



**Australian  
Competition &  
Consumer  
Commission**

# **Analysys cost model for Australian fixed network services**

**Discussion Paper**

**December 2008**



© Commonwealth of Australia 2008

This work is copyright. Apart from any use permitted by the *Copyright Act 1968*, no part may be reproduced without permission of the Australian Competition and Consumer Commission. Requests and inquiries concerning reproduction and rights should be addressed to the Director Publishing, Australian Competition and Consumer Commission, GPO Box 3131, Canberra ACT 2601.

# CONTENTS

Abbreviations .....	4
Glossary .....	6
1. Introduction.....	8
2. The model .....	14
3. Key issues for response.....	19
4. Demand estimates .....	20
5. Architecture and dimensioning issues.....	22
6. Network costing issues.....	42
7. Pricing results.....	48
Appendix A    Template for list of potential errors .....	51
Appendix B    Response pro forma .....	52
Appendix C    Network cost default inputs .....	53

## Abbreviations

ADSL	Asynchronous Digital Subscriber Line
BHCA	Busy Hour Call Attempts
BHE	Busy Hour Erlang
BRAS	Broadband Remote Access Server
BTS	Base Transceiver Station
CAN	Customer Access Network
CMUX	Customer Multiplexer
DNS	Domain Name Server
DP	Distribution Point
DSL	Digital Subscriber Line
DWDM	Dense Wave Division Multiplexer
ESA	Exchange Service Area
FDP	Final Distribution Point
FTTN	Fibre To The Node
GIS	Geographical Information System
G-NAF	Geocoded National Address File
IEN	Inter-exchange network
ISDN	Integrated Services Digital Network
LAS	Local Access Switch
LE	Local Exchange
LPGS	Large Pair Gain System
MDF	Main Distribution Frame
MSAN	Multi Service Access Node
NTP	Network Termination Point

PDH	Plesiochronous Digital Hierarchy
PoC	Point of Confluence
PSTN	Public Switched Telephony Network
RADIUS	Remote Authentication Dial-in User Service
RAU	Remote Access Unit
RIM	Remote Integrated Multiplexer
SDH	Synchronous Digital Hierarchy
SIO	Services in Operation
TDM	Time Division Multiplexer
TNS	Transit Network Switch
ULLS	Unconditioned Local Loop Service
UPS	Uninterruptible Power Supply
VC	Virtual Container
VDSL2+	Very High Speed DSL 2+
xDSL	Any DSL service

## Glossary

Clustered/Spread	In bands 3 and 4, ESAs are categorized on the basis of the degree of clustering as well as the ratio of road length to locations. An ESA is categorized as <i>clustered</i> if more than a certain proportion of addresses lie within a particular distance of their nearest copper centre. Otherwise the ESA is categorised as <i>spread</i> .
Dijkstra Algorithm	Dijkstra is a standard algorithm which finds a shortest path tree from a given node in a graph. Analysys use a modified version of the algorithm which finds a tree with minimum proxy cost for pillar clusters in the urban deployment, pillar-RAU links in both deployments and pillar-pillar links in fibre rings.
DP cluster	In the urban deployment scenario, services are initially aggregated at a distribution point (DP). All locations are grouped into DP clusters, each containing four locations, served by a single DP.
DWDM	Dense Wave Division Multiplexing (DWDM) allows multiple signals to be sent simultaneously over a single optical fibre by sending different signals at different wavelengths.
G-NAF	The Geocoded National Address File is a database containing all physical addresses in Australia, each linked to its latitude and longitude.
Geotype	A geotype is a group of ESAs with similar characteristics. ESAs are allocated to a geotype based on their band and ratio of road length to number of locations. In bands 3 and 4, the degree of clustering in the ESA is also a factor.
p-function	A p-function is a generalisation of a metric to measure distances between two points. The function is of the form $\ x - y\ _{k,p} = k \left(  x_1 - y_1 ^p +  x_2 - y_2 ^p \right)^{\frac{1}{p}}$ , where $k$ and $p$ are parameters. When $k=1$ , $p=2$ are used, the p-function reduces to finding a straight line distance. Analysys determine values for these parameters from geographical analysis in each geotype. An additional trench sharing coefficient, $j$ , is also determined for each geotype. Due to trench sharing, the actual trench lengths required would be less than those determined by the p-function, so when calculating trench lengths, the p-function is scaled by $j$ .
Pillar cluster	All DPs are grouped into pillar clusters, each served by one pillar. The pillar aggregates traffic from all DPs within its cluster.

PoC	A point of confluence (PoC) is a local exchange on a transmission ring. Traffic from other LEs is aggregated at a PoC and transmitted to the LAS.
Prim Algorithm	The Prim algorithm is a standard algorithm which derives a minimum spanning tree for a graph. Analysys use a modified version of the algorithm which finds a tree with minimum proxy cost for DP clusters, rural pillar clusters and wireless clusters.
Travelling salesman algorithm	A travelling salesman algorithm is designed to find the shortest route one can take to visit a given set of cities exactly once each. Analysys use a travelling salesman algorithm to determine the links in the PoC-LAS rings.

# **1. Introduction**

This discussion paper seeks comment from interested parties on the Analysys Mason Limited cost model ('Analysys cost model'). The Analysys cost model is a bottom-up engineering-economic approach of estimating the long run efficient cost of providing services on the Australian fixed network over 2007-2012.

This discussion paper identifies key assumptions and parameter values which the ACCC seeks feedback on. These assumptions and parameter values should be considered as initial starting points for industry comment and, at this stage, do not necessarily reflect the ACCC's views as to the appropriate modelling assumptions. When responding to this discussion paper, interested parties should focus their attention on what they consider to be appropriate modelling assumptions and parameter values that reflect an efficient manner of providing the modelled fixed line services.

Once the model has been finalised, the ACCC intends to undertake a consultation process on pricing principles and indicative prices for declared fixed line services. The Analysys cost model is expected to be an input into that process, but not necessarily the only input.

## **1.1 Purpose of the model**

Under Part XIC of the *Trade Practices Act 1974* (the Act), the ACCC is responsible for arbitrating disputes about access to particular declared services and for assessing access undertakings relating to such declared services. The determination of an appropriate access price is a key issue in these processes. In its performance of these functions, the ACCC is generally inclined to assess access prices, at least in part, with reference to costs.

The eventual purpose of the Analysys cost model will be to help inform the ACCC's estimation of the cost of providing the declared fixed line services. In this regard, the Analysys cost model allows for the testing of various assumptions to understand the impact on costs for declared fixed line services.

In addition to costing of current declared fixed line services delivered on the modern network architecture, the Analysys cost model provides an upgrade path to a next generation network (NGN). This functionality will provide an insight into the costs of current and potential future declared fixed line services under an NGN scenario. The ACCC however, emphasises that neither the Analysys cost model nor the ACCC is seeking to prejudge the outcome of any future declaration inquires which may or may not be held in relation to the modelled (or any comparable) services.

As the model costs fixed line services in future periods, the ACCC notes that certain assumptions were made about potential deployment scenarios. In particular, the Analysys cost model assumes a fibre-to-the-node network with MSAN deployment and VDSL2+ provisioning. The ACCC notes that there are several possible next generation upgrade paths, and that the assumptions in the Analysys cost model do not necessarily reflect the ACCC's views as to the likely next generation upgrade path.

## **1.2 Key features of model**



Key features of the Analysys cost model include:

- *designed with reference to Australian conditions;*

The Analysys cost model has been designed with reference to Australian conditions, in particular:

- the modern core network architecture is similar to the network that has been deployed in Australia;
- the scorched-node approach retains the existing locations of local exchanges, local access switches and transit network switches;
- the model takes into account special network solutions for Australian islands.

- *models a set of declared fixed line services;*

The Analysys cost model costs the following declared fixed line services including:

- PSTN originating and terminating access service (PSTN OTA);
- unconditional local loop service (ULLS);
- local carriage service (LCS),
- wholesale line rental (WLR); and
- line sharing service (LSS).
- In addition to modelling the existing declared fixed line services, Analysys have allowed for an upgrade path to a NGN, which assumes a fibre-to-the-node network, with MSAN deployment and VDSL2+ provisioning.
- *models services across all of Australia;*

The Analysys cost model allows cost estimates for services to be determined for different geographic areas (16 geotypes). In turn, these 16 geotypes have been aggregated into four Bands consistent with the terminology used in current regulatory processes. Band 1 covers the central business districts of: New South Wales; Queensland; Victoria; Western Australia; and South Australia. Band 2 covers densely populated metropolitan areas, which serve about 70 per cent of the population, but covers only 0.2 per cent of the land. Bands 3 & 4 cover less densely populated urban and rural areas.<sup>1</sup>

- *alternative pricing principles can be applied, as the costing module is separate from the engineering and demand modules; and*

---

<sup>1</sup> Telstra, *Service Quality Strategy*, 23 June 2006, p. 9.

The Analysys cost model estimates the value of the fixed network asset. Access prices for the declared fixed line services are the final resulting outcome from the modelling exercise.

In particular, the Analysys cost model estimates the total service long run incremental cost, plus an allocation of common costs denoted by '+' (TSLRIC+), as the default pricing principle.

However, the Analysys cost model gives users the flexibility to apply alternative pricing principles to cost declared fixed line services.

- *key assumptions and default values can be altered by the user.*

The Analysys cost model includes default values for key network cost parameters. The default values are based on benchmark data and represent initial starting values for industry comment. The default values are Analysys's preferred values and do not necessarily reflect the ACCC's current view. The ACCC also notes that some parameters, such as the weighted average cost of capital will change over time. Interested parties are encouraged to alter the assumptions to test the model and submit to the ACCC recommended parameters with supporting evidence.

Upon finalisation of this model, the ACCC will have a full range of cost models covering all declared services including mobile termination access service (MTAS) and domestic transmission capacity service (DTCS). These cost models will assist in informing the ACCC as to the appropriate access price for declared services, and will be one factor amongst others, the ACCC may have regard to when fulfilling its regulatory functions.

### **1.3 Consultation process & engagement of Analysys**

Analysys were engaged following a request for tender issued in February 2007, to develop a bottom up cost model to further inform the ACCC about the long run efficient cost of supplying existing and future fixed network services in Australia. Table 1.1 below sets out the timeframes to date and expected timing of events going forward.

**Table 1.1**            **Timeline of events**

<b>Timing</b>	<b>Milestone</b>
February 2007	Request for tender issued
August 2007	Analysys commissioned
September 2007	Major carriers invited to meet with Analysys and the ACCC to discuss the development and population of the model. A data request was also issued to major carriers
December 2008	Release of the Analysys cost model and related documentation.
February 2009	Close of consultation

First quarter 2009	Proposed Analysys model workshop
First half 2009	Final version of the model to be released following which the process for consulting on indicative prices will commence.

Further details on the proposed Analysys workshop will be provided once the consultation period has closed.

Difficulties in obtaining necessary data, and the complexities in developing a model for a range of difference services across the entire Australian network has resulted in the model taking longer than initially anticipated by the ACCC to develop.

#### **1.4 Accessing the model and making submissions**

The Analysys cost model is available by registering with the relevant ACCC contact for this project. By registering, the interest party acknowledges that the model will be used only for personal non-commercial purposes and that material will not be reproduced, re-transmitted, distributed, displayed or commercialised without written permission from the Director ACCC Publishing.

Where interested parties have an ExchangeInfo licence, full versions of the Access code will be provided. Alternatively, redacted versions of these files will be provided.

The ACCC contact is: Heather Ridley (heather.ridley@acc.gov.au). The related documentation to support the Analysys cost model is available on the ACCC website.

The Analysys cost model is accompanied by four Analysys reports. The ACCC is seeking submissions from interested parties on:

- the *Analysys Fixed LRIC Cost Model Documentation*;
- the *Analysys cost model*; and
- issues raised in this discussion paper.

The three other Analysys reports are reference documents only:

- the *Analysys Fixed LRIC Model User Guide*;
- the *Analysys instructions for key processes in geoanalysis for the fixed LRIC Cost Model*; and
- the *Analysys Description of the Visual Basic in the Fixed LRIC Cost Model*.

As with any model still under development, the ACCC anticipates that industry participants may identify potential errors in the model. Where potential errors are identified, industry participants are encouraged to advise the ACCC. Industry should submit any identified potential errors in the Analysys cost model using the template in Appendix A. The ACCC will publish on its website the list of new and existing identified potential errors and how these have been treated for the benefit of all users of the Analysys cost model.

After receiving and considering submissions from interested parties in response to this discussion paper, the ACCC expects to publish a final version of the Analysys cost model and accompanying reports.

The ACCC encourages industry participants to consider the issues raised in this discussion paper and to make submissions to the ACCC to assist it and Analysys in finalising the cost model and report. The ACCC is seeking submissions in response to this discussion paper by **no later than 5.00pm, Friday 13 February 2009**.

The ACCC prefers to receive electronic copies of submissions and in the form set out in Appendix B. Electronic submissions should be in a PDF, Microsoft Word or (if appropriate) a Microsoft Excel format that contains searchable text and allows 'copy-and-paste'. Electronic submissions should be provided by email to:

**Robert Wright**

General Manager

Compliance and Regulatory Operations

Communications Group

Australian Competition and Consumer Commission

robert.wright@acc.gov.au

The ACCC asks that any electronic submission is also copied to:

**Heather Ridley**

Assistant Director

Compliance and Regulatory Operations

Communications Group

Australian Competition and Consumer Commission

heather.ridley@acc.gov.au

The ACCC also accepts hard copies of submissions. Any hard copy should be sent to the following address:

**Robert Wright**

General Manager

Compliance and Regulatory Operations

Communications Group

Australian Competition and Consumer Commission

GPO Box 520

Melbourne VIC 3001

To allow for an informed and open consultation, the ACCC will treat all submissions as non-confidential, unless the author of a submission requests that the submission be kept confidential. In such a case, the author of the submission must provide a non-

confidential version of the submission. Non-confidential submissions will be published by the ACCC on its website. The existence of confidential submissions will also be noted on the web site.

Any questions about this discussion paper should firstly be directed to Heather Ridley at [heather.ridley@acc.gov.au](mailto:heather.ridley@acc.gov.au) or on 03 9290 1983.

## 2. The model

The Analysys cost model uses a Total Element LRIC (TELRIC) approach as a proxy for TSLRIC+. As such, throughout the discussion paper, the ACCC refers to the Analysys cost model as being based on a TSLRIC+ framework.<sup>2</sup>

These two cost measures are based on similar principles. TSLRIC+ is the total incremental or additional cost a firm incurs in the long term in providing a *service*, assuming all of its other production activities remain unchanged. The '+' refers to an allocation for common costs. TELRIC is the incremental or additional cost a firm incurs in the long run to provide a network *element*, assuming all of its other production activities remain unchanged.

A TELRIC approach has been used as a proxy for TSLRIC+ in the Analysys cost model largely due to the complexities in measuring common costs in a TSLRIC+ framework. A TSLRIC+ model is also comparatively more computationally expensive to run.

The ACCC considers that the gap between results from a TELRIC and TSLRIC+ framework can be small. In particular, a well structured TELRIC model can produce results similar to those produced in a TSLRIC+ framework, so long as the treatment used to allocate common costs are similar. The ACCC has generally adopted an equi-proportionate mark-up (EPMU) to allocate common costs in the TSLRIC+ framework. The ACCC notes that the Analysys cost model applies EPMU which adjusts the routing factors of each network element used by each service, in a manner which endeavours to reduce the gap between the two cost principles.

The ACCC also notes that TELRIC model is computationally easier to run. A TSLRIC+ model would need to be run with various combinations of services to determine the appropriate common costs shared between any sub-set of services. This combinatorial approach generates the incremental cost of each service and combination of services, and is computationally expensive.

In terms of the module structure of the Analysys cost model, the ACCC notes that the Analysys cost model is a flexible model with discrete modules for demand, engineering and cost. This flexibility allows the user to apply different pricing methodologies to different services. In this regard, the costing module may be altered by, for instance, applying different pricing principles, without changing the engineering rules in the model.

### 2.1 Application of TSLRIC+ in the model

The ACCC considers that TSLRIC+ as a broad theoretical economic concept may be an appropriate pricing methodology for some telecommunication services. The ACCC also requires the implementation of a pricing principle to satisfy the legislative criteria which the ACCC must consider in regulatory processes. As such, the ACCC recognises that not all applications of TSLRIC+ will meet the legislative criteria.

---

<sup>2</sup>

The underlying concept of TSLRIC is explained in the ACCC's 1997 paper, *Access Pricing Principles Telecommunications – A Guide*.

The ACCC notes that there are a number of methods that can be used to derive TSLRIC+ estimates of a service. For example, TSLRIC+ may be estimated by reviewing historic and current costs of operators, or through the application of an optimised cost model using forward looking costs. The use of forward looking costs is the most common approach used in the TSLRIC framework.

In principle, the application of fully forward-looking costs would value all existing assets at the cost of a modern equivalent asset (MEA). A MEA is the lowest cost asset with the latest available and proven technology to provide the same service potential. In general, the forward-looking approach is more compatible with the competitive standard of efficiency, since in a competitive market, prices would be set on the basis of the prevailing technology. In a competitive environment, operators would compete on the basis of costs likely to be incurred and would not be compensated for cost incurred through inefficiency. However, the general principles of TSLRIC+ can be implemented in quite different ways in practice, each of which requires trade-offs and matters of judgement to be exercised.

In recognition of actual circumstances, the ACCC generally accepts a number of simplifications to the fully forward-looking TSLRIC+ approach, where it is within the legislative criteria. Some of these simplifications have been adopted in the Analysys cost model, such as the use of scorched nodes and best in use technology.

### **2.1.1 Scorched nodes**

Analysys assumes scorching at the location of the remote access unit (RAU), local access switch (LAS) and transit network switch (TNS) in the network. These locations and the number of nodes are assumed to be reasonably efficient, and reflect the point of interconnection of access seekers. Scorched nodes may be substituted by more efficient commercially available equipment (based on the optimisation assumption). At the distribution area (DA) level, the nodes (pillar locations) from Telstra's network are not retained. The clustering algorithm derives locations for any intermediary points at this level in the access network through the optimisation process.

### **2.1.2 Best in use technology**

The Analysys cost model captures the assumption of deployment of best-in-use technology in two ways:

- the level of equipment capacity of certain best-in-use commercially available network elements. Some network elements are functionally required to have a constant capacity (eg. a pillar will distribute a fixed number of access lines), whereas other network elements have time-varying capacity. For example, the processing capacity of a switch increases with new processor hardware but decreases with the loading of new features; and
- the use of reasonable benchmarks for best-in-use commercially available equipment and operational expenditure.

Combined, these mean that a more pragmatic interpretation of the fully forward-looking assumption has generally been taken when modelling the fixed network.

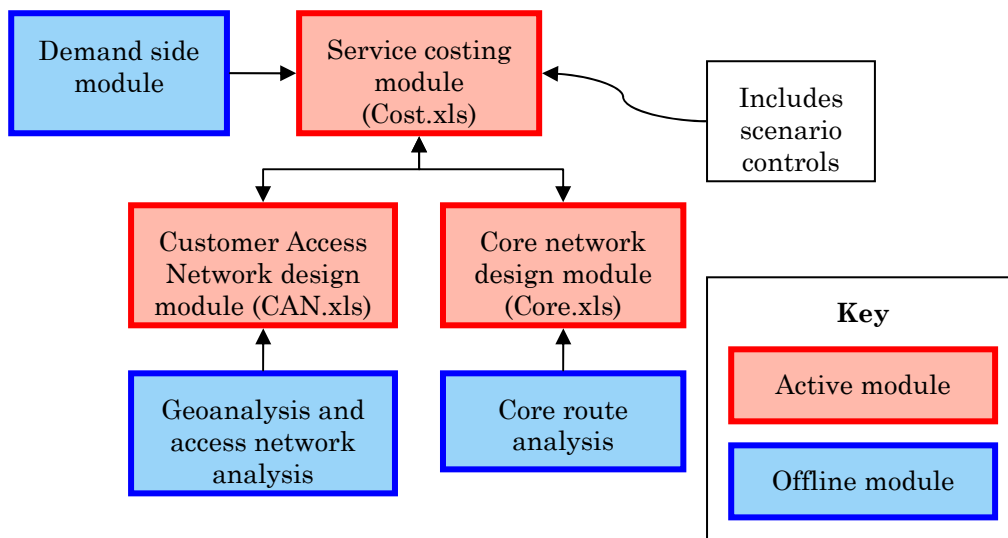
## 2.2 Introduction to the model

The Analysys cost model has been developed in Microsoft Excel through a series of interlinked workbooks and databases. By developing the model using MS Excel, the model can be used without specific programme software. In addition users should be easily able to make modifications if desired. The active modules, whilst being large files, are logically structured and an experienced MS Excel modeller, following the relevant documentation, should be able to navigate and operate the models. Figure 2.1 below summarises the structure of the workbooks and databases.

The Analysys cost model is accompanied by four Analysys reports:

- the Analysys *Fixed LRIC Cost Model Documentation*;
- the Analysys *Fixed LRIC Model User Guide*;
- the Analysys *Description of the Visual Basic in the Fixed LRIC Cost Model*; and
- the Analysys *Description of the Visual Basic in the Fixed LRIC Cost Model*.

**Figure 2.1: Structure of the model**



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

The three active modules are a customer access network (CAN) design module, a core network design module and a service costing (Cost) module. The CAN and core modules calculate the number of assets for these parts of the network. The Cost module ties the active model together, performing a number of key functions:

- defining the calculation scenarios;
- presenting demand drivers, over time, in the network design modules (based on the demand side module);



- costing the dimensioned network;
- calculating unit costs of services;
- allocating the total costs of network elements between the access and core networks; and
- allocating business overhead costs to the access and core networks.

The offline modules, which perform analysis of data that Analysys considers to be constant across the various scenarios used in the model, comprise the following:

- Demand module – presenting access lines and core traffic projections over time;
- Core route analysis – defining the routes between core nodes (local exchange (LE), points of confluence (PoC), LAS, TNS) and calculating the incremental distances; and
- Geoanalysis and access network analysis – estimating certain network dimensions of the access network.

To produce a result from the model, all three active modules need to be open. Pressing **F9** will calculate revised outputs for the given inputs.

### 2.3 Overview of the model process

The modelling process is as follows:

- *estimate demand* across the network;
  - historic, current and projected volume data is used;
- *dimension the network*:
  - the infrastructure required to build an efficient customer access network from the bottom up is calculated; and
  - the infrastructure required to build an efficient core network based around Analysys’s understanding of the current Australian network is calculated. The Analysys cost model assumes 5000<sup>3</sup> LE locations, 133 LAS locations and 14 TNS locations. The core network is modelled for both a modern network and a fully IP-based next generation network.
- *in determining network costs*:
  - capital unit costs are based on benchmark data, with long-term trends assumed;

3

---

Analysys have identified 5070 ESAs, 5117 copper centres; individual ESA-copper centres combine to a total of 5254.

- operational expenditure has been based on analysis of Telstra's 2007 RAF CCA accounts;
- asset life estimates and tilted annuity are calculated to estimate the yearly cost of assets in the network;
- percentage use of each component in the network by each relevant service (xDSL, voice etc) is calculated using routing factors. Asset costs are allocated to each service by each service's respective percentage use.

This modelling process results in a final cost for each relevant service (in \$/line/month, \$/minute, \$/mbits etc).

### **3. Key issues for response**

The purpose of this chapter is to outline key issues which the ACCC is seeking responses from interested parties on. These issues, outlined below, have been broadly categorised into three groups, and are discussed in further detail later in this chapter.

#### **1. Demand estimates**

Demand estimates relate to the methodology and information used in the Analysys cost model to forecast levels of demand. The Analysys cost model uses historical information to create demand estimates from 2007 to 2012, which inform the deployment of the access and the core network.

#### **2. Architecture and dimensioning issues**

The Analysys cost model classifies network elements as either part of the access network, or the core network.

##### **a. the access network**

The access network refers to the section of the network which connects the NTP through to the equipment side of the MDF. Therefore, the local exchange supports both the access network and half of the core network.

The Analysys cost model assumes that the RAU and local exchange is scorched, while pillars are not.

##### **b. the core network**

The core network covers from the equipment side of the MDF to the TNS. All nodes in this section of the network are scorched.

#### **3. Network costing issues**

The network costing issues section relates to the costs associated with building the access and core network parts of the model. Accordingly, issues raised include the appropriate WACC value, asset lives and the appropriate tilt (if any) that should be applied.

Parties may also wish to provide submissions on other issues not directly raised in this section.

As noted above, the default values in the Analysys cost model are Analysys's choices, reflecting benchmark values and, may not necessarily reflect the ACCC's current thinking for some values. Accordingly, some of the issues set out in this chapter request parties views on the appropriateness of particular default values. In responding to those issues, parties should provide evidence supporting the alternative parameter values advanced in their submissions.

## 4. Demand estimates

The Analysys cost model has a shared demand module for both the core and access networks and the modern and next generation architecture.

The common demand module allows the user to determine the network value and the unit prices for services, relative to the parameters included in the model. Additionally, the shared demand estimates allow for analysis of how the *steady-state* cost of a service may change under a significant change in network architecture. The steady-state analysis does not currently accommodate transitional costs of network migration.

### *Volume of demand*

Demand inputs are used to forecast market subscribers and traffic to generate demand projections (and cost estimates) over the model period (2007-2012).

The access and core networks are dimensioned to meet the demand profile for the declared fixed services.<sup>4</sup> Access lines and traffic are attributed to each network element in the access and core network through the use of routing factors. The routing factors are calculated according to the intensity to which the network elements are utilised by the various traffic types.

Analysys's demand projections are based on historical data trends. Up until the end of the proposed modelling period (2012), traffic volumes, access lines and services in operation (SIOs) are projected according to defined growth scenarios.

The ACCC notes that adjusting the demand levels affects the loading on the core network and the number of access services in operation.

The demand estimates can be found in the Demand module.xls file – forecast sheet.

### *Access lines*

The Analysys cost model is calibrated to number of the current access lines in operation.

### *Traffic volumes*

When considering circuit-switched traffic volumes, Analysys split each telephony service according to call attempts<sup>5</sup> and conveyed call minutes<sup>6</sup> so that per-call attempt and per-conveyed minute costs can be calculated.

---

<sup>4</sup> Demand levels are the sum of billed and unbilled traffic (such as call set-up time and unsuccessful call attempts). The network is dimensioned on the basis of busy-hour (Bh) load of the network - this load represents the peak traffic carried on the network.

<sup>5</sup> Certain network elements (e.g. signalling control / call processing elements) support the set-up of calls and are dimensioned on the number of call attempts in a busy period.

<sup>6</sup> Certain network elements (e.g. ports) support the transport of calls and are dimensioned on the number of carried minutes during a busy period.

The traffic volumes are considered across the core network and also include ISDN, DSL, backhaul, and other transmission services.

### **Issues**

- Do you consider that the demand estimates are appropriate? Provide evidence to support your reasoning.
- Are there other factors that Analysys should take into account in estimating demand?

## 5. Architecture and dimensioning issues

The Analysys cost model distinguishes network elements as being attributed to core or access parts of the network. The network physical boundary between the customer access and core network is the equipment side of the main distribution frame (MDF) at the RAU.<sup>7</sup>

This section sets out the access and core network design process. Step-by-step flowcharts and descriptions of the process are provided. The underlying assumptions are then described and numbered to correspond with boxes in the flowchart.

### 5.1 Overview of the access network model design

The access module of the Analysys cost model can be set up to assume either a current (modern) architecture or a next-generation architecture.

In designing the access network, the following process was undertaken:

- geo-analysis;
- application of algorithms to calculate CAN trench and cable lengths;
- application of algorithms for CAN deployment in urban ESAs;
- application of algorithms for CAN deployment in rural ESAs; and
- for urban areas, optional substitution of pillars by multi service access nodes (MSANs) as part of an NGN solution.

Analysys have modelled the modern access architecture, considering: copper (direct to the exchange or via a fibre-fed customer multiplexer (CMUX)), fibre direct to the building, wireless, and satellite. A next-generation access network is considered through the deployment of VDSL-capable MSANs at pillar locations.

The access network topology, illustrated in Figure 5.1, varies depending on the geography.

In urban areas, households are connected via intermediate distribution points (DPs), to the RAU:

- by a pillar, remote from the exchange;
- by a large pair gain system, such as a CMUX or RIM; or
- directly from the exchange, via a pillar next to the exchange.

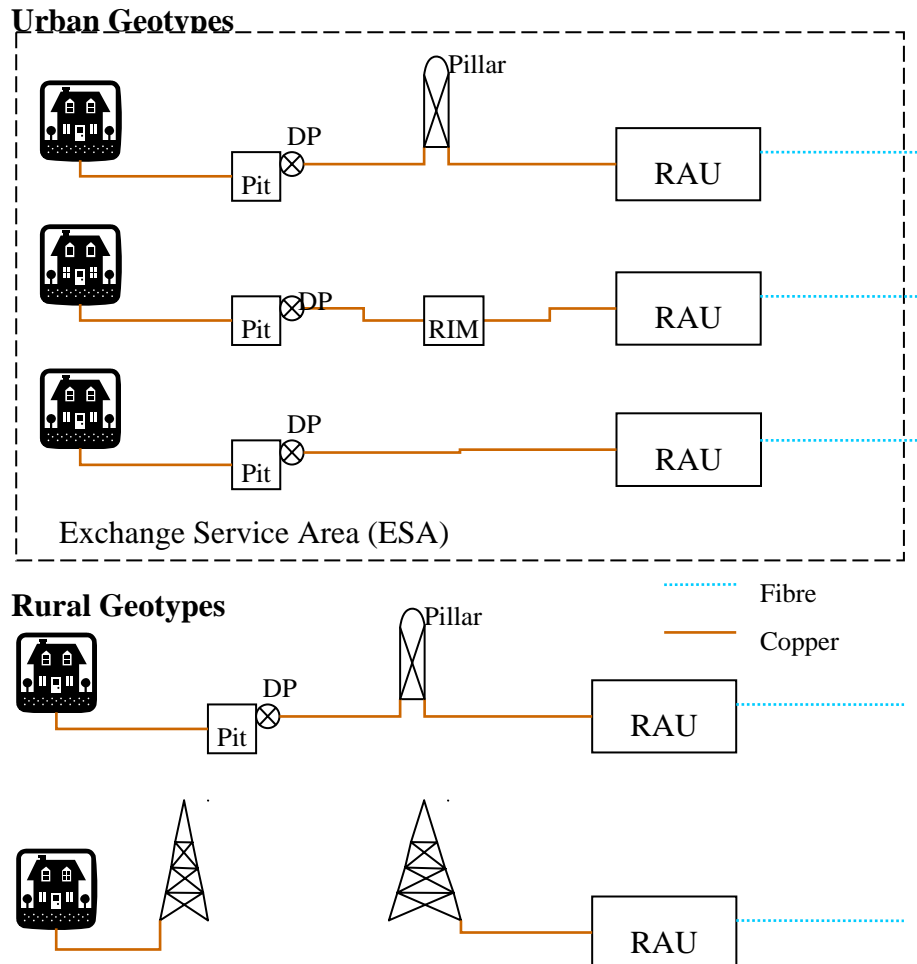
---

<sup>7</sup>

The customer or network side of the MDF is included in the Access part of the network

In remote areas, a mix of copper, radio links and satellite links and radio links are employed. Remote locations served by copper are each served by a DP, which is in turn served by either a remote pillar or a pillar at the RAU.

Figure 5.1 – Access network topology



### 5.1.1 Geo-analysis – categorizing ESAs

Analysys employs geotypes to reduce the data computation time of the model.<sup>8</sup> As a representative sample for all exchange service areas (ESAs), the Analysys cost model has approximately 200 ESAs classified into 16 geotypes. Analysys does not have access to demand data by location so a location and demand database was developed to inform access network algorithms applied to the selected ESAs

These geotypes use the Telstra ULLS band classification of ESAs as a starting point. Each ESA is then classified into a geotype based on the ratio of road length to number of locations. This is taken as a proxy for the length of trench/cable required to connect each location. Further detail on the geo-typing can be found in section 4 of the *Analysys Fixed LRIC cost model documentation*.

<sup>8</sup> A geotype consists of a collection of areas which share the same common characteristics.

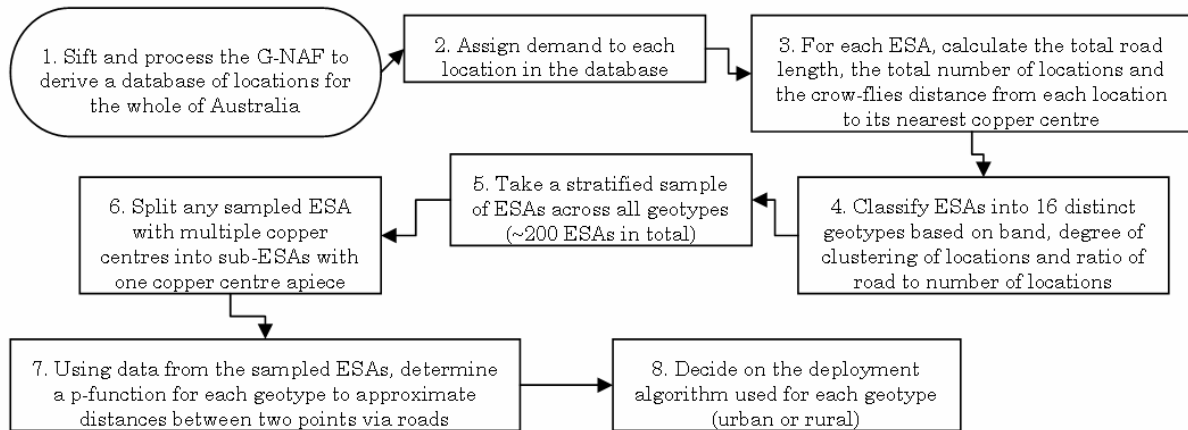
In bands 3 and 4, geotypes are also distinguished as either clustered or spread. An ESA is said to be *clustered* if more than a certain proportion of addresses from the filtered geographic national address file (G-NAF) database lie within a particular distance of their nearest copper centre in the ESA (if any). Otherwise, ESAs are said to be *spread*.

Each geotype is further classified as either urban or rural to determine the variant of the deployment algorithm used. By default, geotypes 8 and 9 and 11 through to 14 are classified as rural. The Analysys cost model can be run with any geotypes using rural deployment, regardless of band.

In order to approximate cabling/trenching distances in an ESA, a p-function<sup>9</sup> is determined for each geotype. The p-function adopted by Analysys is capable of estimating the optimum road distance between two points on a particular road route. This road distance is taken as a proxy for cable/trench distance between two points. The parameters for the p-function are calculated using data from each sample ESA.

Figure 5.2 below outlines the process of categorising the ESAs.

**Figure 5.2 – Categorising ESAs**



### Assumptions in the model

The following are assumptions made at various stages of the process outlined in figure 5.1, numbered to correspond with the relevant boxes in the flowchart.

#### 4. Dividing ESAs into geotypes

*Assumption:* ESAs with similar ratio of road length to locations are similar in layout.

In performing the geotyping analysis, the road length is taken to be a proxy of the trenching length required to deploy copper to each household in the ESA. By grouping ESAs by the ratio of average road length to location, ESAs with similar copper deployment costs are treated alike in the model enabling computation times to be reduced.

<sup>9</sup> A p-function is a generalised metric for finding distances between two points. It is of the form  $\|x - y\| = k \left( |x_1 - y_1|^p + |x_2 - y_2|^p \right)^{1/p}$ . For example, Euclidean, or 'crow-flies' distance is found using  $p=2$ ,  $k=1$ . Analysys determine values of  $k$  and  $p$  for each geotype.



## 7. Using a p-function for cabling distance and an additional j coefficient<sup>10</sup> for trenching

*Assumption:* Cabling is laid in trenches along roads.

In order to capture realistic street distances the model uses a p-function to derive the distance between two points. Analysys notes that longitude and latitude coordinates cannot be used directly with the function as the coordinate system needs to be capable of calculating and aggregating metres. In order to account for trench sharing between cables, an additional trench sharing coefficient is calculated for each geotype.

## 8. Classifying as urban or rural

*Assumption:* The access algorithm used for each geotype is either urban or rural.

The model uses two different copper deployment options, one for urban deployments and one for rural deployments. Urban deployments aggregate all locations into clusters served by DPs first and then aggregate these DPs into clusters served by pillars. Rural deployments aggregate locations directly into pillar clusters, with each location served by a DP. Rural deployments can also utilise wireless connections.

### **5.1.2 Architecture of Customer Access Network**

#### Functionality to deploy four different types of access network solutions

The access network algorithms deploy the most cost-efficient solution for each modelled ESA. The algorithms deploy an appropriate network choosing between:

- copper;
- fibre;
- wireless (modelled using GSM 900MHz parameters); and
- satellite.

In urban areas, the algorithms deploy either copper or fibre depending on the demand to be served at each location.

In rural areas, the algorithms make a cost-based decision between copper and wireless solutions, and subsequently, between wireless and satellite solutions. Fibre can still be deployed to locations with high demand.

#### Measuring trenching and cabling

<sup>10</sup>

---

The j coefficient is an additional parameter to the p-function used when calculating trench lengths. The p-function will overestimate trench lengths when used to calculate link lengths, as it doesn't take into account that several cables can share a trench. Thus the result of the p-function is multiplied by j, which will have a value less than 1, to approximate trench lengths.

An efficient network design optimises the building costs associated with trenches/ducts and cabling. These costs are driven by the amount of civil works required, which is directly linked to the following elements:

- total distance covered by trenches and ducts; and
- length of the copper and optical cables laid within the ducts.

The calculation of CAN trench and cable lengths are based on the p-function for each geotype, which is used to approximate the distance between two points via roads. When calculating trench lengths, an additional trench sharing coefficient is also used. Using the p-function on street distances inherently takes into account topological constraints on the deployment of the network and generates more realistic network deployment architecture. The model also assumes duct sharing between the access and core, and between other networks owned by the operator. This is considered in the costing module.

### Customer access network algorithm

The design of the CAN begins by grouping all SIOs into either DP clusters (in an urban deployment) or pillar clusters (rural deployment). In urban deployments, DPs are then grouped into pillar clusters. In rural deployments, a cost based decision is made to determine whether to serve each pillar cluster by copper or by wireless. The clustering algorithms employ a distance criterion to ensure clusters are not too spread and a capacity criterion to ensure that clusters do not serve too much demand.

Analysys use two minimum spanning tree algorithms to determine the layout of trench and cabling in the CAN. A modified Prim algorithm<sup>11</sup> is used within the pillar clusters in the rural deployment and within DP clusters in the urban deployment. A modified Dijkstra algorithm<sup>12</sup> is used between DPs and pillars in the urban deployment and between pillars in both deployments.

These algorithms minimise a proxy cost function for the spanning tree, which takes into account trenching and cabling costs. Thus a minimum cost deployment is found. Although neither are a Steiner tree<sup>13</sup> methodology, both algorithms have several improvements on a simple minimum spanning tree algorithm; in particular it can account for cable tapering in the access network.

---

<sup>11</sup> The Prim algorithm is a standard algorithm to find the minimum spanning tree of a graph. As a minimum spanning tree would result in a deployment with minimum trenching but not necessarily minimum copper, Analysys have modified the algorithm to minimise a proxy cost function which takes into account cable and trenching costs.

<sup>12</sup> A standard Dijkstra algorithm finds a shortest path tree for a graph, which would result in a network with minimum cable lengths, but not minimum trench lengths. Thus Analysys have modified the algorithm to minimise a proxy cost function which takes into account both cable and trench lengths.

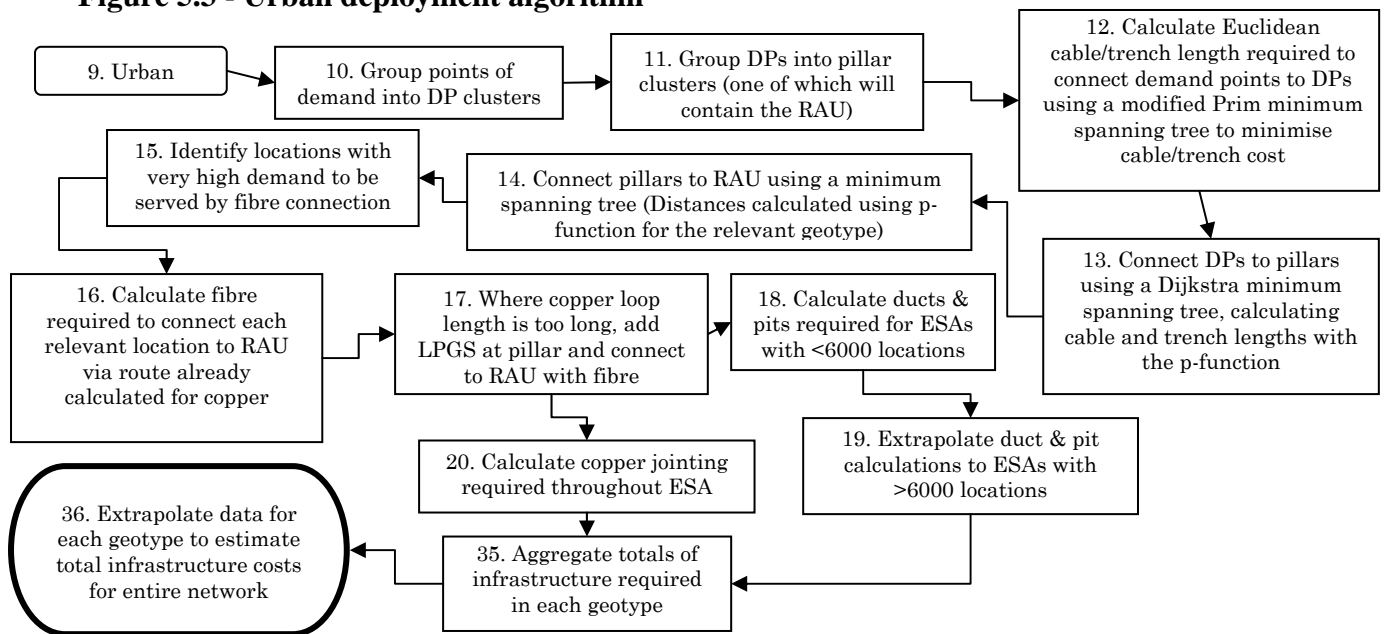
<sup>13</sup> A Steiner tree would allow for extra nodes to be added to minimise cable length. The Prim algorithm is limited to using existing nodes

The ACCC considers that clustering algorithms and minimum spanning tree algorithms have been used to generate realistic trench and cable network architectures.

### 5.1.2.1 Urban CAN deployment

The process for CAN deployment in urban ESAs is outlined in figure 5.3 below. Descriptions of the underlying assumptions, numbered to correspond with the relevant box in the flowchart follow.

**Figure 5.3 - Urban deployment algorithm**



### 10. Grouping into DP clusters

The Analysys cost model's urban deployment requires points of demand to be grouped into clusters that are serviced by DPs.

The DP capacity determines how much demand can be accommodated by a single DP during clustering. The model assumes a maximum of four points of demand per DP (locations with more than four points of demand are their own DP).

*Assumption:* Designed capacity of a DP is four cable pairs with zero per cent capacity reserved as spare.

*Assumption:* The maximum distance that a point can be from DP cluster centre is 100 metres.

The ACCC notes that this value is not a technical limitation. Rather, it is simply used to ensure that DP clusters are not spread over large areas, which would increase the total amount of cable used.

### 11. Grouping into pillar clusters

DPs are grouped into larger clusters serviced by a pillar – the pillar cluster. Each pillar cluster has one point designated as the DP serving the cluster.

The model assumes capacity at the pillar for 900 pairs with 10 per cent spare capacity. A maximum distance of 600 metres from a DP to its pillar cluster centre is also assumed.

*Assumption:* The capacity of a pillar is restricted to 900 pairs.

The ACCC notes that the Analysys cost model uses 900 pair pillars and does not have capacity for 1800 pair pillars and that this may overstate the number of pillars required in some areas.

*Assumption:* Pillar capacity includes a reserve of 10 per cent.

*Assumption:* The maximum distance of a DP from pillar cluster centre is 600 metres.

As with DP clusters, the ACCC notes that this value is not a technical limit, but an optimising constraint placed on the clustering algorithm to prevent the clusters being too spread.<sup>14</sup>

### 12. Calculating FDP-DP links

*Assumption:* DP clusters lie along a single road.

The model assumes that DP clusters lie along a single road, and thus Euclidean distances (as the crow flies) may be used. To account for the fact that some DP clusters may lie around corners, the trench sharing coefficient is applied to all FDP-DP links within an ESA.

The final drop point (FDP) for the copper is taken as the point on the road where a perpendicular line from the road meets the geocoded national address file (G-NAF) point for the address. The model assumes a non-tapered network by default, although this can be changed to a tapered network.

### 13. Calculating DP-pillar links

The model uses a modified Dijkstra algorithm to minimise a proxy cost function for connecting the DPs to their parent pillars. As a default, the model assumes a non-tapered deployment with main cable size of 100 pairs and no minor cable size.

*Assumption:* Distribution network cable utilisation (DP-Pillar) is 75 per cent.

---

<sup>14</sup> Analysys, FLRIC report, 15 September 2008, p. 43

*Assumption:* Main cable size in non-tapered network is 100 pairs.

*Assumption:* Minor cable size in non-tapered network is zero pairs.

This assumption simply indicates that the non-tapered deployment is fully non-tapered – no minor cable size is used.

### 19. Calculating pit requirements

The Analysys model seeks to extrapolate the duct requirements for a whole geotype from smaller ESAs to reduce computation times. Analysys notes that it has deployed pits in the modelled network similar to those employed in the existing network. The Analysys model deploys pits:

- at cluster nodes (DPs and pillars, not FDPs); and
- along trench links in the spanning tree long enough to require additional jointing between endpoints.

In the model every pillar must have at least a P9 pit. The model deploys additional jointing wherever an intra-pillar trench in a DP-pillar is more than 100m in length and wherever an incremental pillar-pillar trench exceeds 250 metres.

*Assumption:* Maximum distance in distribution network between pits is 100 metres.

*Assumption:* Maximum distance in incremental trench between the pillars allowed between pits/manholes is 250 metres.

### 20. Calculating required jointing

*Assumption:* FDP-DP links are short enough to require no jointing.

Between the pillar and RAU a full 400 pair joint is added every 500 metres.

*Assumption:* Maximum distance cable that can be pulled through network without jointing is 500 metres.

Analysys notes that jointing in the distribution network between DPs and pillars is dimensioned in different ways depending on whether tapering is used or not.

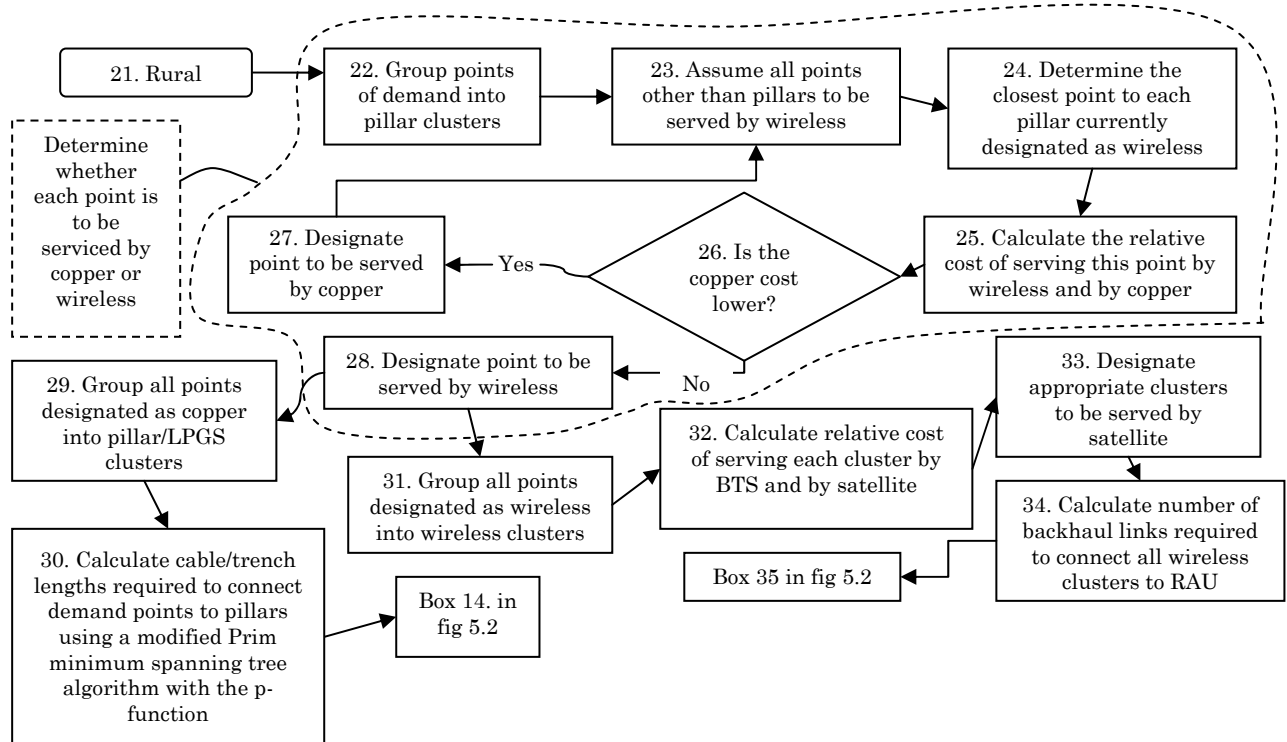
In the tapered case, jointing at the DP is the sum of the capacity of the demand at the DP and the number of pairs in the downstream cabling. Where a DP has more than one incoming branch, a branching kit for each extra branch is deployed.

In the non-tapered case, jointing at the DP is taken to be the demand at the DP. Like the tapered case, where the DP has more than one incoming branch, a branching kit for each branch is deployed. Additional joints are required in each link wherever the cable distance from the pillar exceeds a multiple of 500 metres.

#### **5.1.2.2 Rural CAN deployment**

The process for CAN deployment in rural ESAs is outlined in figure 5.4 below. Descriptions of the underlying assumptions, numbered to correspond with the relevant box in the flowchart follow.

**Figure 5.4 - Rural deployment algorithm**



22. Grouping into pillar clusters

Each location is served by its own DP, which are aggregated into pillar clusters. The clustering proceeds the same as in the urban deployment, except for a different distance criterion.

*Assumption:* The maximum distance of a DP from pillar cluster centre is 4,500 metres.

25. Calculating relative copper/wireless cost (rural deployments for geotypes 8-9 and 11-14)

The output of the copper-wireless decision allocates locations to either category.

To determine whether locations in rural areas are served by copper or wireless, the model applies an algorithm that makes a cost-based decision whether a location is to be serviced by copper or wireless.

*Assumptions:*

- wireless locations are to be served by a 900MHz GSM service;
- copper pillars cost AU \$2000;

- large pair gain systems (LPGS) cost AU \$80,000;
- wireless base transceiver stations (BTSs) cost AU \$200,000;
- copper costs AU \$11 per metre; and
- wireless setup costs AU \$825 per location.

### 29. Grouping points into pillar/LPGS clusters

The decision to deploy an LPGS rather than a pillar is based on the copper distance between a DP and the pillar location.

*Assumption:* The distance constraint for installation of an LPGS rather than a pillar is 6,900 metres.

### 32. Calculating relative cost of wireless/satellite

In some instances where BTSs are serving a handful of locations its may be more prudent to service those areas by satellite.

*Assumption:* The relative cost of serving a location by satellite is AU \$8,300 per location while a wireless BTS costs AU \$200,000 and a wireless service costs AU \$825 per location.

#### **5.1.3 Next-generation access**

In urban areas, the access model design allows for substitution of pillars by MSANs with fibre backhaul as part of an NGN solution. The model assumes fibre to the node (FTTN) deployment with VDSL2+ provisioning.

#### **Issues**

- Do you consider that the access design assumptions set out above are appropriate? Provide reasoning to support your response.

## **5.2 Overview of the core network model design**

This section sets out the core network design process. An overall description of the process is provided below, followed by flowcharts and corresponding assumptions for each of the sub-processes.

The model can be run either as:

- deploying a modern network structure;
- deploying an NGN structure.

The NGN arrangement assumes a converged IP core (using soft-switches and media gateway servers), consistent with previous statements by Telstra<sup>15</sup>.

The design of the modern core network follows the following process:

- calculation of capacity and equipment required at each LE;
- application of a clustering algorithm to identify PoCs (an LE on a transmission ring) and smaller exchanges subtended from the PoC via a minimum spanning tree;
- application of a cost minimisation algorithm to build rings through PoCs back to the LAS;
- calculation of equipment required at each LAS;
- calculation of links in LAS and TNS rings; and
- calculation of special solutions for LEs on islands.

The transit links are logically fully-meshed, but carried on a number of physical rings to reflect Telstra's actual network structure. Where appropriate, resilient network architectures have been modelled.

### **5.2.1 Core network algorithm**

The Analysys cost model groups LEs into clusters based on the number of SIOs served within a cluster. A single LE in each cluster is designated as a PoC which aggregates traffic from the smaller local exchanges. The PoCs then connect to a parent LAS via a multiple ring structure which transmits data using synchronous digital hierarchy (SDH).

Figure 5.5 below provides an example of a single SDH ring. As can be seen from the diagram, the traffic from small LEs is aggregated at a PoC which connects to a LAS.

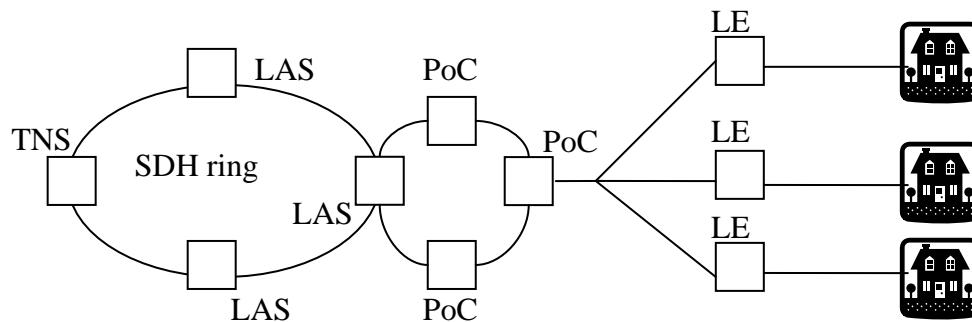
---

15

"Telstra Technology briefing" 16 November 2005. [www.telstra.com.au/abouttelstra/investor/docs/tls385\\_technologybriefing.pdf](http://www.telstra.com.au/abouttelstra/investor/docs/tls385_technologybriefing.pdf)



**Figure 5.5 - Core network structure**



The use of rings creates resilience in the network, ensuring that if any one link is broken, traffic can still be automatically routed. In addition, the cost of cable and trench required for the rings is minimised using a multi-ring Travelling Salesman algorithm. This calculates the shortest method of connecting all nodes.

The LAS-LAS links are also modelled to be in the form of SDH rings. Whilst the location of the LAS nodes are retained, the rings modelled are Analysys' interpretations of an efficient manner in which to deploy the links. Euclidean distance is used initially, and then distance is calibrated based on core route analysis.

The TNS-TNS links are modelled to be deployed along roads and railways, and the actual length of each link is calculated according to geographical information system (GIS) mapping.

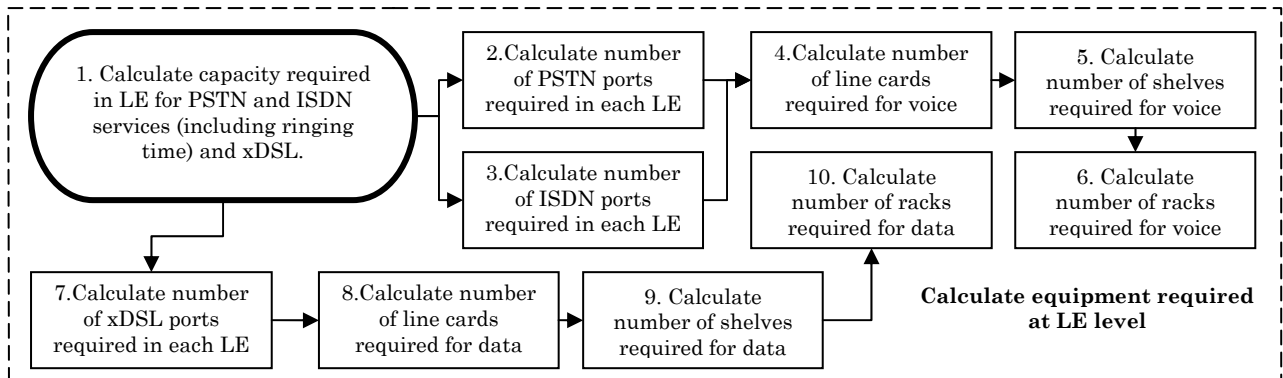
### **5.2.2 Island solutions**

The model uses a mix of microwave, satellite and submarine cables to link the core network to islands. A demand and distance based decision is made to decide which method to employ for each island. The existing 240km submarine cables are modelled for the link to Tasmania.

### **5.2.3 The core network design process and underlying assumptions**

Flowcharts of the modern core network design process are provided below in figures 5.6 to 5.10, along with the underlying assumptions.

**Figure 5.6 - Core network design process (1)**



### 1. Calculating required capacity

In calculating the demand on the network from voice services, in addition to the average time spent on calls, ringing time is added for each call attempt.

*Assumption:* A ringing time of 10 seconds is allowed for successful call attempts, 28 seconds for unsuccessful call attempts and 1.1 call attempts per successful call.

### 2-6. Calculating required voice infrastructure

In order to calculate the number of line cards required at an LE, the model must make an assumption on the type of equipment being used.

*Assumption:* Ericsson AXE equipment is used for voice services.

*Assumption:* ISDN and PSTN services are deployed on separate line cards, but shelves may contain a mixture of ISDN and PSTN line cards.

The following values are also assumed:

- line card utilisation (per port) of 100 per cent;
- shelf utilisation (per line card) of 90 per cent; and
- rack utilisation (per shelf) of 100 per cent.

*Assumption:* A 34MBit/s backhaul link is provisioned for each xDSL rack installed.

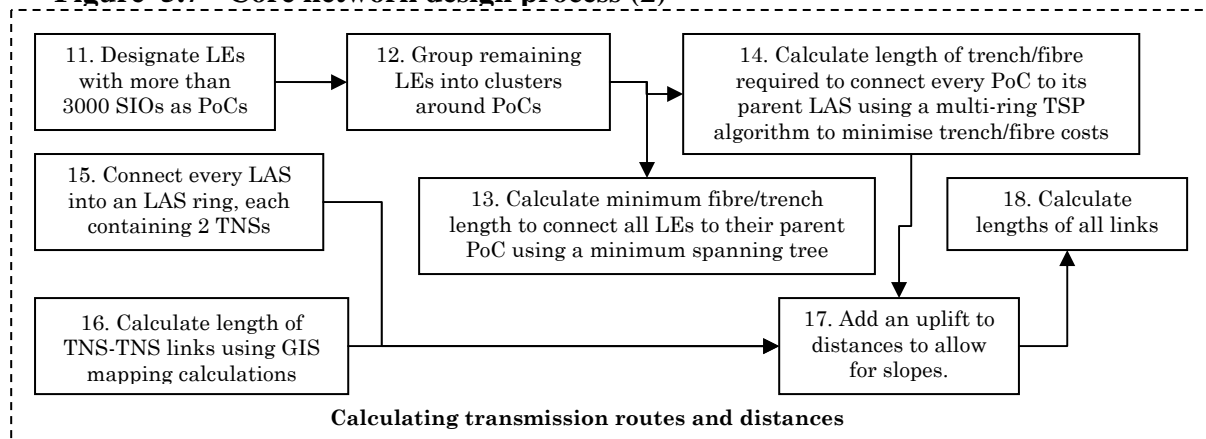
### 8-10. Calculating required data infrastructure

The model uses different equipment for voice and data infrastructure at the local exchange level.

*Assumption:* Alcatel ISAM 7302 equipment is used for data infrastructure.

The utilisation factors of the equipment are the same as those used for the voice infrastructure.

**Figure 5.7 - Core network design process (2)**



### 11. Determining points of confluence

*Assumption:* LEs with greater than 3000 SIOs are designated as points of confluence (PoCs).

The model connects LEs to their parent LAS via PoCs which are large exchanges that are connected to an SDH ring.

Traffic from each LE is aggregated at its parent PoC before being directed to the LAS. Analysys notes that this architecture is more cost effective than simply linking each LE directly to its parent LAS, and also allows a more resilient backhaul network.

### 12. Grouping LEs into PoC clusters

All LEs not designated as PoCs are grouped into PoC clusters. The model uses a top down clustering approach, adding points to clusters one at a time subject to a capacity constraint and a distance constraint.

*Assumption:* A maximum of 16 LEs connected to each PoC.

This process does not necessarily result in an optimal cluster, so the cluster then undergoes a 'refinement' phase, which aims to minimise the total distances of all points. The distance used in the clustering algorithm is the Euclidean (straight line) distance, as only relative distances are required, and the Euclidean distance between pairs of points will behave in a similar way that the actual distance will behave.

### 13. Connecting PoC clusters

The model uses a minimum spanning tree algorithm to connect all LEs within a PoC cluster. Edges in the spanning tree are weighted according to the distance based costs of trenches and fibre, based on a proxy cost function. This proxy cost function is minimised by the algorithm.

### 14. Connecting PoCs to LAS nodes

The model connects PoCs to their parent LAS via SDH rings. Analysys notes that this ring structure creates resilience in the network, ensuring that if a link in the ring is broken, traffic will still be automatically routed.

The rings are created using a multi-ring travelling salesmen problem algorithm, which seeks to minimise a distance based proxy cost function including the cost of both trench and fibre. The algorithm allows a multiple ring structure, whereby a child ring may be connected to the LAS via a parent ring.

The following restrictions are placed on the algorithm:

- no SDH ring may contain more than 8 PoCs;
- maximum of 8 links between a PoC and its parent LAS; and
- any child rings must be connected to their parent ring via at least 2 bridging nodes to ensure resilience.

An add-drop multiplexer unit is also allowed for at each PoC.

### 15. Creating LAS rings

The LAS rings modelled by Analysys are their interpretation of an efficient manner in which to deploy the links.

Cable and trench distances for LAS rings are calculated using Euclidean distance. To account for the fact that the optical fibres would be deployed along roads or railways, a 50 percent uplift is added to the straight line distances. Finally, distances are recalibrated to the results of overlap analysis.

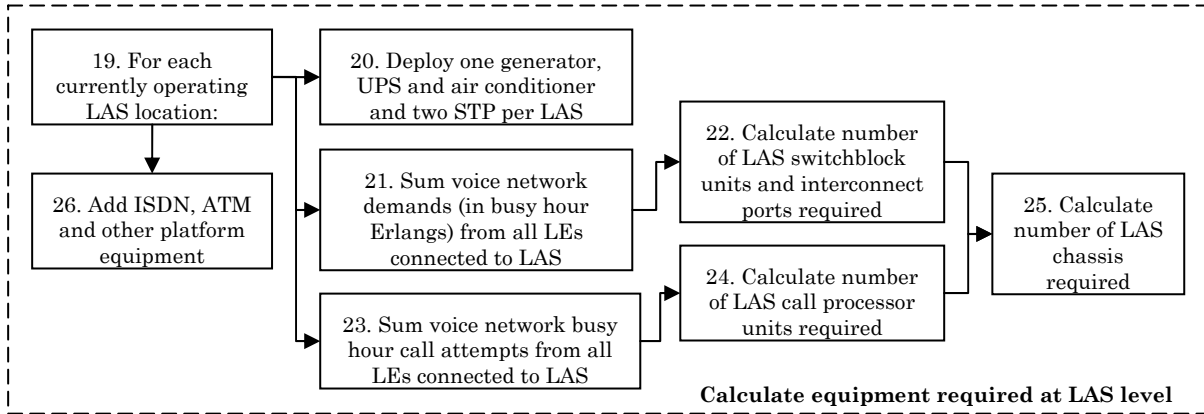
Analysys notes that a realistic deployment would be in the form of LAS-LAS links via a number of exchanges, but that this scenario is extremely difficult to model. Instead, the model assumes trench sharing between different levels of the network, which Analysys claims will mitigate the costs incurred.

The model also has the ability to use dense wave division multiplexer (DWDM) equipment for LAS rings. This can be toggled by the user. When enabled, DWDM equipment is deployed for links where two or more synchronous transfer mode (STM) 64 links are required. The jointing costs are assumed to be included in the equipment costs.

### 17. Adding uplift to allow for slopes

The model allows for an uplift to be added to distances to allow for slopes. By default this is assumed to be 0%.

**Figure 5.8 – Core network design process (3)**



### 19-25. Calculating equipment required at LAS

*Assumption:* All routing/switching for data is carried out at the main transmission hub (MTH).

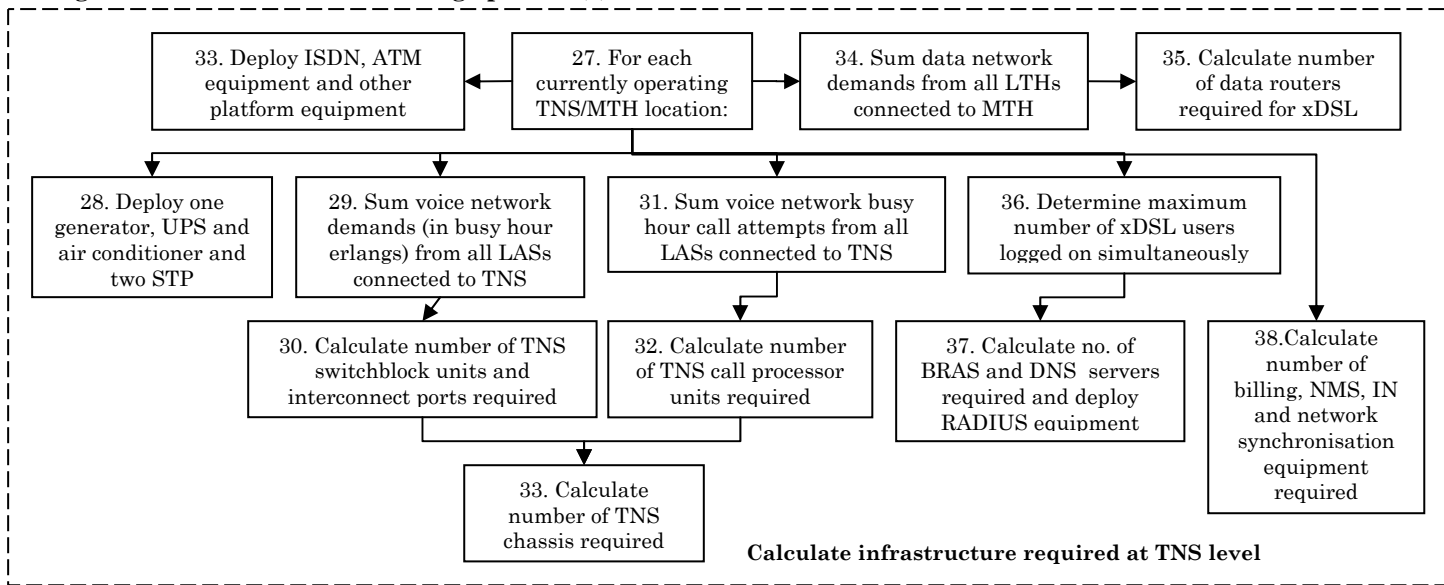
In dimensioning the equipment required at the LAS level, the model assumes that no data routing or switching is performed at the LAS/local transmission hub (LTH).

The cost of all building related infrastructure (generator, uninterrupted power supply (UPS), air-conditioning) is factored in for every LAS.

The number of switchblocks and call processor units is based on demand calculated at that LAS according to the following capacity constraints:

- switchblock capacity of 5000 busy hour Erlangs (BHE) (Analysys estimate);
- switchblock utilisation of 80 per cent (Analysys estimate);
- call processor unit capacity of 800 000 busy hour call attempts (BHCA) (from industry data); and
- call processor utilisation of 80 per cent (from industry data)

**Figure 5.9 Core network design process (4)**



28-33. Calculating TNS equipment for voice services

The cost of building related infrastructure (UPS, generator, air-conditioning) is factored in at every TNS.

The infrastructure required for voice traffic is calculated as at the LAS, but with the following capacity constraints:

- switchblock capacity of 50 000 BHE;
- switchblock utilisation of 80 per cent;
- call processor unit capacity of 800 000 BHCA; and
- call processor utilisation of 80 per cent.

34-38. Calculating equipment required for xDSL

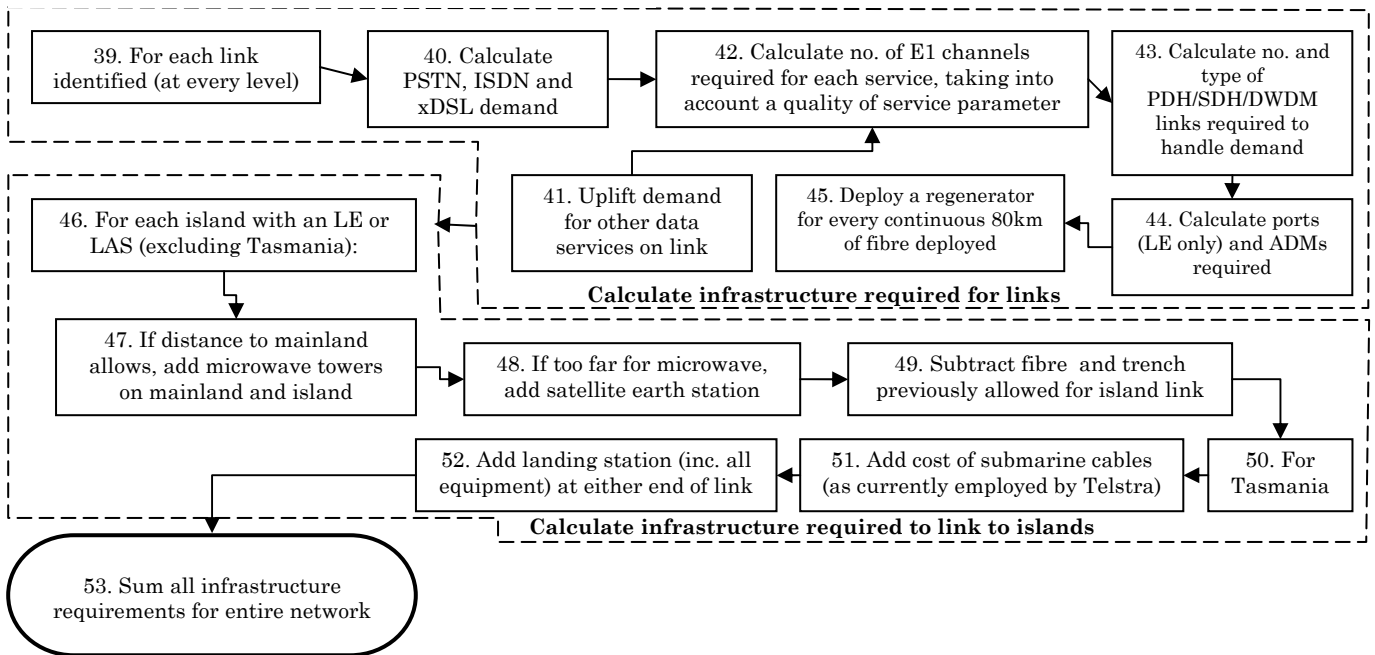
Each TNS is assumed to require broadband remote access servers (BRAS), domain name servers (DNS), and a remote authentication dial-in user service (RADIUS). A remote access server (RAS) is also included at each TNS for routing dial up traffic to the internet.

The number of BRAS required is calculated by dividing the maximum number of simultaneous users by the capacity of one BRAS.

*Assumption:*

- The capacity of a BRAS is 48 000 concurrent subscribers; and
- The proportion of subscribers simultaneously online is 30 per cent.

**Figure 5.10 Core network design process (5)**



#### 40. Calculating demand on links-

*Assumption:* Mobile points of interconnection are located at the TNSs in each capital city.

*Assumption:* International gateway switches are located in every capital city.

Analysys acknowledges that the gateways are not in every capital city and that they are only available in Sydney and Perth.

#### 42. Calculating number of E1 channels required

The capacity required of a link is calculated in terms of E1 virtual containers. Each type of traffic (PSTN, ISDN, xDSL) is treated separately.

*Assumption:* DWDM equipment is used on all TNS-TNS links.

In calculating the number of E1 channels required for links, by default the model assumes that DWDM equipment operates on TNS-TNS links only. The model also has the ability to use DWDM equipment for LAS rings. This can be toggled by the user.

*Assumption:* An end-to-end network probability of 0.5 per cent.

This value is used in the calculation of a quality of service parameter, which is used in calculations of required transmission capacity.

#### 43. Calculating plesiochronous digital hierarchy (PDH)/SDH/DWDM links required

The number and type of PDH/SDH links required for each link is calculated from the number of E1 virtual containers (VCs) according to industry standards:

<i>PDH/SDH transmission level</i>	<i>Number of E1 VCs</i>
E1	1
E3	14
STM-0	21
STM-1	63
STM-4	252
STM-16	1008
STM-64	4032

*Assumption:* A quadrupling in speed leads to an increase in cost by a factor of 2.5

For example, the model would assume that an STM-4 is approximately 2.5 times as expensive as an STM-1. Thus an STM-4 would be deployed in preference to three STM-1s.

By default, the model assumes DWDM equipment is used over TNS-TNS links. TNS equipment is thus deployed at every TNS. The model can also be toggled to use DWDM equipment on LAS-LAS links.

#### 45. Adding signal regenerators

The model accounts for a signal regenerator for every 80 km of optical fibre.

*Assumption:* Signal attenuation up to a distance of 80km is acceptable.

#### 46-49. Linking to islands

Only islands with an LE on them are considered in this part of the model.

*Assumption:* Due to the distance to the mainland, clusters on islands without an LE would be served by satellite or microwave backhaul by the rural deployment algorithm in the CAN model.

The model's first preference for linking to islands is via a microwave link. This requires the addition of microwave towers on the island and mainland.

*Assumption:* The maximum range of a microwave link is 40km.

If distance to island is too great for a microwave link, a satellite link is utilised. In this case a satellite earth station is added.



For every wireless island link added, the length of cable/trench previously allowed for that link is subtracted.

If demand on an island is too great for a satellite link, submarine cables are employed. Landing stations are then added at either end of link.

All equipment required for the landing station (fibre termination equipment, optical fibre drivers/receivers, power supply, back up supply, air-conditioning) is included in the cost of the landing station.

*Assumption:* The capacity of a satellite link is 2000 units.

The model uses the existing 240km submarine cables to Tasmania.

### **Issues**

- Do you consider that the core model design assumptions set out above are appropriate? If not, provide reasoning and alternative options.

## **6. Network costing issues**

A single service costing module aggregates network assets from the CAN and core modules.

The costing modules have been populated with a set of benchmark values provided by Analysys and may not necessarily reflect the ACCC's current thinking for some values. These default input values represent initial starting values for industry comment.

A summary of the network cost default inputs discussed below can be found in Appendix C.

### **6.1 Service set**

The Analysys cost model includes all services — both data and voice — currently being provided on the Australian fixed network to capture benefits of economies of scale and scope. This is particularly relevant in a next-generation environment where both voice and data services are delivered on a single platform. A minimum set of all services (declared and non-declared) provided on the fixed network has been modelled, since a proportion of the network cost will need to be allocated to these services.

Changes to telecommunications markets and the regulatory environment may require new services to be declared, or alternatively some declarations to be revoked. The Analysys cost model provides for these scenarios under a TSLRIC+ framework. However, the ACCC considers Analysys cost model is flexible and that alternative cost modules could be developed to apply different pricing principles in the model.

### **6.2 Estimation of capital costs**

The Analysys cost model assumes that capital expenditure is incurred in advance of activation. It assumes that a period must be allowed for ordering, purchasing, deployment, testing and activation. This assumption is modelled for each asset by including a planning period between zero (no planning required) and 24 months. This lead time is dependent on the size of the network assets.

#### **6.2.1 Asset valuation**

The model includes a schedule of capital costs for each network element in nominal dollars, and a price trend (from 2007 onwards) which enables the price of modern equivalent assets over time to be determined.

The annual capital cost for each asset is estimated using a tiled annuity formula.

#### *Spare uplifts*

A spare uplift can be applied to increase capital cost for a network element to assume the purchase of additional spares within the defined lifetime of the asset.

*Default value:* Spares uplift is 0 per cent.

The default values for the customer access network costs can be found in Cost.xls file – UnitCost.Access sheet. The sheet provides the:

- basic equipment cost (cell reference: E9:E88);
- total capital expenditure (cell reference: L9:L88); and
- percentage of capital expenditure as they relate to the particular asset (cell reference: M9:M88).

The ACCC notes that the three primary contributors to the capital costs are: ducts, pits, and copper cables. Each of these will be discussed further below.

### Ducts

Ducts are protective containers (usually PVC) that the cables are laid in, usually approximately 100mm in diameter and account for over 60 per cent of the access network costs.

#### *Default values:*

Duct: 1 - \$60 per duct

Duct: 2 - \$89 per duct

Duct: 4 - \$105 per duct

Duct: 6 - \$150 per duct

The default values for the ducts can be found in the Cost.xls file – UnitCost.Access sheet (cell reference E27: E30).

The ACCC notes that these default values reflect the cost of providing trenched ducts in urban areas. Therefore, in rural areas, where they can be ploughed into the ground the costs are significantly reduced.

### Pits

Pits are access points deployed periodically throughout the network. They are used to allow access to the network infrastructure for maintenance. Thus they are required at convergence points where several cables meet, for example DPs and pillars, and also at points where jointing is required on long links.

#### *Default values:*

Pits: P5 - \$620 per pit

Pits: P6 - \$1,330 per pit

Pits: P9 and above - \$4,000 per pit

The default values for the pits can be found in the Cost.xls file – UnitCost.Access sheet (cell reference E32: E37).

The ACCC notes that where a pillar is attached to a pit, the minimum requirement is a P9 pit regardless of the number of ducts and links.

### Copper Cable

Copper cable is used throughout the access network to supply services, with the exception of high demand locations served directly by fibre. The copper cable is dimensioned in terms of pairs of copper wire. A basic service (voice and or DSL) is served by a single copper pair.

The two types of copper cable used are the main cable and distribution cable. The mains and distribution cables come in varying size pairs.

#### *Default values:*

Copper distribution 100 - \$8 per unit

Copper main 400 - \$21 per unit

The default values for all of the copper cables can be found in the Cost.xls file – UnitCost.Access sheet (cell reference E39: E56).

The ACCC notes that while the unit costs are relatively low per asset, over half a million copper cables are required in the customer access network.

### **6.2.2 The cost of capital**

The cost of capital is usually calculated as the weighted average cost of capital (WACC) and represents the opportunity cost of the debt and equity funds to finance operations of the access provider.

The Analysys cost model applies a single WACC to represent the risk associated with an operator. The model allows users to change or modify the individual parameters within the WACC framework.

*Default values:* WACC parameters are outlined in Table 6.1

**Table 6.1 - WACC Input Parameters**

<b>Parameter <sup>(a)</sup></b>	<b>Input value</b>
Risk Free Rate <sup>(b)</sup>	4.48%
Debt to equity ratio	40/60
Debt (risk) premium	1.02%
Equity beta	0.83
Equity issuance costs	0.00
Risk premium (market)	6.00%

Tax	30%
Gamma (imputation factor)	0.5
WACC pre-tax	8.88%
WACC post-tax	7.88%

Source: ACCC, *Unconditioned Local Loop Service Pricing Principles and Indicative Prices – 2007-08 WACC parameters*, June 2008, p.19.

Notes: (a) The asset beta can be derived by de-levering the equity beta.

(b) The risk free rate has been updated from 5.58% which was used in the indicatives prices to 4.48%, which based on Bloomberg data reflects the 10-day average Government bond rate up to December 8 2008.

The default values for the WACC input parameters can be found in the Cost.xls file – WACC sheet (cell reference C8: C17 for 2007 values).

### 6.2.3 Depreciation

Depreciation represents the decline in the economic value of assets used to provide telecommunications services. Consistent with the TSLRIC+ methodology, depreciation schedules should be constructed and based on the expected decline in the economic value of assets in a forward-looking framework.

#### Assets lives

*Default values:* Network asset lives are outlined in Table 6.2:

**Table 6.2 – Network asset lives**

<i>Type of asset</i>	<i>Years</i>
Building	50
Network equipment	10
Line card	5
Core Network equipment	20
Building equipment	15
Copper	25
Fibre	25
Trench	40
Duct	40
None	10
Licence	5
IT system	3

The default values for the asset lives can be found in the Cost.xls file – UnitCost.Core sheet (cell reference D10: D21 for 2007 values).

### Tilted annuity

The Analysys cost model incorporates a tilted annuity module. Under a regulatory framework where asset values are revalued each regulator period, the tilted annuity can be used to account for the expected change in the asset value.

*Default value:* overall 3 per cent tilt.

The tilt can be adjusted to each individual asset or overall, in the Cost.xls file - TA.Core sheet (cell reference - K11:K210) and TA.Access sheet (cell reference - F10:F90).

#### **6.2.4 Allocation of operating expenses**

Operating expenses are the costs associated with providing a service. Where the costs are incurred as a result of jointly providing a number of services, there is a need to apportion those costs between the services so the costs attributable to regulated services are separately identifiable from those attributable to non-regulated services.

Analysys has employed an equi-proportionate mark-up (EPMU) approach to allocating joint and indirect costs to services.

Analysys has specified operating expenses as a proportion of the capital cost values grouped and weighted according to capital investment in core and access network elements. The Analysys cost model does not weight operating expenses by geo-type.

*Default values:* Operational expenditure as a percentage of the capital cost range from zero to 9 per cent, depending on the asset type.

Operation expenditure can be adjusted in the Cost.xls file - TA.Core sheet (cell reference – H11:H210).

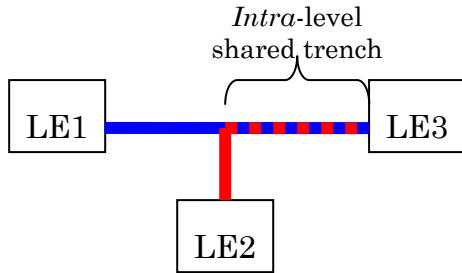
#### **6.2.5 Transfer of costs between CAN & IEN**

Analysys has determined the level of overlap analysis between the modelled access and core network routes; that is, the degree to which access and core network routes is deployed in the same trench.

The overlap analysis determines the percentage of the trench assets shared between the different levels in the core network and the core and access networks.

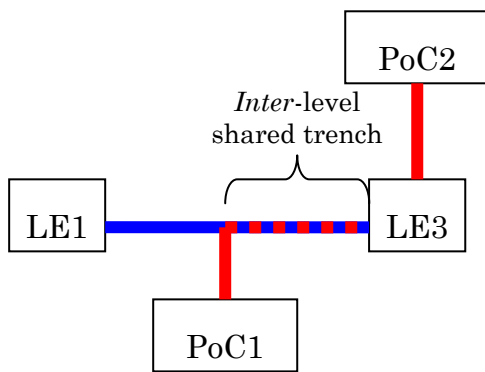
The Analysys cost model allows for trenches to be shared at the intra core network level. For example, parts of the LE–PoC pathways may be deployed along the same route, therefore trench could be shared.

#### **Figure 6.1: Example of intra network level trench sharing**



Alternatively, trenches may be shared inter core network levels, for example, parts of the PoC-rings may be deployed along the same routes as LE–PoC routes:

**Figure 6.2: Example of inter network level trench sharing**



The default trench sharing values in the model are based on the overlap analysis.

Interested parties should refer to section 7.11 in the Fixed LRIC cost model documentation for further details on the overlap analysis.

The ACCC notes that the access and core overlap analysis provides real route distances only applicable to the specific TSP solution. However, the ACCC notes Analysys' view that the results from the overlap analysis, including trench sharing and crow-fly versus actual distance, are likely to be broadly applicable.

The price estimates for the fixed line declared services, based on the default values and assumptions detailed above, can be found in the next chapter.

**Issues**

- Do you consider that the network cost default values above are appropriate? If not, provide evidence for alternative options.

## 7. Pricing results

This chapter sets out price estimates for the fixed line declared services under the model network architecture from the Analysys cost model under default assumptions outlined in this discussion paper. These assumptions and parameter values should be considered as initial starting points for industry comment and, at this stage, do not necessarily reflect the ACCC's views as to the appropriate modelling assumptions.

The ACCC notes that the Analysys cost model provides network cost estimates. It does not include any other costs such as connection charges that may be relevant in an access price.

### **PSTN OTA (AUD cent/minute)**

Domestic PSTN originating access is the carriage of telephone calls from the calling party (the A party) to a PoI with an access seeker's network. A PoI is usually located at a trunk (or transit) exchange.

Domestic PSTN terminating access is the carriage of telephone calls from a PoI within an access seeker's network to the party receiving the call (the B party).

Calls are timed so unit costs are presented on a cents per-minute basis.

	2007	2008	2009	2010	2011	2012
<b>All Bands</b>	0.66	0.67	0.70	0.77	0.80	0.82

The ACCC notes that the indicative price set for 2006-07 is 1 cent per minute.<sup>16</sup>

### **Unconditioned local loop service (AUD/ line/month)**

The unconditioned local loop service allows an access seeker to provide services, including voice and/or xDSL, over the copper loop using its own equipment co-located with the termination point.

	2007	2008	2009	2010	2011	2012
<b>Band 1</b>	2.72	2.66	2.65	2.65	2.66	2.66
<b>Band 2</b>	14.73	14.74	14.78	14.84	14.90	14.98

The ACCC notes that indicative prices for 2006-07 and 2007-08 respectively are:

- Band 1 - \$6.00 and \$6.20
- Band 2 – \$13.70 and \$14.30<sup>17</sup>

<sup>16</sup> ACCC, Pricing principles and indicative prices – Local carriage service, wholesale line rental, and PSTN originating and terminating service, Schedule 3, 29 November 2006.

<sup>17</sup> ACCC, Unconditioned Local Loop Service – Pricing principles and indicative prices, p. 44.



The indicative prices for both the ULLS and LSS include a \$2.50 specific charge<sup>18</sup> which reflects the capital cost of the computer based provisions system. These are not included in the Analysys cost model prices.

### **Line sharing service**

The line sharing service allows an access seeker to provide high-frequency services, principally xDSL, over the copper loop using its own equipment co-located with the termination point. Voice is provided over low-frequency spectrum by Telstra.

While the LSS is included in the Analysys cost model, a price for the service does not result as the relevant assets costs are recovered in the specific costs and connection costs. The ACCC notes that the specific costs and connection costs are not included in the Analysys cost model.

### **Local carriage service(AUD cent/call)**

The local carriage service is a service for the carriage of telephone calls from customer equipment at an end user's premises to separately located customer equipment of an end user in the same standard zone. The service is used by access seekers to resell local calls.

Calls are untimed so unit costs are presented on a per-call basis.

	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>
<b>All Bands</b>	6.57	6.65	7.00	7.63	8.01	8.15

The ACCC notes that the indicative prices for 2006-07 and 2007-08 based on a retail minim retail cost (RMRC) methodology are 17.92<sup>19</sup> and 17.36<sup>20</sup> cents respectively, per call.

The ACCC also notes RMRC is likely to produce prices which are higher than TSLRIC.

### **Wholesale line rental (AUD/ line/month)**

Provision of a line suitable for voice and sold through operators other than Telstra retail.

WLR may be provided over copper pair, fibre (where multiple services may be provided over the same line), and wireless and satellite solutions.

	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>

<sup>18</sup> ACCC, Review of Line Sharing Service Declaration – Final decision, October 2007, p, 9

<sup>19</sup> ACCC, Pricing principles and indicative prices – Local carriage service, wholesale line rental, and PSTN originating and terminating service, 29 November 2006, p, 12.

<sup>20</sup> ACCC, Local carriage service and wholesale line rental -final pricing principles and indicative prices for 2008 and 2009, August 2008, p, 15.

<b>Band 2</b>	15.47	15.54	15.61	15.67	15.73	15.81
---------------	-------	-------	-------	-------	-------	-------

The ACCC notes that the indicative price across all bands for 2006-07 and 2007-08 are RMRC \$23.12 and \$25.57 respectively. When using the Analysys cost model to determine prices for the WLR, the ACCC notes that a specific charge will need to be included to capture the cost of the ordering system in the overall price.

No prices estimate is shown in Band 1 as there is no demand for the service in that area.

## Appendix A      Template for list of potential errors

<b>Name of submitter</b>	<b>Date error was found</b>	<b>Date error was rectified</b>	<b>Description of error</b>	<b>Description of how error has been rectified</b>

## **Appendix B      Response pro forma**

Respondent:

### Demand Issues

[Respondents should note which of the demand issues to which a response is being issued]

### Architecture and dimensioning rules

[Respondents should note the assumption number to which the response is being made]

### Network costing issues

[Respondents should note the default value to which the response is being made]

### Other

[Should respondent wish to raise other concerns or provide additional comments on the model or related documentation, please detail them here providing where relevant, the workbook and sheet reference]

## Appendix C Network cost default inputs

<b>Input</b>	<b>Default Value</b>
<i>Spare uplift</i>	0 per cent
<i>Ducts –</i>	
Duct: 1	\$60 per duct
Duct: 2	\$89 per duct
Duct: 4	\$105 per duct
Duct: 6	\$150 per duct
<i>Pits –</i>	
Pits: P5 -	\$620 per pit
Pits: P6 -	\$1,330 per pit
Pits: P9 -	\$4,000 per pit
<i>Copper cables -</i>	
Copper distribution 100	\$8 per unit
Copper main 400	\$21 per unit
<i>Cost of Capital –</i>	
Risk free rate	4.48%
Debt to equity ratio	40/60
Debt (risk) premium	1.02%
Equity beta	0.83
Equity issuance costs	0.00
Risk premium (market)	6.00%
Tax	30%
Gamma (imputation credit)	0.50
WACC pre-tax	8.88%
WACC post-tax	7.88%
<i>Depreciation (asset lives) –</i>	
Building	50 yrs
Network equipment	10 yrs
Line card	5 yrs
Core network equipment	20 yrs
Building equipment	15 yrs
Copper	25 yrs

Fibre	25 yrs
Trench	40 yrs
Duct	40 yrs
None	10 yrs
Licence	5 yrs
IT system	3 yrs
<i>Titled annuity</i>	3 per cent
<i>Operating expenses</i>	Zero to 9 per cent, subject to asset