Appendix 1

Using the Route Design in the GQ-AAS Domestic Transmission Model

The purpose of this Appendix is to outline the steps required to apply the GQ-AAS Domestic Transmission Model[1] to a specific route. In particular, this Appendix focuses on how the user designs a specific route or routes and uses this information to populate the inputs in the Route Design and the Technology Selection sheets of the model. It must be emphasised that this Appendix does not describe the range of assumptions required to implement the model, for instance, the capital costs of network elements or trenches that are required as inputs in other sheets of the model. For purpose of illustration the Appendix will describe the process to model the Melbourne-Bendigo route using SDH rings.

Modelling the Melbourne-Bendigo Route

The design of optical fibre based SDH transmission systems to cater for a point to point situation such as the Melbourne –Bendigo route in this example requires a diverse return path to be established. A diverse return path from Bendigo to Melbourne has historically been naturally formed by using the lateral routes interconnecting adjacent regional centres. In the case of Bendigo there is a route to Shepparton and another to Ballarat, each of which has a path to Melbourne that is quite separate to the Melbourne to Bendigo direct route. When Ballarat is considered it also has an option via Geelong.

The number of these lateral routes that can be included and therefore the number of regional centres catered for by the capacity of an individual ring is a matter for the designer having consideration, among other factors, to the choice of transmission capacity to be deployed in the SDH ring and the demand for capacity from each regional centre included.

The considerations around these design choices are developed further in the following example.

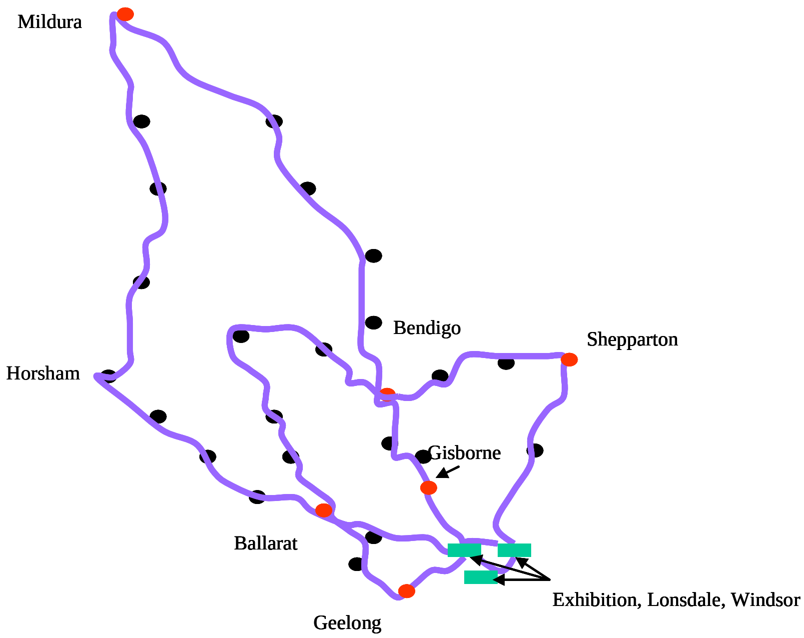
Step 1: Identify Regional Centres

The first step in designing the route is for the modeller to determine the number of regional centres that will potentially be linked by SDH rings, having regard to the geographic locations of the centres. This information will be used in the Route Design sheet of the model. For instance, for the purpose of this example GQ-AAS choose Bendigo, Ballarat, and Geelong and also consider Shepparton, Gisborne and Mildura.

---

[1] For a Description of the Model see GQ-AAS "Australian Competition & Consumer Commission Transmission Network Cost Model Description of Operation" April 2008

Figure 1 Network links between regional centres to available to form SDH transmission rings



The above diagram Figure 1 indicates the optical fibre cable routes available to form a transmission ring that may provide transmission capacity to Bendigo, Ballarat and Geelong. The diagram demonstrates that other locations are in the vicinity of the optical fibre cable routes or would require multiplexers at common sites to form rings to service these sites such as Gisborne, Shepparton and Mildura.

Key considerations are that at least one multiplexer will be required at all of the LTH sites. Multiplexers will also be required at intermediate repeater sites. The decisions about which of these multiplexers will actually be connected together via the available optical fire cable routes will be informed by the capacity required by each transmission hub, efficient use of the optical fibre cable, the technical need for repeaters to be included and also the connectivity required between the hubs that can be most efficiently catered for on a single ring.

(It should be emphasised that these choices are based on the reasonable judgment of the modeller)

Examples of the considerations around these additional transmission hubs are:

- In the case of Shepparton it would be reasonable to assume a ring would be formed including Bendigo to provide a diverse path back to Melbourne and Gisborne for the purpose of providing a repeater site. Having identified a need for a ring with the potential overlap at Bendigo and Gisborne consideration must be given to some of the capacity required by these sites to be catered for by this ring rather than the proposed Bendigo, Ballarat, Geelong Ring.
- In the case of Mildura it would be reasonable to assume an efficient optical fibre path would pass via Bendigo and Ballarat to obtain the required path diversity, with both of these locations serving as repeater sites. The Mildura ring would also consequently be considered as a means of transporting capacity from Bendigo and Ballarat.

- The overlaps resulting from these considerations support flexibility in the allocation of capacity between the rings, thereby facilitating an even distribution of utilisation.

Step 2: Estimating Bandwidth for these Regional centres

It is preferable to have the actual transmission capacity demand for each location provided by the carrier. However failing that, it is necessary to have a method of estimating demand based on the likely requirements of the major sources of transmission capacity demand. GQ-AAS has supplied a calculator in the model to assist the modeller to make an estimate based on four major sources of demand being PSTN, Mobile, Broadband Internet and narrowband Internet.

To estimate the capacity required for a regional centre, the Demand Estimate sheet in the model, requires the population in the call collection area (CCA) to be entered as an input. The GQ-AAS calculator provides two methods to estimate the capacity required for each regional centre:

- First, it can be estimated from macro-data where information regarding national population, services in operation for various services and the total number of LTHs are used as an input to provide an average for services per LTH from which bandwidth requirements are estimated for each service type (see Figure 4[2] first box of the model spreadsheet).
- Alternatively, the population for each area served by the LTH (or CCA) is estimated by inserting the population specific to each CCA (see Figure 4[3], second box of the spreadsheet model) and the sum of the estimated bandwidth capacity for each of the centres is considered together to estimate the bandwidth demand for the ring. This is the approach used by GQ-AAS in this example.

Using the alternative approach outlined above, GQ-AAS estimates that the Bendigo CCA has a population of approximately 120,000 in its area. Using this input for the population in the Demand Estimate sheet a capacity requirement of 4.2Gbps is derived.[4] This is shown in Table 1 below where Population per LTH is set at 120,000, yielding a total capacity of demand of 4.239 Gbps. It can be seen from this calculation the outcome is quite sensitive to the assumption about monthly download capacity and it is noted that the assumption used in this example may be higher than actual input data that carriers may supply the ACCC.

---

[2] GQ-AAS “Australian Competition & Consumer Commission Transmission Network Cost Model Description of Operation” April 2008 p12

[3] GQ-AAS “Australian Competition & Consumer Commission Transmission Network Cost Model Description of Operation” April 2008 p12

[4] Table 1 highlights in yellow all the assumptions required to estimate total capacity for each centre. As can be seen from the table it requires assumptions regarding traffic information and bandwidth per user data.

Table 1: Demand Estimate Sheet

	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	5,000,000	2,000,000
Ratio National Population / Service	2.5	1.25	4	10
Total Number of LTH	180	180	180	180
Population per LTH	120,000	120,000	120,000	120,000
Services per LTH (CCA)	48,000	96,000	30,000	12,000
Bandwidth per user				
ISP Monthly plan (Mbytes)			3000	500
Mbits			24,000	4,000
Packet Overhead			20%	20%
Days			25	25
Hours per day			5	5
Seconds per hour			3600	3600
Average Bandwidth per user (Mbps)			0.064	0.011
Traffic from Phone				
Erlang per Phone	0.02	0.04		
Bandwidth per phone call (kbps)	64	10		
Bandwidth per user (kbps)	1.28	0.4	64	11
Bandwidth All Users(kbps)	61,440	38,400	1,920,000	128,000
Local Calls (Within CCA)	30%	0%	0%	0%
Trunk Calls (Outside of CCA)	70%	100%	100%	100%
Carriage efficiency	70%	70%	50%	70%
Bandwidth Required on MTH to LTH Link (kbps)	61,440	54,857	3,840,000	182,857
Other Products (kbps)				100,000
Total capcity demand for all products per CCA/LTH (Mbps)				4,239

This step is repeated for the other regional centres and the following capacity results are shown in Table 2.

Table 2: Capacity for Regional Centres based on estimates using Demand Estimate sheet

CCA	Population	Capacity1(Gbps)
Bendigo	120,000	4.2
Ballarat	100,000	3.5
Geelong	250,000	8.8
Shepparton	80,000	3
Gisborne	80,000	3
Mildura	60,000	2.2
Total	**690,000**	**24.7**

From the above Table 2 it is shown that to cater for these centres 24.7 Gbps is required.

Once the capacity of these centres is estimated, the modeller then exercises reasonable judgment to determine:

(a) the appropriate technology decision;
(b) the number of rings required to meet this capacity;
(c) which regional centres each ring passes through (see Step 1 above); and
(d) A reasonable allocation of capacity to each ring and the consequential utilisation of the capacity on the route.

For this example the consideration of these matters are shown in the following steps.

Step 3: Technology Decision

With a demand of 24.7Gbps, the technology decision is for an SDH system with 10Gbps rings. The current options are 2.5Gbps or 10Gbps. As the cost of a 10Gbps SDH multiplexer is currently approximating the cost of a 2.5Gbps multiplexer the benefits of using the larger capacity system, which will cater for the required capacity with fewer rings and fewer multiplexers, are considerable.

Given this level of demand and total capacity for the three systems required to service all of the considered locations of 30Gbps an estimate of 82.3% for the average utilisation of all the systems is calculated.

Alternatively had 2.5Gbps SDH technology been chosen 11 rings would be required to provide the same capacity and have an average utilisation of around 90%.

The above data is then used in the Technology selection Sheet. The selections are:

- Select Technology = 1
- Select DXC = 1
- Select Router = 0 (1 only if Ethernet Agg selected)
- Select SDH System Capacity = 10 Gbps
- Select Utilisation = 82.3%
- Select 1 Wavelength (SDH system requires 1 wavelength)
- Utilisation of wavelength = 100% as in circumstances where WDM is not present one only wavelength is possible on the optical fibre and that is fully utilised by the SDH system.

These selections are shown in Table 3 below.

Table 3: Selection of Technology Selection in Inter-Exchange Module

Inter-Exchange

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

Router	0	*mrouter*
DXC	1	*mdxc*
Transmission System (SDH = 1, SDH + WDM = 2, Eth Aggreg = 3)	1	*mttech*

System Capacity	Gbps	Utilisation		Wavelengths		Wavelengths In Use	Utilisation
SDH System Capacity	10	82%	*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%

Step 4: Number of rings chosen

In this example provided by GQ-AAS, three rings are chosen (10Gpbs each). These are:

- a ring covering Bendigo, Shepparton and Ballarat
- Another including Mildura, Ballarat, Geelong and Bendigo
- A further ring catering for Geelong and Ballarat

It is noted that the routes of these rings are chosen by the modeller, exercising reasonable judgment.[5] That judgement can be exercised by utilising an allocation table similar to the example in the following table. The judgement will include consideration of arrangement of rings to provide the diversity required, minimising where possible the length of optical fibre cable used and the number of multiplexers deployed in addition to achieving a balance of capacity between the rings.

Table 4 Example Allocation Table

	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%

Step 5: Choose Specific Ring

GQ-AAS chose the Bendigo, Shepparton and Ballarat route to model. Again this ring is chosen by the modeller, exercising reasonable judgment for the purpose of modelling a route that can be considered representative and typical for servicing the localities of interest.[6] Another approach may be to calculate a separate cost for each ring and apportion costs in some way proportionate to the allocation on each ring.

On the other hand capacity for Bendigo allocated to the Mildura ring does mitigate the need to build another ring to serve Bendigo. This then has the effect of increasing the average utilisation of the rings serving Bendigo and Mildura.

Working through these issues of different costs for each ring but on the other hand having the flexibility to shift capacity between rings to minimise overall costs, as demonstrated with the above allocation table, it is reasonable to form the view that distance based cost outcomes are not precisely relevant to specific point to point routes. However they may be more broadly relevant over wider regional areas having different population densities such as the difference between Victoria and Queensland.

Step 6: Estimate Average MTH to LTH and LTH to LTH links Distances

Once the specific ring is chosen then the modeller needs to obtain:

---

[5] The design of route rings impacts on the outputs of the model

[6] It should be noted that the cost depends on the rings chosen for example using the ring chosen by GQ-AAS the cost of 2Mbps is $286. However choosing the ring passing through Mildura, Ballarat, Geelong and Bendigo the cost of 2 Mbps is $679.

- Route distances of each of the optical fibre cables that form the links of each ring.
- Using the above, estimated average distances of MTH to LTH links and LTH to LTH links are obtained. These in turn are used as inputs into the Route Design Sheet.

For example, for the Bendigo, Ballarat and Shepparton the average distance for the MTH to LTH links is estimated at 154kms. This is the average of the distance between Melbourne and Ballarat (118Kms) and Shepparton- Melbourne (190Kms). Similarly the average LTH to LTH link is estimated at 181Kms. These estimates are then used as input into the Route Design Sheet.

Step 7: Other Distance Inputs

In addition to the average distances estimated above, the model requires inputs for the distance of links between

- MTH and MTH;
- the distance between intermediate exchanges on the MTH to LTH links
- the distance between intermediate exchanges on LTH to LTH links.

GQ-AAS use 5 kms, 20kms and 30 kms respectively. This is consistent with the deployment of the Telstra regional transmission network in Victoria and can be seen to be reasonably consistent with the distance between country towns located along the major highways. The average distance between intermediate towns can be verified by taking the total distance, identify the number of intermediate towns and divide the total distance by that number.

Table 5 below shows the distance assumptions required in the Route Design Sheet.

Table 5: Distance Inputs

Inter-exchange Route

	Value
Tier 1	
MTH - MTH Distance (kms)	5
MTH - LTH Distance (kms)	154
LTH - LTH Distance (kms)	181
MTH - LTH Intermediate Exchange Distance (Each) (kms)	20
LTH - LTH Intermediate Exchange Distance (kms)	30

Step 8: Number of MTH and LTH

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– but this can also be set at 3 as there are 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 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.

Step 9: Number of Links

The next step is to estimate the number of MTH to LTH links; and the number of LTH to LTH links.

The number of MTH to LTH links is normally set at two and would always be the case if a ring is formed with the two MTH adjacent on that ring, thereby requiring two MTH to LTH links to connect to LTH on the ring.

The number of LTH to LTH links equals the number of LTHs minus one.

The Table 6 below shows the inputs into the Design Route sheet for the number of MTH and LTH and their respective number of links

Table 6: Inputs on the Number of MTH and LTH and their Links

No. of MTH	2
No. of LTH	3
No. of LTH Not Included in Transmission Ring	0
No. of MTH to LTH Links	2
No. of LTH to LTH Links	2

Step 10: Estimating the Number of Intermediate Exchanges with Multiplexers

An estimate needs to be undertaken to provide this input. The estimate is based on an assumption that repeaters are required at around 80km distances as the technical guideline. This distance is dependant on the quality of the optical fibre and the capability of the suppliers' technology. Hence this value should be verified with the carrier and/ or the supplier.

The calculation is distance divided by 80km and reduced to the integer value to convert the number of links to the number of intermediate exchanges requiring repeaters/multiplexers.

Therefore the number of MTH to LTH intermediate exchanges with Multiplexers is estimated at three as there are two MTH to LTH with distances of 118 kms (118/80=1.475, therefore one repeater is needed) and 190 kms (190/80=2.375, therefore two repeaters are needed).

Similarly there are two LTH to LTH links between the three LTH locations with distances of 239 kms and 122 kms. These also require three intermediate exchanges with multiplexers. These values are shown in the table below.

Table 7: Intermediate Exchanges

No. of Intermediate Exchanges MTH - LTH	
- With Multiplexer	3
- Without Multiplexer	12
No. of Intermediate Exchanges LTH - LTH	
- With Multiplexer	3
- Without Multiplexer	12

Step 11: Input Other Assumptions Necessary to Run the Model

The route design module is now completed, however at this point the locations that have been allotted a repeater can be reviewed to determine the transmission capacity from these exchange locations that could be placed on the ring by using the repeater as another multiplexer. These increased amounts can be used to increase the estimated utilisation of the ring.

Next, the modeller inputs assumptions regarding:

- The variables in the Trench and Optical Fibre Cable worksheet[7];
- The variables in the Annualised Cost Calc worksheet. This worksheet is important because it inputs the capital cost of each item, its asset life and the price trend for the item. Using these inputs the worksheet estimates the annualised cost for each type of equipment in the model[8];
- The variables in the Accommodation worksheet that mainly relate to the system footprint in square metres of the transmission equipment and the cost per square metre;
- Power consumption in the Inter-Exchange Model, Link Model, Tail Model and the Undersea Cable Route Model; and
- Global input parameters in the Global Parameters and Results sheet related to mark-ups on capital and for operational costs, as well as address the calculation of the WACC.

Once these inputs are made the model displays the estimate for the cost of capacity on the modelled ring in the Results panel of the Global Parameters and Results sheet. This panel does present a range of units of capacity that can be costed and presented simultaneously. These units of capacity are selectable up to the capacity of the transmission system.

A feature of the presentation of these results is that where the result of the capacity of the system multiplied by the utilisation of the system entered in the Technology Selection sheet is less than the unit of capacity selected the results cell turns red to indicate the result for that unit of capacity is not a valid one. As the unit of capacity

---

[7] GQ-AAS "Australian Competition & Consumer Commission Transmission Network Cost Model Description of Operation" April 2008 Section 4.5. p30

[8] GQ-AAS "Australian Competition & Consumer Commission Transmission Network Cost Model Description of Operation" April 2008 Section 4.7. p32

in these cases will produce a higher utilisation the calculated cost will be higher than the result should be. In such a situation the utilisation can be amended to the correct value but the result is only likely to be valid for that unit of capacity as it is likely where lower units of capacity are required a lower utilisation will be valid.