the amount of duct that is deployed

Table 5.12: Key parameters in the ‘In.Network’ worksheet [Source: Analysys]

5.9.2 Calculation description

The table below lists specific sets of network inputs and calculations by row number.

Cell reference	*Description and details of spreadsheet calculations*
Rows 3–7	Industry standard conversion factors
Rows 11–26	Network loading parameters including busy hour data
Rows 31–77	Exchange equipment parameters (backhaul provisioned, ports per line card, line cards per shelf, shelves per rack) by service
Rows 128–161	Transmission planning and engineering factors
Rows 164–169	Link utilisation parameters
Rows 176–242	Element provisioning parameters
Rows 247–252	Island solution parameters

Table 5.13: Inputs and calculations on the ‘In.Network’ worksheet [Source: Analysys]

5.10 ‘NwDes.1.Access’ worksheet

The ‘NwDes.1.Access’ worksheet calculates the dimensioning of the LE (modern network) and Access Tier 1 (NGN) on the basis of the services in operation hosted at each individual node and the busy hour demand carried on the transmission links. Allowance is made for other transmission traffic, spares and other fibre services.

Subscriber numbers and demand data at each LE/AT1 are linked from the 'In.Subs' worksheet and from the 'In.Demand' worksheet respectively.

The number of assets calculated on this worksheet are output to the 'Out.Assets' worksheet.

These linkages are shown in the diagram below:

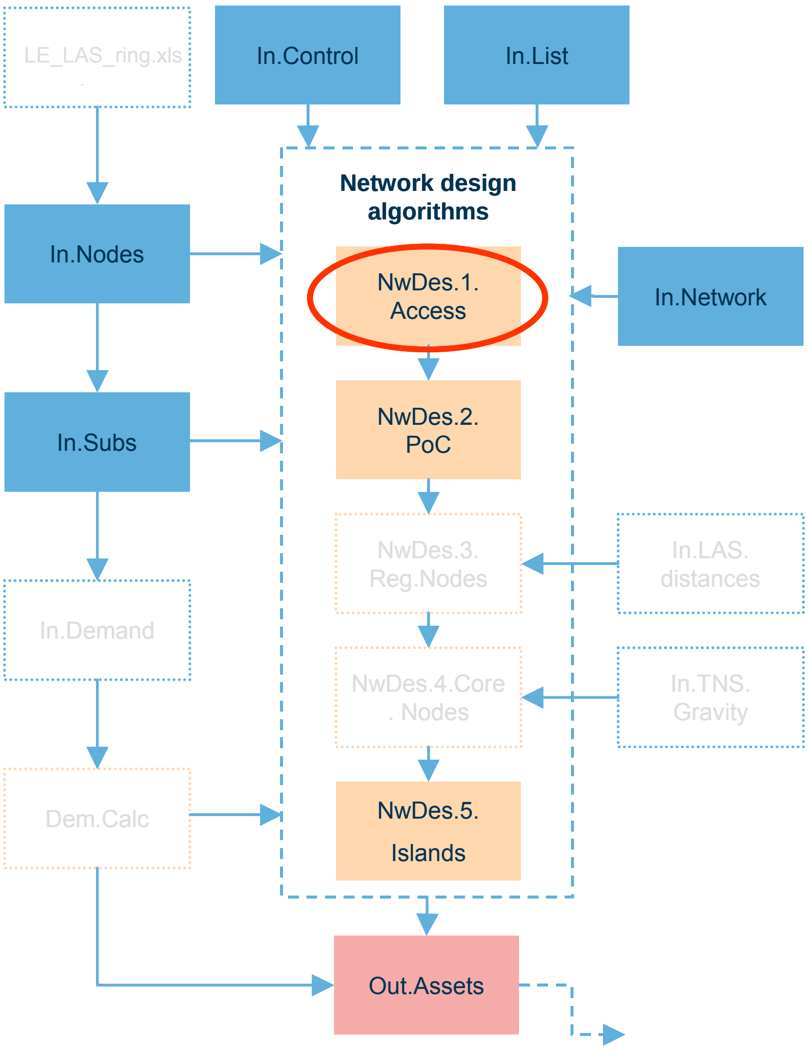


Figure 5.31: Location of the 'NwDes.1.Access' worksheet in the overall Core module structure [Source: Analysys]

5.10.1 Key parameters

No parameter values are inserted manually into this worksheet, but numerous key parameters are linked from the 'In.Network' worksheet. The utilisation parameters, set out below, are the key parameters that can be changed.

Parameter	*Location*	*Impact*
Line card utilisation	Modern TDM - H11:J11 Modern xDSL - P11:Q11 NGN - M5273:O5273	Affects the maximum capacity of a line card – reflecting a deployment strategy of an operator
Shelf and rack capacity factor	Modern TDM - L11:M11, Modern xDSL - R11:S11 NGN - P5273:Q5273	Affects the maximum capacity of a shelf
xDSL backhaul	T11	Drives backhaul provisioning on each LE link
Quality of service	H10533:H10535	Impacts the number of E1s provisioned for voice and ISDN
Fibre uplift parameter for spares and other fibre services	E15804:G15804	Deployment of spare and fibre for other services above those required just for the LE
CAN-IEN and inter-IEN overlap parameters	C21063, C21065	Affects the volume of duct and trench assets calculated for the LE level. The distance of duct within CAN areas is retained for cost allocations between and CAN and IEN.
Percentage of trench that is ducted	K21122	Affects the amount of trench that is ploughed versus that which is deployed with ducts

Table 5.14: Key parameters in the 'NwDes.1.Access' worksheet (linked from the 'In.Network' worksheet [Source: Analysys]

5.10.2 Calculation description

This worksheet contains network design algorithms for the LE level. This includes calculations for the equipment required and link transmission dimensioned for the links from the LE to the point of confluence (PoC). The table below lists specific data inputs and calculations by row number.

Cell reference	*Description and details of spreadsheet calculations*
Row 5	Check that the traffic totals reconcile
Rows 14–5268	Calculation of TDM-based equipment requirements • Column D identifies whether the LE is served by TDM equipment • Columns E–G link in the PSTN & WLR, ISDN-BR and ISDN-PR SIO data from the ‘In.Subs’ worksheet • Columns H–K calculate the PSTN and ISDN line card requirement, taking into account utilisation • Columns L–M calculate the shelf and rack requirement for PSTN and ISDN services (assuming that PSTN and ISDN services are connected on the same equipment) • Columns N–O link in the ADSL and SDSL SIO numbers from the ‘In.Subs’ worksheet • Columns P–Q calculate the xDSL line card requirement, taking into account utilisation • Columns R–T calculate the shelf, rack and backhaul requirement for xDSL services • Column U calculates the total number of LE sites • Column V calculates the total number of network units for LPGS backhaul
Rows 5276–10529	Calculation of NGN MSAN equipment requirements • Column D identifies whether the LE is served by NGN equipment • Column E links in the number of pillars and LPGS from the CAN module, accounting for whether NGN equipment is used • Columns J–L link in the copper SIO numbers (PSTN, ISDN and VDSL) • Columns M–O calculate the required number of line cards based on the available ports per line card • Columns P–Q calculate the shelf and rack requirement • Columns R–S calculate the AT1 and AT2 MSAN requirement • Columns T–W calculate the AT2 Ethernet backhaul link requirement
Rows 10538–15791	Calculation of the transmission requirements for the LE-PoC links • Column D identifies whether the LE is remote from the PoC, i.e. not co-located • Columns E–G calculate the transmission requirements in terms of PSTN and ISDN BHE and xDSL kbit/s – this is based on the average traffic per subscriber linked in from the ‘Dem.Calc’ worksheet and the number of subscribers at a particular LE • Columns H–M calculate the total TDM transmission E1 requirements – an Erlang formula is used to calculate the E1 requirement for the BHE traffic • Columns N–R calculate the total MSAN transmission kbit/s requirements • Columns S–X calculate the SDH transmission link requirement. A payload in terms of E1 Virtual Containers for each STM-x is used to determine the appropriate transmission speed link required • Columns Y–AA calculate the Ethernet transmission link requirement. A

	payload in terms of kbit/s is used to determine the appropriate Ethernet link speed required.
Rows 15796–15799	Calculation of the platform use of links for the allocation of costs – this information is used in the Cost module
Rows 15806–21071	Calculation of the LE-PoC fibre assets deployed. • Columns C–D link in the LE-PoC trench and fibre distances from the ‘In.Node’ worksheet – these distances are based on minimum spanning tree distances • Columns E–I calculate the number of fibres dimensioned, including an allowance for spares and other fibre services. A fibre bundle size is calculated • Columns J–K calculate the resultant distance of fibre for SDH and fibre for other services in metres – this is used in the cost allocation ion the Cost module • Column L calculates the regenerator requirement based on the maximum distance of a fibre link before signal regeneration is required (cell L15804)
Rows 21063–21067	Calculation of the incremental trench outside of the CAN area and the distance in the CAN area that may be utilised by core network ducts.
Rows 21063–21071	Calculation of the fibre sheath length by bundle size and the trench requirements according to the route sharing inputs from the ‘In.Nodes’ worksheet
Rows 21077–21138	Summary table for the Access Tier 1 node equipment requirements

Table 5.15: Calculations performed on the ‘NwDes.1.Access’ worksheet [Source: Analysys]

Equipment requirements

Cell reference	*Description and details of spreadsheet calculations*
Rows 13–5268	Calculation of TDM-based equipment requirements • Column D identifies whether the LE is served by TDM equipment • Columns E–G link in the PSTN & WLR, ISDN-BR and ISDN-PR SIO data from the ‘In.Subs’ worksheet • Columns H–K calculate the PSTN and ISDN line card requirement, taking into account utilisation • Columns L–M calculate the shelf and rack requirement for PSTN and ISDN services (assumption that PSTN and ISDN services are connected on the same equipment)

The methodology for the calculation of equipment requirements for PSTN and ISDN is shown in the figure below:

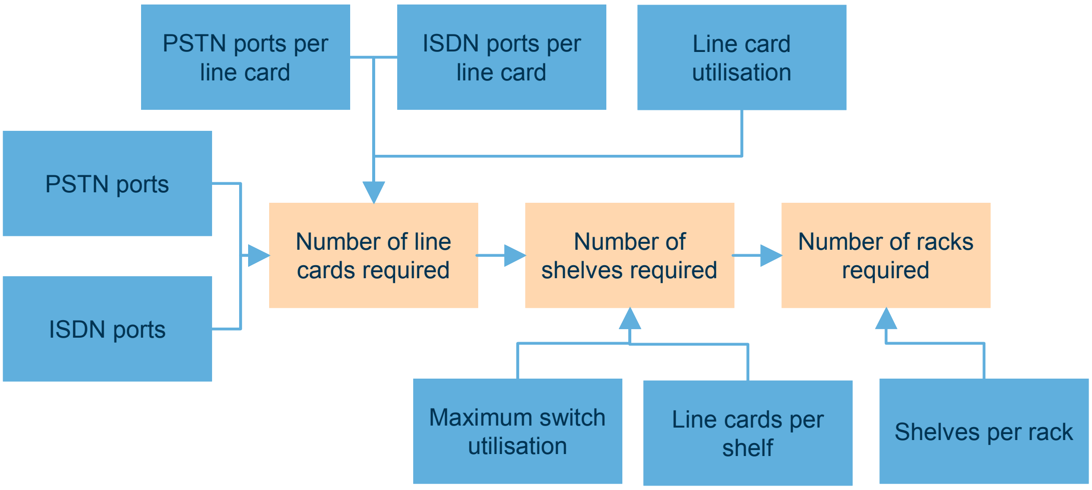


Figure 5.32: Calculation of the number of PSTN and ISDN line cards, shelves and racks required [Source: Analysys]

Line cards are dimensioned on the basis of the number of services in operation at the node and the capacity of a line card. Shelves are calculated on the basis of the dimensioned number of line cards and the maximum capacity of a shelf in terms of line cards. The number of required shelves dimensions the number of racks required on the basis of a maximum capacity of shelves per rack.

The Excel output of these calculations are shown below:

TDM-based equipment (required in areas not served using MSAN equipment)

PSTN and ISDN requirements

						Available ports per line card				Available line cards	Available shelves per
						PSTN & WLR	ISDN-BR	ISDN-PR			
						46	23	15		14	3
			Copper PSTN SIOs			Line cards required (taking into account utilisation)				Shelves required	Racks required
Access Tier 1 (LE) site	Geotype	Served by TDM equipment	PSTN & WLR	ISDN-BR	ISDN-PR	PSTN & WLR	ISDN-BR	ISDN-PR	Total		
AARE	6	1	23,128	590	64	508	26	5	539	40	14
AASS	6	1	678	17	2	15	1	1	17	2	1
ABAY	12	1	2,237	57	6	50	3	1	54	4	2
ABCH	4	1	5,120	131	14	113	6	1	120	9	3
ABCK	6	1	12,564	320	35	276	15	3	294	22	8
ABDN	12	1	982	25	3	22	2	1	25	2	1
ABEE	13	1	71	2	-	2	1	-	3	1	1

Figure 5.33: Excel screenshot showing sample of the calculation of PSTN and ISDN subscriber and equipment requirements [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 13–5268	Calculation of TDM-based equipment requirements • Columns N–O link in the ADSL and SDSL SIO numbers from the 'In.Subs' worksheet • Columns P–Q calculate the xDSL line card requirement, taking into account utilisation • Columns R–T calculate the shelf, rack and backhaul requirement for xDSL services

In the modern network, xDSL lines are modelled to be handled by separate equipment to the PSTN lines, however a similar methodology is used to dimension the xDSL equipment. The methodology for the calculation of equipment requirements for xDSL is shown in the figure below.

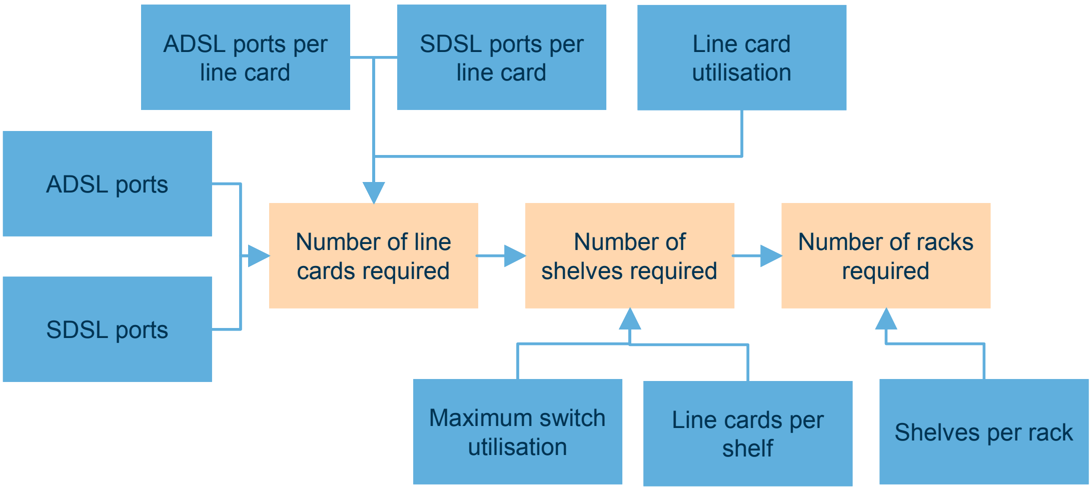


Figure 5.34: Calculation of the number of xDSL line cards, shelves and racks required [Source: Analysys]

The Excel output of these calculations are shown below:

TDM-based equipment (required in areas not served using MSAN equipment)

xDSL requirements

					Available ports per line car ADSL	Available ports per line car SDSL	Available line cards	Available shelves per	Backhaul provisioned
					46	46	15	4	30,720
			xDSL SIOs		Line cards required		Shelves required	Racks required	Backhaul required
Access Tier 1 (LE) site	Geotype	Served by TDM equipment	ADSL	SDSL	ADSL	SDSL			
AARE	6	1	6,165	117	136	3	10	3	92,160
AASS	6	1	181	3	4	1	1	1	30,720
ABAY	12	1	690	10	16	1	2	1	30,720
ABCH	4	1	1,437	19	32	1	3	1	30,720
ABCK	6	1	3,348	64	74	2	5	2	61,440
ABDN	12	1	304	4	7	1	1	1	30,720
ABEE	13	1	-	-	-	-	-	-	-
ABER	13	1	-	-	-	-	-	-	-
ABES	13	1	-	-	-	-	-	-	-
ABFL	13	1	-	-	-	-	-	-	-

Figure 5.35: Excel screenshot showing sample of the calculation of xDSL subscriber and equipment requirements [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 5276–10529	Calculation of NGN MSAN equipment requirements

Analysys

The NGN equipment is calculated using a similar methodology, based on line card, shelf and rack requirements. PSTN/ VDSL and ISDN lines are modelled to be handled by the same MSAN equipment.

Transmission requirements

Cell reference	*Description and details of spreadsheet calculations*
Rows 10538–15791	Calculation of the transmission requirements for the LE–PoC links

The calculation of the transmission equipments takes into account the quality of service to which the network is dimensioned – this reflects the fact that a small percentage of calls will not be connected as there are no available channels in the network.

The calculation also explicitly takes into account a quality-of-service (QoS) parameter in the network by means of a network-blocking probability. This parameter represents the probability that a call is blocked due to all of the available network resources being already busy. The model assumes a network-blocking probability of 0.5% (grade of service (GoS)).

This factor is taken into account in terms of the Erlangs-to-channel conversion (i.e., the number of channels required to provide capacity for a defined number of conveyed Erlangs).

The model converts the BHE load into an Erlang channel requirement using the Excel *NORMINV* function, which approximates the Erlang-B formula:

- *NORMINV (p, mu, sigma)* returns the value *x* such that, with probability *p*, a normal random variable with mean *mu* and standard deviation *sigma* takes on a value less than, or equal to, *x*.

$$p = (1\text{-}GoS)$$

$$mu = Traffic\ \ in\ BHE$$

$$sigma = ErlangConversionFactor \times \sqrt{BHE}$$

Figure 5.36: Parameters used in the calculation of the Erlang-B formula [Source: Analysys]

- The result of the NORMINV formula is divided by the number of circuits in an E1 to calculate the number of E1s required. A rounded-up number is calculated for each traffic type (PSTN/ISDN/xDSL).

The Erlang formula is non-linear at low numbers of channels, however, it becomes broadly linear in nature at higher channel usage – consequently, the model employs an Erlang conversion factor which maps the channel-circuit relationship at a high channel number.

Transmission modelling

In the TDM modern network design, the transmission network is dimensioned in terms of E1 virtual containers (VC).

Unlike the NGN IP network, only transmission of the same type may be aggregated, i.e., PSTN, ISDN and xDSL traffic is maintained separately. Thus, the model calculates the number of E1 VCs required to handle the PSTN, ISDN and xDSL traffic separately.

The capacity of synchronous digital hierarchy (SDH) equipment (STM-x) in terms of E1 VCs is known from industry standards:

PDH/SDH transmission level	*Number of E1 VCs*
E1	1
E2	4
E3	16
STM-1	63
STM-4	252
STM-16	1008
STM-64	4032

Table 5.16: PDH/SDH transmission – capacity of E1 VCs [Source: Analysys]

The model calculates the specific STM-x speed required to carry all of the traffic. The model does apply a cost threshold as it may be cheaper to deploy a larger link speed rather than multiple smaller links. These cost thresholds are directly applied on the 'In.Network' worksheet. It is known from industry data that such cost increases approximately 2.5 times with respect to a quadrupling of speed, i.e., an STM-4 is approximately 2.5 times more expensive than an STM-1. Consequently, instead of deploying three STM-1 links, the model will deploy a cheaper solution of one STM-4 link.

The trench and fibre backhaul distances deployed from the LE/AT1 to the parent PoC are calculated in *LE_LAS_ring.xls*, using a minimum spanning tree algorithm and this data is linked in from the 'In.Node' worksheet.

For the non-MSAN traffic, the total number of E1 Virtual Containers (E1 VCs) required to carry PSTN, ISDN and xDSL traffic are calculated. An uplift is further applied for transmission traffic. The Excel calculations for the non-MSAN traffic are shown below:

Transmission requirements (LE>>POC)

	TDM transmission dimensioning: PSTN BHE/ SIO	ISDN BHE/ channel						
NBED fix 5 links			0.50%	grade.of.service.I			20,480,000	
			92.61%	Erlang.conversion.factor.I			11%	
Traffic per subscriber	0.07	0.14	30	circuits.per.E1.I	1,920			

Access Tier 1 (LE) site	Parent PoC	LE remote to POC	Transmission requirements: PSTN BHE	ISDN BHE	xDSL kbps	TDM Transmission requirements: PSTN traffic (E1)	ISDN traffic (E1)	xDSL traffic (E1)	Load in terms of kbit/s	LE-LAS transmission (E1)	Total (E1s)
AARE	AARE	0	1,619	434	92,160	58	17	48	236,160	14	137
AASS	YOWN	1	47	13	30,720	3	1	16	38,400	2	22
ABAY	YEOD	1	157	41	30,720	7	2	16	48,000	3	28
ABCH	ABCH	0	358	95	30,720	14	4	16	65,280	4	38
ABCK	ABCK	0	879	237	61,440	32	10	32	142,080	8	82
ABDN	CARK	1	69	20	30,720	3	2	16	40,320	2	23
ABEE	HALS	1	5	1	-	1	1	-	3,840	-	2
ABER	BIJR	1	9	1	-	1	1	-	3,840	-	2
ABES	HALS	1	4	0	-	1	1	-	3,840	-	2

Figure 5.37: Excel screenshot showing sample of the calculation table for non-MSAN transmission dimensioning [Source: Analysys]

For the MSAN traffic, the total number of kbit/s required to carry PSTN, ISDN and xDSL traffic are calculated. An uplift is further applied for transmission traffic. The Excel calculations for the MSAN traffic are shown below:

Transmission requirements (LE>>POC)

	MSAN transmission dimensioning: PSTN kbps/ SIO	ISDN kbps/ channel			
	-	-	50.00		Max elements:
					Payload:

Access Tier 1 (LE) site	Parent PoC	LE remote to POC	NGA Transmission requirements: PSTN kbps	ISDN kbps	xDSL kbps	LE-Regional node transmission (kbps)	Total (kbps)
AARE	AARE	0	-	-	-	-	-
CSIM	PIER	1	-	-	-	-	-
KEEL	PIER	1	-	-	-	-	-
LORI	KNST	1	-	-	-	-	-
			-	-	-	-	-
	Check		-	-			

Note: this calculations determine the average use of the links by platform

Platform use of links	TDM only	NGA only	TDM & NGA	Platform use of links
PSTN	28%	-%	28%	PSTN
ISDN	9%	-%	9%	ISDN
xDSL	48%	-%	48%	xDSL
Transmission	15%	-%	15%	Transmissio

Figure 5.38: Excel screenshot showing sample of the calculation table for MSAN transmission dimensioning [Source: Analysys]

The appropriate SDH transmission or Ethernet transmission link speed is subsequently calculated on the basis of the E1 VC or kbit/s requirement respectively:

Transmission requirements (LE>>POC)

Note: traffic from modern equipment is carried using SDH links, whereas traffic from NGN equipment is carried using Ethernet links

			SDH transmission links						Ethernet transmissio		
			2.5	2.5	2.5	2.5	2.5	100	2.5	2.5	100
			1	14	21	63	252	1008	10,000	100,000	1,000,000
Access Tier 1 (LE) site	Parent PoC	LE remote to POC	E1	E3	STM-0	STM-1	STM-4	STM-16	10Mbit/s	100Mbit/s	Gigabit Ethernet
AARE	AARE	0	-	-	-	-	-	-	-	-	-
CSIM	PIER	1	-	1	-	-	-	-	-	-	-
KEEL	PIER	1	1	-	-	-	-	-	-	-	-
LORI	KNST	1	-	-	-	-	-	-	-	-	-
			2,125	4,516	36	2	-	-	-	-	-
	Check										
			SDH: E1 equivalents by platform						Ethernet: kbps by plat		
			E1	E3	STM-0	STM-1	STM-4	STM-16	10Mbit/s	100Mbit/s	Gigabit Ethernet
			2,125	9,668	378	28	-	-	-	-	-
			1,538	4,632	116	8	-	-	-	-	-
			-	54,656	476	56	-	-	-	-	-
			-	12,898	182	17	-	-	-	-	-
			3,663	81,854	1,152	109	-	-	-	-	-

Figure 5.39: Excel screenshot showing sample of the calculation table for MSAN transmission dimensioning [Source: Analysys]

5.11 ‘NwDes.2.PoC’ worksheet

The ‘NwDes.2.PoC’ worksheet calculates the dimensioning of the PoC nodes (aggregator LEs/AT1s) on the basis of the services in operation that are hosted at each individual node and the busy hour demand that needs to be carried on the transmission links. Allowance is made for other transmission traffic, spares and fibre for other services. This worksheet aggregates data from an external file detailing the mapping from local exchanges to PoCs and the distance between each local exchange and its parent PoC. This is used to calculate the most efficient way to link PoC rings to the parent LAS.

The number of assets calculated on this worksheet are output to the ‘Out.Assets’ worksheet.

These linkages are shown in the diagram below:

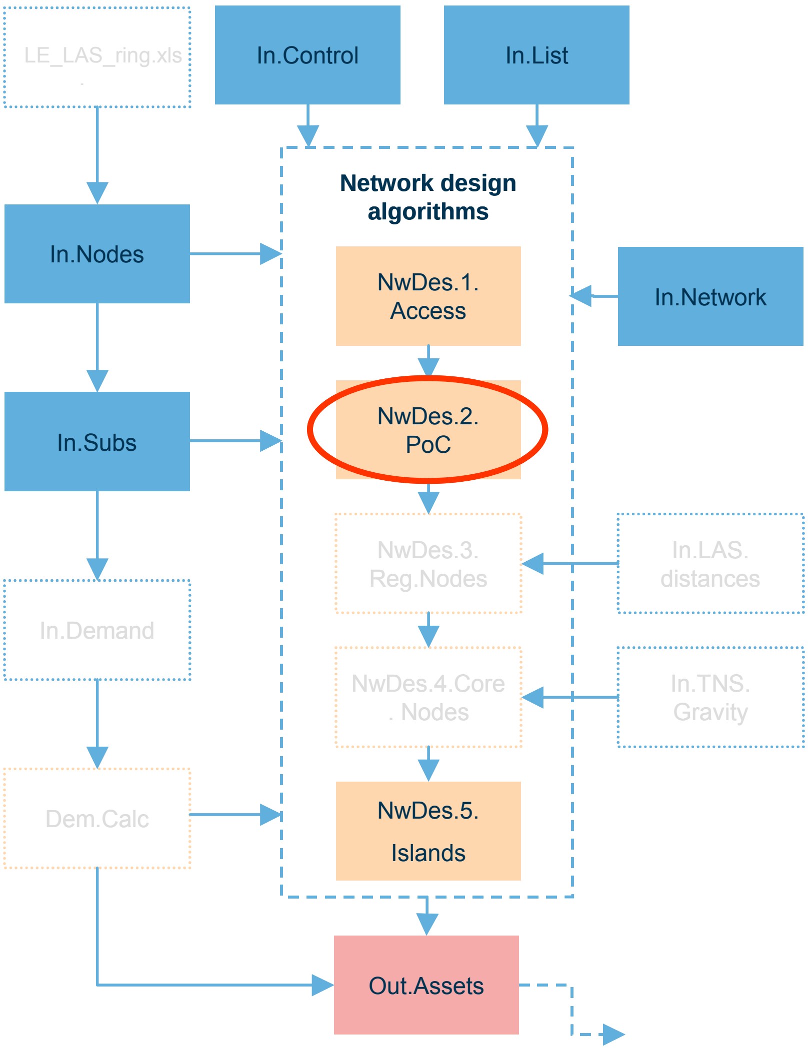


Figure 5.40: Location of the 'NwDes.2.PoC' worksheet in the overall Core module structure [Source: Analysys]

5.11.1 Key parameters

No parameter values are inserted manually into this worksheet, but numerous key parameter values linked in from the network parameters worksheet. The utilisation parameters – linked from the 'In.Network' worksheet – are the key parameters that can be changed.

Parameter	*Location*	*Impact*
Link utilisation parameter	F1518:F1519, H1517:R1519	Affects maximum utilised capacity of the backhaul links from the PoC to the LAS
Fibre uplift parameter for spares and other fibre services	U1519:V1519	Deployment of spare / other fibre above those required just for the PoC ring
CAN-IEN and inter-IEN overlap parameters	S2025, S2027	Affects the volume of duct and trench assets calculated for the PoC level. The distance of duct within CAN areas is retained for cost allocations between and CAN and IEN.
Percentage of trench that is ducted	K2065	Affects the amount of trench that is ploughed versus that which is deployed with ducts

Table 5.17: Key parameters in the 'NwDes.2.PoC' worksheet [Source: Analysys]

5.11.2 Calculation description

This worksheet contains network design algorithms for the PoC level. This includes calculations for the equipment required and link transmission dimensioned for the links from the PoC to the LAS. The table below lists specific data inputs and calculations by row number.

Cell reference	*Description and details of spreadsheet calculations*
Row 7	Check that the traffic totals reconcile
Rows 13–1513	Calculation of the transmission required at each individual PoC location • Columns B–J link in the PoC-ring data from the 'In.Node' worksheet. This identifies the number of PoC nodes on the LAS rings, whether the PoC node is the LAS node, whether the PoC node is a bridging node, and the distance to the next node on the ring. These distances and ring structures have been calculated according to a multi-ring Travelling Salesman Algorithm. • Column K identifies whether the PoC has already been accounted for in the demand calculations – this is the case for bridging nodes which are listed multiple times • Columns L–O calculate the TDM E1 transmission at the PoC - (taking into account whether the demand at the node has already been modelled (column K); the E1 transmission at the PoC, excluding whether it is a LAS node (LAS node transmission does not dimension the PoC rings); the E1 transmission at the PoC, excluding nodes which are bridging nodes. Column O calculates the total transmission requirement on a particular ring. • Columns P–S calculate the NGN transmission at the PoC – a similar process is followed as for the TDM transmission calculations. NGN transmission is calculated in terms of kbit/s. • Column T calculates the number of regenerators required.
Rows 1521–2021	Calculation of the transmission rings deployed • Columns C–D calculate the TDM and Ethernet transmission required on each ring • Column E identifies the type of traffic carried on the ring – either, TDM, Ethernet or TDM & Ethernet. The latter of which requires a dimensioning in terms of VC-3s in order to dimension Ethernet over SDH traffic. • Column F calculates the VC-3 requirement for the Ethernet over SDH traffic • Columns H–N calculate the SDH transmission links required in order to carry the calculated PoC-LAS TDM-based traffic + Ethernet over SDH traffic • Columns O–R calculate the Ethernet transmission link speeds required in order to carry the calculated PoC-LAS Ethernet traffic • Columns S–Z calculate the fibre bundle size and distance of fibre for SDH and other fibre services deployed in the network - this data is used in the cost allocation in the 'Costing' module
S2025-S2029	Calculation of the incremental trench outside of the CAN area and the distance in the CAN area that may be utilised by core network ducts.
X2025–Y2033	Calculation of the fibre sheath length by bundle size and the trench requirements according to the route sharing inputs from the 'In.Nodes' worksheet
Rows 2039–2079	Summary of the equipment units deployed at the PoC level according to demand

Table 5.18: Calculations performed on the 'NwDes.2.PoCs' worksheet [Source: Analysys]

The remainder of this section details the specific calculations that take place on the 'NwDes.2.PoC' worksheet.

The calculation of the transmission at each point on the PoC-rings is informed by a number of parameter values derived from the 'In.Node' worksheet. This information is linked from columns B–J of that worksheet. This is shown below:

Transmission required at each point on the PoC - Regional Node / LAS rings

Note: this is built for 1500 rows

POC Name	LAS	Ring	Number Of POCs in	Is a LAS?	Bridging Node	Dist To Next Node	Ring Joined To	Is in LAS Ring
ADLE-1	ADLJ	1	9	Y	-	5	1	Y
ADLE-2	ADLJ	1	9	-	-	28	1	Y
MPLE	ADLJ	1	9	-	-	24	1	Y
GYRA	ADLJ	2	9	-	-	54	1	N
GNIS	ADLJ	2	9	-	-	77	1	N
ASHD	ADLJ	2	9	-	-	85	1	N
CRBL	ADLJ	2	9	-	-	105	1	N
INLL	ADLJ	2	9	-	-	34	1	N
DISP	ADLJ	2	9	-	-	86	1	N
ADLE-2	ADLJ	2	9	-	Y	28	1	N
NRWD	AFTA	3	4	-	-	4	3	Y

Figure 5.41: Excel screenshot showing sample of the calculation of transmission at each point on the PoC–LAS rings [Source: Analysys]

Transmission at a PoC is calculated on the basis of TDM E1s and Ethernet kbit/s required on a particular ring. Each point on the ring is required to be able to handle the whole capacity of the ring, i.e. each node on the ring is set at the same speed. The calculation of the required capacity takes place in columns L–S, as shown below:

Transmission required at each point on the PoC - Regional Node / LAS rings

Note: this is built for 1500 rows

		TDM transmission (E1s)				NGA transmission (kbps)			
POC Name	LAS	PoC demand	Excluding LAS node	Excluding bridging node	Ring demand	PoC demand	Excluding LAS node	Excluding bridging node	Ring demand
ADLE-1	ADLJ	21	-	21	742	-	-	-	-
ADLE-2	ADLJ	69	69	69	742	-	-	-	-
MPLE	ADLJ	183	183	183	742	-	-	-	-
GYRA	ADLJ	91	91	91	490	-	-	-	-
GNIS	ADLJ	31	31	31	490	-	-	-	-
ASHD	ADLJ	80	80	80	490	-	-	-	-
CRBL	ADLJ	126	126	126	490	-	-	-	-
INLL	ADLJ	38	38	38	490	-	-	-	-
DISP	ADLJ	124	124	124	490	-	-	-	-
ADLE-2	ADLJ	-	-	-	490	-	-	-	-
NRWD	AFTA	144	144	144	242	-	-	-	-
FLNF	AFTA	68	-	68	242	-	-	-	-

Figure 5.42: Excel screenshot showing sample of the calculation of transmission at each point on the PoC–LAS rings [Source: Analysys]

It should be noted that the PoC ring algorithm enables the deployment of multiple ring structures. The following explanation involves the concept of parent and child rings. The parent ring is the ring which contains the LAS node. A child node is one which links on to the parent node (this link is by means of a bridging node (the capacity of which is included in the dimensioning of the parent ring) – in the base case, two bridging nodes are required for resilience purposes (traffic would still be routed in the case of a single point of failure at one of the bridging nodes) between a child and parent ring, unless the bridging point is at the LAS node, in which case only a single bridging node is implemented.

This calculation has been broken up into a number of steps and calculated explicitly in columns L–O and P–S for the TDM and NGN transmission dimensioning respectively.

5.12 'NwDes.3.Reg.Nodes' worksheet

The 'NwDes.3.Reg.Nodes' worksheet is a part of the network design algorithm. It contains the calculations for the dimensioning of equipment and transmission at the LAS level (modern network design) and regional node level (NGN design). As per the scorched-node principle, the LAS calculations are performed on a node-by-node basis for each of the 133 LAS locations.

In the modern network structure, the LAS node specifically only handles voice traffic, with data traffic being handled by alternative equipment at the co-sited local transmission hub (LTH) site. The voice and data traffic is backhauled in the same trenches.

In the NGN structure, the regional node handles both voice and data traffic using IP. Both sets of traffic may be carried on the same fibres. Time Division Multiplexer (TDM) based traffic from NGN parts of the network are modelled to be connected to the IP core at the regional node location by means of a transit gateway switch.

This worksheet uses subscriber inputs from the 'In.Subs' worksheet, based on the parent LAS in each PoC ring. Per subscriber demand from the 'Dem.Calc' worksheet is linked to this worksheet. The required numbers for equipment deployed from this worksheet is linked to the 'Out.Assets' worksheet.

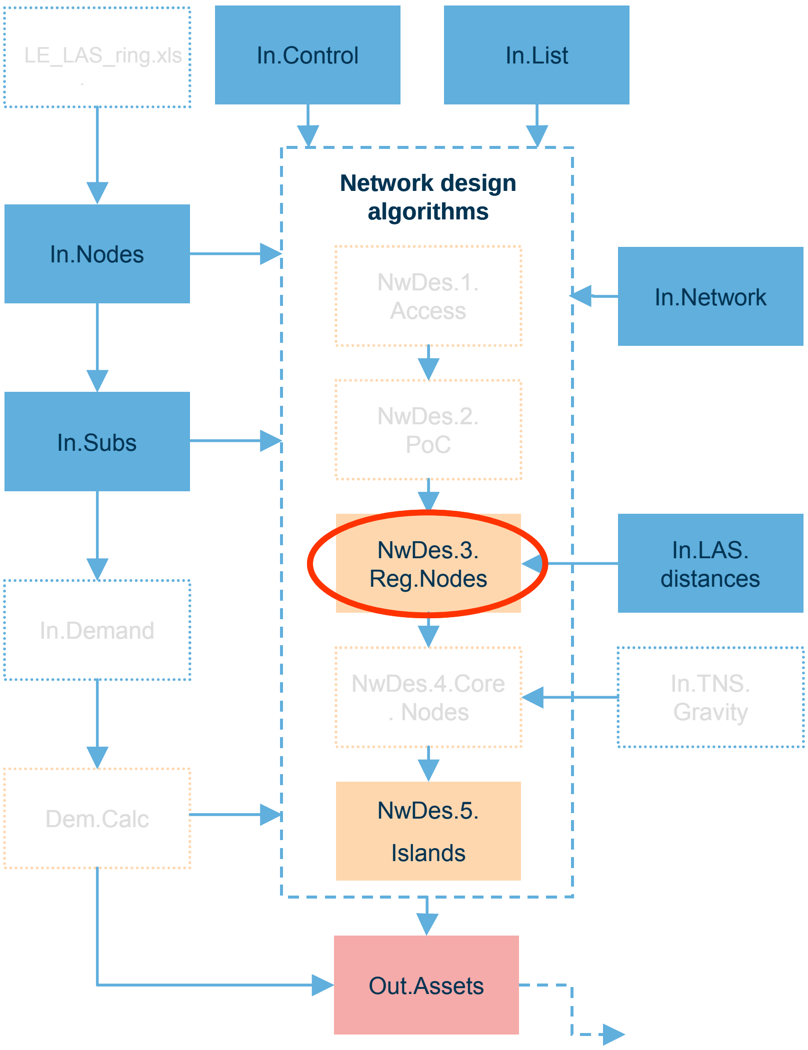


Figure 5.43: Location of the 'NwDes.3.Reg.Nodes' worksheet in the overall Core module structure [Source: Analysys]

5.12.1 Key parameters

No equipment parameter values are inserted manually into this worksheet, but numerous key parameters, set out below, are linked from the 'In.Network' worksheet. If required, these parameter values should be changed directly on the 'In.Network' worksheet.

LAS routes are defined on this sheet, and are only expected to be changed occasionally if an alternative set of routes are required for LAS-TNS rings.

Parameter	*Location*	*Impact*
Equipment capacity parameters	Cells D153–G153, F295 Rows 437, 438, 579, 580	Defines the physical equipment capacity
Link utilisation parameters	Rows 1172–1916	Affects the maximum effective loading of the transmission links – reflects the fact that links are not dimensioned to be fully loaded
Fibre uplift parameter for spares and other fibre services	Rows 1172–1916	Deployment of spare and other fibre above those required just for the LAS ring
Transmission carried (kbit/s)	Rows 1172–1916	Allowance for other transmission requirements on the LAS–TNS links
CAN-IEN and inter-IEN overlap parameters	H1943, H1945	Affects the volume of duct and trench assets calculated for the LAS level. The distance of duct within CAN areas is retained for cost allocations between and CAN and IEN.
Percentage of trench that is ducted	H2011	Affects the amount of trench that is ploughed versus that which is ducted

Table 5.19: Key parameters on the 'NwDes.3.Reg.Nodes' worksheet [Source: Analysys]

5.12.2 Calculation description

This worksheet contains network design algorithms for the LAS level. This includes calculations for the equipment required and link transmission dimensioned for the links from the LAS to the TNS, and the LAS to interconnection with other networks. The table below lists specific data inputs and calculations by row number.

Cell reference	*Description and details of spreadsheet calculations*
Rows 3–10	Check that the traffic totals reconcile
Rows 15–148	Subscriber numbers at each LAS
Rows 157–290	LAS unit switchblock and processor requirement
Rows 299–432	NGN trunk gateway dimensioning
Rows 441–574	NGN edge switch dimensioning
Rows 583–716	NGN edge router dimensioning
Rows 721–738	Transmission demand requirements
Rows 743–881	Transmission requirement for LAS–LAS links
Rows 888–1021	Transmission requirement for LAS–TNS/LTH–MTH links
Rows 1023–1162	Transmission requirement for LAS–Interconnection links
Rows 1173–1966	LAS ring structure calculations, including the capacity calculations for the physical ring dimensioning, and the fibre, trench and duct distance calculations. LAS rings are grouped by major urban area (Perth, Adelaide, Melbourne, Canberra, Sydney and Brisbane)
Rows 1973–2036	Summary of the equipment units deployed at the LAS level according to demand

Table 5.20: Calculations performed on the 'NwDes.3.Reg.Nodes' worksheet [Source: Analysys]

Equipment dimensioning

Cell reference	*Description and details of spreadsheet calculations*
Rows 157–290	LAS unit switchblock and processor requirement

The Excel output of the modern network LAS unit equipment dimensioning is shown below:

LAS ID	LAS Name	LAS traffic BH Erlangs	BH Call attempts	LAS units based on switchblock capacity	based on processor capacity	Total
ALBG	ALBURY	2,426	586	1	1	1
ALSG	ALICE SPRINGS AXE	419	101	1	1	1
ADLJ	ARMIDALE	1,257	304	1	1	1
BALJ	BALGOWLAH S12	1,763	426	1	1	1
BRAJ	BALLARAT S12	3,872	936	1	1	1
BAKN	BANKSTOWN 1 S12	3,276	792	1	1	1
BRPT	BANORA POINT	2,173	525	1	1	1
BATJ	BATHURST AXE	1,066	258	1	1	1
BEGX	BEGA AXE	1,867	451	1	1	1
BENV	BENDIGO LAS	4,203	1,016	2	1	2
BLAP	BLACKTOWN AXE 2	5,453	1,318	2	1	2
BLHJ	BLAKEHURST AXE	5,906	1,427	2	1	2
BHLX	BOX HILL	5,824	1,408	2	1	2

Figure 5.44: Excel calculations for the LAS equipment [Source: Analysys]

The modern network design requires LAS equipment to handle the voice traffic. The LAS equipment consists of:

- a switchblock, which is dimensioned by the busy hour Erlang load on each LAS:

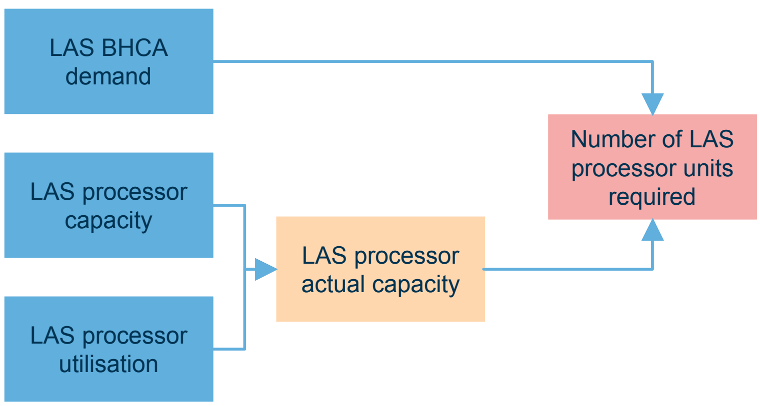


Figure 5.45: Calculation of the number of LAS processor units required [Source: Analysys]

- and a processor unit, which is dimensioned by the busy hour call attempt load on each LAS:

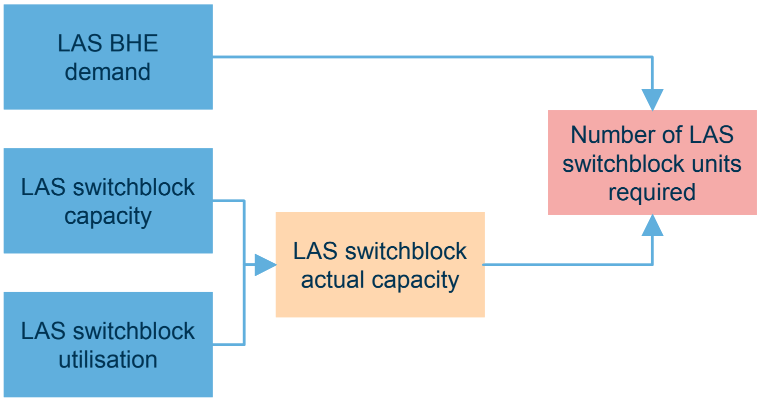


Figure 5.46: Calculation of the number of LAS switchblock units required [Source: Analysys]

The dimensioning of these equipment parts is controlled by the physical capacity of the equipment and the maximum utilisation of the equipment. The busy hour load is determined from the routed service demand on a per subscriber basis, as calculated on the 'Dem.Calc' worksheet.

The NGN equipment at the regional node consists of a trunk gateway switch, an edge switch and an edge router.

Cell reference	*Description and details of spreadsheet calculations*
Rows 299–432	NGN trunk gateway dimensioning

The trunk gateway switch acts as a switch between legacy network and NGN: all non-NGN traffic is aggregated at switches and converted to IP. The trunk gateway is dimensioned in terms of STM-1 gateways.

		Traffic from PoCs		**NGN trunk gateway**
LAS ID	**LAS Name**	SDH (E1s)	NGN (kbit/s	STM-1 ports
ALBG	ALBURY	1,013	-	-
ALSG	ALICE SPRINGS AXE	153	-	-
ADLJ	ARMIDALE	580	-	-
BALJ	BALGOWLAH S12	297	-	-
BRAJ	BALLARAT S12	1,628	-	-
BAKN	BANKSTOWN 1 S12	502	-	-
BRPT	BANORA POINT	756	-	-
BATJ	BATHURST AXE	631	-	-
BEGX	BEGA AXE	1,062	-	-
BENV	BENDIGO LAS	1,857	-	-
BLAP	BLACKTOWN AXE 2	966	-	-
BLHJ	BLAKEHURST AXE	1,020	-	-
BHLX	BOX HILL	916	-	-

Figure 5.47: Excel calculations for the NGN trunk gateway dimensioning [Source: Analysys]

The specific calculation methodology for the trunk gateway switch is outlined below:

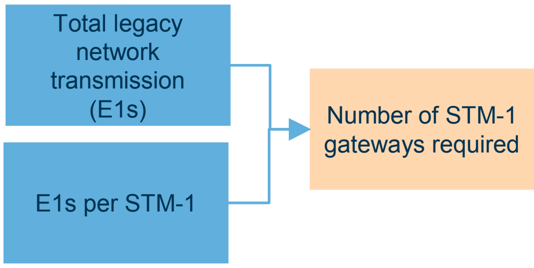


Figure 5.48: Calculation of trunk gateways [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 441–574	NGN edge switch dimensioning

The Edge Switches aggregate traffic from the TGW and MSANs for delivery to and from the core and access nodes.

The Edge Switches are dimensioned according to the links to the Edge Router, the links to the Trunk Gateway, and the links from the PoC nodes. The chassis' required are driven by the number of 48-port cards and 12 port cards dimensioned.

It is assumed that they require 48 port cards to link to the MSANs and 12 port cards to link TGWs and edge routers. The capacity of a chassis is five slots for connectivity cards.

LAS ID	LAS Name	Links to Edge Router 12-port cards	Links to Trunk 12-port cards	Links from PoC nodes 48-port cards	48-port cards required	12-port cards required	Chassis required
ALBG	ALBURY	-	-	-	-	-	-
ALSG	ALICE SPRINGS AXE	-	-	-	-	-	-
ADLJ	ARMIDALE	-	-	-	-	-	-
BALJ	BALGOWLAH S12	-	-	-	-	-	-
BRAJ	BALLARAT S12	-	-	-	-	-	-
BAKN	BANKSTOWN 1 S12	-	-	-	-	-	-
BRPT	BANORA POINT	-	-	-	-	-	-
BATJ	BATHURST AXE	-	-	-	-	-	-
BEGX	BEGA AXE	-	-	-	-	-	-
BENV	BENDIGO LAS	-	-	-	-	-	-
BLAP	BLACKTOWN AXE 2	-	-	-	-	-	-
BLHJ	BLAKEHURST AXE	-	-	-	-	-	-
BHLX	BOX HILL	-	-	-	-	-	-

Figure 5.49: Excel calculations for the NGN edge switch dimensioning [Source: Analysys]

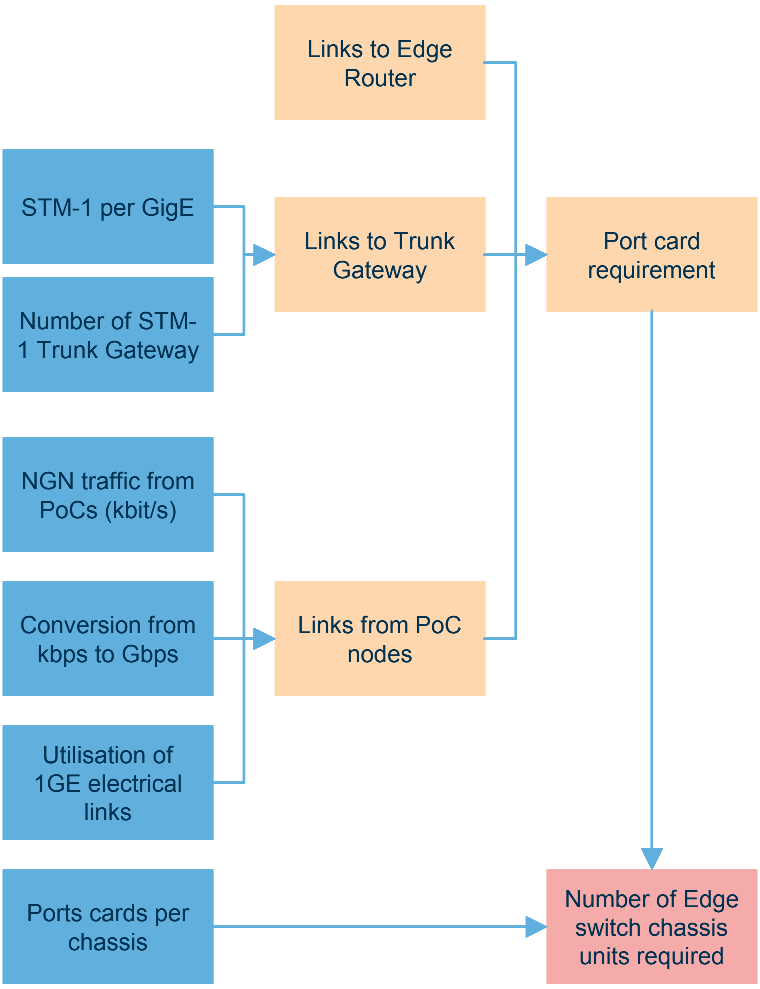


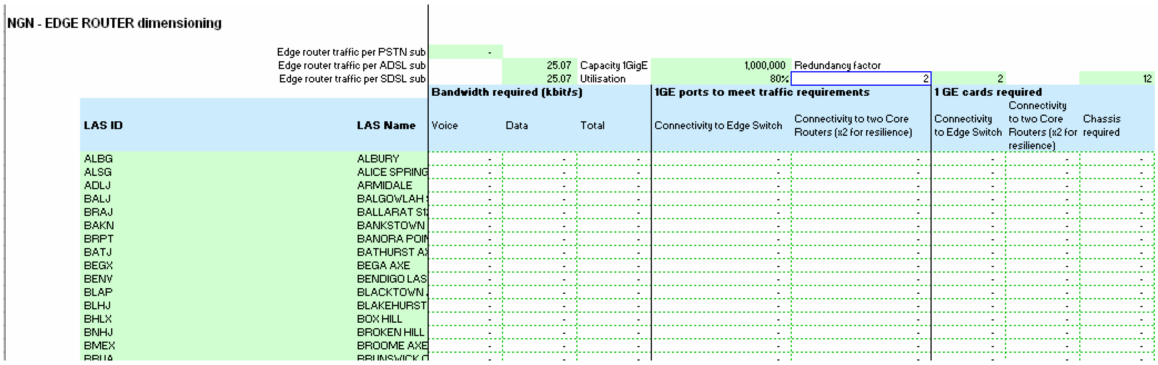
Figure 5.50: Calculation of the number of Edge Switch chassis units required [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 583–716	NGN edge router dimensioning

The Edge Routers are responsible for the routeing of traffic from the regional nodes to the core nodes using 1Gbit/s (two port) cards.

The chassis unit has a capacity of 12 card slots and we assume that each edge router has a minimum of two of these cards.

Analysys



NGN - EDGE ROUTER dimensioning

Edge router traffic per PSTN sub -
Edge router traffic per ADSL sub 25.07 Capacity 1GigE 1,000,000 Redundancy factor
Edge router traffic per SDSL sub 25.07 Utilisation 80% 2 2 12

		Bandwidth required (kbit/s)			1GE ports to meet traffic requirements		1 GE cards required		
LAS ID	LAS Name	Voice	Data	Total	Connectivity to Edge Switch	Connectivity to two Core Routers (x2 for resilience)	Connectivity to Edge Switch	Connectivity to two Core Routers (x2 for resilience)	Chassis required
ALBG	ALBURY	-	-	-	-	-	-	-	-
ALSG	ALICE SPRING	-	-	-	-	-	-	-	-
ADLJ	ARMIDALE	-	-	-	-	-	-	-	-
BALJ	BALGOWLAH	-	-	-	-	-	-	-	-
BRAJ	BALLARAT S1	-	-	-	-	-	-	-	-
BAKN	BANKSTOWN	-	-	-	-	-	-	-	-
BRPT	BANORA POIN	-	-	-	-	-	-	-	-
BATJ	BATHURST AX	-	-	-	-	-	-	-	-
BEGX	BEGA AXE	-	-	-	-	-	-	-	-
BENV	BENDIGO LAS	-	-	-	-	-	-	-	-
BLAP	BLACKTOWN	-	-	-	-	-	-	-	-
BLHJ	BLAKEHURST	-	-	-	-	-	-	-	-
BHLX	BOX HILL	-	-	-	-	-	-	-	-
BNHJ	BROKEN HILL	-	-	-	-	-	-	-	-
BMEX	BROOME AXE	-	-	-	-	-	-	-	-
BRUA	BRUNSWICK C	-	-	-	-	-	-	-	-

Figure 5.51: Excel calculations for the NGN edge router dimensioning [Source: Analysys]

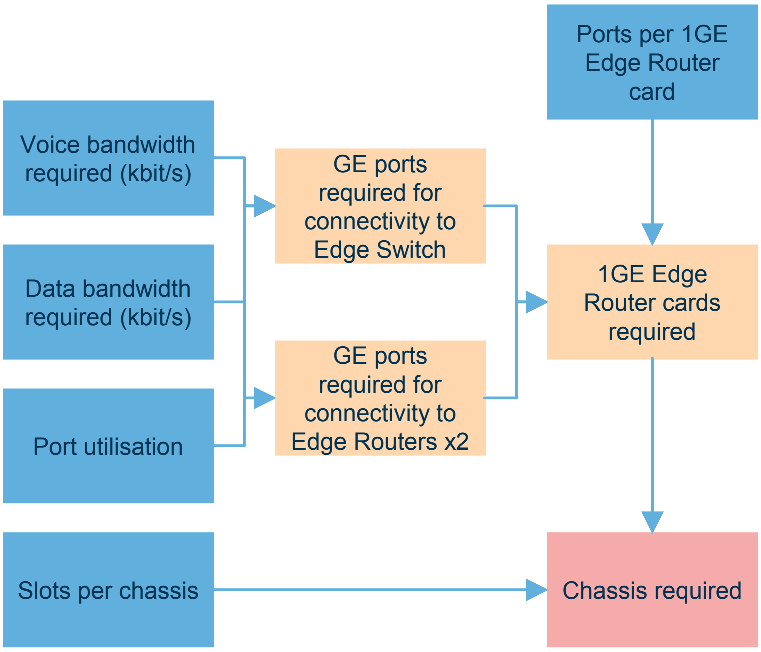


Figure 5.52: Calculation of the number of Edge Router chassis units required [Source: Analysys]

Transmission dimensioning

At the LAS/regional node level, transmission links for LAS–LAS traffic and LAS–TNS traffic are calculated. As per the previously documented transmission calculations, the links are dimensioned by the per subscriber busy hour traffic as calculated on the 'Dem.Calc' worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Rows 743–881	Transmission requirement for LAS–LAS links

A screenshot of the Excel LAS–LAS transmission calculations is shown below:

LAS-LAS traffic

grade of service	0.50%	*grade.of.service.l*
Erlang conversi	92.61%	*Erlang.conversion.factor.l*
circuits per E1	30	*circuits.per.E1.l*

		TDM traffic			**NGN traffic**	**Total**
LAS ID	**LAS Name**	BH Erlangs	E1 links	kbps	kbps	E1 VCs
ALBG	ALBURY	23	2	3,840	-	2
ALSG	ALICE SPRINGS AXE	4	1	1,920	-	1
ADLJ	ARMIDALE	12	1	1,920	-	1
BALJ	BALGOWLAH S12	17	1	1,920	-	1
BRAJ	BALLARAT S12	36	2	3,840	-	2
BAKN	BANKSTOWN 1 S12	31	2	3,840	-	2
BRPT	BANORA POINT	20	2	3,840	-	2
BATJ	BATHURST AXE	10	1	1,920	-	1
BEGX	BEGA AXE	18	1	1,920	-	1
BENV	BENDIGO LAS	40	2	3,840	-	2
BLAP	BLACKTOWN AXE 2	51	3	5,760	-	3
BLHJ	BLAKEHURST AXE	56	3	5,760	-	3
BHLX	BOX HILL	55	3	5,760	-	3

Figure 5.53: Transmission requirement calculation for LAS–LAS traffic [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 888–1021	Transmission requirement for LAS–TNS/LTH–MTH links

A screenshot of the Excel LAS–TNS transmission calculations is shown below:

LAS-TNS/LTH-MTH traffic LT

Note: TDM traffic is transmitted in terms of E1 carriers, NGN traffic is transmit *Uplift for O*

		TDM-based traffic				
		PSTN	ISDN	xDSL	PSTN	ISDN
LAS ID	**LAS Name**	BHE	BHE	kbit/s	E1s	E1s
ALBG	ALBURY	1,764	682	558,744	63	25
ALSG	ALICE SPRINGS AXE	305	127	107,971	12	6
ADLJ	ARMIDALE	914	325	267,899	33	13
BALJ	BALGOWLAH S12	1,282	590	433,883	46	22
BRAJ	BALLARAT S12	2,816	1,113	895,716	99	40
BAKN	BANKSTOWN 1 S12	2,382	1,097	774,294	84	40
BRPT	BANORA POINT	1,580	665	539,894	56	25
BATJ	BATHURST AXE	775	265	232,015	29	11
BEGX	BEGA AXE	1,358	525	451,273	49	20
BENV	BENDIGO LAS	3,056	1,183	958,946	107	43
BLAP	BLACKTOWN AXE 2	3,965	1,806	1,357,767	138	64
BLHJ	BLAKEHURST AXE	4,295	1,967	1,398,920	149	70
BHLX	BOX HILL	4,235	1,950	1,385,528	147	69

Figure 5.54: Transmission requirement calculation for LAS–TNS/MTH links [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 1023–1162	Transmission requirement for LAS–Interconnection links

Interconnection to other networks may also take place at the LAS level. Interconnection ports are presented as STM-1 ports.

A screenshot of the Excel LAS–Interconnection transmission calculations is shown below:

LAS/LTH-Interconnection traffic

Note: TDM traffic is transmitted in terms of E1 carriers, NGN traffic is transmitted in terms

		TDM-based traffic calculations				
		PSTN	ISDN	PSTN	ISDN	Total
LAS ID	**LAS Name**	BHE	BHE	E1s	E1s	E1s
ALBG	ALBURY	77	-	4	-	4
ALSG	ALICE SPRINGS AXE	13	-	1	-	1
ADLJ	ARMIDALE	40	-	2	-	2
BALJ	BALGOWLAH S12	56	-	3	-	3
BRAJ	BALLARAT S12	123	-	5	-	5
BAKN	BANKSTOWN 1 S12	104	-	5	-	5
BRPT	BANORA POINT	69	-	3	-	3
BATJ	BATHURST AXE	34	-	2	-	2
BEGX	BEGA AXE	59	-	3	-	3
BENV	BENDIGO LAS	134	-	6	-	6
BLAP	BLACKTOWN AXE 2	173	-	7	-	7
BLHJ	BLAKEHURST AXE	188	-	8	-	8
BHLX	BOX HILL	185	-	8	-	8
BNHJ	BROKEN HILL	18	-	1	-	1

Figure 5.55: Transmission requirement calculation for LAS–Interconnection links [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 1173–1966	LAS ring structure calculations, including the capacity calculations for the physical ring dimensioning, and the fibre, trench and duct distance calculations. LAS rings are grouped by major urban area (Perth, Adelaide, Melbourne, Canberra, Sydney and Brisbane)

The model has been set up with a series of physical LAS ring structures. A set of these rings are defined for each of the main metropolitan areas in Australia, namely Perth, Adelaide, Melbourne, Canberra, Sydney and Brisbane.

The composition of each of the LAS rings is user defined, and is flexible enough to accommodate changes to the structure. The current composition is based upon Analysys's estimate as to an appropriate ring structure.

Physical ring structures Note: different LAS-ring structures may be entered, however, care should be taken that the routes are realistic when compa

Perth rings

Links to TNS in another metro area	**Nodes**	**LAS**	**LAS**	**LAS**	**LAS**	**LAS**	**LAS**
0	Ring 1	PWTA	PPTA	CANC	MIDN	GNGJ	HMSX
0	Ring 2	PWTA	HMSX	GTNX	KAHX	BMEX	MIDN
0	Ring 3	PWTA	RKHX	BUNX	KAXX	CANC	PPTA
1	Ring 4	PPTA	CANC	MIDN	KALX	PAAX	PROL
1	Ring 5	PPTA	CANC	MIDN	BMEX	DRWH	CSUG
0	Ring 6						

Figure 5.56: Excel layout for composition of LAS-ring structures [Source: Analysys]

The model calculates whether a particular LAS is co-located with a TNS unit. This calculation is used to take into account the assumption that when co-located, the LAS traffic is carried on the transit rings, rather than on the LAS rings.

LAS not colocated with TNS	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-	-	1	1	1	1
Ring 2	-	1	1	1	1	1
Ring 3	-	1	1	1	1	-
Ring 4	-	1	1	1	1	1
Ring 5	-	1	1	1	1	1
Ring 6	1	1	1	1	1	1

Figure 5.57: Excel calculations for co-location of LAS units with TNS units [Source: Analysys]

Due to the physical nature of the LAS ring structures (certain rings may pass through the same node-to-node paths to model the usage of the same trench) the deployment of incremental trench is defined by the user.

Incremental trench deployed	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-		1	1	1	1
Ring 2	-	1	1	1	1	1
Ring 3	1	1	1	1	1	-
Ring 4	-	-	1	1	1	-
Ring 5	-	-	-	1	1	1
Ring 6	-	-	-	-	-	-

Figure 5.58: Excel layout for parameters determining the deployment of incremental trench [Source: Analysys]

For a similar reason, whether a particular node dimensions a particular LAS ring is defined by the user. It is important to ensure that the individual capacity from each LAS node is only counted once.

Node capacity to dimension LAS r	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-	-	1	1	1	1
Ring 2	-	-	1	1	1	-
Ring 3	-	1	1	1	-	-
Ring 4	-	-	-	1	1	-
Ring 5	-	-	-	-	1	1
Ring 6	-	-	-	-	-	-

Figure 5.59: Excel layout for parameters determining whether a particular node dimensions a particular LAS ring [Source: Analysys]

The cumulative number of nodes is calculated as an internal check:

Cumulative number of nodes	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-	-	1	2	3	4
Ring 2	-	-	1	2	3	3
Ring 3	-	1	2	3	3	3
Ring 4	-	-	-	1	2	2
Ring 5	-	-	-	-	1	2
Ring 6	-	-	-	-	-	-

Figure 5.60: Excel calculations for the cumulative number of nodes [Source: Analysys]

The node capacity that dimensions each of the LAS rings is calculated automatically on an individual node basis by looking up the value from the LAS–TNS transmission calculation.

Node capacity (E1 VCs) to be carried on ring	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-	-	2,095	1,275	1,369	1,072
Ring 2	-	-	397	219	88	-
Ring 3	-	1,295	856	444	-	-
Ring 4	-	-	-	344	520	-
Ring 5	-	-	-	-	199	407
Ring 6	-	-	-	-	-	-

Figure 5.61: Excel calculations to determine the node capacity that dimensions each of the LAS rings [Source: Analysys]

The sum of these node capacities dimension the total required capacity of the ring. Furthermore, Columns AI–AM calculate the total numbers of fibres physically required (including an allowance for spares and other fibre services):

Number of fibres dimensione	Fibres required for spares	Dark fibres required	Total fibres required	Bundle size	DWDM dimensioning Deploy DWDM	Scenari o impleme	Wavelen gths deploye	SDH fibre metres	Dark fibre metres	Nodes requirin g ADM	Nodes requirin g
4	1	1	6	6	-	-	-	409,188	81,838	4	0
4	1	1	6	6	-	-	-	22,794,250	4,558,850	3	0
4	1	1	6	6	-	-	-	3,672,125	734,425	3	0
4	1	1	6	6	-	-	-	14,967,500	2,993,500	2	0
4	1	1	6	6	-	-	-	33,993,375	6,798,675	3	0
-	-	-	-	-	-	-	-	-	-	0	0
-	-	-	-	-	-	-	-	-	-	0	0
-	-	-	-	-	-	-	-	-	-	0	0
-	-	-	-	-	-	-	-	-	-	0	0
-	-	-	-	-	-	-	-	-	-	0	0
								75,836,438	15,167,288		

Figure 5.62: Excel calculations to determine the fibres required, DWDM equipment requirement and the total fibre metres split between SDH and other fibre [Source: Analysys]

Columns W–Z calculate the Dense Wave Division Multiplexer (DWDM) equipment required to serve the nodes on the ring. The type of DWDM equipment (metro, long haul, extended long haul, or ultra long-haul) is then calculated (in calculations next to the determination of fibre distance between active nodes on the ring):

Analysys

The distance of the fibre links between each of the nodes is calculated automatically by looking up the appropriate value in the LAS–LAS distance matrix on the 'In.LAS.distance' worksheet.

Fibre Distance (km)	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	1	14	24	27	11	20
Ring 2	20	539	1,397	970	2,504	24
Ring 3	58	174	274	360	14	1
Ring 4	14	24	799	2,332	417	6
Ring 5	14	24	2,504	1,658	16	1,946
Ring 6	-	-	-	-	-	-

Figure 5.63: Excel calculations to determine the distance of the fibre links between each node [Source: Analysys]

These distances are used in the calculation of the total distance between active nodes on the LAS ring. It is these distances that are used in the determination of the number of Synchronous Digital Hierarchy (SDH) regenerators required.

Fibre distance (km) (between active nodes on the ring)	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-	-	40	27	11	20
Ring 2	-	-	1,956	970	2,544	-
Ring 3	-	232	274	376	-	-
Ring 4	-	-	-	3,170	423	-
Ring 5	-	-	-	-	4,218	1,946
Ring 6	-	-	-	-	-	-

Figure 5.64: Excel calculations to determine the total distance between active nodes on the LAS ring [Source: Analysys]

The trench distance required (as shown below) is based on the distances calculated in the LAS–LAS distance matrix, but is only required when the flag for incremental trench is set to 1 (as shown in Figure 5.58)

Trench Distance (km)	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-	-	24	27	11	20
Ring 2	-	539	1,397	970	2,504	24
Ring 3	58	174	274	360	14	-
Ring 4	-	-	799	2,332	417	-
Ring 5	-	-	-	1,658	16	1,946
Ring 6	-	-	-	-	-	-

Figure 5.65: Excel calculations to determine the trench distance required [Source: Analysys]

The number of fibre regenerators required is calculated according to the fibre distances calculated between active nodes on the LAS rings. A fibre regenerator is deployed every *x* km, where *x* is a user-defined parameter in the model.

SDH regenerators required	LAS	LAS	LAS	LAS	LAS	LAS
Ring 1	-	-	-	-	-	-
Ring 2	-	-	24	12	31	-
Ring 3	-	2	3	4	-	-
Ring 4	-	-	-	39	5	-
Ring 5	-	-	-	-	52	24
Ring 6	-	-	-	-	-	-

Figure 5.66: Excel calculations to determine the number of fibre regenerators required [Source: Analysys]

The equipment requirements for each node and ring structure are summarised in the table at the bottom of the 'NwDes.3.RegNodes' worksheet. The trench requirements take into account the trench sharing within the IEN and with the CAN, as calculated in rows 1943–1948.

5.13 'NwDes.4.Core.Nodes' worksheet

The 'NwDes.4.Core.Nodes' worksheet is a part of the network design algorithm. It contains the calculations for the dimensioning of equipment and transmission at the TNS level (for the modern network design) and at the Core Node level (for the NGN design). As per the scorched-node principle, the TNS calculations are performed for each of the 14 TNS locations in the existing network. It is assumed that the Core Nodes are deployed in the same locations as the existing TNS nodes.

It uses subscriber inputs from the 'In.Subs' worksheet, based on two parent TNS nodes for each LAS. Per subscriber demand is from the 'Dem.Calc' worksheet is linked to this worksheet. The required numbers for equipment deployed derived from this worksheet is then linked to the 'Out.Assets' worksheet. These linkages are shown in the diagram below:

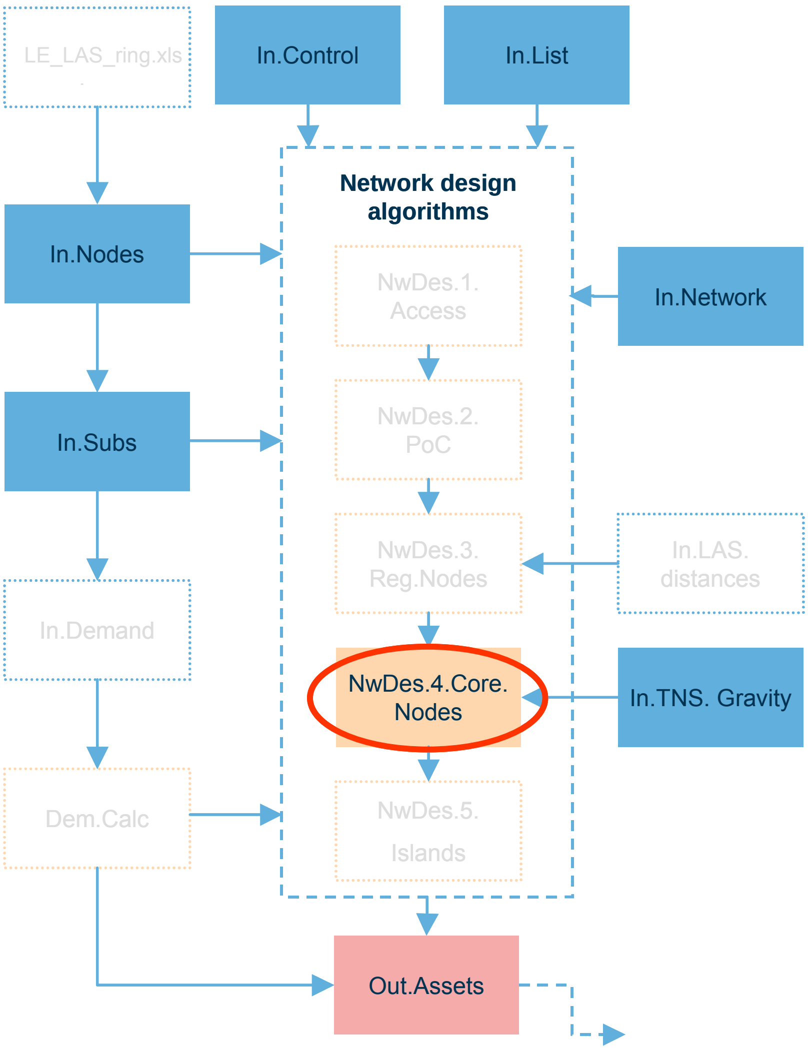


Figure 5.67: Location of the 'NwDes.4.Core.Nodes' worksheet in the overall Core module structure [Source: Analysys]

5.13.1 Key parameters

No parameter values are inserted manually into this worksheet, but numerous key parameter values are linked from the 'In.Network' worksheet. If required, the parameters should be changed directly on the 'In.Network' worksheet.

The utilisation parameters, set out below, are the key parameters that can be changed.

Parameter	*Location*	*Impact*
Equipment capacity parameters	Rows 17–18	Defines the physical equipment capacity
Equipment utilisation parameters	Rows 20–21	Affects the level of effective equipment capacity
Link utilisation parameters	Rows 23–24	Affects the maximum effective loading of the transmission links – reflects the fact that links are not dimensioned to be fully loaded
Fibre uplift parameter for spares	Row 26	Uplift for a number of spare fibres in the bundle
Fibre uplift parameter for other fibre services	Row 27	Uplift for a number of fibres that are available for alternative operators to utilise
Transmission carried (kbit/s)	Row 30	Allowance for other transmission requirements on the LAS–TNS links
Percentage of trench that is ducted	Row 32	Affects the link and trench distances deployed in the network
DWDM equipment parameters	Rows 35–38	Parameters affecting the thresholds for the deployment of DWDM equipment and the distance parameters for the four types of DWDM equipment modelled
CAN-IEN and inter-IEN overlap parameters	I472, I474	Affects the volume of duct and trench assets calculated for the TNS level. The distance of duct within CAN areas is retained for cost allocations between and CAN and IEN.

Table 5.21: Key parameters on the 'NwDes.4.Core.Nodes' worksheet [Source: Analysys]

5.13.2 Calculation description

This worksheet contains network design algorithms at the TNS level. This includes calculations for the equipment and transmission for the core network links from the TNS to the TNS, and for the TNS to interconnection with other networks. The table below lists specific data inputs and calculations by row number.

Cell reference	*Description and details of spreadsheet calculations*
Rows 5–10	Check that the traffic totals reconcile
Rows 16–69	Network parameters that are specific to the calculations at the TNS level, including traffic and switch dimensioning parameters
Rows 74–89	Subscriber numbers at each TNS. Note, due to resilience, each subscriber is parented by 2 TNS units
Rows 95–109	TNS unit switchblock and processor requirement
Rows 112–142	NGN - Core router dimensioning
Rows 147–165	NGN - Core switch dimensioning
Rows 176–190	Transmission requirement for TNS–Interconnection links
Rows 198–212	Transmission requirement for TNS–TNS links
Rows 218–249	Logical link dimensioning for the TNS–TNS transmission links
Rows 255–429	Physical ring dimensioning for the TNS–TNS transmission links
Rows 434–467	Dimensioning of DWDM and SDH equipment
Rows 472–493	Trench distances (including accounting for sharing within the IEN and with the CAN)
Rows 497–515	Dimensioning of softswitch equipment
Rows 520–552	Calculation of the other core network assets that are located at the TNS/MTH location
Rows 559–633	Summary for the TNS-level assets

Table 5.22: Calculations performed on the 'NwDes.4.Core.Nodes' worksheet [Source: Analysys]

The remainder of this section provides an explanation of the calculations in the 'NwDes.4.Core.Nodes' worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Rows 74–89	Subscriber numbers at each TNS. Note, due to resilience, each subscriber is parented by 2 TNSs

For resilience purposes each LAS node is parented by two TNS nodes. The same network architecture is assumed for the NGN architecture.

The Excel output for this calculation is shown below:

Subscriber calculations

Type	Site_ID	Site_Name	PSTN	ISDN-BR	ISDN-PR	ADSL	SDSL
Core node / TNS	AFTA	ADELAIDE TNS	1,100,898	9,905	971	536,804	7,252
Core node / TNS	AWTA	ADELAIDE TNS	875,186	7,908	794	425,847	5,800
Core node / TNS	BWTB	BRISBANE TNS	1,565,144	14,279	1,481	759,909	10,398
Core node / TNS	BCTB	BRISBANE TNS	1,684,732	15,337	1,531	817,396	11,096
Core node / TNS	CCTA	CANBERRA TN	306,651	2,718	267	148,472	2,010
Core node / TNS	CDTA	CANBERRA TN	586,736	5,226	496	285,699	3,827
Core node / TNS	MLTB	MELBOURNE T	2,305,912	20,870	2,168	1,110,819	15,145
Core node / TNS	MWTB	MELBOURNE T	1,275,060	11,591	1,230	624,244	8,553
Core node / TNS	METC	MELBOURNE T	1,427,177	12,897	1,296	685,146	9,278
Core node / TNS	PPTA	PERTH TNS1	1,059,080	9,594	965	489,514	6,653
Core node / TNS	PWTA	PERTH TNS2	930,573	8,454	867	428,711	5,847
Core node / TNS	SKTB	SYDNEY TNS2	1,167,897	10,675	1,161	551,120	7,602
Core node / TNS	SCTC	SYDNEY TNS4	1,528,349	13,827	1,395	728,667	9,871
Core node / TNS	SPTF	SYDNEY TNS5	2,143,780	19,363	1,983	1,050,432	14,285
	Total		17,957,174	162,641	16,604	8,642,780	117,619
	Total divide by 2 (accounting for		8,978,587	81,321	8,302	4,321,390	58,809

Figure 5.68: Calculations for the subscriber numbers [Source: Analysys]

Equipment requirement

Cell reference	*Description and details of spreadsheet calculations*
Rows 95–109	TNS unit switchblock and processor requirement

The modern network design requires TNS equipment to handle the voice traffic. The TNS equipment consists of:

- a switchblock, dimensioned by the busy hour Erlang load on each TNS:

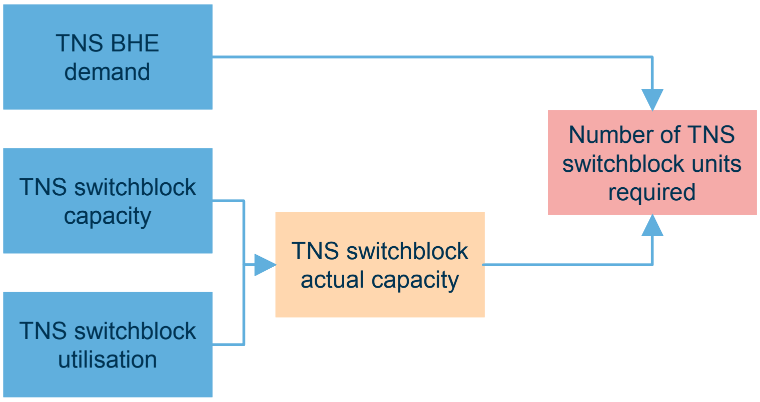


Figure 5.69: Calculation of the number of TNS switchblock units required [Source: Analysys]

Modern - TNS unit requirement

Note: the total number of TNS units is based on the maximum of switchblocks and processor units required at each TNS site

Type	Site_ID	Site_Name	Switchblock capacity of TNS BHE	Switchblock capacity calculation (BHE) TNS BHE	TNS unit requirement (based on switchblock capacity)
TNS	AFTA	ADELAIDE TNS	40,000	30,802	1
TNS	AWTA	ADELAIDE TNS	40,000	24,487	1
TNS	BWTB	BRISBANE TNS	40,000	43,792	2
TNS	BCTB	BRISBANE TNS	40,000	47,138	2
TNS	CCTA	CANBERRA TN	40,000	8,580	1
TNS	CDTA	CANBERRA TN	40,000	16,417	1
TNS	MLTB	MELBOURNE T	40,000	64,518	2
TNS	MWTB	MELBOURNE T	40,000	35,675	1
TNS	METC	MELBOURNE T	40,000	39,932	1
TNS	PPTA	PERTH TNS1	40,000	29,632	1
TNS	PWTA	PERTH TNS2	40,000	26,037	1
TNS	SKTB	SYDNEY TNS2	40,000	32,677	1
TNS	SCTC	SYDNEY TNS4	40,000	42,762	2
TNS	SPTF	SYDNEY TNS5	40,000	59,982	2
				502,431	19

Figure 5.70: Calculations for TNS unit switchblock requirements [Source: Analysys]

- and a processor unit, dimensioned by the busy-hour call attempt load on each TNS:

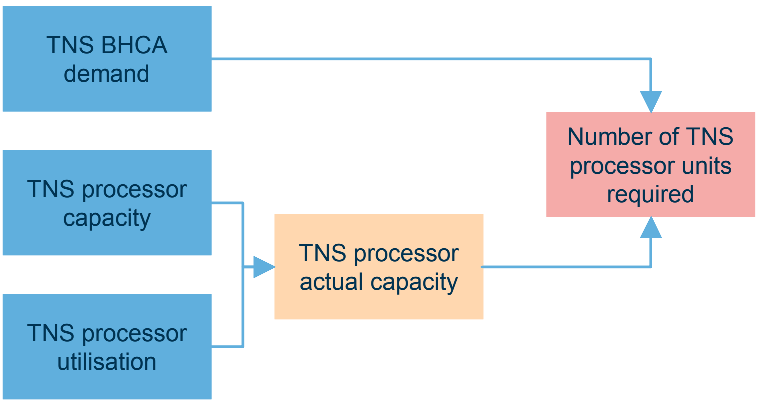


Figure 5.71: Calculation of the number of TNS processor units required [Source: Analysys]

Processor capacity of TNS	Call attempt capacity calculation	TNS unit requirement (based on processor capacity)	TNS units required
BHCA	Total BHCA		
640,000	9,825	1	1
640,000	7,811	1	1
640,000	13,969	1	2
640,000	15,036	1	2
640,000	2,737	1	1
640,000	5,236	1	1
640,000	20,580	1	2
640,000	11,380	1	1
640,000	12,737	1	1
640,000	9,452	1	1
640,000	8,305	1	1
640,000	10,423	1	1
640,000	13,640	1	2
640,000	19,133	1	2
	160,263	14	19

Figure 5.72: Excel calculations for TNS unit switchblock and processor requirements [Source: Analysys]

Similar to the Regional Nodes, in the NGN architecture, Core Routers and Core Switches are deployed at the Core Node location.

Cell reference	*Description and details of spreadsheet calculations*
Rows 112–142	NGN – Core router dimensioning

Core routers are responsible for the routeing of traffic around the core network ring and are assumed to link to the regional nodes using 1Gbit/s (four port) cards. The chassis unit has a capacity of 15 card slots - it is assumed that each core router has a minimum of two of these cards.

The Excel output for the calculation of the core routers is shown below:

NGN - Core router dimensioning

	PSTN	ADSL	SDSL
Bhkbit/s per sub	0.00	22.72	22.72

	Voice	Data
Core router ports used	1	4
Core port capacity (kbps)	1,000,000	
Core router port utilisation	80%	

Ports per 1GE card	4
Cards per chassis	15

Note: core routers are driven by the port requirement for voice and data traffic

Type	Site_ID	Site_Name	BH voice bandwidth	BH data bandwidth	Core router capacity required Capacity for voice traffic	 Capacity for data traffic
Core node	AFTA	ADELAIDE TNS	-	-	-	-
Core node	AWTA	ADELAIDE TNS	-	-	-	-
Core node	BWTB	BRISBANE TNS	-	-	-	-
Core node	BCTB	BRISBANE TNS	-	-	-	-
Core node	CCTA	CANBERRA TN	-	-	-	-
Core node	CDTA	CANBERRA TN	-	-	-	-
Core node	MLTB	MELBOURNE T	-	-	-	-
Core node	MWTB	MELBOURNE T	-	-	-	-
Core node	METC	MELBOURNE T	-	-	-	-
Core node	PPTA	PERTH TNS1	-	-	-	-
Core node	PWTA	PERTH TNS2	-	-	-	-
Core node	SKTB	SYDNEY TNS2	-	-	-	-
Core node	SCTC	SYDNEY TNS4	-	-	-	-
Core node	SPTF	SYDNEY TNS5	-	-	-	-

Figure 5.73: Calculations for NGN Core router dimensioning [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 147–165	NGN - Core switch dimensioning

Core switches aggregate traffic for delivery to and from the core routers, DSL data-related elements and softswitch elements. It is assumed that lower-capacity 48-port electrical Gigabit Ethernet (GE) cards link to the softswitch call server and access gateway plus the DNS and RADIUS servers, as only signalling traffic is carried across these links. The BRAS, Web server and core router are connected via the higher-capacity 12-port optical GE cards. It is further assumed that the capacity of a chassis is five slots for connectivity cards.

The Excel output for the calculation of the core switches is shown below:

NGN - Core switch

Note: core switches are driven by the port requirement for the services in the core network (call server, access gatewat, domain name server, core router, BRAS an

			Call Server	Access Gateway	DNS	Core Router
		Redundancy	100%	100%	100%	100%
		Port cards	48	48	48	12

Type	Site_ID	TNS_name	GE Ports Required at Each Core Node			
Core node	AFTA	ADELAIDE TNS	-	-	2	-
Core node	AWTA	ADELAIDE TNS	-	-	2	-
Core node	BWTB	BRISBANE TNS	-	-	2	-
Core node	BCTB	BRISBANE TNS	-	-	2	-
Core node	CCTA	CANBERRA TN	-	-	2	-
Core node	CDTA	CANBERRA TN	-	-	2	-
Core node	MLTB	MELBOURNE T	-	-	2	-
Core node	MWTB	MELBOURNE T	-	-	2	-
Core node	METC	MELBOURNE T	-	-	2	-
Core node	PPTA	PERTH TNS1	-	-	2	-
Core node	PWTA	PERTH TNS2	-	-	2	-
Core node	SKTB	SYDNEY TNS2	-	-	2	-
Core node	SCTC	SYDNEY TNS4	-	-	2	-
Core node	SPTF	SYDNEY TNS5	-	-	2	-
			-	-	28	-

Figure 5.74: Calculations for NGN core switch dimensioning [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 497–515	Dimensioning of softswitch equipment

The model further calculates the softswitch equipment, which includes the following elements:

Equipment	*Dimensioning*
Call server (signal processing)	the number required is calculated from BHCA, with each processor being capable of processing one million BHCA. There is a minimum of one call processor per main core node.
Access gateway (gateway to IP network)	the number required is calculated as the total number of subscribers divided by the single access gateway capacity (100 000 subscribers).

Table 5.23: Elements dimensioning the softswitch [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 520–552	Calculation of the other core network assets that are located at the TNS/MTH location

The core model also dimensions other core equipment at the TNS/MTH/Core Node location – the drivers for which are shown below:

Equipment	*Driver*
BRAS units	Concurrent DSL subscribers
RAS units	Assumption of one per Core Node
Radius server	DSL subscribers
Domain Name Server	Assumption of one per Core Node
Billing system	PSTN Subscribers
Primary Reference Clock	Assumption of one per Core Node
SSU equipment	Assumption of one per Core Node
Network Management System	Assumption of one per Core Node
Intelligent Network units	Assumption of one per Core Node

Table 5.24: Dimensioning of other core equipment [Source: Analysys]

Transmission dimensioning

At the TNS/Core Node level, transmission links for TNS-interconnect and TNS-TNS traffic are calculated. As per the previously documented transmission calculations, the links are dimensioned by the per subscriber busy hour traffic as calculated on the 'Dem.Calc' worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Rows 176–190	Transmission requirement for TNS–Interconnection links

Transmission requirement

Core unit-Interconnect traffic

Note: TDM traffic is transmitted in terms of E1 carriers, NO

			TDM-based traffic calculations		
Type	Site_ID	Site_Name	PSTN BHE	ISDN BHE	PSTN E1s
TNS	AFTA	ADELAIDE TNS	14,985	798	510
TNS	AWTA	ADELAIDE TNS	11,912	646	406
TNS	BWTB	BRISBANE TNS	21,304	1,189	722
TNS	BCTB	BRISBANE TNS	22,931	1,248	777
TNS	CCTA	CANBERRA TN	4,174	219	145
TNS	CDTA	CANBERRA TN	7,986	413	274
TNS	MLTB	MELBOURNE T	31,386	1,740	1,061
TNS	MWTB	MELBOURNE T	17,355	979	589
TNS	METC	MELBOURNE T	19,426	1,054	659
TNS	PPTA	PERTH TNS1	14,415	784	491
TNS	PWTA	PERTH TNS2	12,666	699	432
TNS	SKTB	SYDNEY TNS2	15,896	915	540
TNS	SCTC	SYDNEY TNS4	20,803	1,133	705
TNS	SPTF	SYDNEY TNS5	29,179	1,601	987
			244,419	13,419	8,298

Figure 5.75: Calculations for the transmission requirement for TNS-Interconnection links [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 198–212	Transmission requirement for TNS–TNS links

Core node-Core node traffic

Note: TDM traffic is transmitted in terms of E1 carriers, NGN traffic is transmit

			TDM-based traffic calculations			
			PSTN	ISDN	xDSL	PSTN
Type	Site_ID	Site_Name	BHE	BHE	kbit/s	E1s
TNS	AFTA	ADELAIDE TNS	4,682	714	12,363,241	162
TNS	AWTA	ADELAIDE TNS	3,722	578	9,808,840	129
TNS	BWTB	BRISBANE TNS	6,657	1,064	17,504,628	229
TNS	BCTB	BRISBANE TNS	7,165	1,117	18,826,839	246
TNS	CCTA	CANBERRA TN	1,304	196	3,419,577	47
TNS	CDTA	CANBERRA TN	2,495	369	6,579,257	88
TNS	MLTB	MELBOURNE T	9,807	1,557	25,586,669	335
TNS	MWTB	MELBOURNE T	5,423	876	14,379,834	187
TNS	METC	MELBOURNE T	6,070	943	15,780,256	209
TNS	PPTA	PERTH TNS1	4,504	702	11,275,016	156
TNS	PWTA	PERTH TNS2	3,958	626	9,875,003	137
TNS	SKTB	SYDNEY TNS2	4,967	819	12,696,535	172
TNS	SCTC	SYDNEY TNS4	6,500	1,014	16,782,701	224
TNS	SPTF	SYDNEY TNS5	9,118	1,432	24,194,884	312
			76,374	12,006	199,073,280	2,633

Figure 5.76: Calculations for the transmission requirement for TNS–TNS links [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 218–249	Logical link dimensioning for the TNS–TNS transmission links

The transit links are assumed to be logically fully-meshed. The output of the gravity model is used to define the destination of the traffic from each TNS/Core Node:

Logical link dimensioning

% traffic flowing to each TNS

Note: the logical link dimensioning is calculated using the

Type	Site_ID	Site_Name	ADELAIDE TNS	ADELAIDE TNS	BRISBANE TNS4
TNS	AFTA	ADELAIDE TNS	0%	6%	7%
TNS	AWTA	ADELAIDE TNS	5%	0%	5%
TNS	BWTB	BRISBANE TNS	9%	9%	0%
TNS	BCTB	BRISBANE TNS	10%	10%	10%
TNS	CCTA	CANBERRA TN	2%	2%	2%
TNS	CDTA	CANBERRA TN	3%	3%	4%
TNS	MLTB	MELBOURNE T	14%	13%	14%
TNS	MWTB	MELBOURNE T	8%	7%	8%
TNS	METC	MELBOURNE T	8%	8%	9%
TNS	PPTA	PERTH TNS1	6%	6%	6%
TNS	PWTA	PERTH TNS2	6%	5%	6%
TNS	SKTB	SYDNEY TNS2	7%	7%	7%
TNS	SCTC	SYDNEY TNS4	9%	9%	9%
TNS	SPTF	SYDNEY TNS5	13%	13%	13%

Figure 5.77: Calculations for the percentage of traffic flowing to each TNS [Source: Analysys]

This is multiplied by the transit traffic at each TNS/Core node to generate the traffic which needs to be carried on the logical transit links.

E1s VC required

Type	Site_ID	Site_Name	ADELAIDE TNS	ADELAIDE TNS	BRISBANE TNS4
TNS	AFTA	ADELAIDE TNS	-	534	556
TNS	AWTA	ADELAIDE TNS	341	-	351
TNS	BWTB	BRISBANE TNS	1,089	1,075	-
TNS	BCTB	BRISBANE TNS	1,261	1,244	1,296
TNS	CCTA	CANBERRA TN	42	41	43
TNS	CDTA	CANBERRA TN	154	152	158
TNS	MLTB	MELBOURNE T	2,346	2,315	2,412
TNS	MWTB	MELBOURNE T	729	719	750
TNS	METC	MELBOURNE T	896	884	921
TNS	PPTA	PERTH TNS1	476	469	489
TNS	PWTA	PERTH TNS2	366	361	376
TNS	SKTB	SYDNEY TNS2	590	582	607
TNS	SCTC	SYDNEY TNS4	1,020	1,007	1,049
TNS	SPTF	SYDNEY TNS5	2,061	2,034	2,120
	TNS.ID	*TNS.name*			

Figure 5.78: Calculations for the number of E1 VCs required [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 255–429	Physical ring dimensioning for the TNS–TNS transmission links

The transit links are dimensioned in terms of fully-meshed logical links, but are transported on discrete physical rings. These physical rings are stated explicitly in the model:

- Physical ring between Perth and Adelaide
- Physical ring between Adelaide and Melbourne
- Physical ring between Melbourne and Canberra
- Physical ring between Canberra and Sydney
- Physical ring between Sydney and Brisbane
- Physical link between Adelaide and Sydney.

An example of the Excel calculation for the Perth–Adelaide ring is shown below:

Physical link dimensioning

Note: This is based on a series of physical rings, and takes into account network resilience, i.e. each link in a ring must be able to carry the whole traffic of the ring

Note: Changes may be made to the ring set up (i.e. to the traffic that is carried on the individual rings)

Ring 1	Nodes	*Fibre.distance.transit.ring.1*		SDH regenerators required	DWDM regenerators required
PWTA	PERTH TNS2	1	Note: this is based on TNS-TNS main road/railway length	-	-
PPTA	PERTH TNS1	2696		33	33
AFTA	ADELAIDE TNS1	0.9		-	-
AWTA	ADELAIDE TNS2	2706	Note: this is the distance to PERTH TNS2	33	33

Figure 5.79: Excel parameters determining the fibre distances in physical ring 1 [Source: Analysys]

For each ring, the logical link traffic which dimensions the physical ring is explicitly entered The examples below are for the Perth–Adelaide ring (Figure 5.80), and for the Adelaide–Melbourne ring (Figure 5.82).

Site_Name	ADELAIDE TNS	ADELAIDE TNS	BRISBANE TNS4	BRISBANE TNS	CANBERRA TN	CANBERRA TN	MELBOURNE T	MELBOURNE T	MELBOURNE T	PERTH TNS1	PERTH TNS2	SYDNEY TNS2	SYDNEY TNS4
ADELAIDE TNS	1	1								1	1		
ADELAIDE TNS	1	1								1	1		
BRISBANE TNS4										1	1		
BRISBANE TNS1										1	1		
CANBERRA TNS1										1	1		
CANBERRA TNS2										1	1		
MELBOURNE TNS1										1	1		
MELBOURNE TNS2										1	1		
MELBOURNE TNS3										1	1		
PERTH TNS1	1	1	1	1	1	1	1	1	1	1	1	1	1
PERTH TNS2	1	1	1	1	1	1	1	1	1	1	1	1	1
SYDNEY TNS2										1	1		
SYDNEY TNS4										1	1		
SYDNEY TNS5										1	1		

Figure 5.80: Excel parameters determining the structure of physical ring 1 [Source: Analysys]

Ring 2	Nodes	*Fibre.distance.transit.ring.2*		SDH regenerators required	DWDM regenerators required
AWTA	ADELAIDE TNS2	0.9		-	-
AFTA	ADELAIDE TNS1	726		9	9
MLTB	MELBOURNE TNS1	5.1		-	-
METC	MELBOURNE TNS3	729	Note: this is the distance to ADELAIDE TNS2	9	9

Figure 5.81: Excel parameters determining the fibre distances in physical ring 2 [Source: Analysys]

Site_Name	ADELAIDE TNS	ADELAIDE TNS	BRISBANE TNS4	BRISBANE TNS	CANBERRA TN	CANBERRA TN	MELBOURNE T	MELBOURNE T	MELBOURNE T	PERTH TNS1	PERTH TNS2	SYDNEY TNS2	SYDNEY TNS4
ADELAIDE TNS	1	1	1	1	1	1	1	1	1			1	1
ADELAIDE TNS	1	1	1	1	1	1	1	1	1			1	1
BRISBANE TNS	1	1								1	1		
BRISBANE TNS	1	1								1	1		
CANBERRA TN	1	1								1	1		
CANBERRA TN	1	1								1	1		
MELBOURNE T	1	1								1	1		
MELBOURNE T	1	1								1	1		
MELBOURNE T	1	1								1	1		
PERTH TNS1			1	1	1	1	1	1	1			1	1
PERTH TNS2			1	1	1	1	1	1	1			1	1
SYDNEY TNS2	1	1								1	1		
SYDNEY TNS4	1	1								1	1		
SYDNEY TNS5	1	1								1	1		

Figure 5.82: Excel parameters determining the structure of physical ring 2 [Source: Analysys]

The trench requirements summarised in rows 472–492 take into account the trench sharing within the IEN and with the CAN.

Cell reference	*Description and details of spreadsheet calculations*
Rows 559–633	Summary for the TNS-level assets

The equipment outputs for the TNS/Core Nodes are collated before export to the ‘Out.Assets’ worksheet. The Excel output of which is shown below:

TNS/Core node summary

Note: These asset numbers are output to the Out.Assets worksheet

Asset	Units	Number deployed	
Modern network assets			
TNS/MTH building - Site acquistic	#	14	*Required.assets.TNS.site*
STP (Signalling Transfer Point)	#	28	*Required.assets.TNS.STP*
UPS (100kVA) and Generator (10	#	14	*Required.assets.TNS.UPS.Generator*
Air conditioning unit (100kVA)	#	14	*Required.assets.TNS.Acunit*
ADM: TNS-ring SDH add-drop mu	#	-	*Required.assets.TNS.ring.ADM.STM1*
ADM: TNS-ring SDH add-drop mu	#	-	*Required.assets.TNS.ring.ADM.STM4*
ADM: TNS-ring SDH add-drop mu	#	-	*Required.assets.TNS.ring.ADM.STM16*
ADM: TNS-ring SDH add-drop mu	#	70	*Required.asset:* Note: at the TNS level, only STM-64 ADMs are considered
Ports: Interconnection-facing - SD	#	147	*Required.assets.TNS.Interconnection.ports.STM1*
Ports: Interconnection-facing - SD	#	-	*Required.assets.TNS.Interconnection.ports.STM4*
Ports: Interconnection-facing - SD	#	-	*Required.assets.TNS.Interconnection.ports.STM16*
Ports: Interconnection-facing - SD	#	-	*Required.assets.TNS.Interconnection.ports.STM64*
ISDN platform	#	14	*Required.assets.MTH.ISDN.platform*
ATM platform	#	14	*Required.assets.MTH.ATM.platform*
Other platforms	#	14	*Required.assets.MTH.Other.platform*
Tandem Switch: Processor	#	14	*Required.assets.TNS.processor*
Tandem Switch: switchblock unit	#	19	*Required.assets.TNS.switchblock*

Figure 5.83: Output summary for the TNS-level assets [Source: Analysys]

% cost of interconnection links attributed to:		E1	E2	STM-0	STM-1	STM-4
PSTN	%	94.45%	94.45%	94.45%	94.45%	94.45%
ISDN	%	5.55%	5.55%	5.55%	5.55%	5.55%
ATM	%	0.00%	0.00%	0.00%	0.00%	0.00%
Transmission	%	0.00%	0.00%	0.00%	0.00%	0.00%

% cost of transit links attributed to:		E1	E2	STM-0	STM-1	STM-4
PSTN	%	2%	2%	2%	2%	2%
ISDN	%	0%	0%	0%	0%	0%
ATM	%	78%	78%	78%	78%	78%
Transmission	%	20%	20%	20%	20%	20%

		PSTN	**ISDN**	**ATM**	**Transmission**	
Allocation of fibre costs	%	2%	0%	78%	20%	*Cost.allocation.T.*

		SDH	**Dark fibre**	
Total fibre metres	metres	86,131,080	86,131,080	*Cost.allocation.TNS.CoreNode.trench*
% trench cost allocated to SDH vs da	%	50%	50%	

Figure 5.84: Excel calculations for the other core network assets that are located at the TNS/MTH location [Source: Analysys]

5.14 ‘NwDes.5.Islands’ worksheet

The ‘NwDes.5.Islands’ worksheet is a part of the network design algorithm. It defines the specific calculations required for special island solutions. These backhaul solutions cannot be modelled to a satisfactory degree using the network design algorithms on the proceeding worksheets. Consequently this worksheet ascribes either a microwave, satellite or submarine cable solution to a particular island.

For the majority of the islands, trench, duct and fibre distances from the LE–PoC calculations are derived in the ‘NwDes.1.Access’ worksheet. Rather than deploy these lengths, an appropriate alternative wireless or satellite solution is implemented. These distances are subsequently subtracted from the LE–PoC distances calculated.

Where several ESAs are on an island[6], it is possible to define a local network so that certain ESAs subtend to a principle ESA where the off-island solution is provided from. Within the island, these links can be defined as fibre-based or microwave-based.

A submarine solution is modelled for the LAS–TNS link from Tasmania to the mainland.

The required numbers for equipment deployed derived from this worksheet is then linked to the 'Out.Assets' worksheet.

These linkages are shown in the diagram below:

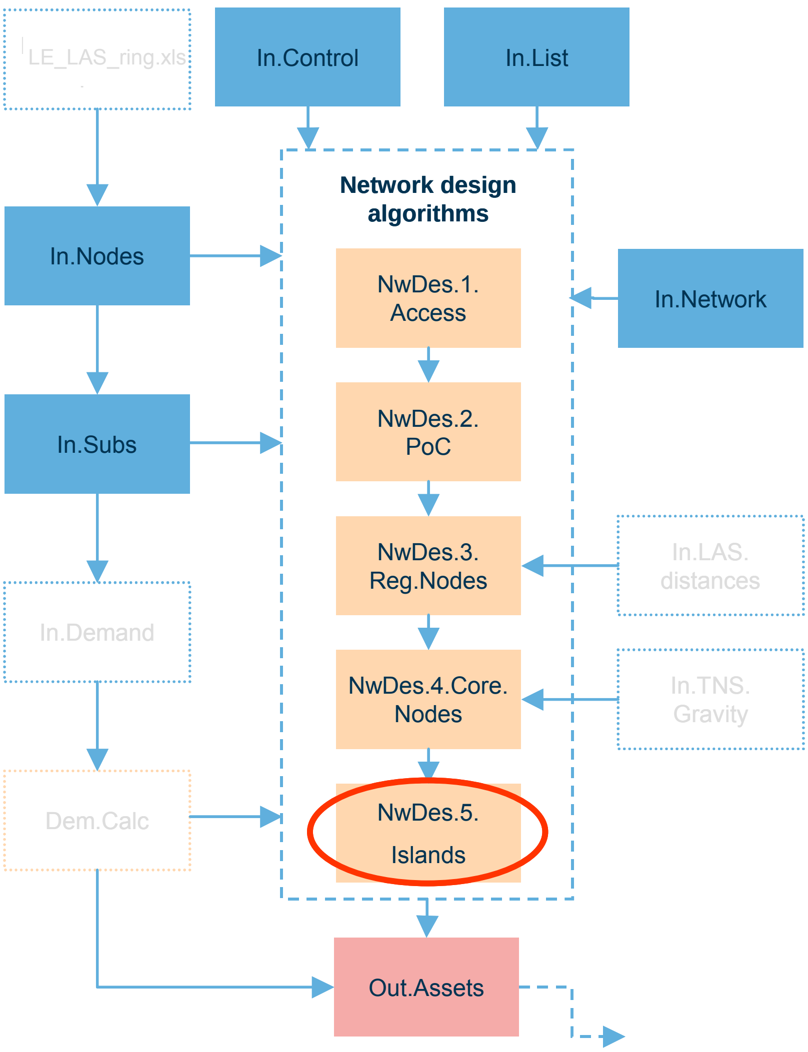


Figure 5.85: Location of the 'NwDes.5.Islands' worksheet in the overall Core module structure [Source: Analysys]

5.14.1 Key parameters

The island backhaul solution implemented for each particular island can be selected as either microwave, satellite or submarine cable. For subtended ESAs, trench can also be selected.

6 For example, Kangaroo Island in South Australia has 11 ESAs.

If addition island solutions are to be implemented, additional lines will need to be inserted above line 69 and links to the output summary should be reviewed.

5.14.2 Calculation description

This worksheet contains network design algorithms for the islands that require a special network solution. The table below lists specific data inputs and calculations by row number.

Cell reference	*Description and details of spreadsheet calculations*
Rows 4–9	Network parameters specific to the calculations for the island solutions
Rows 16–77	Calculations of subscriber, traffic and transmission for each of the islands that require a special network solution
Rows 85–120	Summary of the equipment units deployed for the special island solutions

Table 5.25: Calculations performed on the 'NwDes.5.Islands' worksheet [Source: Analysys]

For each of the islands not connected to the mainland by means of a bridge, an alternative backhaul solution is defined (column F). The upstream ESA which is connected to needs to be defined so that the transmission capacity required for the off-island link is calculated correctly, considering subtended ESAs.

The distances derived from the minimum spanning tree calculation of the LE–PoC links, which was calculated on the 'NwDes.1.Access' sheet, is calculated for each of the island's LEs. These distances are subsequently subtracted from the total LE–PoC distances calculated.

For the microwave solutions, microwave hop towers are required according to the distance constraint of microwave links. The number of microwave hops is calculated according to the trench distance which it replaces.

For the satellite solutions, an earth station is required according to the capacity of an earth station and the number of services in operation on the island modelled.

The Excel output for the islands containing an LE is shown below:

Trench — Note: identifies sub-tended links to agregate
Microwave — Note: assume backhauled by microwave to next closest LE in chain back to PoC
Satellite — Note: assume satellite goes to Earthstation in core

Note: additional LE's may be identified as being served by special backhaul solutions. The user should enter the LE cod note: this allows L

							Data to be deducted			note: remove road uplift	
							Kilometres		Sheath metres		
LE code	Indexed position	LE name	geotype	PSTN & VLR SIOs	Backhaul solution to PoC	Identify next LE in tree	Trench distance	Duct distance	Fibre distance	Microwave hopes required	Number of earthstations required
BNKR	5203	BUNKER	15	-	Microwave	BHDS	133	133	-	1	-
ROTT	5204	ROTTNEST	12	3	Microwave	FMTL	33	33	399,422	-	-
ARNW-1	5205	ARNHEM WEST MINJI	14	-	Microwave	JARU-2	290	290	-	4	-
AYLB	5206	ALYANGULA	12	45	Microwave	ARNE	279	279	3,345,889	4	-
GWKU	5207	GALIWINKU NHULUNBI	14	2	Microwave	ARNE	100	100	1,203,050	1	-
TIWI-1	5208	TIWI MILIKAPITI	13	-	Microwave	GNPT	161	161	-	2	-
TIWI-3	5209	TIWI PULARUMPI	13	-	Microwave	TIWI-1	47	47	-	-	-
TIWI-2	5210	TIWI NGUIU	13	-	Microwave	GNPT	112	112	-	1	-

Figure 5.86: Subscriber, traffic and transmission calculations for each of the islands that require a special network solution [Source: Analysys]

Linking Tasmania to the mainland is modelled using a submarine cable – as per reality. This length replaces that deployed on the 'NwDes.3.RegNodes' worksheet.

					Data to be deducted			
	Note: Submarine cable link from Tasmania				Kilometres		Sheath metres	Note: only build fo LAS ring in Me
LAS code		LAS name	**Links installed for resilience**	**Backhaul solution to TNS**	Trench distance	Duct distance	Fibre distance (sheath metres)	Ring ID
STJQ	114	ST JOHN AXE A 3	2	Submarine cab	240	240	240,000	6

Figure 5.87: Trench, duct and fibre distance calculations for the submarine cable link from Tasmania [Source: Analysys]

The output of the 'NwDes.5.Islands' worksheet is:

- length of trench, duct and fibre to be removed on LE–PoC links
- length of trench, duct and fibre to be removed on LAS–TNS links
- special solution microwave, satellite and submarine cable equipment and lengths.

5.15 'Out.Assets' worksheet

The 'Out.Assets' worksheet collates the outputs from each of the network design worksheets. This output is then used in the core part of the Cost module.

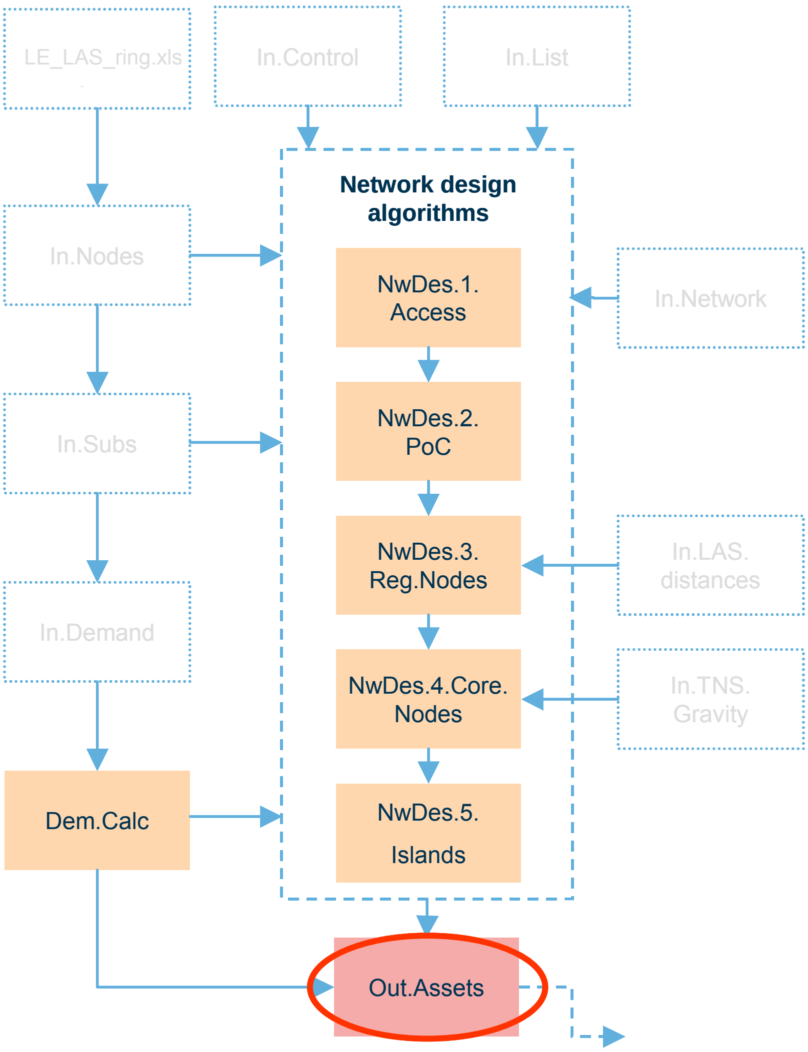


Figure 5.88: Location of the 'Out.Assets' worksheet in the overall Core module structure [Source: Analysys]

5.15.1 Key parameters

This worksheet contains no input parameters.

5.15.2 Calculation description

This worksheet collates the network assets deployed at each level in the network, and the cost allocations at each level of the network. This data is linked to the core part of the Cost module.

6 Cost module

The Cost module determines the network costs of building the access and core networks. The module annualises the capital cost using a tilted annuity calculation – the results of which are used to determine the service cost for each of the services modelled.

The remainder of this section outlines the calculations that take place in each of the worksheets in the Cost module.

The description of the Cost module scenarios / general inputs are outlined in sections 6.1 and 6.3:

- Section 6.1 outlines the key parameters and calculations in the 'Scenario' worksheet
- Section 6.2 outlines the parameters underlying the calculation of the WACC (Weighted Average Cost of Capital) on the 'WACC' worksheet
- Section 6.3 describes the service demand on the 'Inputs.Demand' worksheet for the period 2007–2012 that is used to dimension the access and core networks.

The core network costing worksheet calculations are outlined in sections 6.4 to 6.12.

- Section 6.4 outlines the key parameters and calculations in the 'Inputs.Core' worksheet
- Section 6.5 outlines the key parameters and calculations in the 'I.Building.Core' worksheet
- Section 6.6 outlines the key parameters and calculations in the 'I.Ducts.Core' worksheet
- Section 6.7 outlines the key parameters and calculations in the 'Dem.In.Core' worksheet
- Section 6.8 outlines the key parameters and calculations in the 'CostAlloc.Core' worksheet
- Section 6.9 outlines the key parameters and calculations in the 'RF.Core' worksheet
- Section 6.10 outlines the key parameters and calculations in the 'UnitCost.Core' worksheet
- Section 6.11 outlines the key parameters and calculations in the 'OutputCost.Core' worksheet
- Section 6.12 outlines the key parameters and calculations in the 'TA.Core' worksheet.

The access network costing worksheet calculations are outlined in sections 6.13 to 6.17.

- Section 6.13 outlines the key parameters and calculations in the 'Inputs.Access' worksheet
- Section 6.14 outlines the key parameters and calculations in the 'RF.Access' worksheet
- Section 6.15 outlines the key parameters and calculations in the 'Dem.In.Access' worksheet
- Section 6.16 outlines the key parameters and calculations in the 'UnitCost.Access' worksheet
- Section 6.17 outlines the key parameters and calculations in the 'TA.Access' worksheet.

The resultant calculation of the service costs takes place in Section 6.18:

- Section 6.18 outlines the key parameters and calculations in the 'Results' and 'Results.Pasted' worksheet
- Section 6.19 outlines the key parameters and calculations in the 'Recon' worksheet.

6.1 'Scenario' worksheet

This worksheet controls the general and costing scenario parameters that set up the model.

6.1.1 Key parameters

This worksheet contains several scenario parameters. These are outlined in the table below:

Parameter	*Location*	*Impact*
Modelled year	Cell C5	Selects the relevant year's demand, which dimensions the access and core modules
MSANs deployed in geotype	Cells C8–R8	Identifies the geotypes in which next-generation access network equipment is deployed. This affects the dimensioned core network – it is assumed that an IP core is dimensioned when any geotype is selected as being served with MSAN equipment
Include business overheads	Cell C17	Selects whether business overheads are included in results
Distance uplift for slope effect	Cells C20–C21	If required, can uplift access and core trench distances to reflect slopes (non-flat ground)
Open trench parameter	Cell C22	Accommodates trench that is openly available for cables to be laid in, i.e. without incurring the trenching cost
Select overlap level between core and access	Cell C25	Selects extent of overlap between access and core network, further discussed in section 7.11 of the main model document

Table 6.1: Key parameters on the 'Scenario' worksheet [Source: Analysys]

The figure below shows the Excel parameters defined in this worksheet.

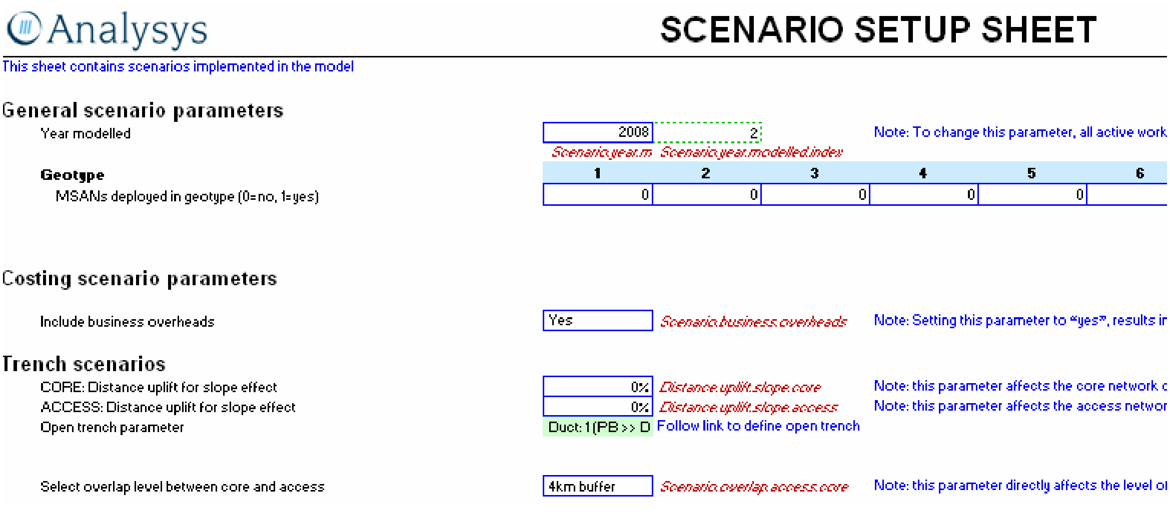


Figure 6.1: Excel scenario parameters [Source: Analysys]

6.2 'WACC' worksheet

This worksheet provides the calculations for the determination of the weighted average cost of capital (WACC).

The WACC is subsequently used in the tilted annuity calculation for the core and access networks – on the 'TA.Core' and 'TA.Access' worksheets respectively:

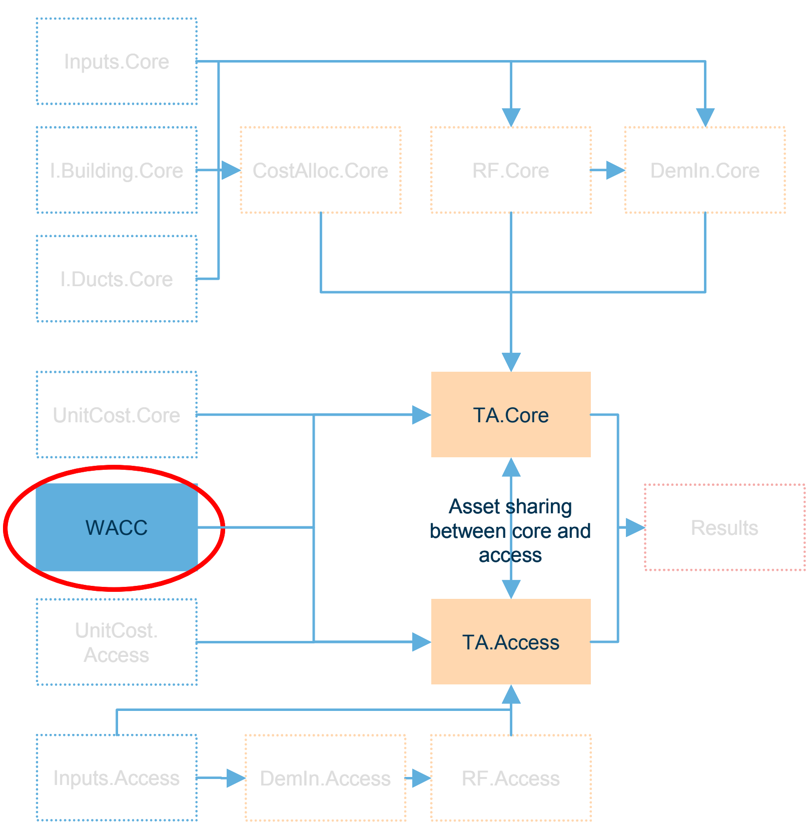


Figure 6.2: Location of the 'WACC' worksheet in the overall Cost module structure [Source: Analysys]

6.2.1 Key parameters

This worksheet contains user-defined the weighted average cost of capital (WACC) parameter values. The default parameter values are based on the ACCC's *Assessment of Telstra's Unconditioned Local Loop Service Band 2 monthly charge undertaking - final decision WACC parameters*, April 2008, with an adjustment to the risk free rate to take account of changing economic conditions. These parameters however, do not necessarily reflect the ACCC's current views on these parameter values.

6.2.2 Calculation description

The WACC is calculated according to the following formula:

$$WACC = ((R_e /(1 - T * (1 - G)) * \frac{E}{V}) + (\frac{D}{V} * R_d))$$

where:

Return on equity, $R_e = R_f + b_e * R_p$, where R_f=risk-free rate; b_e=Equity beta; R_p=Risk premium

Return on debt, $Rd = R_f + D_p + I$, where R_f =risk-free rate; D_p=Debt premium; I=Issuance cost

T = Corporate tax rate

G = Gamma

D, E and V = D and E are the market values of the business debt and equity respectively and V is the sum of D and E. Therefore, D/V and E/V represent the relative weightings of debt and equity employed in the business' operations.

6.3 'Inputs.Demand' worksheet

This worksheet presents the demand forecast for the period 2007–2012 that dimensions the Core and CAN modules.

6.3.1 Key parameters

The inputs at the top of the worksheet are used to set the size of the CAN for each year in the CAN module. It allows the size of the CAN to be separately defined as a fixed size, with the cost recovered over the demand input. To accommodate possible access line inputs growing, the demand used is the maximum of the inputted CAN SIOs and the sum of the access lines calculated below in the service demand calculations.

The worksheet also contains the projection of number of exchanges which are xDSL enabled. This feeds into the 'In.Subs' worksheet of the Core module and impacts the distribution of xDSL subscribers across ESAs.

Service demand projections are based on 2007 values (D17:D80). At the bottom of the worksheet (rows 120–245), there are the calculations for forecasting the modelled services, including the interpolation curves used for the forecasts. Changes to forecasts are controlled through changing CAGR values (column K) and curve shapes (column L).

The service demand projections can also be controlled through a demand sensitivity array which can be manipulated to investigate the effect of different forecast loadings on the network.

6.3.2 Calculation description

The following table outlines the calculations contained in the 'Inputs.Demand' worksheet:

Cell reference	*Description and details of worksheet calculations*
Rows 7–10	Projections of exchanges enabled for xDSL
Row 13	Projections of exchanges enabled for xDSL
Rows 17–46	Service demand forecast for 2007–2012
Rows 51–80	Call forecast for 2007–2012
Rows 85–114	Demand sensitivity array for 2007–2012
Rows 120–245	Demand input for modelled services

Table 6.2: Calculations performed on the 'Inputs.Demand worksheet [Source: Analysys]

6.4 'Inputs.Core' worksheet

The 'Inputs.Core' worksheet provides the link between the outputs from the Core module and the Cost module. It links together the required core asset deployment numbers, routeing factors and allocation parameters from the Core module.

The allocation calculations are subsequently used in the 'CostAlloc.Core' worksheet calculations.

The routeing factor data is used in the setting up of the Core service routeing factors in the 'RF.Core' worksheet.

The service demand data is used in the calculations of network element output on the 'Dem.In.Core' worksheet.

The deployment numbers are used in the annualisation calculations in the 'TA.Core' worksheet.

These linkages are shown in the diagram below:

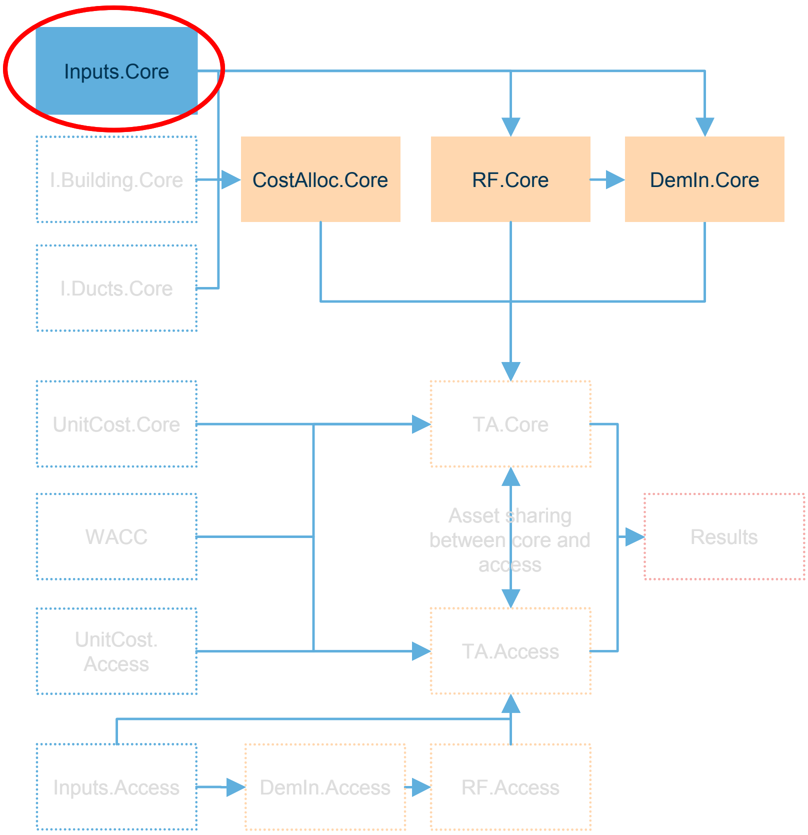


Figure 6.3: Location of the 'Inputs.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.4.1 Key parameters

This worksheet contains key data inputs from the Core module. The key parameters that can be adjusted manually on this worksheet are identified in the table below:

Parameter	*Location*	*Impact*
Sharing of building costs between core and access	Cells D429–D432	Allocates the cost of LE and AT1 building costs (site acquisition, preparation and maintenance, uninterruptible power supply (UPS) and generator costs) between core and access

Table 6.3: Key parameters on the 'Inputs.Core' worksheet [Source: Analysys]

6.4.2 Calculation description

The following table outlines the calculations contained in the 'Inputs.Core' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Row 3	Year modelled
Cells E8–G37	Service demand (total, MSAN, non-MSAN)
Cells I8–I37	Average call duration (minutes) for each traffic service
Cells L8–L23	Flag for geotypes served by MSAN equipment
Rows 42–241	Assets deployed (LPGS are linked into cell F51 from the ‘Inputs.Access’ worksheet)
Cells J42–K45	Trench requirements for the IEN, split by network layer, as well as that shared with the CAN and incremental to the CAN
Rows 246–321	Link cost allocations
Rows 326–329	Trench cost allocations
Rows 334–337	Fibre cost allocations
Rows 345–409	Routeing factors for the modern and NGN networks
Rows 415–422	Allocation drivers for cost allocation
Rows 429–432	Building cost allocation between access and core
Rows 438–452	Exchanges by geotype

Table 6.4: Calculations performed on the ‘Inputs.Core’ worksheet [Source: Analysys]

The remainder of this section provides an overview of the calculations performed on the ‘Inputs.Core’ worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Cells E8–G37	Service demand (total, MSAN, non-MSAN)

The service demand for non-MSAN and MSAN traffic is linked in from the Core module:

Service demand

note: access line volumes overwritten in CORE module where

Services	Units	Demand	MSAN traffic	Non-MSAN traffic
PSTN End User Access	Lines	7,791,116	-	7,791,116
PSTN local traffic (onnet traffic)	Minutes	12,208,132,232	-	12,208,132,232
PSTN national long distance traffic (onnet calls)	Minutes	6,767,032,755	-	6,767,032,755
PSTN outgoing traffic to international destinations	Minutes	557,268,000	-	557,268,000
PSTN outgoing to mobile traffic (mobile terminating)	Minutes	4,508,774,088	-	4,508,774,088
PSTN terminating traffic (from international, mobile, other domestic fixed networks)	Minutes	19,578,714,862	-	19,578,714,862
Local carriage service (LCS)	Minutes	2,463,879,239	-	2,463,879,239
ISDN-BRI access	Lines	81,321	-	81,321
ISDN-PRI access	Lines	8,302	-	8,302
Service 10	none	-	-	-
ISDN - voice traffic	Minutes	3,037,245,424	-	3,037,245,424
Unconditioned local loop service (ULLS)	Lines	767,510	-	767,510
Line sharing service (LSS).	Lines	467,469	-	467,469
Wholesale line rental (WLR)	Lines	1,187,471	-	1,187,471
Service 15	none	-	-	-
Dial-up Internet Traffic	Minutes	14,300,265,561	-	14,300,265,561
ADSL retail lines	Lines	2,760,975	-	2,760,975
ADSL wholesale lines	Lines	1,560,414	-	1,560,414
SDSL retail lines	Lines	27,406	-	27,406
SDSL wholesale lines	Lines	31,404	-	31,404
Other services on ATM	Mbit/s	-	-	-
Lines in CAN	Lines	155,823	-	155,823
Lines in IEN	Lines	77,912	-	77,912
Mbit/s in LE-LTH	Mbit/s	76,041	-	76,041
Mbit/s in LTH-MTH	Mbit/s	152,082	-	152,082
Mbit/s in MTH-MTH	Mbit/s	190,102	-	190,102
Service 27	none	-	-	-
Service 28	none	-	-	-
Service 29	none	-	-	-
Service 30	none	-	-	-

Figure 6.4: Excel sample of inputs for service demand [Source: Analysys]

Similarly, the average call duration is linked in from the Core module.

Cell reference	*Description and details of spreadsheet calculations*
Rows 42–241	Assets deployed (LPGS are linked into cell F51 from the 'Inputs.Access' worksheet)

The total number of assets deployed in the core network according to the specific level of demand modelled is linked in from the Core module:

	Level	Asset	Unit	Number deployed from Core model	Number deployed from Access model	Number deployed in total
1	LE	LE: Site acquistion, preparation and maintenance	#	4,655		4,655
2	LE	LE: Concentrator: Processor	#	7,967		7,967
3	LE	LE: Concentrator: PSTN line card	#	179,835		179,835
4	LE	LE: Concentrator: ISDN 2 line card	#	11,729		11,729
5	LE	LE: Concentrator: ISDN 30 line card	#	2,857		2,857
6	LE	LE: DSLAM (2nd Gen ATM backhaul)	#	3,379		3,379
7	LE	LE: SDSL line card	#	2,256		2,256
8	LE	LE: ADSL line card	#	75,810		75,810
9	LE	LE: Splitter	#	3,622,541		3,622,541
10	LE	LE: LPGS equipment MuX	#	-	9,687	9,687
11	LE	LE: UPS (40kVA) and Generator (50kVA)	#	4,655		4,655
12	LE	LE: Air conditioning unit (10kVA)	#	4,655		4,655
13	LE	LE: Network unit of LPGS	#	3,576		3,576

Figure 6.5: Excel sample of inputs for assets deployed [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Cells J42–K45	Trench requirements for the IEN, split by network layer, as well as that shared with the CAN and incremental to the CAN

The trench requirements for the IEN, as calculated from the core overlap analysis, is linked in from the Core module. This includes the split by core network layer and distinguishes the length of trench that is shared with the CAN.

Distance summary	Distance used in IEN only	Distance used in CAN	
LE	87,360,224	40,717,688	
POC	16,804,425	12,522,773	
LAS	7,449,223	3,119,889	
TNS	2,271,464	307,482	
	113,885,336	56,667,832	Output.distance.deployed.IEN.CAN

Figure 6.6: Excel sample of inputs for service demand [Source: Analysys]

The number of LPGS required are calculated in the CAN module as they are inherently part of the access network calculations – however, they are identified as part of the core network. The number of LPGS is therefore linked to the total number of core network assets deployed.

Cell reference	*Description and details of spreadsheet calculations*
Rows 246–321	Link cost allocations

The calculation of the link allocations is an important input to the allocation of costs between the various platforms that use the core network. This allocation is calculated for each link type in the core network, and is performed for each link speed. These allocations are linked to the 'CostAlloc.Core' worksheet.

The figure below shows an example screenshot for the Interswitch link allocation calculation:

Link cost allocations

	% cost of interswitch links attributed to:	Units	E1	E2
			1	2
LE				
	PSTN	%	50%	7%
	ISDN	%	-%	4%
	ATM	%	-%	55%
	Transmission	%	50%	34%
	SDH platforms	%	50%	66%
	Transmission	%	50%	34%
	PSTN	%	100%	10%
	ISDN	%	-%	6%
	ATM	%	-%	83%

Figure 6.7: Excel sample of inputs for link allocations [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 326–329	Trench cost allocations

As per the link allocation costs, the trench allocation costs are linked from the Core module for the LE, PoC-ring, LAS-ring and TNS-ring levels:

Trench allocation costs

	Units	SDH (AUD)	Dark fibre (AUD)
LE	AUD	2,354,505,058	1,177,252,529
PoC-ring	AUD	340,783,928	170,391,964
LAS-ring	AUD	196,778,160	98,389,080
TNS-ring	AUD	86,131,080	86,131,080

Figure 6.8: Excel sample of inputs for trench allocation costs [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 334–337	Fibre cost allocations

Similarly, the fibre allocation costs are linked from the Core module for the LE, PoC-ring, LAS-ring and TNS-ring levels:

Fibre allocation costs

	Units	PSTN	ISDN
LE	%	17%	4%
PoC-ring	%	17%	4%
LAS-ring	%	10%	4%
TNS-ring	%	2%	0%

Figure 6.9: Excel sample of inputs for fibre allocation costs [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 345–409	Routeing factors for the modern and NGN networks

The routeing factor matrices for the modern and NGN architectures are linked from the Core module:

Routeing factors

Services	Platform / Units / Link/element	Transmission PSTN BHE LE-LAS	PSTN BHE LAS-LAS
PSTN End User Access		-	-
PSTN local traffic (onnet traffic)		2.00	0.05
PSTN national long distance traffic (onnet calls)		2.00	-
PSTN outgoing traffic to international destinations		1.00	-
PSTN outgoing to mobile traffic (mobile terminating)		1.00	-
PSTN terminating traffic (from international, mobile, other domestic fixed networks)		1.00	-
Local carriage service (LCS)		2.00	0.05
ISDN-BRI access		-	-
ISDN-PRI access		-	-
Service 10		-	-
ISDN - voice traffic		-	-
Unconditioned local loop service (ULLS)		-	-
Line sharing service (LSS).		-	-
Wholesale line rental (WLR)		-	-

Figure 6.10: Excel sample of inputs for routeing factors [Source: Analysys]

These routeing factors are used in the routeing factor calculations contained on the ‘RF.Core’ worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Rows 415–432	Allocation drivers for cost allocation

A series of allocation drivers are linked from the Core module:

Allocation drivers for cost allocation

Cost allocation of MuX to platforms	PSTN	ISDN	ATM	Other
Total line cards	168,626	6,462		
Distribution of line cards between platforms	96%	4%	-%	-%

	Ports per ISDN-BR line card	Ports per ISDN-PR line card	Ratio of Ports per ISDN-BR line card to ports per ISDN-PR line card
ISDN distribution of line cards	24	16	1.50

Figure 6.11: Excel sample of allocation driver inputs for cost allocation [Source: Analysys]

These allocation drivers are used in the 'RF.Core' worksheet and the 'CostAlloc.Core' worksheets to distribute costs between the platforms.

6.5 'I.Building.Core' worksheet

This worksheet allocates building costs between the platforms. The current model has been populated with estimated numbers. The building space allocation calculations feed into the cost allocation calculations on the 'CostAlloc.Core' worksheet. This linkage is shown in the diagram below:

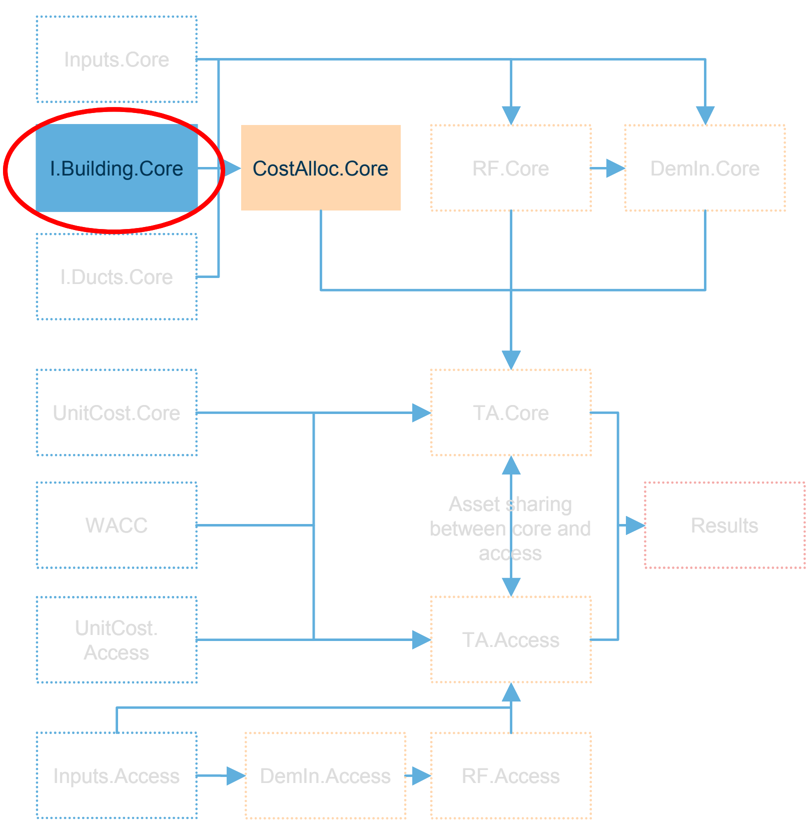


Figure 6.12: Location of the 'I.Building.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.5.1 Key parameters

This worksheet contains estimated parameters for the average building space required by service and network level.

Parameter	*Location*	*Impact*
Average equipment dimensions	Rows 8–10	Affects the cost allocation between the different platforms

Table 6.5: Key parameters on the' I.Building.Core' worksheet [Source: Analysys]

6.5.2 Calculation description

The following table outlines the calculations that are contained on the ‘I.Building.Core’ worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 8–10	Average equipment dimensions
Rows 15–17	Calculated equipment area
Rows 21–23	Cost allocation percentage

Table 6.6: Calculations performed on the ‘I.Buildings.Core’ worksheet [Source: Analysys]

The remainder of this sub-section outlines the specific calculations that take place on this worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Rows 8–23	Calculation of equipment areas

These calculations allocate the costs for buildings and associated building equipment between the various platforms housed in the building. These costs are allocated to the platforms on the basis of the floor space of the platform equipment in the local exchange.

The figure below shows an Excel screenshot of the average equipment dimensions by service type and network level.

Estimate for building space allocations

Note: This array defines the total building space taken up by platform equipment. Exchange building costs (building, power supply, air-conditioning) are

Average equipment dimensions (m)

	PSTN		ISDN		ATM	
	Width	Length	Width	Length	Width	Length
LE	2	4	1	2	2	4
LAS	2	4	1	2	2	4
TNS	2	4	1	2	2	4

Figure 6.13: Sample of the average equipment dimensions by service type and network level [Source: Analysys]

Equipment area (m2)

	PSTN	ISDN	ATM	Other	SDH	Common areas
LE	8	2	8	2	1	20
LAS	8	2	8	2	1	20
TNS	8	2	8	2	1	20

Figure 6.14: Calculation of equipment area by service type and network level [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 21–23	Cost allocation percentage

SDH and common costs are allocated to the other platforms using an equi-proportionate mark-up (EPMU) method.

The figure below shows an Excel screenshot of the cost allocation percentage applied by service type and network level.

Cost allocation (%)

	PSTN	ISDN	ATM	Other
LE	40%	10%	40%	10%
LAS	40%	10%	40%	10%
TNS	40%	10%	40%	10%

Figure 6.15: Calculation of cost allocation percentages by service type and network level [Source: Analysys]

6.6 'I.Ducts.Core' worksheet

This worksheet allocates duct costs between the modelled services and other duct services. The model has been populated with best-estimate values. The duct cost allocation calculations feed into the cost allocation calculations on the 'CostAlloc.Core' worksheet.

The worksheet also contains calculations for the volume of duct used by the core network in the CAN, which feeds into the 'Inputs.Access' worksheet:

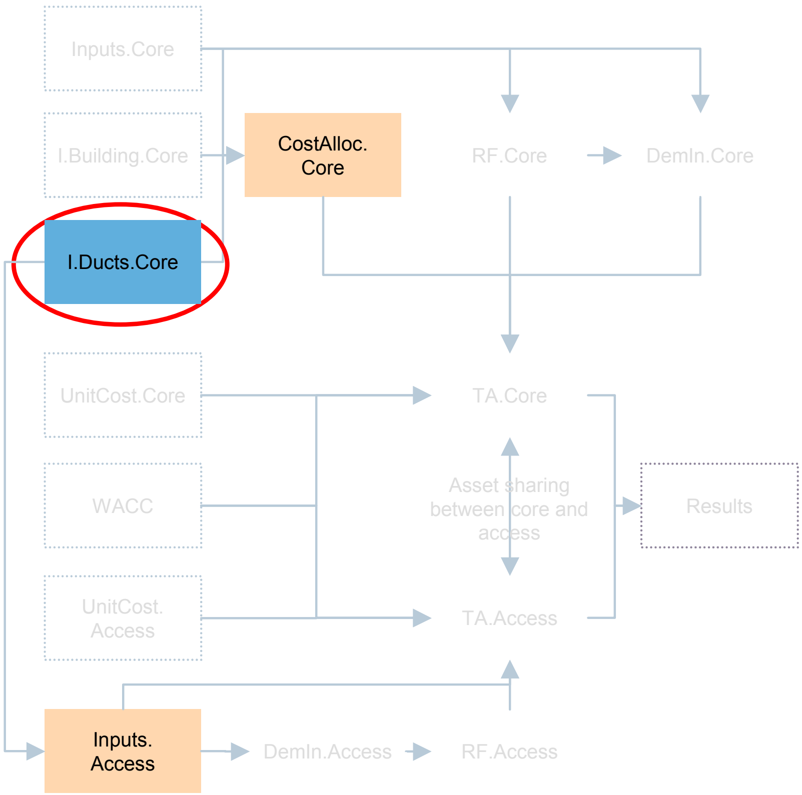


Figure 6.16: Location of the 'I.Ducts.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.6.1 Key parameters

This worksheet contains estimated parameters for the average number of sub-ducts that are available for use and the percentage of these ducts used by the incumbent.

Parameter	*Location*	*Impact*
Average number of sub-ducts	Cells C7–C10	Calculates the number of available ducts
Number of sub-ducts spare	Cells D7–D10	Calculates the number of available ducts
Percentage of ducts used by the incumbents fibre	Cells F7–F10	Affects allocation calculation

Table 6.7: Key parameters on the 'I.Ducts.Core' worksheet [Source: Analysys]

The cost allocations to fibre and other duct services are subsequently linked into the 'CostAlloc.Core' worksheet.

6.6.2 Calculation description

The following table outlines the calculations that are contained on the 'I.Ducts.Core' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Cells C7–I10	Calculation of number of ducts used by the incumbent and other services
Cells K7–L10	Calculation of percentage duct cost allocated to the incumbent and to other
Rows 15-19	Calculation of the volume of duct used by the core network in the CAN

Table 6.8: Calculations performed on the 'I.Ducts.Core' worksheet [Source: Analysys]

6.7 'Dem.In.Core' worksheet

This worksheet calculates the network element output for the TDM and NGN networks. The network element output is calculated by multiplying the service routeing factors (from the 'RF.Core' worksheet) by the total service demand (from the 'Inputs.Core' worksheet). The network element output is calculated for the PSTN, ISDN, xDSL and transmission platforms. These linkages are shown in the diagram below:

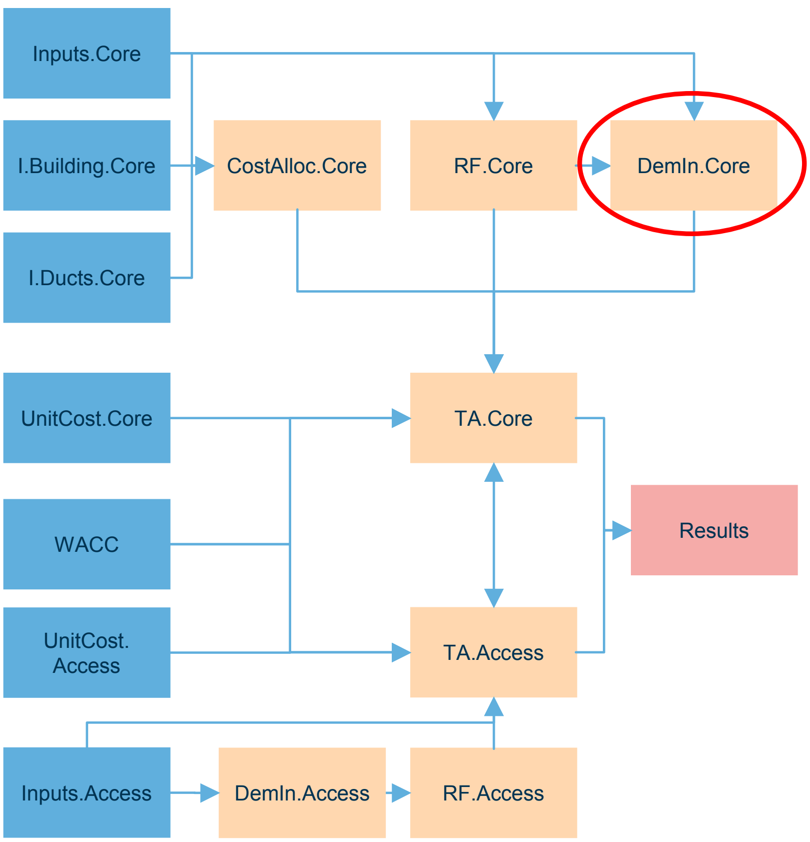


Figure 6.17: Location of the 'Dem.In.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.7.1 Key parameters

This worksheet only contains autonomous calculations.

6.7.2 Calculation description

The following table outlines the calculations that are contained on the 'Dem.In.Core' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 3	Year modelled
Rows 9–11	Transposed service demand for NGN and TDM
Rows 20–219	Network element output for PSTN platform (cells C20–AG219), allocation of PSTN platform cost to services (cells AI20–BL219)
Rows 226–425	Network element output for ISDN platform (cells C226–AG425), allocation of ISDN platform cost to services (cells AI226–BL425)
Rows 432–631	Network element output for xDSL platform (cells C432–AG631), allocation of xDSL platform cost to services (cells AI432–BL631)
Rows 638–837	Network element output for Transmission platform (cells C638–AG837), allocation of Transmission platform cost to services (cells AI638–BL837)

Table 6.9: Calculations performed on the 'Dem.In.Core' worksheet [Source: Analysys]

6.8 'CostAlloc.Core' worksheet

The 'CostAlloc.Core' worksheet allocates the core network asset costs between the various platforms that use the core network. It takes inputs from the 'Inputs.Core', 'I.Building.Core' and 'I.Ducts.Core' worksheets. The cost allocations are used in the platform costing calculations performed on the 'TA.Core' worksheet. These linkages are shown in the diagram below:

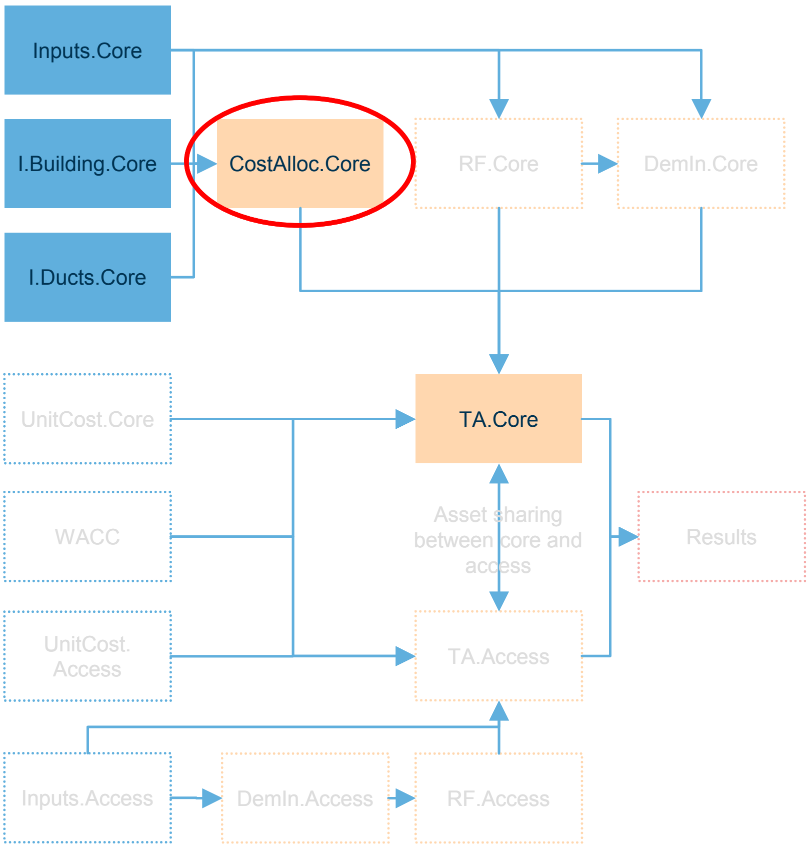


Figure 6.18: Location of the 'CostAlloc.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.8.1 Key parameters

This worksheet contains key cost allocation parameters sourced from the 'Inputs.Core' 'I.Building.Core' and 'I.Ducts.Core' worksheets. The only parameters which can be manipulated on this worksheet are those associated with the allocation of costs to 'Other platforms' in Column X: this affects the cost allocation to different platforms.

6.8.2 Calculation description

The following table outlines the calculations that are contained on the 'CostAlloc.Core' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Columns B–C	Asset and asset group
Column D	Fibre type index
Column E	Core cost type (incremental/shared/business overheads)
Columns F–I	Calculation of cost allocation of duct/trench assets between fibre and other duct services
Columns K–N	Calculation of cost allocation of fibre assets between SDH and other fibre
Columns P–S	Calculation of cost allocation of SDH assets between platforms and transmission
Columns U–AB	Calculation of cost allocation between platforms (PSTN, ISDN, xDSL, other service platforms)
Columns AD–AJ	Calculation of cost allocation across all platforms, transmission and other

Table 6.10: Calculations performed on the 'CostAlloc.Core' worksheet [Source: Analysys]

The remainder of this sub-sections outlines the specific calculations that take place on this worksheet.

The overall flow for the cost allocation calculation is shown below:

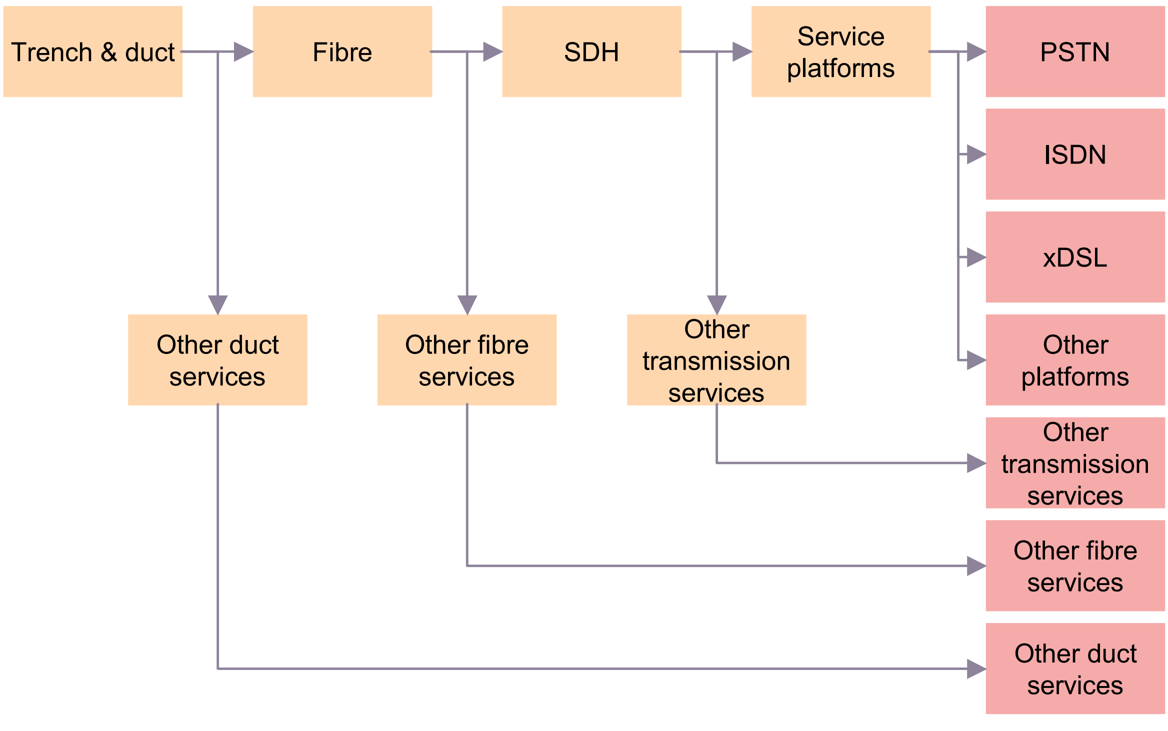


Figure 6.19: Cost allocation calculation flow [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Columns F–I	Calculation of cost allocation of duct/trench assets between fibre and other duct services

Duct and trench asset costs are allocated to either the incumbent or to other services that are located in the trench. These allocation figures are sourced from the calculations that take place on the 'I.Ducts.Core' worksheet.

The figure below shows an Excel output of the calculation of cost allocation of duct/trench assets between fibre and other duct services:

Asset group	Asset	Fibre type index	Core cost type	Calculation Duct/Trench assets Fibre	Other duct services	Cost allocation Duct / Trench assets Fibre	Other duct services
						%	%
AT1	AT2-AT1: Fibre		Incremental			100%	-%
AT1	AT2-AT1: Trench		Incremental	100%	-%	100%	-%
AT1	AT2-AT1: Duct		Incremental	100%	-%	100%	-%
AT2	Ports: AT2-AT1 rings - 10Mbit/s ports	8	Incremental			100%	-%
AT2	Ports: AT2-AT1 rings - 100Mbit/s ports	9	Incremental			100%	-%
AT2	Ports: AT2-AT1 rings - 1GE ports	10	Incremental			100%	-%
LE/AT1	LE-PoC: Fibre		Incremental			100%	-%
LE/AT1	LE-PoC: Trench		Incremental	100%	-%	100%	-%
LE/AT1	LE-PoC: Duct		Incremental	100%	-%	100%	-%

Figure 6.20: Cost allocation calculation of duct/trench assets between fibre and other duct services [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Columns K–N	Calculation of cost allocation of fibre assets between SDH and other fibre services

The cost of the fibre is either allocated to SDH (i.e. to be used by the incumbents products) or to other fibre services (i.e. available for the use of third-parties). This allocation is based on the distances of SDH fibre metres and other fibre metres explicitly calculated in the Core module.

The figure below shows an Excel output of the calculation of fibre assets between SDH and other fibre:

Asset group	Asset	Fibre type index	Core cost type	Calculation Fibre SDH (# or metres)	Calculation Fibre Other fibre services (# or metres)	Cost allocation Fibre SDH (metres)	Cost allocation Fibre Other fibre services (metres)
AT1	AT2-AT1: Fibre		Incremental	2,401,269,947	1,200,634,974	67%	33%
AT1	AT2-AT1: Trench		Incremental	2,401,269,947	1,200,634,974	67%	33%
AT1	AT2-AT1: Duct		Incremental	2,401,269,947	1,200,634,974	67%	33%
AT2	Ports: AT2-AT1 rings - 10Mbit/s ports	8	Incremental			100%	-%
AT2	Ports: AT2-AT1 rings - 100Mbit/s ports	9	Incremental			100%	-%
AT2	Ports: AT2-AT1 rings - 1GE ports	10	Incremental			100%	-%
LE/AT1	LE-PoC: Fibre		Incremental	2,401,269,947	1,200,634,974	67%	33%
LE/AT1	LE-PoC: Trench		Incremental	2,401,269,947	1,200,634,974	67%	33%
LE/AT1	LE-PoC: Duct		Incremental	2,401,269,947	1,200,634,974	67%	33%

Figure 6.21: Calculation of fibre assets between SDH and other fibre [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Columns P–S	Calculation of cost allocation of SDH assets between platforms and transmission

The costs of the SDH assets is allocated either directly to the modelled PSTN, ISDN, xDSL or to other transmission – the level of which is defined in the service demand matrix for the levels in the core network. The split between platform and transmission costs is linked from the 'Inputs.Core' worksheet, having been calculated explicitly in the Core module.

The figure below shows an Excel screenshot of the calculation of cost allocation of SDH assets between platforms and transmission:

Asset group	Asset	Fibre type index	Core cost type	Calculation SDH Platforms (Mbit/s)	Calculation SDH Transmission (Mbit/s)	Cost allocation SDH Platforms (%)	Cost allocation SDH Transmission (%)
AT1	AT1: UPS (40kVA) and Generator (50kVA)		Incremental			100%	-%
AT1	AT1: Air conditioning unit (10kVA)		Incremental			100%	-%
AT1	AT1: Ports: PoC-facing - 10Mbit/s ports	8	Incremental	100%	-%	100%	-%
AT1	AT1: Ports: PoC-facing - 100Mbit/s ports	9	Incremental	100%	-%	100%	-%
AT1	AT1: Ports: PoC-facing - 1GE ports	10	Incremental	100%	-%	100%	-%
AT1	AT1: Ports: PoC-facing - 10GE ports	11	Incremental	100%	-%	100%	-%
AT1	AT2-AT1: Fibre		Incremental	93%	7%	93%	7%
AT1	AT2-AT1: Trench		Incremental	93%	7%	93%	7%
AT1	AT2-AT1: Duct		Incremental	93%	7%	93%	7%
AT2	Ports: AT2-AT1 rings - 10Mbit/s ports	8	Incremental	100%	-%	100%	-%
AT2	Ports: AT2-AT1 rings - 100Mbit/s ports	9	Incremental	100%	-%	100%	-%
AT2	Ports: AT2-AT1 rings - 1GE ports	10	Incremental	100%	-%	100%	-%
LE/AT1	LE-PoC: Fibre		Incremental	93%	7%	93%	7%
LE/AT1	LE-PoC: Trench		Incremental	93%	7%	93%	7%
LE/AT1	LE-PoC: Duct		Incremental	93%	7%	93%	7%

Figure 6.22: Cost allocation calculation of SDH assets between platforms and transmission [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Columns U–AB	Calculation of cost allocation between platforms (PSTN, ISDN, xDSL, other service platforms)

The platform costs are allocated directly to the PSTN, ISDN, xDSL and Other service platforms – the latter of which is user defined. The allocation split between these platforms is linked from the 'Inputs.Core' worksheet, having been calculated explicitly in the Core module.

The figure below shows an Excel output of the calculation of cost allocation between platforms (PSTN, ISDN, xDSL, Other service platforms):

Asset group	Asset	Fibre type index	Core cost type	Calculation Platforms PSTN	ISDN	xDSL	Other platforms	Cost allocation Platforms PSTN	ISDN	xDSL	Other platforms
				%	%	%	%	%	%	%	%
AT1	AT1: Site acquistion, preparation and maintenance		Incremental	72.67%	2.59%	24.74%		73%	3%	25%	-%
AT1	AT1: MSAN - located at Access Tier 2 sites		Incremental	73%	3%	25%		73%	3%	25%	-%
AT1	AT1: Concentrator: PSTN/ xDSL line card		Incremental	100%	-%	-%	-%	100%	-%	-%	-%
AT1	AT1: Concentrator: ISDN line card		Incremental	-%	100%	-%	-%	-%	100%	-%	-%
None	Asset 25		Incremental					100%	-%	-%	-%
None	Asset 26		Incremental					100%	-%	-%	-%
None	Asset 27		Incremental					100%	-%	-%	-%
AT1	AT1: UPS (40kVA) and Generator (50kVA)		Incremental	73%	3%	25%		73%	3%	25%	-%
AT1	AT1: Air conditioning unit (10kVA)		Incremental	73%	3%	25%		73%	3%	25%	-%
AT1	AT1: Ports: PoC-facing - 10Mbit/s ports	8	Incremental	-%	-%	-%		100%	-%	-%	-%
AT1	AT1: Ports: PoC-facing - 100Mbit/s ports	9	Incremental	-%	-%	-%		100%	-%	-%	-%
AT1	AT1: Ports: PoC-facing - 1GE ports	10	Incremental	-%	-%	-%		100%	-%	-%	-%
AT1	AT1: Ports: PoC-facing - 10GE ports	11	Incremental	-%	-%	-%		100%	-%	-%	-%
AT1	AT2-AT1: Fibre		Incremental	36%	11%	52%		36%	11%	52%	-%
AT1	AT2-AT1: Trench		Incremental	36%	11%	52%		36%	11%	52%	-%
AT1	AT2-AT1: Duct		Incremental	36%	11%	52%		36%	11%	52%	-%

Figure 6.23: Calculation of cost allocation between platforms (PSTN, ISDN, xDSL, Other service platforms) [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Columns AD–AJ	Calculation of cost allocation across all platforms, transmission and other services

This final matrix calculates the total cost allocation percentage to each of the cost buckets (individual platforms, transmission, other fibre services, other duct services).

The figure below shows an Excel output of the calculation of cost allocation across all platforms, transmission and other:

Asset group	Asset	Fibre type index	Core cost type	Cost allocation PSTN	ISDN	xDSL	Other platforms	Transmission	Other fibre services	Other duct services
LE	LE: Site acquistion, preparation and maintenance		Incremental	40%	10%	40%	10%	-%	-%	-%
LE	LE: Concentrator: Processor		Incremental	100%	-%	-%	-%	-%	-%	-%
LE	LE: Concentrator: PSTN line card		Incremental	100%	-%	-%	-%	-%	-%	-%
LE	LE: Concentrator: ISDN 2 line card		Incremental	-%	100%	-%	-%	-%	-%	-%
LE	LE: Concentrator: ISDN 30 line card		Incremental	-%	100%	-%	-%	-%	-%	-%
LE	LE: DSLAM (2nd Gen)		Incremental	-%	-%	100%	-%	-%	-%	-%
LE	LE: SDSL line card		Incremental	-%	-%	100%	-%	-%	-%	-%
LE	LE: ADSL line card		Incremental	-%	-%	100%	-%	-%	-%	-%
LE	LE: Splitter		Incremental	-%	-%	100%	-%	-%	-%	-%
LE	LE: LPGS equipment MuX		Incremental	93%	7%	-%	-%	-%	-%	-%
LE	LE: UPS (40kVA) and Generator (50kVA)		Incremental	40%	10%	40%	10%	-%	-%	-%
LE	LE: Air conditioning unit (10kVA)		Incremental	40%	10%	40%	10%	-%	-%	-%
LE	LE: Network unit of LPGS		Incremental	93%	7%	-%	-%	-%	-%	-%

Figure 6.24: Calculation of cost allocation across all platforms, transmission and other [Source: Analysys]

6.9 'RF.Core' worksheet

The 'RF.Core' worksheet calculates the core network service routeing factors which are subsequently used in the calculation of the network element output on the 'Dem.In.Core' worksheet. The sets of routeing factors are also subsequently used in the service costing calculation on the 'TA.Core' worksheet.

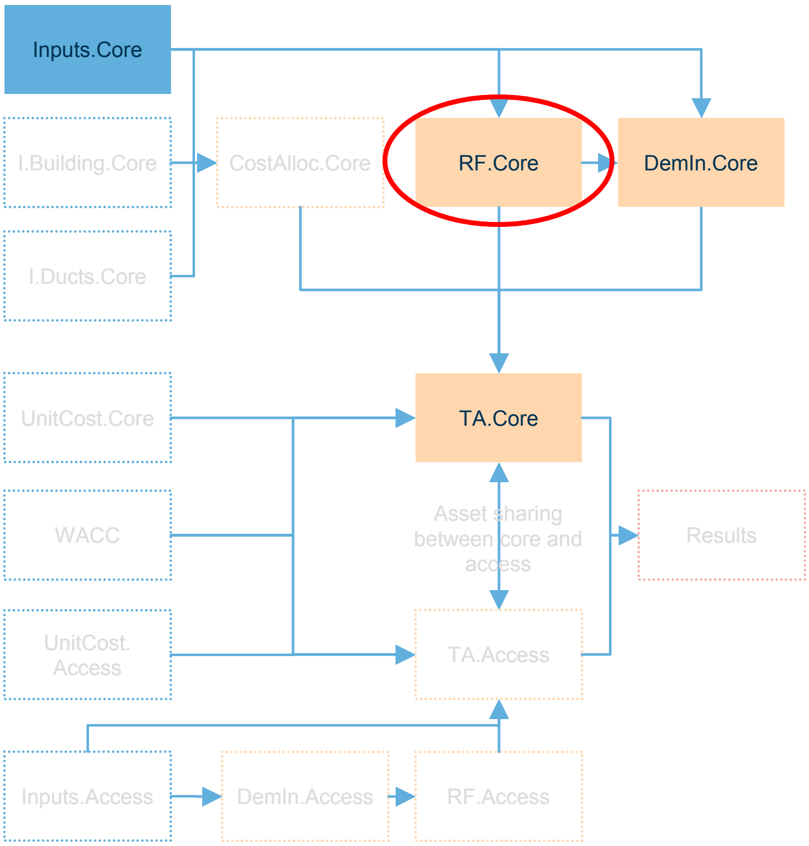


Figure 6.25: Location of the 'RF.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.9.1 Key parameters

This worksheet contains the core service routeing factors linked from the 'Inputs.Core' worksheet. The only parameters which should be changed on this worksheet are those routeing factors associated with the core network operations. These are located on rows 150–156.

6.9.2 Calculation description

The following table outlines the calculations that are contained on the 'RF.Core' worksheet:

Location	*Parameter*
Rows 8–207	Core routeing factors

Table 6.11: Calculations performed on the 'RF.Core' worksheet by row [Source: Analysys]

The routeing factors are calculated from the 'Inputs.Core' worksheet for each asset. The service routeing factors for certain assets, such as line cards, are directly input into the service routeing factor matrix.

The figure below shows the Excel output of the calculation of core routeing factors:

	Asset group	Asset	PSTN PSTN End User Access	PSTN PSTN local traffic (onnet traffic)	PSTN Local carriage service (LCS)
			Lines	Minutes	Minutes
1	LE	LE: Site acquistion, preparation and maint	-	2.00	2.00
2	LE	LE: Concentrator: Processor	-	2.00	2.00
3	LE	LE: Concentrator: PSTN line card	1.00		
4	LE	LE: Concentrator: ISDN 2 line card	-	-	-
5	LE	LE: Concentrator: ISDN 30 line card	-	-	-
6	LE	LE: DSLAM (2nd Gen ATM backhaul)	-	-	-
7	LE	LE: SDSL line card	-	-	-
8	LE	LE: ADSL line card	-	-	-
9	LE	LE: Splitter	-	-	-
10	LE	LE: LPGS equipment MuX	-	2.00	2.00
11	LE	LE: UPS (40kVA) and Generator (50kVA)	-	2.00	2.00

Figure 6.26: Sample of the calculation of PSTN routeing factors [Source: Analysys]

These allocations are used in the annualisation calculations on the 'TA.Core' worksheet.

6.10 'UnitCost.Core' worksheet

This worksheet calculates the unit cost (in real 2007 AUD) for the core network assets, for the modelled year. It further contains the core asset lifetime data.

The unit cost data for the selected year is subsequently used in the calculation of the total cost of the core network on the 'TA.Core' worksheet.

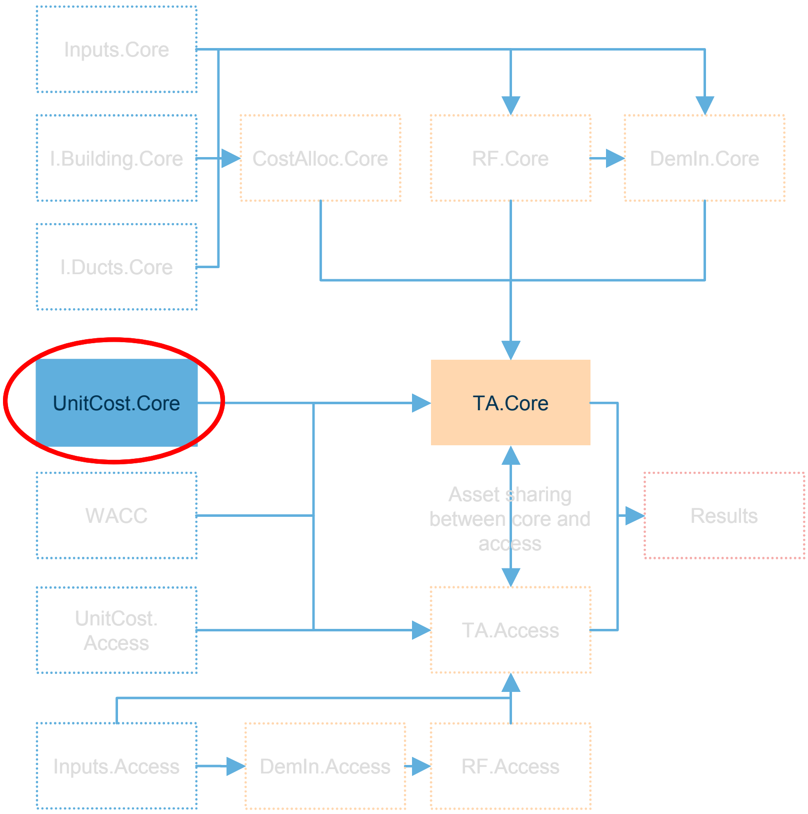


Figure 6.27: Location of the 'UnitCost.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.10.1 Key parameters

This worksheet contains unit cost data for 2007 (cells F27–F226), based on benchmark data sources. An allowance percentage uplift on the asset unit cost is made for spares (cells G27–G226), installation (cells H27–H226), and for indirect assets costs (cells I27–I226). At present, the model is populated with a 0% uplift for spares, a 15% installation uplift for equipment assets (the trench, duct and fibre asset unit costs already contain installation costs), and a 0% uplift for indirect costs.

This worksheet also contains inputs for detailed unit cost data on the site acquisition, preparation and maintenance of sites for LEs, AT1s, LAS and TNS. These inputs are in cells Q27–T43 and can be varied by geotype.

The lifetimes for the major asset types is also listed on this worksheet – cells D9–D21. These are based on benchmark data.

6.10.2 Calculation description

The following table outlines the calculations that are contained on the 'UnitCost.Core' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Row 5	Unit capex cost per network element
Rows 9–21	Lifetime inputs by major asset type
Rows 27–226	Network equipment investment costs in 2007
Rows 29–43	Detailed cost inputs for site acquisition, preparation and maintenance
Rows 231–430	Unit capex cost per network element
Rows 435–634	Opex as percentage of capex
Rows 639–838	Unit capex trends per network element
Rows 843–1042	Unit opex trends per network element

Table 6.12: Calculations performed on the 'UnitCost.Core' worksheet [Source: Analysys]

The unit capex cost is defined for 2007 based on benchmark data. The asset unit capex for the selected year is calculated using the capex price trends defined in rows 636–838.

Unit operating costs are defined for 2007 as a percentage of the unit capex cost in rows 432–634. These percentages are informed by analysis of Telstra's RKR submission data. The asset unit opex for the selected year is calculated using the opex price trends defined in rows 840–1042.

6.11 'OutputCost.Core' worksheet

This worksheet links in data from the 'Dem.In.Core' worksheet and 'TA.Core' worksheet and derives the cost per unit network element output for each of the core platforms. These outputs do not link to other parts of the Cost module.

6.11.1 Key parameters

There are no parameters on this sheet: all calculations on the worksheet are autonomous.

6.11.2 Calculation description

The following table outlines the calculations that are contained on the 'OutputCost.Core' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 8–209	Cost per unit network element output for the PSTN platform
Rows 214–415	Cost per unit network element output for the ISDN platform
Rows 420–621	Cost per unit network element output for the xDSL platform
Rows 626–827	Cost per unit network element output for the transmission platform

Table 6.13: Calculations performed on the 'TA.Core' worksheet [Source: Analysys]

6.12 'TA.Core' worksheet

This worksheet performs the annualisation calculation on the core network costs. It subsequently calculates the service costs.

This worksheet contains data on volumes of equipment deployed, their asset lifetimes and service demand data linked in from the 'Inputs.Core' worksheet and capex and opex parameters by asset linked in from the 'UnitCost.Core' worksheet.

The results of this worksheet are linked onto the 'Results' worksheet.

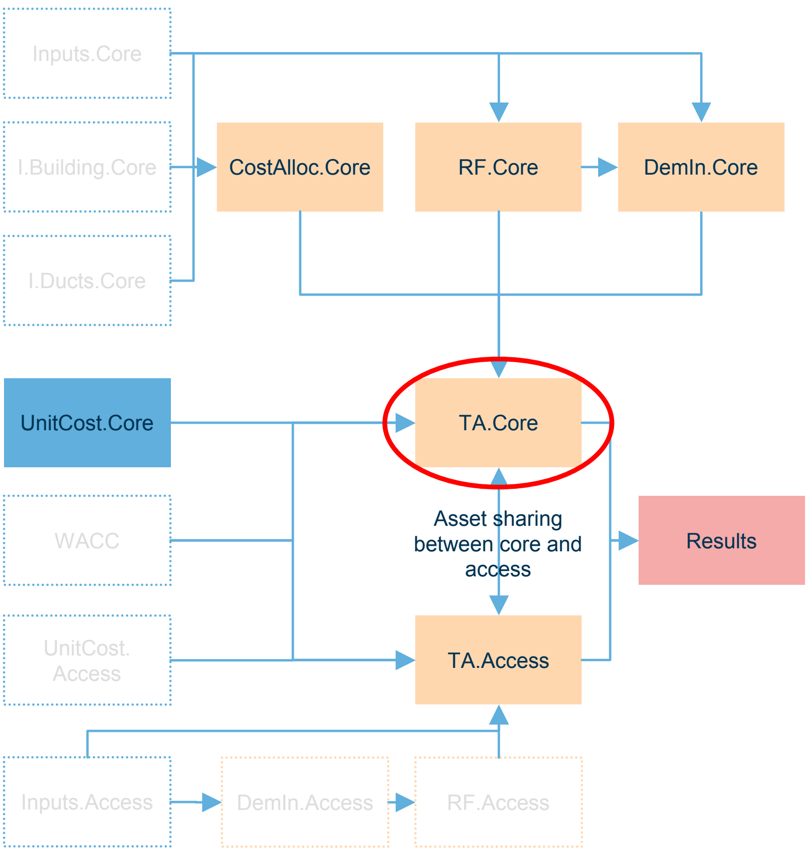


Figure 6.28: Location of the 'TA.Core' worksheet in the overall Cost module structure [Source: Analysys]

6.12.1 Key parameters

Under a slowly evolving market scenario, the tiled annuity cost annualisation methodology, under which the angle of the tilt is controlled by the asset price trend, is a good approximation for economic depreciation. However, under a rapidly changing service demand scenario, an additional tilt parameter is required in order to approximate the effect of economic depreciation. This tilt adjustment parameter is contained in Column K.

All other calculations on the worksheet are autonomous.

6.12.2 Calculation description

This worksheet calculates the annualised capex cost, and subsequently adds the opex cost in year to generate the total cost by asset. For certain assets, there are identified savings within the core network, and with the access network. These cost savings are calculated and allocated to the access network where applicable. These costs are allocated to the various platforms. Shared network costs are marked up on the incremental network costs by platform using an EPMU. Finally, the service cost calculation is performed.

The following table outlines the calculations that are contained on the 'TA.Core' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Cells B11–O210	Asset cost annualisation calculation
Cells P11–P210	Calculation of the proportion of costs allocated to access
Cells T11–T210	Calculations of the core costs transferred to the access network
Cells Y11–AA210	Calculation of the distribution of core costs between shared, business overheads and incremental costs
Cells AC11–AC210	Calculation of the incremental costs that are allocated from the access network
Cells AE11–AK210	Incremental cost allocation to platforms – based on the core cost allocation percentages output from the 'CostAlloc.Core' worksheet
Cells AM11–FE210	Core platform incremental cost allocation to services. PSTN (columns AM–BP), ISDN (columns BR–CU), xDSL (columns CW–DZ) and transmission (columns EB–FE)
Cells AE213–FE213	Calculation of the incremental cost by service for each platform
Rows 217–228	Calculation of the shared cost EPMU and business overheads EPMU
Rows 234–330	Service cost calculation for incremental cost, incremental + shared cost, incremental + shared + business overheads cost

Table 6.14: Calculations performed on the 'TA.Core' worksheet [Source: Analysys]

The remainder of this section provides an overview of the calculations in this worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Cells B11–O210	Asset cost annualisation calculation

- Columns F–L provide the inputs required for the tilted annuity cost annualisation calculation.
  - Column I (total capex cost) is the gross replacement cost (GRC) of the network. It is calculated by multiplying the unit capex (column G) by the total number of network equipment assets deployed (column F)
  - Column J is the annual capex price trend linked from the 'UnitCost.Core' worksheet
  - Columns K is the tilt adjustment parameter

  - Column L is the economic lifetime of the assets in terms of years – this is calculated on the basis of the lifetimes (linked from the 'UnitCost.Core' worksheet) of the asset cost types defined in column C.

- Column M annualises the capex according to the tilted annuity charge formula:

$$AnnuityCharge = \frac{WACC - (MEApriceChange + TiltAdjustment)}{1 - \left(\frac{1 + (MEApriceChange + TiltAdjustment)}{1 + WACC}\right)^{lifetime}} \times GRC$$

- Columns N–O calculate the total cost, by adding the annualised capex and opex number by asset.

Cell reference	*Description and details of spreadsheet calculations*
Cells P11–P210	Calculation of the proportion of costs allocated to access
Cells T11–T210	Calculations of the costs transferred to the access network cost calculations

- Columns P–T calculate the cost to be transferred from the core network to the access network.

Cell reference	*Description and details of spreadsheet calculations*
Cells Y11–AA210	Calculation of the distribution of core costs between shared, business overheads and incremental costs
Cells AC11–AC210	Calculation of the incremental costs that are allocated from the access network

- Columns Y–AA calculate the total shared cost, business overheads cost and incremental costs on the basis of the asset cost type identified in column D.

- Column AC links in the total costs allocated from the access network

Cell reference	*Description and details of spreadsheet calculations*
Cells AE11–AK210	Incremental cost allocation to platforms – based on the core cost allocation percentages output from the 'CostAlloc.Core' worksheet
Cells AM11–FE210	Core platform incremental cost allocation to services. PSTN (columns AM–BP), ISDN (columns BR–CU), xDSL (columns CW–DZ) and transmission (columns EB–FE)
Cells AE213–FE213	Calculation of the incremental cost by service for each platform

- Columns AE–AK calculate the total incremental costs by platform on the basis of the percentages output from the 'CostAlloc.Core' worksheet. These costs are distributed between the modelled services, by platform, on the basis of the percentage distributions calculated on the 'Dem.In.Core' worksheet. The total incremental costs by service for each platform is subsequently total in row 213.

Cell reference	*Description and details of spreadsheet calculations*
Rows 217–228	Calculation of the shared cost EPMU and business overheads EPMU

The shared costs mark-up is performed in two separate stages. One mark-up is performed for shared costs that are to be marked-up for core network elements only – identified with a 'Core network equipment' flag in column E; and a second mark-up is performed for shared costs that are to be marked-up equally for all network elements – identified with an 'All network elements' flag in column E. The mark-ups are distributed across the platforms using an EPMU mechanism (cells AE219–AK219 and AE224–AK224) based on the level of incremental cost incurred by each platform.

The business overheads is marked-up on top of the incremental + shared costs.

Cell reference	*Description and details of spreadsheet calculations*
Rows 234–330	Service cost calculation for incremental cost, incremental + shared cost, incremental + shared + business overheads cost

- Column D links in the service demand for the selected year
- Columns E–H transposes the PSTN, ISDN, xDSL and Transmission platform costs by service
- Column I calculates the unit cost by dividing the sum of the platform costs by the service demand

The unit costs are linked in to the 'Results' worksheet

6.13 'Inputs.Access' worksheet

This worksheet links to the outputs from the CAN module. It links in the required access asset deployment numbers from the CAN module. The service demand data is used in the calculations of network element output on the 'Dem.In.Access' worksheet. The deployment numbers and calculated lifetimes are used in the annualisation calculations on the 'TA.Access' worksheet.

The calculations for IEN use of CAN trench uses data from the 'I.Ducts.Core' worksheet and the 'UnitCost.Access' worksheets.

These linkages are shown in the diagram below:

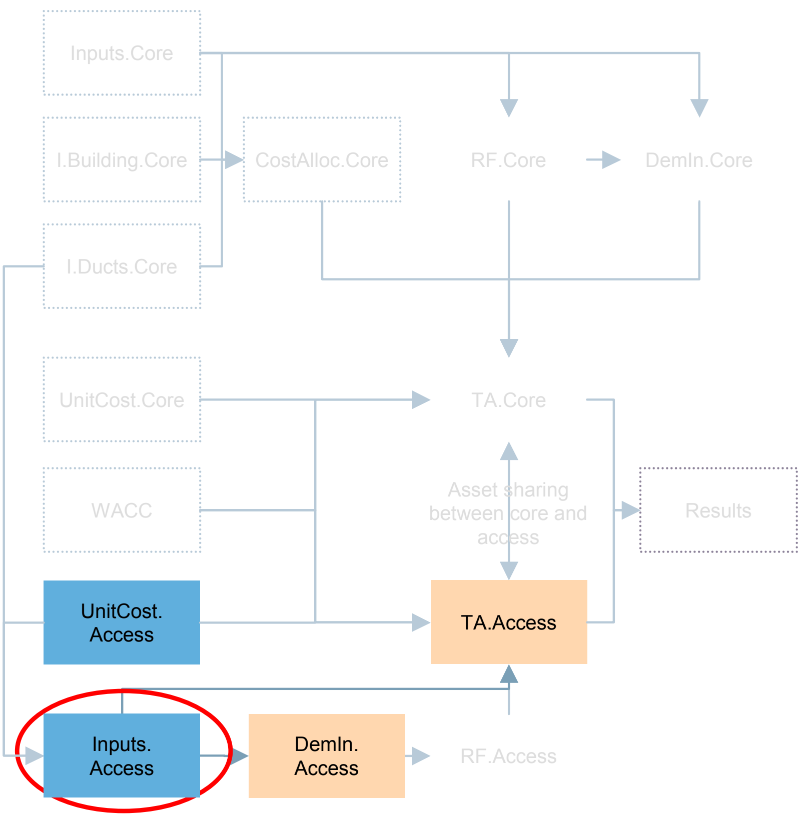


Figure 6.29: Location of the 'Inputs.Access' worksheet in the overall Cost module structure [Source: Analysys]

6.13.1 Key parameters

This worksheet contains key data inputs from the CAN module. The key parameters that can be adjusted manually are the proportion of access network assets that are allocated to the core network. This parameter represents core network assets (such as transmission back from LPGS, i.e. equipment that is core-side of the main distribution frame (MDF)) that has been inherently calculated within the CAN module.

Parameter	*Location*	*Impact*
Proportion of trench and duct cost allocated to core for IEN usage	C230	Allocated asset cost away from the access network and onto the core network.

Table 6.15: Key parameters on the 'Inputs.Access' worksheet [Source: Analysys]

6.13.2 Calculation description

The following table outlines the calculations that are contained on the 'Inputs.Access' worksheet:

Analysys

Cell reference	*Description and details of spreadsheet calculations*
Row 3	Year modelled
Rows 8–37	Service demand by geotype
Rows 42–126	Network assets required by geotype
Rows 130–230	Allocation of duct and trench and fibre asset costs to the core network

Table 6.16: Calculations performed on the 'Inputs.Access' worksheet [Source: Analysys]

The remainder of this section provides an overview of the calculations that are performed on the 'Inputs.Core' worksheet.

Cell reference	*Description and details of spreadsheet calculations*
Rows 8–37	Service demand by geotype

The line service demand by geotype is linked in from the CAN module:

Service demand by geotype

	Services	Unit	Geotype 1	Geotype 2	Geotype 3
1	PSTN End User Access	Lines	36,359	154,865	1,525,455
2	PSTN local traffic (onnet traffic)	Minutes			
3	PSTN national long distance traffic (onnet calls)	Minutes			
4	PSTN outgoing traffic to international destinations	Minutes			
5	PSTN outgoing to mobile traffic (mobile terminating)	Minutes			
6	PSTN terminating traffic (from international, mobile, other domestic fixed networks)	Minutes			
7	Local carriage service (LCS)	Minutes			
8	ISDN-BRI access	Lines	383	1,630	16,057
9	ISDN-PRI access	Lines	43	181	1,783
10	Service 10	none			
11	ISDN - voice traffic	Minutes			
12	Unconditioned local loop service (ULLS)	Lines	3,582	15,257	150,280
13	Line sharing service (LSS).	Lines	2,182	9,292	91,531
14	Wholesale line rental (WLR)	Lines	-	-	238,375

Figure 6.30: Excel sample of service demand data by geotype – linked in from the Access module [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 42–127	Network assets required by geotype

The number of assets required in the access network is linked in from the CAN module:

Network asset demand by geotype

	Assets	Unit	Geotype 1	Geotype 2	Geotype 3	Geotype 4
1	NTP: 2-pair wall socket	#	11,285	7,945	1,398,690	2,122,563
2	NTP: 10-pair building termination	#	1,288	1,017	27,689	22,243
3	NTP: 30-pair building termination	#	94	116	2,839	2,730
4	NTP: 50-pair building termination	#	38	32	989	734
5	NTP: 100-pair building termination	#	-	-	-	-
6	Fibre termination point (E1)	#	181	630	2,662	2,119
7	CPE (radio link) Outdoor unit	#	-	-	-	-
8	CPE (satellite link)	#	-	-	-	-
9	LPGS equipment	#	-	-	93	628
10	LPGS MDF	#	-	-	93	628
11	Copper pillars	#	99	92	5,603	8,705
12	Fibre splicing chamber	#	103	90	144	244
13	Duct: 28	metres	-	-	4,563	7,471
14	Duct: 24	metres	-	-	15,502	8,240
15	Duct: 20	metres	304	-	24,968	36,206

Figure 6.31: Excel sample of access network assets required by geotype – linked in from the CAN module [Source: Analysys]

Cell reference	*Description and details of spreadsheet calculations*
Rows 130–230	Allocation of duct and trench and fibre asset costs to the core network

The dimensioning of certain core network assets has been performed in the CAN module – for example, transmission from the LPGS to the LE is defined as sitting within the core network as an MDF is located within the LPGS. Consequently, these assets need to be recovered from the core increment rather than the access increment. Three sets of matrices are used to allocate a proportion of the access network costs away from the access network and into the core:

- The matrix in cells B139–S160 calculates the overall proportion of access costs allocated to the core (i.e. it takes the percentages derived from the following three arrays)
  - The matrix in cells B164–S185 calculates the overall proportion of access costs allocated to the core for the modern network deployment
  - The matrix in cells B190–S211 calculates the overall proportion of access costs allocated to the core for the MSAN (NGN) deployment
  - The array in row 230, specifies the proportion of trench and duct cost, by geotype, within the CAN that should be allocated to the core for IEN usage. The calculation for this is explained below.

To capture the cost saving arising from the use of CAN trenches by duct used for the IEN, we calculate the distance of overlap between the two networks in the Core module. This is informed by the overlap analysis discussed in section 7.11 of the FLRIC report. The modelling approach adopted is based on deploying IEN duct in existing CAN trench and allocating a proportion of the

CAN trench cost to the IEN. The relative use, and resulting cost allocation, of the CAN by the IEN is calculated based on the following steps:

1. Lines 215-225: The volume of meters of duct deployed in the CAN for the use by the CAN is calculated, informed by the CAN module.
2. Line 227: the volume of meters of duct deployed in the CAN for the use by the IEN is known from calculations on the ‘I.Ducts.Core’ worksheet. This volume is distributed by geotype in the same ratio of CAN duct by geotype.
3. Line 228: the volume of IEN duct deployed in the CAN as a proportion of total duct deployed (CAN & IEN) is calculated.
4. Line 229: the proportion of cost attributable to just trenching in the ‘trench and duct’ CAN asset type is provided from the ‘UnitCost.Access’ worksheet.
5. Cell C230: the proportion of cost saved to be allocated to the IEN is defined. This is assumed at 50%, therefore both the CAN and IEN share the benefit of using trench deployed for the CAN.
6. Line 230: the proportion of cost saved is the product of 3 (IEN duct as proportion of total duct deployed), 4 (proportion of cost attributable to just trenching), and 5 (proportion of cost saved allocated to the IEN).

The resultant allocation of costs is applied to the remaining CAN duct and pit assets, after the allocation of cost for supporting LPGS deployments. It is important to note that the modelled cost saving is dependent on the scenario input ‘Select overlap level between core and access’ described in section 6.1.1.

6.14 ‘RF.Access’ worksheet

This worksheet calculates the access network service routeing factors. The access network service routeing factors are used in the cost annualisation calculation on the ‘TA.Access’ worksheet and in the calculation of the Network Element Output on the ‘Dem.In.Access’ worksheet.

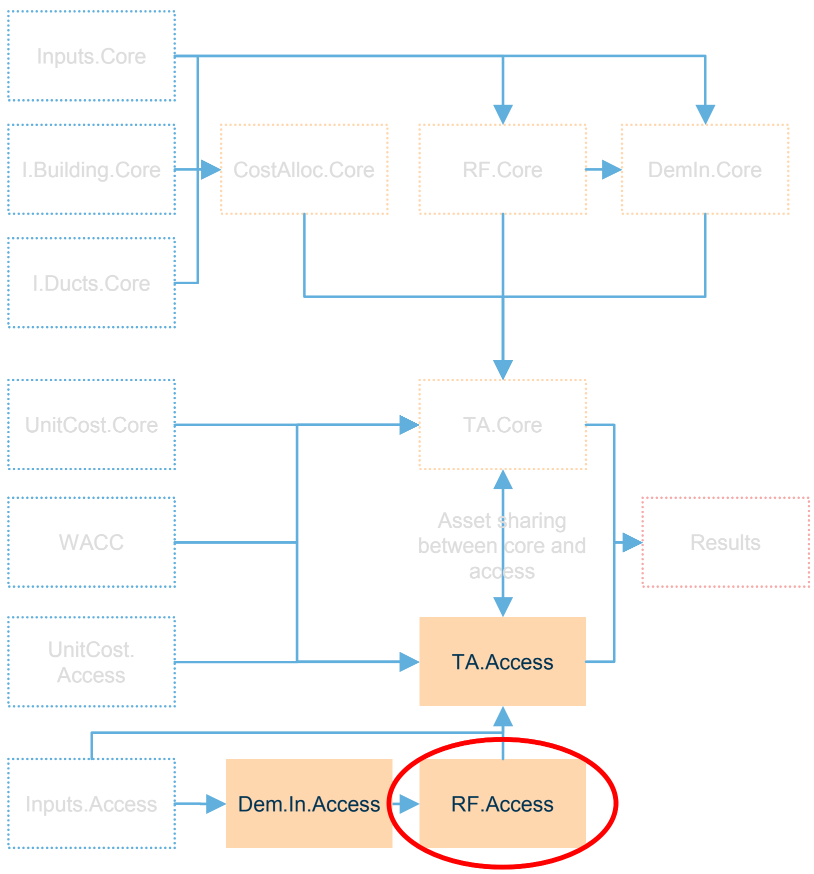


Figure 6.32: Location of the 'RF.Access' worksheet in the overall Cost module structure [Source: Analysys]

6.14.1 Key parameters

This worksheet contains the manually inputted access service routeing factors.

Parameter	*Location*	*Impact*
Access service routeing factors	Rows 6–86	Allocation of service costs

Table 6.17: Key parameters on the 'RF.Access' worksheet [Source: Analysys]

6.14.2 Calculation description

The following table outlines the calculations that are contained on the 'RF.Access' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 6–86	Access service routeing factors

Table 6.18: Calculations performed on the 'RF.Access' worksheet [Source: Analysys]

The figure below shows a screenshot sample of the parameters for access service routeing factors.

This sheet contains the access routing factors used in the workbook
note: cost from core network is LE costs supporting MDF
note: business overheads all

	Asset group	Asset	PSTN End User Access	PSTN local traffic (onnet traffic)	PSTN national long distance traffic (onnet calls)
		Access service volumes:	7,824,961	-	-
1	Other CAN	NTP: 2-pair wall socket	-	-	-
2	Other CAN	NTP: 10-pair building termination	1	-	-
3	Other CAN	NTP: 30-pair building termination	1	-	-
4	Other CAN	NTP: 50-pair building termination	1	-	-
5	Other CAN	NTP: 100-pair building termination	1	-	-
6	Other CAN	Fibre termination point (E1)	1	-	-
7	Radio	CPE (radio link) Outdoor unit	1	-	-
8	Radio	CPE (satellite link)	1	-	-
9	LPGS	LPGS equipment	1	-	-
10	LPGS	LPGS MDF	1	-	-
11	Cable	Copper pillars	1	-	-

Figure 6.33: Sample of the parameters for access service routeing factors [Source: Analysys]

Costs that are linked in from the core network, due to asset sharing between the access and core networks, also have routeing factors defined (see row 85).

6.15 'Dem.In.Access' worksheet

This worksheet calculates the Network Element Output through the multiplication of the service routeing factors, from the 'RF.Access' worksheet, by the total service demand, from the 'Inputs.Access' worksheet. It is calculated for each asset, by geotype. It is then used in the annualisation calculation on the 'TA.Access' worksheet. These linkages are shown below:

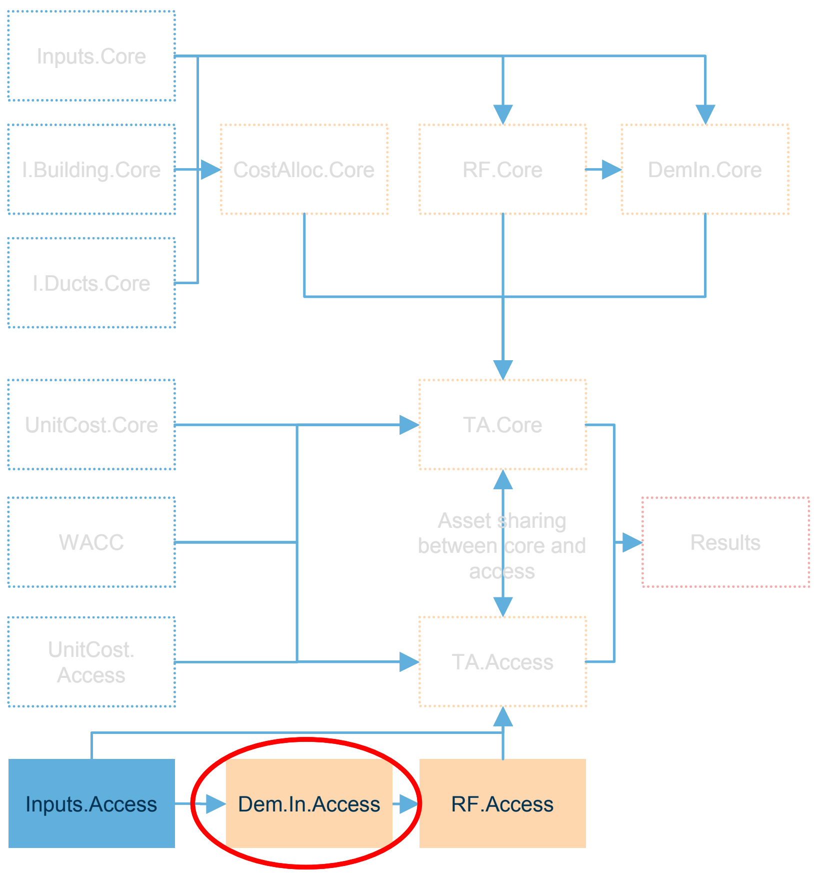


Figure 6.34: Location of the 'Dem.In.Access' worksheet in the overall Cost module structure [Source: Analysys]

6.15.1 Key parameters

This worksheet doesn't contain any manually adjustable parameters. All service demand data is linked in from the 'Inputs.Access' worksheet.

6.15.2 Calculation description

The following table outlines the calculations that are contained on the 'Dem.In.Access' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 8–37	Service demand
Rows 42–122	Network element output

Table 6.19: Calculations performed on the 'Dem.In.Access' worksheet [Source: Analysys]

6.16 'UnitCost.Access' worksheet

This worksheet captures the unit capex and opex inputs for the access network assets. The unit cost data for the selected year is subsequently used in the calculation of the total cost of the core network on the 'TA.Access' worksheet.

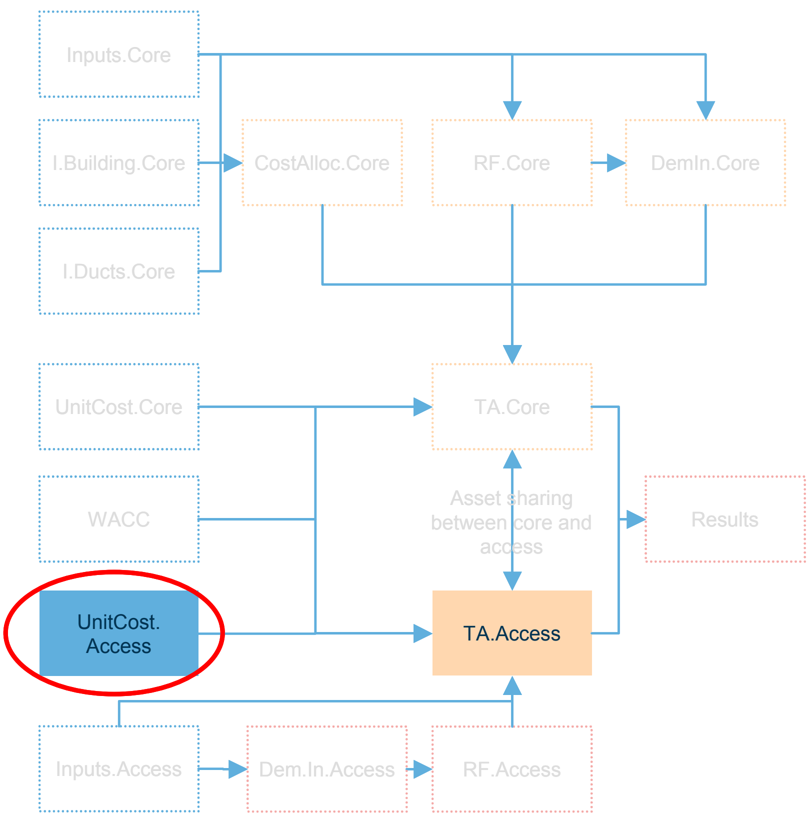


Figure 6.35: Location of the 'UnitCost.Access' worksheet in the overall Cost module structure [Source: Analysys]

6.16.1 Key parameters

This worksheet contains unit cost data for 2007 (cells D118–D198), based on benchmark data sources. An allowance percentage uplift on the asset unit cost is made for spares (cells E118–E198), installation (cells F118–F198), and for indirect assets costs (cells G118–G198). At present, the model is populated with a 0% uplift for spares, a 15% installation uplift for equipment assets (the duct, including trench, and fibre asset unit costs already contain installation costs), and a 0% uplift for indirect costs.

Duct costs are derived by a set of calculations in rows 10–48, with separate calculations for trenched duct, open duct and ploughed cable:

- trenched duct costs are built up from the costs of the trench, the actual duct and the guard wire
- open trench omits the cost of the trench (i.e. assuming access to trench at minimal cost)
- ploughed cable costs use a second set of costs in rows 37–48.

In cells AG10:AW35, calculations are made to determine the relative proportion of the trenching element of the duct deployment costs. This is used to inform the allocation of CAN costs to the IEN for trench sharing and is described in section 6.13.

The proportion of duct which is deployed in open trench is defined in cells AG144–AV155. The cost savings for open trench are assumed to only apply to trenched duct and not to ploughed routes. The proportion deployed via ploughing is defined in cells AG130–AV141. The total capex is adjusted on the 'TA.Access' worksheet to reflect the amount of trench deployed via both ploughed cable and open trench.

Cable costs inputs are specified by gauge in rows 54–82 and are composed of the cost of the cable, hauling, delivery and handling. Two distributions in rows 87–102 are then used to calculate separate blended costs for each cable size for the main and distribution networks. Each cost is blended across the mix of gauges deployed. These distributions are calculated using outputs from the geoanalysis and access network module.

Jointing costs are specified in rows 106–112 and are composed of a jointing rate per pair anda joint enclosure cost.

Opex is defined as a percentage of capex for 2007 in cells D288–D368.

The unit cost trends over time can also be defined by the user. The capex price trends are defined by asset in cells D373–I453, and the opex price trends are similarly defined in cells D458–I538.

6.16.2 Calculation description

The following table outlines the calculations that are contained on the 'UnitCost.Access' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Row 4	Modelled year
Rows 10–112	Capital cost inputs for duct, copper cable and jointing
Cells AG10:AW35	Calculation of relative cost contribution of trenching component as part of the duct deployment costs
Rows 118–198	Access network equipment investment costs in AUD
Rows 203–283	Unit capex cost per network element
Rows 288–368	Opex as a percentage of opex
Rows 373–453	Unit capex trends per network element
Rows 458–538	Unit opex trends per network element

Table 6.20: Calculations performed on the 'UnitCost.Access' worksheet [Source: Analysys]

6.17 'TA.Access' worksheet

This worksheet performs the annualisation calculation on the access network costs. The calculation is presented differently to the core network annualisation as the access network is modelled according to the geotype dimension, and does not require a multi-platform approach.

This worksheet contains data on volumes of equipment deployed, their asset lifetimes and service demand data linked in from the 'Inputs.Access' worksheet and capex and opex parameters by asset linked in from the 'UnitCost.Access' worksheet. It calculates the annualised capex cost, and subsequently adds the opex cost in year to generate the total cost by asset. A defined amount of the access network costs are allocated to the core network costing. Subsequently, a service costing calculation is performed by geotype. The results of which are linked onto the 'Results' worksheet.

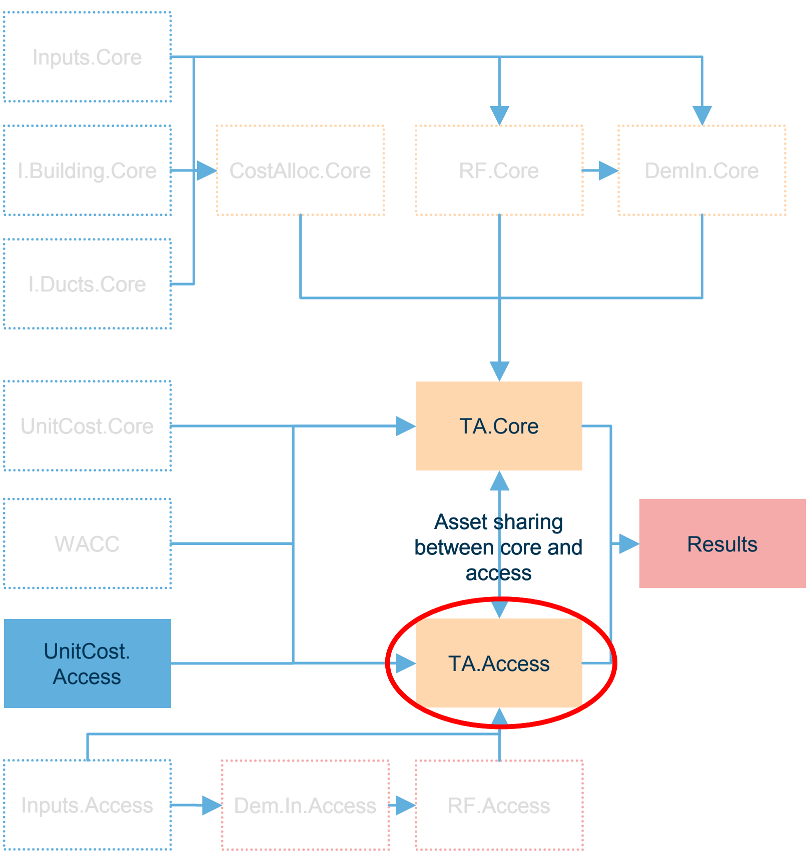


Figure 6.36: Location of the 'TA.Access' worksheet in the overall Cost module structure [Source: Analysys]

6.17.1 Key parameters

This worksheet contains the tilt adjustment parameter – previously discussed in section 6.12.1. This parameter allows for the manipulation of the cost tilt in order to approximate an economic depreciation cost annualisation methodology.

All other calculations on the worksheet are autonomous.

6.17.2 Calculation description

The following table outlines the calculations that are contained on the 'TA.Access' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 4–5	Year modelled and WACC parameters
Cells E10–Q91	Calculation of the total geotype costs (i.e. total capex, total annualised capex, total opex, total cost savings)
Cells V10–AK91	Equipment deployed by geotype (including adjustments for NGN scenario and allocation of costs to the core network)
Cells AM10–BB91	Capex cost per geotype = equipment deployed by geotype (cells U10–AJ90) multiplied by unit capex (cells H10–H90). Totalled in row 91.
Cells BD10–BS91	Calculation of annualised capex cost per geotype using the tilted annuity algorithm
Cells BU10–CJ91	Opex cost per geotype = equipment deployed by geotype (cells V10–AK90) multiplied by unit capex (cells H10–H90) multiplied by opex as percentage of capex (cells I10–I90)
Cells CL10–DA91	Percentage of trench and duct cost allocated to the core network. This is linked from the 'Inputs.Access' worksheet and defines the proportion of access assets that are actually attributed to the core network costing (e.g. transmission from the LPGS to the LE)
Cells DC10–DR91	Percentage of fibre cost allocated to the core network. This is linked from the 'Inputs.Access' worksheet and defines the proportion of access assets that are actually attributed to the core network costing (e.g. transmission from the LPGS to the LE)
Cells DT10–EI91	Total trench and duct costs allocated to the core network = Percentage of trench and duct cost allocated to the core network (cells CL10–DA91) multiplied by the sum of the annualised capex (cells BD10–BS91) and opex (cells BU10–CJ91)
Cells EK10–EZ91	Total fibre costs allocated to the core network = Percentage of fibre cost allocated to the core network (cells DB10–DQJ91) multiplied by the sum of the annualised capex (cells BC10–BR91) and opex (cells BT10–CIJ91)
Cells FB10–FQ91	Cost savings and costs from core allocated to geotypes = total cost coming from core (cells N10–N91) plus cost savings from duct and trench sharing (P10–P91) multiplied by the proportion of equipment purchased by geotype (cells V10–AK91)
Cells FS10–GH91	Total cost per geotype = annualized capex cost per geotype (cells BD10–BS91) + Opex cost per geotype (cells BU10–CJ91) + Trench and duct cost allocated to core (cells DT10–EIJ91) + Fibre cost allocated to the core network (cells EK10–EZ91) + Cost savings and costs from core allocated to geotypes (cells FB10–FQ91)
Cells GJ10–GY91	Cost per unit output by geotype = total cost per geotype (FS10–GH91) divided by the demand by geotype (linked from the 'Dem.In.Access' worksheet)
Rows 93–95	Calculation of the total trench, duct and fibre costs allocated to the core network. These figures are linked in to the 'TA.Core' worksheet.
Rows 111–140	Service costing calculation by geotype. This matrix is linked into the 'Results' worksheet.

Table 6.21: Calculations performed on the 'TA.Access' worksheet [Source: Analysys]

6.18 'Results' and 'Results.Pasted' worksheet

The 'Results' worksheet presents the core and access network results, and calculates the resultant LRIC cost. It takes its inputs from the core and access cost annualisation worksheets – 'TA.Core' and 'TA.Access'.

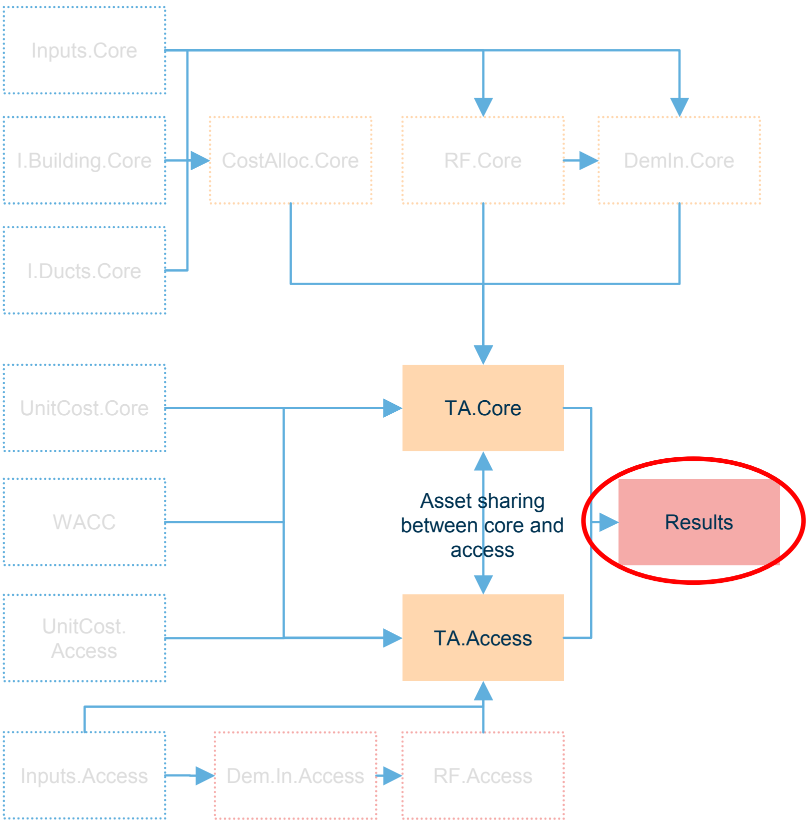


Figure 6.37: Location of the 'Results' worksheet in the overall Cost module structure [Source: Analysys]

The 'Results.Pasted' worksheet contains the pasted unit costs, split by core and access, from running the LRIC model for each year in the period 2007–12. This calculation of the LRIC model can be automated by pressing the "Paste results" button at the top of the worksheet.

6.18.1 Key parameters

The 'Results' worksheet contains an output of all relevant data and only contains a manually adjustable set of parameters for converting volume to demand by geotype (rows 41–70).

The 'Results.Pasted' worksheet contains no parameters.

6.18.2 Calculation description

The following table outlines the calculations that are contained on the 'Results' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 8–37	LRIC results by service for core and access by geotype
Rows 41–70	Conversion parameters for core and access, and geotype demand numbers for access network calculations
Rows 75–104	LRIC unit cost outputs
Rows 109–111	Core platform costs

Table 6.22: Calculations performed on the 'Results' worksheet [Source: Analysys]

The final LRIC costs are generated for each service using a multiplication factor to convert the LRIC cost in minutes/lines per annum into an appropriate cost – either:

- AUD/line/month (access line services)
- AUD cents/minute (voice traffic services)
- AUD cents/call (LCS service)
- AUD/Mbit/s (other data transmission services)

The core network results are presented as a marked up LRIC cost for each of the modelled services in cells G75–G104.

The access network results are presented as a Band 1, Band 2, Band 3/4 (clustered), Band 3/4 (spread) and average access cost in cells I75–M104. Access network results can also be examined by geotype (I41:X70) as annualised costs, before the application of monthly conversion factors.

The costs that are attributed to the other core platform costs (Other platforms, other fibre services and other duct services) are summarized in cells E109–G111.

6.19 'Recon' worksheet

This worksheet provides assumptions of opex as a proportion of capex for particular cost categories and also aggregates cost information from the model.

6.19.1 Key parameters

This worksheet contains assumptions of opex as a proportion of capex for particular cost categories, stated for capex and opex separately.

6.19.2 Calculation description

The following table outlines the calculations that are contained on the 'Recon' worksheet:

Cell reference	*Description and details of spreadsheet calculations*
Rows 6	Assumptions of overheads mark-up
Rows 10–29	Assumptions of opex as a proportion of capex
Rows 36–60	Calculation of capex and opex by category from model
Rows 66–86	Summary of access and core costs from model

Table 6.23: Calculations performed on the 'Recon' worksheet [Source: Analysys]

Annex A: Quick-start guide to active modules

To further aid the model user, a quick-start guide or 'crib-sheet' has been developed for the active modules in the LRIC model. This annex identifies the common tasks and considerations that users may wish to undertake or review when using the LRIC model, following a logical flow. It is intended that this document is supplementary to the main body of the model user guide document above; and which provides a more detailed description of the calculations that take place on each worksheet in the active modules in the LRIC model.

This crib-sheet document specifically outlines, for each of the identified tasks (e.g. changing the modelled year of interest), the location within the model of the appropriate parameter to be adjusted, the description of how to change this parameter, and the effect of changing this parameter.

To produce a LRIC model result, all three active modules needs to be open. To run the model, press **F9** to calculate (the modules are provided with manual calculation enabled).

A.1 Scenario setup

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the modelled year	Cost.xls	Scenario	C5	To change the year modelled, select the appropriate year from the pull-down selection box in the identified cell.	The appropriate year's input data (such as traffic) will be subsequently used in the model.
To change the extent to which NGN equipment is deployed in the access network	Cost.xls	Scenario	C8:R8	The 'MSANs deployed in geotype' parameter deploys NGN equipment in those geotypes that are set to 1. The user may set as many of these geotypes to 1 as desired. It is logical that they are set in order, (e.g. all geotypes from 1–6 are set to 1: it would be illogical to have geotypes 1–2, 4–6 set to 1, but 3 set to 0).	Deploying MSAN equipment in any geotype results in the NGN core network algorithms being implemented, deploying a full IP-MPLS core. Furthermore, some costs from the access network are transferred to the core network, as the core network boundary is pushed out further into the access network as MSANs replace pillars (for the geotypes selected). The transfer of costs from the access to the core

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
					networks is calculated on the 'TA.Access' worksheet (cells M94:N96)

A.2 Service demand forecast

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the traffic modelled: *Option 1*	Cost.xls	Inputs.Demand	D85:I114	The demand sensitivity array allows the user to simply adjust the demand forecast, allowing sensitivity testing.	Adjusting the demand levels affects the loading on the core network and the number of access services in operation.
To change the traffic modelled: *Option 2*	Cost.xls	Inputs.Demand	D120:N241	Alternatively, the traffic demand may be directly manipulated at the bottom of this worksheet. Forecasts are calculated by selecting a CAGR for the period 2007–2012 and an interpolation curve that outputs a demand line between 2007 and 2012.	Adjusting the demand levels affects the loading on the core network and the number of access services in operation.
Define size of the CAN	Cost.xls	Inputs.Demand	D8:I8	This is used to define the number of SIOs used to dimension the CAN. It can be used to reflect that the number of locations reachd by the CAN may be fixed though actual demand is changing over time. It may be appropriate to set to a value consistent with the geoanalysis.	Adjusting the input value of SIOs will change the number of all assets calculated in the CAN module. Note that higher value of input CAN SIOs and sum of access SIOs in the demand forecast.
Defined xDSL enabled exchanges	Cost.xls	Inputs.Demand	D13:I13	This is used to define the number of exchanges which are xDSL-enabled. The order in which exchanges are enabled is defined on the 'In.Subs' worksheet of the Core module.	Enabled exchanges impacts the distribution of xDSL subscribers, and therefore the dimensioning of LE-POC backhaul links.
Review total access demand by	Core.xls	In.Subs	E12:E27	The distribution of access SIOs by geotype is informed from the Location and Demand	Impacts both the access and the core model.

geotype				Database. This can be modified by adjusting locations, and therefore connected SIOs in each geotype. Current default input is 100% for all geotypes, so reflecting the Location and Demand Database.	For access, it will likely skew the cost of an aggregate geotype (e.g. Band 2 comprises geotypes 3–6). For core, it will skew traffic loading between different geotypes.
Review availability of service by geotype	Core.xls	In.Subs	K12:N27; P12:Q27; S12:S27; AD12:AE27; AG12:AH27	Toggle availability of a service in a geotype	Can remove, for example, WLR from CBD ESAs (geotype 1–2).

A.3 Access network

Objective	Workbook	Worksheet	Cell reference	Description	Impact
Updating access network parameters	CAN.xls	In.Access	Rows 7–273	The inputs that are contained on the ‘In.Access’ worksheet are an output of the analysis within the offline geoanalysis and access network module. Changes to these parameters should only be made on the basis of informed adjustments in the files within this offline module. Parameters are found in the *Access – CODE.xls* workbook ‘Summary’ worksheet. Values can be copied in one block and paste-values (skip blanks) onto the ‘In.Access’ worksheet.	Changes to these parameters will affect the dimensioning of the access network and the corresponding number of assets required.
Defining final drop distances	CAN.xls	In.Access	E58:V76	Current values can be reviewed and updated to define the: • lengths of the NTP>>PB links, PB>>S.P links and road crossings for the copper lead-in and associated trench	Defines the distances for the final drop of the CAN.
To change the distance uplift factor in the access model for slope effects	Cost.xls	Scenario	C21	Access network distances may be affected by slope – a parameter in the model is used to accommodate this. The user may change this percentage uplift	Increasing the uplift factor directly increases the trench, cable and fibre distances deployed in the access network in the *CAN.xls* workbook

A.4 Core network: traffic loading

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the volume of busy hour traffic loading on the core network	Core.xls	In.Network	H12:H13; H18:H23	The model uses several parameters in order to convert the annual traffic load into a busy hour traffic load which dimensions the core network. The user may change these parameters (voice/data daily %, and % of traffic occurring during weekdays for different traffic types)	Changing these percentages affects the busy hour load calculation that takes place on the 'Dem.Calc' worksheet (cells M25:N54, M59:N88), which subsequently controls the dimensioning of the core network assets
To change the routeing of traffic across the core network	Core.xls	Dem.Calc	C134:C136; C150; C162; C174:C175; C188:C189;	The percentage of traffic that takes a particular route through the core network may be altered by the user. The routes are described in column B, with the associated percentage of traffic that takes that route through the network is entered in column C (in the identified cells)	Different routes result in different network loadings on particular network elements.
To change the routeing of traffic between core (TNS) nodes	Core.xls	In.TNS.Gravity	C6	This parameter controls the degree to which distance between nodes affects the routeing of traffic across the core network. This parameter may be set to any integer, however as a base case it is set to 0.	When set to 0, distances not taken into account; when set to 2, basic relationship to distance taken into account

A.5 Core network: route configuration and distances

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change node (trench and fibre) distance data	Core.xls	In.Nodes	G41:H5294; B5300:J6799	Core node routes are calculated in *LE_LAS_ring.xls* (described in Annex B here). This workbook can be re-run with new parameters or locations and the values updated in the Core module.	Different parameters and nodes will result in different core network route configuration for LE-POC and POC rings. It should be noted that the access and core overlap analysis, which provides real route distances is only applicable to the specific TSP solution. However results from the overlap analysis, including trench sharing and crow-fly versus actual distance, are likely to be broadly applicable.
To change the distance uplift factor in the model for slope effects	Cost.xls	Scenario	C20	Core network distances may be affected by slope – a parameter in the model is used to accommodate this. The user may change this percentage uplift	Increasing the uplift factor directly increases the trench and fibre distances deployed on core network routes in the *Core.xls* workbook
To change the structure of LAS rings	Core.xls	NwDes.3.Reg.Nodes	C1176:T1185; C1300:T1309; C1424:T1433; C1548:T1557; C1672:T1681; C1796:T1805	LAS rings are identified separately for each of the main city regions in Australia. A particular ring is described by entering a series of LAS nodes on a particular row. Different ring set-ups may be envisaged (by selecting different combinations of LAS nodes). Care need to be taken when changing the current set-up. Ideally, the user should refer to the street and rail network to make sure that the entered ring combinations are sensible and efficient	Changing LAS ring structures impacts upon the LAS trench and fibre distances deployed in the network – the distances of which are calculates from the 'In.LAS.distances' worksheet. It also affects the capacities of the individual rings, resulting in different network equipment requirements
To specify special	Core.xls	NwDes.5.Islands	A16:A33; F16:F33	Certain exchanges (primarily those that	The asset distance to be removed

Objective	Workbook	Worksheet	Cell reference	Description	Impact
backhaul for certain exchange sites				are located on islands) require special backhaul methodologies (i.e. a satellite or microwave solution). In order to ascribe a certain exchange as requiring special backhaul, the user should enter the exchange code in column A, and enter the backhaul methodology in column F. Checks should be made that the resulting calculations are reasonable and flow through to the 'Out.Assets' worksheet	from the modelled calculations is automatically calculated in columns G–I using data calculated on the 'NwDes.1.Access' worksheet. .
To change the structure of TNS rings	Core.xls	NwDes.4.Core.Node s	E262:R275; E285:R298; E307:R320; E329:R342; E351:R364; E373:R386; E395:R408; E416:R429	The TNS rings have been set up with a physical link dimensioning for the routeing of traffic, using a binary matrix for each ring structure. This binary structure (representing whether traffic from a particular TNS location is carried on the TNS ring) may be altered by the user in order to reflect other ring traffic-routeing set-ups. It is however recommended that the current structure is not readily changed without due consideration.	Changing TNS ring structures impacts upon the TNS capacities of the individual rings, resulting in different network equipment requirements

A.6 Core network: technology deployed and equipment parameters

Objective	Workbook	Worksheet	Cell reference	Description	Impact
To implement only DWDM equipment on TNS links	Core.xls	In.Control	C11	This switch set to TRUE forces TNS traffic to be carried using DWDM transmission equipment. With FALSE set, the alternative is a mix of DWDM and SDH dependent on demand.	This affects the calculation on the 'NwDes.4.Core.Nodes' worksheet Rather than carrying traffic on multiple fibres, traffic is carried on individual wavelengths within a single strand of fibre (or several fibres if demand

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
					requires). This effectively reduces the number of fibre metres and SDH systems deployed in the core network
To implement DWDM equipment on LAS links	Core.xls	In.Control	C12	This switch set to TRUE allows LAS traffic to be carried using DWDM transmission equipment (and SDH where demand is lower). Alternative is just SDH.	This affects the calculation on the 'NwDes.3.Reg.Nodes' worksheet
To force the deployment of an IP core structure	Core.xls	In.Control	C8	This parameter is use to force the deployment of IP equipment in the core network. In the base case, it should not be implemented.	Forcing IP core equipment results in the NGN IP core equipment being deployed (as opposed to the TDM-based equipment)
To change the core network equipment capacities	Core.xls	In.Network	H31:H33; H36; H41; H46:H48; H51; H66:H71; H184:H185; H189:H190; H195; H199:H201; H205:H206; H212:H214; H217:H219; H226:H233; H248	Each network equipment asset in the core network has an associated capacity. These capacities are based, where possible, on Australian specific data sourced from operators. The user may wish to changes these capacities	Changing the network equipment capacities will result in a different number of assets required in order to carry the busy hour demand modelled. These asset requirements are calculated on the five 'NwDes…' worksheets.

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the utilisation on equipment (affecting the actual capacity of this equipment)	Core.xls	In.Network	H58:H60; H73:H75; H128:H141; H155; H164:H169; H186:H187; H191:H192; H196; H204; H211; H227	The network equipment may not be fully utilised (for example, to allow for spare capacity when there are spikes in demand). The user may change these equipment utilisation levels in order to change the actual capacity of equipment deployed in the core network	Changing the network equipment capacities will result in a different number of assets required in order to carry the busy hour demand modelled. These asset requirements are calculated on the 'NwDes…' worksheets.
To change the xDSL backhaul provisioned – modern network	Core.xls	In.Network	G45	xDSL backhaul is provisioned on a per rack basis, defining the number of E1 payload equivalents available per rack. Default assumption is an E3 per rack (14 E1's)	Increasing payload per rack increases the size of the LE backhaul, increasing cost, but leading to relative economies of scale across the network.
To change the xDSL backhaul provisioned – next generation network	Core.xls	In.Network	H77	xDSL backhaul for MSANs are provisioned on a per subscriber basis.	Increasing backhaul provisioned per subscriber increases the size of the AT2-AT1 and upstream backhaul, increasing cost, but leading to relative economies of scale across the network.

A.7 Cost modelling changes – allocation

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the allocation of building costs to platforms	Cost.xls	I.Building.Core	D8:O10	This set of inputs defines the building space taken up by platform equipment in the exchanges. Building costs, such as air conditioning and power are assumed to be related to the equipment size.	Adjusting the sizes of the platform building equipment results in a different allocation of costs on the 'CostAlloc.Core' worksheet.
To change the allocation of duct costs between the incumbent and other duct services	Cost.xls	I.Ducts.Core	C7:F10	The inputs in the yellow boxes may be manipulated by the user.	Adjusting the number of sub-ducts and the number of these ducts used by the incumbent results in a different allocation of costs on the 'CostAlloc.Core' worksheet.
To change the level of trench sharing between the access and core network levels	Cost.xls	Scenario	C25	The trench sharing between the various levels in the core network and between the access and core networks has been externally calculated using MapInfo. However, the user is able to select the level of sharing based on different proxy sizes for the access network. To change the size of the proxy access network, select the appropriate size from the pull-down selection box in the identified cell. For more detail on this parameter please refer to the overlap analysis in section 7.11 of the main report.	Adjusting the size of the proxy access network results in a different set of overlap numbers being used in the Core module on the 'In.Nodes' worksheet (cells W20:W33). This results in a different level of core network costs transferred to the access network in the cost module on the 'TA.Core' and 'TA.Access' worksheets.

A.8 Cost modelling changes – unit costs

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To adjust the WACC used in the model	Cost.xls	WACC	C8:C17	The WACC is calculated using a number of parameters. At present, these parameters have been populated using data from the ACCC. A model user may wish to populate the model with different values.	Adjusting the modelled WACC will result in different annualised costs in the tilted annuity calculations on the 'TA.Core' and 'TA.Access' worksheets
To change the unit capital costs for the core network assets	Cost.xls	UnitCost.Core	F27:I226, Q29:T43	The equipment costs used in the model have, where possible, been based on Australia network data. Where this information was unavailable, benchmark data has been used. The total unit asset cost is composed of: • a direct unit cost (column F), • a spares uplift percentage (column G), • an installation uplift percentage (column H), and • an indirect cost percentage uplift (column I). Costs for site acquisition and preparation are specified for LEs, AT1, LAS and TNS in cells Q29:T43	Adjusting any of the unit cost components will result in a different total unit cost flowing through to the 'TA.Core' worksheet (column G).
To change the asset unit cost trend for the core network assets	Cost.xls	UnitCost.Core	E639:J838	The unit cost is defined for 2007. A unit cost price trend is applied in order to calculate the asset unit costs for the years 2008–2012. These trends are, where possible, based on Australian network data . These price trends may be changed by a user	Adjusting any of the unit price trends will result in a different total unit cost flowing through to the 'TA.Core' worksheet for future years (column G). It will also affect the tilted annuity formula (input in column J)

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the lifetime of core network assets	Cost.xls	UnitCost.Core	D9:D21	The lifetime of assets controls their replacement cycle, and more importantly affects the tilted annuity calculation. Where possible, asset lifetimes have been based on Australian benchmark data. The user may change these asset lifetimes if more accurate data becomes available	Adjusting the asset lifetimes will affect the tilted annuity calculation on the 'TA.Core' worksheet (column L)
To change the unit capital costs for the access network assets	Cost.xls	UnitCost.Access	E118:H198	The equipment costs used in the model have, where possible, been based on Australia network data. Where this information was unavailable, benchmark data has been used. The total unit asset cost is composed of • a direct unit cost (column E), • a spares uplift percentage (column F), • an installation uplift percentage (column G), and • an indirect cost percentage uplift (column H)	Adjusting any of the unit cost components will result in a different total unit cost flowing through to the 'TA.Access' worksheet (column H).
To change the asset unit costs for ducted trenched, ploughed trench and open trench	Cost.xls	UnitCost.Access	E11:G22; E37:G48; E24:G35	The unit cost for ducted trench should be first defined in E11:G22. The cost of open trench is then set. The cost of ploughed trench is set separately in E37:G48	The relative cost saving is passed through to the 'TA.Access' worksheet.

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the proportion of cable that is ploughed	Cost.xls	UnitCost.Access	AG130:AV141	The proportion of trench where cable is ploughed, rather than deployed in duct. Where feasible, this is believed to be a cheaper solution. By geotype, the proportion of trench distance which may be ploughed is an input. Note: inputs can also vary by the size of the trench & duct, but assumptions are likely to be consistent for a geotype.	A second set of inputs for lower unit costs is provided for ploughed trench. This relative price and the proportion of trench is used to adjust the unit cost by geotype on the 'TA.Access' worksheet.
To change the proportion of duct and cable that is laid in open trench	Cost.xls	UnitCost.Access	AG144:AV155	This parameter defines the distance of access duct and copper laid without incurring the cost of trench.	Increasing the parameter, reduces the cost of the access network. It can be used to scenario test the impact of proposed trench sharing values. The value can be defined by geotype and assumed to not apply to ploughed cable.
To change the asset unit cost trend for the access network assets	Cost.xls	UnitCost.Access	D373:I451	The unit cost is defined for 2007. A unit cost price trend is applied in order to calculate the asset unit costs for the years 2008–2012. These trends are, where possible, based on Australian network data . These price trends may be changed by a user	Adjusting any of the unit price trends will result in a different total unit cost flowing through to the 'TA.Access' worksheet for future years (column H). It will also affect the tilted annuity formula (input in column E)

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To change the lifetime of access network assets	Cost.xls	UnitCost.Access	I118:I198	The lifetime of assets controls their replacement cycle, and more importantly affects the tilted annuity calculation. Where possible, asset lifetimes have been based on Australian benchmark data. The user may change these asset lifetimes if more accurate data becomes available	Adjusting the asset lifetimes will affect the tilted annuity calculation on the 'TA.Access' worksheet (column G)
To include/exclude business overheads from the calculation of costs	Cost.xls	Scenario	C17	The user may include or exclude business overhead costs from the modelled costs using this parameter	Setting this parameter to "yes", results in a non-zero business overheads figure being fed into the model on the 'UnitCost.Access' worksheet (cell E89), and on the 'UnitCost.Core' worksheet (cell E430)
To change the routeing factors used in the model	Cost.xls	RF.Core	D8:AG207	The majority of the routeing factors should not be changed in this table. Instead, changes should be made to the way in which traffic is routed through the core network – refer to *"To change the routeing of traffic across the core network"* in the *"Core network – traffic loading"* section	Refer to the *"To change the routeing of traffic across the core network"* in the *"Core network – traffic loading"* section

Analysys

A.9 Outputting results

Objective	*Workbook*	*Worksheet*	*Cell reference*	*Description*	*Impact*
To inspect a single year's detailed results	Cost.xls	Results	Rows 75–104	The model produces a number of detailed results. Some of the most interesting are output in the stated cells.	
To generate results over time	Cost.xls	Results.Pasted		The model has a macro to generate results for each of the modelled years. These results are generated by simply clicking the 'Paste results' button at the top of the stated worksheet.	Results for each of the modelled years (2007–2012) are output for each of the modelled services. The check box in cell L1 should read "Results up to date" when this process has been completed. Further adjustments in the model will require that this macro be re-run

Annex B: LE–PoC minimum spanning tree and travelling salesman algorithm

This section outlines the calculations that take place in the *LE_LAS_ring.xls* Excel workbook. This workbook:

- clusters the LEs into PoC clusters, parented by a single PoC location
- identifies the parent LAS to each PoC
- determines the minimum spanning tree for the LE-PoC transmission
- determines the appropriate multi-ring structure for the PoC-LAS transmission.

This workbook contains macros which are controlled by clickable buttons on the appropriate worksheets.

B.1 'Input.Parameters' worksheet

This worksheet contains a number of key parameters which set up the clustering and ring generation algorithms.

Cell reference	*Description and details of spreadsheet calculations*
Cell D6	Maximum local exchanges per PoC
Cell D7	Automatically assign as a PoC if number of SIOs exceeds *x*
Cell D8	Trench cost per metre
Cell D9	Fibre cost per metre
Cell D12	Maximum number of PoCs per ring
Cell D13	Number of bridging nodes required – the number of points at which a child ring is joined to the parent ring (2 bridging nodes are deployed for resilience purposes)
Cell D14	Number of PoCs before using Genetic Algorithm – if set too high, the basic Branch and Bound solution method will take a very long time to calculate the answer
Cell D15	Number of generations to use in Genetic Algorithm – the more generations the more likely the result produced will be optimal

Figure B.1: Key parameters on the 'Input.Parameters' worksheet [Source: Analysys]

B.2 'Input.Table' worksheet

This worksheet contains the local exchange (LE) data – namely LE ID, Parent LAS, distance to parent LAS (straight-line distance), SIOs at LE, latitude and longitude.

The LEs are split into two tables: most sit in the first table starting on row 6 whilst the remainder are in the second table starting on row 5213. These exchanges are on islands and are handled separately in the Core module.

The 'Find PoCs' button runs a macro which clusters the LEs in the first table into clusters served by a PoC location and then calculates the minimum spanning tree links required to route each of these LEs back to their parent PoC. The outputs of this macro are pasted into columns H–N.

This minimum spanning tree distance data is input into the Core module on the 'In.Nodes' worksheet.

The macro also outputs the PoCs and associated characteristics (PoC latitude, PoC longitude, ClusterCentre Latitude, ClusterCentre Longitude, LAS (parent LAS), Number of LEs in the PoC, Number of PoCs in LAS, Is a LAS? (flag identifying whether the PoC is the parent LAS), and SIOs) into the 'Input.PoCs' worksheet.

B.3 'Input.PoCs' worksheet

This worksheet contains the pasted output from the 'Find PoCs' macro. It is used in the calculation of the PoC rings which is determined using the macro contained on the 'Output.PoCs' worksheet.

B.4 'Output.PoCs' worksheet

This worksheet contains the 'Run TSP' button, which runs a macro that calculates the required ring structures for transmission from the PoCs to the parent LAS. This macro takes the data from the 'Input.PoCs' worksheet, and outputs the appropriate ring structure data in rows 6 and below.

It is this output that is input into the Core module on the 'In.Nodes' worksheet.

The individual ring structures are generated in separate worksheets (titled according to the parent LAS code) and graphed appropriately.