AUSTRALIAN COMPETITION & CONSUMER COMMISSION

TRANSMISSION NETWORK COST MODEL

DESCRIPTION OF OPERATION

Prepared by

GIBSON QUAI-AAS PTY. LTD.

Level 15, 575 Bourke Street
Melbourne VIC 3000

Tel: +61 3 8623 3888
Fax: +61 3 8623 3899
Email: melbourne@gqaas.com.au

Reference: 30746

Dated: April, 2008

DISCLAIMER

The original data provided in the transmission cost model excel spreadsheet accompanying this document, and used in this document for the purpose of describing the operation of the model, are test parameters and test scenarios and are not provided as an opinion or advice to the ACCC in regard to specific circumstances or results.

TABLE OF CONTENTS

ABBREVIATIONS

ACCC	Australian Competition and Consumer Commission
bps	Bits per second
CAN	Customer Access Network
CCA	Call Collection Area
DSLAM	Digital Subscriber Line Access Multiplexer
DWDM	Dense Wave Division Multiplexing
Gbps	Gigabits per second
kbps	Kilobits per second
LTH	Local Transmission Hub
Mbps	Megabits per second
MTH	Main Transmission Hub
O&M	Operations and Maintenance
POI	Point of Interconnection
SDH	Synchronous Digital Hierarchy
TPOI	Telstra Point Of Interconnection
TSLRIC	Total Service Long Run Incremental Cost
WACC	Weighted Average Cost of Capital
WDM	Wave Division Multiplexing

GLOSSARY

Access Provider	Carrier or carriage service provider who supplies declared services to itself or other persons — see s. 152AR of the Act.
Access Seeker	Telecommunications service provider who makes, or proposes to make, a request for access to a declared service under s. 152AR of the Act.
Landing Station	A form of telecommunications building located in the vicinity of the shoreline for the purpose of housing specialist undersea cable telecommunications transmission equipment. In this instance the Landing Station is defined to include beach access facilities that protect the undersea optical fibre cable as it comes ashore.
Local Transmission Hub	A telecommunications network operators transmission hub normally located in the vicinity of the centre of a regional area or CCA.
Main Transmission Hub	A telecommunications network operators transmission hub normally located in the vicinity of the CBD of each capital city.
Microwave	A form of terrestrial wireless transmission at a very high frequency that can be used for providing telecommunications links and television services.
Multiplexer	An electronic multiplexer makes it possible for several signals to share one expensive device or other resource, instead of having one device per input signal. In the case of SDH transmission equipment the most commonly used form of multiplexer is an add/drop multiplexer which is used to form a transmission ring and provide for adding transmission capacity to the system or dropping capacity to the location serviced by the multiplexer.
Optical Fibre	Cable made of glass fibres through which signals are transmitted as pulses of light.
Repeater	In the case of SDH transmission systems the repeater is a digital device that amplifies, reshapes, retimes, or performs a combination of any of these functions on a digital input signal for retransmission. As these functions are also functions included in an SDH add/drop multiplexer a repeater is cost effectively supplied by using a multiplexer without the line cards used to terminate capacity at a location. Using the same device (including with the capability to add line cards) increases the flexibility and efficiency of system deployment.

1. INTRODUCTION

The Australian Competition and Consumer Commission (ACCC) commissioned Gibson Quai - AAS to develop a Total Service Long Run Incremental Cost (TSLRIC) model for transmission capacity to assist the ACCC's regulatory role. This document describes the operation of the model, provides guidance on its usage. The original data provided in the transmission cost model excel spreadsheet accompanying this document, and used in this document for the purpose of describing the operation of the model, are test parameters and test scenarios and are not provided as an opinion or advice to the ACCC in regard to specific circumstances or results.

A further section (Section 4.10) addresses the calculation of connection charges.

1.1 SCOPE OF WORK

The model caters for:

a. Link transmission capacity;

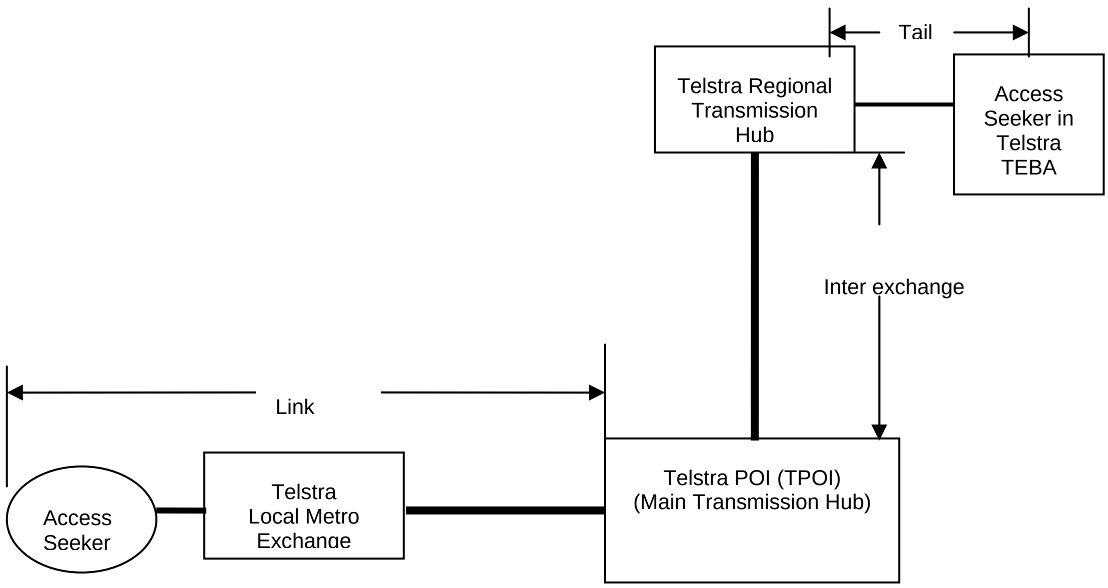
b. Inter-exchange transmission capacity;

c. Tail transmission capacity;

Undersea cable transmission capacity.

Figure 1 identifies in diagrammatic form the interpretation of the 'Link', 'Inter-exchange' and 'Tail' transmission links that have been employed for the purpose of this TSLRIC model.

Figure 1 Diagram of transmission elements to be modelled



For the purposes of the model the following definitions have been applied to the above transmission services.

Link transmission: Transmission capacity services connecting an Access Seeker via a local exchange normally in an inner metropolitan area in close vicinity of Telstra's Main Transmission Hub (MTH). This can include an optical fibre service from the Access Seekers host premises to Telstra's metropolitan Local Exchange.

Inter-exchange transmission: Transmission capacity services connecting a Telstra Main Transmission Hub (MTH) to a Regional Local Transmission Hub (LTH).

Tail transmission: Transmission capacity services connecting a Telstra Regional LTH to a Telstra local exchange within the Call Collection Area (CCA) serviced by the LTH. It is assumed the Access Seeker requires the transmission service to terminate on its equipment located in the Telstra Exchange Building Access (TEBA) space within the local exchange.

Undersea cable transmission: Transmission capacity services connecting Telstra's Main Transmission Hub (MTH) in a capital city to an LTH serving a CCA in an island location via an optical fibre undersea cable which traverses a body of water with a breadth not requiring the use of repeaters.

Definitions previously employed by the ACCC include:

Inter-exchange local transmission, which closely aligns with **'Tail'** Transmission used here;

Tail-end transmission, which is used to identify a Customer Access Network (CAN) link, within a local exchange area, between the Access Providers POI and the Access Seekers premises. The model includes this element in the costing of the 'Link' capacity;

Other transmission is defined as transmission capacity between transmission points located in different CCA's but excludes Intercapital routes and some identified regional routes. This definition is not specific about whether these transmission links are between the transmission hubs (i.e. MTH or LTH) that form the major transmission aggregation hubs for the CCA, whether the transmission links may cross borders and thereby require extensive routing to connect possibly adjoining CCA's that do not have direct connectivity, or whether the costing would consider the efficient alignment of the Access Seekers network with the Access Providers network. The model includes this element of transmission capacity as Inter-exchange transmission and specifically identifies that it is between two transmission hubs, one in the capital city and the other in a regional hub location.

The new definitions have been adopted to ensure a more focused costing approach that realistically aligns the outcomes with an Access Seekers actual use of the Access Providers network.

Further terms employed for the purpose of model Inter-exchange transmission costs are Tier 1 and Tier 2. These refer to the following situations:

Tier 1: where regional CCA's are adjacent to a Metropolitan area; and

Tier 2: where regional CCA's are beyond the adjacent CCA's and the optical fibre cable route passes through close in LTH's to reach more remote LTH's.

Tier 1 elements of the Inter-exchange transmission costing model are best employed where the modeller is comfortable that the distances, utilisation and sharing parameters, and also costs of network components (such as trenching) can be reasonably characterised with fewer options.

Transmission systems including Tier 2 elements must also include Tier 1 elements that conceptually would apply to the CCA's nearest to the MTH. The Tier 2 components provide the flexibility to include a different range of average distances, utilisation and sharing factors and trenching costs that would typically differ from those in Tier 1 situations. Should the modeller not require this added flexibility it is reasonable to conclude the Tier 2 components of the model could be ignored.

Transmission Link capacities modelled includes the generic units of capacity as follows: 2, 8, 10, 34, 45, 140, 155, 622, 2500Mbps services. The model allows these to be selected permitting variations of these values to be costed.

The model does not calculate connection charges for these services. Advice on the calculation of connection charges for Link, Inter-exchange and Tail transmission services is provided in Section 4.10.

1.2 OVERVIEW OF COST MODEL DEVELOPMENT APPROACH

TSLRIC modelling of network costs requires that the model deploys best-in-use technologies and appropriate assumptions relevant to efficient network architectures deployed with the selected technologies. GQ-AAS's understanding is that best-in-use technologies at this point in time, considering the required transmission volumes and deployment locations, will include Synchronous Digital Hierarchy (SDH) and or Wave Division Multiplexer (WDM) equipment on optical fibre routes. Ethernet aggregation equipment is to be included within the capability of the model; however this technology may not be regarded at this time as best-in-use technology for regional routes as to our knowledge it is not in use in these locations and the cost and capacity considerations are more than would be required for regional routes.

Microwave technology which Telstra still uses to connect some exchanges, usually in more remote areas and for legacy reasons, is not considered as an appropriate technology for the purposes of this model. The ACCC considered microwave technology in its 'Review of the declaration for the domestic transmission capacity service – Final Report of April 2004' where it came to the following conclusion:

> *"The Commission considers that optical fibre remains the dominant technology for the provision of all transmission services. In light of information received during this inquiry, it is now inclined not to consider microwave services as a viable substitute on capital-regional routes given that it cannot be utilised effectively across the entire range of downstream demands. Further, the Commission considers that alternative tail-end transmission technologies such as ULLS, HFC, LMDS and MMDS cannot match optical fibre in terms of capacity or customer acceptance for the full range of transmission requirements at this stage."*

The model is designed to cater for the effects of demographic factors (e.g. route distance, population density, terrain, etc). The model provides a facility to estimate the total demand for domestic transmission services in localities serviced by the transmission capacity. The purpose of this estimator is to inform decisions about design parameters.

The model caters for consideration of the asset life, tech factors (rate of equipment cost reduction) and Weighted Average Cost of Capital (WACC) by application of a formula developed by Allen Consulting Group for the Australian Communications Authority[1] to calculate a tilted annualised cost relevant to TSLRIC. These factors are separately selectable in the model for each item of technology employed. Similarly operational costs applying to each item of technology are separately selectable expressed as a percentage of the capital cost.

[1] The Year 1 Cost Problem, Application to the USO and Proposed Solution – Allen Consulting Group – 29th April 1999, Report to the Australian Communications Authority.

1.3 MODEL CONSIDERATIONS

The model is intended to be based on Telstra's network as the Telstra network has the scale required for the purpose of Access Seekers requiring transmission capacity to a broad range of sites. Also a primary driver of the need for the transmission capacity is to serve DSLAMs located in Telstra exchanges therefore it is relevant to consider efficient alignment of the Access Seekers needs with the Telstra Network.

The model is based on a network architecture that includes the arrangement of optical fibre routes in rings utilising optical fibre cable linking exchanges and the deployment of transmission technologies located at exchange sites to complete the transmission capability.

Consideration is given to different configurations that may be used in practice. 'Efficient' network design must consider the capability of the technology and efficient deployment of capacity. For instance in circumstances where a repeater may be required on a long transmission link it may be more efficient to take the opportunity to place a multiplexer, which have the characteristics of a repeater, in a local exchange and use it to supply that exchange with capacity. The model caters for such variants of network configuration.

Specific routes[2] may be modelled in the same manner as other[3] routes. The only consideration for specific routes (which are likely to be carrying higher capacities) versus other routes is refinement of the values of parameters applied that will be tailored to the circumstances of the specific route identified.

1.4 DESIGNED TO HAVE APPLICATION TO AN ACCESS SEEKER

The model assumes that an Access Seeker's POI is arranged efficiently within the vicinity of Telstra's network. This means that the Access Seekers POI will be located in the vicinity of a Telstra POI (TPOI) and the required transmission link will be to a Telstra exchange downstream from the Telstra POI within the Telstra network, thereby not needing to backtrack to a higher level hub to achieve the necessary connectivity.

'Link' capacity is designed to include an MTH to Local Exchange SDH ring (including several Local Exchanges) and also to include 'Tail-end capacity' designed as a local SDH ring servicing a limited number of customers (one of which would be the Access Seeker) located in a Telstra exchange area.

'Tail' capacity is assumed to be from a TPOI located in a transmission/switching hub in a Call Collection Area (CCA) to a local exchange downstream of the TPOI in the same CCA.

[2] Specific Route – A term used by the ACCC to describe high capacity defined inter-exchange routes of particular interest.

[3] Other Routes – A term used by the ACCC to describe inter-exchange routes other than Specific Routes

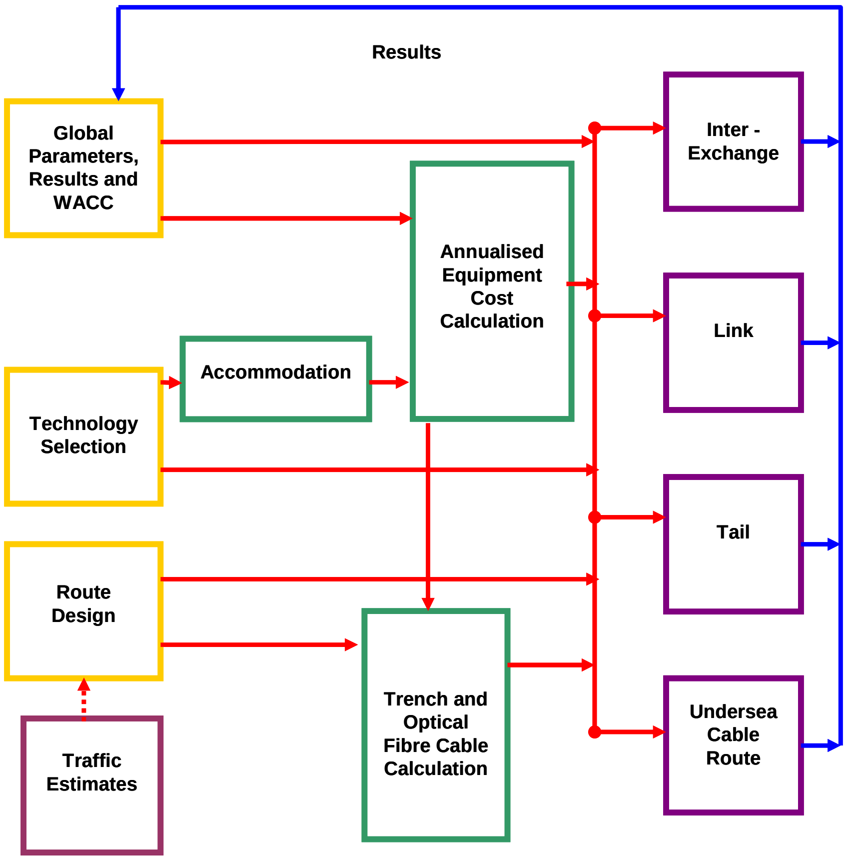
2. OVERVIEW OF THE MODEL STRUCTURE

The TSLRIC spreadsheet model of annualised costs consists of 11 spreadsheets as follows:

i. Global Parameters and Results
ii. Route Design
iii. Technology Selection
iv. Transmission Demand Estimates
v. Accommodation Cost Estimates
vi. Annualised Cost Calculation
vii. Trench and Optical Fibre Cable Calculation
viii. Inter Exchange Model
ix. Link Model
x. Tail Model
xi. Undersea Cable Route

The following diagram (Figure 2) illustrates the relationship between the spreadsheets that form the cost model. As indicated in the diagram the results from the four output models on the right are consolidated and presented for ease of use in the "Global Parameters" spreadsheet. The "Traffic Estimates" spreadsheet has no direct computational linkage to any other sheet. It is only provided for the purpose of providing an indicator as to the likely transmission volumes that could potentially be encountered to inform decisions made within the "Route Design" and "Technology Selection" sheet.

Figure 2 Diagrammatic Overview of the Transmission TSLRIC Model



3. PREPARATIONS FOR INTER-EXCHANGE TRANSMISSION COSTING

3.1 INITIAL CONSIDERATIONS FOR AN EFFICIENT SDH TRANSMISSION NETWORK

Inter-exchange optical fibre based SDH transmission ring systems are normally designed as overlapping rings each serving several communities. The number of communities served by each transmission ring is a function of the capacity of the technology employed and any requirement for efficient direct connectivity between the communities.

To achieve an 'efficient' whole of network cost a carrier will consider its total programme, not just minimise the cost of individual routes. At the core of minimising the carriers cost to service the communities is the minimisation of the cost of optical fibre and multiplexers while constructing diverse paths for the rings in order to achieve the required availability for each transmission path. Consequently a global approach is required to firstly determine capacity requirements over broad regional areas prior to making allocations of capacity that will be carried by individual rings. This allocation process is the first step to design transmission systems that cater for any particular region or locality.

To design an 'efficient' transmission system it is firstly necessary to consider the transmission capacity needs, from all of the potential sources that may have a bearing on the transmission ring design, within a broad regional area. This means it is prudent to start by determining the capacity requirements for all of the centres in at least a broad scope of the locations of interest, whether they are regional or metropolitan. This may require consideration of all regions within a state.

Secondly the modeller needs to be aware of the extent of direct routes that may be required to directly interconnect transmission hubs. These direct routes are most efficiently catered for if they can be accommodated on one ring rather than having to use capacity on two rings.

This demand for direct connectivity between regional centres has been an important consideration for PSTN traffic and a driver to encourage multiple overlapping transmission rings to service the need. We note however the PSTN traffic now forms a small portion of the total demand, consequently this driver no longer has the influence it had in encouraging establishment of overlapping rings.

The next step is to determine the likely system capacity of the transmission equipment considered 'best in use'. i.e. Will it be 2.5Gbps or 10 Gbps? This decision will be informed by both the level of demand and the current pricing of the equipment. The pricing is most likely to be driven by the world wide volume manufacture of the supplier.

We note that the choice of a 10Gbps system significantly reduces the number of systems that are deployed in each exchange and the length of optical fibre used to form rings. We understand that the cost of the components of the 10Gbps systems are very close (if not quite the same) to that of the 2.5Gbps systems. Also in a situation where the 10Gbps capacity is in excess of the requirement of a transmission hub the inclusion of other hubs leads to efficient catering for direct routes.

Coupled with the need to establish repeaters at or near other transmission hubs there is scope for arranging multiple overlaps of the rings which also serves to ease the need to shift capacity allocations as the utilisation nears capacity, thereby ensuring an even distribution of capacity.

3.2 Capacity Allocation Process

Having determined the capacity of the technology to be deployed and the capacity requirements of the sites to be considered the next step is to allocate the capacity from each site that potentially will be placed on each ring. It is considered that this process is best done by the modeller exercising judgement rather than by calculation in a model due to the complex array of considerations that impinge on what is at first sight a relatively simple exercise.

Considerations include the proximity of the sites proposed for inclusion on a ring, which minimises the total length of optical fibre required, and minimising the potential for the placement of repeaters between the major sites. Sites in close proximity also generally have the greatest need for interconnection, consequently including these on the same ring results in more efficient allocation of the capacity.

It also follows that the greater the number of sites on a single ring the greater the amount of capacity that can be catered for on a single ring. In so far as sites may be serviced by multiple rings further consideration to achieving a balance of the capacity between rings is required to ensure an even distribution of spare capacity.

This process points to the potential to balance the load on each ring. This is done by 'shifting' capacity between rings. This ability to shift capacity allocations between rings offers flexibility to manage capacity going forward.

A high level view of this process also leads one to conclude the cost of capacity can be considered to be largely independent of specific route distances.

Having said that this process is best performed manually we recommend a spreadsheet be prepared in the form of a matrix calculator as follows Table 1 that is populated with the names and the capacity of each site on one axis and a nominal number of rings each having the same capacity on the other axis.

Using this spreadsheet matrix the modeller should allocate capacity from each site to individual rings, resulting in the total capacity for each site being catered for. Also the modeller should seek a balance of capacity between each ring across all rings in the vicinity while minimising the number of rings and multiplexers.

The following Table 1 provides an example of how this calculation sheet can be constructed and the allocations made. In this instance Victoria is used as an example with indicative levels of demand that are likely to be typical of demand going forward. This example illustrates an allocation using 10Gbps rings. The example also illustrates how the overlaps occurring at Bendigo, Ballarat and Geelong offer the flexibility to balance the utilisation of the rings by shifting allocated capacity between rings.

	Ring 1	*Ring 2*	*Ring 3*	*Capacity Requirement (Gbps)*	*Sum of Allocations (Gbps)*
Shepparton	3			3	3
Bendigo	3.2		1	4.2	4.2
Mildura			2.2	2.2	2.2
Gisborne			3	3	3
Ballarat	2.1	1.4		3.5	3.5
Geelong		6.7	2.1	8.8	8.8
Total (Gbps)	8.3	8.1	8.3	24.7	24.7
Ring Capacity (Gbps)	10	10	10		30
Utilisation	83%	81%	83%		82.3%

Table 1: Example Capacity Allocation Table

Table 2 below provides a further example of a capacity allocation based on the same capacity requirement for each site but using 2.5Gbps rings rather than 10Gbps rings. This allocation results in a substantial increase in the number of overlaps increasing the potential for direct interconnection between sites on the same ring. It can also be seen that there is considerable potential for shifting capacity between the rings to balance the utilisation of each ring.

	Ring 1	*Ring 2*	*Ring 3*	*Ring 4*	*Ring 5*	*Ring 6*	*Ring 7*	*Ring 8*	*Ring 9*	*Ring 10*	*Ring 11*	*Capacity Requirement (Gbps)*	*Sum of Allocations (Gbps)*
Shepparton	1.4	1.6										3	3
Bendigo	0.8		0.1	1	0.8					1.5		4.2	4.2
Mildura			2.2									2.2	2.2
Gisborne	0.1	0.1		0.7	0.7					0.2	1.2	3	3
Ballarat		0.6	0.1	0.5		0.7	0.2	0.3			1.1	3.5	3.5
Geelong					0.8	1.5	2	1.9	2.1	0.5		8.8	8.8
Total (Gbps)	2.3	2.3	2.4	2.2	2.3	2.2	2.2	2.2	2.1	2.2	2.3	24.7	24.7
Ring Capacity (Gbps)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5		27.5
Utilisation	92%	92%	96%	88%	92%	88%	88%	88%	84%	88%	92%		89.8%

Table 2: Further Example of Capacity Allocation Table Requiring Greater Capacity

A further consideration worth noting is that Ballarat and Gisborne are located in positions that are convenient sites for the placement of repeaters. Having placed repeaters at these sites and in view of the fact these repeaters are in fact multiplexers it is consequently convenient to include these sites in the allocation of capacity to rings constructed mainly for the purpose of serving more remote sites.

The following diagram Figure 3 illustrates the location of most of the transmission hubs in regional Victoria that are likely to be considered together for the purpose of designing SDH transmission capacity.

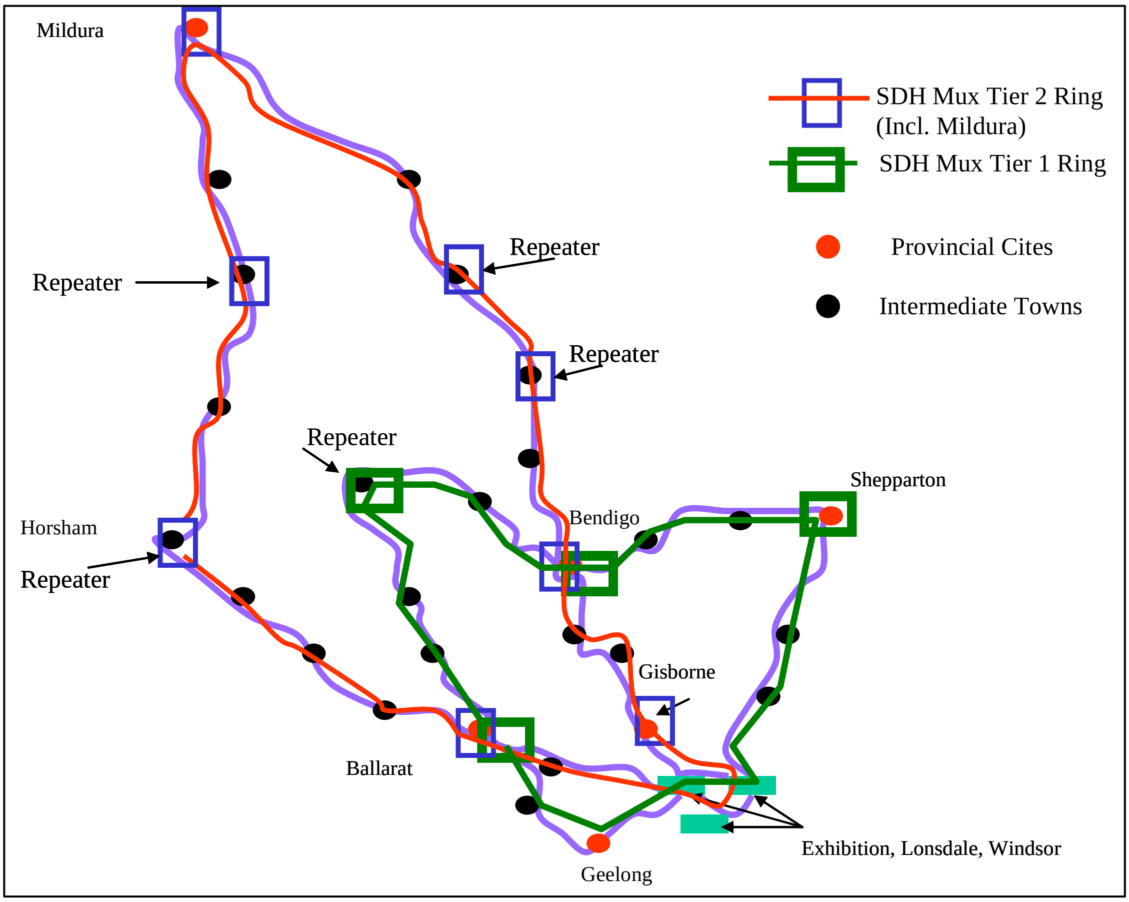


Figure 3 Likely Transmission Ring Structures Connecting Transmission Hubs of Victoria

3.3 TIER 1 AND TIER 2 RINGS

Also illustrated in the above diagram is a concept used within the model of Tier 1 and Tier 2 Rings. As can be seen from the diagram the Tier 2 ring includes the more remote site of Mildura. In the case of the ring serving Mildura it uses optical fibre cable from Mildura to both Bendigo and Ballarat. It also includes optical fibre cable in common with Tier 1 rings from Bendigo or Ballarat to Melbourne. As different costs, allocations of capacity, utilisation values for optical fibre cable and also sharing factors are likely to be apply to an optical fibre cable route in the more remote locations, this concept of Tier 1 and Tier 2 has been included in the model to support a need for the modeller to have the capacity to include a greater range of costs and factors for the relevant cost items. Section 4.3.1 further discusses this feature.

The resulting effect is that in the model Tier 1 rings include only costs for Tier 1 elements. Tier 2 rings, as shown in the diagram below traverse both the inner Tier 1 locations and also the more remote locations. Consequently these Tier 2 rings will include both Tier 1 and Tier 2 cost components thereby having the ability to use a greater range of costs for parameters that may apply.

However the technology that is used to derive the SDH ring must be the same throughout the Tier 1 and Tier 2 components of the Tier 2 ring as it remains a single system throughout the optical fibre path around the proposed ring. i.e. Either a 2.5Gbps ring or a 10Gbps ring with the same utilisation around the full length of the ring.

Where DWDM is used on some links to derive additional wavelengths on which the SDH transmission system is derived, different decisions can be applied at the Tier 1 and Tier 2 level. For instance a DWDM system may be included at Tier 1 but not Tier 2.

3.4 REPEATER PLACEMENT

Also demonstrated on the above diagram (Figure 3) Ballarat, Bendigo and Gisborne are convenient locations to place a repeater on the Tier 2 ring covering Mildura making it convenient to include these sites in the capacity allocation for the ring.

The distance between repeaters varies depending on the quality and condition of the optical fibre as well as the capability of the laser technology employed in the SDH or DWDM line driver cards. The distance is typically of the order of 80 to 90 kilometres. As most of the distances between the centres in the above diagram exceed 80 to 90 kilometres repeaters will need to be placed at some intermediate locations. Intermediate local exchanges or transmission hubs are convenient locations to site this equipment. As the distance between the major hubs is not normally an exact multiple of the required repeater distance there is normally some flexibility about the placement to ensure they are placed at intermediate exchange sites.

As the repeater is simply another SDH multiplexer and includes the capacity to accommodate tributary cards it is often convenient to include the capacity requirements of the intermediate exchange in the demand for the ring rather than include that local exchange in a further local exchange ring, which would incur the cost of a further multiplexer. Local exchanges used as repeater sites will therefore have transmission costs similar to the costs that apply to the LTH to MTH rings.

4. MODEL DESCRIPTION

4.1 CONVENTIONS USED IN THE SPREADSHEET

Throughout the workbook all cells designed to accept the input of data are coloured yellow and are boxed. Cells that are coloured green contain calculations or present results and consequently no attempt should be made to enter data into these fields.

Where cells are 'named' the name is identified to the right or above the cell for ease of tracking the operation of the spreadsheet.

4.2 TRANSMISSION DEMAND ESTIMATES

In the absence of transmission capacity data from the carrier the 'Transmission Demand Estimates' sheet (Figure 4) is designed to inform the inputs by the model user about the capacity that would typically be required to service the needs of all customers of the telecommunications network operator in a CCA. As the scale of demand has an important bearing on the unit cost, knowing the total capacity required from a CCA and adjacent CCA's allows informed decisions to be made about an 'efficient' design to cater for the needs. These decisions will include making suitable trade-offs between transmission equipment capacity and the number of LTH's that will be included on a ring as discussed in the previous section.

Decisions that flow from knowing the broad capacity requirements include, for instance, whether Dense Wave Division Multiplexer (DWDM) equipment may be required, the likely capacity of an SDH system, the number of LTH that an SDH ring is likely to efficiently include, the number of overlayed rings that would typically require optical fibre pairs in the interconnecting optical fibre cables.

The sheets results are not directly linked to other calculations within the TSLRIC Model.

The following Figure 4 shows the layout of the 'Traffic Estimates' sheet. The first panel is based on national averages and therefore the population per LTH is calculated by the spreadsheet.

The second panel permits the 'Population per LTH' to be selected to facilitate the examination of CCA's that may not conform to the average. In each case the calculations for the major sources of transmission capacity needs (being Fixed voice telephony, Mobile, Broadband and Dial-up Internet access) are modelled.

The entries in the first two lines are for the national population and the number of services in use nationally for each type of service. These are used to calculate the 'Ratio of Services Per Head'. The following line accepts an input for the number of LTH locations nationally. This figure is then used to calculate the average population per LTH and also the number of services per LTH.

Different approaches are required to the calculation of the bandwidths generated by each type of service. Consequently different calculations are supported for the Internet services from those used for the voice telephony services.

From experience, our preferred approach to determine the volume of data generated by Internet users is to base the calculation around the monthly download limits of the subscribed plans and the proportion used. For that purpose our example uses 1Gbyte (Broadband) and 500Mbytes (Dial Up) as the average a user on an ISPs plan would generate.

Other inputs required to translate the monthly usage include the packet overheads, the typical average days of usage within the month, the hours which typically reflect the volume generated in the busy periods relative to the 24 hour period, the hours per day and seconds per hour. The result is the 'Average Bandwidth per user' in Mbps.

For the purpose of estimating the bandwidth per user for telephony services, average busy hour occupancy (Erlang) per phone is utilised, along with a bandwidth generated per call.

Both the broadband and telephony bandwidth per user estimates are multiplied by the number of users per LTH to determine the bandwidth attributable to all users. The bandwidth in this case is expressed in kbps.

In the case of fixed voice telephony a certain proportion of calls are switched locally and therefore will not make use of the transmission link interconnecting the region. Consequently a percentage that is nominated to be local calls within the CCA and a percentage that are nominally trunk calls exiting the region is allocated.

For Mobiles and Internet traffic it is unlikely any will be contained locally. Therefore the appropriate value for the local traffic parameter is normally zero percent and the trunk portion 100 per cent. However it is possible to select alternative values.

In addition a factor reflecting the efficiency of the carriage of each type of traffic is also selectable. For fixed voice telephony this is likely to be about 70 per cent whereas for Internet traffic it may be of the order of 50 per cent.

Finally a figure can be entered which is intended to be a broad estimate of the many other forms of service that may require trunk transmission capacity from the CCA.

As mentioned above the second panel is the same calculation as the first but with a different treatment of 'Population per LTH' such that it permits an alternative and more specific calculation.

Two further calculators are also included. The first is useful for determining the likely utilisation of a mobile phone based on the 'Average Revenue Per User' (ARPU).

The second additional calculator provides another approach to calculating the likely transmission capacity that would be required for Mobile base stations located in a CCA. This simply relies on an estimate of the number of Base Stations present in a CCA and the typical transmission capacity supporting each. The value can be used to cross check the value achieved by the above bottom up calculations and may lead the modeller to modify the result if it is considered it is not a simple matter of aggregating the mobile traffic with other traffic to determine the total demand as would occur if it was required to consider that each mobile base station required a fixed capacity of (for example) 34Mbps.

Figure 4 Transmission Demand Estimates

Transmission Demand Estimates

	Fixed	Mobile	Broadband	Dial Up
National Population	20,000,000	20,000,000	20,000,000	20,000,000
National Services	8,000,000	16,000,000	4,000,000	2,000,000
Ratio National Population / Service	2.5	1.25	5	10
Total Number of LTH	120	120	120	120
Population per LTH	166,667	166,667	166,667	166,667
Services per LTH (CCA)	66,667	133,333	33,333	16,667
Bandwidth per user				
ISP Monthly plan (Mbytes)			1000	500
Mbits			8,000	4,000
Packet Overhead			20%	20%
Days			25	25
Hours per day			5	5
Seconds per hour			3600	3600
Average Bandwidth per user (Mbps)			0.021	0.011
Traffic from Phone				
Erlang per Phone	0.01	0.04		
Bandwidth per phone call (kbps)	64	10		
Bandwidth per user (kbps)	0.64	0.4	21	11
Bandwidth All Users (kbps)	42,667	53,333	711,111	177,778
Local Calls (Within CCA)	30%	0%	0%	0%
Trunk Calls (Outside of CCA)	70%	100%	100%	100%
Carriage efficiency	70%	70%	50%	50%
Bandwidth Required on MTH to LTH Link (kbps)	42,667	76,190	1,422,222	355,556
Other Products (kbps)				100,000
Total capcity demand for all products per CCA/LTH (Mbps)				1,997

	Fixed	Mobile	Broadband	Dial Up
National Population	20,000,000	20,000,000	20,000,000	20,000,000
National Services	8,000,000	16,000,000	4,000,000	2,000,000
Ratio National Population / Service	2.5	1.25	5	10
Total Number of LTH	120	120	120	120
Population per LTH	100,000	100,000	100,000	100,000
Services per LTH (CCA)	40,000	80,000	20,000	10,000
Bandwidth per user				
ISP Monthly plan (Mbytes)			1000	500
Mbits			8,000	4,000
Packet Overhead			20%	20%
Days			25	25
Hours per day			5	5
Seconds per hour			3600	3600
Average Bandwidth per user (Mbps)			0.021	0.011
Traffic from Phone				
Erlang per Phone	0.01	0.04		
Bandwidth per phone call (kbps)	64	10		
Bandwidth per user (kbps)	0.64	0.4	21	11
Bandwidth All Users(kbps)	25,600	32,000	426,667	106,667
Local Calls (Within CCA)	30%	0%	0%	0%
Trunk Calls (Outside of CCA)	70%	100%	100%	100%
Carriage efficiency	70%	70%	50%	50%
Bandwidth Required on MTH to LTH Link (kbps)	25,600	45,714	853,333	213,333
Other Products (kbps)				100,000
Total capcity demand for all products per CCA/LTH (Mbps)				1,238

	Fixed	Mobile	Broadband	Dial Up
Bandwidth % of Total	2.1%	3.7%	68.9%	17.2%

Estimator for indicative Mobile Utilisation	
Average Revenue Per User	$700
Per Month	$58
Per Day	$2
Call Rate per minute	$0.35
Minutes per Day	5.56
Hours per day	5.00
Utilisation (Erl per user)	0.02

Note : Used to inform estimate of mobile usage.

Estimator for Transmission Capacity Servicing Mobile Base Stations	
Mobile Towers	42
Capacity per Tower (Mbps)	34
Total Capacity (Mbps)	1428

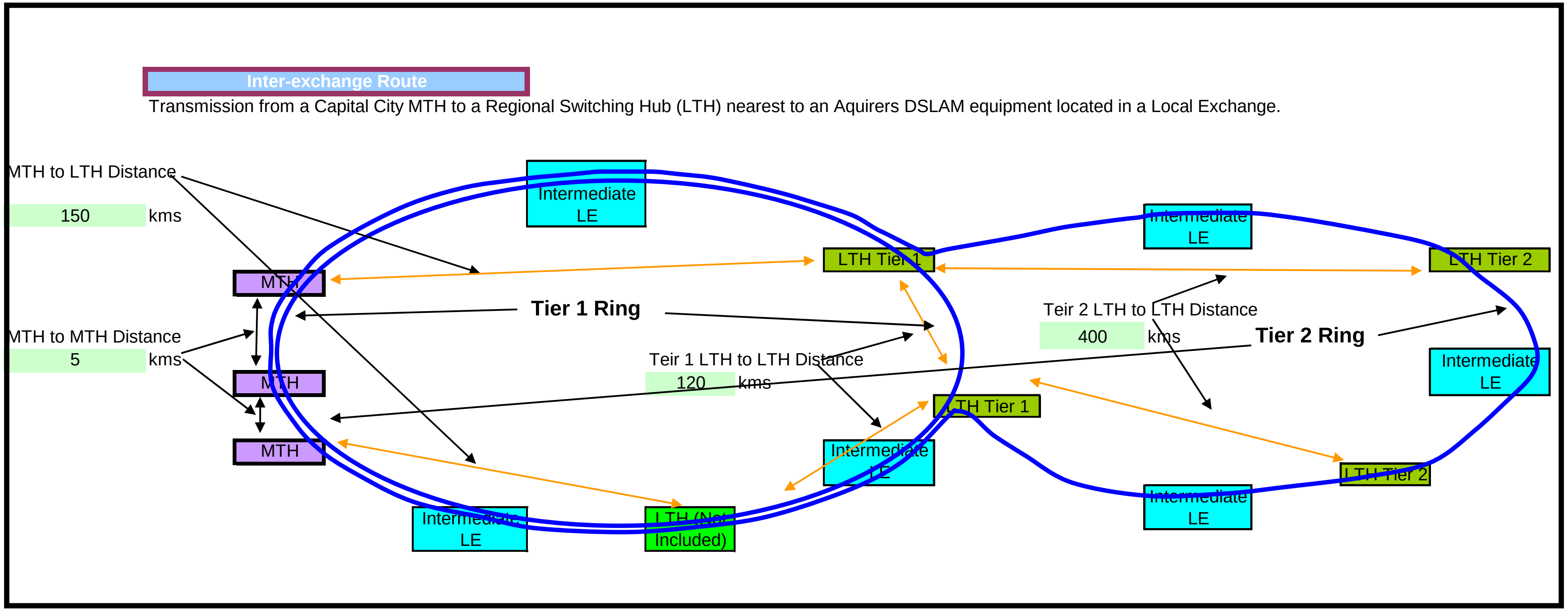
4.3 ROUTE DESIGN

The Route Design sheet contains four panels for data entry and calculation. It also contains diagrams that illustrate the architecture of a route to assist the user to understand the context of decisions made about the data to be entered that dimensions the route.

The panels requiring input data identify the parameters for the Inter-exchange, Link and Tail transmission routes. A further panel caters for a number of considerations which include, the additional lengths of optical fibre employed within an exchange that is in addition to trench and conduit lengths, the number of optical fibres employed per transmission link and factors used to calculate the number of optical fibre cable joints that would be employed.

4.3.1 Inter-exchange Route

Figure 5 Inter-exchange Route Diagram



As depicted in the above diagram (Figure 5) the Inter-exchange Route Panel is arranged to facilitate dimensioning a route that may be arranged as either one or two tiers of optical fibre rings. This will support the calculation of costs in situations where optical fibre routes may be constructed between an MTH located in the capital city and regional Local Transmission Hubs (LTH) located in:

- CCA's (in regional areas) adjacent to the metropolitan area; or alternatively
- CCA's beyond those CCA's adjacent to the metropolitan area.

In circumstances where the optical fibre cable passes through the closer in LTH to get to the more remote LTH many of the factors a modeller may wish to apply to closer in trench and cable may not be reasonable for the trench and cable in the more remote locations. For instance the distance between intermediate exchanges may be different, the optical fibre cable utilisation is likely to be less in the more remote locations and the portion of trench that is ploughed is likely to be greater. Trench sharing is also less likely to occur in the more remote locations and the cable sizes used on the approach to towns will most likely be less commensurate with a lower level of local demand for optical fibre.

Having this tiered structure provides additional flexibility to assume different parameters for items such those mentioned above and also for factors such as numbers of cables, cable size, and sharing factors which may vary in the different geographic areas. The capability includes the possibility of identifying numbers of intermediate exchanges that may or may not have multiplexers included in the design of the transmission system.

The following panel (Figure 6) displays the cells that require data to be entered and should require no further explanation. Colour coding to the left of the yellow boxed cells provide a pointer to the diagram associated with the panel.

The number of MTH in the route is set to two being the number Telstra is understood to normally include on an Inter-exchange route. This can also be set at 3 as Telstra has three MTHs in Melbourne and Sydney. This number can be set at the minimum of two required for the purpose of network robustness and diversity or by collecting evidence from Telstra about what the number actually is. However GQ-AAS's view is that two is sufficient to meet the requirements of best in use practise and one is less than required for best in use practise.

The number of regional LTH depends on the route chosen and the number of regional centres the ring passes through. In our example, the value is 3 – one for each of the centres in Ballarat, Bendigo and Shepparton for which the ring is designed to supply capacity

Where the Tier 2 scenario is selected Tier 1 components can be included as required including Tier 1 trench and cable, and Tier 1 multiplexers may be proposed at the Tier 1 LTH's in circumstances where the ring is proposed to provide for capacity from the Tier 1 hub or the location is to be used as a repeater site.

However where no multiplexer is to be placed at a Tier 1 LTH the Tier 1 LTH should not be included. The reason for this is that entering a No. of LTH's leads directly to including the cost of multiplexers at an LTH. Therefore, where no multiplexers are required, no entry for the No. of LTH should be made. This circumstance is unlikely to occur as in most cases a repeater is likely to be required and the LTH is a convenient place to locate one.

As the optical fibre cable routes are additive it is best but not essential to include the distance to the Tier 1 LTH from the MTH and select the values for the Tier 2 LTH – LTH routes separately such that the two elements are added to obtain the correct value for the cable and trench length. This approach permits different cable sizes, cables per trench and trench factors to be selected if required at each level.

A Tier 2 scenario is most likely to require the number of Tier 1 LTH to LTH links to be zero however scenarios are possible where a Tier 1 LTH-LTH should be included in a Tier 2 transmission Ring. An example would be a ring constructed to take in Mildura would be designed via Bendigo and Ballarat but would not include a link between Bendigo and Ballarat. Another less likely scenario may be to design the route to Mildura such that it includes Geelong as well and Ballarat and Bendigo, in which case it is likely the LTH to LTH cable route between Geelong and Ballarat would be included.

Distances selected for the links between MTH to MTH, MTH to LTH, LTH to LTH and also distances between intermediate exchanges should be selected to most accurately quantify the distances that would be relevant to the particular circumstance that is required to be modelled. Consequently cable route distances should be applied, not radial distances between sites. No adjustment is made in the model to apply uplift factors to distances selected.

Figure 6 Inter-exchange Route Dimensioning Panel

Inter-exchange Route

	Value	Name
Tier 1		
MTH - MTH Distance (kms)	5	m_mdist
MTH - LTH Distance (kms)	150	m_ldistt1
LTH - LTH Distance (kms)	120	l_ldistt1
MTH - LTH Intermediate Exchange Distance (Each) (km	20	iemth
LTH - LTH Intermediate Exchange Distance (kms)	30	ieltht1
No. of MTH	2	mthnoie
No. of LTH (zero if Teir 2 LTH selected)	2	lthnot1
No. of LTH Not Included in Transmission Ring	0	lthnot2add
No. of MTH to LTH Links	2	m_llinknoie
No. of LTH to LTH Links	1	l_llinknoie
No. of Intermediate Exchanges MTH - LTH		
- With Multiplexer	2	m_lintermwithmux
- Without Multiplexer	12	m_lintermwomux
No. of Intermediate Exchanges LTH - LTH		
- With Multiplexer	1	l_lintermwithmuxt1
- Without Multiplexer	2	l_lintermwomuxt1
Tier 2		
LTH - LTH Distance (kms)	400	l_ldistt2
LTH - LTH Intermediate Exchange Distance (kms)	40	ieltht2
No. of Teir 2 LTH	0	lthnot2
No. of LTH to LTH Links Teir 2	0	l_llinknoiet2
No. of Intermediate Exchanges LTH - LTH		
- With Multiplexer	0	l_lintermwithmuxt2
- Without Multiplexer	0	l_lintermwomuxt2

Further, the distances employed are average distances. Consequently when the model is applied to an actual route averages should be obtained from the sum of the actual distances. Other parameters later applied to the average distances, such as utilisation and the proportion that is ploughed trench (among others) should also be determined and applied on the same basis.

The distances between MTH and LTH add to determine the optical fibre trench and conduit costs.

The various "Intermediate Exchange Distances" are used for the purpose of determining the number of intermediate exchanges encountered on a route. Consequently they make no contribution to trench and cable lengths. Some of these may have a multiplexer or repeater others may simply be points at which the optical fibre cable enters and leaves via a cable joint at the building.

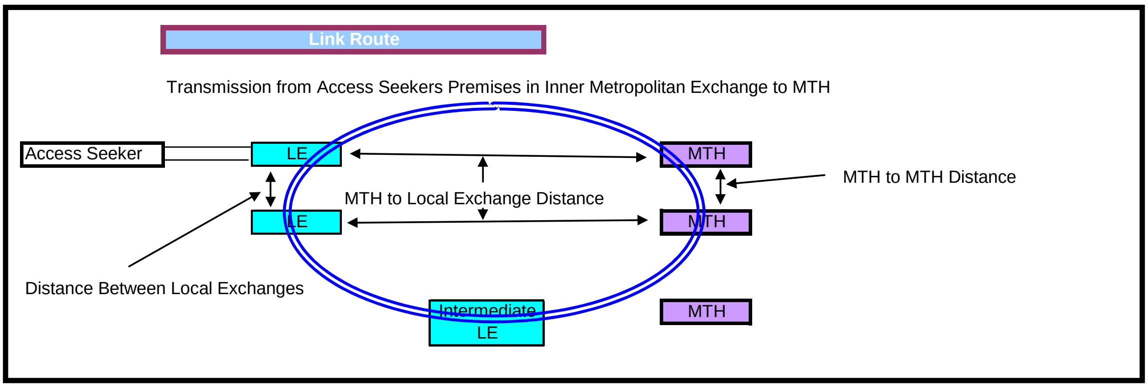
The spreadsheet calculates the number of intermediate exchanges based on the total distance of the links and the nominated distance between intermediate exchanges. The result is rounded up and reduced by 1 to get the correct number of links. This number is then reduced by the number that is nominated to have a multiplexer and the result displayed as the number of intermediate exchanges that are without a multiplexer. This cell is boxed and coloured green.

To ensure the correct interpretation of the link distances required to be entered it is important to note that the total MTH to LTH or LTH to LTH distance is multiplied by the number of links of that type to determine the total distances. Therefore, as mentioned above, the distances to be entered should be average distances of individual links.

Also note, where Tier 2 links are included the relevant Tier 1 quantities should also be included.

4.3.2 Link Route

Figure 7 Link Route Diagram



The above diagram (Figure 7) represents a typical metropolitan optical fibre ring that would be encountered between the MTH in that capital city and a number of local exchanges in the vicinity of the MTH's. Whereas there may be as many as three MTH in the Sydney and Melbourne central city area and normally two in the smaller capitals it is understood two MTH would typically be included in a transmission ring servicing local exchanges in the inner city area.

The number of local exchanges included on the ring of an efficient operator would be a function of the capacity of the transmission systems normally deployed and the transmission capacity requirements of the local exchanges. That is, there are likely to be more local exchanges included on the transmission ring where the requirements are smaller and particularly where they are substantially smaller than the capacity of the multiplexers deployed by the telecommunications network operator.

The above diagram also depicts an optical fibre link from the local exchange to the Access Seeker's premises. This link may or may not include multiplexing equipment at the Access Seeker's premises and the exchange depending on the service offered and the service delivery preferences of the Access Provider and the Access Seeker.

Figure 8 Link Route Dimensioning Panel

Link Route

	Value	Name
MTH to Local Exchange		
MTH to MTH Distance (kms)	As above	
MTH to Local Exchange Distance (kms)	5	m_localdistlink
Local Exch to Local Exch Distance (kms)	5	linkietrdist
No. of MTH	2	mthnolink
No. of Local Exchanges	2	nolocalexchlink
No. of Intermediate Exchanges		
- With Multiplexer	0	intermexchwithmuxlink
- Without Multiplexer	1	intermexchwomuxlink
Local Exchange to Access Seeker		
Distance on Customer Access Network Ring (kms)	1	leastrdist
No. of Local Exchanges on Ring	1	nolocalexchcan
No. of Access Seekers + Customer Premises on Ring	1	nocustprem

Figure 8 above shows the 'Link Route' panel that supports the input of the relevant high level dimensions of the Link Route being the distances between the exchanges and the number of exchanges involved.

The MTH – MTH distance cannot be entered here as the model relies on the selections that are made for the Inter-exchange Route.

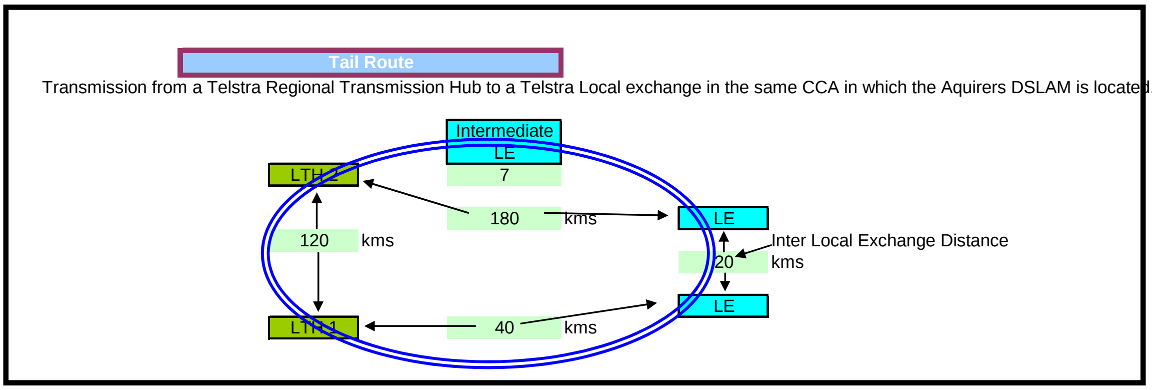
High Level information that forms the basis of the calculation of the cost of providing the service to the Access Seekers premises are also included in this panel. The route to the Access Seekers premises is modelled as a ring providing services to an Access Seeker and a number of other customer's premises.

In the event it is required to model an optical fibre and transmission capacity dedicated to the Access Seeker, the number of customer premises and the number of Local Exchanges on the ring should be entered as appropriate. For instance, if a multiplexer is employed in the exchange and another in the customers' premises, the 'No. of Local Exchanges on Ring' and 'No. of Customer Premises on Ring' would have the value '1' in each case. For the purpose of entering the appropriate data in the model the 'No. of Customer Premises on Ring' includes the Access Seeker plus other customers that may be covered by the same optical fibre ring.

In the case where no multiplexers are provided in which case the optical fibre at one end is connected to an interface on an inter-exchange ring and at the Access Seekers end is connected directly to the Access Seekers equipment, each would have the value ‘0’.

4.3.3 Tail Route

Figure 9 Tail Route Diagram



The above diagram (Figure 9) represents a typical regional optical fibre ring that would be encountered between a regional LTH and local exchanges within a CCA. Typically an optical fibre ring would include two transmission hubs each serving (most likely adjacent) separate CCA’s.

The optical fibre cable distances included in these rings therefore are typically much longer than the radial distance from an LTH to a local exchange in a CCA would intuitively indicate. The cost of doing this is normally largely mitigated by increased utilisation of the optical fibre cable linking each site.

Figure 10 Tail Route Dimensioning Panel

Tail Route

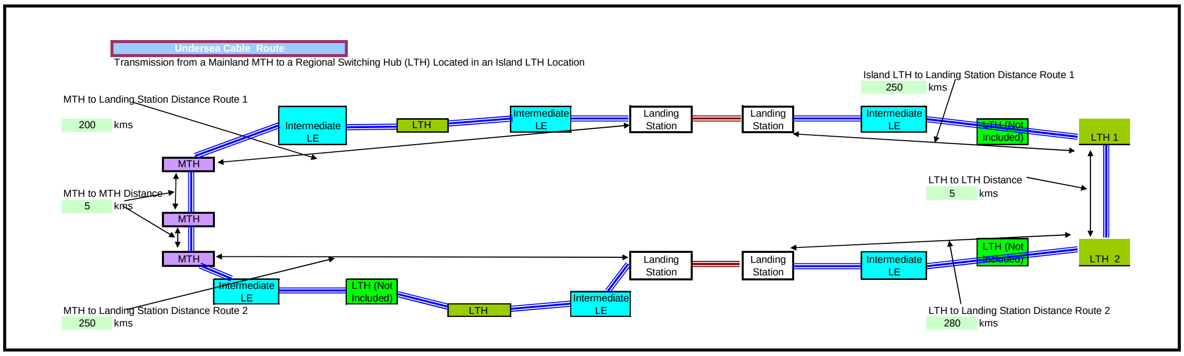
	Value	Name
LTH to Local Exchange		
LTH to LTH Distance - Average (kms)	120	l_ldisttail
LTH 1 to Local Exchange Distance (kms)	40	l_localdisttail
LTH 2 to Local Exchange Distance (kms)	180	l_localdisttail2
Inter Local Exchange Distance (kms)	20	loc_localdisttail
No. of Regional LTH	2	lthnotail
No. of Local Exchanges	2	nolocalexchtail
No. of Intermediate Exchanges		
- Without Multiplexer	5	intermexchwomuxtail
- With Multiplexer	2	intermexchwithmuxtail

Figure 10 above shows the ‘Tail Route’ dimensioning panel that accepts the input of the high level dimensions of the ‘Tail Route’. These include the distances between the various exchanges and the number of the exchanges included in the ring.

The number of intermediate exchanges that appear on the route is also selectable with the choice of these intermediate exchanges that may include a multiplexer to drop off capacity or a repeater.

4.3.4 Undersea Cable Route

Figure 11 Undersea Cable Route Diagram



Undersea cable routes between capital City MTH and regional LTH located on an Island are similar in many respects to Inter-exchange capacity. The major differences include Landing Stations located on the shoreline and the undersea cable. The Landing stations houses the specialised transmission equipment that derives the transmission capacity over the optical fibre undersea cable. For the purpose of this model repeaterless undersea cable technology is employed which is suitable for undersea cable lengths to Tasmania but would not be suitable for much longer undersea routes. If the model was to be used to cost longer undersea cable segments it is likely to require enhancement to cater for the addition of repeaters and /or optical amplifiers.

The above diagram (Figure 11) represents a typical optical fibre ring between three Melbourne MTHs and two LTH in Hobart via two separate undersea cable sections. This ring will pass through several LTH and local exchanges on the path to the landing stations. Some of these intermediate exchanges may or may not have multiplexing equipment installed.

Figure 12 Undersea Cable Route Dimensioning Panel

Undersea Cable Route

	Value	Name
Mainland		
MTH to MTH Distance (kms)	As above	
MTH to Landing Station Distance Route 1 (kms)	200	m_lsd1
MTH to Landing Station Distance Route 2 (kms)	250	m_lsd2
No. Of MTH	2	mthnousc
Route 1		
No of LTH	2	lthnomusc
No of LTH Not Included	2	lthnomnot
No of Landing Stations Route 1	1	nols1
No. of Intermediate Local Exchanges		
- Without Multiplexer	5	intermexchwomuxm
- With Multiplexer	2	intermexchwithmuxm
Route 2		
No of LTH	2	lthnomuscr2
No of LTH Not Included	2	lthnomnotr2
No of Landing Stations Route 2	1	nols1r2
No. of Intermediate Local Exchanges		
- Without Multiplexer	5	intermexchwomuxmr2
- With Multiplexer	2	intermexchwithmuxmr2
Island		
LTH to LTH Distance (kms)	5	tasl-lthd
LTH to Landing Station Distance Route 1 (kms)	250	tas_lsd1
LTH to Landing Station Distance Route 2 (kms)	280	tas_lsd2
Route 1		
No of LTH	2	tasnolth
No of LTH Not Included	0	taslthnot
No of Landing Stations Route 1	1	taslthno
No. of Intermediate Local Exchanges		
- Without Multiplexer	3	intermexchwomuxtas
- With Multiplexer	3	intermexchwithmuxtas
Route 2		
No of LTH	2	tasnolthr2
No of LTH Not Included	0	taslthnotr2
No of Landing Stations Route 2	1	taslthnor2
No. of Intermediate Local Exchanges		
- Without Multiplexer	3	intermexchwomuxtasr2
- With Multiplexer	3	intermexchwithmuxtasr2
Submarine Cable Section		
Undersea Cable Length Route 1 (kms)	250	ucl1
Undersea Cable Length Route 2 (kms)	260	ucl2

The above Figure 12 shows the Undersea Cable Route dimensioning panel that accepts the input of the high level dimensions of the 'Undersea Cable Route'.

This panel is arranged to provide a single optical fibre distance from the MTH's in the Mainland capital city to the 'Mainland Landing Station' for each of two routes as depicted in the diagram Figure 11. A complementary approach is taken for the Island sections of the route. Providing the facility to model two routes separately supports the ability to calculate two distinctly different routes if necessary.

The number of intermediate exchanges that appear on the route is selectable with the choice of these intermediate exchanges that may include a multiplexer to drop off capacity or a repeater.

4.3.5 Additional Selectable values

Figure 13 Additional selectable values

Additional Length of Optical Fibre Into Each Exchange		
MTH (Metres)	100	addofmth
LTH (Metres)	30	addoflth
Local and Intermediate exchanges (Metres)	30	addoflocalex

Optical Fibres in exchange cable lead in		
MTH	24	mthlinof
LTH	24	lthlinof
Local and Intermediate exchanges	24	lelinof
No of Fibres per transmission System Link	2	*fibrespersyst*

Optical Fibre Cable Joints		
At each exchange	1	ofjointsatexch
Distance between Joints (kms)	2	ofjointdist

The final panel in the ‘Route Design’ sheet takes a number of inputs that assist the modelling of costs for additional items including the lengths of optical fibre lead in cables to each type of exchange and the number of cable joints applicable. This is necessary for the optical fibre in particular as in other instances within the model the optical fibre distance and trench distances are in common.

4.4 TECHNOLOGY SELECTION

The 'Technology Selection' sheet includes four panels as shown in the following Figure 14 and a fifth panel shown in Figure 15. Separate panels are provided to accept different decisions on 'Inter-exchange', 'Link', 'Tail' and the 'Undersea Cable' route transmission systems.

4.4.1 Inter-exchange panel

The 'Inter-exchange' panel accepts separate inputs for MTH to LTH Tier 1 links and also MTH to LTH Tier 2 links.

The possible technology selections include:

- SDH alone on optical fibre;
- SDH plus WDM on optical fibre; and
- Ethernet aggregation equipment on optical fibre.

This panel also accepts values for the nominated system capacity for each of the technologies that may be employed. Also values for the average utilisation of each system, the wavelengths employed and the number of wavelengths 'Typically in use' may be entered here. The result of a calculation of the utilisation of the wavelengths, used in later calculations, is also displayed. Consequently this sheet supports the collection of information that allows the calculation of utilisation at the system level and also at the wavelength level required by calculations in later sheets.

The selections for the Gbps capacity will be consistent with the capacity values of the ETSI standards discussed at Section 4.4.5 below. Today these are most likely to be either 2.5Gbps or 10Gbps for Inter-exchange routes. Historically, smaller values have been used and there are still likely to be 622Mbps and 155Mbps systems operating. 40Gbps systems are the next likely future step but the timing of the introduction is uncertain. Utilisation of an SDH system will be a function of the number of rings and the total capacity required as illustrated previously in Section 3.2. Alternatively these values would be available from the carrier.

WDM systems may have any value up to an order of magnitude of around 160 wavelengths for today's top end systems. However these systems have far more capacity than is required on regional routes. It is more likely regional routes are likely to employ more modest systems having of the order of 8 to 10 wavelengths. The values should be consistent with pricing used for these systems and would be available from the carrier or would need to be derived from a detailed network design exercise.

Where the MTH to LTH Tier 2 configuration is employed the MTH to Tier 1 settings should also be used in a consistent manner that reflects the nature of the system design across both environments. For instance the 'Transmission System' selection may be for SDH + WDM at Tier 1 but SDH only at Tier 2 in circumstances where an SDH system is modelled on a WDM system in the Tier 1 region and directly on optical fibre in the Tier 2 region. In this example as the SDH is a single contiguous system across both environments the 'SDH System Capacity' will need to be set at the same value for Tier 1 and Tier 2 as will the utilisation of the SDH system.

Another possible scenario is that WDM is used at both Tier 1 and Tier 2 but may have different numbers of wavelengths supplied by the WDM system and different numbers of wavelengths in use in each of the two regions.

Similar considerations apply in the case of Ethernet aggregation where the Gbps will need to be set at the same value for Tier 1 and Tier 2 as will the utilisation however different values may apply for the number of wavelengths and the number of wavelengths in use.

As an operator may employ a Digital Cross Connect switch (DXC) at a MTH the sheet supports the selection of the number of DXC's at each MTH. This value is normally one or zero. Alternatively in the case of Ethernet aggregation equipment the operator may employ a router in the MTH to perform a similar function. Similarly the value is normally 1 or zero. A router should only be included where the transmission system chosen is Ethernet aggregation. Similarly a DXC should only be selected when SDH or SDH and DWDM is chosen.

The number of ports for a DXC or Router is informed by the number of transmission systems required to be connected to them. The number of regional and metropolitan rings is relatively small in number, particularly if the capacity of each ring is large and a single interface is required per ring. For example where 2.5 Gbps systems are cross connected by a DXC the DXC would require a single 2.5Gbps interface for each ring.

There are other demands for connectivity such as for interconnection between MTH sites and also local metropolitan rings however the demand for ports on the DXC's or Routes can expect to be in the hundreds rather than thousands. A source of these values is from suppliers or the carrier during the pricing process as the two matters go hand in hand. However, the capacity increments are likely to be of the order of 128, 256, etc, each port having the capacity of the system requiring connection.

As these devices are not normally used at other locations no facility has been incorporated in the model to propose DXC's or routers at other locations.

4.4.2 Link, Tail and Undersea Cable Route panels

The 'Link', 'Tail' and 'Undersea Cable Route' panels permit the same selections as does the 'Inter-exchange' panel such that the different technologies, system capacities and utilisations that are likely to occur in each situation can be kept entirely separate for the purpose of flexibility and accurately reflecting the different circumstances that would apply.

The one difference with these panels is that the 'Tail' panel does not support the input for a Router or DXC as this equipment is not relevant to regional tail situations. The cross connection function to interconnect Tail and MTH to LTH rings is adequately catered for at regional LTH locations by the SDH Add Drop Multiplexer used to form the SDH transmission systems. These systems permit the interconnection of the rings via a single high capacity connection each capable of supporting the transfer of all services between the rings as necessary.

4.4.3 Customer Premises Link panel

A separate panel is provided to allow a different capacity link between the local metropolitan exchange and one or more customers premises than is used for the MTH to Local Exchange link. One 'customer' on this 'Customer Premises Link' is intended to be an Access Seeker.

4.4.4 Additional technology selection items

The 'Technology Selection' sheet also accepts inputs relevant to optical fibre patch panel capacity that would exist at each exchange type. In addition the selection of capacity data for Routers and DXC located in MTH sites are also supported. Figure 16 below refers.

Patch panels are purchased in units of capacity to meet each exchanges requirement and would reflect the total capacity of optical fibre cables entering the building and requiring connection within the building.

4.4.5 Hierarchy of SDH capacities

Units of capacity available within the SDH design architecture are determined in accordance with the standards developed by the European Telecommunications Standards Institute (ETSI). The Hierarchy of transmission capacities are as follows:

SDH Level	Line Rate (Mbps)	Nominal Capacity / Common Usage
STM-1	155.52	155 Mbps
STM-4	622.08	622 Mbps
STM-16	2,488.32	2.5 Gbps
STM-64	9,953.28	10Gbps
STM-256	39,813.12	40Gbps

Table 3 ETSI SDH Hierarchy

The values included in the right column are the commonly used values that nominally identify the capacities of an SDH system. The developments have occurred over time in increments of 4 times as shown in the table. It has been the practice to ignore the steps in the STM numbering not included above.

It is the modeller's choice whether to use the more accurate line rate in column two of the table or the values in common usage included in the third column. However this choice, while only having a very marginal impact, should be included in consideration of the value chosen for utilisation of the transmission system. Further considerations include the overheads within the transmission system that cause a difference between the above mentioned 'Line Rate' and useable capacity in addition to the amount of spare capacity.

The next development step is STM-256 (40Gbps). The current most commonly used for high capacity trunk systems are the STM-16 (2.5Gbps) systems moving to STM-64 (10Gbps) systems.

These values are typically used for SDH, capacity derived on wavelengths on DWDM systems and also for Ethernet aggregation equipment.

4.4.6 Wavelengths

SDH systems require a single wavelength which may be a single wavelength on an optical fibre or a wavelength derived on a wave division multiplexing system. The model assumes that when SDH is selected alone it will use a single wavelength on an optical fibre.

The number of wavelengths derived for use with WDM and Ethernet aggregation is specific to the technology costed or relevant to the network design. The chosen technology may be specifically equipped with a range of capabilities. In many cases the values relevant to the use of the model may be of the order of 8 or 10. However in special cases on very high capacity routes Dense WDM systems may range up to 160 wavelengths. The number in use however should be a separate consideration based on the requirements of a route.

In the case where WDM is selected the model assumes each wavelength in use is supporting an SDH system having the nominated capacity.

Similarly with Ethernet aggregation the costing can include a system with a single capacity within the SDH hierarchy (likely to be 2.5Gbps or 10Gbps) or a system supplying multiple bandwidths of this size each on a wavelength. The number of these wavelengths can be nominated to have a value relevant to the equipment costed for the purpose of the model. The number of wavelengths will be typically similar in number to the DWDM equipments.

Figure 14 Technology Selection Panel

Technology Selection

Inter-Exchange

MTH to LTH Teir 1 - (Used for Tier 1 and Tier 2 Scenarios)

Router	0	*mrouter*
DXC	1	*mdxc*
Transmission System	1	*mttech*

(SDH = 1, SDH + WDM = 2, Eth Aggreg = 3)

System Capacity	Gbps	Utilisation		Wavelengths		Wavelengths In Use	Utilisation
SDH System Capacity	2.5	75%	*su1*	1	*wie1*	1	100%
SDH + WDM Capacity	10	50%	*wu1*	8	*wie2*	2	25%
Ethernet Aggregation	2.5	55%	*eau1*	10	*wie3*	3	30%

MTH to LTH Teir 2 - (Used on Tier 2 Scenarios only)

Transmission System	1	*mttech2*

(SDH = 1, SDH + WDM = 2, Eth Aggreg = 3, Tier 1 ony = 0)

System Capacity	Gbps	Utilisation		Wavelengths		Wavelengths In Use	Utilisation
SDH System Capacity	2.5	75%	*su2*	1	*wie4*	1	100%
SDH + WDM Capacity	10	60%	*wu2*	8	*wie5*	2	25%
Ethernet Aggregation	2.5	55%	*eau2*	10	*wie6*	5	50%

Link

MTH to Metropolitan Exchange

Router	1	*mrouter2*
DXC	1	*mdxc2*
Transmission System	1	*mttechl*

(SDH = 1, SDH + WDM = 2, Eth Aggreg = 3)

System Capacity	Gbps	Utilisation		Wavelengths		Wavelengths In Use	Utilisation
SDH System Capacity	2.5	60%	*sul*	1	*wl1*	1	100%
SDH + WDM Capacity	2.5	60%	*wul*	8	*wl2*	2	25%
Ethernet Aggregation	10	55%	*eul*	10	*wl3*	3	30%

Tail

Regional LTH to Local Exchange

Transmission System	1	*mttecht*

(SDH = 1, SDH + WDM = 2, Eth Aggreg = 3)

System Capacity	Gbps	Utilisation		Wavelengths		Wavelengths In Use	Utilisation
SDH System Capacity	2.5	60%	*sut*	1	*wt1*	1	100%
SDH + WDM Capacity	2.5	60%	*wut*	8	*wt2*	2	25%
Ethernet Aggregation	10	55%	*eut*	10	*wt3*	3	30%

Customer Access Network Link

Local Exchange to Access Seeker or Customer Premises

System Capacity	Gbps	Utilisation		Wavelengths		Wavelengths In Use	Utilisation
SDH System Capacity	0.622	60%	*cul*	1	*wc1*	1	100%

Figure 15 Technology Selection Panel for the Undersea Cable Route

Undersea Cable Route

Router	0	*mroutertas*
DXC	1	*mdxctas*
Transmission System	2	*mttechtas*

(SDH = 1, SDH + WDM = 2, Eth Aggreg = 3, Not Included = 0)

System Capacity	Gbps	Utilisation		Wavelengths		Wavelengths In Use	Utilisation
SDH System Capacity	10	60%	*su1tas*	1	*wie1tas*	1	100%
SDH + WDM Capacity	10	60%	*wu1tas*	8	*wie2tas*	2	25%
Ethernet Aggregation	10	55%	*eau1tas*	10	*wie3tas*	5	50%

Figure 16 Additional Items Included in Technology Selection Panel

Optical Fibre Patch Panel	Total Patch Capacity	Patches used per System	Systems Supported	Patches In Use	Utilisation
MTH	144	2	72	100	69%
Intermediate Exch MTH - LTH	72	2	36	30	42%
Intermediate Exch LTH-LTH Teir 1	72	2	36	31	43%
Intermediate Exch LTH-LTH Teir 2	72	2	36	32	44%
Intermediate Exch Regional LTH-LTH	72	2	36	33	46%
Intermediate Exchange MTH to Landing Sta	72	2	36	33	46%
Intermediate Exchange Tas LTH to Landing	72	2	36	34	47%
Regional LTH	72	2	36	33	46%
Intermediate LTH MTH to Landing Stattion	72	2	36	35	49%
Intermediate LTH Tas LTH to Landing Stati	72	2	36	36	50%
Intermediate Exch MTH - Local Exchange	72	2	36	33	46%
Regional Local Exchange	72	2	36	33	46%
Intermediate Exch Local Regional Exch	72	2	36	34	47%
Metropolitan Local Exchange	72	2	36	35	49%
Mainland Landing Station	72	2	36	36	50%
Tasmanian Landing Station	72	2	36	37	51%
Customer Premises	24	2	1	4	17%

MTH System Configurations	Port Capacity (Gbps)	No of Ports	No. of Ports in Use	Utilisation
Router	2.5	128	100	78%
DXC	2.5	128	100	78%

4.5 TRENCH AND OPTICAL FIBRE CABLE CALCULATION

Figure 17 Trench and Optical Fibre Cable Calculations (part - MTH to MTH)

Trench and Optical Fibre Cable Calculations

Inter Exchange and Link

MTH to MTH

Cable / Trench Distance between MTH (Km)	5				
MTH CBD Trench		mthtr1	***MTH CBD Optical Fibre Cable***		mthof1
Percentage of MTH Trench	20%		Optical Fibre Cable Cost/metre	$1	
Trench Length (Km)	1		Optical Fibre Cable Cost + TrenchCost	$6,132	
Sharing Factor	2		Optical Fibre Cable No. of Fibres	24	
No. of OF Cables in Trench	3		No. of Fibres per Transmission System	2	
Trench Cost/metre	$32		Optical Fibre Cable Occupancy	75%	
Trench Cost/OF Cable	$5,343	trenchcb	Optical Fibre Cable + Trench Cost per Transmission System	$681	ofcbd
MTH Metro Level 1 Trench		mthtr2	***MTH Metro Level 1***		mthof2
Percentage of MTH Trench	30%		Optical Fibre Cable Cost/metre	$1	
Trench Length (Km)	1.5		Optical Fibre Cable Cost + TrenchCost	$5,992	
Sharing Factor	2		Optical Fibre Cable No. of Fibres	24	
No. of OF Cables in Trench	3		No. of Fibres per Transmission System	2	
Trench Cost/metre	$19		Optical Fibre Cable Occupancy	75%	
Trench Cost/OF Cable	$4,809	trenchml	Optical Fibre Cable + Trench Cost per Transmission System	$666	ofml1
MTH Metro Level 2 Trench		mthtr3	***MTH Metro Level 2***		mthof3
Percentage of MTH Trench	40%		Optical Fibre Cable Cost/metre	$1	
Trench Length (Km)	2		Optical Fibre Cable Cost + TrenchCost	$7,277	
Sharing Factor	2		Optical Fibre Cable No. of Fibres	24	
No. of OF Cables in Trench	3		No. of Fibres per Transmission System	2	
Trench Cost/metre	$17		Optical Fibre Cable Occupancy	75%	
Trench Cost/OF Cable	$5,700	trenchml	Optical Fibre Cable + Trench Cost per Transmission System	$809	ofml2
MTH to MTH Tunnel		mthtr4	***MTH Tunnel Optical Fibre Cable***		mthof4
Percentage of MTH Trench	10%		Optical Fibre Cable Cost/metre	$1	
Trench Length (Km)	0.5		Optical Fibre Cable Cost + TrenchCost	$875	
Sharing Factor	2		Optical Fibre Cable No. of Fibres	24	
No. of OF Cables in Tunnel	20		No. of Fibres per Transmission System	2	
Tunnel Cost/metre	$38		Optical Fibre Cable Occupancy	75%	
Trench Cost/OF Cable	$481	tunnel	Optical Fibre Cable + Trench Cost per Transmission System	$97	oftunnel
Check - Total Percentage	100%				
Cable Joints	2				
Optical Fibre Cable No. of Fibres	24				
Annualised Cost of Joints	$56	m_mthcjc			

The sheet titled ‘Trench and Optical Fibre Cable Calculations’ performs calculations particular to trench and cable costs required to obtain an output cost that can be included in the final stages of the specific route cost calculation sheets where they are further processed in the same manner as that of exchange based equipment.

Separate panels are provided for the calculation of optical fibre and trench costs for:

- MTH to MTH – Inter-exchange and Link;
- MTH to LTH – Inter-exchange;
- LTH to LTH Tier 1 – Inter-exchange;
- LTH to LTH Tier 2 – Inter-exchange;
- MTH to Local Metropolitan Exchange – Link;
- Metropolitan Exchange to Metropolitan Exchange – Link;
- Metropolitan Exchange to Access Seekers & Customer Premises – Link;
- Regional LTH to LTH - Tail
- Regional LTH to Local Exchange – Tail;
- Tail Regional Local Exchange to Local Exchange – Tail;
- MTH to Mainland Landing Station Route 1 – Undersea Cable Route
- MTH to Mainland Landing Station Route 2 – Undersea Cable Route;
- Island LTH to Island Landing Station Route 1 – Undersea Cable Route; and

- Island LTH to Island Landing Station Route 2 – Undersea Cable Route.

Each panel breaks down the different elements that may make up a route. For instance the MTH to MTH panel caters for:

- MTH to MTH CBD Trench;
- Two types of Metropolitan Trench which may have different cost, cable density and sharing factor values; and
- MTH to MTH Tunnel.

Other panels cater for up to seven forms of trenching, for example:

- MTH to MTH Tunnel;
- Conduit Trench;
    - o Metropolitan; and
    - o Two Regional.
- Three direct buried trench and cable costs.

The costing included in each panel is based on the distance selected in the 'Route Design' sheet. The percentage of the distance along the route that is in each form of trench is selectable as is a sharing factor and the number of optical fibre cables that would be present. A 'Trench cost per optical fibre cable' is calculated based on this data.

A separate calculation is applied to the optical fibre cable that would exist in the trench. Inputs including the number of optical fibres in the cable and the occupancy of the fibres are combined with annualised costs of the trench and cable, along with the cable distance and the number of optical fibres per system to calculate a cost attributable to a system utilising optical fibre in the cable located in the trench.

The process of gathering the required inputs to this sheet should have regard to the fact that the distances are average distances for each common type of link where multiples of a link type is involved. Consequently the proportions, factors and optical fibre parameters gathered from the carrier or by analysis as inputs should be determined on the basis that they will be applied to an average distance.

4.6 ACCOMMODATION COST ESTIMATES

As it is not straightforward to use the same spreadsheet framework for the calculation of accommodation costs that should be apportioned to the transmission capacity, as is used in the modelling of the cost of transmission technology, a separate spreadsheet is provided for this purpose. Figure 18 below illustrates the construction of the 'Accommodation Cost Estimates'. The illustration shown is not the complete sheet as only part is included for the purpose of explaining the calculation.

Having calculated a cost to be attributed to each element of equipment the results are transferred to form the basis for later calculations. As the results form the basis of later calculations that apply an asset life, and annual rates of cost reduction the basis of this calculation should include those items to which common factors for Asset Life and Tech Factor can be applied. These are largely the building costs including building services such as air-conditioning that can be estimated on a per sq. metre basis.

The calculation accepts an estimate of the number of square metres required to accommodate the item of technology. The building 'Cost per Square Metre' and 'Exchange Floor Space Utilisation' are also inputs. As the later calculations rely on the output to be applied on a per SDH system or wavelength basis a factor called "No. of Transmission Capacity units" is also included to permit an appropriate break down of the cost base for the later calculation.

Estimators are supplied for all of the exchange based accommodation types that could require a separate calculation.

Figure 18 Accommodation Costs Estimates spreadsheet (part)

Accommodation Cost Estimates

		System Footprint (Sq. Metres)	Cost per Sq. Metre (Incl. Airconditioning)	Exchange Floor Space Utilisation	Cost per System	No. of Transmission Capacity Units	Cost Per Transmission Capacity Units	Included	Cost Per Transmission Capacity Units Included
Inter Exchange									
MTH	SDH	2	$5,000	100%	$10,000	1	$10,000	1	$10,000
	DWDM	2	$5,000	100%	$10,000	10	$1,000	0	$0
	Ethernet Aggregation	2	$5,000	100%	$10,000	8	$1,250	0	$0
	Router	8	$5,000	100%	$40,000	40	$1,000	1	$1,000
	DXC	8	$5,000	100%	$40,000	40	$1,000	1	$1,000
	Total								$12,000
LTH (Teir 1)	SDH	2	$3,000	40%	$15,000	1	$15,000	1	$15,000
	DWDM	2	$3,000	40%	$15,000	1	$15,000	0	$0
	Ethernet Aggregation	2	$3,000	40%	$15,000	1	$15,000	0	$0
	Total								$15,000
LTH (Teir 2)	SDH	2	$3,000	40%	$15,000	1	$15,000	1	$15,000
	DWDM	2	$3,000	40%	$15,000	1	$15,000	0	$0
	Ethernet Aggregation	2	$3,000	40%	$15,000	1	$15,000	0	$0
	Total								$15,000

4.7 ANNUALISED COST CALCULATION

To facilitate a TSLRIC calculation of the network costs a worksheet is included that converts the cost of each element from its capital and operational components into an annualised cost. The following Figure 19 and Figure 20 illustrate the layout of this sheet showing the structure of the calculation for each item across the sheet.

The sheet has been laid out to maximise the flexibility of this transmission costing model in that separate calculations flow through the sheet for each different network component that could potentially have cost variations or different factors that may apply.

A further consideration is that whereas most components rely on a calculation based on the capital cost of a network component some relevant items require different treatment. For instance power consumption costs are an annual usage based cost. Other items would not normally be supplied with spares and others have the installation included in the base capital cost estimate such as is the case with accommodation. Those cells not requiring inputs for these reasons have been colour coded in orange to indicate input values are not required.

Working across the sheet, the base input is the capital cost of each item. Estimates of the costs and spares are calculated on the basis of the capital cost and the spares factor from the 'Global Parameters and Results' sheet described at Section 4.10.1.

Similarly the installation cost is calculated by applying the mark-up factor from the 'Global Parameters and Results' to the capital cost (not including the spares cost). A further mark-up is applied to calculate the 'Indirect Asset Cost'. This mark-up is again obtained from the 'Global Parameters and Results' sheet and is applied to the sum of the previous three columns.

Asset life and the technology price trend (Tech Factor) is separately selectable for each item except power consumption. The value of the WACC is also obtained from the 'Global Parameters and Results' sheet.

Based on the WACC, Asset Life, Tech Factor and the inflation rate (from the 'Global Parameters and Results' sheet), a conversion factor is calculated for application to the capital costs to convert them into an annuity. For this purpose the Allen Consulting Group formula that converts capital costs into a year zero tilted annuity value is employed. The resulting factor is applied to the sum of each of the capital cost items to calculate an annualised tilted annuity cost.

A column is provided to accept an annual cost for services that are consumed on the basis of an annual consumption cost, largely being for the power consumption. The column is headed 'Services Costs'.

Direct Operations and Maintenance costs are applied as a mark-up on the total capital cost or the 'Services Cost'. A column is provided to separately select a value for each item as may be relevant. A further column is provided to include the a value for the indirect operations and maintenance costs input from the 'Global Parameters & Results' sheet. This factor is applied as a further uplift on the direct O&M costs. These two factors are used in the calculation of 'Total O&M Costs' as described.

The final column titled 'Annualised Equipment Cost Incl. Indirect O&M' is the sum of the columns headed 'Annualised Capital' and 'Total O&M Costs'. This final column is the output of the sheet used in subsequent sheets as the basis of the annualised cost calculations applied in the context of the desired network design.

Figure 19 Annualised Cost Calculation spreadsheet (first part – sample exchange items)

Annualised Cost Calculation

Item	Basis of Unit Cost	Capital Investment	Spares	Installation	Indirect Asset Cost	Assett Life	Price Trend (TECH)	WACC	WACC Convert. to Annuity	Annualised Capital	Services Costs	O&M Costs (% of Capital Cost or Services Cost)	Indirect O&M (% of O&M)	Total O&M Costs	Annualised Equipment Cost Incl Indirect O&M	
MTH																
Router	Per System	$1,000,000	$50,000	$150,000	$60,000	10	-9.0%	10.4%	20.90%	$263,286.26		10%	25%	$157,500.00	$420,786.26	mrac
DXC	Per System	$1,000,000	$50,000	$150,000	$60,000	10	-9.0%	10.4%	20.90%	$263,286.26		10%	25%	$157,500.00	$420,786.26	mdxcac
SDH Multiplexer Equipment	Per System	$75,000	$3,750	$11,250	$4,500	10	-9.0%	10.4%	20.90%	$19,746.47		10%	25%	$11,812.50	$31,558.97	msdheac
DWDM Equipment	Per System	$75,000	$3,750	$11,250	$4,500	10	-9.0%	10.4%	20.90%	$19,746.47		10%	25%	$11,812.50	$31,558.97	mdwdmac
Ethernet Aggregation Equipment	Per System	$100,000	$5,000	$15,000	$6,000	10	-9.0%	10.4%	20.90%	$26,328.63		10%	25%	$15,750.00	$42,078.63	meaeac
OF Patch Panel	Per System	$4,000		$600	$230	10	-3.0%	10.4%	16.89%	$816.02		10%	25%	$603.75	$1,419.77	mofppac
Accommodation/Airconditioning	Per System	$12,000			$600	20	1.0%	10.4%	9.55%	$1,203.34		10%	25%	$1,575.00	$2,778.34	maccac
Power Consumption (Including heat extraction)	Per Floor									$0.00	$100,000	10%	25%	$137,500.00	$137,500.00	mpowac
Power Systems	Per Floor	$20,000		$3,000	$1,150	10	0.0%	10.4%	15.10%	$3,647.67		10%	25%	$3,018.75	$6,666.42	mpowacsys
Batteries / Rectifiers	Per Floor	$50,000		$7,500	$2,875	10	0.0%	10.4%	15.10%	$9,119.17		10%	25%	$7,546.88	$16,666.05	mbatac
MTH Link Multiplexers																
Router	Per System	$1,000,000	$50,000	$150,000	$60,000	10	-9.0%	10.4%	20.90%	$263,286.26		10%	25%	$157,500.00	$420,786.26	mracl
DXC	Per System	$1,000,000	$50,000	$150,000	$60,000	10	-9.0%	10.4%	20.90%	$263,286.26		10%	25%	$157,500.00	$420,786.26	mdxcacl
SDH Multiplexer Equipment	Per System	$50,000	$2,500	$7,500	$3,000	10	-9.0%	10.4%	20.90%	$13,164.31		10%	25%	$7,875.00	$21,039.31	msdheacl
DWDM Equipment	Per System	$50,000	$2,500	$7,500	$3,000	10	-9.0%	10.4%	20.90%	$13,164.31		10%	25%	$7,875.00	$21,039.31	mdwdmacl
Ethernet Aggregation Equipment	Per System	$50,000	$2,500	$7,500	$3,000	10	-9.0%	10.4%	20.90%	$13,164.31		10%	25%	$7,875.00	$21,039.31	meaeacl
OF Patch Panel	Per System	$4,000		$600	$230	10	-3.0%	10.4%	16.89%	$816.02		10%	25%	$603.75	$1,419.77	mofppacl
Accommodation/Airconditioning	Per System	$25,000			$1,250	20	1.0%	10.4%	9.55%	$2,506.96		10%	25%	$3,281.25	$5,788.21	maccacl
Power Consumption (Including heat extraction)	Per Floor									$0.00	$100,000	10%	25%	$137,500.00	$137,500.00	mpowacl
Power Systems	Per Floor	$20,000		$3,000	$1,150	10	0.0%	10.4%	15.10%	$3,647.67		10%	25%	$3,018.75	$6,666.42	mpowacsysl
Batteries / Rectifiers	Per Floor	$50,000		$7,500	$2,875	10	0.0%	10.4%	15.10%	$9,119.17		10%	25%	$7,546.88	$16,666.05	mbatacl
Intermediate Exchanges MTH - LTH																
SDH Transmission Repeaters	Per System	$50,000	$2,500	$7,500	$3,000	10	-9.0%	10.4%	20.90%	$13,164.31		10%	25%	$7,875.00	$21,039.31	iemlsdheac
DWDM Repeaters	Per System	$50,000	$2,500	$7,500	$3,000	10	-9.0%	10.4%	20.90%	$13,164.31		10%	25%	$7,875.00	$21,039.31	iemldwdmac
Ethernet Aggregation Equipment	Per System	$50,000	$2,500	$7,500	$3,000	10	-9.0%	10.4%	20.90%	$13,164.31		10%	25%	$7,875.00	$21,039.31	iemleaeac
OF Patch Panel	Per System	$2,000		$300	$115	10	-3.0%	10.4%	16.89%	$408.01		10%	25%	$301.88	$709.89	iemlofppac
Accommodation/Airconditioning	Per System	$12,500			$625	20	1.0%	10.4%	9.55%	$1,253.48		10%	25%	$1,640.63	$2,894.10	iemlaccac
Power Consumption (Including heat extraction)	Per Floor									$0.00	$50,000	10%	25%	$68,750.00	$68,750.00	iemlpowac
Power Systems	Per Floor	$20,000		$3,000	$1,150	10	0.0%	10.4%	15.10%	$3,647.67		10%	25%	$3,018.75	$6,666.42	iemlpowacsys
Batteries / Rectifiers	Per Floor	$30,000		$4,500	$1,725	10	0.0%	10.4%	15.10%	$5,471.50		10%	25%	$4,528.13	$9,999.63	iemlbatac

Figure 20 Cost Calculation spreadsheet (second part – sample trench and cable items)

MTH to MTH Trench and Tunnel																
MTH CBD Trench	Per Metre	$150			$8	25	4.0%	10.4%	6.61%	$10.40		11%	25%	$21.66	$32.06	cbdtr
MTH Metro Level 1 Trench	Per Metre	$90			$5	25	4.0%	10.4%	6.61%	$6.24		11%	25%	$12.99	$19.24	metrotr1
MTH Metro Level 2 Trench	Per Metre	$80			$4	25	4.0%	10.4%	6.61%	$5.55		11%	25%	$11.55	$17.10	metrotr2
MTH to MTH Tunnel	Per Metre	$180			$9	25	4.0%	10.4%	6.61%	$12.48		11%	25%	$25.99	$38.47	cbdtun
MTH to MTH Optical Fibre Cable																
MTH CBD Optical Fibre Cable	Per Metre	$2.5		$0.38	$0	24	-5.0%	10.4%	13.63%	$0.41		10%	25%	$0.38	$0.79	cbdofc
MTH Metro Level 1	Per Metre	$2.5		$0.38	$0	24	-5.0%	10.4%	13.63%	$0.41		10%	25%	$0.38	$0.79	metroofc1
MTH Metro Level 2	Per Metre	$2.5		$0.38	$0	24	-5.0%	10.4%	13.63%	$0.41		10%	25%	$0.38	$0.79	metroofc2
MTH Tunnel Optical Fibre Cable	Per Metre	$2.5		$0.38	$0	24	-5.0%	10.4%	13.63%	$0.41		10%	25%	$0.38	$0.79	cbdtunof
MTH to LTH Trench																
Conduit Trench (Regional Town - Type 1)	Per Metre	$80.0			$4	25	4.0%	10.4%	6.61%	$5.55		11%	25%	$11.55	$17.10	ctrt1
Conduit Trench (Regional Town - Type 2)	Per Metre	$70.0			$4	25	4.0%	10.4%	6.61%	$4.86		11%	25%	$10.11	$14.96	ctrt2
Conduit Trench (Regional Town - Type 3)	Per Metre	$60.0			$3	25	4.0%	10.4%	6.61%	$4.16		11%	25%	$8.66	$12.82	ctrt3
Direct Buried Trench Type 1	Per Metre	$18			$1	25	4.0%	10.4%	6.61%	$1.25		11%	25%	$2.60	$3.85	dbtrt1
Direct Buried Trench Type 2	Per Metre	$16			$1	25	4.0%	10.4%	6.61%	$1.11		11%	25%	$2.31	$3.42	dbtrt2
Direct Buried Trench Type 3	Per Metre	$14			$1	25	4.0%	10.4%	6.61%	$0.97		11%	25%	$2.02	$2.99	dbtrt3

4.8 INTER EXCHANGE MODEL

The ‘Inter-exchange Model’ sheet is one of three final stage sheets which draw together all of the previously calculated elements to achieve the final results. The summary outputs are returned to the ‘Global Parameters & Results’ sheet for convenience.

The requirements for inputs to this sheet have been kept to a minimum. These include the generalised items such as Accommodation, Power consumption, power systems and batteries. The third column requires an input that indicates the number of systems that would be the basis for estimating these costs. Also the utilisation of these items is required. For instance, if the cost of power is calculated on the basis of a whole exchange floor then the portion that would be required for the system being costed would need to be reflected. i.e. If the power requirement is one 40^{th} of the total then the factor would be 40. Similarly if the utilisation of the system is 70 per cent of its capacity a utilisation of 70 per cent would be entered at the appropriate column.

The sheet uses as a starting point an ‘Annualised Unit Cost’ from the ‘Annualised Cost Calculation’ sheet. ‘Routing Factors’ are derived from the ‘Route Design’ and ‘Technology Selection’ sheets and used to multiply up the annualised cost to reflect the number of times the cost should be applied.

The ‘Number of Systems Supported‘ column derives it values from the ‘Technology Selection’ sheet. These are used to divide into the total cost to provide a cost per system.

The next eight columns layout the ‘Unit of Capacity’ for which a cost is to be calculated. These are obtained from the ‘Global Parameter and Results’ sheet and are selectable from there if variations are required.

The column titled ‘Transmission System Capacity’ displays in Gbps the capacity of the selected technology from the ‘Technology Selection’ spreadsheet.

The following column titled ‘Transmission System Utilisation’ displays the utilisation of the transmission capacity supplied to users as a portion of the transmission system capacity obtained from the ‘Technology Selection’ sheet.

The column titled ‘Utilisation of Supporting Systems’ displays (or requires an input) for the relevant utilisation of the supporting infrastructure that the system is either connected to or occupies. For instance the DXC may have a capacity of 128 transmission systems of the capacity of a 2500Mbps transmission system that is being modelled. The DXC in turn, may only have 40 per cent of its total capacity of 128 in use.

The two utilisation factors are multiplied to obtain a ‘Combined Utilisation’ value that is applied to the cost to obtain the final unit cost that applies to the system.

The final eight columns calculate the cost of the nominated unit of capacity based on the costs derived from earlier columns, the utilisation, and the proportion the unit of capacity in question is of the total.

Figure 21 Inter-exchange Model (first part – example exchange items)

Inter Exchange Model

Equipment	Annualised Unit Cost	Routing Factors	Number of Systems Supported (IE Capability)	Unit of Capacity of Interest (MBps)								Transmission System Capacity (Gbps)	Transmission System Utilisation	Utilisation of Supporting Systems	Combined Utilisation	Cost of Unit of Capacity							
				2	8	10	34	45	155	622	2500					2	8	10	34	45	155	622	2500
MTH																							
Router	$420,786	2	500	2	8	10	34	45	155	622	2500	2.5	75%	40%	30%	$4.49	$17.95	$22.44	$76.30	$100.99	$347.85	$1,395.89	$5,610.48
DXC	$420,786	2	500	2	8	10	34	45	155	622	2500	2.5	75%	40%	30%	$4.49	$17.95	$22.44	$76.30	$100.99	$347.85	$1,395.89	$5,610.48
SDH Multiplexer Equipment	$31,559	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$67.33	$269.30	$336.63	$1,144.54	$1,514.83	$5,217.75	$20,938.32	$84,157.25
DWDM Equipment	$31,559	0	0	2	8	10	34	45	155	622	2500	0	0%	25%	0%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Ethernet Aggregation Equipment	$42,079	0	0	2	8	10	34	45	155	622	2500	0	0%	30%	0%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Optical Fibre Lead In	$1	16.7	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.01	$0.06	$0.07	$0.25	$0.33	$1.15	$4.61	$18.52
Optical Fibre Joint	$333	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.71	$2.84	$3.56	$12.09	$16.00	$55.11	$221.15	$888.86
OF Patch Panel	$1,420	2	72	2	8	10	34	45	155	622	2500	2.5	75%	69%	52%	$0.06	$0.24	$0.30	$1.03	$1.36	$4.69	$18.84	$75.72
Accommodation/Airconditioning	$2,778	2	1	2	8	10	34	45	155	622	2500	2.5	75%	40%	30%	$14.82	$59.27	$74.09	$251.90	$333.40	$1,148.38	$4,608.34	$18,522.26
Power Consumption (Including heat extraction)	$137,500	2	40	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$7.33	$29.33	$36.67	$124.67	$165.00	$568.33	$2,280.67	$9,166.67
Power Systems	$6,666	2	40	2	8	10	34	45	155	622	2500	2.5	75%	70%	53%	$0.51	$2.03	$2.54	$8.63	$11.43	$39.36	$157.96	$634.90
Batteries / Rectifiers	$16,666	2	40	2	8	10	34	45	155	622	2500	2.5	75%	70%	53%	$1.27	$5.08	$6.35	$21.59	$28.57	$98.41	$394.91	$1,587.24
Intermediate Exchanges MTH - LTH																							
SDH Transmission Repeaters	$21,039	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$44.88	$179.54	$224.42	$763.03	$1,009.89	$3,478.50	$13,958.88	$56,104.83
DWDM Repeaters	$21,039	0	0	2	8	10	34	45	155	622	2500	0	0%	25%	0%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Ethernet Aggregation Equipment	$21,039	0	0	2	8	10	34	45	155	622	2500	0	0%	30%	0%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Optical Fibre Lead In	$1	5	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.00	$0.02	$0.02	$0.08	$0.10	$0.34	$1.38	$5.56
Optical Fibre Joint	$333	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.71	$2.84	$3.56	$12.09	$16.00	$55.11	$221.15	$888.86
OF Patch Panel	$710	2	36	2	8	10	34	45	155	622	2500	2.5	75%	42%	31%	$0.10	$0.40	$0.50	$1.72	$2.27	$7.82	$31.40	$126.20
Accommodation/Airconditioning	$2,894	2	1	2	8	10	34	45	155	622	2500	2.5	75%	40%	30%	$15.44	$61.74	$77.18	$262.40	$347.29	$1,196.23	$4,800.35	$19,294.02
Power Consumption (Including heat extraction)	$68,750	2	20	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$7.33	$29.33	$36.67	$124.67	$165.00	$568.33	$2,280.67	$9,166.67
Power Systems	$6,666	2	20	2	8	10	34	45	155	622	2500	2.5	75%	75%	56%	$0.95	$3.79	$4.74	$16.12	$21.33	$73.48	$294.86	$1,185.14
Batteries / Rectifiers	$10,000	2	20	2	8	10	34	45	155	622	2500	2.5	75%	75%	56%	$1.42	$5.69	$7.11	$24.18	$32.00	$110.22	$442.29	$1,777.71

Figure 22 Inter-exchange Model (second part – example trench and optical fibre cable items)

MTH to MTH																							
Trench + Optical Fibre																							
MTH CBD Optical Fibre Cable	$681	1	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.73	$2.91	$3.63	$12.35	$16.35	$56.32	$226.02	$908.46
MTH Metro Level 1	$666	1	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.71	$2.84	$3.55	$12.07	$15.98	$55.04	$220.87	$887.72
MTH Metro Level 2	$809	1	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.86	$3.45	$4.31	$14.66	$19.41	$66.84	$268.23	$1,078.08
MTH Tunnel Optical Fibre Cable	$97	1	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.10	$0.41	$0.52	$1.76	$2.33	$8.04	$32.26	$129.67
Joints	$56	1	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.06	$0.24	$0.30	$1.01	$1.33	$4.59	$18.43	$74.07
MTH to Regional LTH																							
Trench + Optical Fibre																							
MTH Tunnel Optical Fibre Cable	$292	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$0.62	$2.49	$3.11	$10.58	$14.00	$48.24	$193.57	$778.02
MTH - LTH Optical Fibre Cable - Type 1	$18,193	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$38.81	$155.24	$194.05	$659.79	$873.25	$3,007.85	$12,070.20	$48,513.66
MTH - LTH Optical Fibre Cable - Type 2	$5,471	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$11.67	$46.68	$58.35	$198.40	$262.58	$904.46	$3,629.50	$14,588.02
MTH - LTH Optical Fibre Cable - Type 3	$4,538	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$9.68	$38.72	$48.40	$164.56	$217.80	$750.21	$3,010.53	$12,100.19
Direct Buried Optical Fibre Cable Type 1	$15,979	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$34.09	$136.35	$170.44	$579.50	$766.99	$2,641.86	$10,601.52	$42,610.62
Direct Buried Optical Fibre Cable Type 2	$14,554	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$31.05	$124.19	$155.24	$527.83	$698.60	$2,406.28	$9,656.16	$38,810.93
Direct Buried Optical Fibre Cable Type 3	$11,816	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$25.21	$100.83	$126.04	$428.54	$567.18	$1,953.63	$7,839.72	$31,510.11
Joints	$2,083	2	1	2	8	10	34	45	155	622	2500	2.5	75%	100%	75%	$4.44	$17.78	$22.22	$75.55	$100.00	$344.43	$1,382.17	$5,555.35

4.9 LINK, TAIL AND UNDERSEA CABLE ROUTE MODELS

The structure of the Link, Tail and Undersea Cable route models are identical to the Inter-exchange model but have the relevant line items pertinent to those routes. Figure 23, Figure 24, Figure 25 and Figure 26 below illustrate the layout of these calculation sheets.

Figure 23 Link Model (first part – example of exchange items)

Link Model

Equipment	Annualised Unit Cost	Routing Factors	Number of Systems Supported (IE Capability)	Unit of Capacity of Interest (MBps)								Transmission System Capacity (Gbps)	Transmission System Utilisation	Utilisation of Supporting Systems	Combined Utilisation	Cost of Unit of Capacity							
				2	8	10	34	45	155	622	2500					2	8	10	34	45	155	622	2500
MTH																							
Router	$420,786	2	500	2	8	10	34	45	155	622	2500	2.5	60%	40%	24%	$6	$22	$28	$95	$126	$435	$1,745	$7,013
DXC	$420,786	2	500	2	8	10	34	45	155	622	2500	2.5	60%	40%	24%	$6	$22	$28	$95	$126	$435	$1,745	$7,013
SDH Multiplexer Equipment	$21,039	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$56	$224	$281	$954	$1,262	$4,348	$17,449	$70,131
DWDM Equipment	$21,039	0	0	2	8	10	34	45	155	622	2500	0	0%	25%	0%	$0	$0	$0	$0	$0	$0	$0	$0
Ethernet Aggregation Equipment	$21,039	0	0	2	8	10	34	45	155	622	2500	0	0%	30%	0%	$0	$0	$0	$0	$0	$0	$0	$0
Optical Fibre Lead In	$1	16.7	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.02	$0.07	$0.09	$0.31	$0.42	$1.44	$5.76	$23.15
Optical Fibre Joint	$333	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.89	$3.56	$4.44	$15.11	$20.00	$68.89	$276.43	$1,111.07
OF Patch Panel	$1,420	2	72	2	8	10	34	45	155	622	2500	2.5	60%	69%	42%	$0	$0	$0	$1	$2	$6	$24	$95
Accommodation/Airconditioning	$5,788	2	1	2	8	10	34	45	155	622	2500	2.5	60%	40%	24%	$39	$154	$193	$656	$868	$2,991	$12,001	$48,235
Power Consumption (Including heat extraction)	$137,500	2	40	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$9	$37	$46	$156	$206	$710	$2,851	$11,458
Power Systems	$6,666	2	40	2	8	10	34	45	155	622	2500	2.5	60%	40%	24%	$1	$4	$6	$19	$25	$86	$346	$1,389
Batteries / Rectifiers	$16,666	2	40	2	8	10	34	45	155	622	2500	2.5	60%	40%	24%	$3	$11	$14	$47	$62	$215	$864	$3,472
Intermediate Exchanges MTH - Local Exchange																							
SDH Multiplexer Equipment	$31,559	0	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0	$0	$0	$0	$0	$0	$0	$0
DWDM Repeaters	$31,559	0	0	2	8	10	34	45	155	622	2500	0	0%	25%	0%	$0	$0	$0	$0	$0	$0	$0	$0
Ethernet Aggregation Equipment	$42,079	0	0	2	8	10	34	45	155	622	2500	0	0%	30%	0%	$0	$0	$0	$0	$0	$0	$0	$0
Optical Fibre Lead In	$1	0	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Optical Fibre Joint	$333	0	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
OF Patch Panel	$1,420	0	36	2	8	10	34	45	155	622	2500	2.5	60%	46%	28%	$0	$0	$0	$0	$0	$0	$0	$0
Accommodation/Airconditioning	$3,473	0	1	2	8	10	34	45	155	622	2500	2.5	60%	40%	24%	$0	$0	$0	$0	$0	$0	$0	$0
Power Consumption (Including heat extraction)	$68,750	0	20	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0	$0	$0	$0	$0	$0	$0	$0
Power Systems	$6,666	0	20	2	8	10	34	45	155	622	2500	2.5	60%	50%	30%	$0	$0	$0	$0	$0	$0	$0	$0
Batteries / Rectifiers	$10,000	0	20	2	8	10	34	45	155	622	2500	2.5	60%	50%	30%	$0	$0	$0	$0	$0	$0	$0	$0

Figure 24 Link Model (second part – example of trench and optical fibre items)

MTH to MTH																							
Trench + Optical Fibre																							
MTH CBD Optical Fibre Cable	$681	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$1	$4	$5	$15	$20	$70	$283	$1,136
MTH Metro Level 1	$666	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$1	$4	$4	$15	$20	$69	$276	$1,110
MTH Metro Level 2	$809	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$1	$4	$5	$18	$24	$84	$335	$1,348
MTH Tunnel Optical Fibre Cable	$97	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0	$1	$1	$2	$3	$10	$40	$162
Joints	$56	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.07	$0.30	$0.37	$1.26	$1.67	$5.74	$23.04	$92.59
MTH to Metropolitan Exchange																							
Trench + Optical Fibre																							
CBD Trench OF Cable	$202	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$1	$2	$3	$9	$12	$42	$168	$674
Metro Level 1 OF Cable	$1,459	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$4	$16	$19	$66	$88	$301	$1,210	$4,863
Metro Level 2 OF Cable	$280	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$1	$3	$4	$13	$17	$58	$232	$933
CBD Tunnel OF Cable	$29	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0	$0	$0	$1	$2	$6	$24	$97
Joints	$56	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.07	$0.30	$0.37	$1.26	$1.67	$5.74	$23.04	$92.59

Figure 25 Tail Model (first part – example of exchange items)

Tail Model

Equipment	Annualised Unit Cost of Supporting System Elements	Routing Factors	Number of Systems Supported (IE Capability)	Unit of Capacity of Interest (MBps)								Transmission System Capacity (Gbps)	Transmission System Utilisation	Utilisation of Supporting Systems	Combined Utilisation	Cost of Unit of Capacity							
				2	8	10	34	45	155	622	2500					2	8	10	34	45	155	622	2500
Regional LTH																							
SDH Multiplexer Equipment	$31,559	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$84.16	$336.63	$420.79	$1,430.67	$1,893.54	$6,522.19	$26,172.91	$105,196.56
DWDM Equipment	$31,559	0	0	2	8	10	34	45	155	622	2500	0	0%	25%	0.00%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Ethernet Aggregation Equipment	$42,079	0	0	2	8	10	34	45	155	622	2500	0	0%	30%	0.00%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Interface Card	$1,683	2	4	2	8	10	34	45	155	622	2500	2.5	75%	100%	75.00%	$0.90	$3.59	$4.49	$15.26	$20.20	$69.57	$279.18	$1,122.10
Optical Fibre Lead In	$1	5	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.01	$0.02	$0.03	$0.09	$0.12	$0.43	$1.73	$6.94
Optical Fibre Joint	$333	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.89	$3.56	$4.44	$15.11	$20.00	$68.89	$276.43	$1,111.07
OF Patch Panel	$710	2	36	2	8	10	34	45	155	622	2500	2.5	60%	46%	27.50%	$0.11	$0.46	$0.57	$1.95	$2.58	$8.89	$35.68	$143.41
Accommodation/Airconditioning	$3,473	2	20	2	8	10	34	45	155	622	2500	2.5	60%	75%	45.00%	$0.62	$2.47	$3.09	$10.50	$13.89	$47.85	$192.01	$771.76
Power Consumption (Including heat extraction)	$68,750	2	20	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$9.17	$36.67	$45.83	$155.83	$206.25	$710.42	$2,850.83	$11,458.33
Power Systems	$6,666	2	20	2	8	10	34	45	155	622	2500	2.5	60%	75%	45.00%	$1.19	$4.74	$5.93	$20.15	$26.67	$91.85	$368.58	$1,481.43
Batteries / Rectifiers	$10,000	2	20	2	8	10	34	45	155	622	2500	2.5	60%	75%	45.00%	$1.78	$7.11	$8.89	$30.22	$40.00	$137.77	$552.87	$2,222.14
Intermediate Exchanges Regional LTH-LTH																							
SDH Transmission Repeaters	$21,039	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$56.10	$224.42	$280.52	$953.78	$1,262.36	$4,348.12	$17,448.60	$70,131.04
DWDM Repeaters	$21,039	2	0	2	8	10	34	45	155	622	2500	0	0%	25%	0.00%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Ethernet Aggregation Equipment	$21,039	2	0	2	8	10	34	45	155	622	2500	0	0%	30%	0.00%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Optical Fibre Lead In	$1	5	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.01	$0.02	$0.03	$0.09	$0.12	$0.43	$1.73	$6.94
Optical Fibre Joint	$333	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.89	$3.56	$4.44	$15.11	$20.00	$68.89	$276.43	$1,111.07
OF Patch Panel	$710	2	36	2	8	10	34	45	155	622	2500	2.5	60%	43%	25.83%	$0.12	$0.49	$0.61	$2.08	$2.75	$9.47	$37.98	$152.66
Accommodation/Airconditioning	$3,473	2	20	2	8	10	34	45	155	622	2500	2.5	60%	40%	24.00%	$1.16	$4.63	$5.79	$19.68	$26.05	$89.72	$360.03	$1,447.05
Power Consumption (Including heat extraction)	$68,750	2	20	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$9.17	$36.67	$45.83	$155.83	$206.25	$710.42	$2,850.83	$11,458.33
Power Systems	$6,666	2	20	2	8	10	34	45	155	622	2500	2.5	60%	40%	24.00%	$2.22	$8.89	$11.11	$37.78	$50.00	$172.22	$691.09	$2,777.67
Batteries / Rectifiers	$10,000	2	20	2	8	10	34	45	155	622	2500	2.5	60%	40%	24.00%	$3.33	$13.33	$16.67	$56.66	$75.00	$258.32	$1,036.63	$4,166.51

Figure 26 Tail Model (second part – example of trench and optical fibre items)

Regional LTH to LTH																							
Trench + Optical Fibre																							
Regional LTH - LTH Optical Fibre Cable - Type 1	$6,751	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$9.00	$36.01	$45.01	$153.03	$202.54	$697.63	$2,799.50	$11,252.02
Regional LTH - LTH Optical Fibre Cable - Type 2	$5,513	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$7.35	$29.40	$36.75	$124.96	$165.39	$569.67	$2,286.03	$9,188.22
Regional LTH - LTH Optical Fibre Cable - Type 3	$4,800	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$6.40	$25.60	$32.00	$108.81	$144.01	$496.05	$1,990.60	$8,000.82
Regional LTH - LTH Direct Buried Optical Fibre Cable T	$19,175	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$25.57	$102.27	$127.83	$434.63	$575.24	$1,981.39	$7,951.14	$31,957.96
Regional LTH - LTH Direct Buried Optical Fibre Cable T	$14,554	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$19.41	$77.62	$97.03	$329.89	$436.62	$1,503.92	$6,035.10	$24,256.83
Regional LTH - LTH Direct Buried Optical Fibre Cable T	$13,129	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$17.51	$70.02	$87.53	$297.60	$393.88	$1,356.69	$5,444.25	$21,882.02
Joints	$1,667	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$2.22	$8.89	$11.11	$37.78	$50.00	$172.22	$691.09	$2,777.67
Regional LTH to Local Exchange																							
Trench + Optical Fibre																							
Regional LTH to Local Exchange- Type 1	$4,951	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$13.20	$52.81	$66.01	$224.44	$297.05	$1,023.18	$4,105.94	$16,502.96
Regional LTH to Local Exchange- Type 2	$6,064	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$16.17	$64.69	$80.86	$274.91	$363.85	$1,253.27	$5,029.26	$20,214.08
Regional LTH to Local Exchange- Type 3	$5,281	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$14.08	$56.33	$70.41	$239.38	$316.83	$1,091.31	$4,379.33	$17,601.80
Regional LTH to Local Exchange Direct Buried- Type 1	$35,154	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$93.74	$374.97	$468.72	$1,593.64	$2,109.23	$7,265.11	$29,154.18	$117,179.20
Regional LTH to Local Exchange Direct Buried- Type 2	$32,019	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$85.38	$341.54	$426.92	$1,451.53	$1,921.14	$6,617.26	$26,554.44	$106,730.05
Regional LTH to Local Exchange Direct Buried- Type 3	$28,884	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$77.02	$308.10	$385.12	$1,309.42	$1,733.06	$5,969.42	$23,954.69	$96,280.90
Joints	$3,055	2	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$8.15	$32.59	$40.74	$138.51	$183.33	$631.46	$2,533.98	$10,184.81
Regional Local Exchange to Local Exchange																							
Trench + Optical Fibre																							
Regional Local Exch. To Local Exch. - Type 1	$1,987	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$2.65	$10.60	$13.25	$45.05	$59.62	$205.37	$824.14	$3,312.47
Regional Local Exch. To Local Exch. - Type 2	$1,750	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$2.33	$9.33	$11.67	$39.67	$52.50	$180.83	$725.67	$2,916.67
Regional Local Exch. To Local Exch. - Type 3	$908	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$1.21	$4.84	$6.05	$20.57	$27.23	$93.78	$376.32	$1,512.52
Regional Direct Buried Optical Fibre Cable Type 1	$3,089	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$4.12	$16.48	$20.60	$70.02	$92.68	$319.22	$1,281.02	$5,148.78
Regional Direct Buried Optical Fibre Cable Type 2	$2,814	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$3.75	$15.01	$18.76	$63.78	$84.41	$290.76	$1,166.79	$4,689.65
Regional Direct Buried Optical Fibre Cable Type 3	$2,538	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60.00%	$3.38	$13.54	$16.92	$57.54	$76.15	$262.29	$1,052.55	$4,230.52
Joints	$278	1	1	2	8	10	34	45	155	622	2500	2.5	60%	100%	60%	$0.37	$1.48	$1.85	$6.30	$8.33	$28.70	$115.18	$462.95
Total																**$761**	**$3,044**	**$3,805**	**$12,938**	**$17,124**	**$58,984**	**$236,697**	**$951,355**

4.10 GLOBAL PARAMETERS AND RESULTS

Figure 27 Presentation of Global Parameters and Results Spreadsheet

Input Parameters

Markup on Capital Costs		
Spares	5%	*sparesmu*
Installation	15%	*installmu*
Undersea Cable Installatio	100%	*ucinstallmu*
Indirect	5%	*indirectmu*
Markup for O&M Costs (Applied as a Markup on Capital Costs)		
Trench and Conduit	11%	*trencho_mmu*
Optical Fibre	10%	*ofo_mmu*
Transmission Technology	10%	*transo_mmu*
Indirect O&M Cost Markup (Applied as a Markup on O&M Costs)		
All O&M Items	25%	*indo&mmu*
Others		
Inflation	3%	*inf*

Results

A cell turning red indicates the Unit of capacity is greater than the System Capacity * Utilisation and the result should not be relied upon

Results – *Annualised Cost*								
Interexchange Cost	$538	$2,153	$2,691	$9,149	$12,109	$41,707	$167,367	$672,699
Link Cost	$470	$1,882	$2,352	$7,997	$10,584	$36,455	$146,290	$321,553
Tail Cost	$761	$3,044	$3,805	$12,938	$17,124	$58,984	$236,697	$951,355
Undersea Cable Route	$2,346	$9,384	$11,730	$39,882	$52,784	$181,813	$729,597	$2,932,465
	capcosted	*capcosted2*	*capcosted3*	*capcosted4*	*capcosted5*	*capcosted6*	*capcosted7*	*capcosted8*
Unit of Capacity Costed (Mbps)	2	8	10	34	45	155	622	2500

WACC Analysis

Capital Pricing Formula

Rate = Risk free rate +(Beta x Market Premium)

Risk free rate =	5.50%
Beta =	1.02
Market Risk Premium =	7.00%
CAPM rate=	12.64%
Tax rate=	30%

WACC Determination	Weighting	Estimated Cost	Tax Credit	Weight	Weighted Av. Cost of Capital	
Non interest bearing debt	15.0			15.0%	0.00%	
Interest bearing debt	5.0	9.5%	2.85%	5.0%	0.33%	
Share capital & reserves	80.0	12.6%		80.0%	10.11%	
WACC	**100.0**				**10.44%**	*wacc*

The above extract from the 'Global Parameters and Results' spreadsheet indicates the three panels representing the functions of this sheet. They include:

- Global Parameters;
- Results; and
- WACC Analysis

4.10.1 Global Parameters panel

The 'Global Parameters' are a selection of parameters that are globally applied within the spreadsheet and are likely to be of interest to the user when considering impacts on the results. Further input values specific to particular sheets occur in those sheets where they have local significance.

The yellow boxes contained in the 'Global Parameters' panel include the mark up factors used in the calculation of the annualised cost of each cost item. Mark ups applied to capital costs include spares, installation and indirect capital costs. A separate mark-up input for the installation of undersea cable is provided as this value is likely to be significantly different to the mark-up for other installation activities.

Separate mark ups for calculating the Operations and Maintenance (O&M) costs based on a percentage of the capital costs are provided for four categories that may potentially require different values. These are for:

- Trench and Conduit;
- Optical Fibre; and
- Transmission Technology

A single factor is employed for the Indirect O&M Cost Mark up which is applied to all O&M costs.

This panel also permits the entry of a value for inflation.

4.10.2 Results panel

The 'Results' panel contains a yellow boxed cell that permits the selection of a unit of capacity that is to be costed. Green boxes are used to display the results for:

- Inter-exchange Cost;
- Link Cost; and
- Tail Cost
- Undersea Cable Route

The numbers displayed in the green cells are the final results drawn from the respective sheets constructed to calculate the values.

Should it be required, the value for the capacity for which the results are displayed can be adjusted by changing the capacity in the field below the results presentation. This facility is provided to offer the flexibility to explore other capacity scenarios.

Note: Care should be taken with the results where the 'Unit of Capacity Costed' approaches or exceeds the capacity of the technology selected. In these circumstances the selected capacity has the potential to exceed the capacity implied by capacity of the technology selected and the selected system utilisation resulting in greater calculated cost than should be the result. For example, the selected unit of capacity to be costed may be 2500Mbps and the technology selected is a 2500Mbps system. In this circumstance the utilisation should be selected as 100 percent but is likely to be selected at a lower value for the purpose of costing the other selected units of capacity. To warn the user that this circumstance has occurred as a result of model settings the cell displaying the affected result is formatted to turn to red.

4.10.3 WACC Analysis panel

The 'WACC Analysis' panel facilitates the entry of relevant factors and performs the necessary calculation to determine the relevant WACC subsequently employed in later annualised capital calculations.

5. CONNECTION CHARGES

In the environment modelled connection charges for transmission capacity are not bandwidth dependant and are quite minimal. Transmission capacity connections on the modern systems can be set up from a central computer system with a few minutes work. On those routes that can be interconnected via a DXC or Router the resource required is a few minutes for a technician or trained operator at a central computer terminal provided the capacity is available. In normal circumstances an efficient Access Provider would have supplied capacity to cover short term order requirements. The parameter for an 'efficient' network would take these requirements into account. Therefore consideration for the planning and provisioning of additional capacity are not a reasonable consideration for connection charges.

Where an interconnection is required at a regional LTH to link Inter-exchange capacity to Tail capacity a physical cross connect may be required on an optical fibre frame or patch panel in the LTH and a connection may be required between the transmission equipment and the access seekers DSLAM. Where there is an existing connection in place and the capacity can be provided within the capability of the existing connection either of these may not be required. These operations are likely to require no more than 10 minutes of a technicians time at an exchange plus travel time if that is relevant.

In the case of a connection to an access seekers host location, as for a Link capacity, most costs are covered by the initial installation of the underlying system which is included in the annualised cost. In the case of SDH some cross connection may be required at the local exchange. In the case of Ethernet connections that is unlikely.

Consequently reasonable connection charges are in our opinion of the order of half an hour by $80 per hour per transmission link. That is approximately $40 - $50 per connection plus a modest charge for order taking plus an uplift for overheads. A figure of less than $100 in each instance is therefore considered reasonable