ESTIMATING THE LONG RUN INCREMENTAL COST OF PSTN ACCESS

Final Report for ACCC

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1. INTRODUCTION

National Economic Research Associates (NERA) has been commissioned by the Australian Competition and Consumer Commission (ACCC) to construct a total service long run incremental cost ("TSLRIC") model of the costs to Telstra of call conveyance and of customer access, in order to calculate the costs of originating and terminating interconnection services provided by Telstra.

This report describes the main assumptions made and the modelling approach we have used. This report is the final version following the earlier publication of a draft preliminary report (published October 1998). In the draft report we requested feedback from the industry on a wide range of issues and received a number of responses which have been carefully considered in producing this final report.[1]

Before describing the details of our analysis in Sections 2 to 5, we review some general aspects of the approach:

- definition of the costs of conveyance and customer access;
- the “bottom-up” modelling approach;
- the network component based approach;
- the treatment of fixed shared and common costs.

Finally in this section we discuss the approach we have taken regarding economic issues, such as the depreciation profile, and the approach we have taken to data uncertainty.

1.1. Definition of the Costs of Call Conveyance and Access

The cost definition we are using is total service long run incremental cost (TSLRIC). The first question to address is the definition of the increment of output that constitutes "total service". We have taken the service as being the whole of Telstra's inland PSTN and ISDN service together with its leased line (or "private circuit") service. Both Telstra's own customer services as well as the traffic for interconnect operators are taken into account. The ACCC have confirmed to us that this definition is consistent with the document "Access Pricing Principles"[2] in which the ACCC has set out its approach to pricing certain declared services.

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1 Specifically responses were received from: Telstra, Optus and the NERA Response Group (NRG - representing a variety of operators). Throughout this report we comment on the issues raised and explain either the ways in which these have been addressed or why we do not feel it is appropriate to make changes.

2 "Access Pricing Principles - Telecommunications, a guide", July 1997, ACCC.

Our definition is also consistent with the definition used in the US, UK and other parts of the world. The definition ensures that:

- there is a consistent basis for determining a single cost underlying both the price for interconnecting operators and an internal transfer price for Telstra's own retail customers;
- where costs are shared between more than one service (eg the cost of trenching is shared between PSTN and leased line services), the cost saving is shared between the different services;
- services do not have to be listed "in order" - all of the services listed have "equal priority" and share costs equally thus avoiding arbitrary decisions as to which service "came first". It is also the case that causality should be determined on a forward looking basis and hence who comes first is irrelevant.[3]

Costs are split between those that are line related and those that are traffic related. Traffic related costs are clearly relevant to the interconnection service provided by Telstra. Line related costs are also important where there is an access deficit and where it is decided that interconnection charges should help fund this.[4]

Our approach is outlined below:

- we model a “stand-alone” network capable of providing Telstra’s inland PSTN, ISDN[5] and inland private circuit services, including both traffic related and line related costs;
- we identify the TSLRIC of providing these services;
- all traffic related costs (such as switch processors, multiplexing equipment, cable and trench in the core network) are attributed to the cost of call conveyance;
- all line related costs (such as the cost of the copper local loop and line cards) are attributed to the cost of providing customer access;

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3 We note that the NRG argued for a much narrower definition of the "service".

4 NERA has not been asked to look at access deficit directly - though clearly the results in this report are relevant to this issue.

5 Note that ISDN services are included to make sure that any costs which are common to both services are shared. Certain additional costs which arise for ISDN services only (eg the cost of an ISDN line card is greater than the cost of a PSTN line card) have not been included in the model. This is because if we had included these costs we would then have had to exclude them again in considering the costs of PSTN services.

- direct network costs which are common to call conveyance and access (eg the site cost for a local switch) are allocated between conveyance and access on the basis of cost driver proxies within the model;
- to estimate PSTN conveyance costs, leased line conveyance costs are eliminated by splitting transmission costs according to the proportions of capacity used for leased lines and call conveyance respectively;[6]
- indirect costs are modelled as a percentage mark up on either total network costs or total network operating costs as appropriate.

We also note that we have taken account of leased line capacity in the model, and PSTN transmission unit costs will thus be lower than they would otherwise be due to the sharing of trenching, cables and multiplexing equipment.[7]

It should also be noted that we are modelling the costs of the wholesale provision of call conveyance, since this is what would be purchased by an interconnecting telecommunications operator. In other words, we do not include "retail" costs as these are irrelevant to providing call conveyance for interconnection purposes. Such irrelevant retail costs include sales, advertising, marketing and subscriber billing. Similarly our estimates for the costs of customer access do not include retail costs and this should be borne in mind in any comparison with Telstra retail charges.

1.2. “Bottom-up” Modelling

The approach we have adopted in this analysis is usually described as “bottom-up” modelling. We estimate the cost of re-building Telstra’s forward looking network using modern equivalent assets, assuming the network must carry Telstra’s current (ie 1997/1998) traffic levels at the existing grade of service, and assuming that the network is operated efficiently within its existing architecture and node locations.

Two alternative assumptions exist for the specification of the network to be modelled under the “bottom-up” approach. These are usually described as “scorched node” and “scorched earth”.

As stated above, the “bottom-up” approach we have adopted involves calculating the (annualised) cost of re-building and operating Telstra’s network assuming the network structure that now exists (or that will exist within the next few years). This is sometimes

[6] Note that switching costs are only relevant to call conveyance.

[7] PSTN and leased line services share these facilities and consequently there are fixed costs that are common to the two services. Failure to take this into account will exaggerate the PSTN costs.

described as a “scorched node” assumption, since the model is based on the operator’s (Telstra’s) existing number of exchange sites and transmission links but allows for optimisation of equipment within and between the nodes. By way of contrast, under a “scorched earth” assumption, the number of exchange sites and transmission links is also optimised. If, for example, the number of exchange sites in Australia seemed excessively large, compared to other countries, there might be a case for adopting a scorched earth approach. This would ensure that the costs were not inflated by Telstra’s inefficient network design. However, in general, there are quite strong arguments for using the scorched node approach on grounds of:

- practicality - determining an “optimal” Telstra network structure would be a major task. Moreover, it is by no means clear that a unique view exists of what constitutes an optimal network;
- relevance and realism - Telstra’s current network nodes are, to an extent, imposed upon it by historical reasons. It is not necessarily reasonable (or even cost effective) to suppose that its network structure can be reorganised in the near future.

In practice, we have essentially adopted a scorched node approach, but based on Telstra's *proposed forward looking* network, which is not currently fully in place (ie the model is based on the Future Mode of Operation, or "FMO", together with Telstra's plans for bringing "Fibre To the Kerb, or "FTK")[8]. We have taken as given estimates for the number of remote units, local switch and tandem switch sites in Australia on a *forward looking* basis. With regards the numbers of transmission links, we have made estimates based on our understanding of Telstra’s forward looking network plan and planning principles.

While this approach to modelling local and tandem switches has been largely accepted[9], there has been a lot of discussion regarding the appropriate basis for the modelling of remote units. Telstra's forward looking plans for the deployment of remote units are (we can assume) based on internal plans for a least cost investment strategy. Nonetheless, it may be true that what is an optimal strategy for Telstra taking into account all of its activities (including broadband services) may not be optimal for PSTN alone. The key issue in deciding on the number of, and location of, remote units is the trade off between the costs of the access and call conveyance (or "core") networks. Telstra's plans include the deployment of a large number of relatively small concentrator units (IRIMs) which are connected to the local switch via an optic fibre link. This results in the call conveyance network being brought much closer to the customer, with a corresponding reduction in the amount of copper used in the access network. In this approach the costs of the access network are

8 The "FMO" covers the transmission network between local and tandem switches, while it is the FTK which drives the number and location of remote units.

9 Although Optus have suggested some reduction in the number of LAS sites.

reduced while the costs of the call conveyance networks increase. The model has not been designed to examine the trade off in terms of total network cost (both access and core) for PSTN services. The fact that Telstra's forward looking network structure may not be optimal if PSTN services alone were considered is something which the ACCC may wish to take into account when reviewing the final results.

1.3. Overview of the "Bottom-up" Modelling Approach

The "bottom-up" modelling approach requires the following tasks:

- specifying the physical quantities of components in an efficient, forward-looking network (eg the number of local and tandem switches, the numbers and lengths of transmission links, the number of line cards);
- estimating the required capacity of each of these components, based on traffic levels in the network (eg the numbers of ports required in the switches and the capacity of the different transmission links);
- applying costs to each of these components (both fixed costs for each switch or transmission link (dependent on route length), and variable capacity costs);
- averaging traffic related costs across the actual volume of traffic passed over each component to yield a unit cost for conveyance, and averaging line related costs over the number of access lines to yield a per line cost for access;
- aggregating the component unit costs by the use made of them by different call services (using routing factors). For example, a local switch interconnection segment uses one local switch component plus (in some cases) a transmission link between the switch and a remote unit (ie remote concentrator or remote switch).

Each of these steps will be described in more detail in the following chapters.

1.4. Network Component Based Approach

In common with other telecommunications cost modelling studies, we use a network component based approach (eg deriving costs for the different components of the network, such as local and tandem switches, and the different types of transmission links in the network). This approach is adopted for two principal reasons.

First, a component based approach is the most practical since costs are relatively easily identified on a component basis in a "bottom-up" model.

However, secondly, and more importantly, the costs imposed on the network by different forms of usage (eg local exchange interconnection or interconnection at tandem exchanges) are strictly related to the components utilised by each of these services. For example, if

Telstra provides local exchange interconnection to a competitor, it will be required to provide capacity only in its local exchanges and transmission links between local exchanges and remote units. In this case, the competitor will impose no cost on Telstra’s tandem switches. However, if the competitor received single tandem interconnection or double tandem interconnection, then the cost implications with respect to Telstra’s tandem switches and associated transmission links should be included, with more costs being incurred in the case of double tandem than in the case of single tandem. A component cost approach will achieve this.

The linkage between component costs and service costs (whether retail services such as local calls, or interconnection services such as local exchange interconnection segments) is provided by so-called “routing factors”. These simply specify the average number of units of each network component used by a particular type of service and are discussed in more detail in Section 2.2.4. Routing factors are commonly measured from traffic samples and are often already used as a means of establishing the cost of retail call services. In the case of interconnection services, many of the routing factors can often be established almost by definition. For example, a single tandem interconnection segment makes use of one tandem switch, one tandem - local transmission link, one local switch, and lastly a proportion of transmission links between the local switch and remote units (less than one due to collocation of some concentrator/remote switching units with local switches).

If costs are calculated correctly on a component basis, distance is only relevant to the extent that transmission links between network nodes vary in length (thus requiring different lengths of duct, cables and numbers of repeaters). The parts of the network where distance is likely to be a significant cost driver are in the longer distance routes for example tandem to tandem routes. Given that modelling of tandem-tandem routes is not required in order to calculate interconnection charges, we have not split out costs into distance/non-distance related components. However, in view of the fact that different area types (eg urban and rural) have different costs, we have disaggregated the costs of the remote unit to local switch links.

1.5. Fixed Shared and Common Costs

The definition of cost we have been asked to consider is total service long run incremental cost: for a new service TSLRIC measures the increase in costs causally associated with the supply of the new service at the full volume of its likely demand; for an existing service, TSLRIC measures the decrease in costs associated with discontinuing supply of the service in its entirety. Under this definition fixed costs (ie costs that do not vary with output) that are specific to the service being considered are included in the definition of costs. There are, however, two other types of cost that are also relevant to interconnection charges:

- shared fixed costs are the fixed costs associated with the supply of a group of services comprising more than one, but less than all, of a firm's services;

- common fixed costs are fixed costs that are shared by all services produced by the firm.

Examples of shared fixed costs are:

- the cost of the site for a local switch is shared between PSTN and customer access - the site hosts both line related pieces of equipment (such as line cards) and traffic related pieces of equipment (such as the switch processor). The cost of the site itself, however, is fixed and does not depend directly on either on lines or traffic;
- trenches that are shared between the access network and the core network;
- the transmission link costs in the core network are shared between leased line and PSTN services.

Classic examples of common costs are the company's headquarters and the chairman's salary.

In principle applying "TSLRIC" would imply that shared and common costs are not included in our cost estimates for interconnection services. Some kind of "mark up" over the costs estimated using TSLRIC would then be needed to ensure adequate cost recovery.

In practice in building the model we have included all costs relevant to customer access and to PSTN, ISDN and leased lines. Costs that are shared or common have then been allocated in one of several ways:

- drivers in the model may be used to determine the split of costs (for example the split of switch site costs is done on the basis of estimating the proportion of equipment costs (other than site costs) which are line/traffic sensitive and using this proportion as the basis for splitting site costs;
- a simple "rule" is used - for example the costs of portions of trench that are shared between the access and core network are split 50:50 between TS and NTS services;
- non-network costs (both fixed costs and operating costs) are estimated as a proportion of network costs and included as a mark up on network costs for each part of the network.

In this sense the model is not pure "TSLRIC". The advantages of this approach are that:

- all costs are accounted for within the model;
- costs are allocated on some reasoned basis - the alternative is to estimate some "lump" of cost that lacks any basis for allocation;

- having built in these shared and fixed costs it is then relatively easy to subtract them out again, so "pure" TSLRIC costs can still be estimated.

We can distinguish between shared/common costs which:

- could be attributed if the analysis were sufficiently detailed;
- reflect intrinsic economies of scope in providing more than one service.

The "indirect" costs in our model (eg the costs of accounting services or non-network buildings) generally come into the former category - with the adoption of a proper cost attribution method (such as activity based costing) the shared/common costs of such "overheads" would be small. The shared/common costs of the network itself generally arise from economies of scope between the core network and the access network (for example trench sharing).

In principle, we can also distinguish "intra-core" shared/common costs, for example trench sharing between remote to local switch links and local to tandem switch links. In practice the data we have received does not allow us to distinguish this (eg the estimates of duct length for different types of link provided by Telstra have already taken account of this sharing, but do not show it explicitly).

In Section 4 we discuss the proportion of network costs which are in fact shared/common and we consider the impact on the results for interconnection charges if these costs are separated out.

1.6. Economic Issues Regarding Asset-Related Costs

If the market for the provision of call origination and termination services were contestable, prices would be set so that (on a discounted basis) future revenues would exceed operating costs by an amount sufficient to recover the current gross replacement cost of optimised network assets.[10] If prices were set higher than this, entry would occur, while if they were set at a lower level there would be insufficient recovery of capital costs of the assets concerned.

An equivalent way of looking at this is that prices would be set so that future revenues exceeded operating costs by an amount sufficient to recover:

- the (optimised) depreciated replacement cost of existing network assets; plus

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[10] It should be noted that the definition of operating costs used here excludes depreciation.

- the higher costs of maintaining the service capability of old assets, relative to new ones; plus
- the cost associated with the need to replace old assets at an earlier date than new assets providing an equivalent service capability. [11]

This indicates that there are two possible ways of estimating the asset-related costs of call origination and termination services:

1. Estimate the current investment cost of an optimised replacement network. The investment cost is then multiplied by the required rate of return to obtain the cost of capital. Depreciation is derived by applying an appropriate depreciation profile.
2. Estimate the optimised depreciated replacement cost of existing network assets. Derive the cost of capital from this and apply an appropriate depreciation schedule going forward. Then estimate the difference between existing and optimised network operating costs and the additional cost associated with the need to replace old assets sooner than new ones.

While the two methods are conceptually equivalent, the information required to implement the second option is very substantial. In particular, it would be necessary to:

- define the optimised existing asset base;
- estimate the depreciated replacement cost of each of the assets. The net book value (on a current cost accounting basis) will generally not be an appropriate measure unless economic depreciation schedules have been used. This means therefore that the depreciated replacement cost would have to be estimated de novo for each and every asset;
- the efficient operating cost of existing assets would need to be estimated as well as the operating cost of new assets. In practice, data will be available for actual rather than efficient operating costs of existing assets, so that a separate assessment of efficient operating costs of existing assets would be required;
- the additional cost associated with earlier asset renewal would need to be estimated.

In contrast, the first option requires only the capital and operating costs of an optimised replacement network to be estimated, does not involve any retrofitting of depreciation

[11] The depreciated replacement cost represents the (maximum) price that a new entrant would be willing to pay for second hand assets given the savings in operating and renewal costs that are realised if brand new assets are purchased.

schedules to derive the existing (depreciated) value of assets and avoids the need to estimate the additional cost associated with earlier asset renewal.

Reflecting this, the approach that we have adopted has been to estimate the current investment cost of an optimised replacement network and then to derive the associated cost of capital and depreciation cost. This is consistent with the approach adopted in the UK and other countries when using a bottom-up modelling process to estimate LRIC for call origination and termination.

One issue that arises in this context is the question as to what is the appropriate level of trench sharing. In particular, if a new network were being constructed today, to what extent would it be possible to share trenches, and hence the associated costs, with other utilities or other telecommunications operators. The answer is likely to vary from area to area and will depend, among other things, on the extent to which different utilities and operators have the same geographical coverage, the condition and capacity of existing trenches and the extent to which they offer end to end sharing opportunities. [12] Given the uncertainty about what would constitute a realistic optimal level of trench sharing, we have conducted a sensitivity analysis of how estimated costs vary with the extent of trench sharing.

A second issue, which takes on particular importance when, as is the case with the telecommunications industry, there is substantial technological progress, is the proper measurement of depreciation. The economic value of an asset at a particular point in time is the present value of expected future revenues derived from the output of the asset less the present value of the operating costs associated with running the asset. Economic depreciation in any particular period is the change in the value of the asset during the period.

The profile of economic depreciation over time will depend on:

- changes in technology, trends in capital equipment prices and trends in the productivity of new capital assets, all of which will be reflected in the future costs of potential entrants and hence the prices that can be charged for the services provided by the assets;
- the future pattern of output, which will be affected by trends in demand, the development of substitute services and changes in market share;
- the pattern of operating costs (e.g. maintenance costs) over the life of the asset concerned;

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12 It is also necessary to reach a view of what level of trench sharing is consistent with the scorched node approach that underpins this study and which reflects the ACCC’s Access Pricing Principles.

- the cost of capital which directly affects the value of the asset and hence changes in it.

Falling capital equipment prices, increasing productivity of new capital assets, declining output and rising operating costs over the lifetime of an asset will all be associated with a higher level of depreciation (fall in asset value) when an asset is new that at the end of its life.

If the depreciation profile that is actually used fails to mirror the economic depreciation profile, this will lead to a failure to recover the cost of investment over an asset's life. This can be seen from the fact that, as price and output falls and costs increase over the lifetime of an asset, it will become progressively more difficult to finance depreciation.

Methods of depreciation used for accounting purposes typically fail to mirror economic depreciation profiles when equipment prices and output are falling over time. Whereas depreciation in these circumstances needs to be "front loaded", straight line depreciation provides an even level of depreciation over time. Annuity depreciation profiles are even less appropriate because a constant annualised capital cost (depreciation plus cost of capital) means that depreciation increases each year, i.e. it is actually "back loaded".[13] While it is possible to tilt the annuity to allow for price and output declines, it requires a large tilt to achieve a declining depreciation profile over time.

Even where asset prices are not falling over time, declining output and rising operating costs may still require a declining depreciation schedule.

In practice, where there is significant technological progress (as is expected to be the case for things like switching and multiplexing equipment) and hence reducing capital equipment prices over time, sum of the years' digits depreciation often gives the best approximation to economic depreciation.

There are two ways in which we can approach the treatment of the depreciation profile:

- derive economic deprecation profiles and use these directly;
- use proxies to economic depreciation for different asset types.

The first option is discussed in Appendix A. However, as can be seen from this Appendix, deriving economic depreciation profiles requires a number of assumptions to be made (eg the rate of future price change, the future pattern of operating costs etc). Given the

13 This is because the cost of capital element declines over time in line with the written down value of the asset. Annuity depreciation profiles are appropriate if the value of output can reasonably be expected to remain constant over the life of the asset. This is why they are typically used in the case of mortgage repayments and leases.

uncertainties regarding these assumptions we have not used these economic profiles in the main body of the report. Instead we have used the economic depreciation profiles we have derived as a guide to deciding the best proxy to economic depreciation for different asset types. For each asset type we have assigned the depreciation schedule that most closely approximates economic depreciation (the detailed assignment can be seen in Tables B.1 and B.2 in Appendix B) and it is these profiles that we have used in calculating the key results in the report (though sensitivities on depreciation methods are also reported). The shapes of the profiles derived in the Appendix suggest:

- straight line depreciation is a reasonable proxy for assets where there is little technological change (eg trenches, accommodation and copper cable);
- sum of digits depreciation is a reasonable proxy for assets where there is significant technological change (eg switches, line cards, transmission electronics, optic fibre).

The results that we present are mainly "year one" prices relevant for the year 1997/98. The ACCC, however, will be considering a price that will remain in place for a number of years. We would expect that prices should reduce in real terms over time:

- technological and economic progress will reduce new entrant costs;
- increased volumes (numbers of customers and traffic) will reduce the unit cost of access and conveyance as there are economies of scale in telecom networks.

These factors should be borne in mind in considering an appropriate price to remain valid for a number of years. We have also run sensitivities to consider the difference between year one pricing and an average over prices in the first four years.

1.7. Approach to Data

In the draft report we relied to a considerable extent on data provided by Telstra (although some data, particularly on investment costs, asset lives and operating costs, from other operators was taken into account and NERA also used some data from its international experience). We have now had the opportunity to review both Telstra's comments on the use we have made of the data they provided and comments from other industry participants on those aspects of the data which they did not believe to be appropriate.

This exercise has allowed us to clear up some misunderstandings regarding the data provided by Telstra. We have also asked Telstra to provide further data for those areas where the input assumptions are particularly important.

The consultation exercise has also provided us with valuable input from other industry participants.

Where we have been able to form a view of the most appropriate basis for moving forward, the relevant changes have been made to the model. However, in a number of cases the issues are not clear cut. In these cases we have run the model under a variety of input assumptions. This approach allows us to:

- understand better those parameters which are important for the end result and those which are less important - one outcome of this is to highlight those areas where it may be worthwhile pursuing better data in future;
- determine a range of values for our results, rather than a point estimate.

One of the areas where it is difficult to reach firm conclusions is the appropriate network provisioning rules (or the amount of spare capacity). In reality there is a trade off between investment costs on one hand and a combination of operating costs and service standards on the other. Within the model this trade off is not explored:

- operating costs are modelled in a relatively simple way - we have not carried out the detailed analysis that would be required to understand how operating costs increase as spare capacity decreases;
- to take service levels into account a detailed cost/benefit analysis would be required.

Without examining this trade off it is difficult to comment on whether Telstra's provisioning rules are "efficient", though comparisons with other operators elsewhere may help provide benchmarks.

A further point regards the time scale over which the investment is considered. Building in extra capacity for expected future growth may well be a sound business strategy particularly where the marginal cost of providing spare capacity at the time of the original installation is relatively low compared to the cost of adding additional capacity at a later stage (additional copper pairs are a good example of this). However, this still leaves the question of who pays for this - ie are costs recovered now or in the future if and when services are taken up. In principle, additional costs associated with the future provision of services should be recovered from future customers. This would require that this additional provisioning (as opposed to provisioning for faults say) be separately identified.[14] This is not straightforward.

The approach we have adopted in practice is to use a range of values and to examine the consequences for the results. It is worth noting that, given the economies of scale inherent in

[14] There is a need to distinguish between the margin for (uncertain) growth over the next year and capacity to provide service over a longer time period. The former gives rise to a cost that should be recovered now, while the latter gives rise to a cost that should be recovered in the future.

the cost of a number of elements, the additional cost of extra provisioning is not as great as might at first be thought.

Other areas where there is uncertainty are trench and cable lengths, and trench sharing. Again we have explored sensitivities for these quantities.

2. ASSUMPTIONS

We have modelled Telstra's network under the assumptions of full digitalisation of switches and a full SDH network.[15] This is appropriate given that the model is based on Telstra's FMO plus FTK.

We use the following terminology:

- "IRIM" denotes a remote concentrator;
- "RSS/RSU" denotes a remote switch;
- "RAU" denote a remote access unit, which may be either an IRIM or an RSS/RSU;
- "LAS" denotes a local switch;
- "TS" denotes a tandem switch.

2.1. Network Architecture

It is assumed that customers are located in one of five geographical area types as follows:

- CBD;
- Metropolitan;
- Provincial;
- Rural;
- Remote rural;

which range from "CBD", describing the densest customer inner city areas, to "remote rural" describing areas with very low customer density.

The following sub-sections look in more detail at the assumptions made regarding:

- the access network;
- switching;
- the different parts of the transmission network.

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15 The use of PDH on some low capacity routes is also considered as an option.

2.1.1. Access network

We have modelled the costs of a line from a customer site up to the first switching unit (which may be a remote concentrator (IRIM), a remote switch (RSS/RSU) or host local switch (LAS)). In principle we can consider two types of access:

- copper local loop;
- fibre local loop;
- radio.

Copper access will be by far the most common form of access. However, radio access is relevant for some remote rural areas. Fibre will be relevant mainly for large business customers, who make up a small proportion of all customers.

Customer connection may be one of several types:

- CBD - customers connect directly to the LAS;[16]
- Metropolitan, provincial and rural - customers connect to a remote unit (IRIM or RSS/RSU);
- Remote rural - customer have a radio connection to an IRIM.

Telstra have provided the following information (see Table 2.1) for each area type:[17]

- typical distance from the customer to the first switching stage;
- for connections direct to an LAS or to an RSS/RSU a pillar is used, and the distance from the customer to the pillar has been given;
- the proportion of lines for each area type and each connection type;
- customer density by area type.

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16 In this case an RSS/RSU unit is co-located with the local switch .

17 In these figures, the radial distance from the customer to the MDF has been increased by a factor of 1.27 to take account of the fact that trench routes cannot in practice follow a direct "as the crow flies" route. This uplift figure was provided to us by HAI acting on behalf of Optus and is consistent with NERA experience elsewhere.

Table 2.1
Proportion of Lines and Typical Distances, by Area and Connection Type

Area type	Connection type	Proportion of lines	Typical distance in m	Distance from customer to pillar in m	Density (SIO/Sq km)*
CBD	to LAS	4.83%	754		9,279
Metropolitan	to IRIM	20.82%	359		121
	to RSS/RSU	47.39%	638	269	
Provincial	to IRIM	5.47%	359		9.5
	to RSS/RSU	10.18%	638	269	
Rural	to IRIM	5.12%	2,811		0.15
	to RSS/RSU	5.94	638	269	
Remote rural	Radio access	0.26%	80,000		

Source: Telstra
** Density figures are for each area type, not by connection type. The overall density figure is 1.3.*

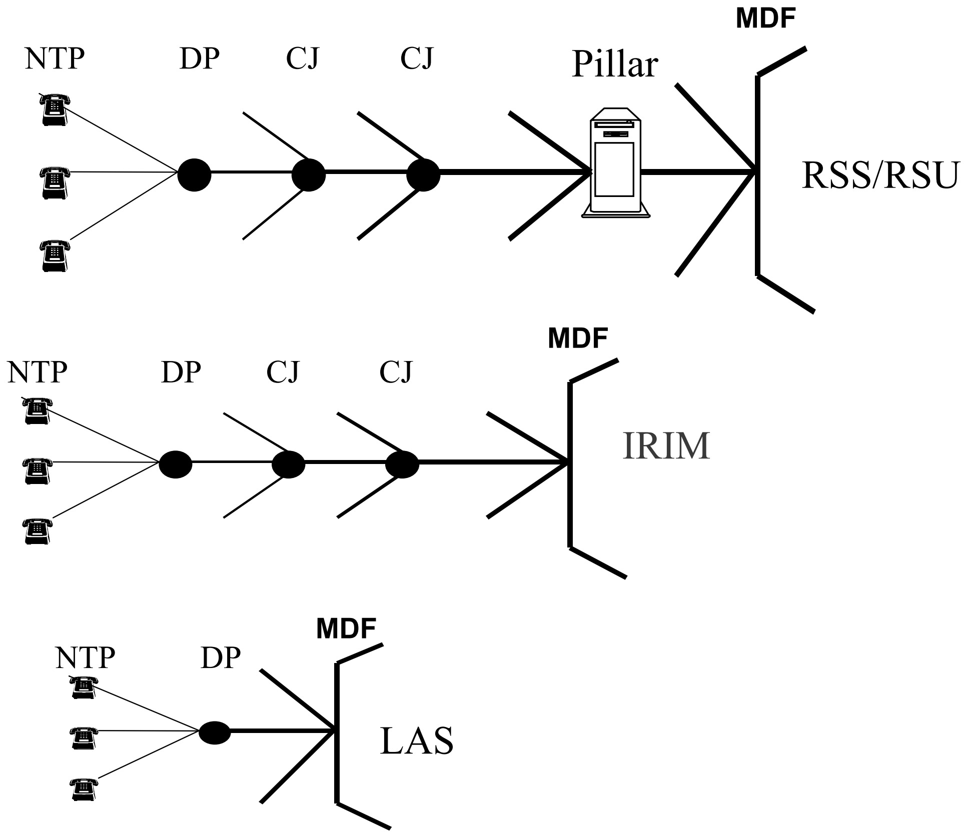
2.1.1.1. Copper access

The architecture that we have modelled is illustrated in Figure 2.1. The network has a "tree and branch" structure, and each section of the network is characterised by cables of different typical sizes. The structure differs according to the type of unit which a customer connects to.

We have assumed that the link from the customer up to the main distribution frame (MDF) at the first switch site (which may be an IRIM, RSS/RSU or LAS) is made up of the following sub-links:

- the network termination point (NTP) within the customers premises;
- a dedicated single copper pair running from the customer site to the distribution point (DP);
- a multi-pair cable running from the DP to the first cable junction (CJ);
- a number of different sections made up of multi-pair cables running from CJ to CJ;
- for connections which use an RSS/RSU, a pillar is used;
- there is a final multi-pair cable running from the last CJ/the pillar to the MDF (there may also be additional cable jointing between the pillar and MDF).

Figure 2.1
Access Network Architecture



An important cost driver is distance, and we have characterised each area type by the "typical distance" listed in Table 2.1.

It is then important to know the proportion of the access network which uses cables of different sizes. One way of doing this is to explicitly sub-divide the "typical distance" to give the proportion of the route using different cable sizes.

Telstra have not provided data to us in this form. Instead they have carried out some analysis that indicates that *on average* the cable size in the "distribution network" (ie that part of the access network running from the customer site to the IRIM or pillar) is 47.5 pairs.

Telstra's estimate of the average cable size in the "feeder" network (ie that part of the network running from the DP to the LAS for CBD areas or from the pillar to the RSS/RSU in other areas) is 580.

We have not explicitly modelled the cable junctions or pits. Instead Telstra have provided an estimate for cable costs which rolls in the cost of cable junctions and pits and based on averaging over different cable sizes (with an average cable size of 47.5 pairs). This implies an uplift of around 7% on the pure cable cost. We have used the same uplift for cable in the feeder network.

The costs per customer are derived from:

- the cost of the network termination point (NTP) - this cost is customer specific;
- the cost of the "final drop" - this cost is customer specific;
- the cost of copper cables (of varying sizes) leading up to the MDF - these costs are shared;
- the cost of the distribution points and the cable junctions (these are implicit in the "average" cable cost) - these costs are shared;
- the costs of trenching - these costs are shared;
- the cost of the pillar if appropriate - this cost is shared;
- the cost of a line card at the switch/concentrator site - this is a cost per customer (though the cost of "sparing" is shared);
- a proportion of the cost of the switching/concentrator site - these costs are shared.

The number of copper lines installed in the access network is not the same as the number of end user lines , or "services in operation" (SIO). Additional capacity is installed to cover for growth margins, sparing for faults etc. Telstra have indicated that provisioning of copper pairs is as follows:

- in the distribution network (between the customer and the IRIM or pillar) 2 copper pairs are installed for every 1 SIO;
- in the feeder network (between the pillar and the RSS/RSU or LAS) 1.66 copper pairs are installed for every 1 SIO.

However, other operators have suggested lower figures are appropriate. In particular Optus has put forward data that suggests the figures should be 1.33 pairs per SIO in the distribution network and 1.25 pairs per SIO in the feeder network.

Telstra have provided data regarding the size of a pillar as used in their network. Typically a pillar can accommodate up to 5 x 100 pair cables coming in from the distribution network and 3 x 100 pair cables going out to the feeder network (fewer cables are required on the feeder network side as there is less spare capacity in this part of the network). Pillar utilisation on average is given as 70%. If the level of spare line capacity were to be reduced then this utilisation would drop even further - in practice in this case we would expect a smaller sized pillar would be installed.

At the switch or concentrator site, copper lines connect to line cards. The number of line cards is related to the number of SIO with additional cards being provided to allow for growth margins and sparing. The rules used by Telstra in providing line cards are as follows:

- at an IRIM 1.3 line cards are provided for every SIO;
- at an RSS/RSU (either remote or co-located), the average occupancy is 85%, so 1.18 line cards are provided for every SIO.

Again other operators have suggested lower figures may be appropriate. Optus have suggested a figure of 1.13 be used for both IRIMs and RSS/RSUs. Telstra's figures are driven by 2 features: the intention to install spare line cards to cover for faults and the modularity of the line card panels which they purchase (each panel contains 60 line cards). The modularity has a relatively greater impact on the IRIMs as these have a lower capacity.

As regards trenching, as well as costs being shared between the PSTN and private circuit customers using the trench, there are further opportunities for sharing:

- trench may be shared between the access and the core network;
- each trench may hold several access cables;
- trench may be shared with other services (for example cable TV or utility services).

Data provided by Telstra suggests:

- the average number of additional utilities sharing the trench is 0.075;[18]
- the average trench sharing is 10% for the feeder cable;
- the average number of cables in a distribution cable conduit is 1.24 cables;
- there is some sharing of trench with the core network - see section 2.1.3.

There is also trench sharing with Foxtel (Telstra's cable TV subsidiary). Optus have estimated the total length of trench which is shared to be 14,000km (in Metro areas). This also seems to be consistent with comments provided by Telstra's.

Finally there will be a limited amount of trench sharing with other telecommunication operators. Estimates from Optus suggest the extent of this is small in relation to Telstra's

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[18] Trench sharing with other utilities only occurs in the distribution network. In new estates the number of additional utility cables sharing the trench is on average 1.5. However, new estates account for only 5% of the distribution network.

total trench length, though the proportion in CBD areas is nonetheless relatively high. The distances provided by Optus for the length of trench which is shared are as follows:

- CBD = c-i-c km;
- Metropolitan = c-i-c km;
- Provincial = c-i-c km.

We have taken these distances as being shared with the access, rather than the core network (in practice we would expect some sharing with both networks).

We note that where cable is ploughed, there is no trench sharing. We have assumed that in rural areas all cable is ploughed.

The data underlying our estimates for costing the access network is not as precise as would be hoped implying that there will be some uncertainty in the end results. One point in particular which we note is the fact that many parameters are provided as a single average over all areas, where in practice we would expect the numbers to vary by area type. In particular we would expect that: cable size (both distribution and feeder) and cables per trench would vary by area type. In general we have not adjusted for this (instead we do some broad sensitivities on trench and cable lengths).

We have at a late stage been provided with direct estimates for trench length by areas type by both Telstra and Optus. For CBD areas there is reasonable agreement on the figures and the figures also agree with analysis carried out by the ACCC. We have in this case adjusted the input parameters in the model to ensure that the model results are consistent with these estimates (this is achieved by increasing the number of cables per trench to 2.25). For other areas, Telstra and Optus estimates do not agree. Furthermore Telstra's estimates are not consistent with the data provided on cable sizes and typical distances. For these reasons we have not used these trench length estimates directly, though we comment on the comparison with the model results.

A question arises regarding the costs of the "final drop" (including the NTP), ie the customer specific costs incurred when there is a new connection. We would normally expect that the cost of new connections are fully expensed in the year in which they occur, ie they are treated as an operating cost rather than a capital cost. The total annual operating cost that arises as a result of the final drop is then the sum of:

- the capital cost for new connections in the year;
- the annual operating cost for all final drops.

Telstra have estimated that gross new connections as a proportion of all connections is around 3.1%. The alternative approach would be to capitalise all connections and then annualise this. In practice the approach adopted makes very little difference to the end result and we have retained the "operating cost" approach.

2.1.1.2. Radio access

In remote rural areas access via radio links is more cost effective than copper wire.

It has not been possible to obtain data in a disaggregated form to allow a proper modelling of these costs, although both Telstra and Optus have provided estimates of typical investment costs.

We have treated rural and remote rural customers as a single category and have taken account of the additional costs of radio access by using a simple multiple of the investment cost per rural customer. We have used a multiple of 5, implying a total investment cost per remote rural customer of around $10,000. This is a somewhat arbitrary assumption, though given the relatively small number of remote rural customers the impact on the end result is not that big.

2.1.1.3. Fibre access

Given that only a small number of customers use fibre access for PSTN services we have not modelled this. See section 3.3.1 for further discussion.

2.1.2. Switching

2.1.2.1. Switch nodes

The assumptions we have made about the number of switch nodes are shown in Table 2.2.

Table 2.2
Number of switch nodes

Type of node	Forward looking number of units	Forward looking number of sites
IRIM	16,863	16,863
RSS/RSU* (remote)	4,629*	1,020
LAS	191	135
TS	20	20

Source: Telstra

* *Telstra's data had a total of 4,980 units and 1,155 sites - this includes co-located RSS/RSUs and hence the number for remote units has been reduced by the ratio of the number of lines using a remote RSS/RSU to the total number of lines using an RSS/RSU, and the number of sites has been reduced by the number of LAS sites.*

The figures are based on analysis carried out by Telstra of the equipment that will be required under the FMO and FTK (they do not relate to the number of pieces of equipment currently in the network). We understand that the number of IRIMs and RSS/RSUs is determined with reference to the assumption that customers are connected to an IRIM if they are located more than 2 km away from the location of an RSS/RSU site (or if they are in a small rural exchange service area). Customers are connected to an RSS/RSU if they are within 2 km of an RSS/RSU site. We note that where IRIMs are used, traffic from these feed into a MUX located at an RSS/RSU site. IRIMs are not co-located (as an IRIM can be thought of as a piece of street furniture there is no site cost as such, though the cost of an IRIM does include some "civils" cost).

From the number of IRIM and RSS/RSU units together with the number of customers attached to these equipment types, we can estimate the utilisation rates. Using the figures in Table 2.1 we can see that 32% of customers connect to an IRIM, ie a total of 3.2 million customers. An IRIM can accommodate up to 480 line cards, implying a maximum capacity of 8.1 million services - actual utilisation is then around 40%. This figure is driven by the modularity of the equipment and the dispersion of population in the areas where IRIMs are used. Reducing the number of IRIMs (and increasing their utilisation) would imply greater lengths of copper in the access network (as the remaining IRIMs would have larger catchment areas), and lower lengths of optic fibre. IRIMs can also be obtained in a smaller 180 line size, though we have not received cost data for these and they are not included in the model. Use of these units would increase the utilisation rate (and lower the costs) somewhat, though the effect is not likely to be very significant.

The remaining 68% of customers (6.8 million) connect to an RSS/RSU unit (which may be either located remotely or co-located with the LAS). Up to 2,048 line cards can be accommodated at each RSS/RSU unit, implying a maximum capacity of 10.2 million services. The actual utilisation is then around 68%of maximum capacity.

2.1.2.2. Signalling and synchronisation

Associated with the costs of switching are the costs of signalling and synchronisation. These costs are included in the costs of LAS and TS switching.

For the signalling system we have assumed that there a total of 20 Signalling Transfer Points (STP), and the total cost is simply the number of STPs times the unit cost.

For synchronisation we have assumed a total of 4 clocks (or PRCs) are needed. In addition to the cost of these we have included cost elements for:

- synchronisation (SSU) costs;
- synchronisation (SSU) licence.

2.1.3. Transmission network

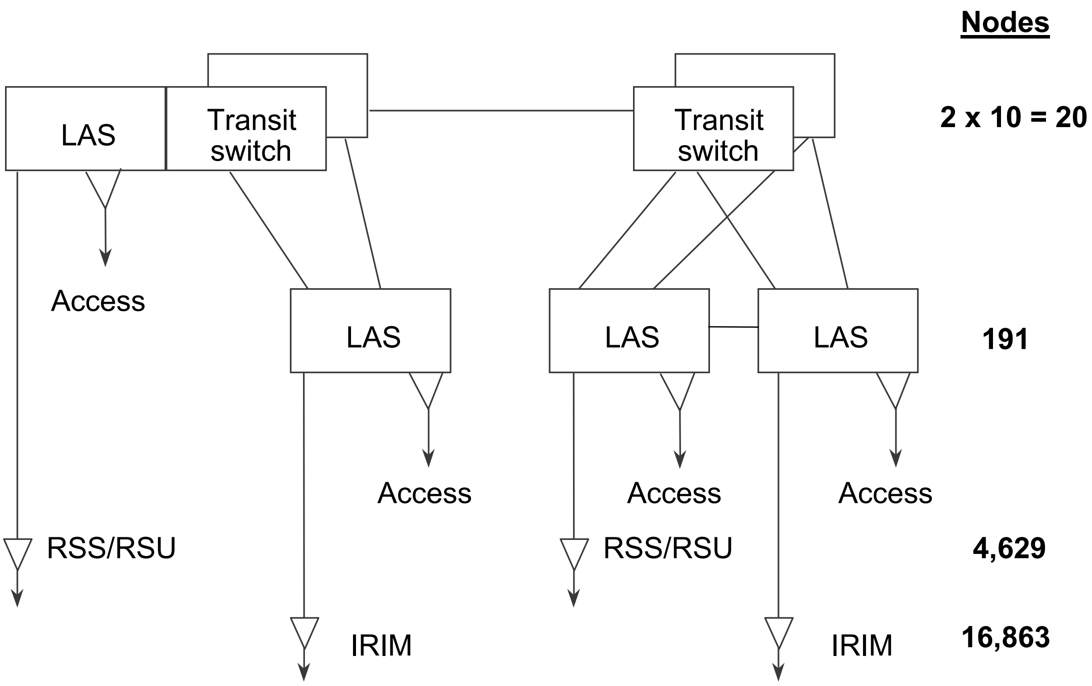
The transmission network includes the following;

- links from an IRIM (via a MUX) to the LAS;
- links from an RSS/RSU to the LAS;
- LAS-LAS links;
- LAS-TS links;
- TS-TS links.

We have assumed that SDH is used throughout the network apart from on IRIM-MUX links where the least cost solution is explicitly considered (we consider it unlikely that SDH will not be the cheapest solution elsewhere).

A schematic of the network is given in Figure 2.2 (this is shown as a simplified "point to point" structure - in practice the network consists mostly of SDH rings).

Figure 2.2
Schematic of Telstra Core Network



In the network IRIMs are linked to a "point of confluence" via a point to point link. The point of confluence is generally at an RSS/RSU site and the multiplexer at the site can therefore be sized to take account of all of the traffic (IRIM plus RSS/RSU). The total number of points of confluence is given by Telstra as 1,075 (slightly greater than the number of RSS/RSU sites). A number of these points are then linked in an SDH ring which also contains LAS sites. The number of SDH rings is 320. Further up the hierarchy, there are SDH rings which link LAS and TSs.

The transmission network costs consist of the following:

- the trench costs, which will be driven by trench length and areas types. There will also be some sharing of trench costs between different sections of the network, which will reduce overall costs;
- cable costs, which will be driven by cable size and cable length;
- the numbers of units of, and costs of, the electronic equipment required for multiplexing, cross connects, repeaters etc.

The information we have from Telstra relates to the drivers for duct costs - as a significant proportion of fibre is "ploughed" and not in ducts this does not give us the total trench length. We have been given a figure of 68,400 km for the total core network duct distance, which is split 96% RAU to LAS, 3% LAS-LAS and 1% LAS-TS. For TS-TS links the duct distance is close to zero (though the ploughed trench will clearly be significant). We were not initially provided with data for the ploughed trench lengths, though at a late stage Telstra have given us data both subdividing the duct lengths further and for ploughed trench.[19]

We have been given the information shown in Table 2.3 on trench sharing between CAN and transmission fibre by area.

Table 2.3
Duct and Trench Sharing

Area	% of fibre ring in ducts	% of ducts in shared trenching
CBD	100%	100%
Metro	90%	40%
Provincial	40%	10%
Rural	10%	

Fibre that is not in ducts is assumed to be ploughed in

Telstra have also provided us with data relating to typical distances for IRIM to LAS links and RSS/RSU to LAS links by area type. These figures are given in Table 2.4.

Table 2.4
Average Distances in km

Area	IRIM-MUX	MUX-LAS	IRIM-LAS (total)*	RSS/RSU-LAS
CBD	n/a	n/a	n/a	n/a
Metro	4.3	8.6	13.0	9.8
Provincial	12.8	25.6	38.4	34.6
Rural	40.4	80.8	121.1	121.2

**The figures in this column are just the rounded sum of the figures in the previous 2 columns.*

Average distances for LAS-LAS and LAS-TS links were not provided by Telstra. We have used: LAS - LAS distance = 50km and LAS-TS distance = 100 km (these were based on the sorts of distance seen in other countries, together with trying to ensure that the trench sharing factors implied by Telstra's duct km seemed reasonable). These two assumptions make very little practical difference (which is why we did not pursue more accurate data with Telstra) - the key cost drivers are the total physical duct and trench lengths for each type of link (see above).

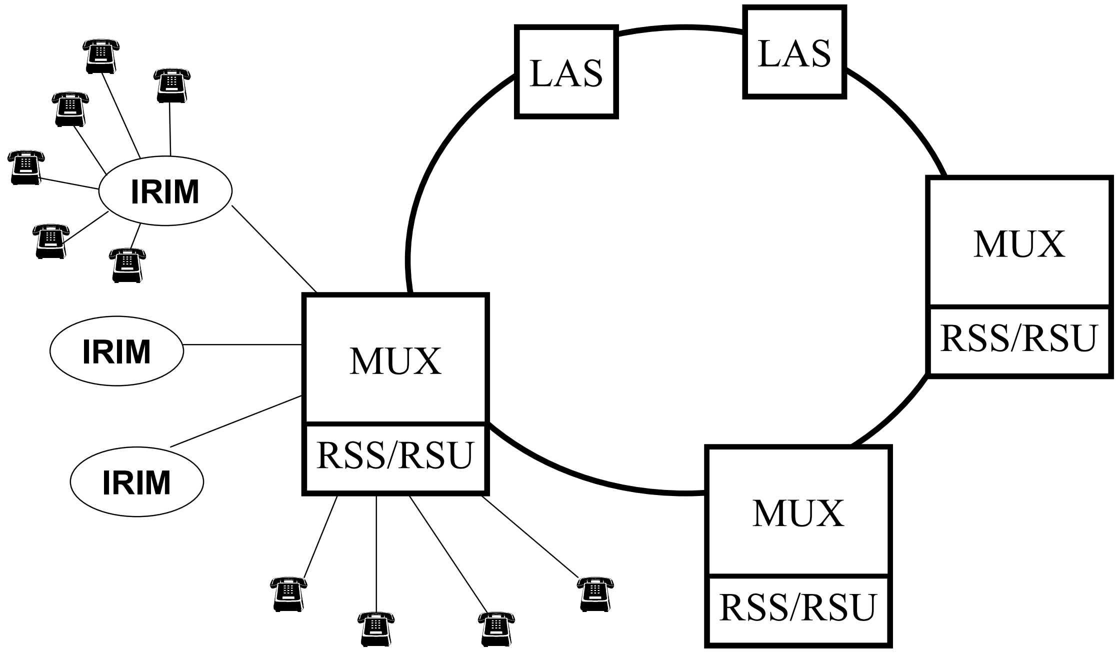
We discuss each part of the network (and how we use Telstra's data) in more detail in the following sections.

2.1.3.1. Remote to LAS links

In all areas apart from CBD, customers link first to a remote unit, and we have modelled the transmission links from this remote unit up to the LAS (see Figure 2.3).

19 We have not used this data directly, though comparisons of the model results with Telstra's estimates are commented on.

Figure 2.3
Schematic of Telstra Network - Remote to LAS links



For this modelling the following are required:

- estimates of trench length - Telstra have provided a figure for total duct length for remote units to LAS - this needs to be allocated by connection type and area, the length for ploughed trench needs to be deduced and trench sharing with the CAN needs to be taken into account;
- estimates of cable length - Telstra have not provided data on this and we have modelled cable length by assuming there are 2 cables per trench;
- number and size of multiplexers.

For each area and connection type, the duct and trench lengths for remote access unit - LAS ("RAU"-LAS) links have been approximated using the following steps:

- calculate the total number of "logical" routes for each connection type (for IRIM-LAS this is equal to the number of IRIMs etc);
- calculate total logical route length by area and connection type using the number of logical routes split by area type according to the proportion of customers by area and the typical route length by area and connection;
- calculate the total logical duct route length by area and connection type using the % of fibre ring in ducts figures provided by Telstra;

- allocate the total actual duct length for RAU-LAS by connection type according to logical duct route lengths;
- calculate a trench sharing factor for ducted routes as the ratio of logical duct length over actual duct length;
- it is assumed that this "trench sharing" factor can also be used for buried trench and total trench length is calculated as logical route length/trench sharing factor;
- trench sharing with the access network is calculated using the % of ducts in shared trenching figures provided by Telstra (it is assumed that where duct/trench is shared 50% of the costs are allocated to access and 50% to conveyance);[20]
- finally this gives estimates of trench (split into duct and ploughed) by area and connection type, taking account of trench sharing with the access network.

Clearly this involves a fair degree of approximation and simplification, both in deducing the ploughed trench length and in allocating the duct and ploughed trench lengths between areas and connection types. Given that we have now received data from Telstra, the model results can be compared with these figures.

For the IRIM - MUX links we have considered two possibilities: using STM1 (but partially equipping this where the full capacity is not required) and using PDH. The annualised costs of these options can then be compared.

The RSS/RSU sites provide "points of confluence" where traffic flows from several IRIMs together with that from the RSS/RSUs on the site are multiplexed together and sent on to an LAS. The size and quantity of multiplexing equipment can be estimated in one of 2 ways:

- traffic per SDH ring can be calculated from total capacity required and the number of rings - each ring can then be sized to provide this average capacity;
- the SDH rings can be proxied by point to point links - the advantage of this approach is that it allows a more detailed modelling of capacity over different routes.[21]

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20 Note there is no trench sharing with the access network for ploughed trench.

21 We have modelled the capacity distribution for routes from the MUX to LAS (for an IRIM - LAS link) and for routes from an RSS/RSU to LAS. These distributions have been estimated using data provided by Telstra. The data provided by Telstra gives the number of lines per MUX site and per RSS/RSU site. Using an average figure for minutes of conversation per line, and a typical figure for number of minutes per 2Mbit/s we can estimate the number of 2Mbits/s per route. The information for each individual MUX site and RSS/RSU site can then by turned into a "distribution" by calculating the number of routes with capacity between given limits. This calculation is used to determine the shape of the distribution only - the actual capacity requirements are

We have adopted the first approach, but the second approach has also been considered as a cross check (the overall difference in costs in the two cases is small).

2.1.3.2. *LAS-LAS and LAS-TS links*

For calls that go outside a customer's "own exchange" area, calls will be routed from the first LAS to a second switch, which may be either an LAS or TS. Again there are SDH rings connecting LAS and TSs.

For the modelling of LAS-LAS and LAS-TS links we require:

- an estimates of trench length - Telstra have provided an estimate of the total duct length for LAS - LAS and LAS-TS, but not of the ploughed trench length;
- Telstra have not provided any estimates for total cable length - we have modelled this by assuming there are 2 cables per trench and multiplying trench length by number of cables per trench;
- number and size of multiplexers.

The total duct length needs to be broken down according to the type of area that is crossed. We do not have estimates of this from Telstra and have had to put in assumptions - these can be varied as a sensitivity on the base case results. For the base case we have assumed that the proportion of duct length by area type is as shown in Table 2.5.

Table 2.5
Proportion of Duct Length by Area Type

Area type	LAS-LAS	LAS-TS
CBD	5%	0%
Metropolitan	10%	0%
Provincial	10%	0%
Rural	75%	100%

Source: NERA assumptions

These figures are based on the assumption that we would not expect that much of the trench for these types of link will actually cross dense urban areas.[22] Using these assumptions we

determined in the main model and the capacity figures in the distribution are rescaled to ensure the correct total amount of capacity is provided for.

22 We can contrast short distance links (eg the link from the customer to the first switching stage) where the area type for the duct will generally be the same area type as the location of the customer, to long distance links (such as TS-

can follow similar steps in allocating duct lengths by area types, and in deducing ploughed trench lengths, as for the RAU-LAS links.

Again we can model the multiplexing equipment in one of two ways - the choice of method makes little practical difference to the results.

2.1.3.3. TS-TS links

The final part of the network is the TS-TS links. It is our understanding that this type of link does not form part of any interconnection service, and hence in principle need not be part of the model.

Nonetheless, we have included this type of link for the following reasons:

- it adds flexibility to the model should this be needed at a later stage;
- it ensures that any cost sharing is taken into account (eg trenching sharing[23]).

We have adopted the following procedure:

- in the absence of trench figures from Telstra we have made some crude estimates based on a map of the long distance network - this would need to be reconsidered if these figures were to be used in earnest (note that it is assumed that 100% of trench is ploughed);
- we assume that there are 3 cables per trench and calculate total cable length as trench length times 3;
- multiplexing equipment is determined by the average capacity per route;[24]
- the number of routes is calculated assuming complete intermeshing of 10 TS pairs.

TS) where virtually none of the trench length is across urban areas (reflecting the fact that urban areas cover only a very small proportion of total area). LAS-LAS and LAS-TS links are intermediate between these two extremes.

23 In practice as we have not had detailed trench km figures from Telstra, it is difficult to say anything about trench sharing.

24 This is a simplification - ideally we would have estimated a distribution based on traffic data. In view of the fact that this section of the modelling is not as crucial we have not pursued obtaining the data we would require to do this from Telstra, however the functionality is there to improve this at a later stage.

2.2. Traffic and Lines

Once the network architecture has been established, it is then necessary to analyse the number of lines in the access network and traffic flows in the core network.

The number of lines in the access network is based on:

- the number of PSTN access lines;
- the number of ISDN access;
- the number of leased lines.

To ensure that all access lines are counted consistently, "routing" factors are defined that take account of the fact that:

- PSTN and ISDN lines have a single end (at the customer's premises);
- leased lines have two ends - one at each of the sites that are connected.

Traffic flows are needed in order to be able to determine the capacity requirements. This involves three stages:

- estimates of numbers of originating calls of different types;
- estimates of leased line capacity
- application of routing factors to each call type to estimate network component usage.

2.2.1. Number of lines

For 1997/98 we have estimates for the number of lines from Telstra as follows:

- PSTN = 9,954,800;
- ISDN = 152,604;

The total number of 64Kbit equivalent access line ends for leased lines is given by Telstra as c-i-c.

Routing factors in the access network are based on the proportion of customers with different connection types for different areas (ie direct to LAS, to RSS/RSU and to IRIM). The sum over routing factors in the access network for all connection types is 1 for PSTN and ISDN lines (which have one end only) and 2 for all leased lines (which have two ends).

The above figures all refer to end to end lines.

2.2.2. Originating calls of different types

Figures for Telstra's conversation minutes and successful calls are shown in Table 2.6 and Table 2.7. These figures represent annual figures for the year 1 July 1997 to 30 June 1998.

Table 2.6
Conversation Minutes for 1997/98

Type of call	Number of minutes
Local call minutes	c-i-c
Trunk call (STD) minutes	c-i-c
International call minutes - outgoing & incoming	c-i-c
Call to mobile minutes	c-i-c
Call from mobile minutes	c-i-c
Toll Free Local minutes	c-i-c
Toll Free Long distance minutes	c-i-c
ISDN Local call minutes	c-i-c
ISDN Long Distance call minutes	c-i-c
Interconnect: local call minutes	c-i-c
Interconnect: Long Distance call minutes	c-i-c
Total all minutes	c-i-c

c-i-c = commercial-in-confidence information removed

Table 2.7
Successful Calls for 1997/98

Type of call	Number of successful calls
Local call attempts	c-i-c
Trunk (STD) call attempts	c-i-c
International call attempts - incoming & outgoing	c-i-c
Call to mobile attempts	c-i-c
Call from mobile attempts	c-i-c
Toll Free Local call attempts	c-i-c
Toll Free Long distance call attempts	c-i-c
ISDN Local call attempts	c-i-c
ISDN Long Distance call attempts	c-i-c
Interconnect: local call attempts	c-i-c
Interconnect: Long Distance call attempts	c-i-c
Total call attempts	c-i-c

c-i-c = commercial-in-confidence information removed

2.2.3. Leased line capacity

The estimate of the amount of leased line capacity is important in that it is assumed that costs which are common to switched traffic and private circuits are shared in proportion to the amount of capacity for each service.

To estimate the amount of capacity, we need estimates of the number of and average capacity of leased lines for each line type. Figures from Telstra indicate that the number of leased lines of different types are as follows:

- 2Mbit/s links: c-i-c retail, c-i-c carriers, c-i-c mobile and c-i-c own use;
- Network Connected Leased Lines: c-i-c
- Private Lines: c-i-c
- Tie Lines: c-i-c

The total number of 2Mbit/s links including figures for retail, carriers and mobile, but excluding Telstra own use is c-i-c. If the leased lines used by Telstra for the mobiles network are excluded then the number of 2Mbit/s links becomes c-i-c. Where leased lines share duct and cable with PSTN services it appears appropriate to allocate these shared costs across the two services, and in the base case of the model the shared costs are allocated on the basis of the relative amount of capacity provided. An important question is to understand to what extent the mobile leased line links (which are used to connect a mobile base station to a mobile switch) also share duct and cable with the PSTN network. Telstra have indicated that these links would not usually share duct with IRIM-LAS links, but have been unable to provide information on the degree of sharing with other link types. In what follows we have included the mobile links.

We have assumed:

- 2Mbit/s links have a capacity of 2Mbit/s (true by definition);
- all the other lines have on average a capacity of 32 KBit/s (information provided by Telstra indicates that the average capacity of these lines is less than 64 KBit/s, but does not provide us with an accurate estimate).

We note that leased line capacity is dominated by the 2Mbit/s links, and hence that the assumption for capacity/line for the other lines is less important than it might otherwise be.

2.2.4. Network component usage

The analysis requires the estimation of traffic passing over different components of Telstra's network. This depends on routing factors for each call type.

Starting with the links from remote units to the LAS network, data from Telstra (Table 2.1) indicates that 32% of lines connect to an IRIM and 64% of lines connect to a remote RSS/RSU. This implies, for example, that international calls (with only one domestic end) will pass over an average of 0.32 transmission links between an IRIM and an LAS. Domestic calls, on the other hand (with two domestic ends), will pass over an average of 0.64 such links.[25] Similar considerations lead to the derivation of routing factors for RSS/RSU to LAS links and for the IRIM and RSS/RSU themselves.[26]

Routing factors for other components can be built up from a description of the possible routes a particular type of call may take, and the relative frequency of each route. For each route the number of components used by the call can be listed and routing factors are calculated as the average number of components used, weighted by the frequency of the route.

For each route the number of components used can be defined very simply, and this is illustrated in Table 2.8.

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25 This can be shown by considering all possible routings together with their frequency.

26 These routing factors are based on nation-wide traffic. For interconnection we also consider routing factors by area type, where the routing factors relate to the proportion of lines within a given area, using a given type of connection (eg routing factors for IRIM - LAS = 0 for CBD, 0.31for Metro, 0.35 for Provincial and 0.48 for Rural).

Table 2.8
Component Usage for Different Routes

Route	LAS - LAS	LAS - TS	TS - TS	LAS	TS
End to end calls					
A - LAS - B	0	0	0	1	0
A - LAS - LAS - B	1	0	0	2	0
A - LAS - TS - LAS - B	0	2	0	2	1
A - LAS - TS - TS - LAS - B	0	2	1	2	2
Single end calls*					
A - LAS	0	0	0	1	0
A - LAS - LAS	1	0	0	2	0
A - LAS - TS	0	1	0	1	1
A - LAS - TS - TS	0	1	1	1	2

* *for mobile calls there is an additional link to the gateway - this is assumed to be equivalent to an additional LAS-TS link, ie the routes are A - LAS - gateway (using 1 "LAS-TS"), and A - LAS - TS - gateway (using 2 "LAS-TS").*

We have examined Telstra estimates for routing factors of different types of call and have checked that these are consistent with a breakdown into the kinds of routes in Table 2.8 - we have checked for internal consistency as well as efficient routing (ie there are no more than 2 switches per call). In Table 2.9 we have listed the assumptions implicit in the routing factors provided by Telstra.[27]

[27] The model in fact uses the routing factors provided by Telstra directly. Table 2.8 provides a means of checking that the routing factors provided are consistent.

Table 2.9
Assumptions Implicit in Routing Factors

Route	Proportion of calls using this route			
	Local	National	International	Mobile
End to end calls				
A - LAS - B	8%	10%		
A - LAS - LAS - B	46%	45%		
A - LAS - TS - LAS - B	46%	23%		
A - LAS - TS - TS - LAS - B		23%		
Single end calls				
A - LAS (-gateway)				50%
A - LAS - LAS				
A - LAS - TS (-gateway)			90%	50%
A - LAS - TS - TS			10%	

Source: NERA analysis of Telstra data

We also need to make assumptions about the routings used by leased lines. One way of approximating routing factors for leased lines is to use the information we have on routings for local and national calls - ie we assume that on average leased lines have the same routing factors as PSTN traffic.[28] The routing factors implied by this approach are shown in Table 2.10.

Table 2.10
Leased Line Routing Factors

Route	Proportion for local calls	Proportion for national calls	Proportion for leased lines	LAS-LAS	LAS-TS	TS-TS
A-LAS-B	7.5%	10%	7.9%	0	0	0
A-LAS-LAS-B	46.25%	45%	46.1%	1	0	0
A-LAS-TS-LAS-B	46.25%	22.5%	42.7%	0	2	0
A-LAS-TS-TS-LAS-B	0	22.5%	3.3%	0	2	1
Routing factor				**0.461**	**0.92**	**0.033**

28 Data for the UK, for example, suggests that leased line capacity as a percentage of PSTN capacity is approximately the same for different types of link - our assumption ensures that this applies (approximately) in the Telstra network (apart from the IRIM-LAS links, due to the difference in routing assumed for mobile network links).

The "proportion for leased lines" has been calculated as the weighted average of the figures for local and national calls, with the weights given by the relative numbers of local and national call minutes.

For the RAU to LAS links the routing factors are just as for any end to end call, apart from for mobile links where no IRIM-LAS links are assumed.

Using these figures we get results for leased line capacity as a percentage of total capacity in each level of the network as shown in Table 2.11. Figures are presented both for the case where we include the mobile network links and when we exclude them.

Table 2.11
Leased Line Capacity as a Proportion of the Total Network Capacity

Part of network	Leased line capacity/total capacity	
	Include mobile links	Exclude mobile links
IRIM-LAS	25%	25%
RSS/RSU-LAS	44%	25%
LAS-LAS	46%	27%
LAS-TS	40%	22%
TS-TS	41%	23%
Average	**38%**	**24%**

We note that if we include mobile links then leased line capacity accounts for around 38% of all capacity while if mobile leased line links are excluded, then leased line capacity accounts for around 24% of all capacity.

2.3. Network Design Assumptions

Assumptions need to be made in order to deduce the level of capacity required to carry a certain expected volume of traffic at an acceptable grade of service. We have already commented in Section 2.1.1.1 and Section 2.1.2 on the provisioning rules used in our modelling of the access network (for cable and linecards) and on the impact of modularity in determining the usage of IRIM and RSS/RSU units.

Assumptions used elsewhere in the network are as follows:

- for switching capacity for unsuccessful calls, international experience indicates that typically around 65% of call attempts are successful, and that a typical "holding time" per call is around 15 seconds;
- in line with the experience of operators in other countries, the amount of traffic in the average working day busy hour as a percentage of the total traffic in the week and the "uplift" factor to go from the average busy hour to the annual busiest busy hour

are assumed to be 1.5%, and 1.15 respectively, giving the ratio of traffic in the busiest busy hour to annual traffic as 0.033%(=1.5%*1.15/52);[29]

- in line with the experience of operators in other countries, target fills are generally assumed to be 85%. This reflects the design margins to cope with daily fluctuations in busy hour traffic levels and planning margins based on lead times for ordering and installing new equipment;
- finally, a blocking margin is needed to achieve a certain grade of service (assumed to be a congestion level of less than 1% in the busy hour) taking account of the random arrival of traffic during the busy hour. This blocking margin is used together with erlang tables to derive the actual number of channels required, given an initial estimate based on the assumption of uniform traffic.

Assumptions also need to be made regarding the level of resilience and diversity provided for in the network. We have assumed that:

- multiplexing equipment is sized to be able to cope with double the amount of capacity actually required (though we consider varying this as a sensitivity);
- to the extent that diverse *routing* is required it is assumed that this is already implicit in the total duct length figures provided by Telstra;
- tandem switches are taken to be located in pairs to provide diversity - but are sized to deal with 50% (not 100%) of the traffic in the peak busy hour. A transit switch failure in the peak busy hour would cause some traffic to be blocked (though the proportion blocked would be less than 50% due to the fact we have incorporated: a 15% design margin, a 10% margin for growth and spare capacity arising from the modularity of equipment).

2.4. Equipment Costs

We have categorised costs under three headings:

- equipment costs (capital expenditure), including installation;
- equipment maintenance and operating expenses;
- other capital costs and expenses.

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[29] The model has the functionality to distinguish the remote to LAS links from the rest of the network, as this is what Telstra have stated that they do. At present however, the same figure is used for all links.

2.4.1. Equipment costs

Capital equipment cost assumptions, together with assumptions about expected annual price changes, are needed for each type of equipment. The figures we have used (based on 1998 costs) are derived from data provided by Telstra and OPTUS as well as NERA's experience of working with telecommunications operators around the world. The figures for "equipment cost" include both the capital investment and the installation cost.

We have put together two tables of costs:

- the first is based on an average of data provided by Telstra and OPTUS and also NERA's international benchmarks;[30]
- the second is based on Telstra data to the extent this has been provided - NERA/OPTUS data is used where Telstra have not provided estimates of equipment costs.

These tables are shown in Appendix B (in practice we have only used the cost data in the first set of tables).

There are some important issues that arise for IRIM and RSS/RSUs and these are discussed in Appendix C.

Telstra have in some cases provided data either:

- on an historical cost basis;
- in an aggregated form (eg for network site costs).

In these cases we have not used Telstra's data directly.

A similar approach has been used for data on:

- price trends;
- asset lives;
- network operating costs as a percentage of investment cost.

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30 Note that the amount of data varies - for some equipment we have 3 estimates, but for others only Telstra or NERA data is available.

Based on the capital expenditure costs for 1997/98, it is necessary to calculate an annualised cost, taking account of:

- the depreciation of the asset over an appropriate time period, ie the asset life;
- an appropriate depreciation method. Our views on the appropriate method of depreciation for different assets are discussed in Section 1.6. Suggestions for other depreciation profiles (for particular types of asset) have also been made by various parties and hence the model includes the functionality to use any of the following profiles for any particular asset:
  - tilted straight line depreciation which takes into account the anticipated changes in the price of the asset over its lifetime - if the asset price is falling, depreciation of the asset is accelerated to compensate for its declining economic value;[31]
  - "sum of the years digits" depreciation - this is a method that gives some form of crude approximation to "economic" depreciation by tilting the depreciation schedule towards the early years (ie front loading it) to take account of technological progress. It is also possible to define a "backloaded" sum of digits profile which may be relevant for some asset types;[32]
  - geometric (front or back loaded);[33]
  - straight line deprecation with no tilt;[34]
  - an annuity function (this function covers both the return on capital and the return of capital - the depreciation function is implicit in the overall formula);[35]
- the cost of capital (CoC), ie. the return that Telstra can expect to earn on its investment. We have assumed this to be 10% on a nominal basis, though variations on this are considered as sensitivities.

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31 The formula used for the annual charge as a percentage of the capital investment is: 1/asset life + CoC - price trend.

32 The formula used for the annual charge as a percentage of the capital investment is, for eg an asset life of 10 years: 10/55 + CoC, for front loaded, and 1/55 + CoC, for back loaded, where 55 = 10+9+8+7+6+5+4+3+2+1.

33 The formula used for the annual charge as a percentage of the capital investment is: 1-exp(log(scrapvalue/investment)/asset life) + CoC for front loaded and 0 +CoC for backloaded.

34 The formula used for the annual charge as a percentage of the capital investment is: 1/asset life + CoC

35 The formula used for the annual charge as a percentage of the capital investment is: (CoC) / {1 - [1 / (1 + CoC)] ^ asset life}. This can also be "tilted" using the price trend in which case the formula becomes: (CoC - price trend) / {1 - [(1 + price trend) / (1 + CoC)] ^ asset life}

It is important to be clear about the time at which the assets are to be costed and the time over which prices are to be estimated. We are using traffic data relating to the period July 1997 to June 98, so implicitly we are "building" our new network in July 97 and sizing it to deal with the average traffic level over 1997/98 (to the extent that there is growth in traffic over the year, and investment is continuous rather than discrete, this is a simplification). To be consistent, the equipment prices we use should relate to July 97. We have assumed that the cost data provided by Telstra and Optus relates to the period July 97-June 98, so on average can be thought to be Dec 97 prices. We have "rolled" back these equipment prices to July 97 using the nominal price trends.

To estimate interconnection prices for July 1997 to June 98 we have:

- calculated all costs in real terms;
- translated these costs to nominal terms using a value for inflation of 2.5%.

Further details of this approach are given in Appendix D.

2.4.2. Maintenance and operating costs

For each equipment type we have estimated the annual operating/maintenance cost as a percentage of the capital cost in 1998. These figures are based on estimates provided by Optus (for certain equipment in the core network) together with NERA experience elsewhere. We note that Telstra have provided data on the basis of their current operating costs by equipment category group for historic assets - this data has not been used as it does not represent the optimised operating costs for new assets..

2.4.3. Other "indirect" costs

There are a number of other capital costs and operating costs which are relevant to call conveyance and access but which do not form part of the direct "network" costs.

To model these costs we have used data for the US LECs and AT&T reported to the FCC, as well as data for BT. The data for the LECs is a relevant comparator for costs associated with the access network and the "local" network (in which we include the remote to LAS links, the remote units and the LASs). The data for AT&T is a relevant comparator for costs associated with the longer distance networks (the LAS-LAS, LAS-TS and TS-TS links and the TSs).

For each capital cost item that we identify as being relevant to call conveyance and access we carry out the following procedure:

- the "indirect" capital cost is expressed as a percentage of the total direct network cost for each LEC/AT&T;

- for the LECs, the median percentages are calculated;
- an adjustment to take into account any differences in environment between Australia and the US is made;
- the relevance of the cost item to interconnection charges is estimated, and the figures adjusted to make sure only relevant costs are included.

A similar procedure is followed for indirect operating costs, where here the LEC/AT&T costs are expressed as a percentage of total direct network operating costs.

For capital costs the cost items we consider relevant, together with the adjustments we have made are shown in Table 2.12.

Table 2.12
Indirect Capital Costs as a Percentage of Direct Network Capital Costs

Expense category	Benchmark (median)	Benchmark (median)	Environment adjustment	Relevance to InterConnection		
	Local	Trunk			Local	Trunk
Land	0.20%	0.28%		50%	0.10%	0.14%
Vehicles	1.00%	0.03%		90%	0.90%	0.03%
Other equipment	0.87%	1.31%		90%	0.79%	1.18%
Buildings	3.59%	7.45%		50%	1.79%	3.73%
Furniture	0.29%	0.07%		50%	0.15%	0.03%
Office equipment	0.74%	0.03%		50%	0.37%	0.02%
General computers	2.00%	0.78%		40%	0.80%	0.31%
TOTAL	**8.69%**	**9.95%**			**4.89%**	**5.43%**

For operating costs the cost items we consider relevant, together with the adjustments we have made are shown in Table 2.13.

Table 2.13
Indirect Operating Costs as a Percentage of Direct Network Operating Costs

Expense category	Benchmark (median) Local	Benchmark (median) Trunk	Environment adjustment	Relevance to Interconnection	Local	Trunk
Cost of carrier services*	6.00%	6.00%		100%	6.00%	6.00%
Executive	1.70%	3.56%		40%	0.68%	1.42%
Planning	0.28%	0.28%		60%	0.17%	0.17%
Accounting and finance	4.08%	8.90%		60%	2.45%	5.34%
External relations	3.20%	2.71%		60%	1.92%	1.63%
Human resources	3.17%	2.85%		50%	1.58%	1.43%
Information management	12.93%	17.25%		40%	5.17%	6.90%
Legal	1.06%	4.86%	50%	50%	0.26%	1.21%
Procurement	0.69%	0.16%		80%	0.55%	0.13%
Other general and administrative	11.98%	38.59%		50%	5.99%	19.30%
TOTAL	**45.09%**	**85.17%**			**24.78%**	**43.53%**

** BT benchmark*

It is important to note that this uplift applies to the direct network operating cost only, not to the total annualised cost (which also includes depreciation and return on capital) - this appears to have been mis-understood in our draft report. On average these figures suggest just over 50% of these non-network costs are relevant to network activities. The estimation of the proportion of costs that is relevant to interconnection involves a degree of judgement. However, we note, that non-network expenses account for around 10%-20% of total interconnection charges. Misjudging the overall proportions of cost that are relevant to interconnection by say 10 percentage points (ie adjusting the average allocation to interconnection to around 40% rather than around 50%), would result in over estimating interconnection charges by around 2-4%. This implies that our results are relatively robust to these estimates. In presenting our results we have separated out the uplift for indirect costs. It is then straightforward to see what the impact of altering our assumptions would be.

3. MODELLING ACCESS COSTS

The following steps summarise our modelling of the copper access network for each area type:

- figures for the various cable "end" points are calculated as follows:[36]
  - number of network termination points (NTP) = number of subscriber lines;
  - number of pillars = number of lines connecting to a pillar (ie lines to LAS or to RSS/RSU) (including margins for growth and sparing)/ no of lines per pillar/average utilisation;
  - number of main distribution frames (MDF) = number of IRIM plus RSS/RSU plus LAS;
- cable lengths are calculated as typical customer distance times number of lines provided/cable size (split into distribution/feeder network where appropriate);
- trench length is based on cable length adjusted for trench sharing within the access network with further adjustments to take account of sharing with other services and also trench sharing with the core network (the cost of trench that is shared is assumed to be allocated on a basis of 50% to access and 50% to conveyance);
- an additional cost element is added into the cost for rural customers to take account of the additional cost of serving remote rural customers (it is assumed that the investment cost for a remote rural customer is 5 times that for a rural customer);
- the number of line cards at IRIMs is the number of lines (with allowances for growth and sparing) times the proportion of lines that go to an IRIM; the number of line cards at RSS/RSUs is the number of lines (with allowances for growth and sparing) times the proportion of lines that go to an RSS/RSU; the number of line cards at LASs is the number of lines (with allowances for growth and sparing) times the proportion of lines that go directly to a LAS;
- the number of sites for IRIM, RSS/RSU and LAS are as in Table 2.2 (costs are allocated between access and call conveyance using the percentage of other costs that are non-traffic sensitive/traffic sensitive);
- unit equipment costs are then applied to estimate total equipment investment;

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36 These are the only items modelled explicitly - distribution points, cable junctions, pits are all incorporated in the estimates for cable costs.

- investment costs are annualised, taking account of asset lives, anticipated price changes and the cost of capital;
- maintenance / operating costs are estimated and added in;
- finally other support investments (annualised) and expenses are added.

This gives a total cost for access by area type, which can then be divided by the number of lines to give a per line cost.

In the following we:

- present results for a variety of different options;
- consider further sensitivities on the results;
- discuss other issues that have been raised in industry responses to our draft report.

3.1. Key Results Under Different Options

Results are presented for a variety of different options. For the depreciation profile we have used the profiles discussed in Section 1.6 (eg straight line depreciation for trenches, copper cable, switch sites; sum of digits depreciation for line cards).

An annuity profile is considered later as a sensitivity, as are straight line depreciation and the mix of depreciation profiles proposed by Telstra.

There are a number of "network" options that we consider.

Option 1. Telstra's provisioning rules for line cards and copper cable are used (ie 1.3 line cards per service in operation (" SIO") at an IRIM and 1.18 line cards per SIO at an RSS/RSU; 2 copper pairs per SIO in the distribution network and 1.67 copper pairs per SIO in the feeder network). Trench sharing with Foxtel and other telecom operators is treated on a leasing basis. To do this we subtract from the costs, the amount of revenue Telstra would receive for leasing out its trench (this revenue is calculated by multiplying the lengths of trench that are shared by the current lease price which is taken as $ c-i-c per metre in CBD and $ c-i-c per metre in other areas).[37]

Option 2. Provisioning rules are modified. The number of line cards is reduced to 1.25 per SIO at an IRIM and 1.11 per SIO at an RSS/RSU (these figures reflect an average fill rate of

[37] Note that for new estates a "share according to number of parties" rule is applied in all cases.

92%, similar to that as suggested by Optus, with an additional allowance to take account of the line card panel modularity). The number of copper pairs installed is reduced to 1.33 per SIO in the distribution network and 1.25 per SIO in the feeder network (these figures are based on Optus' suggestions). It is assumed that the trench length remains unchanged - the only cost saving derives from the use of a smaller copper cable. An analysis of cost data provided by Telstra and by HAI (on behalf of Optus) suggests that reducing the average cable size in the distribution network from 47.5 pairs to 32, results in a price reduction for the copper cable of around 18%. Similarly reducing the average cable size in the feeder network from 580 to 435, results in a price reduction of around 17%. We have assumed that the number of pillars remains the same. In principle the size of pillar could be reduced with some cost saving. However, given that pillars account for only a very small proportion of total cost, this would make a negligible difference to the result.

Option 3. Instead of treating trench sharing with Foxtel and other telecom operators on a "leasing revenue" basis, we have assumed that costs are shared in proportion to the number of parties using the trench.

The physical quantities implied by the modelling are given in Table 3.1 below. Note that these quantities do not vary with the assumptions listed under options 1 to 3 (apart from the trench length "after sharing" figures which differ according to whether third party trenching is considered on a leased or "shared between the parties" basis - both sets of figures are shown). The split of total investment cost by equipment type is given in Table 3.2. To avoid presenting results for each option we have had to choose a particular option to use for illustrative purposes. We have used "Option 1" - this is not intended to suggest that this option is favoured over the others. The total investment cost will clearly vary depending on the option chosen, though the relative split of costs will not differ greatly. Investment per customer by area type is shown in Table 3.3. Again these are figures given under "Option 1".

Table 3.1
Key Physical Parameters Calculated in the Model

	CBD	Metropolitan	Provincial	Rural	Total
Total cable length distribution (km)	0	88,429	20,561	73,040	182,030
Total cable length feeder (km)	1,079	5,180	1,113	649	8,022
Total trench length before trench sharing is taken into account (km)	480	76,494	17,694	73,689	168,357
Total trench length after trench sharing is taken into account (km) (1)*	256	62,920	15,761	73,689	152,626
Total trench length after trench sharing is taken into account (km) (2)*	216	55,543	15,578	73,689	145,026
Number of pillars		28,092	6,035	3,522	37,649

** The trench length has been reduced to reflect the fact that parts of the trench are shared, ie that length of trench which is shared is apportioned between the parties leading to a reduced effective trench length for Telstra.*

(1) before taking Foxtel and other Telecom operators into account
(2) after taking Foxtel and other Telecom operators into account

Table 3.2
Breakdown of Investment Costs in the Access Network (Option 1 Values)

	Investment ($ million)	% of total
Pillars	$ 314	2%
Copper cable	$ 3,497	25%
Trench	$ 6,709	47%
Line cards	$ 2,392	17%
Other non-traffic sensitive parts of switch	$ 1,047	7%
Additional costs for remote rural customers	$ 220	2%
Total	**$ 14,178**	

Table 3.3
Investment Cost per Customer by Area Type (Option 1 Values)

	CBD	Metropolitan	Provincial	Rural/remote rural
Total investment $million	$ 224	$ 9,372	$ 1,673	$ 2,614
Number of customers, million	0.50	7.1	1.6	1.2
Investment per customer $	$ 448	$ 1,325	$ 1,031	$ 2,226

The results in terms of annual cost per line by area type for each of the options 1 to 3 are given in Table 3.4. We note that in these tables the effects of options 2 to 3 are *cumulative*, ie in each case we build on the results of the previous option. We find that:

- reducing the number of line cards reduces costs by around 1% (we note that the impact would be somewhat bigger if didn't take account of the line card panel modularity) and reducing the amount of copper reduces costs by a further 4%. The total effect of option 2 is a cost reduction of 5%;
- treating trench sharing on an equi-proportionate basis, rather than using the lease cost, reduces costs by a further 3%.

Table 3.4
Annual per Line Costs for the Access Network Under Different Options
Proxy Economic Depreciation

Area type	Option 1	Option 2	Option 3
CBD	$ 167	$ 158	$ 156
Metropolitan	$ 412	$ 396	$ 380
Provincial	$ 340	$ 323	$ 322
Rural/remote rural	$ 709	$ 645	$ 643
Average	$ 423	$ 401	$ 390

We note that the access costs in Table 3.4 include both direct network costs plus an uplift costs to account for indirect costs. Indirect costs account for around 15% of the total access cost.

In comparing the results across area types it is important to note that certain input parameters are averaged across area types. In particular it has not been possible to obtain estimates of typical cable size in the distribution network by area type. This may imply, for example, that costs in metropolitan areas are overestimated while those in rural areas are underestimated. If, for example, we increase the average cable size in metropolitan areas by 10%, while reducing it by 10% in rural areas then we find that costs per line in metropolitan areas decrease by 6.6% while those in rural areas increase by 8.6%. This example illustrates the sensitivity of the model results to the assumptions that drive trench and cable costs and highlights the importance of obtaining accurate estimates for trench and cable lengths - this is further discussed in Section 3.2.

3.2. Further Sensitivities

Further sensitivities have been carried out on trench and cable length assumptions. This reflects the fact that there is considerable uncertainty over the correct figures.

We have also carried out further sensitivities on the economic assumptions (cost of capital and treatment of depreciation).

3.2.1. Trench and cable sensitivities

At a late stage, Telstra have provided us with direct estimates of trench lengths for the distribution and feeder network by area type. Optus have also provided us with estimates for trench lengths. Both these sets of trench length figures are shown in Table 3.5, where they are compared to the model results. There are clearly some significant differences between the Telstra and Optus numbers - the distances calculated in the model in general lie between these two sets of estimates.

Table 3.5
Trench Distances in the Access Network - Comparison of Telstra and Optus Estimates and Model Results

Area Type	Telstra (km)	Optus (km)	Model (km)
CBD	c-i-c	c-i-c	480
Metropolitan	c-i-c	c-i-c	76,494
Provincial	c-i-c	c-i-c	17,694
Rural/remote rural	c-i-c	c-i-c	73,689
Total	c-i-c	c-i-c	168,357

c-i-c = commercial-in-confidence information removed.

Given the uncertainties over the correct data to use, we have run two sensitivities to investigate the importance of accurate trench lengths for the end result. The sensitivities considered are:

- altering the trench length by ± 10% (but keeping cable lengths constant);
- altering the cable length by ± 10% (and hence also changing the trench length).

The first of these can be thought of as a way of exploring the impact of additional trench sharing. The second is a way of exploring the impact of changes to some of the input parameters which drive *both* cable and trench length (eg cable size).

The results of these sensitivities are shown in Table 3.6.

Table 3.6
Impact on Results of Sensitivities on Trench and Cable Lengths

	Impact on results of varying distances by ±10%
Trench only	±4.3%
Trench and cable	±7.3%

We note that the impact of a 10% variation in length, either for trench or for trench and cable, is substantial. The discrepancies between Telstra's and Optus estimates (and also between the model results and either operator's estimates) for individual areas are often greatly in excess of 10%. This represents a key area of uncertainty for the model results and we would recommend that further work be carried out to try to obtain reliable estimates for trench and cable lengths and hence enable costs to be modelled with a greater degree of certainty.

A related issue is the extent to which the feeder and distribution networks share trenches. We have assumed that 10% of the feeder trenches are also used by distribution cables - this is based on Telstra's estimate. However, we might expect that this figure would be higher particularly in metropolitan and provincial areas. We have carried out a sensitivity where the extent of sharing is increased to 100% in these areas. However, given the relatively short feeder trench distances this does not have a big impact on the end results - costs per line are reduced by around 3%.

3.2.2. Sensitivities on economic assumptions

We consider a number of types of sensitivity:

- the impact of using an annuity function for all assets to estimate the annualised capital charge;[38]
- the impact of using straight line depreciation for all assets to estimate the annualised capital charge;
- the impact of using the depreciation profiles proposed by Telstra for different asset types;
- the impact of using an average over the first four years prices rather than year one prices;
- the impact of varying the cost of capital.

The results for the access costs per line using an annuity function for all assets are shown in Table 3.7. The results of using an annuity function are around 13% lower than those derived from the economic depreciation proxies.

Table 3.7
Annual per Line Costs for the Access Network Under Different Options
Annuity Function

Area type	Option 1	Option 2	Option 3
CBD	$ 134	$ 127	$ 125
Metropolitan	$ 358	$ 344	$ 330
Provincial	$ 292	$ 278	$ 277
Rural/remote rural	$ 630	$ 573	$ 571
Average	$ 368	$ 349	$ 339

We have also run the model using straight line depreciation profiles for all assets. These profiles were used in our draft report and the results presented in Table 3.8 can be directly compared to the results in that report. These results are around 5% below the results we obtain by using proxies to economic depreciation (this is due to the fact that sum of digits depreciation, which is higher than straight-line depreciation in year one, is used for line cards).

38 This sensitivity was requested by the ACCC.

Table 3.8
Annual per Line Costs for the Access Network Under Different Options
Straight Line Depreciation

Area type	Option 1	Option 2	Option 3
CBD	$ 147	$ 139	$ 137
Metropolitan	$ 393	$ 378	$ 361
Provincial	$ 319	$ 304	$ 302
Rural/remote rural	$ 688	$ 625	$ 624
Average	$ 403	$ 383	$ 371

We have also run the model using Telstra's proposals for different depreciation profiles for different assets types. The results are shown in Table 3.9. The results are close to those for straight line depreciation.

Table 3.9
Annual per Line Costs for the Access Network Under Different Options
Telstra Proposals for Depreciation Profiles

Area type	Option 1	Option 2	Option 3
CBD	$ 127	$ 120	$ 117
Metropolitan	$ 381	$ 366	$ 349
Provincial	$ 308	$ 292	$ 291
Rural/remote rural	$ 721	$ 650	$ 648
Average	$ 396	$ 374	$ 363

Results using the average price over the first four years, rather than the year one price, are shown in Table 3.10 (this is motivated by the fact that the price set by the ACCC may remain in place for a number of years).[39] This reduces costs, compared to year one prices, by around 4%.

39 Note that we have not incorporated a volume effect. If the number of Telstra customers grows over the 4 year period we will be underestimating the rate of price decline, assuming that the extra volume can be provided, at least in part, using the existing asset base.

Table 3.10
Annual per Line Costs for the Access Network Under Different Options
Proxy Economic Depreciation - Average Price Over First Four Years

Area type	Option 1	Option 2	Option 3
CBD	$ 153	$ 145	$ 143
Metropolitan	$ 395	$ 379	$ 363
Provincial	$ 323	$ 307	$ 306
Rural/remote rural	$ 686	$ 624	$ 622
Average	$ 405	$ 384	$ 373

The impact of using different values for the cost of capital is shown in Table 3.11. The impact differs somewhat depending on the base which is chosen, though in general we see that a change of ± 1% on the cost of capital results in a change of around 3.0 - 3.5% in the results.

Table 3.11
Impact on Results of Varying the Cost of Capital (Compared to Cost of Capital = 10%) for Different Depreciation Profiles

Cost of capital	Proxies to Economic Depreciation	Straight Line	Annuity
8%	-6.7%	-6.9%	-5.6%
9%	-3.3%	-3.5%	-2.9%
10%	0.0%	0.0%	0.0%
11%	3.3%	3.5%	3.0%
12%	6.7%	7.0%	6.0%

3.3. Other Points That Have Been Raised

While this is not intended to be an exhaustive list we felt it would be helpful to consider some of the other points raised by industry members. The main additional points were regarding:

- optic fibre in the local loop;
- the use of aerial cable;
- treatment of the final drop.

3.3.1. Optic fibre in the local loop

Telstra are of the view that the use of optic fibre in the local loop is driven by the requirement for non-PSTN services, and hence the option of using optic fibre is not relevant to the current exercise. Optus, however, feel that costs (particularly in CBD areas) are being overestimated by not considering this option.

In general copper will be cheapest where only a small number of lines are provided to a user, while optic fibre can be cheaper where a large number of lines (or a large amount of capacity) are required for a single user - this is usually only the case for large business premises. Given that, in the country as a whole, the number of residential and small business lines will be greatly in excess of the number of large business lines it is generally not a bad approximation to consider copper access only. It is possible that in CBD areas, where there is a high concentration of business premises, the use of fibre would have some impact on the results. It is difficult to estimate the impact of this without further information regarding the distribution of end users with respect to the number of lines per premise in CBD areas. From a preliminary analysis, we would expect any cost saving to be relatively small and further investigation does not seem warranted.

3.3.2. Aerial cable

Optus have estimated that the amount of aerial cable in Telstra's access network is around 40-50%. Telstra's estimate is that currently there is around 10% aerial cable in their distribution network, but that this is likely to decrease in future. It is the ACCC's view that, on a forward looking basis, it is unlikely that there will be much aerial cabling. In addition, the costs of aerial cabling are uncertain as aerial cabling now requires negotiation with local councils. For these reasons we have assumed zero aerial cabling for the forward looking network.

Data from Optus suggests that the cost per metre for aerial cabling is similar to that for ploughed trench. We have run a sensitivity in which we have assumed 10% aerial cable - this has been done by simply reducing the duct and trench cost per metre to be the weighted average of the cost of duct and trench and the cost of aerial cable (this implicitly assumes the same degree of sharing of assets). This reduces the overall cost per line by around 3.7%. We note that is a relatively crude sensitivity as neither the feasibility nor the cost have been properly explored.

3.3.3. Treatment of the final drop

The treatment of the final drop has attracted some comment. In particular it has been commented that in general there is more than one copper pair per household (the average number of SIO per dwelling is 1.25) and for businesses the number is significantly greater than one. This may suggest that the model has overestimated these costs as there are economies of scale in supplying more than one line to a single premise.[40] At present the cost of the final drop is a small portion of the total line cost (as we would expect). Consequently, further refinements are unlikely to have a material impact on the results.

[40] Ie for a given number of SIO, total costs will reduce as the number of lines per premise increases.

4. MODELLING THE COSTS OF CONVEYANCE

In this section we consider the costs of conveyance, and in particular the costs of interconnection services. We describe our approach to modelling of switch costs, then transmission costs and combine the results to estimate the costs of particular conveyance services.

4.1. Modelling Switch Costs

The following steps summarise our modelling of IRIM, RSS/RSU, LAS and TS costs:

- the number of pieces of different types of equipment required for switching are estimated as follows:
  - the number of switch sites (for each switch type) are as provided by Telstra (see Table 2.2);[41]
  - the number of N line units (for IRIM, RSS/RSU and LAS) are as provided by Telstra (see Table 2.2);
  - the number of ports is calculated as a function of the traffic through the switch, which is derived from the figures for originating traffic, routing factors and design margins;[42]
  - the number of switching units (including the processor) for LAS and TS are as provided by Telstra (see Table 2.2);
  - the number of BHCA for LAS and TS is calculated from the originating traffic, routing factors and design margin figures (this is needed to reflect the fact that for an increase in traffic, there may be a need to add additional processing modules to the switch or to upgrade the switch to a switch with a higher processing capacity, and there is a cost associated with this);

41 For TS the whole site cost is relevant for call conveyance. For LAS, RSS/RSU and IRIM the site cost is allocated between the access network and the core network on the basis of the ratio of traffic sensitive to non-traffic sensitive costs for LAS, RSS/RSU and IRIM components.

42 The number of ports for a IRIM or RSS/RSU is equal to the number of (whole) 2Mbit/s of traffic through an average IRIM or RSS/RSU times the number of IRIM or RSS/RSUs; the number of ports for LAS is equal to the number of (whole) 2Mbit/s of traffic through an average LAS times the number of LAS plus the number of ports on remote units (to take account of traffic from remote units); the number of ports for TS is equal to the number of (whole) 2Mbit/s of traffic through an average TS times the number of TS times 2 (to take account of ports on both sides of the switch).

- the numbers of other pieces of equipment related to switching are either as provided by Telstra or based on international practice (eg there are 20 STPs forming the SS7 signalling system in Telstra's network; we have assumed 4 clocks are required for synchronisation);[43]

- unit equipment costs are then applied to estimate total equipment investment;
- investment costs are annualised, taking account of asset lives, anticipated price changes and the cost of capital
- maintenance/operating costs are estimated and added in;
- finally other support investments (annualised) and expenses are added.

Our approach gives a total cost for switching. The estimated conveyance costs are then divided by the number of minutes of use of IRIM, RSS/RSU, LAS and TS respectively to give network component unit costs.

4.2. Modelling Transmission Costs

The following steps summarise our modelling of transmission costs for the different link types in the transmission network:

- the total traffic passed over each part of the network is estimated from the originating traffic, routing factors and design margins;
- design capacity is calculated using the percentage of traffic in the busy hour, and aggregating PSTN and leased line capacity;
- using the assumptions about the structure of the SDH rings, together with the calculated design capacity, numbers for different types of multiplexers and repeaters are calculated;
- total length of ducted trench has been provided by Telstra - this is allocated by area type and also used to deduce total trench length (ducted and buried);
- the total "logical" route length is calculated by multiplying the typical distances per link by the number of links - this figure is divided by the actual total trench length to give the trench sharing within a network (we do not have proper estimates of "typical" distances for LAS-LAS, LAS-TS and TS-TS this calculation is very crude - however the impact on any final results is not big);

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[43] The cost of synchronisation is spread over the TS and the cost of signalling across all TS and LAS.

- total cable length is calculated from trench length times NERA's assumption for the number of cables per trench;
- the required number of fibres per cable is calculated by dividing the total logical route distance by the total cable length - a minimum size of 12 fibres per cable is used (this is where poor estimates of "typical" route distance may have some limited impact);
- unit equipment costs are then applied to estimate total equipment investment;
- investment costs are annualised, taking account of asset lives, anticipated price changes and the cost of capital;
- maintenance/operating costs are estimated and added in;
- finally other support investments (annualised) and expenses are added.

This gives a total cost for each type of transmission link. This cost is then divided by the number of minutes of use of the different transmission link types to give a network component unit cost for each type of transmission link.

4.3. Results for Conveyance Under a Variety of Options

As for the access network, results are presented for a variety of different options. For depreciation we have used the "proxy" economic depreciation profiles discussed in Section 1.6 (eg straight line depreciation for trenches and switch sites; sum of digits depreciation for switches, multiplexers and optic fibre).

An annuity profile for all assets is considered later as a sensitivity, as are straight line depreciation for all assets and the mix of profiles proposed by Telstra.

There are a number of "network" options that we consider.

<u>Option 1.</u> The spare capacity rules used are as follows: utilisation of switch processing capacity = 85%; utilisation of MUX capacity =50%. SDH links are used for IRIM - MUX, though the SDH equipment is assumed to be partially equipped.[44] Trench sharing with the access network only is considered.

<u>Option 2.</u> As for Option 1 except that PDH links are used on IRIM - MUX routes.

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44 To estimate the cost of this we have taken Optus' split of the STM1 cost: ie 57% of the cost is fixed and 43% is variable. On average a single line card (6Mbit/s) is adequate.

First we show results for physical quantities in the network in Table 4.1 - these do not vary according to the option chosen. The breakdown of investment costs is shown in Table 4.2. To avoid presenting results for each option we have had to choose a particular option to use for illustrative purposes. We have used "Option 1" - this is not intended to suggest that this option is favoured over the others. The relative split of costs does not differ greatly if Option 2 is used.

Table 4.1
Key Physical Parameters for the Transmission Network

Physical quantities Total length of core network	**IRIM-LAS**	**RSS/RSU-LAS**	**LAS-LAS**	**LAS-TS**	**Total**
Length of optic fibre (km)	331,010	40,606	16,094	13,680	401,391
Length of ploughed trench (km)	108,162	11,983	5,995	6,156	132,295
Length of duct (km)*	49,622	7,127	1,690	684	59,123
Number of STM1	16,863**	0	0	0	16,863
Number of STM4	0	2,186	0	0	2,186
Number of STM16	0	0	128	300	428
Number of logical routes	16,863	1,020			
Concentration ratio***	4	6			

**Note that the duct length is the total length after adjustments for sharing with the access network.*
*** replacing these links with PDH is considered as an option*
****The "concentration ratio" is the ratio of copper pairs coming in to the RAU to the number of 64kbit/s channels provided on the RAU-LAS link.*

Table 4.2
Breakdown of Investment costs in the Conveyance Network (Option 1 Values)

	Investment ($million)	**% of total**
Switching		
Switch*	$1,161	11%
Ports	$725	7%
Sites	$662	6%
Other	$51	0.5%
Transmission		
Electronics	$752	7%
Optic fibre	$2,022	20%
Trench	$4,978	48%
Total	**$10,349**	

**Includes the traffic sensitive part of the concentrator and the processor*

The costs per network element are shown in Tables 4.3 and 4.4, and the costs for remote to LAS links by area type are shown in Table 4.5.

Table 4.3
Calculation of Switching costs
Proxy Economic Depreciation (Option 1)

Switching costs	IRIM	RSS/RSU	LAS	TS
Total annual cost ($ million)	$ 114	$ 331	$ 429	$ 69
Minutes of use (million)	46,377	93,003	141,226	45,127
Cost per minute	$ 0.0025	$ 0.0036	$ 0.0030	$ 0.0015

Table 4.4
Calculation of Transmission Costs
Proxy Economic Depreciation (Option 1)

Transmission costs	IRIM - LAS	RSS/RSU - LAS	LAS - LAS	LAS - TS
Total annual cost ($ million)	$ 1,678	$ 281	$ 89	$ 79
Minutes of use (million)	62,902	171,093	58,611	134,794
Cost per minute	$ 0.027	$ 0.0016	$ 0.0015	$ 0.0006

Table 4.5
Remote to LAS Link Costs per Minute by Area Type
Proxy Economic Depreciation (Option 1)

RAU - LAS link costs by area type	IRIM-LAS	RSS/RSU-LAS
CBD	n/a	n/a
Metro	$ 0.019	$ 0.0015
Provincial	$ 0.028	$ 0.0018
Rural	$ 0.055	$ 0.0024

Costs for remote to LAS links are highest in rural areas due to the longer route lengths, despite the lower trenching costs per metre.

These results can now be combined with the routing factors discussed in Section 2 to give unit costs for interconnection charges for different services.

It is possible to derive the costs of originating and terminating access from different levels in the network, ie:

- interconnection at an LAS, with no use of LAS-LAS links, "Local exchange";
- interconnection at an LAS, with use of an LAS-LAS link, "Inter-LAS";
- interconnection at a single TS (with no TS - TS link), "Single Trunk";
- interconnection using two TSs (with one TS - TS link), "Double Trunk".

We note that for the purposes of assessing Telstra's charges for originating and terminating access it is the local exchange (for interconnection at the local exchange) and single trunk (for interconnection at the trunk exchange) charges that we are concerned with.[45] However, we present results also for "inter LAS" for completeness.[46] The results are shown in Tables 4.6.

Table 4.6
Results for Interconnection Charges for 1997/98
Proxy Economic Depreciation (Option 1)

		Routing factors for interconnection service		
Cost per minute	**Unit cost**	**Local exchange**	**Inter-LAS**	**Single trunk**
IRIM - LAS	$ 0.027	0.32	0.32	0.32
RSS/RSU - LAS	$ 0.0016	0.64	0.64	0.64
LAS - LAS	$ 0.0015	0	1	0
LAS - TS	$ 0.0006	0	0	1
IRIM	$ 0.0025	0.32	0.32	0.32
RSS/RSU	$ 0.0036	0.64	0.64	0.64
LAS	$ 0.0030	1	2	1
TS	$ 0.0015	0	0	1
Cost of interconnection service		**$ 0.016**	**$ 0.020**	**$ 0.018**

We note that transmission costs account for around 60% of the total single trunk charge. This can be compared to the UK where transmission accounts for around 40% of the single tandem interconnection charge (the single tandem charge in the UK is around $0.012).[47] Our results indicate that transmission costs are a much larger share of conveyance costs than in the UK. This is mostly accounted for by the high cost of IRIM-LAS links (which is driven by the large number of these links). As discussed in Section 1.2, it is possible that Telstra's plans to extend the conveyance network to bring it closer to customer premises is not optimal from a cost point of view if PSTN services only (as opposed to broadband services) are considered.

Results by area type are shown in Table 4.7.

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45 Any interconnect call in the Telstra network always travels via remote (if applicable) to LAS and then, for single trunk, to TS/POI. A call that involves the use of Telstra's trunk network has an additional separate charge for the equivalent of the TS-TS segment (an overlay network is used for this section).

46 Results for "double trunk" are not shown in this report due to the fact that our estimation of these charges is crude given the lack of data.

47 "Current Cost Financial Statements for the Businesses and Activities 1998 and Restated Current Cost Financial Statements 1997", 1998, BT.

Table 4.7
Results for Interconnection Charges for 1997/98 by Area Type
Proxy Economic Depreciation (Option 1)

Area type	Local exchange	Inter - LAS	Single trunk
CBD	$ 0.003	$ 0.008	$ 0.005
Metropolitan	$ 0.013	$ 0.018	$ 0.015
Provincial	$ 0.017	$ 0.022	$ 0.019
Rural	$ 0.034	$ 0.038	$ 0.036

The results differ due to the different use made of remote units and remote to LAS links, as well as the different costs of these links, according to area type. CBD costs are lower as there are no remote units in these areas.

Having considered in some detail the results for Option 1, we now consider the variation in results from considering Option 2. We focus on the results for single trunk across all areas.

The results for single tandem interconnection rates for Options 1 and 2 are shown in Table 4.8. The difference between these results for the two options is around 2%.

Table 4.8
Cost of Single Tandem Interconnect for Different Physical Options
Proxy Economic Depreciation

	Costs for single tandem
Option 1	$ 0.0177
Option 2	$ 0.0173

We note that the interconnection costs in Table 4.8 include both direct network costs plus an uplift costs to account for indirect costs. Indirect costs account for around 12% of the total interconnection cost.

4.4. Further Sensitivities

We have considered further sensitivities as follows:

- sensitivities on trench lengths;
- sensitivities on utilisation rates;
- sensitivities on the economic assumptions.

4.4.1. Trench lengths

We have run a sensitivity to show the effect of altering duct and trench lengths by ± 10%. This could be considered as a sensitivity either to investigate the impact of uncertainty in data, or the impact of additional trench sharing. As a second sensitivity we have reduced the number of cables per trench to 1.2 for the IRIM to MUX links (reduced from two cables per trench). The results of these sensitivities are shown in Table 4.9.

At a late stage Telstra have provided us with direct estimates of lengths for both duct and ploughed trench by area type for RAU - LAS links (Table 4.10). There is a significant difference between the total ploughed trench length estimated by Telstra (180,000km) and that calculated by the model (108,000km, see Table 4.1), however the effect on overall costs (see Table 4.9) is not great. This is because the additional cost of the longer ploughed trench length estimated by Telstra is offset by lower duct costs (the allocation of duct length to different area types differs between Telstra's estimates and the model calculation).

Table 4.9
Sensitivities on Duct, Trench and Cable Lengths

	Impact on results of varying lengths
Duct and trench lengths varied by ± 10%	±3.6%
Cable length reduced by reducing cables per trench	-5.2%
Telstra duct and trench lengths replace model estimates	-1.0%

Table 4.10
Telstra Duct and Trench Lengths (km)

	IRIM-MUX		SDH rings	
	Duct	Ploughed trench	Duct	Ploughed trench
CBD	c-i-c	c-i-c	c-i-c	c-i-c
Metropolitan	c-i-c	c-i-c	c-i-c	c-i-c
Provincial	c-i-c	c-i-c	c-i-c	c-i-c
Rural	c-i-c	c-i-c	c-i-c	c-i-c
Total	c-i-c	c-i-c	c-i-c	c-i-c

c-i-c = commercial-in-confidence information removed.

As with the access network, the results for conveyance costs are sensitive to the assumptions about trench length. Further work needs to be done to obtain accurate data for these distances.

4.4.2. Utilisation rates

We have considered a sensitivity in which the spare capacity built in for multiplexing equipment is reduced to 18% (ie 85% utilisation).

The impact of this on results for single trunk is very small - a reduction of about 1%.

4.4.3. Economic assumptions

We have considered the following sensitivities:

- using an annuity function for all assets;[48]
- using straight line depreciation for all assets;
- using Telstra's proposed depreciation profiles;
- taking the average price over four years rather than the year one price;
- varying the cost of capital.

4.4.3.1. Annuity function

The results obtained using an annuity function for all assets are shown in Table 4.11. Using an annuity function has a significant effect on the results: results are 20% lower than the results obtained using proxy economic depreciation profiles.

Table 4.11
Cost of Single Tandem Interconnect using an Annuity Function

	Cost per min
Option 1	$ 0.0142
Option 2	$ 0.0139

The following tables (Table 4.12 to Table 4.16) show detailed results for conveyance costs using an annuity function. Option 2 (ie PDH links for IRIM - MUX) has been used to derive these results.[49]

Table 4.12
Calculation of Switching Costs
Annuity Function (Option 2)

Switching costs	IRIM	RSS/RSU	LAS	TS
Total annual cost ($ million)	$ 79	$ 256	$ 318	$ 52
Minutes of use (million)	46,377	93,003	141,226	45,127

48 This sensitivity is included at the request of the ACCC.

49 These tables are included at the suggestion of the ACCC.

Cost per minute	$ 0.0017	$ 0.0028	$ 0.0023	$ 0.0011

Table 4.13
Calculation of Transmission Costs
Annuity Function (Option 2)

Transmission costs	IRIM - LAS	RSS/RSU - LAS	LAS - LAS	LAS - TS
Total annual cost ($ million)	$ 1,381	$ 231	$ 73	$ 61
Minutes of use (million)	62,902	171,093	58,611	134,794
Cost per minute	$ 0.022	$ 0.0014	$ 0.0013	$ 0.0005

Table 4.14
Remote to LAS Link Costs per Minute by Area Type
Annuity Function (Option 2)

RAU - LAS link costs by area type	IRIM-LAS	RSS/RSU-LAS
CBD	n/a	n/a
Metro	$ 0.016	$ 0.0012
Provincial	$ 0.023	$ 0.0015
Rural	$ 0.045	$ 0.0021

Table 4.15
Results for Interconnection Charges for 1997/98
Annuity Function (Option 2)

		Routing factors for interconnection service		
Cost per minute	**Unit cost**	**Local exchange**	**Inter-LAS**	**Single trunk**
IRIM - LAS	$ 0.022	0.32	0.32	0.32
RSS/RSU - LAS	$ 0.0014	0.64	0.64	0.64
LAS - LAS	$ 0.0013	0	1	0
LAS - TS	$ 0.0005	0	0	1
IRIM	$ 0.0017	0.32	0.32	0.32
RSS/RSU	$ 0.0028	0.64	0.64	0.64
LAS	$ 0.0023	1	2	1
TS	$ 0.0011	0	0	1
Cost of interconnection service		**$ 0.012**	**$ 0.016**	**$ 0.014**

Table 4.16
Results for interconnection charges for 1997/98 by Area Type
Annuity Function (Option 2)

Area type	Local exchange	Inter - LAS	Single trunk
CBD	$ 0.002	$ 0.006	$ 0.004
Metropolitan	$ 0.010	$ 0.014	$ 0.012
Provincial	$ 0.014	$ 0.017	$ 0.015
Rural	$ 0.027	$ 0.031	$ 0.029

4.4.3.2. *Straight line depreciation*

The results obtained using straight line depreciation for all assets are shown in Table 4.17. The results obtained using straight-line depreciation are around 11% lower than those obtained using proxy economic depreciation. These results allow a comparison with the results reported in our draft report.

Table 4.17
Cost of Single Tandem Interconnect for Different Physical Options
Straight Line Depreciation

	Cost per min
Option 1	$ 0.0157
Option 2	$ 0.0154

4.4.3.3. *Telstra proposals for depreciation profiles*

The results obtained using Telstra's proposals for depreciation profiles are shown in Table 4.18. These results are very close to the annuity results. This is due to the fact that switching equipment is assumed to have a back-loaded profile and the profile for optic fibre is such that there is no depreciation in the first year - these factors outweigh the fact that other assets have straight-line or sum of digits (frontloaded) depreciation.

Table 4.18
Cost of Single Tandem Interconnect using Telstra's Proposed Depreciation Profiles

	Cost per min
Option 1	$ 0.0143
Option 2	$ 0.0139

4.4.3.4. *Average price over 4 years*

Results using the average price over the first four years, rather than the year one price, are shown in Table 4.19 (this is motivated by the fact that the price set by ACCC may remain in place for a number of years).[50] This reduces costs, compared to year one prices, by around 7%.

Table 4.19
Cost of Single Tandem Interconnect - Average Price over Four Years
Proxy Economic Depreciation

	Cost per min
Option 1	$ 0.0165
Option 2	$ 0.0161

4.4.3.5. *Cost of capital*

We have run the results for a cost of capital of: 8%, 9%, 10%, 11% and 12%. The results are shown in 4.20.

Table 4.20
Impact on Results of Varying the Cost of Capital (Compared to Cost of Capital = 10%)

CoC	Proxy Economic Depreciation	Straight Line	Annuity
8%	-6.8%	-7.7%	-6.4%
9%	-3.4%	-3.9%	-3.2%
10%	0.0%	0.0%	0.0%
11%	3.4%	3.9%	3.3%
12%	6.8%	7.7%	6.7%

The impact differs somewhat depending on the depreciation option chosen. In general though we see that a 1% change in the cost of capital leads to a change of 3.2-3.9% in the end result.

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50 Note that we have not incorporated a volume effect. If the volume of Telstra traffic grows over the 4 year period we will be underestimating the rate of price decline, assuming that extra traffic can be handled, at least in part, by existing equipment.

4.5. Other Points That Have Been Raised

While this is not intended to be an exhaustive list we felt it would be helpful to consider some of the other points raised by industry members. The main additional points were regarding:

- cost sharing with mobile switches;
- issue of common costs between access and core network.

Telstra have stated that currently their fixed and mobile switches are not integrated. As we have not included Telstra's mobile network in our definition of the total service increment, it is not appropriate to try to establish the cost of an integrated switch and then allocate that cost to fixed and mobile services. However, Telstra's mobile switches are likely to be co-located with fixed switches. We have not obtained actual data for Telstra's network on this. If, for example, Telstra had 5 mobile switches co-located with tandem switches then sharing these site costs on a 50:50 basis would reduce the cost of tandem switching by 6% and the cost of single tandem interconnection by around 0.5%.

Little comment was made in industry responses on the issue of the allocation of costs which are common to access and conveyance and hence we have not undertaken any further investigation of this (see Appendix C for a discussion of this and an explanation of the approach taken). In an environment where the access deficit is funded through conveyance charges it is likely to be the case that the issue has little practical effect.

5. CONCLUSIONS

In Sections 3 and 4 we have presented a large number of different results based on varying the input assumptions used in the model. In this Section we summarise what we feel are the key results and highlight the main areas of uncertainty.

5.1. Access Network

The average access cost per line (over all areas) is estimated to be in the range $390 to $423 when an approximation to economic depreciation is used together with a cost of capital of 10% and year one pricing. The upper end of the range corresponds to a case where Telstra's provisioning rules (for line cards and copper pairs) are used and where any sharing of Telstra's trenches is treated on a leasing basis (ie Telstra receives the current lease price for the use of its trenches). The lower end of the range uses provisioning rules which result in much lower spare capacity for line cards and copper pairs and sharing of Telstra's trenches is treated on an equi-proportionate cost basis (ie the cost of the shared trench is apportioned according to the number of parties using the trench).

There is a wide variation in results by area type. Estimated costs per line per year for the different areas (on the same basis as above) are in the following ranges:

- CBD: $156 - $167;
- Metropolitan: $380 - $412;
- Provincial: $322 - $340;
- Rural and remote rural: $643 - $709.

The low costs in CBD areas reflect the high density of customers and the short distances involved (together with high trench costs) and the high costs in rural areas reflect the low density of customers and the long distances (together with low trench costs). The comparison between metropolitan and provincial areas indicates that the higher density in metropolitan areas is more than offset by the higher trench costs in these areas. This may, however, be an artefact of the inputs into the model - certain key input parameters that have been provided to us are only available as an average over all area types (eg typical cable sizes) and this is likely to distort the relative costs by area type. Assuming that cable size is on average greater in metropolitan than rural areas, the use of an average over all area types will overestimate costs in metropolitan areas while underestimating costs in rural areas. For example, an 10% increase in cable size in metropolitan areas reduces costs in these areas by 7%, while a decrease in cable size of 10% in rural areas increases costs by 9%. This is a consideration that should be borne in mind when viewing our results.

The choice of depreciation profile also has a significant impact on the results. Compared to results using proxy economic depreciation profiles we find that:

- use of an annuity function for all assets reduces the costs by 13%;
- use of straight-line depreciation for all assets reduces the costs by 5%;
- use of Telstra's proposals for different asset types reduces costs by 6%.

On the basis of estimated economic depreciation profiles, we believe that the proxy economic depreciation profiles we have used represent a better estimate of true economic depreciation than the alternatives listed above. Nonetheless, further investigation into true economic depreciation profiles is an area that may be worth pursuing.

The figure used for the cost of capital also impacts significantly on the results: a 1 percentage point change in the cost of capital results in a change of around 3.3% in the final result.

Results for the average price over the first four years are around 4% lower than the year one prices. This should be borne in mind if the price set is to be kept constant for a number of years.

The majority of the investment cost in the access network is accounted for by trenching (nearly 50% of the total) and cable (25% of the total). This means that the results are very sensitive to the assumptions that drive trench and cable lengths. Varying trench lengths by 10% changes the results by around 4%, while varying both trench and cable lengths together changes the results by around 7%. This represents a key area of uncertainty for the model results and we would recommend that further work be carried out to try to obtain reliable estimates for trench and cable lengths.

5.2. Conveyance Network

The cost per minute for single trunk interconnection is estimated to be in the range $0.018 to $0.017 when an approximation to economic depreciation is used together with a cost of capital of 10% and year one pricing. The upper end of the range corresponds to a case where SDH links (partially equipped) are used on the low capacity IRIM-LAS routes and the lower end of the range corresponds to the case where PDH equipment is used on these routes.

The choice of depreciation profile has a significant impact on the results. Compared to results using proxy economic depreciation profiles we find that:

- use of an annuity function for all assets reduces the costs by 20%;
- use of straight-line depreciation for all assets reduces the costs by 11%;
- use of Telstra's proposals for different asset types reduces costs by 19%.

However, as for the access network, we believe that the proxy economic depreciation profiles we have used represent a better estimate of true economic depreciation than the alternatives listed above. Nonetheless, further investigation into true economic depreciation profiles is an area that may be worth pursuing.

The figure used for the cost of capital also impacts significantly on the results: a 1 percentage point change in the cost of capital results in a change of around 3.4% in the final result.

Results for the average price over the first four years are around 7% lower than the year one prices. This should be borne in mind if the price set is to be kept constant for a number of years.

Trench costs are a significant proportion of the total investment cost (nearly 50%) for the conveyance network. Varying the trench length by 10% changes the results by around 4%. Again further work is recommended to obtain accurate data for trench distances.

The costs for conveyance are higher than, for example, in the UK. This appears to be mainly due to the high cost of IRIM-LAS links which is driven by the large number of these links. Telstra's forward looking network is based on the plan to bring the conveyance network much closer to the customer than has been the case in the past. This would be expected to increase the cost of conveyance, but reduce the cost of access. In practice both the cost of conveyance and of access are higher than in the UK. In part this may be due to genuine geographical differences between the two countries. However, it is also possible that part of the reason for this is that while Telstra's forward looking network may be optimal when taking account of all Telstra's activities (including broadband services), it may not be optimal for PSTN services alone. This is a further consideration that should be borne in mind when viewing the results.

APPENDIX A. ECONOMIC DEPRECIATION

In this Appendix we consider how by making a number of assumptions for different types of asset we can derive economic depreciation profiles. These economic depreciation profiles are then used in two ways:

- they are used to indicate which out of straight line depreciation, sum of digits depreciation and an annuity function, most closely approximates to economic depreciation;
- they can be used directly in the TSLRIC model to derive results for access and conveyance charges.

A.1. Derivation of Economic Depreciation Profiles

As discussed in Section 1.6, in order to model economic depreciation, assumptions need to be made regarding:

- the trend in asset prices;
- the future pattern of output;
- the initial level of operating costs;
- the future pattern of operating costs;
- the cost of capital.

The steps required to derive the economic depreciation profiles are as follows:

- set the "year 1" price for output (this is determined in a self consistent way within the model to ensure that the value of the asset in year 1 is equal to the NPV of future cash flows);
- roll forward the year one price using the price trend for the asset;
- set the year 1 volume of output and roll this forward using the future output profile;
- calculate revenue in any year = price x volume;
- operating cost in any year = initial operating cost x time trend;
- cash flow = revenue - operating cost. This is the total required cash flow and hence is equal to depreciation plus return on capital;
- value of asset = NPV of future cash flows (the year 1 price is determined iteratively to ensure that this is so);

- depreciation = change in value of asset from year to year;
- the asset life is established by the point at which cash flows become permanently negative.

Note that the asset life is determined self consistently within the calculation.

A.2. Assumptions Used and Results

We have considered six broad asset types:

- switching;
- switch sites;
- transmission equipment (multiplexers etc);
- optic fibre;
- trench;
- copper cable.

We already have values for some of the assumptions required, namely the price trend, initial level of operating cost and the cost of capital.

The values for initial operating cost (as a proportion of asset value) and for the price trends are taken from Table B.1 and B.2 (the origin of these figures is discussed in Section 2.4 of the report). Where there is more than one type of asset in our category (eg switching covers ports and processors) we have taken a view as to what constitutes an appropriate overall value (this was done simply to limit the number of profiles derived). These operating costs represent *direct* operating costs only. To allow also for indirect operating costs we have applied a mark up for these indirect costs (see Section 2.4). The assumptions used are shown in Table A.1.

Table A.1
Assumptions Used to Derive Economic Depreciation Profiles

Asset type	Annual price trend	Initial operating cost as % of asset value
Switching	-7%	7%
Switch sites	-1%	11%
Transmission equipment	-10%	6%
Optic fibre	-5%	10%
Trench and duct	0%	11%
Copper cable	-0.5%	13%

The nominal cost of capital is taken to be 10%.

We still require assumptions regarding the future pattern of operating costs and the output profile of the assets. There are two ways to approach this:

- either we can make exogenous assumptions about these variables, in which case the asset lives will be "unconstrained" and will differ from the views on asset lives provided by industry participants (see Section 2.4); or
- we can constrain the asset lives and ensure that the other variables are set in such a way as to be consistent with this.

Which of these approaches is to be preferred is largely a question of the degree of confidence that can be attached to the assumptions about the different variables. We have considered both approaches. In the first case we have taken the assumptions on the future pattern of operating costs and the output profile that were used by Oftel, the UK regulator, when modelling LRIC in the UK (see below). Oftel's assumptions were obtained from talking to industry representatives in the UK. We do not know how robust they are. In the second case we have used asset lives based on an average of the data provided by Telstra and Optus as well as NERA figures (based on experience gained elsewhere) and adjusted the Oftel assumptions to ensure consistency.

A.2.1. Oftel assumptions and unconstrained asset lives

In this case, we have in general taken the assumptions used by Oftel in 1997 for the future pattern of operating costs.[51] However, as Oftel was concerned with modelling the core network only, there are no assumptions for copper cable and we have set assumptions with a view to obtaining a reasonable value for the asset life.

The output profile of the assets is in all cases taken to be constant. This again is in line with the assumptions used by Oftel.

The assumptions used are detailed in Table A.2 below.

Table A.2
Oftel Assumptions on Operating Costs

Asset type	Future pattern of operating costs
Switching	Rises at 5% per year after 10 years
Switch sites	Rises at 1% per year after 10 years and 3% per year after 25 years
Transmission equipment	Rises at 10% per year after 7 years
Optic fibre	Rises at 1% per year after 20 years
Trench and duct	Rises at 1% per year after 20 years and 2% per year after 30 years
Copper cable	Rises at 3% per year after 10 years

The asset lives determined by this approach are shown in Table A.3 where they are compared with those used in the TSLRIC model.

51 "Long Run Incremental Costs: The Bottom-Up Network Model", Annex D, Oftel, March 1997.

Table A.3
Comparison of Asset Lives

Asset type	Asset life used in TSLRIC Model	Asset Life Derived from Economic Depreciation Model
Switching	10	14
Switch sites	20	29
Transmission electronics	10	10
Optic fibre	24	18
Trenching	34	45
Copper cable	22	23

There are clearly some differences between the asset lives we have assumed in the TSLRIC model and those derived using the economic depreciation profiles, though the overall match is not too bad. We would caution that economic depreciation profiles (and the associated asset lives) are sensitive to the assumptions made and hence it is inappropriate to infer too much from the observed differences.

The results given by the economic depreciation model for the total capital charge (depreciation plus return) in year 1 are shown in Table A.4.[52] The results are compared with the capital charge for a range of "proxy" depreciation profiles namely, straight line depreciation, sum of digits depreciation and an annuity function. The asset lives used for this comparison are those derived from the economic depreciation profiles.

Table A.4
Comparison of Year 1 Capital Charge using Economic Depreciation Profiles with that Generated by "Proxy" Depreciation Profiles (Unconstrained Asset Lives)

Asset type	Economic	Straight Line	Sum of Digits	Annuity
Switching	21%	14%	21%	12%
Switch sites	11%	11%	14%	8%
Transmission electronics	25%	17%	25%	14%
Optic fibre	19%	13%	18%	10%
Trenching	8%	10%	12%	8%
Copper cable	12%	12%	16%	9%

52 Note that in this Table, and in the subsequent Tables, the figure for the total capital charge is in real (rather than nominal) terms.

From this we can see that (at least for the 1st year) the following proxies to economic depreciation are reasonable:

- switching: sum of digits;
- switch sites: straight line;
- transmission equipment (multiplexers etc): sum of digits;
- optic fibre: sum of digits;
- trench: annuity;
- copper cable: straight line.

A.2.2. Adjusted assumptions and constrained asset lives

As an alternative to using Oftel's assumptions regarding the future pattern of operating costs (and hence unconstrained asset lives), we have reconsidered these input assumptions and made adjustments to bring the economic depreciation asset lives more into line with those used in the TSLRIC model. In particular we have changed the operating cost assumptions to bring forward (or to push back) the increase in operating costs in those cases where the asset lives used in the TSLRIC model differ from those generated by the economic depreciation model. We have again kept the output profile constant. We can then make the same comparison as is made in Table A.4, based on these new assumptions. The results are shown in Table A.5.

Table A.5
Comparison of Year 1 Capital Charge using Economic Depreciation Profiles with that Generated by "Proxy" Depreciation Profiles (Constrained Asset lives)

Asset type	Economic	Straight Line	Sum of Digits	Annuity
Switching	24%	16%	24%	14%
Switch sites	13%	12%	16%	9%
Transmission electronics	25%	17%	25%	14%
Optic fibre	16%	12%	16%	9%
Trenching	10%	10%	13%	8%
Copper cable	12%	12%	16%	9%

While the levels of capital charges shown in Table A.5 differs from those shown in Table A.4, in general the choice of proxies to economic depreciation remains the same. The exception to this is trenching for which straight line depreciation, as opposed to an annuity function, now appears the most appropriate.

A.2.3. Average over 4 years

As well as considering year one pricing we can also consider the effect of averaging over the first 4 years prices (as may be appropriate if constant interconnection prices are to be set for this period).

The results of this are shown in Table A.6 (for the constrained asset lives case). Again we can compare the results from the economic depreciation calculation with the results using different proxies.

Table A.6
Comparison of 4 Year Average Capital Charge using Economic Depreciation Profiles with that Generated by "Proxy" Depreciation Profiles (Constrained Asset Lives)

Asset type	Economic	Straight Line	Sum of Digits	Annuity
Switching	20%	15%	20%	14%
Switch sites	13%	12%	15%	9%
Transmission electronics	20%	16%	21%	14%
Optic fibre	14%	11%	14%	9%
Trenching	10%	10%	12%	8%
Copper cable	11%	11%	14%	9%

Taking a 4 year average clearly reduces the capital charge (and the price for the service) compared to the year 1 price, particularly for those assets whose depreciation profile approximates to sum of digits depreciation. However, the choice of "proxies" remains the same whether we consider "year 1" or "4 year average" pricing.

A.2.4. Method Used in the Report

We have one of two options regarding the choice of proxy economic depreciation profiles to be used in the TSLRIC model:

- either we use the proxies described in Section A.2.1 together with the asset lives determined by the economic depreciation profile; or
- we use the proxies described in Section A.2.2 and asset lives are based on the views of industry participants.

The asset lives derived through the economic depreciation calculation are very dependent on the input assumptions we have used and we feel that to use these would give too much weight to these results. We have therefore chosen to retain our original asset lives and to use the proxies described in Section A.2.2.

We conclude that it is possible to assign proxy depreciation profiles to different asset types as follows:

- straight line depreciation for trenching, switch sites and copper cable;
- sum of digits depreciation for switches, transmission electronics and optic fibre.

These are the proxies we have used in the report.

A.3. Results from the TSLRIC Model using Economic Depreciation

We have also run the TSLRIC model using the economic depreciation profiles directly – given the uncertainties regarding some of the input parameters needed to derive the economic profiles (eg the future pattern of operating costs and the output profile) we have chosen to report the results in this Appendix rather than in the main body of report.

We have run this sensitivity under 4 different scenarios:

- unconstrained asset lives:
  - year 1;
  - average of first four years.
- constrained asset lives:
  - year 1;
  - average of first four years.

The results are shown in Table A.7 where they are also compared to the results obtained using the proxy depreciation profiles.

Table A.7
Results for Access and Conveyance Using Economic Depreciation
(Option 1 for physical parameters)

	Access cost per line ($/year)	Single trunk interconnection charge ($/min)
Unconstrained asset lives - year 1	$ 381	$ 0.0165
Unconstrained asset lives - average over 4 years	$ 374	$ 0.0155
Constrained asset lives - year 1	$ 408	$ 0.0172
Constrained asset lives - average over 4 years	$ 394	$0.0162
Proxy economic depreciation profiles - year 1	$ 423	$ 0.0177
Proxy economic depreciation profiles - average over 4 years	$ 405	$ 0.0165

The proxy economic depreciation profiles give results around 3-4% higher than when the profiles we have calculated, with asset lives constrained, are used directly. The results from the economic depreciation profiles when asset lives are not constrained are somewhat lower - this is due to the fact that the asset lives derived in the economic depreciation model are generally longer than those used in the TSLRIC model.

The impact of using a 4 year average is to reduce charges by around 2-4% for access costs and 6-7% for single trunk interconnection.

APPENDIX B. COST DATA

Table B.1
Assumptions for equipment costs for access network

	Capital investment AUS $	Asset life	Price trend	Operational costs as a % of capital cost	Deprec method code*
NTP	c-i-c	17	2%	8%	1
DP	c-i-c	17	1%	9%	1
Pillar (900 pair)	c-i-c	17	1%	9%	1
MDF	c-i-c	12	-3%	13%	1
Copper drop / metre	c-i-c	22	-1%	13%	1
Copper cable 10 pair / metre	c-i-c	22	-1%	13%	1
Copper cable 50 pair / metre	c-i-c	22	0%	13%	1
Copper cable 100 pair / metre	c-i-c	22	0%	13%	1
Copper cable 400 pair / metre	c-i-c	22	-1%	13%	1
Copper cable 800 pair / metre	c-i-c	22	-1%	13%	1
Copper cable including pits and cable joints	c-i-c	22	-1%	13%	1
Trench / metre - CBD	c-i-c	29	0%	12%	1
Trench / metre - Metro	c-i-c	29	0%	12%	1
Trench / metre - Provincial	c-i-c	29	0%	12%	1
Trench / metre - Rural (ploughed)	c-i-c	29	0%	12%	1
Line card in IRIM (per line)	c-i-c	10	-4%	7%	2
Line card in RSS/RSU (per line)	c-i-c	10	-5%	7%	2
Line card in LAS (per line)	c-i-c	10	-5%	7%	2
Access network management centre per access line	c-i-c	9	-7%	20%	2

c-i-c = commercial-in-confidence information removed.

* *Note that the depreciation method codes are as follows:*

- *Straight line:* 1
- *Sum of digits front loaded:* 2
- *Sum of digits back loaded:* 3
- *Geometric front loaded:* 4
- *Geometric back loaded:* 5
- *Tilted straight line:* 6
- *Tilted annuity:* 7
- *Annuity:* 8

Table B.2
Assumptions for equipment costs for transport network

	Capital investment AUS $	Asset life	Price trend	Operational costs as a % of capital cost	Deprec method code
IRIM (per 480 line unit, excl MUX))	c-i-c	10	-4%	7%	2
IRIM - port	c-i-c	10	-4%	7%	2
IRIM - site	c-i-c	24	1%	12%	1
RSS/RSU (per 2048 line unit)	c-i-c	10	-4%	7%	2
RSS/RSU - port	c-i-c	10	-4%	7%	2
RSS/RSU - site	c-i-c	21	0%	11%	1
LAS (per 2048 line unit)	c-i-c	10	-5%	7%	2
LAS - port	c-i-c	10	-5%	7%	2
LAS - fixed (processor)	c-i-c	10	-8%	7%	2
LAS - per BHCA (processor)	c-i-c	10	-8%	7%	2
LAS - site	c-i-c	20	-1%	11%	1
TS - port	c-i-c	9	-6%	7%	2
TS - fixed (processor)	c-i-c	9	-6%	7%	2
TS - per BHCA (processor)	c-i-c	9	-6%	7%	2
TS - site	c-i-c	17	-1%	10%	1
Synchronisation PRC	c-i-c	4	0%	13%	2
Synchronisation SSU equipment per tandem switch	c-i-c	9	0%	13%	2
Synchronisation SSU licence per tandem switch	c-i-c	9	0%	13%	2
SDH MUX STM1	c-i-c	10	-10%	6%	2
SDH MUX STM4	c-i-c	10	-10%	6%	2
SDH MUX STM16	c-i-c	10	-10%	6%	2
Digital cross connect	c-i-c	10	-9%	7%	2
Line termination system	c-i-c	10	-9%	6%	2
STM - 1 Regenerator	c-i-c	9	-10%	5%	2
STM - 4 Regenerator	c-i-c	9	-10%	5%	2
STM - 16 Regenerator	c-i-c	9	-10%	5%	2
Repeater Site Cost	c-i-c	23	1%	12%	1
12 fibre cable / metre	c-i-c	24	-5%	10%	2
24 fibre cable / metre	c-i-c	24	-5%	10%	2
48 fibre cable / metre	c-i-c	24	-5%	10%	2
96 fibre cable / metre	c-i-c	24	-5%	10%	2
Trench / metre - CBD	c-i-c	34	0%	11%	1
Trench / metre - Metro	c-i-c	34	0%	11%	1
Trench / metre - Provincial	c-i-c	34	0%	11%	1
Trench / metre - Rural (ploughed)	c-i-c	34	0%	11%	1
Trench / metre - Rural (ploughed - no duct)	c-i-c	34	0%	11%	1
Signalling transfer point	c-i-c	9	-5%	8%	2
Core network management centre per switch node	c-i-c	9	-7%	62%	2

c-i-c = commercial-in-confidence information removed.

Table B.3
Telstra equipment costs for access network*

	Capital investment AUS $	Asset life	Price trend	Operational costs as a % of capital cost	Deprec method code
NTP	c-i-c	17	4%	8%	1
DP	c-i-c	17	1%	9%	1
Pillar (900 pair)	c-i-c	17	1%	9%	1
MDF	c-i-c	11	-3%	13%	3
Copper drop / metre	c-i-c	15	-1%	13%	2
Copper cable 10 pair / metre	c-i-c	15	-1%	13%	2
Copper cable 50 pair / metre	c-i-c	15	2%	13%	2
Copper cable 100 pair / metre	c-i-c	15	2%	13%	2
Copper cable 400 pair / metre	c-i-c	15	1%	13%	2
Copper cable 800 pair / metre	c-i-c	15	0%	13%	2
Copper cable including pits and cable joints	c-i-c	15	-1%	13%	2
Trench / metre - CBD	c-i-c	25	4%	12%	1
Trench / metre - Metro	c-i-c	25	4%	12%	1
Trench / metre - Provincial	c-i-c	25	4%	12%	1
Trench / metre - Rural (ploughed)	c-i-c	25	4%	12%	1
Line card in IRIM (per line)	c-i-c	9	5%	7%	3
Line card in RSS/RSU (per line)	c-i-c	9	3%	7%	3
Line card in LAS (per line)	c-i-c	9	3%	7%	3
Access network management centre per access line	c-i-c	9	-7%	20%	1

c-i-c = commercial-in-confidence information removed.

* *Note that not all of this data is Telstra data - where no data has been provided by Telstra, figures are as in Table B.1.*

Table B.4
Telstra equipment costs for transport network*

	Capital investment AUS $	Asset life	Price trend	Operational costs as a % of capital cost	Scrap value as a % of equipment capital cost	Deprec method code
IRIM (per 480 line unit, excl MUX))	c-i-c	9	5%	7%		3
IRIM – port	c-i-c	9	5%	7%		3
IRIM – site	c-i-c	24	1%	12%		1
RSS/RSU (per 2048 line unit)	c-i-c	9	3%	7%		3
RSS/RSU - port	c-i-c	9	3%	7%		3
RSS/RSU - site	c-i-c	21	0%	11%		1
LAS (per 2048 line unit)	c-i-c	9	3%	7%		3
LAS - port	c-i-c	9	3%	7%		3
LAS - fixed (processor)	c-i-c	9	-8%	7%		3
LAS - per BHCA (processor)	c-i-c	9	-8%	7%		3
LAS - site	c-i-c	20	-1%	11%		1
TS - port	c-i-c	6	-6%	7%		3
TS - fixed (processor)	c-i-c	6	-6%	7%		3
TS - per BHCA (processor)	c-i-c	6	-6%	7%		3
TS - site	c-i-c	17	-1%	10%		1
Synchronisation PRC	c-i-c	4	0%	13%		2
Synchronisation SSU equipment per tandem switch	c-i-c	9	0%	13%		2
Synchronisation SSU licence per tandem switch	c-i-c	9	0%	13%		2
SDH MUX STM1	c-i-c	15	-8%	6%		2
SDH MUX STM4	c-i-c	15	-8%	6%		2
SDH MUX STM16	c-i-c	15	-8%	6%		2
Digital cross connect	c-i-c	15	-8%	7%		1
Line termination system	c-i-c	15	-6%	6%		1
STM - 1 Regenerator	c-i-c	15	-9%	5%		1
STM - 4 Regenerator	c-i-c	15	-9%	5%		1
STM - 16 Regenerator	c-i-c	15	-9%	5%		1
Repeater Site Cost	c-i-c	23	1%	12%		1
12 fibre cable / metre	c-i-c	25	2%	10%		5
24 fibre cable / metre	c-i-c	25	1%	10%		5
48 fibre cable / metre	c-i-c	25	1%	10%		5
96 fibre cable / metre	c-i-c	25	0%	10%		5
Trench / metre - CBD	c-i-c	40	4%	11%		1
Trench / metre - Metro	c-i-c	40	4%	11%		1
Trench / metre - Provincial	c-i-c	40	4%	11%		1
Trench / metre - Rural (ploughed)	c-i-c	40	4%	11%		1
Trench / metre - Rural (ploughed - no duct)	c-i-c	40	4%	11%		1
Signalling transfer point	c-i-c	9	-5%	8%		1
Core network management centre per switch node	c-i-c	9	-7%	62%		2

c-i-c = commercial-in-confidence information removed.

* *Note that not all of this data is Telstra data - where no data has been provided by Telstra, figures are as in Table B.2..*

APPENDIX C. COST ALLOCATION ISSUES FOR SWITCHING

The costs of remote units and local switches need to be split into those that are line related and can be allocated to access, and those that are traffic related and can be allocated to transport.

For certain costs categories the appropriate allocation is clear cut:

- the cost of line cards (assuming this is just the cost of the card) is a per line card and should be attributed to access;
- the cost of ports is a traffic related cost and should be attributed to traffic.

The other principal cost categories for IRIM and RSS/RSU are:[53]

- the site cost/housing cost;
- the cost of an N line unit.

The costs of both of these can both largely be allocated, if a sufficiently detailed cost break down is provided.

For example the site cost could be allocated on the basis of floor space. Where the site cost includes the cost of power and air conditioning, these costs can be allocated on the basis of the relative power/cooling needs of different pieces of equipment.

The cost of an N line unit should be split according the functionality of the unit (ie an analysis needs to be carried out of what exactly the unit does in terms of a series of stages taking the traffic from the line card to the port; how each stage best fits with a description of "line related" vs "traffic related" and the relative costs of each stage can then be considered).

Unfortunately this kind of detailed break down is difficult to achieve.

In comparing Telstra data with data NERA has obtained elsewhere, there appear to be some clear differences (see Table C.1) for remote switches.

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53 Since an LAS is assumed to contain co-located RSS/RSUs, the same principles apply for the RSS/RSU part of the LAS.

Table C.1
Comparison of remote switching costs

Component	Telstra	NERA*
Line card	c-i-c	c-i-c
2048 line unit	c-i-c	c-i-c
Total	c-i-c	c-i-c

c-i-c = commercial-in-confidence information removed.

**Note these figures are averages over data provided by a number of different operators*

What we see is a very different cost *structure* - although the total cost is also different. We note the following:

- the Telstra figure for the line card is much lower. The fixed cost includes all of the functionality (as well as eg the cabinet) of the RSS/RSU to take traffic from the line card to the port and some of this cost should potentially be allocated to access;
- in the NERA figures the cost per line card includes more than just the line card - the cost of the line card controller is implicitly included (possibly a portion of this cost should in fact be allocated to transport).

These figures represent different extremes for allocating costs - and we will get different end results. Given that the figures do not seem to have been provided on a comparable basis, it is not appropriate to average over them for the purposes of arriving at a "base case" figure.

For the IRIM we have not used independent NERA data, as the figures we have do not seem to be directly comparable - hence we have relied on Telstra data. This still leaves the same issues as above. We would normally expect that the cost of a line card is about the same irrespective of where it is used. Our 2 cost scenarios are then built from:

- Telstra data;
- Telstra data reallocated to give a line card cost equivalent to that for an RSS/RSU.

Results are shown in Table C.2.

Table C.2
Comparison of IRIM costs

Component	Telstra	NERA*
Line card	c-i-c	c-i-c
480 line unit (excluding MUX)	c-i-c	c-i-c
Total	c-i-c	c-i-c

c-i-c = commercial-in-confidence information removed.

**The total cost has been taken to be the same - but the costs have been reallocated between line and traffic*

LAS sites are assumed to include RSS/RSU units and the same fixed and per line card costs are used.

In both cases we can compare the proportion of line card costs to traffic related costs - this ratio can then be compared with what we expect to find based on international comparison. In practice in this report we have presented results using the "NERA" figures.

Site costs are allocated in the model on the basis of the ratio of line to traffic related costs - this is clearly a simplification.

APPENDIX D. REAL VS NOMINAL COST OF CAPITAL AND DEPRECIATION

This Appendix looks at the issue of how to treat the required annual revenue in terms of real vs nominal figures.

The procedure we are currently using is as follows:

- all components of "required revenue" are estimated in real terms (in money of the day at the beginning of the year);
- nominal required revenue (and subsequently nominal charges) is estimated by inflating the real figures by an estimate of inflation over the year.

The following traces through the real terms calculation and shows how the end result can be restated in terms of nominal figures.

Real required revenue is calculated as follows. All the following parameters are defined in "money of the day" at the beginning of the year, ie time t_0.

Value of assets at time t_0	$= V_0$
Real rate of return	$= r$
Return on capital required	$= r \cdot V_0$
Value of assets at end of year (time t_1)	$= V_1$
Depreciation[54]	$= V_0 - V_1$
Operating costs as % of initial investment	$= Op$
Operating costs	$= Op \cdot V_0$
Required real revenue	$= V_0 \cdot [r + (V_0 - V_1)/V_0 + Op]$

Making the simplifying assumption that all transactions (including consumption of capital) take place at the end of year, we can translate real revenue into nominal revenue by multiplying by (1+I), where I= inflation over the year.

54 Note that real depreciation measures the change in real value of the asset by comparing the value of the asset at two points in time using the same currency terms or "unit of measurement", eg March 1997 dollars.

Nominal revenue required $= (1 + I) . V_0 . [r + (V_0 - V_1)/V_0 + Op]$

It is possible to re-express this using nominal parameters (so that, for example, the nominal rate of return appears explicitly).

Nominal rate of return $= R$

Where the relationship between R and r is: $1 + R = (1 + r) . (1 + I)$

Or: $(1 + I) . r = R - I$

Using this we have:

Required nominal revenue $= V_0 R - V_0 I + (1 + I) V_0 - V_1 (1 + I) + Op V_0 (1 + I)$

$= V_0 R + (V_0 - V_1^1) + Opex^1$

where V_1 = value of asset at time t_1 in t_0 prices, V_1^1 = value of asset at time t_1 in t_1 prices; $Opex^1$ = operating costs over year in t_1 prices.

In this form of expressing the result, all parameters are nominal. However the "depreciation" term incorporates both the real change in the value of the assets and the effect of inflation. This has the effect that, in principle, the "depreciation" term could be negative. This result is not in a form that accountants would normally recognise.[55]

To give a numerical example, we need to define a depreciation profile. If we simply use straight line depreciation then we have the following relationships.

Asset life $= AL$

$V_0 - V_1$ $= 1/AL$

$V_0 - V_1^1$ $= V_0 - V_0 (1 - 1/AL) . (1 + I) = (1 + I) . V_0/AL - IV_0$

Using some simple numbers we can illustrate the two approaches as shown in the following two tables. We take I=3% and AL=10 years in these examples.

[55] Note that from an accounting point of view, the nominal gain on assets is put through the total gains account, rather than being used to reduce the depreciation charge in the P&L.

Table D.1
Example 1: Start with everything in real terms and convert end result to nominal terms

Parameter	Value
V_0	100
V_1	90
Depreciation (=V_0/10)	10
Rate of return	9%
Allowed return	9
Total real capital charge	19
Total nominal capital charge	**19.57**

Table D.2
Example 2: Use nominal terms throughout

Parameter	Value
V_0	100
V_1^1 [= V0 (1 - 1/AL) (1 + I)]	92.7
"Depreciation"	7.3
Rate of return	12.27%
Allowed return	12.27
Total nominal capital charge	**19.57**

We note that in example 1 the nominal total capital charge is only 3% higher than the real total capital charge, even though the nominal cost of capital is approximately 3 percentage points higher than the real cost of capital. This is because as we see in example 2, increases in the asset value due to a rise in the general price level reduce the "depreciation" charge by the holding gain.

Theoretically the two approaches are identical. In practical terms the first approach is marginally easier to apply as the depreciation term is simpler. Note that even with the second approach we do not avoid a need to identify the level of inflation - this is needed to estimate the change in asset value in nominal terms.