Australian Terrestrial Trunk Transmission Capacity Study

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ABOUT THIS DOCUMENT

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ABSTRACT: DCITA commissioned Telsyte to investigate the current supply of high bandwidth transmission links operated by both dedicated telecommunications operators and non-telecommunications operators such as electricity transmission businesses and rail corporations.

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1 Introduction

Background

The 1999 National Bandwidth Inquiry (NBI) investigated the supply of trunk transmission capacity existing at that time. Since 1999, there has been considerable evolution in technology and in the competitive market for trunk transmission capacity that has resulted in substantial growth in the capability and capacity of telecommunications trunk transmission infrastructure. There has also been some increase in the diversity of suppliers.

New market entrants have emerged on the inter-capital and regional routes including IP1 Australia (IP1), NextGen, ntl Telecommunications (ntlT), Soul Pattinson Telecommunications (SPT), Telecasters and other regionally oriented players.

In addition, the market for broadband services throughout the Australian populace has undergone significant growth. That growth going forward has the potential to place strains on the capacity of carrier's networks to consistently meet demand across all Australian communities.

In order to assess market changes with respect to trunk capacity, the Department of Communications Information Technology and the Arts (DCITA) initiated a consultancy to investigate the current supply of high bandwidth transmission links operated by both dedicated telecommunications operators and non-telecommunications operators. These include such organizations as electricity transmission businesses and rail corporations.

Telsyte, a business unit of Gibson Quai Pty Ltd (Gibson Quai), was engaged for that consultancy to conduct a trunk transmission capacity study.

Appendix B contains Definitions of terms used in this report.

Objectives

The purpose of this consultancy is to update the work of the NBI in relation to the supply of trunk transmission capacity and provide further clarity and insight into the factors affecting the supply of future services.

The terms of reference for the consultancy are:[1]

1. Updating the work of the NBI in relation to the supply of communications capacity by dedicated telecommunications carriers' domestic trunk networks. It is expected that the response to this task will include:

   - ❑ The characterisation of the supply of communications capacity between

[1] DCITA Project Brief

capital cities and to regional centres, in terms of the transmission technology utilised, network routes, the bandwidth currently available and the ability for this to be upgraded; and

- Details regarding the availability and network routes of unutilised network infrastructure (eg dark fibre) capable of being provisioned for the supply of communications services between capital cities and to regional centres.

2. To the extent possible, detail the supply of communications capacity across networks deployed by non-dedicated telecommunications operators, such as electricity transmission businesses and rail corporations. It is expected that this task will provide:

   - Information on the supply of communications capacity between capital cities and to regional centres, in terms of the transmission technology utilised, network routes, the bandwidth currently available and the ability for this to be upgraded; and

   - Details regarding the availability and network routes of unutilised network infrastructure (eg dark fibre) capable of being provisioned for the supply of communications services between capital cities and to regional centres; and

   - A methodology to inform advice on further investigation of the availability and supply of network communications capacity.

It is intended that this consultancy will supplement the continuing work of DCITA's Communications Research Unit (CRU) in mapping the location and characteristics of high-bandwidth links.

Telsyte/Gibson Quai have also undertaken to add further value to the consultancy by providing insight into certain matters affecting the supply of trunk transmission services to the market.

2 Key Findings

Based on the survey responses, which confirmed and augmented our existing industry knowledge, we have reached the following conclusions:

1. There are only five carriers with inter-capital optical fibre based transmission capacity — Telstra, Optus, NextGen, IP1 and PowerTel. Of the microwave providers, only three — FLOW Communications, ntl Telecommunications (ntlT) and Soul Pattinson Telecommunications (SPT) have any reasonable amount of inter-capital capacity. These providers, however, confine their activities to the eastern states.
2. New forms of Wave Division Multiplexing (WDM) and higher bandwidth Synchronous Digital Hierarchy (SDH) systems will permit more than adequate capacity to be provided on existing fibres for quite a long time to come.
3. Telstra and Optus extensively employ Dense Wave Division Multiplexing (DWDM) and SDH technologies on all of the major inter-capital routes. Both of these carriers justify deployment of very high capacity systems on these routes on the basis of capacity demand. The fact that less expensive smaller units of capacity are not chosen, or an upgrade is required indicates the existing lit capacity has relatively high levels of utilisation (typically between 50% to 75%). Carriers employ DWDM technology to obtain additional capacity on the existing optical fibre. The presence of DWDM indicates that the existing fibre has relatively high levels of utilisation. Both Telstra and Optus continually upgrade their capacity to remain ahead of demand. The fact that multiple systems are in place and further systems are in the process of being installed, or have recently been installed, is evidence that utilisation is at a relatively high level.
4. IP1 and NextGen, both of which could be reasonably described as speculative ventures, have limited demand for services. Subsequent to the commencement of the trunk transmission capacity study, both of these organizations entered receivership. As of this writing, it is unclear as to whether the capacity deployed by these organizations will be taken over by a new owner, or indeed whether it will be 'mothballed'.
5. Inter-capital capacity provided by Telstra, Optus, NextGen and IP1 is mostly deployed as point-to-point 2.5 Gbps or 10 Gbps SDH transmission systems. These links are arranged as SDH systems deployed either directly on optical fibre or on DWDM systems that increase the number of wavelengths and consequently the number of SDH systems that can be deployed on a an optical fibre pair.
6. The capacity provided in this way is tailored to the level of demand Optus has in those locations. The major regional centres where this capacity is available are also normally the Point of Interconnect (POI) with Telstra's PSTN in regional centres. (These POIs are listed in Appendix C.)
7. Telstra designs its regional optical fibre and transmission routes in such a way that it is separate from their inter-capital capacity. This is done primarily to avoid the need to deploy additional optical fibre cable capacity. The capacity provided on each route is significantly lower than that required on inter-capital routes.
8. Increasing the number of sites included on a ring reduces the capacity available per site (given that an SDH ring has a fixed capacity shared between all sites). We therefore conclude that the capability of the technology is possibly outstripping the growth in demand from individual Exchange Service Areas (ESA).

9. Optus and NextGen are deploying DWDM systems with a capability of 80 wavelengths. We are confident that (if necessary) Telstra could purchase higher capacity systems, as needed, to further add to the current capacity.

10. Vodafone has a number of fibre-based SDH rings around capital cities, but tends to lease capacity for its inter-capital transmission requirements. Transmission links between Vodafone mobile base stations and switches utilise a combination of leased capacity and Vodafone owned microwave radio links.

11. Providers such as ntlT and Telecasters operate on the periphery of the voice and data trunk transmission market. The main focus of these organizations has been providing for the transport of television signals. SPT is also a niche operator, highly focussed on meeting specific contractual commitments on the eastern seaboard. Our market experience, leads us to conclude that these carriers are likely to upgrade microwave capacity only when there is a business case to do so, and then only in tightly controlled regional localities on the eastern seaboard.

12. The industry has gone into conservative mode with respect to capital expenditure. A strong business case is required for any infrastructure investment, and many infrastructure builds are driven by customer contracts and involve access links rather than trunk transmission.

13. Due to the current market climate demonstrated by the failure of IP1 and NextGen, we are of the opinion that it is unlikely that new players will enter the trunk transmission market in the near future. Consequently network designs are tailored specifically for business-justified purposes. This results in carriers having little surplus lit capacity, although the infrastructure deployed typically has large amounts of potential (unlit) capacity.

14. Regional centres have similar constraints. There are a small number of transmission providers, and infrastructure investment is done on a business case basis. For all intents, the major carriers in this area are Telstra, Optus and to a lesser extent FLOW Communications and SPT. However, there are also, some carriers such as Agile, ntlT and Telecasters, who have microwave infrastructure in particular states.

15. Where optical fibre is available to regional centres, there is no impediment to providing additional capacity. WDM systems are deployed to avoid the need for further investment in optical fibre cables along these routes. Wavelengths and additional SDH capacity are deployed only as required.

16. Tier 3 regional capacity (e.g. capacity to satellite towns) is problematic from a competitive perspective. These towns tend to be located in geographies where only Telstra has optical fibre and/or microwave infrastructure. During the course of this study, Telstra made it clear that where they currently have transmission capacity to any given locality, there are no issues that would preclude them from providing additional capacity — should the demand for that capacity materialise.

17. A number of non-dedicated operators, such as rail and electricity authorities, deploy infrastructure to meet their own needs but have not entered the carrier market, and do not seem inclined to do so (at least not at the present time).

18. A number of electricity transmission providers such as ETSA (SA), Powercor (VIC), Powerlink (QLD), SPI PowerNet (VIC), TransGrid (NSW) and Western Power (WA) are venturing into the telecommunications market, primarily in Customer Access Networks, and to a lesser extent regional trunk routes, but this is not a main business activity (at least not yet). These companies are mainly focussed on providing capacity in metropolitan areas and are not supplying inter-capital trunk

capacity. Power companies tend to have a limited number of regional centres in their area of coverage. For example, Powercor has capacity to Geelong, Ballarat, Bendigo and West Melbourne. However, as demonstrated by Powercor's footprint, this capacity tends to cover regional centres that already have plenty of capacity from the two major carriers.

19. Rail operators such as VicTrack (VIC), NSW State Rail and Queensland Rail have extensive networks of optical fibre cables on which they typically link to railway stations and train depots. These operators are normally amenable to proposals to sell access to capacity to carriers that may wish to include the rail network infrastructure in their network designs. However each of them has reported that the cost of providing access from the locations at which the capacity is available has in most cases made interconnection unattractive.
20. Rail operators also reported that DWDM systems are likely to be deployed to avoid the future need to invest in additional optical fibre cables.

Details on inter-capital terrestrial trunk transmission capacity are located in Section 7, whereas Section 8 contains details on trunk transmission capacity within each State and Territory.

2.1 Inter-Capital Trunk Transmission Capacity (Tier 1)

One of our key findings to date is that the new entrant infrastructure-based carriers with significant bandwidth potential (such as NextGen, IP1 and PowerTel) provide capacity between capital cities.

Carriers such as Telecasters, ntlT and SPT have microwave POPs on the tops of hills (mainly for broadcast TV), which are removed from the communities that may wish to access capacity. As a consequence, the advice to us was that reasonably significant capital investments would be required to access this trunk capacity.

Many of the microwave-based providers and non-dedicated operators have an interest in providing capacity for their own purposes, rather than for general telecommunications use. These operators tend not to augment their capacity without a sound business case. While they will exploit this capacity for other carriers, they need a sound business case to do so.

By contrast, FLOW Communications has established their network in a way that allows them to pick up capacity from towns/cities along their trunk transmission (microwave) paths.

2.2 Capital City to Regional Area Trunk Transmission Capacity (Tier 2)

The main infrastructure-based providers for this tier are Telstra, Optus and to a lesser extent FLOW Communications and SPT. SPT is now focussing on NSW Government business, and one would expect that they would build capacity to suit individual business case requirements.

Carriers such as ntlT are primarily focused on broadcast (radio and TV) applications.

Rail organizations tend to be geographically based, and as a result operators such as NSW State Rail and VicTrack have significant optical fibre networks around their respective metropolitan areas, although there is some infrastructure in regional areas.

The major observation here is that rail organizations have sufficient capacity to meet their own requirements. While they will consider approaches from other providers, for the most part they have not gone out of their way to enter the telecommunications market.

The other point to make is that the cables are laid along railway tracks and the end points are at railway stations — and a reasonably significant capital expenditure would be required to deliver telecommunications capacity to communities along the rail lines.

2.3 Regional to Regional Trunk Transmission Capacity (Tier 3)

Our assessment is that Telstra provides most capacity to Tier 3 locations. However, there may be some Optus capacity that fits into this footprint. Locations that were identified during the course of this study are included in the Tables in Section 8. We do note, however, that Optus' inter-capital networks pass through the Telstra POIs (mainly around the eastern seaboard) and can be utilised to provide inter-regional capacity between these locations. A Table listing the Telstra Points of Interconnection (POIs) is included as Appendix C.

Our findings indicate that capacity into the many smaller towns surrounding regional locations is only available from Telstra. Many of these towns have access to fibre capacity, but a significant amount of sites in the more remote locations are serviced by microwave.

Non-dedicated operator organizations, such as Snowy Hydro, have capacity between power substations for their own internal requirements. However, these sites are well removed from the local communities and would require a significant capital expenditure to provide any useful telecommunications capacity. Snowy Hydro, like other similar operators, does not have transmission linkages to capital cities that could be utilised to provide network connectivity.

3 Methodology

This section of the report describes the methodology used by Telsyte to collect and analyse data from carriers and non-dedicated operators for the purpose of obtaining route-by-route information about the transmission capacity available in Australia.

3.1 Request for Information

Australia's transmission networks reflect the communities they serve in that they take the form of a three-tier structure. This structure was utilised as the basis for analysing transmission capacity and the penetration of competition in the market. The three tiers are:

- **Tier 1**: The inter-capital routes linking the major population centres and the major switching hubs located at these centres. These also form the aggregation points for international routes as well as being the major Gateway locations for the interconnection of switched networks (i.e. Mobile/PSTN interconnection).

- **Tier 2**: The second tier routes link the capital cities in each state to the major regional hubs, which are the major regional cities. These regional hubs are the location of Telstra's Local Area Switches (LAS) that form the point of interconnection (POI) for the competitive carriers seeking PSTN Originating and Terminating access. The list of Telstra POIs is included in Appendix C. The competitive carriers are understood to normally plan their transmission routes to include these locations, as these are the points at which they can most effectively utilise their transmission capacity. It is also true that roadways and rail easements that carriers rely on naturally lead to these intermediate communities. The routes to these locations are typically the first choice for investment in transmission capacity for power and rail companies. Consequently, there is typically strong competition and frequently excess capacity (but not necessarily excess lit capacity) on these routes.

- **Tier 3**: The third tier is between the major regional hubs and the smaller satellite towns surrounding these locations. Competitive carriers have little or no incentive to build transmission capacity to these locations, as it is not required for PSTN interconnection. Where competitive capacity is available it is likely to be as a result of the town's position along the route between larger centres. However, in many instances it is not economically viable to install expensive transmission multiplexing equipment in a town simply because the route passes through it. For these reasons, the majority of third tier routes have little or no competitive transmission capacity and are therefore reliant on Telstra. Most are, however, served by Telstra's optical fibre cables. Consequently, the adequacy of provisioned capacity is normally only a question of the inherent capability of the multiplexing equipment deployed by Telstra.

A range of carrier and non-dedicated operator organizations were identified as potential study participants. The carrier community and transmission infrastructure deployments are well known to Telsyte/Gibson Quai. Nonetheless, we contacted a range of carriers whom we did not expect would qualify for the study in order to verify our understanding.

Identification of non-dedicated operators who own/operate transmission infrastructure was a somewhat more complicated task, as in some cases, details of the transmission infrastructure utilised by this group of stakeholders was not as well known to the consultants. Organizations of particular interest to the study included electricity transmission businesses and rail organizations.

In order to verify that we contacted all appropriate electricity organizations, we contacted NEMMCO (National Electricity Market Management Company Limited) who maintains a registry of electricity providers in accordance with Chapter 2 of the National Electricity Code. Eighty-five (85) electricity companies are currently registered under the code. However, only seven (7) organizations are considered to be Transmission Network Service Providers, all of whom were contacted for this study. As a further check, we discussed the terms of reference and potential stakeholders with NEMMCO and the electricity (and gas) organizations contacted.

A similar process was used to identify rail organizations with qualifying transmission infrastructure. In this case, we consulted with our in-house rail/transportation specialist group as well as key individuals within a number of rail organizations.

As a final check, we reviewed our list of stakeholders with the managers of each of our national offices (located in Sydney, Melbourne, Brisbane, Canberra, Adelaide and Perth). We also sought advice from the Tasmanian Government on alternative transmission providers with infrastructure in that State.

In order to obtain the best possible results in the shortest period of time, the project terms of reference, timeframes and commercial issues were discussed with executives from each stakeholder organization.

Following the initial project discussion, each target company was sent a letter from DCITA describing the background to the survey and a structured questionnaire outlining the data required. In addition, a spreadsheet containing the preferred format for the response was also sent to each organization except for Telstra. (Due to the complexity of the Telstra network, the information collection mechanism was discussed directly with Telstra.)

The data collection spreadsheet contained several Tabs (a worksheet within an Excel spreadsheet), which were designed to facilitate the collection of data in relevant categories of interest, and also to facilitate the use of appropriate column headings.

The following Tabs (worksheets) were included in the spreadsheet:

- Confidential Information;
- Tier 1 and 2 Optical Fibre Cable;
- Tier 3 Optical Fibre Cable;
- Microwave;
- PDH on Fibre;
- SDH on Microwave; and
- Capacity Issues.

The information requested in each section of the spreadsheet is described below.

3.1.1 Confidential Information

This tab (worksheet within an Excel spreadsheet) was employed to give instructions on how each respondent should code data into the three categories agreed with the Department. For each of the questions/information requests in this document, study respondents were asked to indicate the level of confidentiality surrounding the information provided. The classification categories were:

- Data that was available for Telsyte on a confidential basis to conduct an analysis of available transmission capacity;
- Data that was also available to provide to the Department for their internal use on a confidential basis;
- Data that could be disclosed in a public report.

3.1.2 Tier 1 and 2 Optical Fibre Cable

Due to our knowledge that some carriers combined the function of inter-capital transmission capacity with capacity that serviced capital city to regional centre transmission requirements, we considered it prudent to request responses for both forms of optical fibre routes on a single Tab (worksheet within an Excel spreadsheet).

The following column headings were employed:

- Carrier Name
- Route Designation
- Which Diverse Route Linked to
- Town Names on Route
- NZDF or SMOF
- Number of Fibres per Cable
- Number of Fibre Cables
- Fibres in Use
- Multiplexer Present (First Named)
- POI
- Number of WDM/DWDM Devices Deployed on Fibre Pairs
- Capability of WDM/DWDM Equipment (Number of Wavelengths Supported)
- Wavelengths Currently In Use
- Number of SDH Muxs Deployed
- Capacity of each SDH Mux (Mbps)
- Number of 2 Mbps Capacity Increments Available
- Number of 2 Mbps Capacity Increments In Use
- Nominal Capacity Not Available

- Spare Capacity
- Number of sites that share the capacity

Explanatory notes were also included in some column headings where further explanation was deemed to be required.

These column headings were repeated for each of five (5) years to permit the entry of planned infrastructure investments/capacity enhancements.

3.1.3 Tier 3 Optical Fibre Cable

Optical fibre capacity on routes from regional centres to nearby satellite communities was requested on the Tier 3 Tab (worksheet within an Excel spreadsheet). The same column headings were employed as for the Tier 1 and 2 data.

3.1.4 Microwave

Information on microwave routes was requested employing the following column headings including appropriate explanatory notes on some columns:

- Link
- Tower Locations Not Shared
- Tower Locations Shared with Others
- Origin/Destination
- POPs from which service is offered
- Capacity Deployed (Number of 2 Mbps Capacity Increments)
- Capacity in Use (Number of 2 Mbps Capacity Increments)
- Technology: SDH, PDH or others such as LMDS
- Capacity in Use
- Multiplexer Present (First Named)
- POI
- Capacity to POI (Number of 2 Mbps Capacity Increments)
- Capacity in Use to POI (Number of 2 Mbps Capacity Increments)
- Is the site also served by your optical fibre?
- If Not, Why Not
- Impact/constraints on capacity resulting from the choice of technology
- Notes

3.1.5 PDH on Fibre

Information on PDH systems employed on optical fibre routes was requested employing the following column headings including appropriate explanatory notes on some columns:

- Town Names Served
- Name of Hub or B-End of Link
- Number of Fibres per Cable
- Number of Fibre Cables
- Fibres in Use
- Capacity of PDH Multiplexer (Mbps)
- Capacity Available (Number of 2 Mbps Links)
- Capacity In Use (Number of 2 Mbps Links)
- Nominal Capacity Not Available
- Is the site served by other means (describe)?
- Reason for not deploying SDH
- How does this technology impact on available Capacity?
- Notes

3.1.6 SDH on Microwave

Information on SDH systems employed on microwave routes was requested. The following column headings (including appropriate explanatory notes on some columns) were utilised:

- Town Names Served
- Name of Hub or B-End of Link
- Capacity of SDH Multiplexer System
- Capacity Available (Number of 2 Mbps Links)
- Capacity In Use (Number of 2 Mbps Links)
- Nominal Capacity Not Available
- Is the site served by other means (describe)
- Reason for not deploying SDH on Optical Fibre
- How does this technology impact on available Capacity?
- Notes

3.1.7 Capacity Issues

Respondents were also asked to provide specific information on issues or constraints they had with providing capacity in locations of interest to them. The following column headings were utilised:

- Name of sites where Capacity is a Problem
- State Limitations
- Capacity
- Capacity Available (Number of 2 Mbps Links)
- Capacity In Use (Number of 2 Mbps Links)
- Nominal Capacity Not Available
- Planned Date for Resolution
- Form of Resolution
- Are there technical issues constraining deployment of capacity?

In addition, the following prompts were also included in rows of the spreadsheet to assist respondents with the categorisation of issues.

- What are the issues in getting extra capacity to smaller towns? (List)
- Where are the locations that have insufficient transmission capacity to permit the provision of further services? (List)
- In what circumstance is Microwave used rather than Optical Fibre? (List)
- In what circumstances are lesser quantities of transmission provided or where microwave is the preferred transmission?
- What are the exceptions?
- What are the cost considerations with respect to a decision to upgrade a transmission link to optical fibre as opposed to utilising a microwave spur to pick up a Point of Presence or customer site?

3.2 Survey Follow-Up

Information pertaining to all project stakeholders was tracked in spreadsheet format, with separate Tabs (worksheets within an Excel spreadsheet) for Carriers and Non-Dedicated Operators. The tracking sheet was colour coded to indicate status, and contained the following columns:

- Organization Name;
- Brief description of transmission infrastructure;
- Name of Contact Person(s);
- Title of Contact Person(s);
- Phone Number(s) for Contact Person(s);
- Email address for Contact Person(s);
- Comments (by date and research analyst);
- Status/Depth of Information Request;
- Confidentiality Level of Information Received; and
- Indication of whether an infrastructure map was provided.

In order to adhere to project time frames, the Telsyte analyst team maintained regular contact with project stakeholders.

The main reasons given were: time constraints, confidentiality and lack of resources (usually all three reasons).

3.3 Receipt of Information

As each spreadsheet was received from a respondent it was examined to ensure that it contained the required information and that the form of the data was usable. Where differences in interpretation were evident or the data was not immediately understandable by us, a follow up telephone call was made to ensure the data was understood. In some cases consultation also occurred prior to the respondent submitting the data.

We also ensured the respondent had addressed the question of the confidentiality level they required for their data. Colour coding of the data ensured that the classification of each line item travelled with the data as it was collated with other carrier/operator data.

Having verified the data as being suitable and also following a review of our experience with the earlier respondents, we decided the spreadsheet into which all data was to be placed should have several further columns (at Columns A, B and C). These columns allowed us to enter information pertaining to the identity of the carrier as well as other route identification to ensure this information was retained on a line-by-line basis.

Our data analysis spreadsheet utilised a modified version of the spreadsheet provided to the carriers/operators. Additional workbook Tabs were designed for specific inter-capital routes and the collection of intra-state route information.

3.4 Data Qualification

Having collected the data from all respondents, the data qualification process included the examination of each line item to ensure that subsequent operations (calculations) would be supported. For instance, in some cases carriers responded with a form of capacity such as 2.5 Gbps rather than the 2,500 Mbps requested.

The next step of the data analysis was to ensure consistency of route designations so that routes between the same locations could be aggregated. This required us to process each line item, and in many cases define the relevant origin-destination pairs where operator's means of identification differed.

In some cases diverse routes are employed by operators to make SDH rings — in order to provide protected transmission systems. In these cases, the diverse path provides protection but no additional capacity. Also, some carriers have built a route, but have also purchased capacity on another carrier's optical fibre cable or DWDM system to form a diverse path. A further matter for consideration is that an SDH ring can have multiple sites at which it is capable of offering transmission capacity. The fixed capacity can be made available at any site on the ring, but all of the capacity

must be shared between the sites. These matters, and several others, were taken into account before the capacity was calculated and reported.

3.5 Analysis

Having ensured the data was of the best possible quality, the line items were sorted by the relevant route names and the appropriate columns summed. The summed data indicates, for each route, the number of optical fibre cables, the total number of fibre cores, the number of fibres in use, transmission capacity deployed on the fibre cores and how much of that capacity is in use. Transmission capacity that is shared between several sites was apportioned on the basis of the number of sites on the SDH ring that have access to the capacity. Where we received planning data, we were able to include the same analysis for future years.

Other forms of transmission capacity were treated in a similar manner and further matched with the optical fibre routes to find the total capacity on routes that have several forms of transmission capability.

Our approach to reporting the study findings is to detail Tier 1 capacity to the extent allowed by carrier confidentiality undertakings.

For Tier 2 routes (covering 120-150 locations), we have reported the average number of fibres deployed by operators on each cable and the number of fibres that have transmission systems in use (STM-1, STM-4, STM-16 or WDM systems). For WDM systems we have examined the capability of the equipment, as well as the number of wavelengths actually deployed on the fibres. For wavelengths that have been deployed, we have also examined the capacity of the SDH systems that are deployed on the wavelengths, where applicable.

A similar approach was used for microwave systems, looking at bearer capacity deployed, additional bearer capacity that could be added and the use of SDH transmission systems. Our ability to provide this information in report form was largely dependent on the quality and depth of information provided by the carrier/operator community. Reporting of this information was also subject to confidentiality constraints.

The third tier of infrastructure includes the most problematic routes from a policy viewpoint, as these include the areas that have the perception (and in many cases the reality) they are missing out on the benefits of competition. These are also the routes that Telsyte/Gibson Quai had perceived were outside of our original scope.

All stakeholders were asked to provide detailed information on Tier 3 infrastructure. However, due to the fact that these routes have little or no competition, we also requested that Telstra provide information with respect to the average capacity for this type of route, the number of fibres in use, the capacity equipped on the fibres and the capacity utilised on this type of route. Similarly, we requested that Telstra provide details for any route where capacity problems are known to be an issue — in other words, we asked Telstra to identify specific areas (towns/routes) that deviated from the average deployment rules; e.g. to identify "cold spots."

Telstra maintains that all locations requiring capacity have their needs met. Additional capacity is driven by demand, as and when the capacity is required. Consequently, Telstra maintains there are no “cold spots”.

A further transmission layer not included in this analysis is the network of radio systems providing very thin routes to Digital Radio Concentration systems that serve remote communities. These routes were not considered to be within the scope of the trunk transmission capacity project.

3.5.1 Quality of Stakeholder Information

3.5.1.1 Quality of Carrier Information

Those carriers with whom we have held discussions, and who have responded in spreadsheet format, have provided reasonably detailed information with respect to the number of fibres, cables, muxes and so on.

Telstra did go to some lengths to give us comfort that there was no material impediment to the provision of additional transmission capacity to any locality that currently has transmission capacity — should the demand materialise.

Telstra also described its processes for managing a rolling program of network capacity increases. This program targets completion of upgrades prior to existing capacity being exhausted. Telstra has advised that this process includes monitoring at the local level of utilisation and forecasting of transmission capacity on a route-by-route basis. Prior to the projected exhaustion of that capacity, Telstra indicated it would normally program a suitable upgrade, considering the forecasted needs and all of the potential engineering solutions available, to affect a cost effective and timely outcome.

3.5.1.2 Quality of Non-Dedicated Operator Information

Many of the non-dedicated operators provided us with a broad overview of their infrastructure.

We found that it is difficult to line up this capacity with the dedicated telecommunications sector, as the non-dedicated operators mainly have metropolitan capacity within their service area, which is specifically designed for their own purposes.

Non-Dedicated Operator Networks:

These networks are not built to service the telecommunications market. While opportunities may arise to access these networks for telecommunications purposes, it is likely that additional build costs would apply. Hence this capacity is unlikely to have a significant bearing on the investment decisions taken by organizations looking to service the telecommunications carriage market.

However, the rights of way along rail/electricity lines could serve as the routes for additional infrastructure — and indeed many of the non-dedicated operator organizations are prepared to negotiate access along their rights of way.

Should an opportunity arise, organizations could effectively recover and reuse the optical fibre that is in place through the use of WDM — in effect, reusing existing fibre capacity. However, operators are unlikely to put in additional optic fibre cables to service these needs. The addition of transmission technology, such as WDM, is seen

as more cost effective than putting in new fibre. Hence it is unlikely that new fibre will be required for a very long time — irrespective of the fact that most of the fibre is SMOF rather than NZDF.

3.6 Secondary Research

In order to verify the information received and to fill in any gaps from industry stakeholders who have declined participation in the trunk transmission study (or have provided only partial information), Telsyte conducted an extensive secondary research activity that included:

- A literature search of industry publications, press releases, magazine articles, transmission operator web sites, carrier/industry presentations and other relevant materials.
- Utilisation of Telsyte's primary and secondary research databases covering the Australian telecommunications market.
- The consulting team's in-depth knowledge of Australian transmission networks — including a deep knowledge of the Telstra transmission network, its dimensions and its architecture.
- Discussions with selected individuals/organizations.

4 Market Structure

Telstra has a customer relationship with their direct PSTN and Mobile service retail customers and customers of Telstra telecommunications products such as data services. Telstra also has wholesale carriage agreements with other carriers. Taken together, we estimate these generate approximately 70% of the transmission volume required for Tier 1 and Tier 2 Australian routes. On Tier 3 routes, we estimate that Telstra accounts for well over 95% of this capacity.

Optus is the second most significant owner of Australian trunk transmission capacity. Optus' retail and wholesale customers generate significant amounts of traffic. This is bolstered by Optus' long-term agreements with AAPT and Primus for use of Optus inter-capital and regional bandwidth. Hence, we estimate that a further 20% of Australian Tier 1 and Tier 2 trunk transmission capacity is directed over the Optus' network.

Telstra and Optus are therefore in a position to direct approximately 90% of the aggregate transmission demand to their own infrastructure. Consequently, other suppliers of transmission capacity are left to contest a very small portion of the total transmission volume.

As the incremental cost of providing additional transmission capacity on an optical fibre cable route is relatively small, the new entrants are not in a position to challenge the unit costs of the major carriers. New entrants have new technologies such as NZDF optical fibre and DWDM systems that permit the derivation of enormous capacity and have a potentially much lower unit cost of deployed capacity. However, without comparable capacity sales, the costs per unit of capacity sold to customers remains high compared to what is achieved by the incumbent carriers.

Certain new entrants have invested in infrastructure in the hope that Telstra would take capacity on their network. If they had been successful in that strategy they would have been able to achieve the low unit costs described above. These companies would then have the potential to challenge Telstra's low unit costs, and be in a position to offer this advantage to others.

Telstra have demonstrated that they have the capacity to upgrade their own network, and that this would likely be cheaper in the long term than buying capacity from others. This strategy also has the added benefit that competitors do not have a source of transmission capacity at unit costs comparable to that of Telstra's.

A further consideration is that the advantages offered by the newer technologies (such as DWDM) that are suitable for servicing very large volumes of transmission capacity are only applicable to major routes. Other transmission routes have much smaller volume requirements. Consequently, much higher unit costs apply and fewer opportunities arise for rational investment in competitive transmission capacity.

4.1 Demographics

ABS data indicates that there are only 113 communities (including 6 metropolitan areas) in Australia with a population above 10,000.

Table 1. — Regional/Rural Demographics (Source: Calculations Based on ABS 2001 Census Data)

Regional	
Population	**Regional Towns Total**
10,000+	108
10,000 – 1,000	607
1,000 – 500	416
Below 500	582
Total	**1713**

Large metropolitan areas include a significant proportion of Australia's population and are serviced by approximately 1300 Telstra exchange locations. These exchange locations are normally well served by transmission capacity, but mainly by Telstra.

The demographics cited in Table 1 indicate that the market for transmission capacity is characterised by a relatively small number of locations that are reasonably large in size, and a significant majority are relatively small communities and rural areas distributed throughout regional Australia.

The practical reality is that the primary form of telecommunications service in the majority of the smaller locations is PSTN and Mobile voice services. PSTN and satellite services in these locations are currently the primary means of obtaining Internet access.

To date, demand for services in the smaller sites has not provided a suitable return on investment to warrant competitive infrastructure deployment. Key considerations include equipment costs and the potential upgrade of transmission capacity to these locations when services such as DSL are offered.

Telstra has been careful with its deployment of capital for the purpose of promoting the availability of ADSL capability having only equipped approximately 900 known exchange sites at the time of this study. These are mostly in metropolitan areas and the major regional cities — most of which have significant amounts of transmission capacity available. More recently, Telstra has installed ADSL capacity in smaller towns surrounding the major regional centres. According to Telstra's advice, this rollout pattern is driven by customer demand. However, Telstra did not disclose the thresholds employed to determine where and when ADSL infrastructure is deployed.

The following table was derived from Telstra data[2] listing exchange sites equipped to deliver ADSL services. As each ADSL equipment site is also an exchange site, comparisons can be made about ADSL coverage in metropolitan and regional exchange locations. Using this data, Table 2 was constructed to show the demographics of DSL-equipped exchange sites in regional locations.

[2] Based on data from the Telstra wholesale website, June 2003.

Table 2. — Telstra ADSL Exchange Sites

Type	Number of Exchanges Equipped for ADSL
Metro	458
Regional 1	267
Regional 2	176
Total	**901**

Other DSL service providers directly investing in their own DSLAM infrastructure have confined their activities to the inner metropolitan areas and rely on the resale of Telstra's ADSL infrastructure to achieve wider network coverage.

4.1.1 Capital Cities

The Capital cities that form the primary inter-capital transmission backbone in Australia include Brisbane, Sydney, Canberra, Melbourne, Adelaide and Perth. Other significant cities that complete the picture but are of less interest to the majority of transmission capacity suppliers are Darwin and Hobart. These metropolitan locations include the bulk of the Australian population, and are the primary target for most competitive telecommunications service providers.

These localities are also the major switching hubs in the Telstra network, forming the major aggregation point for all forms of telecommunications traffic within each state.

4.1.2 Metropolitan and Country Commercial/Regional Centres

Each Metropolitan area has (apart from the CBD) a number of commercial centres that form the major hubs of business and community activity. These commercial hubs have also historically been the appropriate location for Telstra's major switching nodes in these metropolitan regions.

Similarly, in regional country locations each state has major regional cities that form the commercial centres of country localities. Again, Telstra has historically deployed its major country switching nodes in these locations.

These major switching nodes also form the Point of Interconnect (POI) to Telstra's PSTN. Consequently these locations are the first choice for competitive carriers seeking to exploit an investment in telecommunications infrastructure. Consequently the majority of competitive capacity is focused on these locations.

4.1.3 Metropolitan and Country Satellite Communities/Towns

Smaller population centres that have some commercial characteristics, but are mainly urban in nature, surround both the metropolitan and regional commercial centres. Competitive carriers normally only deploy capacity in these locations in response to a specific customer order.

4.1.4 Remote Communities

Remote communities are normally only supplied by Telstra transmission capacity.

Some examples do exist where another carrier has provided capacity to these locations, but this is usually in response to a specific order from a large customer with premises in the remote location.

Satellite services, with Australia-wide reach, provide the only major exception to this general observation.

4.2 Target Markets for Competitive Carriers and Non-Dedicated Suppliers

As a consequence of the structure of Australian communities, the most attractive target markets are the larger population centres, as these offer the best prospects for attracting sufficient volume of business to make an investment worthwhile.

The second major driver for competitive carriers is to gain access to Telstra's PSTN via the Points of Interconnection (POIs).

Consequently, competitive carriers tend to be interested in further opportunities to exploit an investment in capacity to the POI.

Due to the small size of other localities (and the lack of need or ability to access the Telstra PSTN at the smaller localities), there is little incentive to invest in transmission capacity in these smaller population centres.

5 Technology Considerations

5.1 Optical Fibre

Optical fibre cable is the preferred form of transmission media for transmission capacity providers with very large capacity demands.

Two forms are now of interest to this study. The first is Single Mode Optical Fibre (SMOF), which has been the preferred type of optical fibre for an extensive period of time.

The second form is Non Zero Dispersion Fibre (NZDF), which is slightly more expensive but offers improved capacity characteristics when deployed in conjunction with higher capacity DWDM equipment. Hence, NZDF optical fibre cables are of particular interest for major routes.

5.1.1 Single Mode Optical Fibre (SMOF)

Telstra's network is almost exclusively made up of SMOF cable. The very high proportion of Telstra's Exchange Service Areas (particularly the most significant ones) are linked with optical fibre. Telstra's inter-capital routes also utilize SMOF, largely because these cables have been in place for a considerable time.

SMOF cable remains the preferred choice for shorter routes, where the advantages of the relatively more expensive NZDF optical fibre cables used in long haul and very high capacity situations is not warranted.

5.1.2 Non Zero Dispersion Fibre (NZDF)

Newer entrants, such as NextGen and IP1, have taken advantage of the improved characteristics of NZDF that can best be utilised when designing a new high capacity long haul route. However, we note with interest that the IP1 cable includes both NZDF and SMOF fibres. The capacity activated by IP1 to date is understood to be using the SMOF fibres. The NZDF fibres were reported to be included to "future proof" IP1's network capabilities.

5.2 Wave Division Multiplexing (WDM)/Dense Wave Division Multiplexing (DWDM)

To increase the capacity of an optical fibre cable, transmission capacity providers are now deploying Wave Division Multiplexing (WDM) equipment or the higher capacity Dense Wave Division Multiplexing (DWDM) equipment. This equipment allows multiple wavelengths to be deployed on a single optical fibre pair.

WDM/DWDM equipment is being deployed on inter-capital routes to service the very large capacity requirements of these routes.

A number of operators are also using WDM/DWDM technology on short haul routes to avoid the need to provide additional optical fibre cables. During this study we found that Telstra, as well as some rail operators, were using WDM/DWDM technology for this purpose. This practice is referred to as "harvesting the fibre."

Telstra is understood to be using WDM systems. In our opinion, this would be suitable for "harvesting" fibre on the many smaller regional routes. Also, having considered the needs on the major inter-capital routes, these systems would most likely comfortably meet current needs on these routes.

Other operators, such as Optus and NextGen, have deployed systems with the capability to support up to 80 wavelengths per fibre pair.

Equipment suppliers are indicating they have, or will shortly have, DWDM equipment with the capability to support up to 160 wavelengths per optical fibre pair. And, laboratory experiments have demonstrated equipment that supports up to 1000 wavelengths per optical fibre pair.

In our opinion, we see no reason why Telstra would not be able to deploy higher capacity systems as and when demand for additional capacity eventuates.

5.3 Synchronous Digital Hierarchy (SDH)

Synchronous Digital Hierarchy (SDH) is a form of transmission multiplexing that utilises a wavelength on either an optical fibre pair (or a wavelength provided by a DWDM system) and normally supplies an end transmission product for users. The preferred deployment for SDH systems is in the form of a ring of Add Drop Multiplexers (ADM) using optical fibre cables between multiple sites.

Lower capacity systems were historically deployed between approximately four sites. The capacity of a system is fixed and can be shared between all locations on the ring. Our own experience also leads us to believe that 2.5 Gbps systems are normally the preferred choice of multiplexer at this time, due to the price performance results arising from most network designs.

Each step of this multiplexing hierarchy brings a fourfold increase to the capacity of a ring.

In addition, the demand for optical fibre in existing cables is also alleviated.

Inter-capital SDH routes have normally been provided by way of specialised line transmission equipment optimised for high capacity long haul routes.

Optus has been deploying 10 Gbps systems; and NextGen and IP1 have done the same. While providing for high capacity, these systems and capacities are not suited to dropping off capacity at intermediate regional localities.

5.4 Plesiochronous Digital Hierarchy (PDH)

Today, carriers rarely install new Plesiochronous Digital Hierarchy (PDH) transmission systems, preferring to use SDH technology.

We found no evidence of PDH systems appearing as a relevant transmission capability by any carrier contacted for this study. Those PDH systems that are present have been in place for some time and may be regarded as legacy systems. Telstra is understood to have a considerable network of PDH capacity on microwave systems (in many cases overlapping the optical fibre capacity) that was installed before the deployment of its extensive optical fibre and SDH transmission network.

5.5 Microwave

Microwave systems are currently employed on major trunk routes by smaller (niche) carriers such FLOW Communications, ntlT, SPT and Telecasters.

In the case of a carrier such as Telecasters, which provides capacity to television transmission towers located on the tops of hills, microwave transmission is an ideal media.

Other carriers such as Datafast and OmniConnect utilise microwave technology in specific geographical locations, typically at 34 Mbps.

Vodafone, the other major user of microwave systems, utilises this technology to connect their base transceiver stations where other leased options are not available.

Non-dedicated operators, such as rail and power companies, also utilise microwave systems to service their internal needs.

Microwave systems usually have capacities that are multiples of 155 Mbps and for major routes are typically 5+1 (x155 Mbps) systems.

These systems may utilise either PDH or SDH transmission technologies, with SDH being more common today.

6 Carriers Network Architectures/Strategies

6.1 Telstra

Telstra's transmission network architecture is fundamentally grounded on the structure and location of Australian communities. Its purpose is to efficiently interconnect those communities.

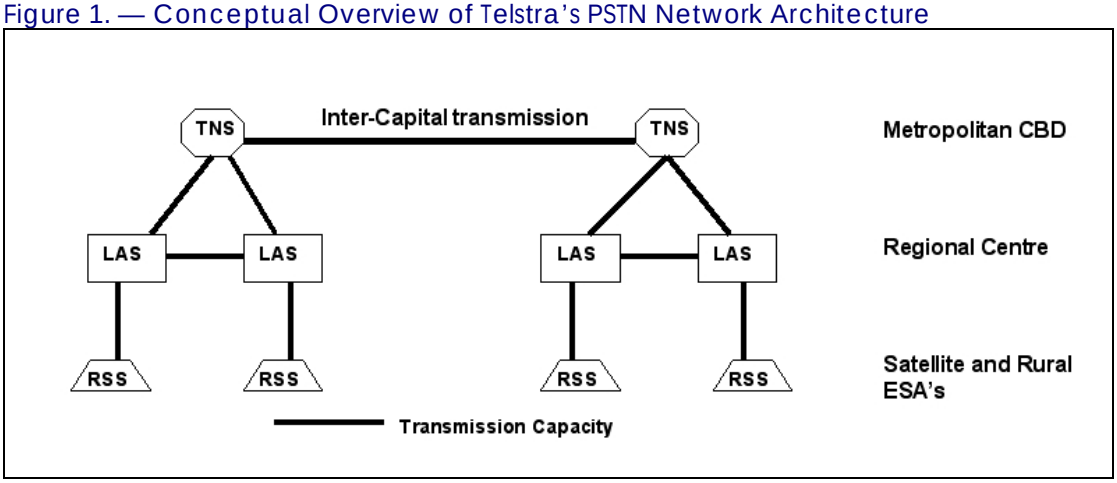
The network consists of high capacity inter-capital trunk routes between Transit Network Switches (TNS) located in each mainland capital city.

Additional transmission systems link the TNS locations to Local Access Switches (LAS) located in the major commercial centres of both metropolitan and country regions.

A third tier in the transmission architecture links the LAS locations to Remote Switching Stages (RSS) located in the smaller "satellite" towns that surround the regional centres.

This concept is illustrated in Figure 1.

Figure 1. — Conceptual Overview of Telstra's PSTN Network Architecture



The transmission capacity that serves the PSTN is depicted above, and also serves the demand for transmission capacity for other forms of telecommunications services such as mobile networks, the Internet, and dedicated transmission services. This is because it forms an efficient linkage of community centres that also reflect the communities' communication needs.

SDH multiplexers, deployed on optical fibre cables, are the primary form of transmission capability utilized by Telstra to link these centres. These optical fibre cables are normally laid along road easements between exchanges, also located along those roadways. In this way, a web of optical fibre cables linking towns is formed. Consequently, cable routes linking TNS and LAS sites also pass through the smaller towns that are RSS sites.

Inter-capital optical fibre cable routes are normally specifically designated and designed for that purpose in order to maximize the efficiency of those long haul routes.

These optical fibre cables are linked together to form a ring that has a diverse return path, which acts as a protective ring. The network designer has the option of deciding which towns, given their capacity requirements, should be included in a transmission ring. A ring will include links between a higher order switch and the lower order switch. It may also include the capacity between two higher order switches. Also, the network designer has the flexibility to vary the number of ADM sites included in the ring.

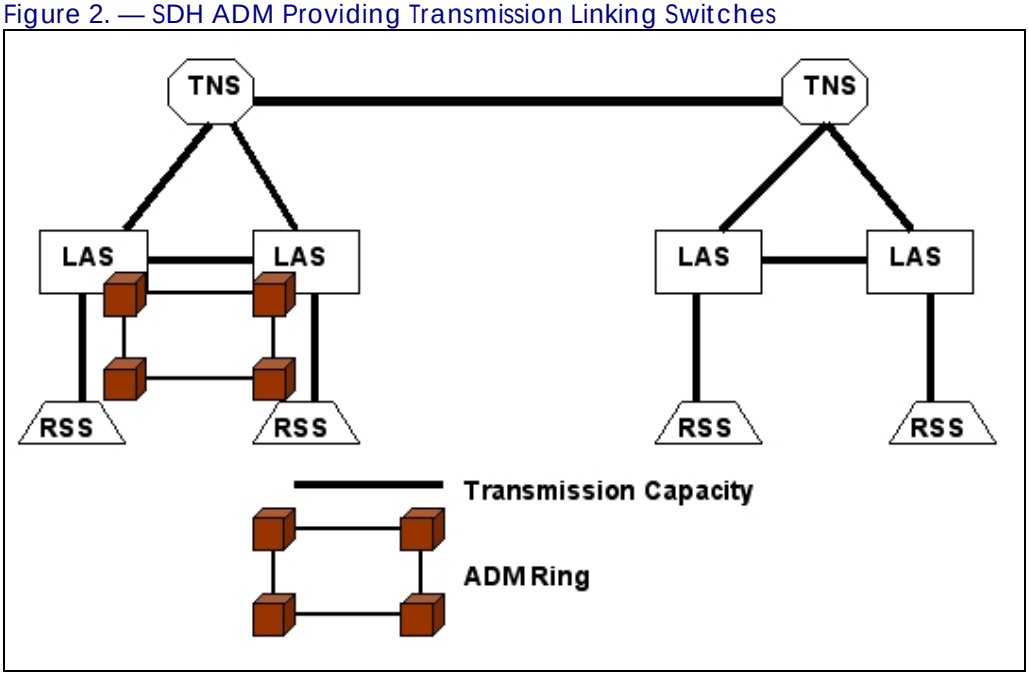
A further consideration is that any given optical fibre cable will usually have fibre pairs that make up several SDH rings serving widely different localities.

DWDM equipment is used on sections of optical fibre cables that have become congested — avoiding the need for additional investment in optical fibre cables.

Figure 2 indicates that the transmission capacity linking PSTN switching equipment is physically provided on an SDH ADM ring that passes between a number of other sites that are dispersed over a wide area. These rings also provide diverse return paths to cover disruption to a leg of the ring. In this case, the ring can provide capacity between LAS and RSS switching equipment and also LAS to LAS capacity. Each link actually takes up a portion of the fixed capacity at all locations around the ring.

Overlaid on top of this are Telstra's Mobile and Data networks.

Figure 2. — SDH ADM Providing Transmission Linking Switches

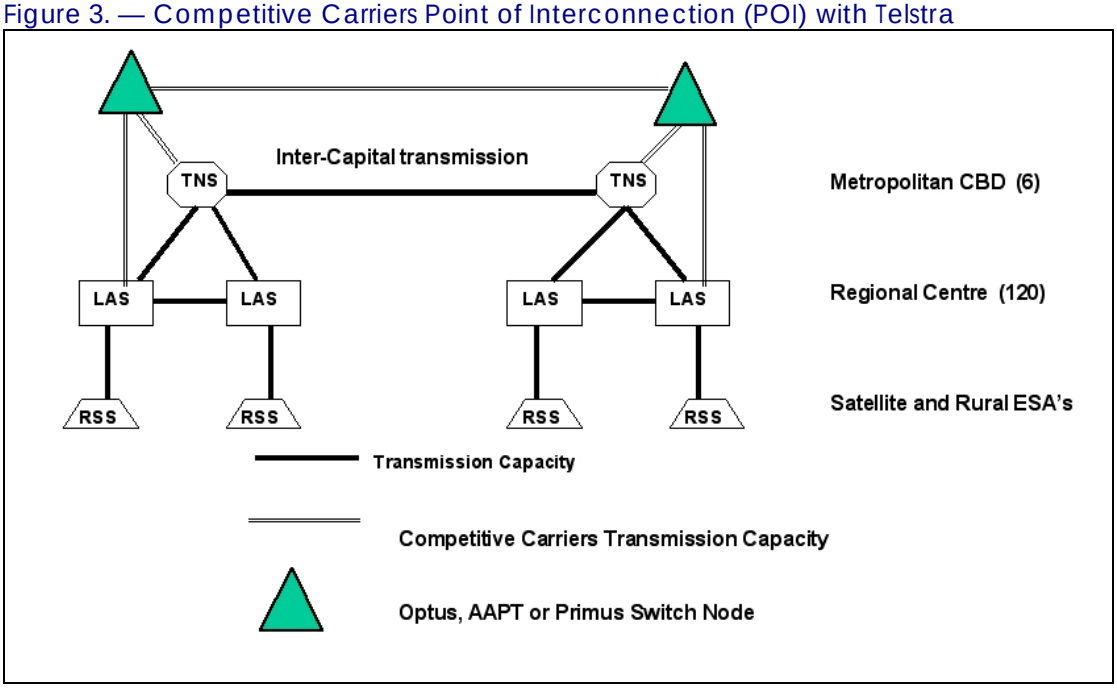


6.2 Optus

In some respects, the Optus SDH transmission network is similar to Telstra's in that it must serve transmission capacity requirements between the major population centres. It must also form a framework to provide interconnection to the Telstra POI's that are located at the LAS and TNS sites. Figure 3 provides an example of this structure.

From industry information, our understanding is that Optus has direct fibre connections to most, but not all, of Telstra's sixty-six (66) Points of Interconnection.

Figure 3. — Competitive Carriers Point of Interconnection (POI) with Telstra



Optus has concentrated its own direct investment in optical fibre cable between Brisbane, Sydney, Canberra and Melbourne by providing both inland and coastal routes between these destinations. The bulk of this capacity is designed as direct point-to-point transmission systems between the capital cities that are the location for Telstra's TNS, and also the major Optus switching nodes.

Some of Optus' capacity on inter-capital routes is set aside to form transmission capacity to LAS locations and other Points of Presence that Optus has selected. Both the inland and coastal optical fibre cables pass through the important regional centres in the vicinity of the route. A number of fibre pairs are set aside for ADMs located at these intermediate sites in order to form SDH rings with sufficient capacity to meet Optus' needs in these localities.

On other routes such as Perth to Adelaide, Optus has a single optical fibre cable and leases capacity from IP1 to form a diverse path. On the Brisbane to Cairns route,

Optus relies on the Reef network[3]. Optus is understood to rely on Telstra leases to access other locations.

Optus makes extensive use of DWDM equipment with a design capacity of 80 wavelengths. Each wavelength is capable of supporting 10 Gbps SDH equipment.

6.3 Competitive Transmission Suppliers — Optical Fibre

The other competitive transmission suppliers offering trunk transmission capacity based on their own optical fibre cables are PowerTel, IP1, NextGen Reef Networks and Uecomm. While AAPT has a significant transmission footprint, much of its trunk transmission capacity is leased from Optus.

6.3.1 AAPT

AAPT operates a high-bandwidth national transmission platform supported by a combination of AAPT and Optus fibre networks. This transmission platform provides high-speed links between Cairns, Brisbane, Sydney, Canberra, Melbourne, Adelaide and Perth, as well as many major regional centres.

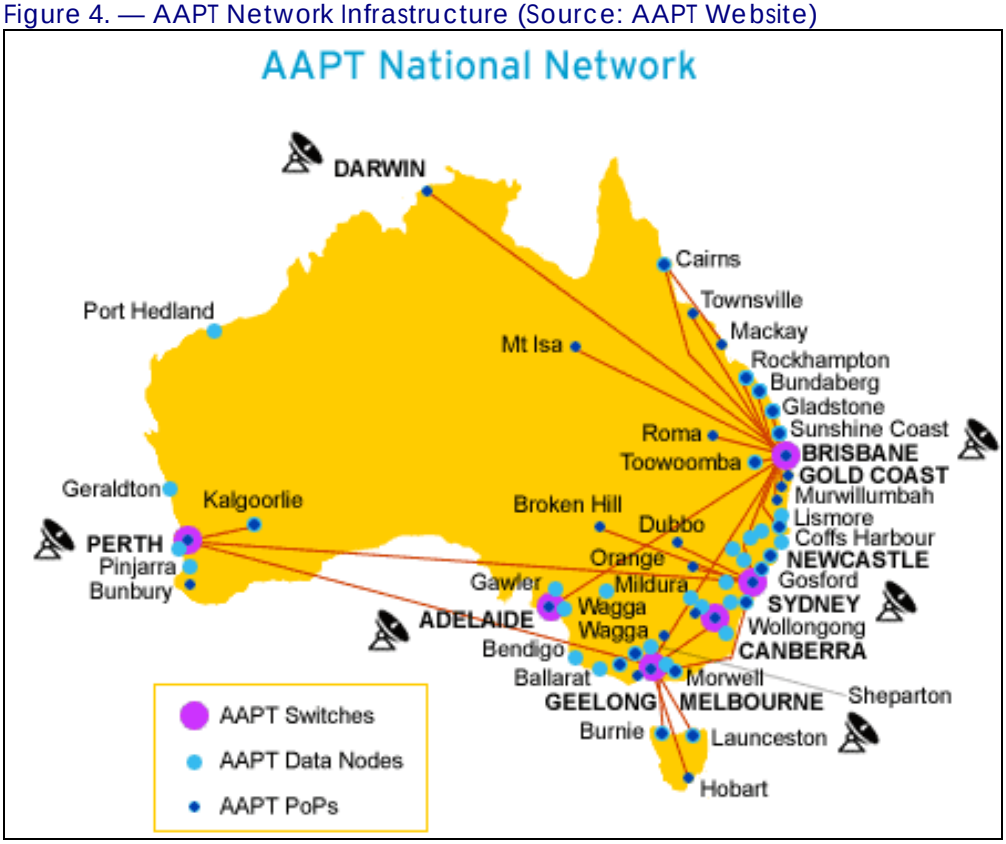
AAPT has leased capacity on Optus' national backbone linking Cairns, Brisbane, Sydney, Canberra, Melbourne, Adelaide and Perth. AAPT also uses a microwave link between Sydney, Canberra and Melbourne.

The majority of AAPT's trunk transmission investment is in the form of SDH multiplexers deployed on leased capacity.

However, AAPT has built a number of fibre SDH (Synchronous Digital Hierarchy) and microwave links to major regional centres.

[3] Visionstream Pty Ltd, a subsidiary of Leighton Group, operates Reef Network. Optus leases the entire capacity of the Reef Network and resells wholesale capacity to AAPT. (Reference: Customer Access Network Study, Queensland Government, Department of Innovation and Information Economy. Written by Gibson Quai Pty Ltd October 2001.)

Figure 4. — AAPT Network Infrastructure (Source: AAPT Website)



AAPT's voice and data network of switches and POPs are linked via broadband lines. AAPT's inter-capital links are supported by the AAPT/Optus fibre network, as well as leased microwave capacity between Sydney, Canberra and Melbourne. Extensive network infrastructure has also been installed throughout regional Victoria to support the Victorian Government and regional hospitals.

Where AAPT does not provide its own backbone infrastructure, capacity from Telstra is used to link AAPT's regional POPs.

AAPT's access network has been installed in all major capital cities and AAPT has installed over 800 kilometres of fibre optic cable in the CBD and metropolitan areas of Sydney, Melbourne, Brisbane, Adelaide, Perth, Canberra and selected major regional cities, providing connectivity between service platforms and customers, using technology such as fibre radio and DSL (Digital Subscriber Lines).

AAPT also extends its LMDS (Local Multipoint Distribution System) radio infrastructure to customers. LMDS is a high capacity point to multi-point technology where a number of customers are aggregated through an LMDS node via radio. LMDS is available in the CBD and broader metropolitan business areas of Sydney, Melbourne, Brisbane, Canberra, Perth, Adelaide, as well as Geelong, Bendigo and Shepparton in Victoria.

6.3.2 PowerTel

PowerTel has been operating for some time with a single optical fibre cable route (i.e. with no diverse path) between Brisbane and Sydney, and a further system between Sydney and Melbourne. PowerTel also has an optical fibre cable between Brisbane and the Gold Coast. This capacity appears to be adequate for PowerTel's needs at

this time. We are not aware of any plans to deploy additional capacity on these routes, and we have not found any evidence to the contrary during our survey and research. This is to be expected given PowerTel's market share.

PowerTel's network infrastructure links the eastern seaboard capital cities with over 2,400 kilometres of fibre. PowerTel's Pacific Innovation Corridor fibre links Brisbane to the Gold Coast. Services are also available in Toowoomba, Newcastle and Tamworth. CBD networks have also been built and completed in Sydney, Melbourne and Brisbane.

6.3.3 IP1 Australia

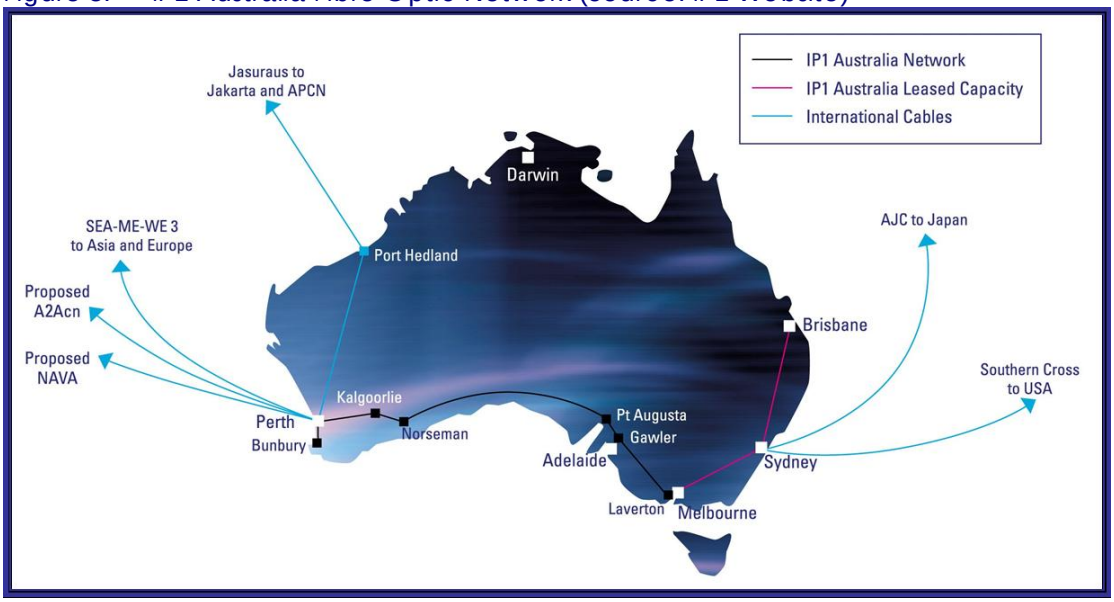
IP1 has constructed an optical fibre cable from Perth to Melbourne (via Adelaide) that has included in it both SMOF and NZDF optical fibre cores. The IP1 optical fibre cable has no diverse route.

The complete IP1 Australia cable runs on a physically diverse route to the existing Telstra and Optus cables connecting Perth to Melbourne. IP1's network stretches over 3800 kilometres between the east and western seaboards, through Bunbury, Perth, Norseman, Kalgoorlie, Port Augusta, Adelaide, Ballarat and Melbourne.

The IP1 Australia cable uses Marconi soliton-based UPLx160 equipment in what is believed to be the world's longest commercial deployment of an overland optical transmission network without signal regeneration. As currently deployed, the fibre optic network has a 10 Gbps capacity.

Although IP1 attracted customers such as AT&T, PowerTel, Panaseer, RSL COM, FLOW Communications, SingTel, CSIRO and Optus, the company went into receivership in May 2003.

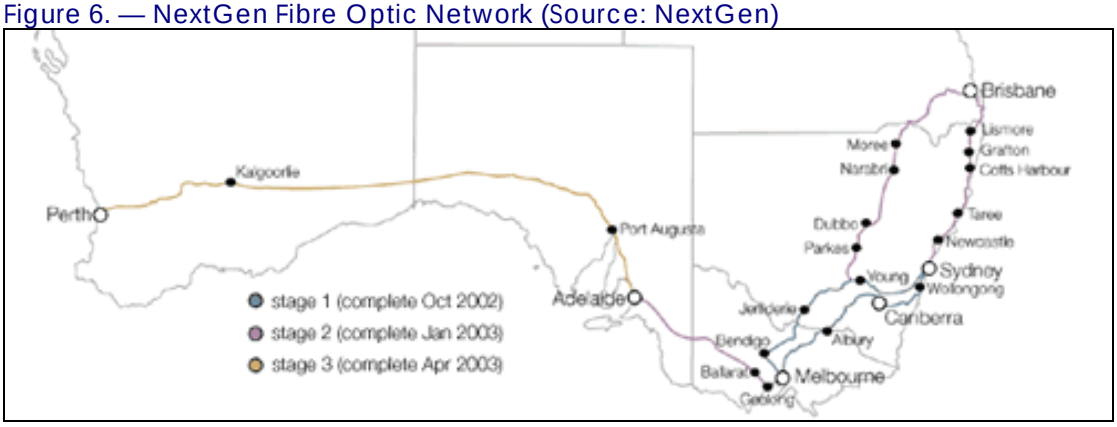
Figure 5. — IP1 Australia Fibre Optic Network (Source: IP1 Website)



6.3.4 NextGen Networks

NextGen has constructed an optical fibre cable system from Brisbane through Sydney, Canberra, Melbourne, Adelaide and Perth. The Brisbane, Sydney, Canberra, Melbourne sections have a diverse path, but the route between Melbourne and Perth does not.

Figure 6. — NextGen Fibre Optic Network (Source: NextGen)



Both IP1 and NextGen have deployed DWDM systems that have a design capacity of 80 wavelengths. The DWDM systems are currently only equipped to deliver a fraction of that capability, reflecting expected demand in the near future.

Both companies are able to add further DWDM capacity to their existing systems, as well as adding further DWDM systems to existing fibres. They can also add SDH multiplexers to the DWDM capacity.

6.3.5 Reef Network

The Reef Network delivers trunk transmission capacity along Queensland's coastal region via 1,820 kilometres of underground fibre optic cable stretching from Brisbane to Cairns along the rail corridor.

Figure 7. — Reef Network (Source: Reef Network Website)

The history of the Reef Network is interesting in that it has its origins in railway rights-of-way. In 1998, Queensland Rail issued a Request for Proposals (RFP) for the commercial development of their telecommunications assets. In 1999, the winning tenderer, Visionstream Pty Ltd, trading as Reef Network, was granted exclusive rights to develop fibre optic broadband infrastructure on Queensland Rail's right-of-way from Brisbane to Cairns.

In late 1999, agreements were reached between the Queensland Government, Optus and Reef Networks, for Optus to use the new broadband cable to deliver telephony, data and Internet services to coastal Queensland.

Optus leases the entire capacity of the Reef Network and also resells wholesale capacity to AAPT. By passing through a number of regional centres, the Reef Network fibre optic link added nine Points of Interconnection (POIs) to the Optus network

including Wurtulla, Maroochydore, Maryborough, Bundaberg, Gladstone, Rockhampton, Mackay, Townsville and Cairns.

6.3.6 Uecomm

Uecomm's optical fibre network is mainly concentrated in the greater metropolitan areas of Melbourne, Sydney, Brisbane, Adelaide, Perth and the Gold Coast. The company has more than 650 buildings directly connected to the network.

In terms of trunk transmission capacity, Uecomm has a fibre optic link between Brisbane and the Gold Coast. Additional trunk transmission requirements are serviced via wholesale arrangements with other carriers.

6.4 Competitive Transmission Suppliers — Microwave

The competitive transmission suppliers that rely on Microwave networks include Datafast, FLOW Communications, ntl Telecommunications (ntlT), OmniConnect, Soul Pattinson Telecommunications (SPT) and Telecasters and Vodafone. Some carriers declined to provide us with any information about their network, and in other cases information provided by operators was in the form of a network overview, rather than the detailed information requested for the study. Consequently, we have relied on a combination of operator information, our own knowledge of these networks, and publicly available information for the purposes of this report.

Each of these operators concentrate their activities in the more densely populated eastern states having networks that traverse south east Queensland through the eastern portion of New South Wales and Victoria.

Prior to the widespread use of optical fibre, microwave was a preferred technology for trunk transmission. Its characteristics result in it being cost effective for transporting capacities in the region of small multiples of 155 Mbps (STM-1). These multiples are typically 5 to 7 x 155 Mbps.

Optical fibre becomes more cost effective when used to transport much larger capacities, offsetting the relatively higher establishment cost of optical fibre cables.

Consequently, microwave is a useful technology for a company seeking to enter the market with more limited expectations of the transmission capacity it may be able to attract to its network.

A further consideration for microwave is that it is an efficient means of providing capacity to hill tops, as it normally efficient for a long haul route to make use of high ground. Line of sight is normally required from these points to drop off capacity into a nearby town. For this reason, it is a technology favoured by broadcasters transporting TV signals to transmission towers.

For these reasons, and also based on our market knowledge, we estimate that the above mentioned operators are capable of delivering reasonable amounts of capacity to towns in the vicinity of their routes. However they would not have, nor are they likely to need, the very much larger capacities that optical fibre networks are capable of delivering.

In our opinion it is likely that the strategy of these operators would be to capture market share in the regions covered, and use the resulting cash flows to invest in optical fibre cables only when such an investment was warranted.

It is possible that there is a high degree of cooperation between organizations such as ntlT, SPT and Telecasters in terms of sharing capacity on each other's networks. We note the similarities between microwave transmission network diagrams, which points to the possibility that operators may be sharing a single amount of capacity to a significant number of the sites, which each claims (possibly for marketing reasons) to cover. This will have the effect that less aggregate capacity may actually be available at each site.

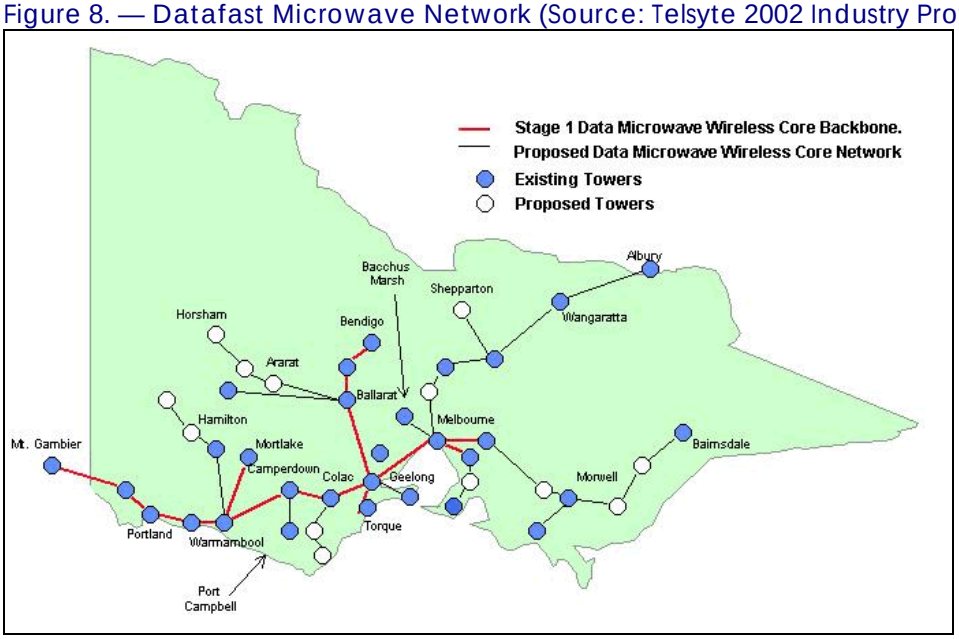
The following sub-sections provide additional detail on microwave network infrastructure. Organizations are listed in alphabetical order.

6.4.1 Datafast

In February 2003, Vertel (Vertical Telecoms Pty Ltd) completed its purchase of Datafast's radio assets. Our understanding is that this did not include Datafast's data (microwave) network. As a result of the recent ownership and personnel changes, detailed information on Datafast's microwave assets was difficult to obtain.

Our understanding is that the Datafast 34 Mbps microwave backbone runs from Melbourne to Geelong, Colac, Warrnambool, Camperdown, Portland, Mt Gambier and Ballarat. The map depicted below was provided to Telsyte as part of our ongoing *Industry Profile* research series. While many additional sites were planned, our expectation is that the actual rollout was limited to Stage 1 sites.

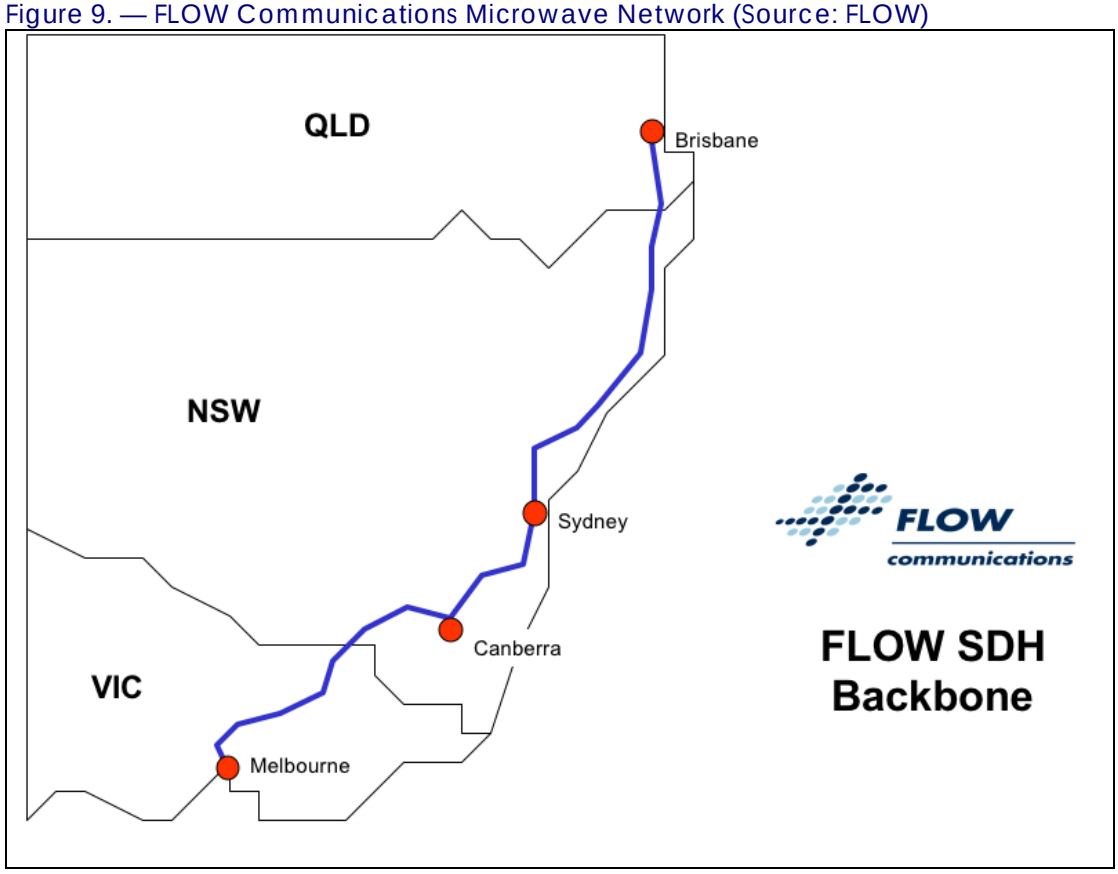
Figure 8. — Datafast Microwave Network (Source: Telsyte 2002 Industry Profile)



6.4.2 FLOW Communications

FLOW Communications' SDH microwave backbone stretches from Brisbane-Sydney–Canberra-Melbourne and includes regions.

Figure 9. — FLOW Communications Microwave Network (Source: FLOW)



6.4.3 ntl Telecommunications (ntlT)

NtlT provided information to Telsyte for our *Industry Profile* research series. ntlT's network covers the East Coast of Australia — stretching 4,000 kilometres from Cairns to Melbourne and extends to regional areas such as Orange, Tamworth, Dubbo and Dandenong. The majority of sites are located in regional and rural Australia.

Their network covers 561 strategic antenna sites across metropolitan, regional and rural Australia and their core business is transmitting the television and radio broadcasts of the ABC and SBS to over 98% of households. The network is an important resource for the company's other customers including commercial television and radio broadcasters, community broadcasters, telecommunications operators and the emergency services who share the facilities on ntlT sites.

SDH transmission is utilised across the network.

ntlT has a relationship with Soul Pattinson Telecommunications (SPT) to offer retail services. This joint venture is called SPT-T (for SPT Telecommunications). This group is a separate entity to ntlT Australia (NTLA). ntlT remains focused on the broadcast market.

Figure 10. — ntlT Transmission Network (Source: Telsyte Industry Profile)

6.4.4 OmniConnect

OmniConnect has limited microwave infrastructure in Victoria.

Publicly available information indicates that OmniConnect's rural developments include Ballarat, Bendigo, Shepparton, Swan Hill, Kerang, Horsham, Ararat, Stawell and surrounding areas. The company claims to be continuing their VPN and POP rollout through Gippsland, including Churchill, Sale and Moe districts. Extensive Mornington Peninsula coverage is currently in the short-term rollout phase.

6.4.5 Soul Pattinson Telecommunications (SPT)

SPT Telecommunications is a joint venture company between Soul Pattinson's telecommunications arm and network infrastructure provider ntl Telecommunications. The combined microwave network ranges from Melbourne to Cairns with over 120 Points of Interconnect (POIs) along the Eastern seaboard. The network covers Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Toowoomba, Stanthorpe, Sunshine Coast, Brisbane, Lismore, Gold Coast, Coffs Harbour, Port Macquarie, Armidale, Tamworth, Newcastle, NSW Central Coast, Sydney, Wollongong, Canberra, Dubbo, Orange, Wagga Wagga, Albury, Shepparton, Bendigo, Mt. Dandenong, Melbourne, Geelong, Ballarat, Mildura and others.

Soul Pattinson has a joint venture with ntlT.

Our understanding is that SPT's direct microwave assets are mainly focussed along the Sydney-Newcastle-Brisbane route, with coverage in many regional NSW towns.

6.4.6 Telecasters Communications

Telecasters' microwave SDH network spans from Cairns to Brisbane.

The network backbone follows the Queensland coast adjacent to all major coastal population centres. Access to these towns and cities from the backbone is via readily deployed PDH or SDH spur microwave links.

ATM switches and ADM equipment at microwave terminals adjacent to major population centres provide backbone access. The SDH microwave radio network utilises third party sites. ATM and SDH services are supported through distributed POPs at all major regional centres.

6.4.7 Vodafone

Transmission links between Vodafone mobile base stations (BTS) and switches (BSCs) are a combination of leased capacity and Vodafone owned connections links. Vodafone also has fibre rings in capital cities, which serve to aggregate capacity from their base stations into major mobile switching centres. Vodafone's capacity is dimensioned solely for the operation of their mobile network.

Detailed information on Vodafone's (primarily microwave) infrastructure/capacity was provided to Telsyte on a confidential basis, and was utilised in our calculations.

6.5 Non-Dedicated Transmission Suppliers

Most companies that we identified as non-dedicated transmission suppliers have transmission capabilities designed for their own purpose, and focus on the needs of their own businesses. However, most of these operators are prepared to listen to proposals from external organizations seeking to exploit the capacity for the purpose of servicing the telecommunications services market.

Rail operators such as VicTrack (Victoria) and NSW State Rail have extensive networks of optical fibre cables on which they link to railway stations and train depots. These operators are normally amenable to proposals to sell access to capacity to carriers that may wish to include the rail network infrastructure in their network designs. However, each of them has reported that the cost of providing access from the

locations in which the capacity is available has, in most cases, made interconnection unattractive.

A number of other non-dedicated operators have taken decisions to launch into the telecommunications services market. Uecomm, with an extensive optical fibre network in the metropolitan area of a number of capital cities, and Powercor that has a regional optical fibre network covering parts of western Victoria are examples of this type of venture.

ETSA Utilities, owner of a high-capacity fibre optic network in South Australia, also fits this profile. Similarly, Energy Australia, CitiPower, and Energex (the Downtown Utilities consortia) through their investment in PowerTel, has also sought to leverage their transmission infrastructure and rights of way, in the telecommunications market.

Each of these companies has a different approach and normally covers limited geographic areas. Consequently, the approach to the market is fragmented and largely opportunistic.

We also note that many other electricity organizations have metropolitan based infrastructure that is used for telecommunications, but did not fit the profile of the trunk transmission capacity study.

6.5.1 Electricity/Utility Companies

6.5.1.1 Australian Gas Light Company (AGL)

Australian Gas Light Company leases transmission infrastructure from Telstra for its SCADA networks, and hence did not qualify for this study.

6.5.1.2 Basslink (TAS)

The planned Basslink interconnector will run from Loy Yang in Gippsland, Victoria across Bass Strait to Bell Bay in northern Tasmania. When implemented, the undersea cable component will span 295 kilometres. Basslink is a major energy initiative that will enable electricity trading between Tasmania and the mainland, and allow Tasmania to enter the National Electricity Market (NEM, Australia's competitive wholesale market for electricity). Basslink is still under construction and National Grid Transco the builder, owner and operator of Basslink Pty Limited does not anticipate making dark fibre available to the market until mid to late 2005.

We understand that the Basslink cable is planned to include 12 fibre pairs, four of which are needed for telemetry, leaving up to 8 pairs available for transmission purposes.

6.5.1.3 Country Energy (NSW)

Country Energy reported that its trunk infrastructure is minimal (microwave in the central west district of NSW) and is all fully utilised for internal communications.

6.5.1.4 ElectraNet (SA)

ElectraNet is a specialist in the transmission of electricity over long distances and to remote areas. Operating in a unique geographic location with a widely dispersed population, ElectraNet provides transmission services to customers in South Australia.

ElectraNet's microwave transmission system comprises a network of almost 6,000 circuit kilometres of transmission lines and 71 substations/switchyards, and is complemented by state-of-the-art monitoring, controlling and switching operations. It is linked to the eastern States' electricity network via a 500MW transmission interconnection with Victoria.

ElectraNet's business is dedicated to supplying competitive electricity transmission services and provides transmission capacity for its own use for the management of its power transmission network.

6.5.1.5 EnergyAustralia (NSW)

EnergyAustralia's primary interest in the telecommunications market is via the company's 24.5% ownership in PowerTel.

EnergyAustralia is not in the market of providing telecommunications capacity, and has only provisioned the capacity necessary to meet their own requirements. They have identified no spare telecommunications capacity that fits the scope of this study.

6.5.1.6 Epic Energy (WA)

Epic Energy has a 4,112-kilometre gas pipeline covering: Dampier-Bunbury (WA), Dampier-Port Headland (WA), the Southwest Queensland Pipeline (QLD), the Moomba-Adelaide Pipeline (SA) and the Katnook-Mt Gambier pipeline (SA).

It is unclear as to whether Epic Energy's gas pipeline also includes transmission capabilities.

6.5.1.7 Ergon Energy (QLD)

Ergon Energy's footprint covers regional communities, rather than trunk transmission capacity. Ergon Energy uses Powerlink fibre to connect Cairns, Townsville, Mackay, Bundaberg, Gladstone, Rockhampton, Maryborough, Toowoomba and Dalby.

6.5.1.8 ETSA Utilities (SA)

ETSA Utilities is the owner of a high-capacity fibre optic network in South Australia. Their fibre optic network is spreading through the Adelaide metro area and the state. However, ETSA's network is almost solely metropolitan based. ETSA has minimal intra-regional and no interstate services.

6.5.1.9 Hydro Tasmania (TAS)

information about Hydro Tasmania's trunk transmission capabilities is not available. However, we understand that Hydro Tasmania is replacing equipment at 16 sites with

SDH microwave links. The three-stage project is due for completion in mid 2007, with stage one to be commissioned by August 2003.

6.5.1.10 Integral Energy (NSW)

Integral Energy is the second largest state-owned energy corporation in NSW. As a NSW State Owned Corporation established to supply electricity to Western Sydney and the Illawarra, Integral's major exposure is to the NSW market. However, Integral is also active in the Victorian and ACT markets. Integral Energy's network franchise spans 24,500 square kilometres in Greater Western Sydney, the Illawarra, and the Southern Highlands. The network is made up of 25,000 transmission, zone and distribution substations, 370,000 power poles and 150,000 streetlights bound together by 33,000 kilometres of underground and overground cable.

The extent (if any) of Integral Energy's transmission capacity that is suitable for telecommunications is unknown. However, given the practices in the power industry, Integral Energy is likely to have telecommunications capacity for management of SCADA systems.

6.5.1.11 Origin Energy (VIC)

Origin Energy is in the business of providing natural gas and electricity services, mainly in Victoria, but also on a retail basis in NSW. Origin has a small amount of fibre in the Adelaide CBD and also at its Brompton depot. However, they started as a gas company in the days when gas companies were not permitted to have a distribution network. Therefore, they do not have a backbone transmission infrastructure.

6.5.1.12 Power and Water (NT)

Power and Water (NT) has a Darwin metropolitan network that they lease to Optus. Their large networks are in the immediate vicinity of Darwin and would cover the rural area within a 50-kilometre radius of Darwin. They have a microwave radio link from Darwin to the Katherine region. However, the company was not able to provide additional information about this link within the timeframe of the study. It is unknown as to whether this capacity is available for telecommunications purposes.

6.5.1.13 Powercor (VIC)

Powercor's fibre network connects Melbourne to the regional centres of Geelong, Ballarat and Bendigo. The network also includes access loops in each regional centre. In addition to its electricity business, Powercor also provides telecommunications services. The extent of Powercor's telecommunications transmission capacity is unknown.

6.5.1.14 Powerlink (QLD)

Powerlink Queensland is a government-owned corporation that owns, develops, operates and maintains high-voltage electricity transmission networks. Powerlink's network extends 1,700 kilometres from north of Cairns to the New South Wales border.

Powerlink's telecommunications network was deployed to protect and control the high voltage power transmission network of lines and substations. Powerlink is also constructing a network between Brisbane, Rockhampton and Townsville to provide

services to universities in Queensland through agreements with AARNet and to other potential bulk users of telecommunications capacity.

All optical fibre cables are Optical Fibre Ground Wire (OPGW) and generally carry fibres in the cable sheath. The number in use by Powerlink is generally for SDH transmission. The remaining unused fibres are reserved for the future implementation of high-speed transmission line protection and substation control systems. There are generally spare fibres.

All sites serviced by the Powerlink network are either substations or corporate offices within the electricity industry.

Powerlink makes very limited use of SDH and has not deployed WDM systems. Powerlink's network capacity is designed to meet requirements of the operational network and is expanded as required.

6.5.1.15 Snowy Hydro (NSW)

Snowy Hydro Limited operates an extensive private communications network (under the electricity business exemption provisions in the Telecommunications Act) over the geographic region roughly between Cooma, Khancoban and Blowering, south of Tumut. This network spans approximately 90 kilometres in the east-west direction and 120 kilometres in the north-south direction. Its purpose is to support the operation of eight (8) power/pumping stations and associated hydraulic structures and other assets which are all located outside of regional towns, predominantly in the Kosciusko National Park, with the exception of the Cooma Office located on the northern side of Cooma.

The network is primarily radio-based due to environmental and economic issues. There are approximately 40 radio links, 3 SDH radio links, and plans for another 5 SDH radio links. Snowy Hydro has approximately 30 optical fibre cable links that are mostly short (all are less than 15 kilometres, most less than 5 kilometres. as Snowy Hydro embarks on building an SDH ring between its critical sites).

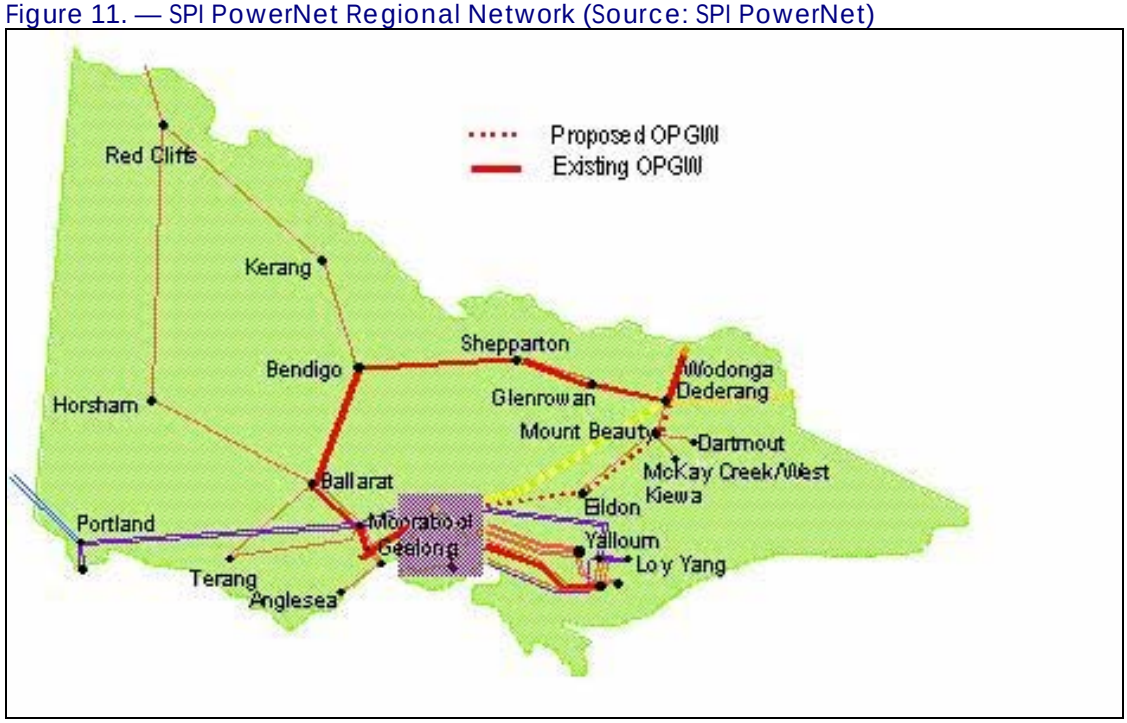
Currently the network topology is a star. based on PDH technology. Snowy Hydro is working towards creating an SDH ring (or rather ring plus sub rings locally), with a mass of PDH minor spur links joining and exiting the ring along the way.

The Snowy Hydro network is justified and dimensioned on the basis of Snowy Hydro's own requirements. The sites at which capacity is delivered are outside of community centres and the transmission links formed do not readily lend themselves for purposes other than Snowy Hydro's. Consequently this network is unlikely to have a material role in making broadband capacity available to community localities.

6.5.1.16 SPI PowerNet (VIC)

SPI PowerNet is the high voltage transmission network infrastructure provider in the state of Victoria. In the course of the company's business they own operate and maintain a substantial telecommunications network, which includes over 700 kilometres of installed fibre optic cable within Victoria, with more currently in planning.

Figure 11. — SPI PowerNet Regional Network (Source: SPI PowerNet)



SPI PowerNet has installed fibre optic capacity that is available for the establishment of a commercial broadband backhaul network.

SPI PowerNet's network is constructed using a combination of:

- All Dielectric Self Supporting Cable (ADSS);
- Under Ground Fibre Optic Cable; and
- Optical Fibre Ground Wire (OPGW).

SPI PowerNet's fibre optic cables conform to the ITU-T G.652 specification and are suitable for most broadband applications including Dense Wave Division Multiplexing.

In addition to SPI PowerNet's metropolitan fibre optic ring, SPI PowerNet has an inter-regional network passing through a large number of regional provincial cities including; Geelong, Ballarat, Bendigo and Shepparton.

SPI PowerNet also has arrangements with its fellow interstate transmission companies, with the express intent of providing backhaul to Sydney or Brisbane (subject to agreed commercial terms).

SPI can provide fibre optic pairs for commercial operation, timing for the availability of pairs will be dependant on the fibre count required.

6.5.1.17 TransGrid (NSW)

Electricity carrier, TransGrid, a NSW State-owned electricity corporation, has an extensive fibre optic network throughout NSW, with links to Victoria and Queensland. The primary use of its fibre optic network is to provide internal "protection and control" for its power network, using fibre optic cables to send switching information

between exchanges. TransGrid's Fujitsu-based SDH transmission equipment is said to carry control circuits for the electricity network, as well as data and voice services (mainly for TransGrid's own use).

In 2001, TransGrid began rolling out approximately 1300 kilometres of state-wide fibre optic cabling alongside the stations that carry its electricity wires. The implementation was sparked by the re-allocation of the 1.92 GHz spectrum, the frequency band the carrier communicated on. Prior to mid-2001, microwave point-to-point services shared this frequency. However, 1.92 GHz spectrum is now used purely for cordless telecommunications services.

TransGrid's NSW power network consists of over 12,000 kilometres of transmission lines, 81 major substations and power station switchyards, 83 microwave radio sites and 495 power line carrier links. Its interconnections with Victorian and Queensland networks make the TransGrid high-voltage (HV) transmission system an important component of one of the largest HV AC grid networks in the world.

Excess capacity on TransGrid fibres will reportedly be available to private telecommunications companies on a commercial basis, to provide increased bandwidth and more competitive services, especially to regional NSW.

Additional information in support of the trunk transmission capacity study was provided to Telsyte on a confidential basis and has been utilized in our calculations.

6.5.1.18 United Energy (VIC)

United Energy utilises Uecomm transmission for fibre links. United Energy does have other links, but they are copper supervisory cables for SCADA systems. They are also using SPI PowerNet for additional capacity. As such, United Energy did not qualify for the scope of the trunk transmission capacity study.

6.5.1.19 Western Power (WA)

Western Power's electricity network contains over 6,750 kilometres of transmission lines and cables; and 83,000 kilometres of overhead and underground transmission networks. The network covers vast areas in the southwest and northwest of WA. However, the extent of Western Power's telecommunications transmission capacity is unknown.

6.5.2 Rail Corporations

6.5.2.1 NSW State Rail

NSW State Rail has an extensive network of optical fibre linking all of its Sydney metropolitan railway stations and train depots. This is largely a legacy of the Olympic games. Each rail station is equipped with capacity for its security video cameras that are linked to its control centre.

In our discussion with NSW State Rail, their representative stated it was open to offers for access to its optical fibre capacity.

6.5.2.2 Queensland Rail

Queensland Rail has an extensive network of optical fibre linking Brisbane, Rockhampton, Mackay, Bowen, Emerald, Coppabella and Helidon. Our understanding is that this fibre capacity is only utilised for internal Queensland Rail purposes.

It is also worth noting that Reef Network was granted exclusive rights to develop fibre optic broadband infrastructure on Queensland Rail's right-of-way from Brisbane to Cairns. Additional information on Reef Network's infrastructure is contained in Section 6.3.5

6.5.2.3 VicTrack

VicTrack has an extensive optical fibre network between Melbourne Metropolitan railway stations and rail depots for its own purposes. VicTrack is also prepared to consider commercial arrangements for access to its optical fibre.

6.5.3 Television Transmission Infrastructure

6.5.3.1 ntl Telecommunications (ntlT)

As described in Section 6.4.3, ntlT's core business is transmitting the television and radio broadcasts of the ABC and SBS. The network is also utilised by other customers including commercial television and radio broadcasters, community broadcasters, telecommunications operators and the emergency services who share the facilities on ntlT sites.

ntlT also has a commercial relationship (joint venture) with Soul Pattinson for the provision of wholesale capacity used by SPT's retail customers.

6.5.3.2 Telecasters

Telecasters' capacity was built for the purpose of servicing its television business. This means that in the first instance they provide for their own capacity needs, but may consider deals for the provision of additional capacity if a customer's needs fit Telecasters network. The Points of Presence at which Telecasters has capacity are normally on the high points of any locality, which means that this capacity is typically not readily available to residential and or business premises.

Potential customers are most likely to be other carriers. However, the capital investment required to deliver capacity to communities is a significant barrier to exploiting Telecasters transmission capacity for the purposes of delivering broadband services to another carrier or a large customer.

Additional detail is available in Section 6.4.6.

6.6 Capacity Swaps/Diversity

A number of transmission infrastructure providers have provisioned only one optical fibre cable on some routes, whereas two are normally required to provide a diverse path for reliability purposes. In these circumstances a carrier may purchase additional

capacity on another transmission infrastructure provider's network in order to form the required diverse path.

For example, Optus has a single optical fibre cable between Adelaide and Perth, and purchases wavelengths from IP1 to form a diverse path. Other carriers such as AAPT have similar arrangements. Notably, Optus has long-term agreements with AAPT and Primus for use of Optus inter-capital and regional bandwidth.

Consequently, examination of these operators' networks requires consideration of the fact that the SDH or DWDM technology may utilize optical fibre from one or more third-party companies. Also, the transport media used by an SDH system may be via direct access to optical fibre on one path and a wavelength over a DWDM system on another path. Furthermore, either or both of these systems may be leased from another company.

7 Supply of Transmission on Inter-Capital Networks

Telstra and Optus have well-established optical fibre routes between the major capital cities and continue to upgrade capacity to meet their own requirements. Telsyte is aware that Optus has capacity agreements with the next two largest carriers — AAPT and Primus.

This has the effect that the capacity requirements of four of the largest carriers are directed to the optical fibre networks of the two largest transmission carriers. This gives Optus and Telstra a significant advantage in terms of unit costs over other suppliers of broadband wholesale transmission capacity.

Both Telstra and Optus are in a position to augment their networks for the purpose of meeting the capacity needs of their customers. Consequently utilisation on these networks can be expected to be relatively high (typically in the order of 50-75%.)

Both Optus and Telstra are deploying DWDM systems and are upgrading 2.5 Gbps multiplexers to 10 Gbps multiplexers to meet growing demand for bandwidth without having to resort to building further optical fibre infrastructure. Capacity upgrades to meet the growing demand are a relatively simple matter, and should not face serious impediments from capital constraint perspective in an environment where growth in demand has a high measure of certainty.

The other significant suppliers of capacity on inter-capital routes such as PowerTel, NextGen and IP1 are more speculative and are faced with a situation where they have a quite small market share, and therefore transmission volumes, but have access to technology with very significant potential for low unit costs.

Full deployment of that potential capacity requires substantial capital investment that is not supported by the transmission volumes generated by their market share. The capability of optical fibre technology significantly exceeds current needs on the largest routes.

With such a small market share, compared to that enjoyed by Optus and Telstra, these new carriers struggle to be able to achieve competitive unit costs. Trunk transmission between major capital cities comprise the only transmission routes that have the potential to generate the transmission volumes that would offer a reasonable commercial return for this technology.

Intermediate locations that the optical fibre routes pass through are not equipped in a manner that allows the capacity of the optical fibre along these routes to be made available to these communities. Deployment of capital to make the capacity available to the smaller communities requires a satisfactory business case — one that involves consideration of significant capital expenditure that is not normally justified by the size of the intermediate communities.

These considerations are a significant barrier to the delivery of technology benefits (in the form of high-bandwidth transmission carrying capacity) to smaller communities along these routes. On the other hand, it could be argued that as the small communities do not require such large capacities, the benefits are not relevant to the needs of these communities.

The following table contains our findings about the extent of capacity currently available on optical fibre cables along inter-capital routes. No carrier gave indications of their forward plans. However each indicated it would meet demand as and when it eventuated. Each carrier has, as an integral part of their core business, a rolling construction program that continuously monitors capacity requirements and upgrades capacity with a sufficient lead-time to cover growth in demand.

Table 3. — Current Capacity on Inter-Capital Optical Fibre Routes

Route	Estimated Number of Fibre Cables	Estimated Number of Fibres	Estimated Fibres in Use	Estimated DWDM Deployed On Fibre Pairs	Estimated Number of Wavelengths DWDM Equipment	Estimated Wavelengths Currently In Use	Estimated Number of SDH Mux's Deployed	Estimated Capacity Available (Gbps)	Estimated Capacity In Use (Gbps)	Estimated Capacity Spare (Gbps)
Sydney-Brisbane	7	180	70	7	384	18	35	91	58	25
Sydney-Melbourne	9	270	148	9	352	40	59	205	140	47
Sydney-Canberra	3	96	44	3	176	14	12	49	30	8
Melbourne-Canberra	2	72	42	2	96	11	12	36	21	9
Melbourne-Adelaide	6	144	56	6	304	24	34	310	194	17
Adelaide-Perth	5	124	56	5	224	28	33	170	67	14
Perth-Darwin	1	24	18	1	80	3	3	8	6	2
Adelaide-Darwin	1	24	18	1	80	3	3	8	6	2
Brisbane-Darwin	1	24	18	1	80	3	3	8	6	2
Victoria-Tasmania	4	78	20	1	16	6	4	17	1	0
Grand Total Inter-Capital	39	1036	490	36	1792	150	198	902	527	126

The following table presents the amount of capacity provided by Microwave capacity providers on inter-capital routes.

Table 4. — Current Capacity on Inter-Capital Microwave Routes

Route	Estimated Capacity Available (Gbps)
Sydney-Brisbane	1.72
Sydney-Melbourne	0.78
Sydney-Canberra	1.88
Melbourne-Canberra	1.88
Total	6.25

Carriers were generally not prepared to disclose details of their optical fibre capacity and utilization. Consequently we have made estimates of what the carriers are likely to have based on the information provided, and also from our industry knowledge.

We have used this estimate to further approximate the potential capacity of that optical fibre, should it be fully equipped with the latest DWDM equipment. In forming our estimate we have assumed the following:

- We assume the current optical fibre count is the appropriate basis for our calculation.
- DWDM equipment with a design capacity of 80 wavelengths (with capacities of either 2.5 Gbps or 10 Gbps, depending on the equipment design) is being deployed by a number of carriers such as Optus and NextGen. We therefore

assume this to be the best "in use" technology that can potentially be employed on the current base of optical fibre.

- We further observe that both Optus and NextGen have deployed 10 Gbps SDH technology, and Telstra is shortly to do so. We therefore assume this technology can be potentially deployed on all of the wavelengths supplied by the DWDM equipment.
- We have also taken into account the fact that two optical fibre cores are required per DWDM system, and wavelengths on two diverse DWDM systems would be required for each 10 Gbps SDH system.
- Where information is available, capacity calculations are based on the inherent capabilities of the DWDM equipment currently deployed by individual carriers/operators.

Table 5. — Estimate of Potential Inter-Capital Capacity

Route	Estimated Number of Fibre Cables	Estimated Number of Fibres	Estimated Fibres in Use	Estimated Number of DWDM Systems Deployed on Fibre Pair	Estimated Number of Wavelengths Capability DWDM Equipment	Estimated Wavelengths In Use	Estimated Potential Fibre Capability (Wavelengths)	Estimated Potential Fibre Capability (Gbps)
Sydney-Brisbane	7	180	70	7	384	18	7,200	36,000
Sydney-Melbourne	9	270	148	9	352	40	10,800	54,000
Sydney-Canberra	3	96	44	3	176	14	3,840	19,200
Melbourne-Canberra	2	72	42	2	96	11	2,880	14,400
Melbourne-Adelaide	6	144	56	6	304	24	5,760	28,800
Adelaide-Perth	5	124	56	5	224	28	4,960	24,800
Perth-Darwin	1	24	18	1	80	3	960	4,800
Adelaide-Darwin	1	24	18	1	80	3	960	4,800
Brisbane-Darwin	1	24	18	1	80	3	960	4,800
Victoria-Tasmania	4	78	20	1	16	6	3,120	15,600
Grand Total Inter-Capital	39	1036	490	36	1792	150	41,440	207,200

Further considerations we have made in making this estimate include the ability of the transmission capacity operators to complete the upgrades that underpin the above estimates. We have also taken into account the promised future 40 Gbps SDH technology that suppliers indicate will be available in coming years. We are also mindful of the claimed 160 wavelength capacity DWDM equipment that suppliers claim to offer.

Having considered these matters, and being aware there are a number of engineering issues that must be addressed to fully exploit the technological capability of the newer high capacity technology, we see no reason why the above estimate could not be achieved on the current base of optical fibre. Indeed, we feel our estimate may be conservative in view of the (above-mentioned) technology that is likely to be deployable in the near future. We are of the further opinion that the potential capability is likely to far exceed Australia's needs in the foreseeable future.

8 Supply of Transmission Regional Networks

Telsyte collected and collated the transmission capacity information that was made available by survey respondents, as well as publicly available information and supplementary data obtained via confidential sources. We also made estimates about the capacity that Telstra is likely to have to the regional centres that form the major switch nodes at those locations.

The methodology used to construct the Tables in this section is described below.

1. The data from all survey respondents (and secondary sources) was copied into a single Excel spreadsheet. Each line item in the consolidated spreadsheet was examined to determine correct origins and destinations.

2. A summary spreadsheet was used to collate and alphabetically sort all the place (location) totals on a State/Territory basis.

Due to the limited amount of information provided by study respondents, material in the following set of tables is not precise, nor complete, but does provide indicative capacities associated with the named locations for which a respondent has provided information.

Capacity into capital cities and their surrounding metropolitan areas is not included in these tables.

This capacity listed in the following tables is an estimated aggregate of the number of fibre cables, fibres, wavelengths and so on that are available at any given locality. Hence, the capacity reported for any given locality may originate from a variety of capital city or regional locations.

Many of the entries in the following tables, which show optical fibre capacity, but no transmission capacity, result from non-dedicated telecommunications operators that have responded with details of their optical fibre but without corresponding data on the multiplexing capacity deployed on that optical fibre. Where this has occurred, these entries are noted as Not Available (N/A).

In situations where we show no optical fibre capacity but indicate transmission capacity, the respondent has not provided the optical fibre capacity. In some circumstances this situation arises when a carrier uses optical fibre or DWDM capacity from another carrier, and the other carrier has not provided the details of the underpinning capacity.

Note: Carriers/operators were instructed to only provide details of capacity that they owned, so that we could eliminate the potential double counting of capacity that would arise from carriers who purchased optical fibre, DWDM or SDH capacity from another carrier then derived their own capacity on that infrastructure by adding further multiplexing equipment.

For each state/territory, we have provided separate tables with indicative fibre and microwave capacity.

8.1 Victoria

Victoria is well served by Telstra's optical fibre cables, with a high proportion of Country and Metropolitan telephone exchanges having fibre-based capacity. Telstra is also known (from publicly available information) to have legacy microwave systems still operational to many country locations.

The alternative capacity providers have a much more limited coverage of Victoria — generally limited to a relatively small number of conveniently located Points of Presence (POPs) that have been established along the path of inter-capital optical fibre routes. Optus is the major competitive supplier of transmission capacity that uses this strategy. Optus has established POPs on its two routes through Victoria, via Gippsland and also via Albury.

As part of the VicOne project, AAPT has established switching centres located throughout Victoria. Extensive transmission networks have also been installed throughout regional Victoria to support the Victorian Government and regional hospitals. This investment is further supported by leased capacity, where AAPT's trunk transmission investment is in the form of SDH multiplexers deployed on the leased capacity.

A number of other capacity suppliers have, or plan to have, capacity to a small number of regional centres. Publicly available information about Powercor indicates that it has capacity to regional centres such as Geelong, Ballarat and Bendigo.

VicTrack also has an extensive optical fibre network linking its rail stations and depots. At this point, it has used this network for its own purposes. VicTrack is open to proposals from others to utilise its network, but to date, little use has been made of VicTrack's potential transmission capacity. One impediment to doing so is that the network, which has been designed to suit VicTrack's needs, is unlikely to be efficient for a telecommunications transmission provider.

Uecomm has an extensive optical fibre network around metropolitan Melbourne. Much of this network is in the form of overhead fibre cable, as is the Powercor network in country locations. Uecomm relies on others to provide its inter-capital capacity.

SPI PowerNet offers only dark fibre on its Optical Fibre Ground Wire (OPGW) network, which is accessible at a significant number of locations throughout Victoria. SPI PowerNet is also able to provide managed services by negotiation.

Microwave transmission capacity providers such as ntlT and SPT, which claim in their marketing literature to have capacity covering large parts of Victoria, may at this point only have plans to do so.

Datafast has a relatively small capacity network of 34 Mbps links, mainly linking their POPs in Southwest Victoria to Melbourne.

Beyond the POPs established by Optus and AAPT in country Victoria, there is little in the way of competitive trunk transmission capacity other than that provided by Telstra.

Telstra's view about its capacity to meet demand at any location applies for Victoria, as it does for other states. Telstra's view is that its' rolling capacity upgrade program

will continue to provide capacity in advance of the needs of any location that has demand for capacity. This should apply to any existing location that currently has either optical fibre or microwave capacity.

Table 6 provides information on fibre capacity, whereas Table 7 provides information on microwave capacity.

Table 6. — Victorian Fibre Capacity Into Specified Localities

State	To	Estimated Capacity Available (Mbps)
VIC	Albion	N/A
VIC	Altona	2,064
VIC	Ararat	645
VIC	Armadale	N/A
VIC	Bairnsdale	8,258
VIC	Balaclava	N/A
VIC	Ballarat	10,967
VIC	Batman	8
VIC	Bendigo	18,645
VIC	Box Hill	N/A
VIC	Brooklyn	2,064
VIC	Brunswick	N/A
VIC	Bundoora	129
VIC	Burnley	N/A
VIC	Camberwell	N/A
VIC	Campbellfield	6,322
VIC	Caulfield	31
VIC	Clayton	N/A
VIC	Coburg	N/A
VIC	Corio	N/A
VIC	Cranbourne	N/A
VIC	Dandenong	129
VIC	Dederang	N/A
VIC	Essendon	N/A
VIC	Fawkner	N/A
VIC	Flagstaff	N/A
VIC	Footscray	N/A
VIC	Geelong	13,935
VIC	Gisborne	14,451
VIC	Glen Waverley	N/A

State	To	Estimated Capacity Available (Mbps)
VIC	Glenrowan	N/A
VIC	Greensborough	N/A
VIC	Hawthorn	N/A
VIC	Heidelberg	N/A
VIC	Holmesglen	N/A
VIC	Horsham	645
VIC	Kyneton	6,193
VIC	Lara	8
VIC	Laverton	N/A
VIC	Little River	8
VIC	Maidstone	129
VIC	Malvern	N/A
VIC	Merlynston	N/A
VIC	Mildura	2,064
VIC	Mitcham	N/A
VIC	Moorabool	N/A
VIC	Moreland	N/A
VIC	Morwell	8,258
VIC	Mt Waverley	8,258
VIC	Newport	39
VIC	Nth Geelong	8
VIC	Nth Shore	16
VIC	Nth Williamstown	N/A
VIC	Nunawading	N/A
VIC	Richmond	31
VIC	Ringwood	129
VIC	Sale	6,193
VIC	Seymour	66
VIC	Shepparton	12,452
VIC	Spotswood	N/A
VIC	St Albans	4,129
VIC	Sunshine	N/A
VIC	Sydenham	N/A
VIC	Syndal	N/A
VIC	Tottenham	55
VIC	Traralgon	6,193

State	To	Estimated Capacity Available (Mbps)
VIC	Wangaratta	4,145
VIC	Warragul	14,451
VIC	Warrnambool	2,064
VIC	Werribee	2,120
VIC	Williamstown	N/A
VIC	Wodonga	N/A

Table 7. — Victorian Microwave Capacity Into Specified Localities

State	To	Estimated Capacity Deployed (Mbps)
VIC	Bacchus Marsh	32.8
VIC	Ballarat	1331.2
VIC	Bendigo	1331.2
VIC	Camperdown	32.8
VIC	Colac	32.8
VIC	Dartmoor	32.8
VIC	Geelong	1331.2
VIC	Hamilton	774.1
VIC	Mildura	524.3
VIC	Mortlake	32.8
VIC	Mt Dandenong	557.1
VIC	Port-Fairy	32.8
VIC	Portland	32.8
VIC	Rowville	32.8
VIC	Shepparton	2072.6
VIC	Smeaton	32.8
VIC	Swan Hill	1548.3
VIC	Traralgon	1548.3
VIC	Warrnambool	806.9

8.2 New South Wales

New South Wales is similar in most respects to Victoria, in that Telstra has wide coverage and acknowledges no impediment to servicing demand as it arises. Optus has a number of POPs along its inter-capital routes from Sydney to Melbourne and Brisbane. These appear on both the inland and coastal routes in both cases.

Uecomm has an extensive optical fibre network in Sydney, as is the case with Melbourne. SPI PowerNet has dark fibre capacity on its Optical Fibre Ground Wire (OPGW) network in a number of locations in NSW. TransGrid also has a network for its own purposes providing capacity to power stations.

NSW State Rail has an extensive optical fibre network between all of the metropolitan rail stations and train depots throughout Sydney.

We observed this philosophy with a number of the respondents to the study.

Microwave transmission providers have a stronger footprint in NSW with FLOW Communications, ntlT and SPT all having the majority of their POPs focussed on NSW and up to Brisbane. The presence of these operators is largely confined to the Central and Eastern Seaboard locations in NSW. SPT is building out its network to provide services in fulfilment of its contracts with the NSW Government.

Table 8 provides information on fibre capacity, whereas Table 9 provides information on microwave capacity.

Table 8. — New South Wales Fibre Capacity Into Specified Localities

State	To	Estimated Capacity Available (Mbps)
NSW	Albury	12,386
NSW	Armidale	4,129
NSW	Bathurst	8,258
NSW	Bega	10,322
NSW	Blacktown	129
NSW	Broken Hill	2,064
NSW	Campbelltown	12,386
NSW	Carlingford	129
NSW	Coffs Harbour	8,258
NSW	Dapto	N/A
NSW	Dubbo	4,129
NSW	Gosford	8,903
NSW	Goulburn	12,386
NSW	Grafton	8,258
NSW	Griffith	2,064
NSW	Hurstville	129
NSW	Hyde Park	129
NSW	Jindera	258
NSW	Lismore	4,129
NSW	Liverpool	129
NSW	Marulan	N/A

State	To	Estimated Capacity Available (Mbps)
NSW	Newcastle	8,258
NSW	Nowra	14,451
NSW	Orange	8,258
NSW	Parramatta CBD	129
NSW	Pennant Hills	129
NSW	Penrith	8,258
NSW	Queanbeyan	6,193
NSW	Tamworth	8,258
NSW	Taree	8,258
NSW	Wagga Wagga	12,386
NSW	Wauchope	6,193
NSW	Windsor	6,193
NSW	Wollongong	14,451
NSW	Yass	N/A

Table 9. — New South Wales Microwave Capacity Into Specified Localities

State	To	Estimated Capacity Deployed (Mbps)
NSW	Albury	1191.9
NSW	Armidale	1161.2
NSW	Batemans Bay	645.1
NSW	Bega	645.1
NSW	Byron Bay	516.1
NSW	Central Coast	516.1
NSW	Coffs Harbour	2322.4
NSW	Cooma	645.1
NSW	Coonabarabran	645.1
NSW	Cootamundra	1161.2
NSW	Dubbo	1161.2
NSW	Gosford	645.1
NSW	Goulburn	675.8
NSW	Griffith	645.1
NSW	Gundagai	645.1
NSW	Kiama	645.1
NSW	Lismore	516.1
NSW	Murrumbin	516.1
NSW	Murrundi	645.1
NSW	Narrabri	645.1
NSW	Newcastle	1032.2
NSW	Newcastle, Maitland, Cessnock, Lake Macquarie	645.1
NSW	Nowra	1161.2
NSW	Orange	1161.2
NSW	Parramatta	129.0
NSW	Port Macquarie	516.1
NSW	Shellharbour	706.6
NSW	Shoalhaven	30.7
NSW	Tamworth	645.1
NSW	Taree/Port Macquarie	1161.2
NSW	Wagga Wagga	1191.9
NSW	Wollongong	1191.9
NSW	Wyong	645.1

8.3 Australian Capital Territory

Unlike the other States and Territories surveyed for this project, the Australian Capital Territory is considered to be a metropolitan/capital city area. Trunk transmission capacity servicing the ACT is described in Section 7 of this report; namely, capacity servicing the Sydney-Canberra and Melbourne-Canberra routes.

8.4 Queensland

In addition to Telstra and Optus, competitive transmission providers service Queensland along the eastern seaboard (from Gold Coast to Cairns).

The major difference with the optical fibre capacity available in Queensland from that of Victoria and New South Wales is the presence of the Reef Network (managed by Optus) that offers capacity to major population centres located between Brisbane and Cairns.

PowerTel's network provides capacity from Sydney to Brisbane via Toowoomba, and also to the Gold Coast.

The majority of AAPT's trunk transmission investment is in the form of SDH multiplexers deployed on leased capacity.

While Uecomm is mainly focussed on capacity within CBDs and surrounding metropolitan areas, they have extended their fibre network from Brisbane to the Gold Coast.

Powerlink's telecommunications network was deployed to protect and control the high voltage power transmission network of lines and substations. However, Powerlink is also constructing a network between Brisbane, Rockhampton and Townsville to provide services to universities in Queensland through agreements with AARNet and to other potential bulk users of telecommunications capacity.

Telecasters has an extensive network of capacity, up the coast from Brisbane to Cairns, for the purpose of transporting television signals to transmission towers that serve communities along the coast. Telecasters' capacity is tailored to its requirements. They are prepared to look at a business case from others seeking access to the Telecasters network, but to date no suitable proposal has been offered.

The communities located in North and Central Queensland are heavily dependent on Telstra's microwave networks.

Table 10 provides information on fibre capacity, whereas Table 11 provides information on microwave capacity.

Table 10. — Queensland Fibre Capacity Into Specified Localities

State	To	Estimated Capacity Available (Mbps)
QLD	Beaudesert	6,193
QLD	Beenleigh	25,031

State	To	Estimated Capacity Available (Mbps)
QLD	Bundaberg	10,838
QLD	Cairns	10,322
QLD	Caloundra	2,064
QLD	Chermside West	129
QLD	Cloncurry	6,193
QLD	Currumbin	25,031
QLD	Eagle Farm	129
QLD	Gladstone	10,451
QLD	Gold Coast	6,838
QLD	Mackay	10,451
QLD	Manly West	129
QLD	Maroochydore	10,838
QLD	Maryborough	10,838
QLD	Mt Gravatt	129
QLD	Mt Ommaney	645
QLD	Nambour	6,193
QLD	Parkwood	129
QLD	Pimpama	129
QLD	Rockhampton	10,451
QLD	Southport	25,031
QLD	Springwood	129
QLD	St Lucia	645
QLD	Toowoomba	8,258
QLD	Townsville	10,451
QLD	Wurtulla	4,645

Table 11. — Queensland Microwave Capacity Into Specified Localities

State	To	Estimated Capacity Deployed (Mbps)
QLD	Bald Knob	129.0
QLD	Bundaberg/Maryborough	645.1
QLD	Cairns	645.1
QLD	Cardwell	153.6
QLD	Clairview	645.1
QLD	Cooloolabin	1290.2

State	To	Estimated Capacity Deployed (Mbps)
QLD	Dalby	645.1
QLD	Dulong	129.0
QLD	Gayndah	645.1
QLD	Gladstone	129.0
QLD	Gold Coast	774.1
QLD	Goodwood	645.1
QLD	Gumlu	645.1
QLD	Halifax	153.6
QLD	Kinduro	645.1
QLD	Mackay	645.1
QLD	Maroochydore	903.2
QLD	Maryborough	1290.2
QLD	Maurice Hill	774.1
QLD	Miriam Vale	645.1
QLD	Portsmith	1290.2
QLD	Raglan	645.1
QLD	Rockhampton	774.1
QLD	Sarina	645.1
QLD	Southport	30.7
QLD	Stanthorpe	645.1
QLD	Tewantin	129.0
QLD	Toowoomba	774.1
QLD	Townsville	1677.3
QLD	Warwick	645.1

8.5 South Australia

South Australia relies on Telstra more heavily than the Eastern States. Optus, IP1 and NextGen have optical fibre capacity routes that pass through South Australia, but have very few POPs in localities they pass through. As is the case elsewhere, these routes are primarily for the purpose of providing inter-capital capacity.

Telstra has an optical fibre cable between Adelaide and Darwin that has the capacity to service the larger locations on its path. Most other locations in the sparsely populated Central and Northern parts of South Australia are dependent on Telstra's microwave network.

Agile and ElectraNet provide microwave capacity in parts of South Australia. ElectraNet provides capacity for its own use for the management of its power transmission network.

Agile's telecommunications services are available throughout the South East corner of South Australia. Agile, like other transmission providers, manages its capacity to meet customer needs and provides incremental capacity as required.

ETSA Utilities' network is almost solely metropolitan based. ETSA has minimal intra-regional and no interstate services.

Table 12 provides information on fibre capacity, whereas Table 13 provides information on microwave capacity.

Table 12. — South Australian Fibre Capacity Into Specified Localities

State	To	Estimated Capacity Available (Mbps)
SA	Gawler	6,580
SA	Mount Gambier	2,710
SA	Murray Bridge	2,710
SA	Port Augusta	6,580

Table 13. — South Australian Microwave Capacity Into Specified Localities

State	To	Estimated Capacity Deployed (Mbps)
SA	Aldinga	30.7
SA	Angaston	30.7
SA	Cape Jervis	30.7
SA	Coorong/Murray	61.4
SA	Crafers	65.5
SA	Delamere	30.7
SA	Eden Valley	30.7
SA	Freeling	30.7
SA	Gawler	30.7
SA	Gifford Hill	33.6
SA	Goolwa	30.7
SA	Greenock	30.7
SA	Keith	30.7
SA	Lyndoch	30.7
SA	Meningie	30.7
SA	Mt Barker	30.7
SA	Mt Compass	30.7
SA	Mt Burr	4.9

State	To	Estimated Capacity Deployed (Mbps)
SA	Mt Charles	8.2
SA	Murray Bridge	30.7
SA	Narrung	30.7
SA	Normanville	30.7
SA	Nuriootpa	30.7
SA	Peake	30.7
SA	Robertstown	8.2
SA	Second Valley	30.7
SA	Strathalbyn	30.7
SA	Tanunda	30.7
SA	Victor Harbour	30.7
SA	Willaston	30.7
SA	Williamstown	63.5

8.6 Western Australia

In Western Australia, Telstra's inter-capital optical fibre crosses the Nullarbor and goes up the north coast to Darwin. These cables pick up most significant communities along their path.

Optus, NextGen and IP1 also have optical fibre cable across the Nullarbor. Telstra has further regional optical fibre routes, mainly in the South West corner of Western Australia, but many communities are exclusively served by microwave systems owned by Telstra.

Table 14 provides information on fibre capacity. Information on microwave capacity was not available from the operators. However, we are aware of non-dedicated telecommunications operators that have microwave systems. However, this capacity tends to be fully utilised by the (mainly) rail and power utilities for their own internal use.

Table 14. — West Australian Fibre Capacity Into Specified Localities

State	To	Estimated Capacity Available (Mbps)
WA	Beaufort River	4,129
WA	Bunbury	6,580
WA	Geraldton	2,064
WA	Kalgoorlie	2,064
WA	Karratha	2,064

State	To	Estimated Capacity Available (Mbps)
WA	Katanning	6,580
WA	Pinjarra	2,064
WA	Rockingham	387

8.7 Northern Territory

In terms of fibre optic cable, the Northern Territory is serviced via Telstra's inter-capital optical fibre cables from Perth, Adelaide and Brisbane. A mixture of optical fibre and microwave systems service remote communities. Some locations have both. To our knowledge, no competitive trunk transmission capacity supplier has invested in the Northern Territory.

Carriers such as Optus rely on leased capacity from Telstra to support the services they supply in the Northern Territory.

Table 15 provides information on fibre capacity. Information on microwave capacity was not available from the operators. However, we are aware of non-dedicated telecommunications operators that have microwave systems — although this capacity tends to be fully utilised by the (mainly) rail and power utilities for their own internal use.

Table 15. — Northern Territory Fibre Capacity Into Specified Localities

State	To	Estimated Capacity Available (Mbps)
NT	Alice Springs	2,245
NT	Katherine	2,066
NT	Nhulunbuy	2,066
NT	Tennent Creek	2,066

8.8 Tasmania

Tasmania is largely dependent on Telstra for its transmission capacity.

Telstra's two Bass Strait optical fibre cables and its microwave link are the primary links to the mainland. Optus use leased capacity from Telstra to derive its capacity to Tasmania.

The planned Basslink interconnector will run from Loy Yang in Gippsland, Victoria across Bass Strait to Bell Bay in northern Tasmania. When implemented the undersea cable component will span 295 kilometres. Basslink is a major energy initiative that will enable electricity trading between Tasmania and the mainland, and allow Tasmania to enter the National Electricity Market (NEM, Australia's competitive wholesale market for electricity.) Basslink is still under construction and National Grid Transco the

builder, owner and operator of Basslink Pty Limited does not anticipate making dark fibre available to the market until mid to late 2005.

The Tas21 initiative is building fibre capacity in conjunction with the State's trunk gas network. Initially owned by EDI Downer, in May 2003, the Tasmanian Government announced that it would take ownership (for $23.1 million) of the new optic fibre cable. The State government is planning to conduct a public expression of interest process to identify strategic partners for the next stage of the project. The natural gas pipeline gives Tasmania an unprecedented opportunity to roll out fibre optic cable at considerably reduced cost, and the government is determined to make the most of that opportunity. The fibre infrastructure now spans 420 kilometres from George Town to Hobart and across to Port Latta on the North West Coast of Tasmania.

A 24-fibre Single Mode Optical Fibre (SMOF) ITU G.652 cable is installed in a conduit along the entire route. The design of the fibre optical cable network is such that the initial network of 2.5 Gigabits per second (Gbps) can be upgraded to 10 Gbps. The electronics will be designed and equipped to provide non-diverse self-healing rings with a working and protect side activated. Four STM-16 Points of Presence (POPs) are located at Burnie, Gawler for Devonport, Deloraine for Launceston and Bridgewater for Hobart. In each case the configuration is such that the electronics can be relocated or extended to the major city without a change in design.

Table 16 provides information on fibre capacity, whereas Table 17 provides information on microwave capacity.

Table 16. — Tasmanian Fibre Capacity Into Specified Localities

State	To	Estimated Capacity Available (Mbps)
TAS	Burnie	2,064
TAS	Campbell Town	2,064
TAS	Launceston	6,193
TAS	Stanley	2,064

Table 17. — Tasmanian Microwave Capacity Into Specified Localities

State	To	Estimated Capacity Deployed (Mbps)
TAS	Burnie	645.1
TAS	Devonport	129.0
TAS	Launceston	2193.4

9 Capacity Available at an Exchange Service Area (ESA) Level

As indicated earlier in this report the structure of communities to which transmission capacity is provided is divided into the following categories.

- Tier 1 — Capital cities that form the major transmission and switching hubs;
- Tier 2 — Metropolitan and Regional commercial centres that form the regional hubs and also serve as the POI to Telstra's network; and
- Tier 3 — Local Exchange Service Areas (ESAs) located in the smaller satellite towns.

The capital cities are the focus of international and inter-capital transmission capacity with the greatest volumes and the greatest number of competitive service providers.

The metropolitan and regional centres form the next layer of communities that are of interest to competitive transmission service providers, particularly those that have built capacity to Telstra's POI in those locations. There are approximately 120 of these locations — evenly divided between metropolitan and country regions.

Very few of the remaining smaller satellite towns have competitive transmission provision and therefore rely solely on Telstra for capacity. We are aware that Telstra has optical fibre access to quite a high proportion of these. Where this is the case, the potential capacity that can be delivered to these locations — should the demand eventuate — is quite considerable.

Some locations are served by microwave systems that have commonly deployed capacity increments of 34 Mbps and 155 Mbps. These systems would have adequate capacity for many of the smaller sites.

Telstra has advised us that it has a rolling program of assessment and augmentation of all ESA locations to ensure capacity meets demand. This program is driven by demand forecasts. New capacity, when it is identified as being required, is scheduled for completion some months prior to exhaustion of the current capacity. Telstra further assured us that any site that currently has capacity would not present a difficulty should increased capacity be required.

Telstra, like all other respondents, indicated that commitment to the installation of capacity is driven solely by the business benefits of doing so. We understand from the advice offered by Telstra that where demand eventuates for capacity, the business case is virtually assured.

Appendix A: Acronyms

ACA — Australian Communications Authority

ACCC — Australian Competition and Consumer Commission

ACIF — Australian Communications Industry Forum

ADM — Add Drop Multiplexer

CBD — Central Business District

DCITA — Department of Communications, Information Technology and the Arts

DSL — Digital Subscriber Line

DSLAM — DSL Access Multiplexer

DWDM — Dense Wave Division Multiplexing

ESA — Exchange Service Areas

LAS — Local Area Switches

NBI — The 1999 National Bandwidth Inquiry

NZDF — Non Zero Dispersion Fibre

OPGW — Optical Fibre Ground Wire

PDH — Plesiochronous Digital Hierarchy

POI — Point of Interconnect

POP — Point of Presence

PSTN — Public Switched Telephone Network

RSS — Remote Switching Stages

SIO — Services in Operation

SDH — Synchronous Digital Hierarchy

SMOF — Single Mode Optical Fibre

TNS — Transit Network Switches

WDM —Wave Division Multiplexing

Appendix B: Definitions

ACA (Australian Communications Authority) — Commonwealth regulatory authority for telecommunications and radio communications.

ACCC (Australian Competition and Consumer Commission) — Commonwealth regulatory body with responsibilities derived from the Trade Practices Act 1974 and other telecommunications-specific legislation, with competition and trade practices responsibilities in relation to the telecommunications industry.

ACIF (Australian Communications Industry Forum) — Established in May 1997 as a communications industry self-regulatory body. ACIF is responsible for developing industry codes and standards and service specifications.

Backbone — A central network that connects several other, usually lower bandwidth networks. The backbone network is usually composed of a high capacity communications medium, such as fibre optic cable. Backbone networks are often referred to as Trunk or inter-exchange networks.

Bandwidth (Data Transmission) — The range of frequencies, expressed in Kilobits per second, that can pass over a given data transmission channel within a network. The bandwidth determines the rate at which information can be sent through a channel — the greater the bandwidth, the more information that can be sent in a given amount of time. The term bandwidth can also be used to define the maximum data transfer rate between two points. Bandwidth is typically measured Kilobits per second (Kbps), Megabits per second (Mbps) or Gigabits per second (Gbps).

Bandwidth (Frequency) — The range of frequencies, expressed in Hertz (Hz), that can pass over a given transmission channel. The bandwidth determines the rate at which information can be transmitted through a circuit.

CAN (Customer Access Network) — The network sometimes referred to as the 'local loop' consisting of the customer telephone attached to a local area switch which is mainly comprised of copper cable but may use wireless or satellite technologies. The term is typically used to refer to copper cables connecting customer premises to the local (Telstra) exchange.

Capacity — In the context of this report, capacity refers to transmission (bandwidth) capacity along fibre or microwave routes provisioned for the supply of communications services between Australian capital cities, from capital cities to regional centres, and between regional centres.

Carrier — The holder of a telecommunications carrier license in force under the Telecommunications Act 1997.

Core Network — A combination of switching offices and transmission plant connecting switching offices together.

CRU (Communications Research Unit) — An economic research branch within the Department of Communications, Information Technology and the Arts.

DCITA (The Department of Communications, Information Technology and the Arts) — The Australian Government Department responsible for communications policy.

DSL (Digital Subscriber Line) — DSL is a copper access-transmission technology with a range of symmetrical and asymmetrical flavours including ADSL, HDSL, SDSL, SHDSL and VDSL.

DSLAM (Digital Subscriber Line Access Multiplexer) — A DSLAM is a DSL multiplexer, typically located at an exchange site that links many customers' DSL connections to a single high-speed bandwidth link.

DWDM (Dense Wave Division Multiplexing)— DWDM is a higher capacity version of WDM, which increases the bandwidth of optical communications networks. DWDM puts sources together onto an optical fibre, with each signal carried at the same time on its own separate light wavelength. Using DWDM, up to 80 (and theoretically many more) separate wavelengths or channels of data can be transmitted on a single optical fibre. In DWDM, wavelengths are closely spaced, commonly at intervals as small as 0.4 or 0.8 nm. To keep the signals distinct, DWDM manipulates wavelengths of light to keep each signal within its own narrow band. (See also **WDM**).

ESA (Exchange Service Area)[4] — In Australia, charges for telephone calls are based on a system known as Group Charging. Under this system, telephone numbers are grouped into exchange service areas (ESA), and a number of ESAs are grouped together to form a zone. Zones are grouped to form charging districts. Local call access is available between customers in the same standard zone or in adjoining standard zones, while STD rates (trunk calls), based on the radial distance between zone or district charging points, apply to other calls.

Exchange — A network node where the telecommunications network operator switches various numbers and types of communication lines. Exchanges operate at local, trunk and international levels.

Fibre optic cable — A cable incorporating a number of very thin strands of glass on which information is conveyed in the form of pulses of light. When used as a transmission medium, pulses of light are emitted from a laser-type source. Fibre optic cabling is the cabling of choice for all inter-exchange trunk networks, and increasingly for local metropolitan loops as well. Fibre optic cables support high bandwidth (when layered with wave division multiplexing techniques), and take up little conduit space.

Gbps (Gigabits per Second) — A measure of bandwidth capacity or transmission speed that stands for a billion bits per second.

[4] Telstra Zoning Review Submission Summary Report, 29 August 2000 (http://www2.ozland.net.au/savage/TelstraReviewSummary_290800.htm)

Interconnection — The inter-working of two separate networks. Interconnection is used in reference to both the technical interface and to the commercial arrangements between the two network operators providing service.

Kbps (Kilobits per Second) — A measure of bandwidth capacity or transmission speed that stands for a thousand bits per second.

LAS (Local Access Switches) — In the Telstra transmission hierarchy, LASs form an additional layer of transmission systems that link the TNS locations to Local Access Switches located in the major commercial centres of both metropolitan and country regions.

Leased Line — A leased line digital data transmission link, which provides guaranteed point-to-point bandwidth. Leased lines are available in a range of speeds typically starting at 2.4 Kbps and ranging up to 10 Gbps. Also defined as a communication channel contracted for exclusive use from a common carrier, frequently referred to as a private line.

Lit Capacity — In the context of this report, network transmission infrastructure (eg fibre or microwave) that has been provisioned with SDH and/or DWDM equipment, which enables communications service delivery. Although the transmission infrastructure may be provisioned with SDH and/or DWDM equipment, it is possible that the full potential of the equipment has not been provisioned; e.g. there are additional empty card slots that can be fitted with transmission line cards. (See also **Potential Capacity** and **Spare Capacity**.)

Mbps (Megabits per Second) — A measure of bandwidth capacity or transmission speed that stands for a million bits per second.

Metropolitan ("Metro") Area — A geographic area such as an entire city and its outlying area. In Australia, typically defined as the geographic area within a 0-25 kilometre radius of the General Post Office of a city.

Microwave — A high frequency form of radio transmission (generally over 1 GHz).

Multiplexing — A range of techniques to enable transmission of multiple signals or circuits simultaneously along a single transmission medium. It is also defined as the process of interleaving or simultaneously transmitting two or more messages on a single channel using a device called a Multiplexer or Mux. A de-multiplexer completes the process by separating multiplexed signals from a transmission line. Frequently a multiplexer and de-multiplexer are combined into a single device capable of processing both outgoing and incoming signals.

Narrowband Service — A telecommunications service that provides bandwidth up to 64 Kbps.

NZDF (Non-Zero Dispersion Fibre) — NZDF is a new generation of fibre optic cable designed for use with Dense Wavelength Division Multiplex (DWDM) systems. In order to use high capacity transmission systems, it is necessary to analyse and overcome the non-linear effects that may arise and negatively effect transmission efficiency where a significant number of high power channels are used. One solution for avoiding non-linear effects is Non Zero Dispersion (NZD), thus called because of its low, although never zero, levels of chromatic dispersion in the window between 1530

nm and 1625 nm. This new category of fibre has become widely used for DWDM applications.

Optical Fibre — A thin filament of drawn or extruded glass or plastic having a central core and a cladding of lower index material to promote internal reflection. It may be used singly to transmit pulsed optical signals (communications fibre) or in bundles to transmit light or images.

PDH (Plesiochronous Digital Hierarchy) — Plesiochronous means nearly synchronous, and the technology was developed to carry digitised voice over twisted pair cabling more efficiently. This evolved into the North American, European, and Japanese Digital Hierarchies where only a discrete set of fixed rates were available, namely, nxDS0 (DS0 is a 64 Kbps rate), followed by the next levels in the respective multiplex hierarchies.

POI (Points of Interconnection) — Telstra Points of Interconnection (POI) allow competitive carriers can use to gain access to Telstra's PSTN. The locations are also LAS locations that are the local switching hub for exchange areas in the vicinity of the LAS. Additional information is contained in Table 21 (Appendix C).

POP (Point-of-Presence) — Physical locations where a carrier has a network switching or access device.

Potential Capacity — In the context of this report, unutilised network infrastructure (eg dark fibre or SDH/DWDM equipment with spare card slots) capable of being provisioned for the supply of communications services. (See also **Lit Capacity** and **Spare Capacity**.)

Spare Capacity — In the context of this report, network transmission infrastructure (eg fibre or microwave) that has been provisioned with SDH and/or DWDM equipment, which enables communications service delivery, but is not currently (fully) utilised to carry telecommunications traffic. (See also **Lit Capacity** and **Potential Capacity**.)

PSTN — The Public Switched Telephony Network is a circuit-based network with centralised control, and with media (voice) and signalling (call set-up) on different networks, Signalling is done via the SS7 portion of the network. Media is circuit based and utilises the E.164 Addressing (phone number) format. The PSTN is characterised by high reliability, high availability, secure connections and low latency. The term PSTN also refers to nationwide telephone switching systems operated by various telephone companies, which enable the general public to communicate with each other.

RSS (Remote Switching Stages) — A third tier in Telstra's transmission architecture links the LAS locations to Remote Switching Stages located in the smaller "satellite" towns that surround the regional centres.

SDH (Synchronous Digital Hierarchy) — The International Telecommunications Union-T standard for transmitting information over optical fibre.

Service Provider — A collective terminology for PSTN Service Provider, Internet Service Provider, Corporate Network and Locally Hosted Content provider. Service providers are businesses that use network facilities to provide basic or value-added telecommunications services.

SMOF (Single Mode Optical Fibre) — A fibre with a relatively narrow diameter, through which only one mode will propagate. SMOF carries higher bandwidth than multimode fibre, but requires a light source with a narrow spectral width.

STM (Synchronous Transfer Module) — STM is a basic building block used for a synchronous multiplexing hierarchy defined by the CCITT/ITU-T. STM-1 operates at a rate of 155.52 Mbps (the same as STS-3).

STM-1 — The Synchronous Transport Module 1: SDH standard for transmission over OC-3 optical fibre at 155.52 Mbps.

STM-n — A Synchronous Transport Module "n": (where n is an integer) SDH standards for transmission over optical fibre (OC-'n x 3) by multiplexing "n" STM-1 frames, (e.g., STM-4 at 622.08 Mbps and STM-16 at 2.488 Gbps).

Synchronous — Signals that are sourced from the same timing reference and have the same frequency. For example, in high-speed wide area digital communications, the network commonly provides a reference clocking source to which each subscriber's equipment synchronizes its transmissions.

Tier 1 — In the context of this report, transmission capacity provisioned along the inter-capital routes linking the major population centres and the major switching hubs located at these centres. These also form the aggregation points for international routes as well as being the major Gateway locations for the interconnection of switched networks (i.e. Mobile / PSTN interconnection).

Tier 2 — In the context of this report, the second tier of transmission capacity linking capital cities in each state to the major regional hubs, which are the major regional cities. These regional hubs are the location of Telstra's Local Area Switches (LAS) that form the point of interconnection (POI) for the competitive carriers seeking PSTN Originating and Terminating access.

Tier 3 — In the context of this report, the third tier of transmission capacity provides linkages to/from the major regional hubs and the smaller satellite towns surrounding these locations.

Transit Network Switches (TNS) — Telstra's transmission network architecture is fundamentally grounded on the structure of the location of Australian communities. Its purpose is to efficiently interconnect those communities. The network consists of high capacity inter-capital trunk routes between Transit Network Switches located in each mainland capital city.

Trunk Transmission Capacity — In the context of this report, transmission (bandwidth) capacity along fibre or microwave routes provisioned for the supply of communications services between Australian capital cities, from capital cities to regional centres, and between regional centres.

Unutilised Capacity — Unutilised network infrastructure (e.g. dark fibre) capable of being provisioned for the supply of communications services between capital cities and to regional centres.

WDM (Wavelength Division Multiplexing) — In optical fibre communications, any technique by which two or more optical signals having different wavelengths may be simultaneously transmitted in the same direction over one fibre, and then be

separated by wavelength at the distant end. The first WDM systems combined two signals and appeared around 1985. (See also **DWDM**).

Appendix C: Telstra Points of Interconnection

The following table of locations are the Telstra Points of Interconnection (POI) that competitive carriers can use to gain access to Telstra's PSTN. The locations are also LAS locations that are the local switching hub for exchange areas in the vicinity of the LAS. Table 21 includes the POI at each state capital city as well as the regional POIs.

Table 18. — Telstra Points of Interconnection

ACT	NSW	QLD	VIC	SA	WA	TAS	NT
Canberra	Albury	Beaudesert	Ballarat	**Adelaide**	Bunbury	**Hobart**	Alice Springs
	Armidale	**Brisbane**	Bendigo	Gawler	Geraldton	Launceston	**Darwin**
	Bathurst	Bundaberg	Geelong	Mount Gambier	Kalgoorlie		
	Bega	Caboolture	Kyneton	Murray Bridge	Karratha		
	Broken Hill	Cairns	**Melbourne**	Pinjarra	Katanning		
	Campbelltown	Cloncurry	Mildura	Port Augusta	**Perth**		
	Coffs Harbour	Gladstone	Morwell		Port Hedland		
	Dubbo	Mackay	Shepparton				
	Gosford	Maryborough	Wangaratta				
	Goulburn	Nambour	Warragul				
	Grafton	Rockhampton	Warrnambool				
	Griffith	Toowoomba					
	Lismore	Townsville					
	Newcastle						
	Nowra						
	Orange						
	Penrith						
	Sydney						
	Tamworth						
	Taree						
	Wagga						
	Wauchope						
	Windsor						
	Wollongong						

Appendix D: Telstra Questionnaire

This document has been provided as a separate attachment.

Appendix E: Carrier/Non-Dedicated Operator Questionnaire

This document has been provided as a separate attachment.

Appendix F: Data Collection Spreadsheet

This document has been provided as a separate attachment.