Final report

Technology Pathways for Connect Australia

A report to DCITA

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Melbourne
+61 (3) 9601 6726
emilie.ditton@ovum.com

www.ovum.com

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1. Executive summary

In August 2005, the Australian Government announced plans to spend $1.1 billion on the Connect Australia Program. The program will invest in infrastructure for the delivery of broadband and mobile services to rural and regional Australia.

This consultancy study is an assessment of the technology options for mobile and broadband infrastructure deployments for rural and regional Australia.

Methodology of Technology Pathways for Connect Australia

Ovum's approach has been to undertake market analysis, to make an assessment of the technology options available, and to undertake scenario analysis for nine Australian rural and regional towns.

Market analysis

Market analysis has been undertaken by drawing on Ovum's expertise in Australia and internationally, as well as analysis provided by DCITA from previous consultancy studies, and drawing on information provided from consultation responses from the Broadband Connect and Mobile Connect consultations, and interviews with major stakeholders within Australia conducted by Ovum as part of this study.

Technology assessment

Each technology option included in this study has been assessed against common criteria including:

- Suitability of the technology
- Maturity
- Timing
- Integratability with other technologies
- Issues for NGN investment
- Demand and competitive pressures
- Cost

Scenario Analysis

Nine towns in rural and regional Australia were selected for inclusion in the scenario analysis. The scenario analysis has included calculation of technology costs, comparative assessment of performance and preferred choice analysis.

The scenarios were chosen to represent likely scenarios for rural and regional Australia. Towns were selected on the basis of the following elements.

- Existing infrastructure in the town
- Population level in the town
- Usage level required: 256 Kbps, 1.5 Mbps, 10 Mbps

For each town an assessment of the technology choices most suitable to that town has been made. There are many factors that affect the limitations and benefits of a particular technology over other choices.

Market analysis

Available infrastructure

Mobile and broadband infrastructure deployments are focused across the populated areas around the east and southeast coasts of the continent, particularly around the capital cities. Infrastructure availability for backhaul is similar. Satellite backhaul services can be leased everywhere in Australia. Fibre and microwave point to point services are available in many areas. Areas around the eastern third of the continent have greater backhaul density, and more competitive backhaul providers.

Infrastructure investment plans

Telstra has announced plans for its mobile network and the build out of a Next Generation Network (NGN). Telstra plans involve significant investment that will include building a 3G network by shutting down their CDMA mobile network and deploying WCDMA across Australia, and an IP based NGN network incorporating FTTN. These plans are dependent on the regulatory environment in place, and the plans have been put on hold while these regulatory issues are negotiated.

Few providers other than Telstra have plans to build new broadband or mobile infrastructure in rural and remote areas. A number of small players such as Internode and BroadbandNet have small localised broadband network projects. These are not national in nature. Optus utilises ULL in regional towns, and alternative operators such as AAPT provide services based on Telstra's infrastructure.

In mobile infrastructure, Telstra's announcements for shutdown of the CDMA network and deployment of WCDMA have led other operators to take a 'wait and see' approach.

Competition in rural areas

There is limited broadband and mobile competition in rural and regional Australia. Competition is largely a commercial response to demand, focussed on targeting larger regional towns. Most operators find construction of profitable business cases in rural and regional Australia extremely difficult. There are a number of elements that are affecting the development of competition in these areas:

- *Cost of backhaul*: All operators interviewed as part of this project commented on the cost of backhaul being prohibitive to profitable entry to rural and regional markets. The prices for backhaul in Australia are not directly cost related, and available prices vary significantly according to location, scarcity, and overall purchasing levels. Bigger operators typically get better deals.

- *Telstra's market response*: Much evidence has been provided of Telstra's typical response to new market entrants in rural areas. Operators interviewed have referred to Telstra being more responsive to their competitive infrastructure rollouts than to underlying demand.
- *Population*: The limited population in rural and regional areas means limited returns. Additionally, there is usually a lower proportion of young people living in rural areas which affects takeup of mobile and broadband services.

Market demand for services

There is strong demand for GSM and CDMA services in rural and regional areas as in the rest of Australia. While mobile services are well established, there are drivers such as geography, pricing and existing culture, which affect mobile usage.

Broadband penetration in Australia reached 31.8% in September 2005. This is mostly in urban areas, where the majority of exchanges are deployed. There is no reason to suggest that takeup in rural and regional areas would be less than that in urban areas. The remoteness of many locations is a key driver for broadband take-up. The time savings, the financial rewards and the potential opportunities offered by broadband can be even more attractive to country Australians because broadband offers access to services that were previously impossible or hard to get to for many people.

Pricing

Mobile prices in Australia are becoming cheaper. Internationally and domestically, broadband pricing is trending downwards also. Alternative operators providing services over broadband access technologies other than DSL are providing services at DSL prices available in metro areas.

By international standards, Australia's entry level deal of 256/64 Kbps with a 200MB cap is extremely poor and will need to improve if operators are going to grow revenues from value added services. Evidence has shown that as takeup of broadband services increases demand for lower prices and higher speeds follows.

Bundling of fixed line phone, broadband Internet and mobile is a large part of the Australian competitive environment. All major operators bundle their services aiming to attract customers and reduce churn.

Technology options

The technologies included in this study are shown in Figure E1.

Figure E1 **Technologies included in study**

DSL: ADSL, ADSL 2+, SHDSL, VDSL	Microwave point to point
Satellite	GSM
Fibre/HCF	Broadband wireless access: WiFi, WiMAX, iBurst
Broadband over Powerline	Flash OFDM (Flarion)
HSDPA	CDMA
WCDMA	

DSL: ADSL, ADSL 2+, SHDSL, VDSL

DSL is the most commonly deployed technology for delivery of broadband services internationally. This is a result of the ubiquitous availability of copper CAN infrastructure utilised by DSL. It is a fully proven technology and standardised.

ADSL is the most cost-effective choice where appropriate copper infrastructure is available. It provides high quality, reliable and robust broadband services. The major limiting factor of ADSL is its reach. Customers further than 5km from an enabled exchange can not be served via ADSL. Range extenders can be used to extend the reach of ADSL up to around 20km from the exchange. This is particularly an issue for service delivery in regional and rural Australia where exchanges are located in the centre of towns. Households between towns are unlikely to be able to obtain broadband services via DSL. Additionally, ADSL's ability to deliver services is dependent on the quality of copper infrastructure at the customer location.

DSL can be upgraded to ADSL2+, VDSL and SHDSL to provide services well in excess of 10 Mbps. Such higher speeds can only be provided to customers close to the exchange. Customers further than 2km from the exchange can only get speeds approximating the performance of ADSL. Additionally, while SHDSL can provide very high speeds, it is a niche application that is not commonly deployed in Australia.

Fixed wireless broadband (WiMAX and iBurst)

Fixed wireless broadband technologies both, WiMAX certified and proprietary technologies such as iBurst, are new technologies and yet to be fully proven in practice. Deployments have only just begun. These technologies are shared and are expected to provide maximum speeds of 1 Mbps to 1.5 Mbps per customer. The range achievable in rural and regional areas is still unclear, but around 15km is likely for a standard solution. There is a relationship between deliverable speed and range, and therefore at lower speeds services can be delivered to a much greater range.

Fixed wireless broadband can be deployed quickly and cheaply relative to terrestrial broadband services, but they are limited by a number of factors such as available spectrum.

Fixed wireless broadband does not compete directly with ADSL very well. ADSL is a more robust and reliable technology that has the potential to provide higher speeds to the customers. However, fixed wireless broadband can work to complement DSL deployments by providing services either outside the range of ADSL, where there is no exchange or to customers who cannot receive ADSL services for technical reasons.

WiFi

WiFi is a cheap deployment option for areas with very small populations where there are no other options. WiFi can deliver speeds of up to around 512 Kbps reliably up to a range of 5km where line of sight is possible. WiFi is therefore really an interim solution where a best efforts broadband service is required.

Broadband over powerline

Broadband over powerline is an unproven technology. It has the potential to provide up to 20 Mbps to customers via the power grid that connects all households. Commercial trials are still under way, and while the possibilities are exciting, Ovum is not able to comment further on the possibilities of BPL prior to the completion of these trials, and cannot recommend BPL ahead of other proven technology choices.

Fibre/HFC

Fibre access networks can provide up to 100 Mbps (HFC 30 Mbps) and as such are by far the leading technology in terms of capability. However, both these technologies are extremely expensive to deploy and typically only an option in CBD deployments where heavy users such as corporate customers are located.

Satellite

Satellite is an appropriate technology choice where nothing else is available. This applies to mobile, broadband and backhaul services via satellite. Satellite suffers from technical limitations such as delay and rain interference, and is very expensive for medium and heavy users. For broadband and backhaul services, satellite pricing includes high penalties for download overuse, and pricing for broadband speeds above 256 Kbps can make it a prohibitive choice.

GSM

GSM is the most deployed 2G mobile technology internationally and in Australia. It is a well understood and mature technology that is a preferred choice with mobile users due to its broad availability. Upgrades to GPRS and EDGE can enable use of GSM networks for data services at slower speeds than that available from 3G.

CDMA

CDMA is the second most deployed 2G network in Australia and internationally. Telstra's 2005 announcement to shut down the CDMA network in Australia has introduced some uncertainty into the mobile market in Australia. Operators are waiting to see the outcome of these announcements.

WCDMA

All the major mobile operators have deployed UMTS networks in Australia. Deployments to date have been in the major capital cities. Telstra has announced plans to replace the CDMA network with a WCDMA network operating at 850 MHz.. There is uncertainty in relation to the coverage that the WCDMA equipment will achieve, handsets and roaming rights for customers of alternative operators. This is introducing uncertainty in the mobile market as a whole.

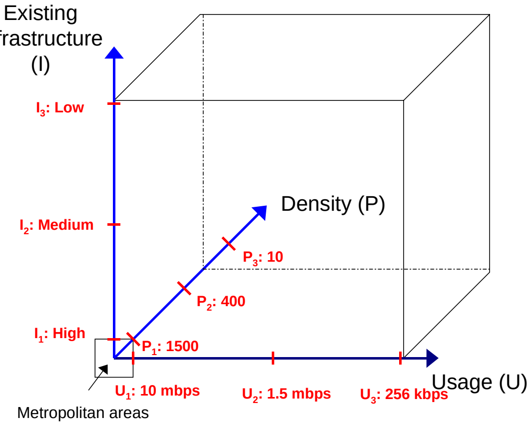
Scenario analysis

Scenario towns

Scenarios were constructed based on three factors; population, existing infrastructure and usage levels required.

Figure E2 shows the three dimensional matrix which has been used to construct scenarios for analysis.

Figure E2 **Scenario analysis matrix**



Based on the matrix above, nine towns were chosen which represent the range of likely situations in rural and regional Australia. The following towns were included in the analysis:

- Christmas Creek, Western Australia

- Leyburn, Queensland
- Innamincka, South Australia
- Tibooburra, New South Wales
- Warburton, Victoria
- Marla, South Australia
- Marysville, Victoria
- Carnarvon, Western Australia
- Wadeye, Northern Territory

Approach to scenario analysis

The scenario analysis includes an assessment of the technology choices for each scenario, a comparative assessment of all the technologies and an assessment of the cost to deploy each technology in that scenario.

The scenarios have been undertaken on the following basis:

- *Backhaul:* Backhaul requirements have been considered on a town by town basis. It should be noted that this would not be the approach taken in practice where typically new backhaul systems would be built for a whole region. Backhaul requirements for each scenario have been assessed based on the number of customers and the usage level for the scenario, and assuming a contention ratio of 50 to 1. Options for leasing backhaul have been considered in each scenario based on infrastructure available at that town in line with information provided to Ovum by DCITA[1].
- *Access technologies:* The analysis of access technologies in each scenario has been established in the context of the existing infrastructure in the town. A few of the towns do not have an exchange. In these cases we have assumed that the copper reticulation is not suitable for deployment of ADSL. Where there is already CDMA or GSM coverage, we have assumed that coverage is available to the whole town. This does not include towns where there is known to be limited or only carkit coverage.

Approach to cost analysis

The cost analysis has been designed to focus on the main elements of cost and to ensure simplicity of analysis.

For each access technology deployment the costs have been assessed based on the capital costs, operating costs and backhaul costs of providing services to that town.

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[1] Note that infrastructure information was last updated in 2001.

In order to enable comparison across technology options, the net present value of the operating costs for each deployment has been considered over 5 years. For each scenario, the backhaul costs to lease available existing infrastructure, and the cost to build new microwave point to point and fibre backhaul has been calculated. Leasing costs of backhaul have been based on Telstra's publicly available backhaul pricing.

There are a number of technologies which have not been costed. These include SHDSL, VDSL, BPL, Flash-ODPM, satellite broadband.

Technology choice analysis

In each scenario there are a range of technology options that would be suitable. The preferred choice in each case depends upon the cost requirements and usage levels. In most cases the best outcome is a combination of technologies that together will allow the greatest number of end-users in the town centre and surrounding areas to be serviced.

Figure E3 shows the towns included in the scenario analysis and those technologies which are good choices for delivery of the requirements of the scenario.

Figure E3 **Technology choices**

Town	**Usage**	**ADSL/ADSL2+**	**SHDSL/VDSL**	**WiFi**	**WiMAX/iBurst**	**Sat.**	**FTTH/HFC**	**BPL**
Christmas Creek, WA	256 Kbps			✔	✔	✔		✔
Leyburn, QLD	1.5 Mbps	✔	✔	✔	✔			✔
Innamincka, SA	256 Kbps			✔	✔	✔		✔
Tibooburra, NSW	1.5 Mbps	✔	✔	✔	✔			✔
Warburton, VIC	1.5 Mbps	✔	✔		✔		✔	✔
Marla, SA	256 Kbps	✔	✔	✔	✔			✔
Marysville, VIC	1.5 Mbps	✔	✔		✔		✔	✔
Carnarvon, WA	256 Kbps	✔	✔		✔		✔	✔
Wadeye, NT	1.5 Mbps				✔			✔

The choices are subject to cost comparison and heavily influenced by environmental and infrastructure factors in each town.

Additionally, Figure E3 shows that broadband over powerlines (BPL) is potentially suitable in each scenario. Ovum does not have evidence to suggest that BPL will not be able to deliver services to these towns, whether it can is yet to be proven. Therefore, BPL has not been recommended ahead of other proven access technologies.

Findings

Backhaul choices

The choice between leasing satellite, fibre or microwave point to point backhaul services, or building a new backhaul system depends upon what is available in the town and how far the town is from the nearest national network point of presence (POP).

Compared to satellite and microwave point to point systems, fibre is by far the preferred option for delivery of backhaul services. This is due to its greater reliability, scalability, resilience and quality of service.

The scenario analysis shows that, for towns more than 1,200 kilometres away from the nearest POP, it is generally more cost effective to lease satellite services rather than fibre or microwave. In most cases, when considered over a 5 year period, building a fibre network is viable only when very high usage levels are reached that require a 155 Mbps backhaul link. It is most unlikely that this level of usage and takeup will be achieved in medium and small rural towns in Australia in the 5 year period. Additionally, it is typically viable to build a microwave point to point link to a town in cases where a 34 Mbps backhaul link is required. While this is a much more likely case, microwave is a less effective medium for backhaul and has significantly higher operating costs than fibre, which makes it a much less desirable choice.

Broadband access technology choice

Appropriate technology choice is driven by the usage level and the aggregate demand in the town. Figure E4 shows typical choices for different usage levels considered in the scenario analysis for various town sizes. It should be noted that these choices are heavily affected by technology availability in a town.

Figure E4 **Preferred access technology choices**

		Town size		
Capacity required	**Preference order**	Small Pop: 200 or less	Medium Pop: 200 to 1000	Large Pop: Over 1000
256 Kbps	Preferred choice	ADSL	ADSL	ADSL
	Second choice	WiFi	WiMAX/iBurst	WiMAX/iBurst
	Third choice	WiMAX/iBurst		
1.5 Mbps	Preferred choice	ADSL/ADSL 2+	ADSL/ADSL 2+	ADSL/ADSL 2+
	Second choice	WiMAX/iBurst	WiMAX/iBurst	WiMAX/iBurst
	Third choice			
10 Mbps	Preferred choice	ADSL 2+	ADSL 2+	ADSL 2+
	Second choice	BPL[2]	BPL[2]	Fibre
	Third choice			BPL[2]

This analysis shows that for DSL, WiFi, WiMAX and iBurst, FTTH, and BPL the following generalisations can be made about where each technology is best applied.

- *DSL*: At 256 Kbps, 1.5 Mbps, and 10 Mbps, DSL (ADSL, ADSL 2+ and VDSL) is the preferred choice where possible. Service availability for DSL is limited by distance from the exchange and quality of the copper infrastructure. Range extenders should be applied where possible.
- *WiFi:* In very small towns, particularly where DSL is not available WiFi is a cheap and effective choice. WiFi is not an option where there are more than about 50 customers and is best suited to delivering up to 512 Kbps. Scalability beyond these levels is an issue.
- *WiMAX and iBurst:* WiMAX and iBurst provide greater coverage than DSL and are good choices for small, medium and large towns for 256 Kbps and 1.5 Mbps, but cannot provide services at 10 Mbps. These technologies are likely to be best suited to medium and large towns due to cost.
- *FTTH:* FTTH is unlikely to be viable at all without a major source of aggregate demand such as government organisations or a large business. However it is the only proven option in towns where DSL is not possible for delivery of 10 Mbps.

[2] BPL has been included in Figure E4, as it is a technology option considered in this study. BPL is an unproven technology and therefore it cannot be recommended ahead of other technology options

- *BPL:* BPL has the potential to compete with ADSL for ubiquitous delivery of broadband services. Currently, BPL is not a proven technology, and despite it's potential to deliver higher bandwidth than ADSL and WiMAX for example, we cannot recommend it ahead of other proven technology options at this stage.

A clear outcome of the analysis is that delivery of 10 Mbps to small towns where DSL cannot be deployed is unlikely on a cost effective basis.

Mobile access technology choice

Mobile access technology choice in rural and regional Australia is heavily affected by Telstra's CDMA and WCDMA plans.

Deployment of CDMA in towns where it is not available is not viable given Telstra's plans to shut down the CDMA network. GSM services are more widely used than CDMA, and GSM therefore is probably a preferred choice for end-users. Additionally, GSM is not affected by Telstra's network deployment plans. Whether GSM is a deployment choice for a town depends on whether there is a GSM network anywhere near the town in question. If there is no GSM network anywhere near the town of the scenario, there is little point in deploying GSM.

Telstra has announced plans to deploy WCDMA across Australia utilising existing CDMA towers. There is some uncertainty about whether existing CDMA infrastructure (such as towers) can be utilised without further tower building cost for deployment of a WCDMA network. Telstra's vendor claims that the WCDMA equipment will have the same footprint as the current CDMA equipment deployed by Telstra. Deployment of WCDMA technologies in rural and remote areas by other operators will depend on whether roaming onto the Telstra network is available to their customers.

Broadband data applications are available at slow speeds on GSM networks upgraded for GPRS and EDGE. Current developments in cellular network technologies are producing mobile network elements and devices capable of delivering broadband speeds which can compete with wireless broadband technologies such as WiMAX and iBurst. HSDPA deployments in the USA, for example, can deliver 400 to 700 Kbps. Telstra's deployments of HSDPA are capable of 3.6 Mbps, however this is based on speeds in a laboratory testing environment. HSUPA, which is not yet deployed, is expected to deliver around 5.8 Mbps (uplink). The availability of handsets which can deliver these speeds is a key limitation currently. However, vendors are expecting that cellular technology developments will continue to enable faster speeds to mobile devices.

Market considerations

Dynamic competition in rural and regional Australia will continue to be limited until problems relating to the availability and pricing of backhaul services are improved.

- *Backhaul availability* – In many cases fibre and microwave point to point services are available.

- *Backhaul pricing* – Particularly where towns are a considerable distance from the nearest POP, backhaul pricing is not cost related and priced well above what is considered commercially reasonable.
- *Telstra's market response* – There are many examples of Telstra's competitive response to alternative operator deployments in rural and regional Australia. This results in a major disincentive for competition in broadband and mobile infrastructure in rural and regional areas where demand levels are often low.

The planned closure of the CDMA network is resulting in market uncertainty. Much of the remote areas of Australia only have access to CDMA and it is unclear whether WCDMA equipment at 850 MHz will be able to provide the same coverage footprint across Australia. Telstra is expecting that the same coverage will be possible, although it may be at considerable cost to Telstra due to adjustments that will be required to standard WCDMA equipment. Whether the same coverage is achievable by WCDMA, shutdown of the CDMA network will leave many CDMA users with assets that are unusable.

Roaming between GSM and WCDMA is technically possible; this is part of the WCDMA standard. Whether customers can roam is limited by what handsets they are using, a GSM only handset cannot roam onto a WCDMA network for example. Additionally, utilisation by Telstra of the 850 MHz band for WCDMA services will allow Telstra to obtain large ranging coverage from the WCDMA equipment, but it will mean that the handsets available for customers over the next 2 or 3 years will be limited and most likely expensive.

Funding considerations

The Connect Australia funding program offers the opportunity to make a step change in the scale of government funded programs in rural and regional Australia. As such, the focus must be to support projects of greater scale that can improve and deliver services and competition to whole regions.

The funding structure can affect the technology choices made by operators deploying infrastructure. The focus of the funding structure must be on ensuring the optimum outcome for end-users, rather than the operator, and to be as flexible as possible. For example, funding criteria that is only structured on a per end user deployment cost may result in a biased technology choice. This will lead to failure to adopt technologies that are capable of catering for additional users and increased capacity. Funding for access technologies to a customer should be assessed on a town by town basis.

There are a number of issues relating to funding that are relevant to backhaul. The cost of leasing backhaul is a major component of the cost of providing services to rural and regional areas. It takes the form of an annual operating cost. Government funding tends to focus on providing one off capital funding contributions. Funding procedures need to explicitly address ongoing costs such as backhaul.

2 Introduction

2.1 The Connect Australia Program

On 17 August 2005, the Government announced the $1.1 billion Connect Australia package, with funding dependant on the passage of legislation enabling the sale of the Government's remaining shareholding in Telstra. On 15 September 2005, legislation enabling the Telstra sale passed in Parliament, with related Acts receiving Royal Assent on 23 September 2005.

Funding for Connect Australia includes:

- $878.0 million for Broadband Connect;
- $113.4 million for Clever Networks;
- $29.5 million for Mobile Connect; and
- $89.9 million for Backing Indigenous Ability.

2.2 Terms of reference

2.2.1 The Services

The consultancy involves the analysis of potential communications technology developments that can be used to improve the sustainability of solutions implemented through the *Connect Australia* programs. Specific tasks are to:

(a) identify and describe the effect of communications technologies likely to be developed and available in the Australian market over the next three to five years that would be relevant to *Connect Australia* programs, with particular regard to the:

> (i) extent that such technologies may relate to particular demographics, eg. remote communities,
>
> (ii) timeframes for likely roll out of technologies to particular geographic locations,
>
> (iii) potential use of common infrastructure to deliver fixed broadband and mobile telecommunications in regional Australia,
>
> (iv) likely impact of investment in next generation networks,
>
> (v) likely cost structures for establishing and operating the infrastructure and services, and likely strategies for pricing to consumers,
>
> (vi) impact on competition in service provision,
>
> (vii) emerging issues in demand and applications;

(b) analyse viewpoints and input from governments (Australian, state, territory, and local), communications service providers and carriers, industry associations, regional business representatives, rural representative organisations and academia; and

(c) advise on the potential capabilities and implications of the identified technologies generally, and in regard to *Connect Australia* programs.

2.3 Scope of the report

In this report, Ovum has addressed the terms of reference above.

The body of the report, contains analysis of the mobile and broadband technology options including:

- Existing service availability in rural and regional Australia
- Operator infrastructure investment plans
- Market analysis including demand and competition considerations
- Pricing strategies of operators in Australia
- Mobile and broadband technology options according to the criteria set by DCITA and Ovum

The final part of the report presents scenario analysis of nine Australian towns.

3 Ovum's methodology

3.1 Analytical approach

Our approach to the technology pathways for Connect Australia consultancy project has been to undertake the following analysis:

- *Market analysis:* Using existing Ovum research and expertise, DCITA documents, consultation papers and interviews with stakeholders
- *Assess technologies:* We have assessed possible technology options for delivery of broadband and mobile services.
- *Scenario analysis:* Scenario analysis has been undertaken for nine towns in rural and regional Australia.

3.2 Market analysis

We have undertaken market analysis of the mobile and broadband markets in rural and regional areas of Australia. The market analysis has been undertaken utilising existing information available from Ovum and DCITA and stakeholder interviews. Figure 3.1 lists the stakeholders interviewed.

Figure 3.1 **Stakeholder interviews undertaken**

Organisation type	**Organisation**	**Organisation type**	**Organisation**
Academic	Leith Campbell	Equipment provider	Extel
Academic	Reg Coutts	Equipment provider	Alcatel
National Telecoms Operator	Optus	Equipment provider	NEC
National Telecoms Operator	AAPT	Satellite provider	Ipstar
Regional Telecoms Operator	Internode	Satellite provider	Globalstar
Regional Telecoms Operator	BroadbandNet	Satellite provider	AUSTAR
State Government	MultiMedia Victoria	Utility provider	TasTel
State Government	State Gov't of SA		

Telstra was invited to be interviewed but declined.

The market analysis includes assessment of:

- Infrastructure and service availability in mobile and broadband markets
- Competition in rural areas

- Mobile and broadband demand
- Pricing strategies

3.3 Technology options

Assessment of technology options available for delivery of mobile and broadband services was undertaken. Figure 3.2 shows the technologies that have been examined in this study.

Figure 3.2 **Technology choices**

DSL: ADSL, ADSL 2+, SHDSL, VDSL	Radio point to point
Satellite	GSM
Fibre/HFC	Broadband wireless access: WiMAX, iBurst
Broadband over Powerline	Flash OFDM (Flarion)
HSDPA	CDMA
WCDMA	WiFi

Each technology has been described according to the following characteristics:

- Technology: what it is and how it works
- Maturity (including deployment timing considerations and technically fully proven)
- Open standards
- Bandwidth and range limitations
- Scalability and costs of scaling for higher speeds
- Deployment, operational and maintenance costs
- Existing base of infrastructure and issues for NGN investment
- Issues for competition, demand and applications

The limitations and benefits for rural and regional Australia for each technology were assessed.

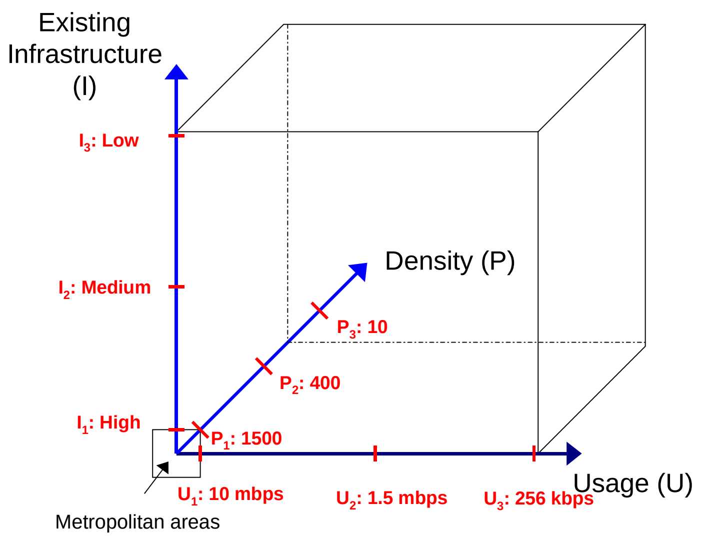
3.4 Scenario Analysis

Scenario analysis has been undertaken for scenarios which represent typical situations in rural and regional Australia. We have tested the suitability of each technology in each scenario and identified a preferred option in the context of those scenarios.

3.4.1 Choosing scenarios

The scenarios used in this analysis have been based on three dimensions, existing infrastructure, population density, and usage. These factors provide a representative picture of the different situations in the Australian market. Figure 3.3 shows the three dimensional framework which has been used for selection of scenarios.

Figure 3.3 **Three dimensional scenarios**



In Figure 3.3, levels of existing infrastructure, I_1, I_2 and I_3 correspond to:

- I_1 - High: Fully copper wired, major backhaul, connected to trunk routes, availability of switching mode results in fairly short loops
- I_2 – Medium partial copper wired, reasonable backhaul available, longer loops
- I_3 - Low: Backhaul by thin routes which could be based on radio platforms, poor copper wire infrastructure

Similarly, levels of population density, P_1, P_2 and P_3 in Figure 3.3 correspond to:

- P_1 – 1500 households per km^2. Similar to large towns.
- P_2 – 400 households per km^2 . Medium and smaller towns.
- P_3 – 10 households per km^2: Isolated townships, very small towns.

From all the possible scenarios, 9 scenarios were selected that provide a sample of representative scenarios of the range of possibilities for towns in rural and regional Australia.

3.4.2 Scenario towns

Figure 3.4 shows the scenarios that have been selected for analysis. These towns have been chosen as their characteristics matched their individual scenarios.

Figure 3.4 **Selected scenarios**

Scenario number	**Population density**	**Existing infrastructure**	**Usage**	**Town**
1	P_3	I_3	U_3	Christmas Creek Aboriginal Community, Western Australia
2	P_3	I_3	U_2	Leyburn, Queensland
3	P_3	I_2	U_3	Innamincka, South Australia
4	P_3	I_2	U_2	Tibooburra, NSW
5	P_2	I_2	U_2	Warburton, Victoria
6	P_2	I_2	U_3	Marla, South Australia
7	P_1	I_2	U_2	Marysville, Victoria
8	P_1	I_2	U_3	Carnarvon, Western Australia
9	P_1	I_3	U_2	Wadeye, NT

3.4.3 Technology choice analysis

For each scenario, we identified and assessed suitable technology choices for the town. The scenario analysis includes an estimation of the cost of deployment for each technology, a comparative assessment of all the technologies for the town and an assessment of the technologies that are best suited to provision of services in each town. Figure 3.5 shows the criteria used to undertake the comparative analysis for each scenario.

Figure 3.5 **Comparative analysis framework**

Criteria	Question	Outcome
Suitability	Does it meet the range requirements of the scenario?	Yes or no
	Does it meet current bandwidth capacity requirements?	Yes or no
	Is it scalable?	Yes or no
	What is the scaling cost?	High, medium or low (Note 1)
Maturity	Has it been proven in operation elsewhere?	Yes or no (Note 2)
	Are there reference cases in rural and regional Australia?	Yes or no
	Where is it placed on the cost volume curve?	Beginning, middle, end (Note 3)
Timing	Is it available for deployment this year as an operating technology?	Yes or no
	Is it available in sufficient quantities to meet likely requirements?	Yes or no
Issues for NGN investment	Is the technology likely to be forward compatible with the requirements of an NGN (IP-based) network?	Yes or no (Note 4)
Demand and competitive pressure	Are the customers locked into one service provider?	Yes or no
	Is there a wide range of customer handsets? (mobile only)	Yes or no

Notes:

1. The continuum, high, medium and low will be assessed in relation to the cost of the original installation. If scaling requires a high percentage of cost replication, it will be assessed as 'high' on this continuum.
2. We will weight positively evidence of operational maturity and robustness.
3. These phases broadly equate to initial production, widespread adoption, and mature/late life production.
4. Although we are seeking binary answers, there may be shades of compliance here. The main aim is to avoid investments in stranded assets.

3.5 Costing analysis

We have not attempted to build costs on an engineering basis. This cost assessment is an estimation, and therefore should be considered on this basis. The approach has been to maintain simplicity in the calculations as much as possible and focus on the core drivers of cost in each scenario.

The costing uses information provided by DCITA to Ovum for each scenario town including:

- Availability and type of backhaul
- Availability of GSM and CDMA services
- Availability of ADSL and wireless services

Based on this information Ovum has made assumptions for each technology in order to estimate cost. Costing assumptions are shown in Annex 2.

For each scenario, the bandwidth required for broadband services has been considered at the usage level set for that scenario. That is, 256 Kbps, 1.5 Mbps, or 10 Mbps. The scalability of the technology options in each scenario was assessed by looking at the technology options available if capacity is required at the next level up.

4 Infrastructure and service availability

4.1 Existing infrastructure

This section identifies the nature and availability of broadband, mobile and backhaul services in Australia.

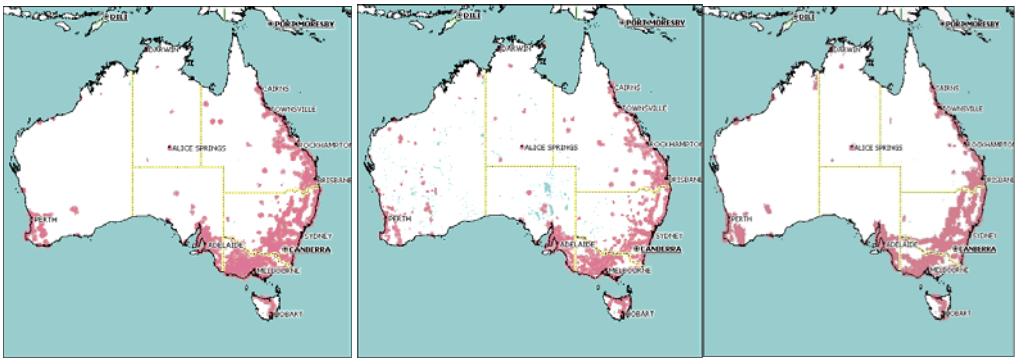
4.1.1 Broadband infrastructure

ADSL, cable and/or wireless broadband are available over much of the east coast of Australia. As would be expected, there is less broadband accessibility in the less densely populated central, northern and western areas of Australia. The most dense areas of broadband infrastructure availability are along the east coast[3].

4.1.2 Mobile infrastructure

There is mobile coverage over the whole of Australia, although much of this is through mobile satellite. Figure 4.1 shows the GSM coverage of Telstra, Optus and Vodafone.

Figure 4.1 **Optus, Telstra and Vodafone GSM coverage**



Optus Telstra Vodafone

Source: GSM Association

The GSM network covers most of the east coast, Perth and its surroundings on the west coast, and small pockets of the Northern Territory.

Telstra's CDMA service covers an extended area of Australia, but much of the north and west of Australia that have small populations and are remote from the capital

[3] In more populated areas more than one access technology choice is typically available.

cities are not able to access either network. These areas are covered by mobile satellite only.

Telstra, Optus and Globalstar offer satellite mobile phone services over the whole of Australia.

4.1.3 Existing backhaul infrastructure

There is backhaul coverage over most of Australia. Companies including Telstra , Optus and Agile Communications have backbone networks that extend to many or all of the capital cites. Their main purpose is the delivery of traffic between capitals and very large regional cities.

Telstra is very often the only provider of backhaul coverage beyond the backhaul links between the capital cities. Most of the backhaul is available in areas such as the east cost of NSW, Victoria and Queensland where there is greater population density and shorter distances between towns. More remote areas such as the Northern Territory, northern South Australia, and mid and northern Western Australia are served by only very limited backhaul services. In these areas the only technologies available are often satellite and HCRCS.

Figure 4.2 shows the Optus network. The backbone is made up of links between capital cities.

Figure 4.2 **Optus network**

Source: Optus

4.2 Use of common infrastructure

4.2.1 Mobile network

There is a strong mobile reseller/MVNO market in Australia. As at September 2005, wholesale subscribers, that is, subscribers using services through a retail provider that is not Optus or Vodafone, comprised 19% of Optus subscribers and 9% of Vodafone Australia's customer base.

Inter-roaming agreement exists between operators. GSM subscribers of 3 Australia can roam onto the Telstra's GSM network when they are outside 3 Australia's coverage areas. There is a similar agreements made between Vodafone and Telstra for GSM services. Arrangements also exist for CDMA. For example, customers of Orange, which owns CDMA networks in some metropolitan areas, can roam onto the Telstra CDMA network when they are outside the Orange coverage area.

Telstra's plans to shut down their CDMA network have led to questions from operators concerned about the availability of roaming on the 3G network following the CDMA shut down. Telstra has indicated an intention not to make roaming available on the 3G network.

The accessibility of the mobile networks for outsiders depends upon the level of competition and the operator attitude. This can differ markedly between metropolitan and regional areas. There have been problems for new operators to access mobile networks at an acceptable commercial rate. For example, the mobile satellite provider Globalstar was interested in providing mobile services to Dubbo by building a satellite station with base stations locally in Dubbo and enabling roaming through the CDMA network outside of that area. However Globalstar was unsuccessful in negotiating access to AAPT's CDMA spectrum at a commercial rate acceptable to Globalstar, and was therefore unable to deliver services to Dubbo on this basis.

Roaming

Roaming between GSM and WCDMA technologies is technically possible and it is one of the requirements of the WCDMA standard. The ability of customers to roam across networks depends on commercial agreements allowing the customers of one operator to roam onto the network of another operator. Even where there is an obligation to provide roaming to other operator's network as part of the requirements of public funding, unless the rates are commercially attractive the other operators will not take up their roaming rights.

Handsets will also limit the capacity for roaming. Telstra's planned rollout of WCDMA at 850MHz is driven by the desire to achieve better coverage by using the lower spectrum band. WCDMA handsets at this spectrum band are currently not produced on volume. So while Telstra customers with the special handsets will be able to roam onto GSM at 900 and 1800MHz, the customers of the other operators will not be able to roam onto WCDMA at 850MHz unless there is a roaming agreement in place and they have purchased one of the special handsets.

4.2.2 Broadband network

There is a high level of wholesale and ULL activity in Telstra's DSL network. This is mostly confined to the urban areas. In rural and regional Australia, there are pockets of wholesale and ULL activity, typically in major regional towns. This makes sense given that metropolitan areas and major regional towns are the most densely populated with demand levels that can provide a return on investment.

Telstra ULL pricing, which until recently priced remote/rural areas at $100, also reduced the attractiveness of regional Australia to alternative operators. Since February this year Telstra has been charging $30 for remote/rural areas, which is above the common entry level price for broadband of $29.95.

Apart from DSL, there are no other fixed broadband networks which wholesale to alternative operators. Wireless broadband is available in some towns, but these are not provided using common access infrastructure.

4.2.3 Backhaul

As Telstra owns much of the only available backhaul in regional areas, many operators share the backhaul. For operators serving rural and regional Australia, the problem is often not lack of access to broadband infrastructure, but the cost of access. In rural areas away from the main network of backhaul linking capital cities, and especially where Telstra is the only provider, backhaul is typically priced at a level which reduces the attractiveness of the business case. While backhaul is a declared service, its pricing is not regulated. As Telstra is the only operator with backhaul in a lot of regional and rural Australia, there is no competitive pressure to lower its pricing.

The pricing of backhaul, and its relationship with broadband access outside metropolitan areas, was a common theme among stakeholders at interview. All operators interviewed said that one of the major limitations on competition in rural and regional areas was the price of backhaul available to smaller players. One stakeholder commented that backhaul was a major challenge to their business case as the further away from the capital cities they went, the harder it was to get backhaul at an acceptable price.

4.3 Infrastructure investment plans

4.3.1 Telstra

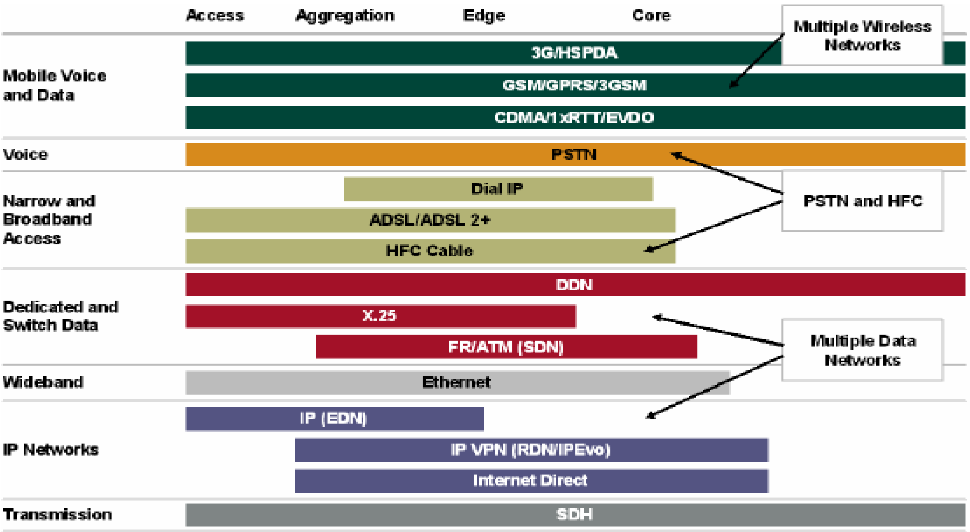
In November 2005 Telstra announced the results of its strategic review. Telstra is building its strategy around three core points:

- IP – to achieve lower operational costs,
- A simplified network strategy (one-factory approach) of integration,
- A simple, seamless convergence of services for customers, based on micro-segmented, highly targeted value propositions.

As part of this review Telstra announced significant plans for its mobile network and the build-out of a next-generation-network (NGN). In essence, Telstra plans to run a single 3G network (shutting down its CDMA network) and an IP based NGN incorporating FTTN. Much of these plans are dependent upon the regulatory environment in place. Telstra has now placed these plans on hold, with the exception of the mobile network, until it achieves a 'reasonable regulatory outcome'. By this, Telstra means that new investments should not be subject to the existing access regime, under which competitors may obtain access to wholesale services and infrastructure at regulated rates. In the interim, pending resolution of this stand-off, Telstra has upgraded its cable network.

Figures 4.3 and 4.4 shows an overview on the proposed changes to the existing network. Currently Telstra has 400 network platforms, over 1,000 products, 1,200 business/operational support systems and multiple mobile, fixed and data networks.

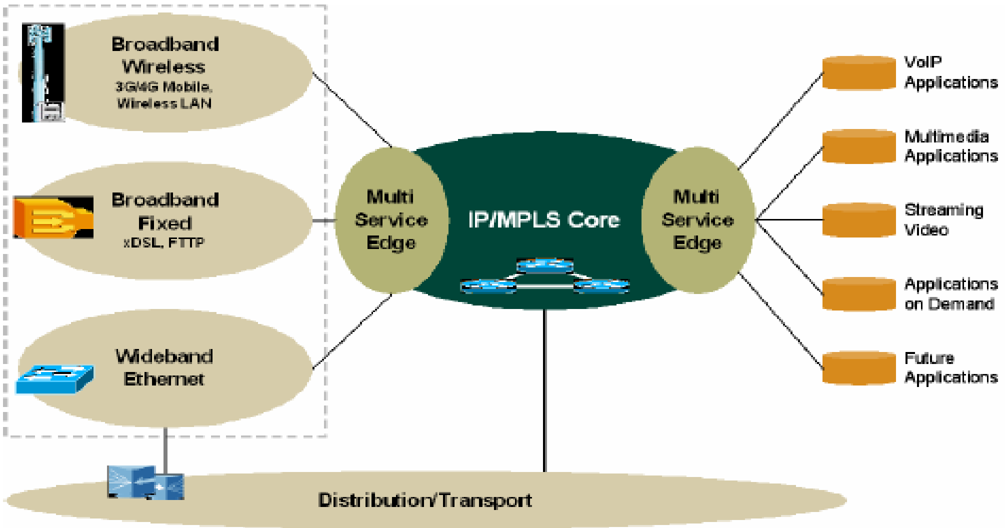
Figure 4.3 **Current Telstra network**



Source: Telstra Strategic Review, Lehman Brothers (2005)

Figure 4.4 shows the proposed Telstra network. The number of technologies, platforms and systems are greatly reduced.

Figure 4.4 **Proposed Telstra network**



Source: Telstra Strategic Review, Lehman Brothers (2005)

Telstra is planning to complete this overhaul within a five year timeframe. Given that this plan requires a complete re-engineering of its networks, systems, processes, services and customer proposition and that the level of integration required to achieve the sophisticated customer relationship system envisioned is very high, actual execution of this strategy will be a difficult challenge.

Next-generation network build-out

The next-generation build-out for Telstra is focused on unifying disparate components of the network, streamlining platforms and technologies and ultimately saving money.

MPLS core

Currently there are separate cores for Internet and business. The new network will have a single IP-MPLS core.

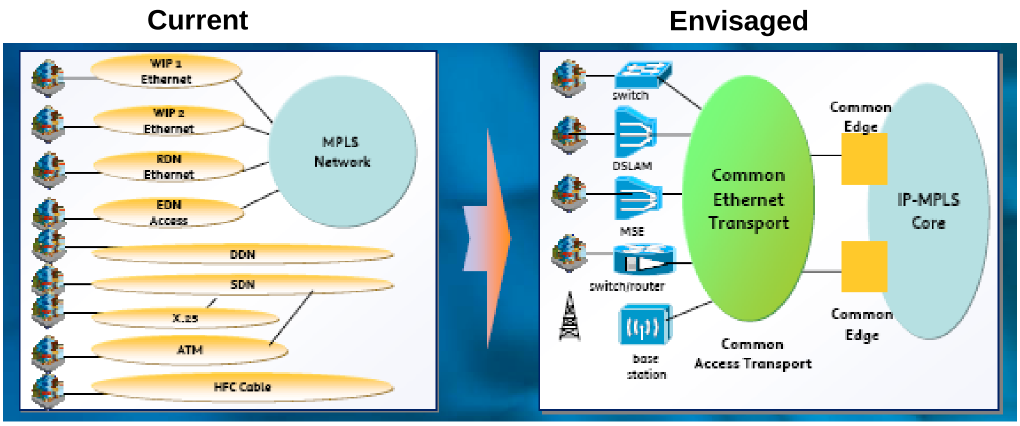
Multi-service edge

Telstra plan to remove the separate edge and core for ATM/Frame Relay and IP VPN services. Telstra will build a common, multi-service edge. Capacity of the platform will increase from 60 to 400 Gbps.

Ethernet distribution

There are currently nine different types of distribution networks. Telstra intends to provide a common Ethernet transport network as part of its build-out. This is expected to increase capacity from 40 Gbps per node to 160 Gbps per node. Figure 4.5 shows the change envisaged by Telstra.

Figure 4.5 **Ethernet**



Source: Telstra Strategic Review (2005)

Access

All of fixed services within the upgrade footprint will be migrated onto a Multi-Service Access Network with an IP core. Telstra plans to progressively roll out softswitch infrastructure to transit from the PSTN core network. Ten high capacity soft switches will replace 116 class 5 switches. This transition may take up to five years. Approximately half of Telstra's customers will then be served from softswitches.

FTTN

Telstra announced a three year plan to roll out FTTN in five major Australian cities at it November 2005 briefing. These cities were not named specifically, but we assume it to be the five largest cities: Sydney, Melbourne, Brisbane, Perth and Adelaide. Telstra states that this equates to 4 million addresses. It is expected that the upgrade will allow Telstra to offer speeds of up to 12 Mbps.

As part of this deployment, 450 exchanges will be upgraded and there will be 20,000 FTTN deployments. Telstra will also condition the network. 7,500 pair gain systems will be removed as well as other broadband blockers such as loading coils. Two thirds of customers will be served by FTTN with the remainder to be served by DSLAMs. Additionally, FTTP will be deployed in greenfield estates.

Impact of the NGN

The impact of the NGN on the Australian telecommunications market is largely dependent upon the regulatory environment. The ability of alternative operators to access the new network will affect market structure and competition levels.

Open access to NGN

Should the NGN go ahead and other operators have access to Telstra's NGN, the major impact will be for consumers. Faster speeds will then be available to consumers from a range of providers. Competition will likely continue at current levels. The ULL arrangements will determine whether there is a move back to wholesaling for alternative operators.

Closed access to NGN

Should alternative operators not be able to access Telstra's NGN, it is expected that there would be stronger impetus to build or extend alternative networks. It would be difficult to compete with a fibre network, given the economies of scope and scale entailed, and there would be a real risk of re-monopolisation.

Copper network

Regardless of which outcome occurs, a central question remains – what will happen to the copper network. Alternative operators across Australia have recently made significant investments in ULL infrastructure and will be loath to see it go to waste, either because it is no longer feasible due to the structure of the network or because Telstra is no longer required to maintain the copper network. The future of the copper network and ULL will be an important factor in the impact of a NGN in the Australian telecommunications market.

As Telstra has announced its plans are on hold, and the Minister has not shown any sign of implementing a more favourable regulatory ruling on access to the network, the future of a NGN and its impact on the market is uncertain.

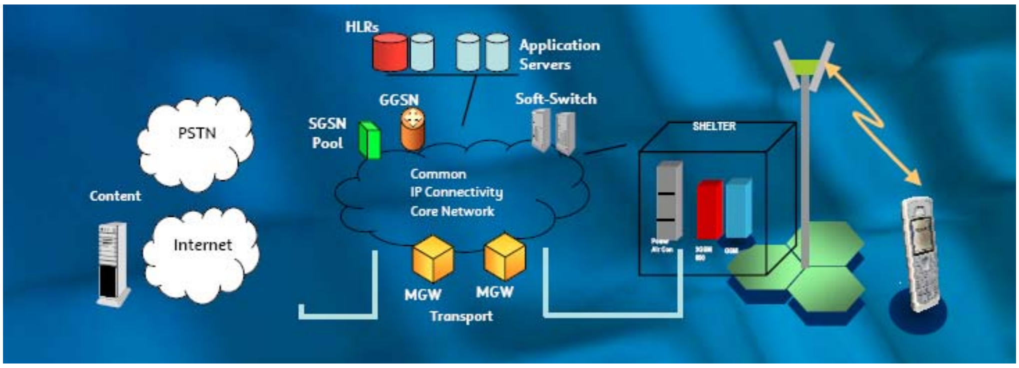
Cable upgrade

Telstra recently announced that it had upgraded its copper network. Trial users could access download speeds of up to 17 Mbps, significantly faster than the current cap at 8 Mbps. Telstra plans to offer faster broadband cable plans in March 2006 for $10 more per month than current prices. The upgrade was based on the DOCSIS 1.0 standard.

Mobile infrastructure

Telstra currently has three networks (CDMA, GSM and WCDMA) with three core switching systems. Telstra plans to upgrade this into one network with one soft-switch based core. The operator has announced plans to progressively shut down the CDMA network and only utilise the GSM and WCDMA network. Telstra will build out additional WCDMA coverage at 850 MHz, the same frequency band as CDMA. Figure 4.6 shows the envisaged network.

Figure 4.6 **Envisaged WCDMA network**



Source: Telstra Strategic Review (2005)

Telstra is planning to not only ensure that the WCDMA 3G network provides at least the same coverage achieved by the combined GSM/CDMA network, but to also extend the current coverage, fill in blackspots, and improve in-building coverage and national highway coverage. Telstra expects to launch its WCDMA 3G network with HSDPA nationally by the end of 2006. WCDMA at 850 MHz will be deployed in over 5,000 base stations. The wider reach of the lower frequency 850 MHz gives it a large advantage over the traditional WCDMA 2 GHz deployments. Telstra plans to utilise the current regional CDMA base stations and antennas, claiming they can use the same frequency and have similar distribution patterns.

Telstra expects to deploy base stations with 161 kilometres extended cell range in the first half of 2007 with 200 kilometres extended cell range in the last half of 2007. Currently WCDMA has in-built timing limitations that define maximum coverage from a base station. Telstra will work with its equipment supplier, to alter standards and extend coverage. Similar limitations were overcome to achieve large cell-site coverage in CDMA rollout. Telstra's vendor has promised to enable 161 kilometres by the end of 2006 and 200 kilometres by the end of 2007. It is uncertain whether this goal is achievable.

CDMA will be retired over 2008 but will be available until replacement services are available at the same or better standard.

Handsets

Terminal availability for WCDMA850 is uncertain. However, Telstra is confident that it will have many handset options available. Telstra claims that 850MHz capability is already incorporated into chipsets. Telstra is also confident that vendors will include 850MHz capabilities and that devices will support WCDMA at 2GHz and 850MHz. Sierra Wireless and Novatel Wireless are already producing data cards that support WCDMA in the 850MHz band.

However, what devices will be available is currently uncertain, and for production of well priced handsets more scale will be required. WCDMA at 850MHz is believed to be gathering momentum. Before Telstra, Cingular (with 52.3 million users) was the only operator that had announced a plan to deploy WCDMA at 850MHz. Telstra, however, claim that at least ten other carriers have put out requests for information for devices at 850MHz, and believe that handsets will be a ‘non-issue’.

In December 2005, Nokia launched the first WCDMA/HSDPA handset for the US. We currently know that Ericsson Mobile Platforms plans to launch a WCDMA/HSDPA solution for 850MHz handsets in 2006. Sharp has also worked on WCDMA handsets in the 850MHz band, and Motorola has released the A845, which supports WCDMA850 and GSM1800. However, none of these handsets fulfil Telstra's exact needs. It will require a multi-mode GSM900/1800MHz and WCDMA850/2100MHz handset. Vendors' promises often require extended timeframes, and we doubt these handsets or Telstra's plans will eventuate as quickly as it has proposed. However, if handsets do not become available in the short term, we have no doubt they will be available long term. Operators moving from GSM and other technologies will deploy WCDMA and subsequent revisions at 850MHz. NTT DoCoMo is one such operator that will close its PDC network in 2010 and hopes to deploy extensive WCDMA at 800MHz. Additionally, since there is no guarantee that all WCDMA devices will include 850MHz, it is questionable whether device costs will be equivalent to those of other WCDMA devices.

4.3.2 Other telecoms operators

There are various planned investments across Australia by alternative operators. The main focus is on installing DSLAMs and utilising Telstra’s copper network. Other small operators are rolling out wireless networks in regional areas.

Fixed broadband

There has been strong activity from many different Internet Service Providers in the area of DSLAM rollouts. Most of this activity has been centred on metropolitan areas.

Optus, the second largest fixed operator in Australia, is planning to invest in a DSLAM rollout. The operator is planning to install DSLAMs and fibre connections from the exchanges back to the main Optus network. This is expected to be an investment in excess of $150 million and reach an additional 2.9 million households and businesses, including Adelaide, Perth and Canberra. Optus also has a strong presence in regional Victoria and, through a partnership with the State Government, Queensland. To date, Optus has rolled out DSLAMs and fibre to 70 exchanges. This is expected to reach 100 by April 2006.

Other operators have also installed DSLAMs into Telstra’s infrastructure. iiNet has installed around 200 DSLAMs into Telstra exchanges nationally. Internode has installed, is installing or is planning to install, 64 DSLAMs into Victoria, New South Wales, Queensland and South Australia, with the majority of installations in Adelaide.

WestNet, a Western Australian regional ISP, has also installed DSLAMs nationally with more deployments planned.

In Tasmania, Aurora Energy is trialing Broadband over Powerline (BPL) technology. The technical trials have suggested that BPL can achieve download speeds of 20 Mbps for customers. A commercial trial began in September 2005 which is expected to conclude in March 2006. Currently Aurora has targeted four suburban areas of Hobart. Other areas will be announced as the trial is expanded.

Wireless broadband

There are a variety of operators using different technologies to extend existing wireless broadband networks throughout Australia. For example, iBurst is extending its coverage using proprietary ArrayCom Intellicel technology. Unwired will be extending its coverage by deploying WiMAX in metropolitan Melbourne.

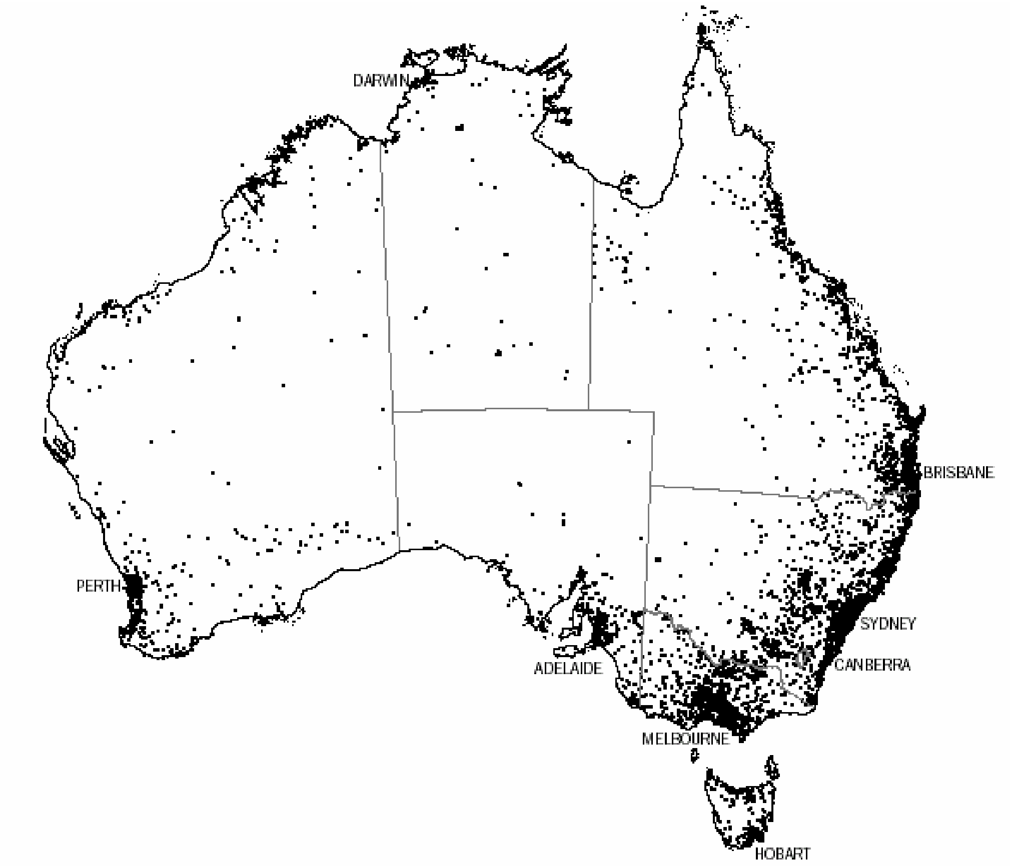
Austar, the regional Pay TV provider, is deploying WiMAX in its coverage area. Austar is in the early stages of rollout using a Navini NLOS solution. Navini is a TDD technology and can provide service up to 8 kilometre from the base stations, although 3 kilometre is a more typical range. The CPE used by Austar can deliver 2 Mbps/1 Mbps speeds depending upon the location of the base station. The base stations can deliver 4.5 Mbps per sector and Austar have modelled for 300 customers per sector. Bandwidth will not be dedicated to any one customer.

5 Mobile and broadband markets

5.1 Rural and regional demographics

Figure 5.1 shows the population distribution in Australia. Australia's population is concentrated on the east coast of the continent and particularly in major cities and towns. However there are also small spots of populated areas spread across Australia.

Figure 5.1 **Population distribution in Australia**



Source: Australian Bureau of Statistics

The rural population of Australia has been stabilising over the last three decades. In 1911, 43% of Australians lived in rural areas. By 1976 this had reduced to 14% of the population. The percentage of the population living in rural areas has hovered around this point since that year.

The ABS lists 38 major population centres of Australia, including the capital cities. Five cities, Sydney, Melbourne, Brisbane, Adelaide and Perth, have populations of over 1 million. Figure 5.2 outlines the population distribution in the 38 major population centres.

Figure 5.2 **Major population centres in Australia**

Population	<50,000	50,000 to 100,000	100,001 to 500,000	> 500,000	Total
Number of cities	8	15	10	5	38
Percentage of total	21%	39%	26%	13%	100%

Source: Australian Bureau of Statistics

The majority (66%) of major population centres in Australia have populations between 50,000 to 500,000.

Figure 5.3 shows the proportion of the population in major cities, regional areas and remote areas by state. The Northern Territory has the highest proportion of remote and outer regional populations. Tasmania also had a high percentage of its population in outer regional areas.

Figure 5.3 **Australian population by state**

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Major cities	71.4%	73.5%	52.5%	71.8%	70.6%	0.0%	0.0%	99.8%
Inner regional	20.6%	21.2%	25.9%	12.5%	12.4%	63.7%	0.0%	0.2%
Outer regional	7.3%	5.2%	17.7%	11.7%	9.7%	34.0%	54.2%	0.0%
Remote	0.6%	0.1%	2.5%	3.0%	4.7%	1.8%	21.0%	0.0%
Very remote	0.1%	0.0%	1.4%	1.0%	2.6%	0.5%	24.8%	0.0%

Source: Australian Bureau of Statistics

5.2 Competition in rural areas

5.2.1 Typical competition limiting factors in rural and regional Australia

There is limited mobile and broadband competition in rural and regional Australia. There is really no wireline competition, but small wireless operators are appearing in the larger towns. However this is often a cherry picking exercise. The reason is simple: lack of a business case. Many stakeholders have commented that without additional funding there is no business case for entering the regional and remote areas of Australia. The existing competition in these areas is, not surprisingly, present in the more affluent and densely populated areas of regional Australia. For example, Optus has a ULL presence in much of rural Victoria and Queensland and an estimated market share of 30% of rural Australia. Other operators such as AAPT have no infrastructure in rural and regional Australia, but do operate as resellers of Telstra's DSL network.

5.2.2 Telstra and the cost of backhaul

The major negative impacts on the business case for alternative operators, and consequently competition in rural and regional Australia, are

- the cost of backhaul, and
- Telstra's market response.

Cost of backhaul

Many stakeholders, including Austar, Internode, and AAPT, have commented that often the only backhaul available in rural and regional areas is owned by Telstra and priced at non-competitive rates. They argue that one of the fundamental problems of serving regional and rural areas in Australia is the cost of backhaul. One vendor estimates that backhaul for an ADSL DSLAM amounts to 37% of the cost per customer. An operator estimates that 60% of costs relate to backhaul. This means that expensive backhaul will seriously impact the business case for many regional areas in Australia. AAPT, for example, considered building its own CDMA network, but backhaul prices made this impossible. Internode built a microwave point to point network on the Yorke Peninsula to avoid high backhaul costs from Telstra.

The cost of backhaul is affected by the size of the operator. This makes the business case for smaller players even more difficult to justify. Evidence from the operator interviews is that smaller operators may have to pay up to 4 times the amount for backhaul paid by large operators such as Optus and Vodafone.

Telstra market response

Stakeholders interviewed believed that the typical Telstra response to other operators entering new markets in rural and regional areas has stifled competition in these areas. Many operators commented that Telstra has been known to enable its exchanges for ADSL after the other operator launches a competing network, usually wireless broadband.

It has been claimed that Telstra's actions reduce the potential demand for broadband accessible by other operators. Unwired's experience with Telstra shows the incumbent's willingness to follow rival operators' rollouts. Prior to Unwired rolling out in Sydney, 30% of the city were blackspots for ADSL coverage. Now, after Unwired's rollout, Telstra has reduced this to 6%. Another example of Telstra's response to competition is the Western Australian education project. At the beginning of the project, Telstra claimed that there was no ADSL available in the target towns, and therefore all the schools would have to be served by satellite. Once the project began, Telstra decided that ADSL could be provided to most schools in the project, with the exception of 7 to 8 locations that were served by satellite.

5.2.3 Other issues

Additional factors that can negatively impact the business case for broadband in rural areas, and the resulting disincentive for competition, are set out below.

Population

A limited population means limited returns. For one small regional operator, a community must have the potential for at least 30 subscribers for profitable deployment.

Additionally in some areas of Australia particularly where there are mining towns and defence towns in isolated rural areas, town populations can be unstable. For infrastructure providers unstable populations mean greater commercial risks and in turn low incentives for new infrastructure deployment. If the cycle of the town population growth and fall is shorter than the period required for full cost recovery of deployed infrastructure, there will be exceptionally low incentive to build infrastructure on a commercial basis. Recovery of costs can be achieved within 5 to 10 years for radio systems and in the range of 15 years for fibre. .

Additionally there is a lower proportion of younger people living in these communities. According to Internode, this means that it takes longer to build momentum for a broadband service and in their experience the adoption curve is not linear. Based on their deployments in rural areas, it takes about 18 months to get a real response to new service availability before the change in take-up jumps up dramatically. It is a different curve to that in metropolitan areas. This slow take-up trend will again negatively impact the business case.

Environmental

The distances involved in getting last mile access to a population can prove prohibitively expensive. The terrain to be crossed to serve these areas can be flat and rocky, mountainous, or covered with forests, all environmental conditions that further increase the cost of deployment. Violent weather conditions, particularly in isolated areas where there are not multiple backhaul alternatives, can damage exposed backhaul and access equipment. For example, Cyclone Larry which devastated townships in March 2006 near Cairns in far north Queensland.

Temperature

In the west and north of Australia, the heat can be damaging to the equipment causing it to overheat, which in turn increases maintenance costs and makes a profitable business case more difficult. In isolated areas, where the power can be limited or run on solar, air conditioning is often not a possibility.

Power

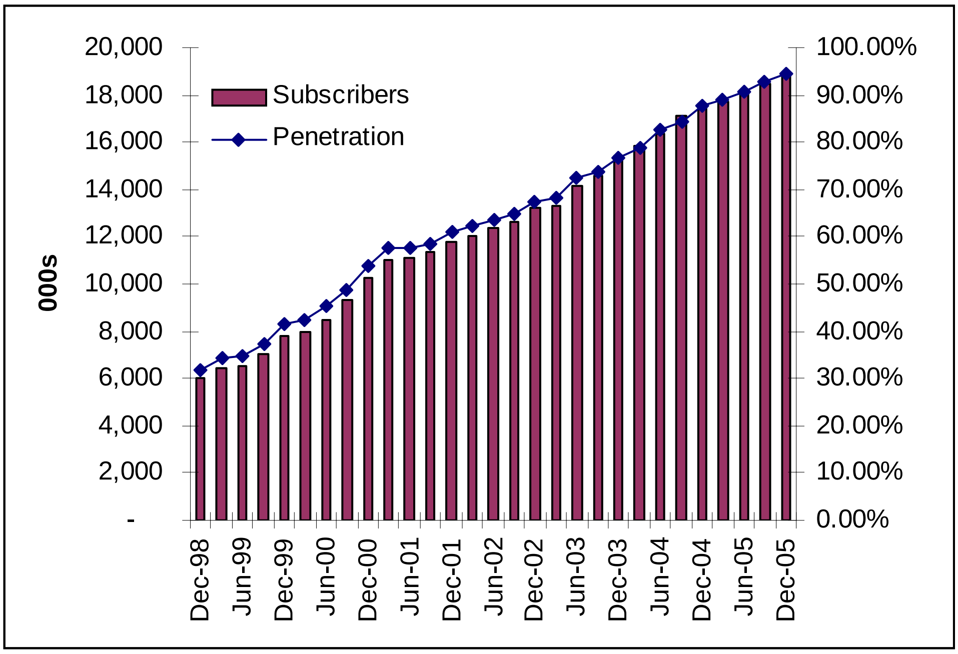
Operators interviews all mentioned the difficulty of obtaining power in isolated rural and regional areas in Australia. Power can often be hard to get and, in some cases, can involve a substantial waiting period for a quote. Further it can be very expensive. There can be cheaper alternatives, such as solar power, but power is still a significant cost.

5.3 Mobile demand

5.3.1 Mobile take up in Australia

There is strong demand for GSM and CDMA mobile phone services across Australia, as evidenced by high mobile penetration rates. At December 2005, mobile penetration as a percentage of the population in Australia was 95% as shown in Figure 5.4.

Figure 5.4 **Australian mobile market growth**



Source: Wireless Intelligence

Demand in rural and regional Australia

Mobile phones are now well established in Australia. The mobile has become part of our communication patterns. SMS has become part of our daily lexicon as an entertainment and communication service. For example, the television shows, *Big Brother* and *Australian Idol*, encourage viewers to vote for their favourite housemate or singer by text message.

Consequently, non take-up of mobile services is not due to unfamiliarity with the service but most likely a result of non-coverage. While GSM and CDMA cover most of populated Australia, some remote regional inhabitants are only covered by mobile satellite services. The relative expense of this service in comparison to terrestrial mobile services is a barrier to take-up. Age, such as older people and children, is also a barrier for take-up of mobile services in general.

Other drivers for demand of mobile services include geography, pricing, and the existing culture of mobile usage in Australia. Mobile services and applications are unlikely to attract new users but will serve as levers for users to upgrade to 3G. This is less applicable for regional inhabitants currently, but may become an issue in the future.

5.3.2 Geography

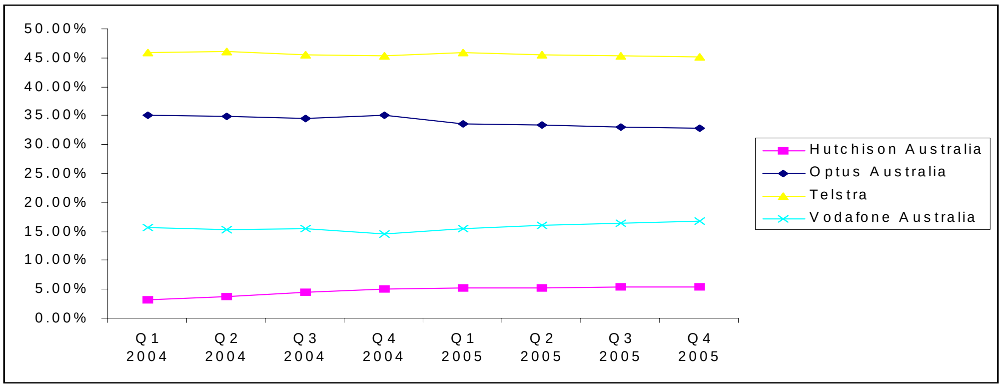
Many Australians live or work in isolated areas. This drives demand for connectivity - for social, business and operational reasons.

5.3.3 Pricing

Cheaper pricing stimulates take-up. The intensifying price war between mobile operators over 2004 and 2005 benefited regional and rural Australian covered by GSM and CDMA networks. For example, Vodafone’s pricing strategy, involving bundles of minutes for a set monthly price, has had a positive effect on its market share, showing how pricing impacts take-up.

Figure 5.5 shows that the market shares, while stable, are declining for both Telstra and Optus while Vodafone and 3 are increasing their share of the mobile market. Vodafone was able to halt a stable decline in share in late 2004, showing only growth since the first quarter of 2005. This coincides with the introduction of bundled minutes in late 2004.

Figure 5.5 **Australian mobile operators market share**



Source: Wireless Intelligence

The introduction of prepaid pricing has also encouraged take-up in many mobile markets. This has been particularly important for emerging markets where potential users often do not have the guaranteed income or identification requirements for a fixed line phone. This issue is less important in Australia, but prepaid has lowered to cost of entry for young people, students, and other low income users. Given that regional Australians tend to have less spending power and disposable income than the urban population, the lowered cost of entry offered by prepaid mobile services is an important demand driver.

5.3.4 Services and applications

Services and applications, apart from the basic voice and text, will not attract non-users of mobile phones. Rather, advanced services like mobile TV are drivers for users to upgrade from 2G to 3G. The possibilities presented by 3G are being used by operators as a lever to upsell their existing customers. Given that there is currently no 3G coverage of rural and regional Australia, this is not an issue in the short-term. However in the medium-term, as 3G coverage expands and Telstra implements it's WCDMA plans, services and applications will become important drivers.

Mobile Internet

There are now a wide variety of Internet services aimed at the mobile phone. For example, Optus has a content partnership with Lonely Planet and their mobile subscribers can download Lonely Planet information on cities to their mobile phone. Telstra has a partnership with realestate.com.au that allows Telstra 3G or i-Mode subscribers to search for a property online through their mobile. Mobile Internet services in Australia have not had strong usage to date, with the majority of data usage centred around SMS. Ovum forecasts that non-text or messaging based data usage in Australia will increase from 5% of total revenues in 2005 to 9% in 2009. This equates to an increase in revenues from $336 million in 2005 to $748 million in 2009.

Mobile TV

Mobile TV is a much-discussed emerging service. Operators see it as a way of attracting consumers with content and increasing data traffic, although mobile TV is likely to use broadcasting channels rather than cellular radio delivery technologies in the long-term due to its greater efficiency in serving large audiences. The early indications are that there is interest in mobile TV from consumers, although the level is uncertain. A Nokia survey completed in late 2005 found strong interest in Mobile TV, particularly in the 13-19 male age group, where 40% of respondents indicated that they would watch mobile TV. Conversely, a survey conducted by Research International Finland found that 70% of respondents had no desire to watch TV on their mobiles. The potential audience for mobile TV is uncertain but the early indicators from South Korea indicate that there is some demand. The South Korean mobile operator, SKT, launched a S-DMB Mobile TV service in May 2005. Subscriber levels reached 173,000 by September 2005. Mobile TV is definitely a lever to upsell customers, but it would need to be done at the right price and with the right content to be successful. Specific applications, such as sporting highlights, may prove to be the way in which this application gains initial traction. Full length movie watching on mobile devices would not seem to match current or near-term demand.

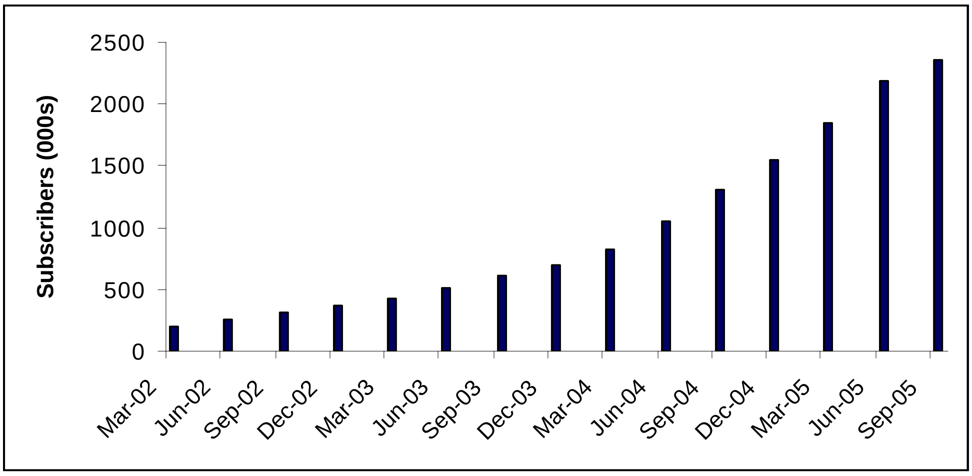
5.4 Broadband demand

5.4.1 Broadband take-up in Australia

Australian household broadband penetration reached 31.8% in September 2005. This was mostly in the urban areas where the majority of exchanges are ADSL enabled. Wireless broadband is also making an appearance, although much of the deployments have been in the capital cities of Australia.

Figure 5.6 shows that Australian broadband growth accelerated in the last three quarters of 2004. This was driven in large part by Telstra dropping the entry level price of broadband in February 2004 to $29.95 per month, close to dial-up prices, albeit with a 400 MB download limit.

Figure 5.6 **Broadband subscriber growth in Australia**



Source: ACCC, Point-topic, Ovum

As discussed in the following pricing strategies section, broadband consumer costs in rural and regional Australia are on par with the metropolitan areas. This has been driven by political pressure, competitive pressures, and a perception that regional Australians have less spending power and so can not afford broadband that is more expensive than the prices offered in urban areas.

The remoteness of many locations in rural and regional Australia is a key driver for broadband take-up. The time savings, the financial rewards and the potential opportunities offered by broadband can be even more attractive to country Australians because it is offering access to services that were previously impossible, or hard to get to, for many people.

Apart from pricing and geography, other factors that drive broadband take-up in rural and regional Australia includes cultural factors and services and applications.

5.4.2 Cultural

Australia has relatively high PC penetration and digital literacy. Overall, the Australia market is mature and there will be strong demand for entry-level and higher speed broadband. This also applies to rural and regional Australia, albeit with a slower demand curve. The smaller number of younger people in rural Australia means that there are relatively fewer early adopters in these areas and the rate of adoption can often be slow. Internode estimates that it takes approximately 18 months to build a base broadband subscriber base in these areas before take-up jumps dramatically.

5.4.3 Business opportunities

There are a variety of factors driving businesses onto broadband. One of the most important in the rural and regional context is that businesses, particularly small and medium size, are moving towards online interaction with their clients. The Sensis e-business 2005 survey found that 50% of small, and 59% of medium, sized businesses sell goods or services and receive payment over the Internet. Broadband is clearly a significant opportunity for small and medium size businesses in rural and regional Australia, as it offers them access to customers that they would not otherwise be able to serve without a huge investment.

5.4.4 Service and applications

Bandwidth capabilities

Many of the services and applications associated with broadband need faster speeds to work adequately than what is presently available in Australia. Figure 5.7 shows the bandwidth required by various broadband services and applications.

Figure 5.7 **Broadband services**

Service	Broadband requirements	Driver for high speed Broadband
VoIP	80-100 Kbps symmetrical	Low
Streamed/download		Low - mid
Games	256 Kbps symmetrical recommended	
Video	Will use what bandwidth is available with the trade-off being the time it takes to download. 4 Mbps – 6 Mbps speeds are recommended to allow downloading within a reasonable time-frame.	
Triple-play (1 TV)		High – very high
Basic IPTV services	2 – 10 Mbps	
With VoD	8-15 Mbps	
With HDTV	24-30 Mbps	

Source: Ovum

The services and applications made available by broadband, most particularly high-speed broadband, also encourage broadband adoption.

VoIP

The most attractive aspect of VoIP for users is its price. It is estimated that VoIP will need to be discounted by at least 20% to 30% on standard PSTN charges to attract customers.

VoIP requires speeds of 80-100 Kbps symmetrical, which means that users need more than an entry level broadband package offering speeds of 256/64. Consequently VoIP is a lever to upsell existing broadband customers, rather than encouraging initial broadband adoption.

Streamed/downloaded services

A streamed or downloaded service is content that is downloaded or streamed from a portal (either within the same network or the broader Internet) to the PC. Portals offer services such as video clips, music downloads, movies, games and short videos as well as applications and storage for user-generated content.

This content is both an attraction to encourage initial broadband adoption and upselling to faster speeds as bandwidth requirements depend upon the nature of the video. Fast-moving sports action requires a higher bit-rate than a sports interview.

Government services

Access to essential government services, which saves time and cost for both the provider and recipient will be a key driver of broadband take-up in rural and regional Australia. A prime example is education. For many children in rural Australia, school is accessed through a radio. Broadband will allow fast delivery of more interactive audio-visual activities, such as seeing the teacher’s face and other class members on the computer screen during a lesson.

IPTV

IPTV services involve the delivery of broadcast television over an IP network to a set-top box. This includes broadcast channels, movies and music videos. Even at the most basic level, IPTV services require bandwidth of around 2- 10 Mbps. Video-on-demand services involve customers accessing current and archived content which is immediately delivered to the TV over an IP network and requires bandwidth of around 8 to 15 Mbps. Both services are levers to upsell customers to higher speeds of broadband.

5.5 Pricing strategies

5.5.1 Overview

Pricing strategies involve balancing a range of commercial factors to maximum returns, such as:

- Cost recovery
- Market demand and elasticity
- Customer expectations
- Competition

Operators will set prices that recover investment as quickly as the market will allow, having regard to competition, demand and usage patterns.

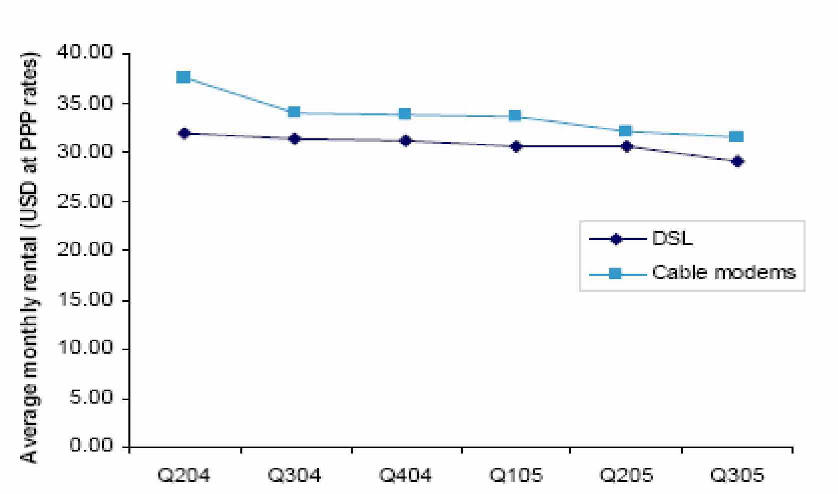
Strategies vary between operators and between regions. In Australia, operators are additionally concerned to provide prices in rural areas that follow metropolitan prices and are equivalent to them. Some operators, such as Internode, adopt similar strategies as in metropolitan markets for both price levels and pricing structure. This can be due to competition, political pressure, and a recognition that regional areas tend to have less spending power than their urban counterparts. Others reflect higher cost structures in their prices to rural and regional markets. This is particularly true for areas that only have access to one provider.

5.5.2 Broadband pricing

Pricing flattening

In both international and domestic experience, broadband pricing is trending downwards. An analysis of changes to entry-level broadband price packages across 18 markets, shown in Figure 5.8, demonstrates that DSL monthly rental prices have registered an average 30% fall between March 2000 – 2005, although stabilising from mid-2004. Cable modem prices fell on average 21% between June 2003 and March 2005. However prices for both DSL and cable began to stabilise from mid-2004. This reflects increasing market maturity, where market shares stabilise and operators shift strategy from simply acquiring customers, to increasing revenues and profitability. Ovum believes future decreases in the medium term will be between 2 to 5% pa.

Figure 5.8 **Changes in broadband tariffs**



Source: Point-Topic

Matching Telstra

As part of this downward pressure on pricing, there is unwillingness amongst operators and politicians to charge more than metropolitan prices in regional Australia. This is based on the idea of overall community equity. It also reflects assumptions on affordability. Rural incomes are less than metropolitan incomes, which is a problem given that the cost of service delivery is higher. Consequently, Telstra is trying to drive down the costs of traditional services in regional and rural Australia. Due to these issues of affordability and demand, prices need to be lower or at least equivalent to metropolitan areas in order to ensure adequate take-up. Many of the alternative operators price according to the local cost of Telstra's ADSL packages - the latter being regarded as a ceiling in the market. For example, while Unwired believes that the additional features of a wireless solution give it differentiation, it still prices its product at or below the Telstra benchmark. Operators yet to enter the market are also expecting to price their products at Telstra levels. Aurora, the Tasmanian energy provider, commented that the pricing of their packages will be comparable with Telstra.

Decreasing CPE costs

In conjunction with, and as an enabler for, the drop in broadband pricing, there has been a steady trend downwards in CPE costs. Many of the operators interviewed commented that they expected even greater drops in CPE costs in the future as the subscriber base widened and economies of scale increased.

The sliding cost of CPE improves the business case for subsidising CPE cost for the consumer. Many of the operators interviewed stated that they subsidised the prices for their equipment. BroadbandNet, the Western Australian regional operator, gives away the equipment for free on top of a one month free trial period. iBurst subsidises its desktop modem terminals, selling them for $199.

Pricing and faster speeds

Some operators expect to be able to charge more for faster speeds. One operator expects to be able to charge between $40 to $50 a month for 1.5 Mbps and upward speeds. International experience suggests that this will not be sustainable in the long-term. Customers expect more for less over time and, in this case, the perception of what should be in the entry level offering will become more demanding.

The value offered at entry level has grown considerably over time. For example, BT progressively raised the entry-level speed to 1 Mbps and increased the usage cap to 1GB while maintaining its price. Yahoo Japan offers both 960 Kbps and 8 Mbps services for just $20.12. By international standards, Australia's entry level deal of 256/64 Kbps with a 200MB cap is extremely poor by comparison and will need to improve if operators want to grow revenues from value-added services.

Additionally, Australia is one of the few countries where relatively small download limits exist for entry level broadband services. Compared to download restrictions in the UK for example, those in Australia are extremely restrictive. It would be expected that download caps in Australia will be raised and then removed altogether as Australian end-users demand services comparable with what is offered across the rest of the world.

Figure 5.9 compares entry-level deals and prices across a number of operators.

Figure 5.9 **Entry level prices, download speeds, restrictions and tariffs**

Country	Operator	Speed	Restrictions	Local currency	AUD
UK	BT	1 Mbps	1 GB cap	GBP 17.99	$42.83
Taiwan	Chunghwa	256 kbps	Unlimited	NT$360	$15.12
Japan	Yahoo! BB	8 Mbps	Unlimited	Yen 2,280	$25.08
Korea	KT	4 Mbps	Unlimited	KRW 28,500	$39.90
Canada	Bell Canada	256 kbps	Unlimited	$C27	$47.08
Australia	Telstra	256 kbps	200 MB cap	$29.95	$29.95
Australia	Optus Cable	512 kbps	200 MB cap	$39.95	$39.95
Singapore	SingTel	512 kbps	30 hours	$S26.20	$21.75
Hong Kong	PCCW	1.5 Mbps	20 hours	$HK198	$34.65

Source: Point-Topic, Ovum

It is expected that the entry level pricing for broadband will remain stable while the speeds will slowly increase.

Pricing and bundles

Bundling is a large part of the competitive landscape in Australia. Telstra, Optus and other alternative operators bundle their fixed line phone, broadband Internet and mobile. Telstra offers reward points, such as a certain amount of free SMS or local calls. Optus offers more one-off rewards, such as free installation or reduced monthly fees. Both operators are also starting to offer capped plans for bundled home phone and mobile plans. These marketing strategies are reflected in alternative operators' behaviour. Other operators, such as AAPT and iiNet, also bundle their services.

The benefits for operators are that bundling attracts customers and reduces churn. Optus reports a local telephony bundling rate of 72% of its 478,00 local telephony customers on the HFC network at December 2005. Optus' plans cover packages offering local telephony, television, and Internet access. It has a local telephony bundling rate of 67% for its 649,000 resale customers on Telstra's network. As at June 2005, Telstra had 341,000 bundled subscribers, equating to 6% of its fixed residential phone customer base.

Mobile pricing

Trending downwards

In early 2004, '3' Australia first introduced bundles of minutes for a set monthly price. Vodafone soon followed. Telstra and Optus were slow to join, waiting to see whether it would impact their market share. However both have now bowed to the market pressure and offer their own form of mobile caps. Figure 5.10 shows how the advent of capped plans has pushed down mobile pricing.

Figure 5.10 **Mobile pricing plans**

Operator	Plan name	Plan Type	Monthly cost	Value	Flagfall	Cost per 30 seconds	Estimated minutes included*
Optus	$49 Cap	Capped plan	$49	$230	$0.30	$0.35	135
Optus	Yes $45	Traditional plan	$45	$45	$0.25	$0.37	26
Telstra	3G cap plan	Capped plan	$49	$250	$0.35	$0.40	128
Telstra	$40 plan	Traditional plan	$40	$48	$0.25	$0.36	28
Vodafone	$49 value bundle	Capped plan	$49	$230	$0.25	$0.30	159

**Based on average length of call = 2 minutes*

Source: operators

Mobile satellite pricing is fairly stable, but remains more expensive than terrestrial mobile pricing. Globalstar, Optus and Telstra are now offering free minutes as part of the pricing packages. Globalstar charges users a $100 a month subscription package and 30 cents for 30 seconds. For lower end-users on a $35 a month subscription package, Globalstar charges $1.80 per minute, which includes $10 of free minutes. Optus pricing has remained stable but they have introduced an entry level $35 per month budget plan. Telstra has included a level of free calls in the monthly access fee at a similar level to Globalstar. $10 free calls with the $35 monthly plan and $50 free calls with the $80 monthly plan.

Given the difference in infrastructure and ongoing costs between terrestrial and satellite mobile services, as well as the environment in which they operate, the price differential is not expected to change.

Mobile handset subsidies

Australian operators do not subsidise handsets, although they do offer staggered payments through a twelve month or twenty four month contract. Telstra, Optus and Globalstar, subsidize their mobile satellite handsets to approved applicants through the Commonwealth Governments Phone Subsidy Scheme. Subsidies are up to $1,500, reducing the cost of a satellite phone from $1,999 to a minimum of $499.

6 Mobile technologies

6.1 Overview

In this section 2G and 3G mobile technology options are covered. There are two 2G mobile technologies deployed across Australia, GSM and CDMA. These are widely available in rural and regional areas. In 3G, UMTS has been deployed in Australia by all four major mobile operators, although predominantly in urban areas. Telstra has started to deploy HSDPA.

Future plans for mobile deployments in Australia are currently heavily affected by Telstra's CDMA shutdown and WCDMA deployment plans.

6.2 GSM / GPRS / EDGE

6.2.1 Overview

GSM is the most widely deployed 2G cellular network technology in Australia and internationally, with more than 2 billion users worldwide. GPRS is also widely deployed in Australia and operators are increasingly offering EDGE.

GSM's broad availability makes it a preferred option with users. GSM/GPRS and EDGE are scalable, but available speeds are limited by the technology. In rural and regional areas, GSM/GPRS/EDGE hand held services are likely to achieve a range of around 10 km.

6.2.2 Technology type

GSM supports several dedicated data network bearer services including Circuit Switched Data (CSD) and 2.5G upgrades High Speed Circuit Switched Data (HSCSD), GPRS packet radio service, and EDGE (Enhanced Data rates for GSM Evolution). The network structure for GSM, the GPRS and EDGE upgrades are included in Annex 6.

GPRS / EDGE

The GSM standard was originally designed for voice. The European Telecommunications Standards Institute (ETSI) later upgraded the standard in order to better support data transmissions. This was made possible by the development of HSCSD, which enables higher bit rates but remains a circuit-switched technology. GPRS, which introduced packet-switching techniques into the core network, followed. Lastly EDGE, an extension of GPRS, appeared, offering data speeds 2 to 3 times faster than GPRS.

6.2.3 Maturity

GSM, GPRS and EDGE are fully proven and mature technologies.

All major infrastructure vendors provide GSM/GPRS/EDGE solutions. Most GSM base stations are pre-equipped with GPRS/EDGE capability. This means that a GSM operator will have to pay for a software only upgrade of its radio infrastructure instead of deploying new hardware and software.

All major handset vendors now make mobile handsets supporting the three technologies. Initially EDGE was mainly available through the use of data cards supplied by Sierra Wireless or Motorola. Now most of the mid- and high-end range mobile phones support EDGE.

6.2.4 Open standards

ETSI has been responsible for the development of the GSM standard and its evolution: HSCSD, GPRS and EDGE. ETSI is now a partner of 3GPP for the development of 3G mobile standards.

It is important to note that all these evolutions are backward compatible.

6.2.5 Bandwidth and range limitations

GSM cells' ranges vary depending on:

- the nature of the cell (urban, suburban, and rural)
- the type of penetration (indoor, outdoor)
- the frequency used
- the power

Figure 6.1 gives more information on GSM service range used for business planning for a GSM network operating in the 900MHz band.

Figure 6.1 **Maximum GSM range**

	Max cell radius (kilometres)
Urban indoor	1
Urban outdoor	3
Suburban indoor	2
Suburban outdoor	5
Rural indoor	4.5
Rural outdoor	15

Source: Ovum

For deep indoor penetration in urban areas, operators deploy pico-cell base stations that have a very short range (50-150 metres).

Figure 6.2 compares the different technologies peak downlink rates and average rates in live networks.

Figure 6.2 **GSM/GPRS/EDGE downlink speeds**

	Peak downlink speeds	Average downlink speeds
GSM	9.6 Kbps	-
CSD	14.4 Kbps	-
HSCSD	43.2 Kbps	-
GPRS	171.2 Kbps	35-50 Kbps
EDGE	384 Kbps	100-150 Kbps

Source: Ovum and 3GPP

3.5.1 Scalability

GSM/GPRS/EDGE networks are scalable. To support a higher number of users or higher air traffic, an operator has to add new transceivers in base stations, add new sectors (cells) or add new base stations. The operator may also have to upgrade the backhaul network by adding new microwave links or renting additional E1 lines. This means that the operator only has to install incremental capacity where required by expected additional demand.

The evolution from GSM to GPRS requires the rollout of a mobile IP core network to the circuit-switched GSM core by the addition of SGSN and GGSN routers. The migration from GPRS to EDGE requires a software-only upgrade of the radio network. Refer to Annex 6 for more details.

6.2.6 Existing base of infrastructure

As set out in Section 4 of this report, GSM networks are available across many regional and remote parts of Australia. GSM coverage is available to 96% of the Australian population and GPRS is also widely deployed.

The coverage of GSM in major regional towns and cities makes it a preferred option with many users in rural and regional areas.

6.2.7 Competition, demand and applications

Competition with 3G services

GSM and GPRS are primarily suitable for voice services, but are capable of delivering data services. Data speeds, and consequently the data applications that mobiles can support, differ between GSM, GPRS and EDGE. GSM is essentially limited to supporting SMS (Short Message Service). GPRS allows access to WAP services, e-mail and slow mobile Internet. EDGE enhances the user experience when browsing the Internet using a mobile handset but it does not support carrier-grade mobile VoIP services.

GSM roaming

GSM roaming for customers across competitor networks (where roaming agreements don’t exist) in rural and regional Australia remains an issue for competition in rural and regional areas where GSM coverage is available.

6.2.8 Deployment, operational and maintenance costs

The biggest CAPEX investment when deploying a cellular network is the radio network element. This consists of base stations and BSCs and can represent up to 65% of the total infrastructure investment. Typically, a base station in a rural Australian town could provide coverage up to 10km in radius from the base station. Therefore most small and medium towns in Australia can be served by one base station.

In recent years, parts of the network costs have decreased. For example, vendors have developed high-capacity core network equipment that limits the number of MSCs or HLRs required. Today, the information to support up to 1.5 million subscribers could be managed by a single HLR rack. A MSC could scale from 2,500 to 2 million mobile subscribers, and even more. This means that it is less scalable for small populations (less than 2,500).

Vendors have developed optimised solutions for emerging countries and rural areas in order to reduce both the cost of deployment and the cost of ongoing maintenance and support (OPEX). For example, vendors have developed 'shelterless' base stations that place the base station equipment on the top of a tower, enabling the operator to benefit from OPEX savings due to reduced site acquisition costs. The absence of a shelter also lowers some site development costs (such as air conditioning, wiring and power consumption). The costs of network equipment for any particular operator will depend on size of the operator, smaller operators and particularly new market entrants will have much higher equipment costs than operators such as Vodafone and Optus.

Maintenance costs typically represent a ratio of between 5% and 10% of the network CAPEX depending on the age of the cellular network.

6.3 CDMA / CDMA2000 1x RTT / CDMA2000 1x EV-DO

6.3.1 Overview

CDMA is the second most widely deployed mobile technology. Like GSM, CDMA can be scaled for more customers but the technology is limited in the speed it can deliver. The range of CDMA is greater than GSM.

Telstra’s announcement in 2005 of plans to close their CDMA2000 1x network has led to market uncertainty. Operators are waiting to see the outcomes of Telstra’s plans and for issues, such as roaming rights, to be resolved.

6.3.2 Technology

Code Division Multiple Access (CDMA) is a digital wireless telephony transmission technique that allows multiple frequencies to be used simultaneously (Spread Spectrum).

CDMA2000 is the upgrade path for CDMA networks. A phased road map offers increasingly higher data rates via CDMA 1x RTT and different releases of CDMA 1x EV-DO (Release 0 through Revision A and B).

The 1x EV-DO functions on an “always-on” basis and is bi-mode (1x for voice and 1x EV-DO for data). Users can switch to the 1x mode for data if they move out of the coverage area for 1x EV-DO services.

6.3.3 Maturity

CDMA technologies are supported by all North American and Chinese major cellular infrastructure equipment vendors, and some Korean and Japanese equipment vendors. In 2005, Ericsson decided to exit the CDMA infrastructure business. The other leading European equipment vendor, Nokia, does not make CDMA infrastructure. In 2006, it entered a partnership with Sanyo to jointly develop CDMA terminals.

The first iteration of CDMA2000 is CDMA20001x. This has been deployed in volume worldwide, with 212.4 million connections at the end of 2005. CDMA2000 EV-DO has begun to gain traction: there were 21.2 million CDMA2000 EV-DO connections at the end of 2005.

Initially Qualcomm was committed to develop chipsets for the EV-DV technology but it decided to halt the development of CDMA 1x EV-DV and focus its efforts on EV-DO variants due to low-demand for EV-DV technology.

6.3.4 Open standards

Work on developing the CDMA standard is conducted mainly by the following bodies:

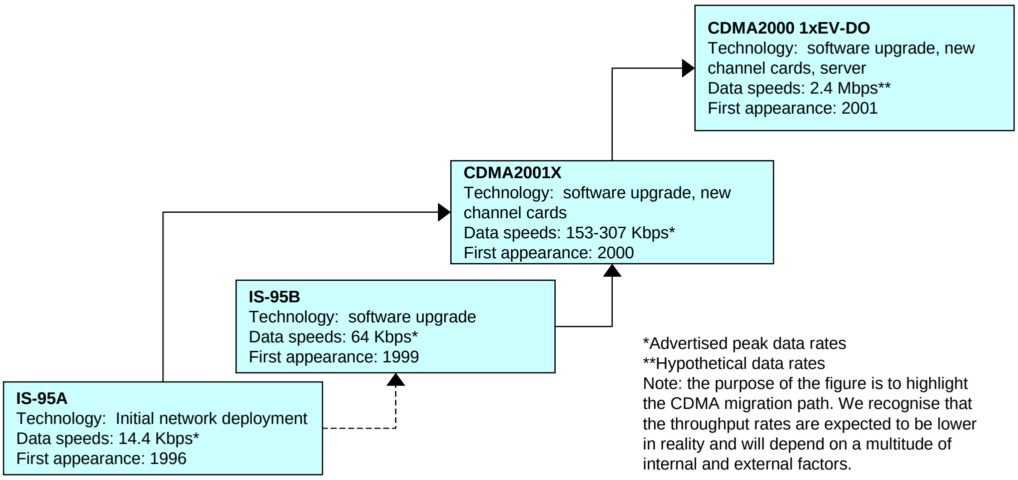
- the US-based CDMA Development Group (CDG), a consortium of the main CDMA manufacturers and operators, which was formed to standardise and promote CDMA technology
- the 3GPP2 (Third-Generation Partnership Project 2), which, rather like the 3GPP, is a consortium of interested players, but these advocate CDMA2000 rather than WCDMA as a 3G technology.

These standards bodies have led the development of CDMA technology, through CDMAOne to the iterations of CDMA2000. The latest release to be fully commercialised, CDMA2000 1x EV-DO Release 0 is part of the family of 3G CDMA2000 standards. It was approved by 3GPP2 and TIA TR45.5 as an advance on CDMA2000 standards (IS-856) and was approved by the ITU as a member of the IMT2000 family of standards.

6.3.5 Bandwidth and range limitations

Figure 6.3 outlines the currently available iterations of CDMA.

Figure 6.3 **CDMA migration path to CDMA2000 EV-DO Release 0**



Source: Mobile@Ovum

CDMAOne (IS-95A and IS95-B)

Data rates of 14.4 Kbps are supported in IS-95A. This is increased to 64 Kbps in IS-95B, although its theoretical maximum is 115.2 Kbps. Many CDMA network operators have chosen not to deploy IS-95B and go instead straight to 1x.

At lower frequencies, such as 850 MHz, the range of CDMA is significant, with cell radii of 55-150 kilometres. This was a driving factor in Telstra's decision to deploy CDMA for its wireless network to service rural areas in Australia. Range of up to 200 kilometres has been demonstrated, but this involves both ideal conditions and considerable trade-offs in performance.

CDMA2000 1X

1X deployments are 50–80 Kbps range for mobility usage, although data rates of around 105 Kbps, with a maximum of 120 Kbps, have been noted for stationary users in commercial deployments.

In addition to higher data speeds, 1X also offers doubled channel capacity and increased handset battery life. The doubling of voice capacity is a core part of the 1X offering – it is a key practical consideration for many operators, more so than the promise of offering 'multimedia' wireless connectivity, as in many markets, and particularly the urban core, spectrum within the licensed bands is becoming scarce as the number of subscribers and the volume of voice traffic grows.

CDMA2000 1XEV-DO

Using a single dedicated 1.25MHz channel, Qualcomm claims that 1XEV-DO has a peak potential throughput on the forward link of up to 2.4 Mbps, with uplink potential of 153 Kbps. However, commercial deployments in loaded networks record between 200-600 Kbps.

CDMA2000 1X EV-DO Release A

EV-DO Release A is optimised for data packet services and supports theoretical speeds of up to 3.1 Mbps on the downlink and 1.8 Mbps in the uplink. The technology also introduces a number of measures designed to increase Quality of Service and reduce latency. These potentially enable support for Voice over Internet Protocol (VoIP), although this is not a technical enhancement, per se.

CDMA2000 1X EV-DO Release B

Although Revision A is not a commercial reality at the time of writing in February 2006, work has begun on Release B. This release, possibly available in 2H07, introduces the concept of dynamically scalable bandwidth. This can theoretically combine up to fifteen 1.25 MHz carriers (20Mhz) in the uplink or downlink in order to increase available bandwidth. Thus if three 1.25Mhz carriers are combined, available bandwidth would be three times that of Rev A, or 9.3 Mbps.

6.3.6 Scalability

CDMA technology upgrades facilitate the support of more users on the network, and/or more bandwidth per user, as a result of an increasingly efficient use of spectrum resources. However certain parameters need to be available, in order to benefit from this scalability. For example, with CDMA2000 EV-DO, operators need to be able to separate a 1.25Mhz carrier and devote this to the carriage of data. Having done this, the CDMA network can support increased users as well as increased bandwidth per user.

Successive releases of CDMA2000 enhance this scalability, most notably in the proposed Revision B standard, with its support of dynamically scalable bandwidth.

EV-DO Release O and the next releases are not backwardly compatible with 1X or IS95, in order to maximise the future advantages of an all-IP network. However, compatibility is guaranteed via multi-mode phones.

6.3.7 Deployment, operational and maintenance costs

The cost to upgrade the CDMA system is considerably less than that for a GSM operator migrating to UMTS technology, which requires the introduction of new cell sites and infrastructure.

The technologies have been designed to promote the maximum re-use of existing hardware, via an ‘in-band’ evolutionary path. The benefits of this approach are as follows:

- Hardware reuse: RF equipment, such as amplifiers, filters, and transmitters, has to be optimised for the frequency band in which it operates. Major CDMA suppliers offer Multi-carrier RF solutions, meaning that existing kit can support different carriers, regardless of whether one is 1X and the other EV-DO.

- Ease of network engineering. Because WDCMA is deployed at a higher frequency than 2G for GSM operators, the operator will require new sites as well as pre-existing sites used for GSM. With CDMA migration, this is not an issue.
- No mandatory auctions. This is a large part of the migration cost for operators who need to purchase additional spectrum to launch new/3G services.

Radio Access Network (RAN) upgrades:

- IS95 to 1X. Requires addition of a new channel card in the RAN to sit alongside the IS 95 A/B channel card.
- 1X to EV-DO Release O. The only modification required is the addition of a new channel card, which is responsible for processing the EV-DO signal.
- Release O to Release A. In 2006, operators will begin seeding their networks with Rev A channel cards. These cards can be inserted alongside 1X and Release O cards. These can then be upgraded when the Release A software becomes available later in 2006.
- Release A to Release B. This may require a new channel card, or simply a software upgrade.

Core Network (CN) evolution: this is relatively straightforward, with a clear path to an all-IP core transport and switching architecture. These are very compatible with new technologies such as the work that the 3GPP has done with IP Multimedia Subsystem (IMS), and has adopted IMS in large part.

- IS95 to 1X and EV-DO: new hardware elements such as the Packet Data Server Node (PSDN), Foreign Agent (FA), Authentication, Authorisation and Accounting Server (AAA) and a Home Agent (HA) are required when migrating to 1X.
- Transition to All-IP. Until recently, a circuit switch network has handled real-time services such as voice. The introduction of Rev A and its inherent ability to support QoS and low latency applications on an IP RAN means that it will be possible to extend IP throughout the core network.

6.3.8 Existing base of infrastructure

There were 293.7 million CDMA subscribers worldwide at the end of 2005. Originally limited to the Americas and a few developed Asian countries, it has made inroads into other parts of the world, notably India and Eastern Europe.

Telstra’s CDMA network covers 98% of the Australian population. CDMA EV-DO coverage is present in capital cities and major regional centres, CDMA2000 1x in all other areas where coverage exists. Telstra’s strategic review announcement in November 2005 stated that it would close down this network by 2008, reusing the towers and frequency to deploy a UMTS network. This has caused international and domestic repercussions.

Many stakeholders are unconvinced that Telstra will be able to easily replicate the quality and coverage of CDMA using UMTS. The ability of UMTS to cast the signal to the same range as the existing CDMA towers is unproven elsewhere.

Additionally, in line with Telstra's announcements, Hutchison Telecommunications Australia announced that it would close its CDMA network and attempt to migrate its subscribers to its WCDMA network.

More broadly, Telstra's announcement and its claim that eight other carriers are considering a similar move has raised a question over the future scale (and ultimately, viability) of CDMA internationally. Domestically, closure of the CDMA network has introduced much greater uncertainty into the rural and regional market for mobile services.

6.3.9 Competition, demand and applications

CDMA technology competes directly with what can be characterised as 3GSM – the migration path from GSM through GPRS and EDGE to UMTS.

There are few applications that are specific to CDMA. It has periodically had a market lead in improving data rates. In certain markets, such as Japan, this has led to KDDI having an advantage in offering music download services. NTT DoCoMo, deploying WCDMA, has had neither the capacity nor the cost efficiency to match this service.

Platinum Multicast has been introduced with EV-DO Revision A: this is a one-to-many solution (incorporating OFDM technology) that enables operators to deliver multiple content streams to many subscribers by dedicating any fraction of a 1.25Mhz carrier to Multicast services.

In the future, the CDMA path aims to offer a variety of new services, such as:

- Push to talk/see
- Video telephony
- Multimedia conferencing
- Person-to-person gaming
- Interactive shows and events

An all IP core is not a necessary requirement to deploy these services over EV-DO Release A. However, it is likely that operators will move to an IP core to take advantage of the benefits throughout the network. All of these services however, feature on the roadmap for UMTS.

6.4 UMTS

6.4.1 Overview

UMTS has been deployed in Australia by each of the four major mobile operators, although mostly in urban areas.

6.4.2 Technology

UMTS (Universal Mobile Telecommunication System) is the 3G upgrade for the GSM family. UMTS was introduced by 3GPP Release 99 and refers to the interconnection of a new type of access network, the UMTS Terrestrial Radio Access Network (UTRAN), to the adapted pre-Release 99 GSM/GPRS core network infrastructure. UMTS is based on a Wideband CDMA (WCDMA) radio access technology that has high spectral efficiency and combines voice and high speed data on the same channel.

As a consequence, the introduction of UMTS requires the rollout of new radio access equipment and new Radio Network Controller (RNC) elements while the modifications of the core network are limited if the mobile operator has already deployed a GPRS core network (GGSN and SGSN). Refer to Annex 7 for details.

Two WCDMA modes can coexist in UTRAN: the Frequency Division Duplex FDD) mode and the Time Division Duplex TDD) mode. In the FDD mode, two different frequency bands are used for the uplink and downlink directions. The frequency separation between uplink and downlink, also called duplex distance, is 190 MHz or 80 MHz. For instance, in Europe, operators use the 2110-2170 MHz band for downlink and the 1920-1980 MHz band for uplink. What is called UMTS and currently deployed by most GSM operators owning 3G spectrum worldwide is the FDD version. Later in this report is described the TDD version, called UMTS TDD (or TD-CDMA).

6.4.3 Maturity

All major cellular infrastructure equipment vendors support UMTS. UMTS handsets are now widely available. Some infrastructure vendors have also experienced difficulties with their first generation of UMTS base stations but these problems are now resolved.

6.4.4 Open standards

UMTS was introduced by 3GPP Release 99. Other 3GPP releases improve UMTS capabilities and effectiveness.

UMTS Release 4 describes the migration of the circuit-switched voice network to an Asynchronous Transfer Mode (ATM) or Internet Protocol (IP) core network.

3GPP Release 5 introduces a new radio access technique described later in the report, called High-Speed Downlink Packet Access (HSDPA), and the IP Multimedia Subsystem (IMS) in core network.

3GPP Release 6 enhances IMS and also introduces HSUPA (High-Speed Uplink Packet Access) in radio access network to significantly improve the uplink speeds.

6.4.5 Bandwidth and range limitations

Current UMTS Rel99 implementations have achievable speeds of around 200 Kbps depending on traffic conditions. Uplink speed is limited to 64 Kbps.

The range is very much dependent upon the terrain. In highly built-up areas the range can often be less than a kilometre, while in lowly populated rural areas the range can be 50 kilometres with some trade-off in performance.

Telstra's CDMA shutdown plans include utilisation of existing CDMA towers by WCDMA equipment. Telstra's vendor claims that WCDMA equipment operating at 850MHz will achieve at least the same coverage footprint as currently provided by CDMA, this will be achieved by changes to the standard WCDMA equipment to extend the range. Telstra's vendor has promised the equipment will deliver services to a range of 161 km by the end of 2006, and 200 km by the end of 2007. If this range is not achieved, further base stations will be required to enable coverage. This will add time and costs.

6.4.6 Scalability

UMTS networks are scalable. To support more users or higher air traffic, an operator has to add new cards, new sectors or new base stations. The operator may also have to upgrade the backhaul network by adding new microwave links or renting additional E1 lines.

The evolution from a GSM/GPRS/EDGE network requires the rollout of a new mobile access network (Node Bs and RNC). For a GSM 2G operator, the addition of an IP mobile core network would also be necessary.

6.4.7 Deployment, operational and maintenance cost

UMTS is an upgrade of GSM/GPRS networks and the main cost is related to the rollout of a new radio access network including Node Bs and RNCs.

Typically, Node Bs are co-located with existing GSM Base Transceiver Station (BTS) as much as possible in order to reduce the cost of UMTS implementation. As UMTS uses a different frequency compared to GSM/GPRS/EDGE, there is no risk of interference between the signals. However collocation with other UMTS operators would require cautious network planning and fine-tuning work in co-ordination with other operators.

Additional backhaul capacity might also be needed. This is particularly true for dense areas such as airports, rail stations or business centres.

6.4.8 Existing base of infrastructure

UMTS is mainly licensed and deployed in Europe and Asia. Mobile operators began to offer UMTS services using data cards targeting business users and progressively introduced handset-based services as availability of 3G handsets increased.

Today, UMTS services have been launched commercially by more than 100 operators worldwide.

All four mobile operators have deployed UMTS in Australia.

6.4.9 Competition, demand and applications

UMTS FDD competes with UMTS TDD, CDMA2000 and TD-SCDMA technologies.

6.5 HSDPA

6.5.1 Overview

Telstra has started to deploy HSDPA in Australia, in high usage urban areas. Other operators are evaluating their HSDPA deployment plans.

6.5.2 Technology

The 3GPP Release 5 specification introduces HSDPA. Like UMTS R99, HSDPA is based on the WCDMA technique to support multiple access to the air interface. However, several enhancements have been included in order to provide higher data rates and capacity with HSDPA compared to UMTS R99.

6.5.3 Maturity

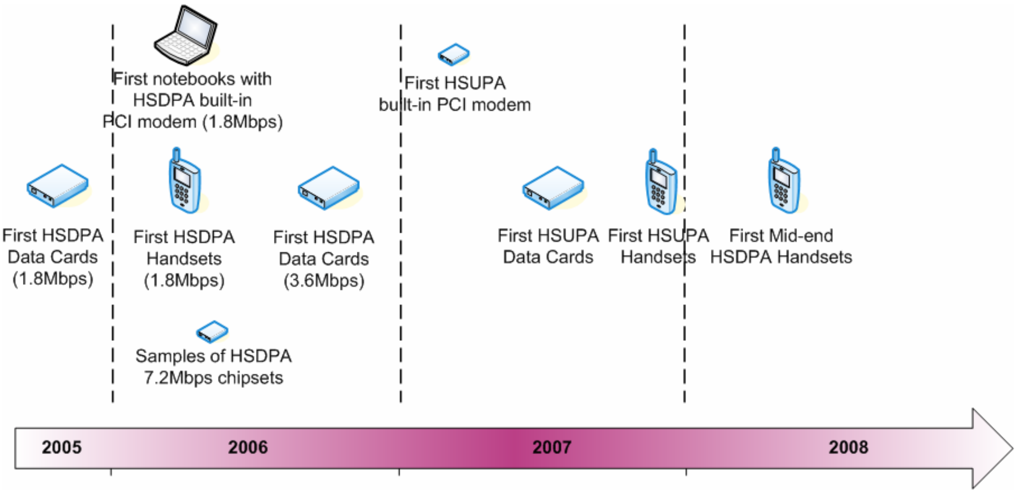
HSDPA is a new technology that has to be proven in practice. It is currently being tested by operators worldwide and only deployed in two countries for commercial purpose using data cards.

Infrastructure vendors are providing HSDPA solutions with differing capabilities. For instance, following HSDPA trials in China, Nokia announced that its first commercial HSDPA software release for network infrastructure will support up to 1.8 Mbps download speeds and will require an additional software upgrade to offer 3.6 Mbps speeds. This second software upgrade will be available from mid 2006. During trials with Vodafone KK, Ericsson announced that the upgraded base stations support downlink and uplink speeds of up to 3.6 Mbps and 384 Kbps respectively. Lucent's HSDPA solution can offer peak data rates of up to 7.6 Mbps, while future upgrades will provide maximum speeds of up to 14.4 Mbps.

In terms of devices, data cards supporting up to 1.8 Mbps speeds are already available on the market but not in volume. Shipping has just begun. Ovum expects to see the first data cards supporting up to 3.6 Mbps speeds during the 2nd half of 2006.

We expect the first HSDPA handsets to be available in mid-2006. A wider range of HSDPA handsets developed by the major handset manufacturers is expected for late 2006 and would support data speeds of up to 3.6 Mbps. Figure 6.4 shows the expected roadmap for HSDPA end user equipment.

Figure 6.4 **Roadmap for HSDPA user equipment**



Source: Ovum

Vendors plan to introduce their first HSUPA, systems in the second half of 2006. For example, Siemens and NEC plan to initially provide 1.4 Mbps HSUPA solutions, starting in H2 2006. The uplink is expected to later support rates of up to 5.8 Mbps. Nokia expects to launch its HSUPA commercial offering in 2007. Ericsson performed HSUPA demonstrations with 3 Scandinavia in May 2005, during which uplink data rates reached 1.5 Mbps.

6.5.4 Open standards

HSDPA is an evolution of UMTS standard defined by 3GPP in its Release 5 specification. As a consequence, multiple vendors can produce HSDPA products that will be interoperable with each other.

The 3GPP Release 6 specification enhances HSDPA and introduces HSUPA. HSUPA complements HSDPA as a full upgrade of UMTS networks, by enhancing the uplink capability to 5.76 Mbps.

The main technological improvements with HSUPA are:

- fast uplink scheduling function based in the BTS, and
- fast retransmission with control in the BTS.

6.5.5 Bandwidth and range limitations

The data speeds achievable on end-user devices will depend on the 3GPP category of the device (see Figure 6.5 below). The range is similar to UMTS at around 50 kilometres in rural areas with some trade-off in performance and less than a kilometre in highly built-up areas.

The first HSDPA devices will be data cards for laptops that will only support peak rates of 1.8 Mbps - far from the theoretical 14.4 Mbps. Globally, using this kind of data cards, operators expect to provide average data speeds of 400-700 Kbps with burst rates of 1-1.5 Mbps.

Figure 6.5 **Maximum HSDPA data rates depending on 3GPP categories**

	Max number of HS-DSCH codes	Min inter TTI interval	Modulation	Max data rates
Category 1	5	3	QSPK & 16QAM	1.2 Mbps
Category 2	5	3	QSPK & 16QAM	1.2 Mbps
Category 3	5	2	QSPK & 16QAM	1.8 Mbps
Category 4	5	2	QSPK & 16QAM	1.8 Mbps
Category 5	5	1	QSPK & 16QAM	3.6 Mbps
Category 6	5	1	QSPK & 16QAM	3.6 Mbps
Category 7	10	1	QSPK & 16QAM	7.2 Mbps
Category 8	10	1	QSPK & 16QAM	7.2 Mbps
Category 9	15	1	QSPK & 16QAM	10.2 Mbps
Category 10	15	1	QSPK & 16QAM	14.4 Mbps
Category 11	5	2	QPSK	0.9 Mbps
Category 12	5	1	QPSK	1.8 Mbps

Source: Ovum, from 3GPP

6.5.6 Scalability

Scalability depends upon the existing equipment. Most vendors have been releasing WCDMA Release 99 equipment that is physically compatible (HSDPA-ready) for some time now and this infrastructure will be upgraded by a software-only upgrade. Operators that have deployed non HSDPA-ready base stations will have to deploy new hardware to support the technology.

The support of HSDPA services may increase mobile data traffic and consequently require an upgrade of the backhaul network.

6.5.7 Deployment, operational and maintenance cost

In an HSDPA network, the base station plays a more important role compared to a UMTS R99 network, as it is now responsible of the scheduling algorithm and the retransmission mechanism. As a consequence the implementation of HSDPA in a UMTS network mainly involves changes in the Radio Access Network. Generally the HSDPA upgrade only involves a software upgrade.

Because of scheduling, HSDPA base stations will require higher processing power in order to support as many users as possible. For core network and radio network controllers, limited changes mainly concern the signalling part due to the higher bandwidth access allowed by HSDPA. Therefore, the rollout of HSDPA is mainly considered as an incremental cost for most UMTS operators. Operators with 3G spectrum who have not yet deployed UMTS can deploy HSDPA directly at a similar price to a UMTS rollout.

However, mobile operators may have to make additional changes that could be expensive. For instance, if HSDPA is a success the backhaul part of the network will have to be upgraded as well in order to deal with the increased capacity. This will mean additional microwave links, new E1/T1 lines' rental or investments in new backhauling technologies (fixed optical, DSL, WiMAX).

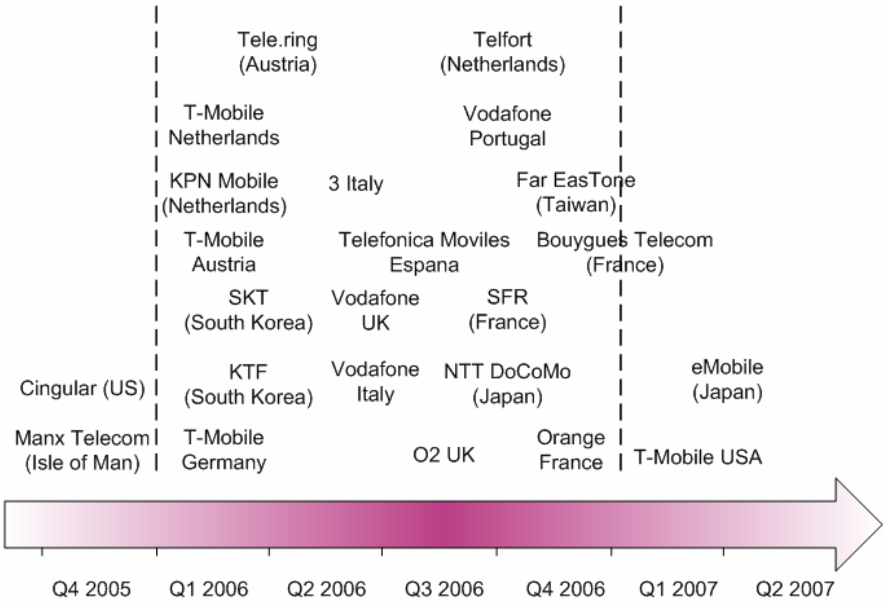
As was the case with 3G handsets, the first HSDPA phones will be expensive and prices will decrease progressively when volumes increase due to the increasing availability of HSDPA services worldwide. The first HSDPA handsets could cost around $676(US$500)-$1,081(US$800).

6.5.8 Existing base of infrastructure

The technology is currently deployed by several operators worldwide however only two HSDPA services have been launched to date; one in the US by Cingular and one in the Isle of Man by Manx Telecom. Telstra has started deploying HSPDA in high usage urban areas. Other operators in Australia are evaluating their HSDPA deployment plans.

Dozens more HSDPA service launches are expected for 2006, mainly in Western Europe as shown in Figure 6.6.

Figure 6.6 **Examples of planned HSDPA commercial launches worldwide**



Source: Ovum

6.5.9 Competition, demand and applications

HSDPA competes with other wireless broadband technologies such as mobile WiMAX, Flarion's Flash-OFDM and ArrayComm's iBurst technologies.

Some vendors also position HSDPA as an alternative to DSL and cable. However the indoor capability of HSDPA may suffer in the comparison with DSL.

The main objective of mobile operators with HSDPA is to enhance the average speed of each user in order to improve the user experience of current applications using UMTS. For instance, streaming content and video telephony services.

The addition of HSUPA will be a key improvement allowing the provision of carrier-grade mobile VoIP or multi-player mobile gaming services. Coupled with IMS, HSDPA/HSUPA technologies will be the basis of the development of new value added services.

6.6 UMTS TDD (or TD-CDMA)

6.6.1 Technology

UMTS TDD technology is a packet data implementation of the UMTS standard using Time-Division-Duplexing (TDD). With a data transmission speed of 4 Mbps per second in theory, TDD technology is supposed to offer a bandwidth capacity that is twice that of FDD. Initially, UMTS TDD was developed by 3GPP to add extra capacity to UMTS FDD networks in high demanding areas such as business centres. Details of the UMTS TDD network architecture are in Annex 6.

6.6.2 Maturity

UMTS TDD is a fully proven mature technology even though there are few commercial UMTS TDD deployments worldwide. The main UMTS TDD backer, IPWireless, has provided end-to-end UMTS TDD solutions since 2001.

UMTS TDD network infrastructure equipment is available today but only supplied by a limited number of vendors.

Currently, TDD data cards for laptops, gateways and modems are produced by a handful of vendors and available in limited volume. To provide TDD based voice services to mass market, operators need to have access to affordable TDD-enabled handsets but there are no UMTS TDD handsets available in volume in the market. IPWireless has worked on a prototype for several years and now offers a UMTS TDD handset that supports VoIP using a SIP protocol stack. The handset has been developed in partnership with Atmel and UTStarcom.

6.6.3 Open standards

UMTS TDD was defined in 3GPP Release 99 in the UTRAN standard (UMTS Terrestrial Radio Access Network) alongside the WCDMA FDD (Frequency Division Duplex) standard.

China has developed a variant of UMTS TDD, called TD-SCDMA, which has also been adopted by 3GPP.

6.6.4 Bandwidth and range limitations

The time based rather than frequency based duplexing nature of UMTS TDD enables reallocation of capacity between the uplink and downlink according to traffic demand. This is particularly effective for asymmetric traffic in picocellular (indoor) environments, but becomes less effective at larger distances from the base station.

Coverage is dependent on network configuration, and the reach ranges from approximately 2.5 kilometres in a suburban cellular environment to 30 kilometres in a rural LOS deployment.

The overall capacity depends on the nature of the base station. Vendors supply different base station configurations from mono-sectored to 6-sectored base stations. IPWireless claims that UMTS TDD solutions have been shown to support peak downlink sector capacities of up to 12 Mbps. Typically operators have deployed tri-sector base stations, bringing the capacity up to 36 Mbps per base station.

6.6.5 Scalability

UMTS TDD is a scalable technology like UMTS FDD.

6.6.6 Deployment, operational and maintenance cost

Spectrum can be a major cost for UMTS TDD deployments. The price varies widely with some European operators paying billions for spectrum and others paying far less.

UMTS TDD is a cellular technology and therefore requires the rollout of base stations, backhaul equipment and core network equipment site survey, network planning, and other costs common to deploying mobile networks. IPWireless has estimated the upfront cost of rolling out a UMTS TDD at around $6.50 per subscriber. Apart from that, there is no public information on IPWireless equipment prices.

6.6.7 Existing base of infrastructure

In New Zealand, Woosh Wireless has deployed IPWireless technology and approximately two thirds of the country is covered.

The technology is also used for commercial services by Sentech (South Africa), UK Broadband (a subsidiary of PCCW in the UK), T-Mobile Czech Republic, Aksoran (Kazakhstan), UAB "Neltes tinklas" (Lithuania), Airdata (Germany) and Accelerated Wireless Communication (Sweden). There have also been limited deployments in Australia, including an Optus trial in Sydney in late 2004.

3.5.2 Competition, demand and applications

The lack of support for this technology by a sufficient range of major vendors will inhibit rollout of this technology. In particular, the lack of international roaming opportunities is a disincentive for using UMTS TDD as a mobile broadband network technology.

TDD is especially suited to data applications where the traffic to and from the users is not symmetric.

UMTS TDD allows the supply of mobile VoIP services supporting handover and consequently can compete with traditional circuit-switched mobile voice services from existing mobile operators. However, in some countries, such as Germany, operators who deploy UMTS TDD can be asked not to provide handover between cells in order to avoid the introduction of mobile VoIP services.

6.7 TD-SCDMA

6.7.1 Technology

The TD-SCDMA (Time Division – Synchronous Code Division Multiple Access) standard uses TDD modulation and, unlike the WCDMA standards and CDMA2000, supports asymmetrical capacities. TD-SCDMA transmits uplink traffic and downlink traffic in the same frame in different time slots. Chinese vendor Datang, the CATT and Siemens have jointly developed TD-SCDMA. TD-SCDMA is part of a broad effort by Beijing to create Chinese-made standards in order to demonstrate Chinese know-how as well as cut spending on imported WCDMA and CDMA2000 technologies.

6.7.2 Maturity

TD-SCDMA industrialisation testing began in March 2005. Technical trials sponsored by the Chinese Government in June 2005 were disappointing. Notwithstanding this, China's Ministry of Information Industry formally approved TD-SCDMA in late January 2006. This means that, according to Chinese authorities, the technology is now technically proven and mature for commercial deployment.

There have only been only citywide trials to date in China. They have occurred in several Chinese cities such as Beijing and Shanghai. One trial has also been announced in Romania with ZTE.

Several mobile infrastructure vendors claim to have TD-SCDMA products ready for commercial deployment. For instance, Alcatel and Datang Mobile announced in August 2005 that they were ready to provide an end-to-end TD-SCDMA solution, including core equipment, radio access equipment, application platform and terminals. LG plans to introduce a triple-mode phone that supports TD-SCDMA, WCDMA and GSM standards in the first half of 2006. Other handset manufacturers such as Bird, DBTel and Lenovo are reportedly finalising prototype testing of their own TD-SCDMA handsets.

6.7.3 Open Standard

In May 2000, TD-SCDMA was accepted by the ITU as a 3G IMT-2000 standard and by 3GPP in March 2001. 3GPP Release4 introduces TD-SCDMA.

Most of the key TD-SCDMA Intellectual Property belongs to Chinese companies.

6.7.4 Bandwidth and range limitations

Because there have been no commercial deployments of TD-SCDMA to date, information on its bandwidth and range are based on the Chinese government testing results.

TD-SCDMA can achieve 384 Kbps to 2 Mbps. Ovum expects that TD-SCDMA will have comparable speeds to WCDMA/HSDPA and CDMA2001x EV-DO.

Depending upon the spectrum band used by the technology, coverage can be up to 11 kilometres.

6.7.5 Scalability

TD-SCDMA can be deployed alongside an existing UMTS FDD network or can be deployed as a stand-alone network. In the first case, the mobile core network can be shared; the operator will only have to deploy TD-SCDMA base stations. As for RNC, the hardware of the two networks is nearly the same; the main difference between the system and the WCDMA system lies in the radio resources management arrangements. In the second case, the mobile operator will need to deploy both core and radio networks.

TD-SCDMA is not suitable for large-area coverage compared to CDMA2000 and UMTS FDD. Rather, TD-SCDMA is generally considered as a complement to UMTS FDD network in dense areas where additional capacity is needed. Consequently this technology has limited relevance for this project.

6.7.6 Deployment, operational and maintenance cost

Costs are not available, as there have been no large-scale deployments. It is expected that the costs will be similar to other mobile technologies both in terms of deployment and operational and maintenance costs as a proportion of capital costs.

6.7.7 Existing base of infrastructure

There have been no TD-SCDMA network deployments.

TD-SCDMA is due to be deployed in Mainland China, however Chinese authorities hope that the technology will also be adopted abroad.

It is likely that at least one of the Chinese operators will have to deploy TD-SCDMA.

6.7.8 Competition, demand and applications

TD-SCDMA competes with CDMA2000 and WCDMA standards.

Using TDD technique, TD-SCDMA is particularly well suited for asymmetrical applications such as web browsing, downloads and streaming, where the download capacity greatly exceeds the upload requirement.

7 Broadband access technologies

7.1 WiFi

7.1.1 Overview

WiFi deployments are cheap and can provide a best efforts broadband service where there are no other options. WiFi has been used in combination with satellite backhaul in very remote areas in Australia and internationally to make broadband available on this basis.

WiFi is only really an option for very small towns in very remote locations where there are no other alternatives apart from satellite broadband. ACMA has allocated spectrum bands for WiFi that allow non-exclusive use (licence free) so spectrum access is not an issue for WiFi.

7.1.2 Technology

WiFi is the common name for Wireless LAN networks that adhere to specifications contained in IEEE 802.11, usually 802.11b. 802.11b and g operate in the 2.4 GHz band while 802.11a operates in the 5 GHz spectrum.

7.1.3 Maturity

WiFi is a commercially established technology that has been deployed all over the world. Equipment and products are widely available.

7.1.4 Open standards

IEEE 802.11a and 802.11b was ratified in July 1999. IEEE 802.11g was ratified in June 2003. IEEE 802.11i was ratified in June 2004. There are also a variety of standards being developed, such as 802.11n which is expected to increase the theoretical maximum speed to 100 Mbps. A full description of the WiFi standards is contained in Annex 4.

7.1.5 Bandwidth and range limitations

WiFi has very limited range. The data range and coverage area provided by WiFi depends upon the underlying technology, access points and the radio conditions at each site. The distance and configuration of nearby walls affect the quality of radio conditions, the material content of the walls, the proximity of reflective service as well as the number of people moving around.

802.11b can theoretically provide a maximum theoretical speed of up to 11 Mbps in a 50 metre range. Typically around 5.5 Mbps is available to be shared among users.

802.11a, certified by the WiFi alliance as WiFi5, can provide speeds ranging from 6 Mbps to a theoretical maximum of 54 Mbps at a range of 10 metres in the basic standard. This is theoretically extendable to 100 Mbps plus in 'turbo' or '2x' mode.

802.11g can theoretically provide speeds of up to 54 Mbps at a range of 25 metres. In practice it provides speeds of around 17-19 Mbps. Typically in a WiFi technology to a small town, services up to 512 Kbps could provide services to a radius of around 5km if direct line of sight can be achieved.

7.1.6 Scalability

802.11a is the most scalable of the WiFi standards. 802.11a operates in the 5 GHz unlicensed spectrum and uses OFDM to define eight non-overlapping 20 MHz channels across the 5.15 – 5.35 GHz frequency range. Each of these channels are then split into 52 sub-carriers that transmit signals simultaneously, in parallel, at these different frequencies. Consequently, 802.11a is theoretically highly scalable as higher data rates can be provided by simply breaking up the carrier into more and more parts and then transmitting them on additional sub-carriers. In practice, regulators restrict the amount of bandwidth available for additional sub-carriers, which limits the scalability of the service.

7.1.7 Deployment, operational and maintenance costs

WiFi hotspots are very expensive to deploy on a large-scale basis. Rather they are more suited to covering small areas that will require a minimum of hotspots. 802.11b is the cheapest to deploy of the standards.

Clear Advantage & Associates estimate that a WiFi base station would cost between $20,000 to $50,000 in equipment costs. This calculation excludes any of the related costs such as leasing of space, civil works, and backhaul. The location chosen (size and terrain), the equipment used, and the required coverage will affect the cost of setting up the hotspot. Any of these factors will have a major impact on the price and could drive the cost below or above the estimates given by Clear Advantage and Associates.

7.1.8 Existing base of infrastructure

WiFi spots have been deployed throughout the world, generally in cities. Telstra alone has 937 WiFi hotspots with other operators also providing their own hotspots.

Following are two examples of use of WiFi in isolated locations for delivery of wireless broadband from Europe.

Broadband in the Scottish highlands

Highlands and Islands Enterprise (HIE) is a government sponsored organisation that is aiming, among other things, to provide the Highlands and islands of Scotland with as wide a coverage as possible of broadband.

The organisation managing the rollout of broadband in this area, HI-WIDE, is jointly funded by HIE and the European Regional Development Fund. The purpose of HI-WIDE is to fund the capital infrastructure in order to bring low-cost broadband solutions to these communities. It is not designed to meet the ongoing maintenance costs of the broadband network. The program is also focused on providing broadband at ADSL equivalent rates. Consequently subscription levels, at competitive prices, needs to reach a level that will fund the ongoing cost of the network.

Environment

Communities in this region are often not more than 20 people. The terrain is challenging for broadband deployment due to a dispersed population and the mountains, lakes and coastline. Lastly, there is limited access to affordable backhaul.

Chosen technology

HI-WIDE has chosen to deploy a wireless network, as they believe this is the only way to keep capital infrastructure to reasonable levels. Long distance underground cable routes in these areas will incur huge costs. This technology chosen was wireless broadband in an unlicensed frequency band: 2.4 GHz FHSS (Frequency Hopping Spread Spectrum). The technology has limitations in terms of power and so has limited coverage. Interference can also be an issue, although this is less of a problem in rural areas. Additionally, weather affects the quality of the radio signal. The practical length, in order to provide comparative speeds in both rainy and dry weather, is 1.5 kilometre assuming a 15dBi antenna at one end and an 18dBi at the other end.

HI-WIDE has chosen satellite as backhaul, as it is seen as a relatively low cost solution with easy deployment. Satellite service offerings are available nationally in the UK. However, it is recognised that the performance issues with satellite may prove problematic for subscribers in the long term.

In the pilot installation there was six coverage sites. The subscriber locations were served and interconnected using point-to-multi-point BWA technology. There are an average of three and a maximum of five radio hops per subscriber back to the central hub location for the backhaul link - a 2 Mbps satellite. A diagram of the network outlay is shown in Figure 7.1.

Figure 7.1 **Trial network**

Broadband in Ireland

Until recently, Ireland had lagged behind its European counterparts in terms of broadband growth. However in the past eighteen months this situation has been reversed with Ireland showing strong and healthy broadband growth, ranking 19th in the world in terms of broadband growth in the first nine months of 2005. This is in large part the result of strong involvement of the national government, regional government and local authorities in broadband programs. The national government undertook three initiatives to encourage the rollout of broadband infrastructure.

MANS

The government set up Metropolitan Area Networks (MANs) in 26 towns. This involved the construction of new broadband infrastructures with a separate state-owned entity in each town selling to local service providers. For example, the MAN in Cork is a city-wide WiFi network offering uncontended 512/128 Kbps services throughout the 1.5 kilometre city centre. MANs are now being extended to an additional 94 towns with populations of more than 1,500 which do not have DSL coverage.

Alternative backbone network

The government is constructing an alternative backbone network to connect the MANs and areas that are not connected by the existing core networks. The chosen technology is mostly point-to-point microwave links at 155 Mbps. The backbone is state-owned by is available to all service providers as a way of providing competition in backbone provision ahead of the possible unbundling o f the local loop.

Country and Group Broadband Scheme

This scheme entailed the Irish government asking local authorities in the country for proposals that would make use of a combination of national and EU regional development funds. Key aspects of this program are:

- Grants of up to 55 per cent of total capital costs are available.
- Position of technological neutrality.
- Proposals are vetted by the regulator to ensure that they offer acceptable parameters for quality of service, contention ratios, transmission speeds, number of users, overall costs, pricing, financial viability and future scalability.
- Broadband is defined as a flat-rate, always-on service of a minimum of 512 Kbps although higher speeds are encouraged.
- All service providers are able to bid or promote their services to communities. Although the government authorities supply information on them, it is left to the local communities to select their preferred service provider.

Aggregating demand

The South West Regional Authority (SWRA) in Ireland conducted a trial of satellite broadband services in 2003 and 2004. This involved both individual direct-access satellite services and WiFi networks with satellite backhaul to the core network. User type was mixed, consisting of schools, businesses and residential consumers.

The trial was considered broadly successful and contributed to considerable growth in satellite services around the country. By the end of 2004 it was estimated that there was between 1,200 and 1,500 satellite terminals in Ireland in late 2004. Satellite terminals also grew strongly in 2005, with 2,000 schools obtaining their first broadband connections through satellite. This means that for the first time there is large satellite based networks in Ireland run by large service providers rather than the collection of small networks and providers previously seen.

7.1.9 Competition, demand and applications

It is very easy for consumers to access a WiFi network. Most WiFi enabled portable devices are laptop computers. Laptop vendors building laptops with integrated WiFi radios include Toshiba, Compaq, HP and Dell. Dual-mode WiFi phones are being introduced, although this is more focused on fixed-mobile convergent solutions for the residential user.

802.11b's restricted speeds means that it can not be used for more demanding Internet applications, such as multimedia streaming. This limits its attractiveness for consumers in the long-term.

802.11a's eight channels mean that enterprises or public WLAN providers can sited up to eight 802.11a access points (each using a different channel) in close proximity without causing co-channel interference. This allows the provision of Internet services in densely packed environments, such as delivering content to PDAs at the Olympics. This also reduces the chance of co-channel interference from other WLAN deployments nearby. This is a major advantage in areas that are likely to support multiple WLAN deployments, such as multi-tenant units or popular hotspot locations like airports.

7.2 Fixed WiMAX (IEEE 802.16-2004)

7.2.1 Overview

WiMAX is a new technology that is yet to be fully proven in practice. Further announcements of certified deployments internationally are expected over the next 6 to 12 months.

In rural and regional areas, WiMAX have the capacity to fill gaps between areas where DSL is available. WiMAX is a shared technology, bandwidth per customer for rural and regional deployments in Australia would be expected to reach a maximum of around 1 to 1.5 Mbps. WiMAX is scalable for more customers, but the speeds are limited by the technology.

7.2.2 Technology

WiMAX is the common name for applications initially operating in the 3.5 GHz band of the IEEE 802.16-2004 standard, and is a radio frequency technology that enables fixed broadband wireless access systems employing a point-to-point or point-to-multi-point architecture.

As with many new standards and technologies, WiMAX has suffered from industry hype. This led to early disappointment, with the launch of the WiMAX certification process postponed until July 2005. Consequently, WiMAX-certified products were delayed until the end of January 2006, and in the interim, all the so-called 'Pre-WiMAX' equipment were proprietary developments based on IEEE 802.16-2004.

Fixed WiMAX, based on 802.16-2004, can be used to provide fixed wireless services to residential users and enterprises as well as providing backhaul services for fixed, cellular or WiFi traffic. WiMAX has clear potential to be an interesting alternative to traditional backhaul technologies such as E1/T1 lines or microwave SDH/PDH optical links. One of the main advantages that WiMAX standardisation brings, compared to proprietary LMDS solutions, is the reduction in the cost of equipment.

7.2.3 Maturity

WiMAX is a new technology and a complex one.

Founded in June 2001, the WiMAX Forum is a non-profit organisation that promotes a unified standard and develops certification for interoperable fixed-wireless services based on IEEE 802.16-2004 and 802.16e-2005 standards. The WiMAX Forum has also set up a certification process to ensure interoperability between the different products based on the 802.16 standards (infrastructure and end-user equipment). The lack of interoperability was a reason for the failure of the first generation of fixed-wireless technologies.

The WiMAX Forum decided to define a limited number of profiles in the 3.5 GHz and 5.8 GHz bands (see Figure 8.1). However, the WiMAX Forum finally decided to focus on the TDD and FDD profiles operating in the 3.5 GHz band and using a 3.5 MHz channel (the 3.5T2 & 3.5F1 profiles in Figure 7.2).

Figure 7.2 **Profiles defined by the WiMAX Forum**

Profile Code	**Frequency band**	**Duplexing format**	**Channel size**
3.5T1	3.5 GHz	TDD	7 MHz
3.5T2	3.5 GHz	TDD	3.5 MHz
3.5F1	3.5 GHz	FDD	3.5 MHz
3.5F2	3.5 GHz	FDD	7 MHz
5.8T	5.8 GHz	TDD	10 MHz

Source: Ovum, WiMAX Forum

After several delays, the first certified WiMAX-802.16-2004 products were unveiled in January 2006. All operate in the 3.5GHz band and comply with the first wave of WiMAX Forum certification process, which focuses on WiMAX basic features. Next certification waves will gradually add new functionalities such as QoS, indoor capability, and support of mobility.

However the various delays related to the certification process have illustrated the complexity of the technology and also highlighted that ensuring interoperability between all WiMAX-compliant products is a challenging goal.

It is unsurprising, given that WiMAX was certified in January 2006, that there has only been one announced rollout to date. We expect there will be many announcements of WiMAX network rollouts over the year, particularly in rural and emerging markets. The services will mainly target enterprises initially and progressively be extended to residential users when lower cost end-user devices are widely available.

7.2.4 Open standards

The IEEE 802.16-2004 standard was ratified in June 2004.

7.2.5 Bandwidth and range limitations

The 802.16-2004 standard can provide data rates up to 75 Mbps in a 20MHz channel, and have a range of up to 45 kilometres in Line Of Site (LOS) environments. Performances are different in practice, where depending on the rollout scenario, WiMAX systems can be limited to data rates of a few Mbps, while cell radius could be limited to just a few kilometres.

As the first WiMAX profiles to be certified only concern the 3.5 GHz band and are limited to the use of 3.5 MHz channel sizing, the peak over-the-air bit rate achievable by basic WiMAX products will be in the range of 11 Mbps using a 3.5 MHz channel.

Most tests have shown that WiMAX has difficulty providing reliable high-speed data rates for urban indoor usage beyond 3 kilometres from the base station. The industry is converging towards the provision of indoor services within a 2 to 3 kilometre radius cell. It is expected that the range will be between 10 to 20 kilometres for outdoor purposes.

Figure 7.3 presents performance results from a study conducted by the European Institute for Research and Strategic Studies in Telecommunications (Eurescom) related to 802.16-2004 equipment in LOS and NLOS environment.

Figure 7.3 **802.16-2004 performance**

Environment	Typical cell size	Throughput
Suburban terrain type A (NLOS)	0.7 kilometres	11.6 Mbps with a 7 MHz channel
Suburban terrain type B (NLOS)	1.2 kilometres	11.6 Mbps with a 7 MHz channel
Suburban terrain type C (NLOS)	1.7 kilometres	11.6 Mbps with a 7 MHz channel
Suburban Obstructed LOS	4.7 kilometres	11.6 Mbps with a 7 MHz channel
Rural Outdoor (LOS)	10 kilometres	11.6 Mbps with a 7 MHz channel

Source: Eurescom

Type A: hilly terrain with moderate-to-heavy tree densities
Type B: intermediate path loss condition
Type C: mostly flat terrain with light tree densities

This figure shows that Suburban type terrain has a significantly shorter range than rural outdoors terrain with LOS. It is expected that for deployments in rural areas in Australia, a range of up to 15km would be achievable.

7.2.6 Scalability

WiMAX networks are scalable. Depending on the number of users, a WiMAX operator may have to increase the density of its network with the addition of new base stations or new sectors.

Because fixed and mobile standards are incompatible, a fixed WiMAX operator wanting to migrate to mobile WiMAX would generally have to replace the hardware (or add new hardware) to support mobility even if the operator uses the same spectrum band.

7.2.7 Deployment, operational and maintenance costs

Most of the current solutions are proprietary and there have been limited commercial deployments. Consequently, pricing policies for base stations and other key elements in the network infrastructure have not stabilised yet. Vendors have advised that each sale, to date, is on a case-by-case basis, and that price patterns have yet to form. For that reason, prices are highly subject to variations between vendors. The average price for pre-WiMAX macro-cell base stations is around $33,784 (US$25,000) per sector. The micro-cell base stations could cost up to a fifth of this, ranging from $5,405 (US$4,000) to $6,757 (US$5,000) for a one-sector micro-cell base station. 3-sector macro base station costs around $101,351 (US$75,000). This is for the pre-WiMAX radio equipment only. On top of that, service providers have to add all the other related costs (such as cabinets, interface cards and cabling, and installation costs). Maintenance costs for WiMAX networks are similar to those of cellular networks. Customer Premises Equipment for WiMAX systems (CPEs) have been launched. In April 2005, Redline unveiled its RedMax line of CPEs, introducing a product combining an outdoor antenna and an indoor box that is expected, when available in mass, to cost around $675(US$500) for end-users. Compared to the $2,027 (US$1,500) outdoor antenna used for LMDS, this is a significant improvement but it's it is still too expensive for service providers aiming at offering WiMAX services in dense areas where DSL and/or cable are present. A DSL modem is often available for free as part of the DSL service or for around its unit cost ($54 – 68(US$40-50)) in any case. Customers will compare the WiMAX CPE costs with this.

These situations point out the necessity of supplying indoor CPE with integrated antenna to target urban residential markets in developed countries. Vendors, such as Airspan Networks, identified and answered with the coming launch of its EasyST product. The cost of these modems is expected to be initially in the range of $484 and to fall to around $161 as soon as next-generation chips are available in 2007. This applies in built up areas.

For remote areas the problem is quite different. Due to radio limitations, an outdoor antenna will always be needed for households and enterprises that are over 4 kilometres distant from the base station. Customers may be forced to accept these prices because they do not have the choice of other access technologies.

7.2.8 Existing base of infrastructure

Currently only pre-WiMAX solutions have been commercially deployed. Vendors claim that their proprietary solutions can be easily upgraded to standard version and are interoperable with other vendors' WiMAX solutions. This claim remains to be proven in practice.

In late January 2006, HT , the incumbent operator in Croatia, announced the first deployment of Certified WiMAX products. HT will deploy Redline solutions in and around Cakovec, one of the main urban areas of Croatia.

7.2.9 Competition, demand and applications

End-users prefer to have CPE that they can install and which is installed indoors. However end-users too far from base stations will need to use outdoor antennas. Outdoor CPE needs professional installation in order to align the equipment with the service provider's base station. This means that for residential households costs may exceed affordability. Consequently the CPE may need to be subsidised for successful WiMAX deployments.

7.3 Mobile WiMAX (802.16e)

7.3.1 Technology

Mobile WiMAX is based on the IEEE 802.16e standard, which basically enhances 802.16-2004 by adding mobility (up to 120 kilometres/h, supporting hand-off) to what is currently a fixed wireless technology.

7.3.2 Maturity

As the standard has only recently been approved, the technology is immature. Much remains to be done before commercial products will be available in the market.

Vendors are planning to provide 16e base stations for trials in mid-2006 and for commercial deployments in late 2006. Alcatel has announced it will start shipping mobile WiMAX equipment in 3Q 2006. However, as with fixed WiMAX, it is expected that vendors will market their portable proprietary technologies as pre-mobile WiMAX solutions. For instance, Navini Networks plans to introduce “dual-mode” proprietary/standard-compliant base stations (Ripwave-MX BTS) during the first half of 2006. The passage from proprietary to standard version will be achieved through a software-only upgrade.

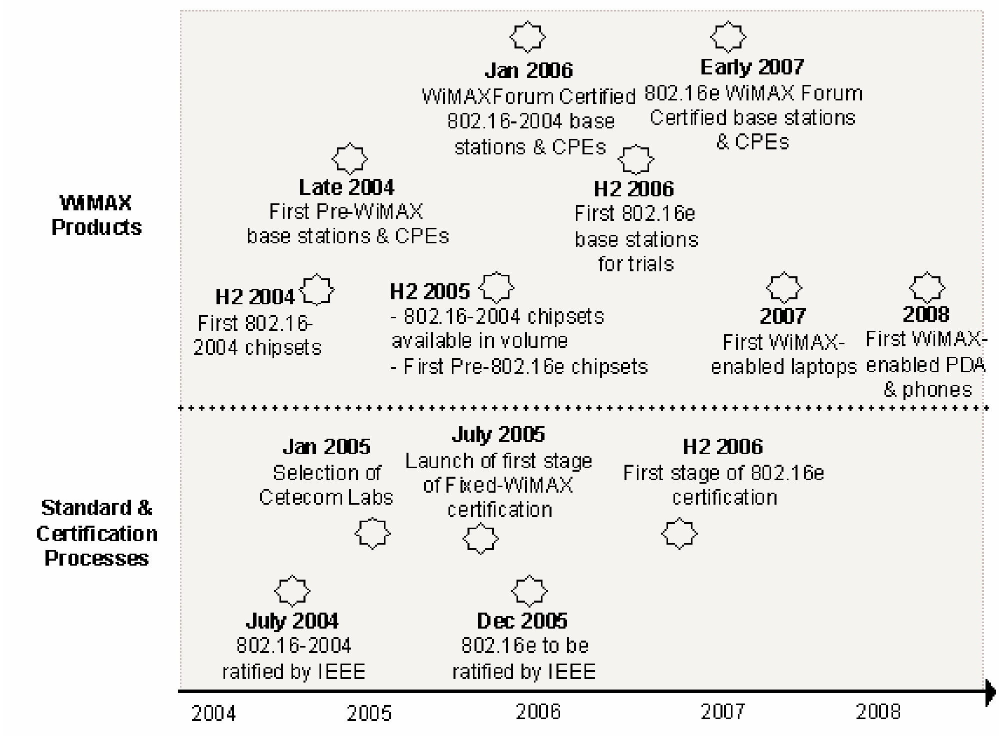
The WiMAX Forum has to first define profiles and then define a certification process for 16e. We expect that the first profiles to be defined will operate in the 2.5 GHz and in the 3.5 GHz bands. We do not expect to see certified 16e products commercially available before 2007.

Service providers will initially sell portable modems and data cards for laptops but the addressable market for 16e will increase once 16e-enabled chipsets are embedded directly into laptops. Intel has announced that it will provide chipsets for laptops in 2007.

The next step in demand will be the provision of mobile phones with 16e capability. Nokia plans to introduce 16e-enabled mobile handsets sometime in 2008. Motorola who also expects to develop 16e-enabled mobile phones.

Figure 7.4 shows the WiMAX product roadmap.

Figure 7.4 **WiMAX product roadmap**



Source: Ovum

7.3.3 Open standards

IEEE approved the 802.16e standard in December 2005. The final ratification is expected in Q1 2006.

7.3.4 Bandwidth and range limitations

As for fixed WiMAX, mobile WiMAX performance depends on the nature of the area to cover (LOS, NLOS), the frequency band used, the channel size used and the modulation used.

The first applications for 16e will be in the 2.5 GHz and 3.5 GHz bands. Using the 3.5 GHz band for mobility is not ideal due to poorer propagation characteristics compared to lower spectrum bands. Additionally the 3.5 GHz band is more likely to have regulatory issues as this band is generally dedicated to fixed broadband wireless technologies and consequently does not allow handover between cells.

7.3.5 Scalability

The rollout of a 802.16e network is similar to the rollout of a cellular network. The capacity of the network can be improved by adding base stations or sectors. The operator can also use a wider channel size if enough spectrum is available.

7.3.6 Deployment, operational and maintenance cost

As the 802.16e standard has recently been approved, there is no standard-compliant product available on the market yet, and therefore no prices. We have estimated prices taking into account proprietary technologies that are marketed as pre-mobile WiMAX technologies such Navini's Ripwave or NextNet's Expedience solutions.

In Australia, Unwired is using Navini's solution to support a 'portable' wireless broadband service at speeds up to 1 Mbps, but that does not allow cell-to-cell handover. It owns 2.3 GHz and 3.4 GHz spectrum in major cities as a result of its spectrum swap with Austar. To date Unwired has only rolled out a network in Sydney.

Figure 7.5 outlines Unwired's infrastructure costs.

Figure 7.5 **Unwired infrastructure costs**

Base station cost	$80,000 for a 4-sector base station. $20,000 per sector
Coverage per base station	3.2-3.4 kilometres (in-building)
Connections per base station	280 (70 per sector)
CPE cost	$189 modem/$320 PC card

Source: Unwired

7.3.7 Competition, demand and applications

Mobile WiMAX competes with other proprietary cellular and portable technologies such as Flarion's Flash-OFDM and ArrayComm's iBurst. It is also a rival technology to 3G.

7.3.8 Other considerations

802.16e and WiBro

Samsung, South Korea Telecom (SKT), the Electronics and Telecommunications Research Institute (ETRI) and the MIC have jointly developed the WiBro technology. WiBro delivers similar data rates to IEEE 802.16e in the 2.3GHz band, and supports mobility at speeds of up to 60kilometres/h.

Currently there are at least four commercial WiBro deployments planned worldwide: two in South Korea, one in Venezuela and one in Brazil. None of these deployments are in rural environments. Samsung has begun a WiBro field trial for KDDI in Japan and has agreements with BT, Telecom Italia and Sprint Nextel.

7.4 Flash-OFDM

7.4.1 Technology

Flash-OFDM (Fast Low-latency Access with Seamless Handoff - Orthogonal Frequency Division Multiplexing) is a proprietary all-IP architecture developed by Flarion Technologies to offer broadband mobile services. Based on OFDM technique, Flarion's solution is using a proprietary forward error correction code method, called Vector-LDPC (Low-Density Parity-Check).

7.4.2 Maturity

Flarion's technology is fully proven and has been intensively tested by some of the main operators in the world such as Vodafone, KT, T-Mobile and Sprint-Nextel.

Products are available today and ready for deployment.

Flarion Technologies works with infrastructure vendors and end-user equipment manufacturers. For instance, Flarion has partnered with Netgear to jointly develop its Mobile Broadband Router 814 (MBR814), a gateway supporting Flash-OFDM, WiFi and Ethernet access technologies.

Flarion also licenses the Flash-OFDM technology to facilitate the design of FLASH-OFDM enabled network equipment and devices. Siemens has concluded an OEM agreement with Flarion to provide Flash-OFDM solutions in the 450 MHz band. With this solution, Siemens is targeting rural areas and emerging countries, in particular the Eastern European and Asian markets.

7.4.3 Open Standard

Flash-OFDM is a proprietary technology. Big players are reluctant to deploy proprietary technologies due to interoperability restrictions and limited economies of scale regarding equipment and in particular end-user devices. To solve this issue, Flarion Technologies tried to push its solution as the basis of IEEE 802.20 standard. However, the standardisation working group has been struggling with internal lobbying that led to a slow standard development. Companies such as ArrayComm and Navini Networks who were also hoping to see their proprietary solutions being adopted as the reference for 802.20 have finally committed to mobile WiMAX for Navini or to ANSI's HC-SDMA for ArrayComm.

Furthermore, Qualcomm has recently acquired Flarion Technologies for $600 million and it is not clear how Flarion will fit into Qualcomm's strategy. Up to now, Qualcomm has insisted that existing agreements related to Flash-OFDM technology will be maintained but we believe the future for Flarion is uncertain.

7.4.4 Bandwidth and range limitations

In order to improve data speeds, Flarion Technologies also developed another proprietary technology, called Flexband, which allows doubling end user data rates. As a consequence, an operator can deliver peak downlink data rates of 5.3 Mbps and up to 1.8 Mbps UL for uplink using a 1.25 MHz Flexband carrier sector. Furthermore it allows 800 Kbps at the cell edge. In a 5 MHz multi-carrier system, each sector would support up to increase to 186 voice calls and peak data rates would increase up to 15.9 Mbps.

Flarion's Flash-OFDM solution also works in the 450 MHz band (and 700 MHz band in the US). This means coverage can be extended as the lower frequency that is used, the better the signal's propagation performance.

7.4.5 Scalability

Flarion's Flash-OFDM solution is a flexible and scalable solution because of the autonomy of the RadioRouter base stations. In adjacent cells, RadioRouter base stations do not need to be aware of each other, and timing or frequency synchronisation is not required between them. Furthermore RadioRouter base stations are backhaul-agnostic, meaning that they can attach to an IP domain via any backhaul technology (T1, Gigabit Ethernet, ATM, etc.). Consequently backhaul does not need to be replaced as the number of users and overall usage increases.

7.4.6 Deployment, operational and maintenance cost

Flarion Technologies' pricing policy is confidential and limited information is available. At lower frequencies less sites are needed to provide network coverage due to the better radio propagation. For example, Flarion claims that up to 60% fewer sites are needed in the 450 MHz band compared to the 2.1 GHz band resulting in reductions in capital and operating expenditure.

A UMTS operator can also deploy Flash-OFDM solution in parallel with its UMTS network. Flash-OFDM base-band cards using non-3G spectrum can be integrated into existing 3G base stations, thus preserving the investment that operators have already made in their 3G networks.

Flarion also claims that its solution implies lower system planning, deployment and maintenance costs because RadioRouter base stations are autonomous. It allows the deployment of a cellular infrastructure more similar to that of a wireless LAN.

7.4.7 Existing base of infrastructure

Flash-OFDM was not commercially deployed until June 2005. Deployment locations include Finland, Slovakia and the US. The primary objective of the Finnish deployment is to provide mobile broadband coverage in remote areas in Finland.

7.4.8 Competition, demand and applications

Flarion’s technology is proprietary and Siemens is the only major telecom infrastructure vendor to have set up an OEM agreement with Flarion for its 450 MHz product range. Few commercial services use the technology. As a consequence, the industry support of Flash-OFDM is not sufficient to allow mass production of Flash-OFDM equipment at a level that would drive the costs down.

Qualcomm’s acquisition of Flarion may change the situation by enlarging the market reach of Flash-OFDM but Qualcomm’s strategy regarding the technology is still uncertain.

Flarion’s IP technology supports mobile VoIP.

7.5 iBurst

7.5.1 Overview

iBurst is a shared technology. Bandwidth per customer for rural and regional deployments in Australia would be expected to reach a maximum of around 1 to 1.5 Mbps. Like WiMAX, iBurst has the capacity to fill gaps between areas where DSL is available.

7.5.2 Technology

ArrayComm, a US-based smart antenna software specialist, has developed a proprietary IP-based wireless broadband access technology called iBurst. At the core of the iBurst system is ArrayComm’s IntelliCell adaptive antenna (spatial processing software) technology. However, the iBurst system employs the same core network and service network architectures as other broadband IP systems, both wired and wireless.

ArrayComm's iBurst system uses TDD in which base stations and users share a single block of frequencies, alternatively transmitting in time. iBurst uses multi-carrier wideband technology that divides the 5 MHz band into 8 channels. This system assigns each channel asymmetrically. iBurst can deliver 20 Mbps of aggregate net useable subscriber throughput per sector in a fully loaded multi-cell network, operating in a single 5 MHz TDD channel.

7.5.3 Maturity

ArrayComm’s iBurst is a fully proven technology and is currently supporting two commercial networks, in Australia and South Africa.

iBurst technology is available today. At least two of iBurst licensees, Kyocera and Dewell, have developed products that are currently commercialised.

Kyocera's iBurst base stations are operating in the 1.8, 1.9, and 2.3 GHz frequency bands. iBurst base stations have a range of between 3 kilometres in built-up areas and 13 kilometres in LOS areas. Kyocera's iBurst network solution is able to provide data rates of up to 1 Mbps to each user with a maximum base station capacity of 20 Mbps. By 2009, Kyocera plans that its iBurst base stations will support the provision of up to 10 Mbps downlink data rates per user.

7.5.4 Open standard

Initially a proprietary technology, iBurst was adopted as a standard technology in the U.S. in September 2005 and was defined as "HC-SDMA" (High Capacity Spatial Division Multiple Access) by the American National Standards Institute (ANSI).

The iBurst technology also takes part in the work done by the IEEE 802.20 group.

The proprietary aspect of iBurst was a barrier to the adoption of the technology worldwide. ArrayComm's iBurst technology has only been licensed to a limited number of telecom equipment manufacturers that includes Kyocera, Dewell, LG Electronics and EADS Telecom.

7.5.5 Bandwidth and range limitations

Although, in theory, the iBurst protocol can support up to 16 Mbps for downlink, today commercial products can only offer up to 1 Mbps download speeds at maximum. Later this limit will be improved to 2 Mbps.

In its technical documents, ArrayComm claims that iBurst systems have demonstrated high user data rates at ranges of 1-2 kilometres in dense urban environments, such as downtown Sydney, with mobile PCMCIA-card terminals and over 12 kilometres in suburban environments with a desktop modem and small indoor patch antenna.

ArrayComm also claims that the iBurst system's adaptive antenna technology increases the coverage area of its base stations by roughly a factor of four higher than other systems offering comparable aggregate data rates. This may make the technology more relevant for rural and remote deployments.

7.5.6 Scalability

iBurst is a scalable wireless technology.

7.5.7 Deployment, operational and maintenance cost

There is limited information available on costs.

PBA purchased 5MHz of 3G 1905-1910MHz TDD spectrum in all Australian capital cities for $9.5 million during the Australian 3G TDD auctions held in March 2001. The coverage of all capital cities in Australia represents 75% of the population.

As of July 2005, PBA has spent approximately $20 million rolling out its Sydney network, and estimates that it will require another $140 million to fund its national rollout and OPEX to break even. This assumes a basic rollout of upwards of 550 base stations, with more to increase capacity in high use areas. It provided guidance that a base station costs approximately $300,000 to build and connect. Approximately half of this sum represents the hardware cost.

7.5.8 Existing base of infrastructure

Several operators have conducted iBurst trials worldwide. In South Korea, KT and Hanaro Telecom performed iBurst pilot trials in 2003. The system has also been tested in Japan in late 2004.

Today, at least two service providers have launched commercial services: Personal Broadband Australia (PBA) in Australia and Wireless Business Solutions (WBS) in South Africa. WBS' iBurst network is in service in Johannesburg, Cape Town, Pretoria, Durban, and Robin Island. WBS is rolling out additional base stations in metropolitan areas and is currently looking at beginning rollout to rural areas.

7.5.9 Competition, demand and applications

The fact that iBurst was a proprietary technology was the main barrier to wide adoption. This has now partially solved as a result of the recent acceptance of iBurst as a standard by ANSI. However there are still a limited number of equipment providers and few commercial deployments worldwide. Consequently, there is a risk that prices for both network equipment and CPE will remain high. Furthermore, iBurst has to compete face-to-face with technologies, such as HSDPA and WiMAX that benefit from wider support.

iBurst is a TDD-based technology and TDD is especially suited to data applications where the traffic to and from the users is not symmetric.

7.5.10 Comparison of BWA technologies' key characteristics

The following figure briefly provides a comparison of the key parameters of the BWA technologies from a service provider's point of view.

Figure 7.6 **Comparison of key BWA technologies parameters**

	HSDPA*	UMTS TDD	WiMAX 802.16-2004	WiMAX 802.16e	FLASH-OFDM	iBurst
Infrastructure costs	++	-/+	+	+	-	-
Rates / Capacity	-/+	+	++	+/++	+	++
Coverage	+	+	++	+	+	+
Backing level by the industry	++	-/+	+	++	-/+	-
Mobility capability	++	+	-	+	++	++
Product availability	+	+	+	-	-/+	+

Source: Ovum

* HSDPA is considered from a mobile operator's perspective

7.6 DSL - ADSL/ADSL 2+

7.6.1 Overview

ADSL is by far the dominant technology for broadband service provision. ADSL and its variants can provide high quality high speed broadband services to users. The nature of the copper infrastructure available and the distance of the end-user from the exchange limit serviceability. Potential customers further than 5km from the enabled exchange are not serviceable, but faster speeds can be delivered to customers closer to the exchange than 5km.

As such ADSL is the best technology choice currently available for delivery of cost effective, robust, high speed broadband services.

7.6.2 Technology

Many of the issues related to ADSL deployment are shared with other DSL technologies. The description of ADSL is therefore more extensive than those that follow for other DSL technologies.

ADSL is run over the existing copper PSTN access network. The ability of a local loop to support ADSL and the speed of service will depend on the quality of the local loop and the line length:

- In some circumstances, local loops have bridge taps, which are points in the circuit where line stubs or poor installation work may leave unused circuits attached. These taps can interfere with the high frequency ADSL signals and impair transmission.

- In some cases, loading coils are used to extend the range of a local loop for voice grade communications. These are inductors added in series with the phone line, which compensate for the parallel capacitance of the line. They benefit the frequencies in the high end of the voice spectrum at the expense of the frequencies above 3.6kHz. Because of this loading coils prevent xDSL connections.
- The type of cable used and its routing can also influence suitability for ADSL. Crosstalk and electrical interference will impair ADSL performance.
- ADSL access speeds reduce with increasing loop length. This is discussed in more detail later.

7.6.3 Maturity and open standards

ADSL is the predominant broadband access technology for access speeds up to (and beyond) 4 Mbps. ADSL is commercially established and any technical issues have mostly been resolved.

The reasons are clear:

- ADSL and other DSL variants are highly standardised, supported by ITU standards which are (with some regional or country variants) adopted worldwide. This common base leads to high volumes of product being available from many competitive vendors. It is a virtuous circle: high volumes and strong competition lead to higher levels of integration, enhanced chipsets and lower prices. DSL technology is being built into routers, home gateways, wireless LAN DSL gateways and other Internet access devices. The DSL product volumes already shipped have helped vendors to invest strongly in product innovation. As a result vendors continue to reduce prices and they have an established customer base which no longer requires high investment in sales and marketing.
- Operators are able to exploit the local loop in which they have invested strongly in recent years in line qualification, testing methods and automated processes. With some operators activating many tens of thousands of lines a month, they have needed to develop efficient operating processes. Regulatory conditions which require incumbent operators to open their local loops to competition, and the establishment of wholesale network operations (providing network operators with massive purchasing and negotiating power), have allowed ISPs and all operators to also benefit from significant economies of scale. The size of the market then allows wholesale providers to create differentiated products, with different access speeds, contention ratios and traffic volumes (peak and long term), which further help to create competitiveness.

7.6.4 Bandwidth and range limitations

All terrestrial broadband technologies have limited reach. ADSL customers ideally need to be within a five or six kilometre loop length of a DSLAM. For higher speed services (ie. above 2 Mbps using VDSL) the practical distance is no more than 1.5 kilometres for typical operating speeds. Essentially, the further from a DSLAM the customer is, the lower the bandwidth that can be supplied. This has particular implications for rural areas, where:

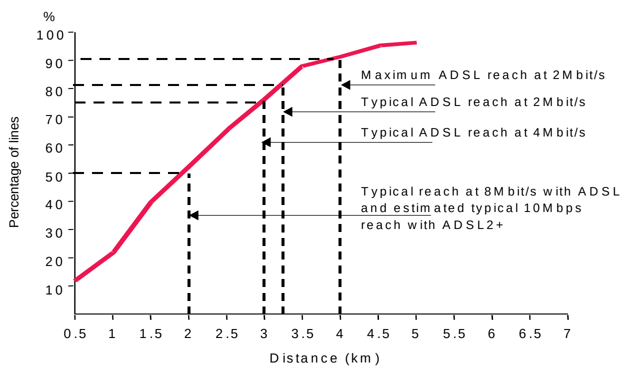
- households are more dispersed than in urban areas and consumers may be many kilometres from the exchange
- local exchange buildings may not be located in the most densely populated areas
- the more affluent customers in metropolitan areas (the ones that the operator really wants to reach) may be the furthest from the exchange
- copper pairs will be routed along streets and the loop length may be more than double the straight-line distance between the exchange and the customer.

ADSL is capable of providing speed up to 9 Mbps. Typically it can achieve speeds of 2 Mbps within a 4 kilometre distance of the exchange. ADSL customers for 512 Kbps services ideally need to be within a five or six kilometre loop length of a DSLAM.

ADSL 2+ is capable of speeds of up to 20 Mbps. However, it typically provides speeds of 4 Mbps within a 4 kilometre distance of the exchange.

The profile of local loop length and proportion of users served will vary for each location in Australia. Figure 7.7 shows a typical profile, with indications of how access speed varied with line length.

Figure 7.7 **Typical local loop length profile and access speeds**



7.6.5 Scalability

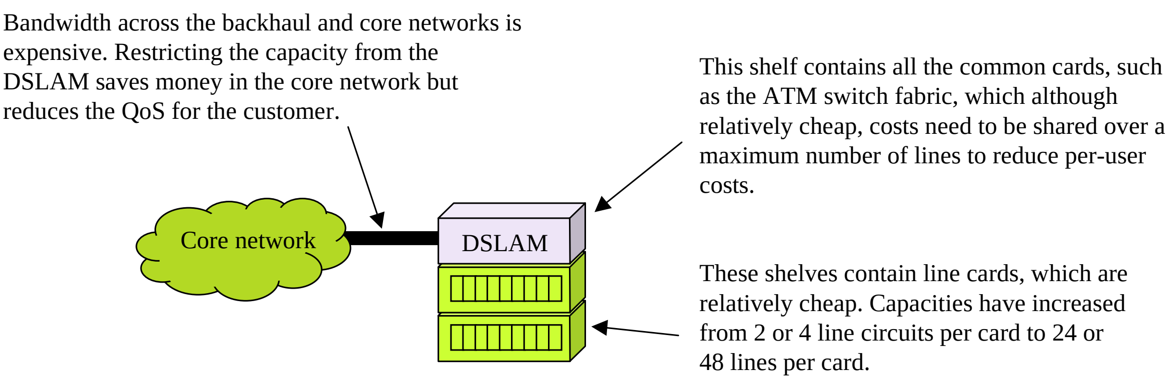
The number of customers can be scaled up dramatically on ADSL infrastructure. DSLAMs have been developed to handle around 5,000 customers per multiplexer. There are other solutions for areas with smaller potential customer bases. For example, in rural areas small cabinet-based DSLAMs designed to serve 8-16 lines and use SHDSL bonded copper lines for backhaul can be deployed.

7.6.6 Deployment, operational and maintenance cost

The original DSL design philosophy was to maximise infrastructure sharing and hence minimise costs per user. This principle is shown in Figure 7.8. DSLAMs capable of handling approximately 5,000 customers per multiplexer were developed and high contention ratios set in the DSLAMs, up to 50:1 for residential customers. Expensive common services and backhaul are shared between many users.

Whilst large DSLAM racks may be viable in urban areas, rural areas often have insufficient potential customers to allow this kind of sharing. Large common equipment racks would be expensive due to low levels of equipment utilisation, which in turn would lead to high costs and even lower take-up. This problem is overcome in many areas through the deployment of small DSLAM systems. These can be configured in the local exchange with as few as 16 ADSL lines, or alternatively, remote, cabinet-based DSLAMs can be served by SHDSL(refer next section) bonded copper lines.

Figure 7.8 **Cost reduction through infrastructure sharing**



Source: Ovum

Deployment costs for ADSL have been falling because of the mass market for the product. Both incumbents upgrading their copper network, and competitors accessing the local loop through regulated access, buy ADSL infrastructure. As a result of the large market and the many vendors selling the product, deployment costs have been reducing. The number of chips needed per circuit and cost of the chip sets has fallen significantly.

The cost of DSLAMs (with slots for allowing cards to support 8, 16, 24, 28 ports) has now fallen to the tens of thousands of dollars depending upon the number of lines to be serviced. One stakeholder estimated that the cost for a 48 ADSL2+ exchange including Telstra access and mileage fees would be approximately $50,000. The additional project management costs, site preparation and backhaul interface costs would be approximately $10,000.

ADSL lines can be automatically tested from the DSLAM. Once installed, ADSL has reasonably low maintenance costs. DSLAMs can be remotely monitored and configured to provide PSTN or ADSL services and the speed of ADSL access. In some cases the type of DSL service offered can be configured. It should be remembered that DSL runs over the copper network which is aging and will require increasingly high maintenance costs.

7.6.7 Existing base of infrastructure

ADSL runs over the existing copper network, although some of the infrastructure may need to be upgraded to support the technology. For example, rural exchange buildings were built to hold basic voice equipment. Consequently there is little space to hold additional equipment, inadequate or no air-conditioning facilities, they are often poorly located for broadband purposes, and have limited additional power supply capacity. It will add additional cost to address these issues. Australia has a copper network providing over much of the country.

7.7 Range extenders

Range extenders enable the reach of ADSL to be extended. In Australia, Extel and NEC have developed the Expandsl solution which can extend the range of DSL. They claim the reach of ADSL can be extended up to 20 km. The range extender is an outdoor proof remote DSLAM which can be placed in pit and connected to a pair gain system. Each remote DSLAM has 8 lines. Telstra has placed an order for Expandsl from Extel very recently.

There are a number of limitations of Expandsl. It requires availability of a pit at an appropriate position for the customer, and it requires the appropriate long copper loops to be available at the right place for the customer. It is only available for ADSL and ADSL 2+.

7.8 SHDSL

7.8.1 Overview

SHDSL is a niche DSL technology primarily focused on the business sectors. It was used the most in the first DSL deployments in the US. There are a small number of SHDSL deployments in Australia.

7.8.2 Technology

Symmetrical high-speed DSL (SHDSL) services can be run over the existing copper PSTN access network and also over other copper networks, eg. inter-exchange circuits. The use of SHDSL in a copper-pair network is subject to the same physical requirements of the local loop as described under the previous description of ADSL.

DSL Bonding Applicability

The bonding capability of SHDSL allows service providers to use DSL as an access trunk technology to support backhaul of traffic from subtended DSLAMs or other remote network elements.

SHDSL can also be used for backhaul of ATM-based or packet-based traffic. For example, the link between remote DSLAMs, next generation Digital Loop Carriers (DLCs) and 3G wireless base stations can be achieved by bonding a number of DSL lines. For these applications the arrangement is more efficient than the use of multiple separate links and symmetrical DSLs such as SHDSL provide a more cost effective alternative to traditional T1 technology because of their much better transmission rate/reach characteristics.

Applicable DSLs

Typically, symmetrical DSLs (often SHDSL), are used for backhaul and uplink services. Because of its symmetry, flexible framing structures, and coverage of the common DS1 access rates, SHDSL, and bonded SHDSL, is particularly well suited to deployment for high-speed transport. However, bonded ADSL or VDSL has a strong potential appeal to provide the uplink in the case of a subtended residential DSLAM that is providing ADSL or VDSL service. In this case, a bonded ADSL- or VDSL-based uplink would have aggregate uplink and downlink rates that match the traffic characteristics of the ADSL or VDSL subscribers served from the subtended DSLAM.

7.8.3 Maturity and open standards

SHDSL is commercially established and the technical issues have been resolved.

It should be noted that symmetrical DSL (SDSL) is a proprietary technology that can provide equal upstream and downstream bandwidth between a local exchange and the customer's premises. It is sometimes described as single-line DSL, as it replaces the older multi-pair service solutions using HDSL. SDSL was the main technology used in the first generation of DSL deployments by competitive local exchange carriers in North America, mainly to deliver high-speed data services to enterprise locations, where it performs well and delivers highly cost-effective solutions. However, it has now been overtaken in numerical terms by the extensive deployment of ADSL.

Symmetrical high bit-rate DSL (SHDSL) is a more recently developed symmetrical solution, designed to replace SDSL as a fully standardised and interoperable technology, and exhibiting better compatibility with other DSL solutions.

SHDSL equipment is designed to conform to the ITU Recommendation G.991.2, which is also known as G.shdsl. The standard was approved by the ITU-T in February 2001. SHDSL achieves 20% better loop-reach than older versions of symmetric DSL, it causes much less crosstalk into other transmission systems in the same cable, and multi-vendor interoperability is facilitated by the standardisation of this technology. Although SHDSL does not carry voice like ADSL, new voice-over-DSL techniques may be used to convey digitised voice and data via SHDSL.

7.8.4 Bandwidth and range limitations

Symmetrical high-speed DSL (SHDSL) fills a need in a certain niche market. It is the only ATM-based DSL technology that can currently provide a true leased line replacement service, and the only standardised DSL technology that supports pair bonding.

A key aspect of SHDSL is that bandwidth can be increased without losing reach by bonding fibre pairs together. A single pair can deliver 2.3 Mbps over approximately three kilometres, but by bonding two pairs together, 4.6 Mbps can be delivered over the same distance, and 9.2 Mbps can be delivered over four pairs, and so on. Some vendors offer solutions that can offer in excess of 20 Mbps. However, like all DSL technologies, the speed performance drops off with line length, and the both ends of a SHDSL link will need to be within the line length requirements for satisfactory performance.

7.8.5 Scalability

SHDSL is subject to the same scalability limitations as ADSL.

7.8.6 Deployment, operational and maintenance cost

SHDSL offers a flexible range of symmetrical and asymmetrical data rates, which is crucial for both incumbent and competitive access providers, because it presents a market development opportunity for them in the SME sector and as a means of reaching remote communities. SHDSL can be used to provide end-to-end services, which can for example be used by businesses as a replacement for leased lines. The service is characterised by high initial set up costs per exchange and then a much lower marginal cost per subscriber. Costs are falling as the market and volumes of DSLAMs increase.

SHDSL can allow multiple copper pairs to be bonded together, which allows higher bandwidth to be provided over longer circuits. This characteristic has generated a market for point to point loop extenders, which may for example be used to connect a small remote DSLAM back to the local exchange. A typical bonding unit will cost between $800 and $2,500, depending on capacity and configuration. Installation costs, housing costs (if required), power supply and line costs are not included. Once installed units have low maintenance requirements.

A line reconfiguration to provide or remove service will need a site or exchange visit as there will be fewer deployments of SHDSL and the line cards are based on different chip sets. However, once operating, SHDSL services should have maintenance requirements as low as other xDSL services.

7.8.7 Existing base of infrastructure

SHDSL is a niche technology, used when true 2 Mbps symmetrical service is required, or where pair bonding is required. Specialist operators targeting purely business customers were among the first to deploy SHDSL. For example, Catch Communications in Norway. There have been some small deployments in Australia.

7.8.8 Competition, demand and applications

SHDSL has not taken off in the way many first thought that it would, as enterprises, concerned about the reliability of DSL, have been reluctant to replace their leased lines with DSL. By early 2006, SHDSL is also seeing competition from the higher bandwidth capabilities of ADSL2+ and the ability of ADSL to be configured to provide symmetrical services. The larger market, and the consequent economies of scale, for ADSL means that services can be deployed far more cheaply than SHDSL.

However, as the market becomes more accepting of DSL services, so SHDSL will find a market in SMEs for a variety of services including hosting applications, deploying collaborative working tools, web conferencing services, instant messaging, online security, broadcasting and e-learning. SHDSL will become a key technology for those companies with hosted services and high upstream applications such as backup services.

7.9 VDSL

7.9.1 Overview

VDSL can provide very high broadband speeds (up to 52 Mbps) to customers very close to the exchange. At distances from the exchange greater than 2km VDSL can deliver speeds which approximate ADSL.

7.9.2 Technology

VDSL runs over the existing copper access network. Its performance is however limited to very short loop lengths with the same needs for physical quality as described under ADSL.

VDSL can be deployed from the local exchange, but is more usually deployed from in-building cabinets such as offices or apartment blocks or street cabinets close to the premises being served. In all cases it is usual to provide a fibre feed to the local exchange.

7.9.3 Maturity and open standards

The technology is proven, but the business model for VDSL is not. There are well established deployments of VDSL in Japan and Korea, and trials (large-scale and small-scale) being undertaken in other markets. A key issue to assess is whether there is demand for the service that can be offered by VDSL, or whether the higher speed ADSL2+ will suffice.

VDSL is standardised by the recommendation ITU-T G.993.1. ITU-T G.993.2, the VDSL2 recommendation was formally released by the ITU in May 2005. It is designed to support the wide deployment of Triple Play services such as voice, video, data, high definition television (HDTV) and interactive gaming, VDSL2 enables operators and carriers to gradually, flexibly, and cost efficiently upgrade existing xDSL-infrastructure.

7.9.4 Bandwidth and range limitations

VDSL can achieve 52 Mbps downstream and 13 Mbps upstream within a 300 metre distance of the node (exchange or cabinet). Speeds of 13 Mbps can be achieved within 1 kilometre of the node. To achieve speeds of above 2 Mbps, users need to be within 1.5 kilometres of the node.

The recently standardised VDSL2 has been designed to support even higher rates over short loops and can provide 100 Mbps at 0.5 kilometres and 50 Mbps at 1 kilometre. However, at longer loop lengths the performance degrades and is approximately equivalent to ADSL2+ from 1.6 kilometre. The long reach variant of VDSL2 (LR-VDSL) are able to support speeds of up to 4 Mbps (downstream) over distances of 4 to 5 kilometre, but operational and commercial requirements may mean that this not practically achievable. This makes LR-VDSL very much more attractive to provide services that are not limited to short loops or deployment from cabinets in offices or apartments, as is VDSL. Fibre feed is still a requirement for VDSL2.

7.9.5 Scalability

The main limitation to the scalability of VDSL is the need for fibre distribution to the remote cabinets. It will only be in dense urban areas that significant numbers of lines are short enough to be served from the exchange building. If the service provider wants to provide service to a significant number of its customers, then fibre-fed cabinets will be required.

Furthermore, if a service provider is offering VDSL services, then it will also be offering video and content services that require the bandwidth offered. This places demands on backhaul. It must be capable of sustaining high levels of continuous streaming with lower contention ratios than are used for lower bandwidth broadband services. Content distribution networks and partnerships with content providers are also required.

7.9.6 Deployment, operational and maintenance cost

VDSL has a higher deployment cost than other DSL technologies due to the need for fibre deployment and the small number of subscribers that can be supported per unit. The cost of fibre installation is a key factor to the success of VDSL. It is hugely expensive to provide underground ducts and associated access chambers, but using other methods can reduce costs. If the terrain is suitable, it is possible to plough and bury reinforced fibre cable in a single pass. Alternatively, fibre can be deployed using existing power or telephone posts, which can also be used to mount cabinets, reducing the need for expensive street cabinets. Pole mounted fibre and systems do have the severe disadvantage that they are open to the weather and may suffer storm damage, but may also be subject to accidental or malicious damage.

The deployment and operational costs will fall if mass deployment starts to occur, not only in the lower prices of systems, but as operational processes become standardised, allowing more cost-effective installation and commissioning.

The maintenance costs of VDSL have to be assessed against other access technologies and content distribution networks that are comparable. The costs are higher than those of ADSL running on standard PSTN lines.

7.9.7 Existing base of infrastructure

The cost of deploying VDSL and the need for a high density consumer base to support the content services (TV and media) will mean that VDSL services are only likely to be deployed in urban areas. In particular where the service provider needs to compete with establish cable operations.

On 1 Sep 2005, TransACT launched 'Channelvision', a locally produced content for its digital TV subscribers in Canberra. TransACT's network is based on a FTTC (Fibre- to-the-Curb) / VDSL architecture, capable of delivering a full range of communications services such as VoD, pay TV, high speed Internet and various mobile and fixed line services. The network passes around 60,000 homes and 5,000 businesses in Australian Capital Territory (ACT), Canberra. This suggests that VDSL requires scale to be economically viable.

7.9.8 Competition, demand and applications

VDSL is only likely to find a market in areas of high population density. It is expected to be deployed first where a fixed line service provider is suffering from the effects of triple play services from cable broadband. Many Telcos and ISPs are being cautious about the deployment of VDSL as the costs of fibre feed are high and demand may be uncertain.

7.10 Summary of DSL technologies

DSL technologies are mature. ADSL benefits from significant economies of scale when deployed in larger towns, and is available in small units that can be economically deployed to meet demand from a few tens of customers. However in remote areas, which may be served by copper access, or low capacity microwave designed for handling voice services, the infrastructure may not be able to support the high bandwidth backhaul that broadband access requires. This is a limiting factor that will need to be taken into account when technology choices are being made.

Many commercially available DSLAMs are now able to support a variety of different line cards which support different xDSL variants, some can be switched between different variants of ADSL and a line cards has recently been introduced which allows different DSL variants to be supported from the same card.

7.11 Hybrid fibre Co-axial cable (HFC)

7.11.1 Overview

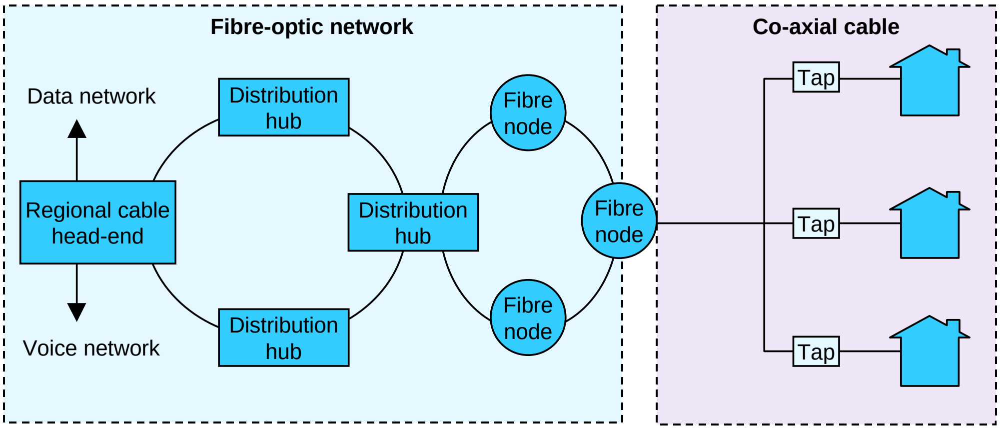
Internationally, HFC has been typically deployed in areas where pre-existing cable television networks can be upgraded to deliver voice and high speed broadband services. Compared to fibre, HFC is very cost effective for large scale deployments, but for deployments to small towns it is as expensive as fibre to the home (FTTH) which can deliver much faster speeds. Optus and Telstra have deployed HFC in urban areas in Sydney and Melbourne.

7.11.2 Technology

Cable networks were originally deployed for the delivery of broadcast TV services. To make sure that standard TV sets could be used, the operators simply recreated the analogue TV signals on the co-axial cable. As the only service delivered was TV, there was no need to develop a two-way communications network, and thus the first cable networks were one-way only.

To deliver both TV and high-speed Internet access, and to support two-way communication, the newer cable networks use a hybrid fibre co-axial cable (HFC) architecture, shown in Figure 7.10. Most older networks are in the process of being upgraded to this standard as well.

Figure 7.10 **Hybrid fibre co-axial cable architecture**



Source: Ovum

7.11.3 Maturity and open standards

HFC is commercially established and technology issues have been resolved. The DOCSIS 3.0 standards, managed by Cable Television Laboratories, a non-profit research and development consortium, are developed and pre-standardisation units are expected to become available in 2006, with full production units in 2008.

The technologies for HFC networks have been developed through industry collaboration and the establishment of the DOCSIS and Euro-DOCSIS standards.

7.11.4 Bandwidth and range limitations

HFC has fewer technical capacity limitations than the copper local loop. HFC based on DOCSIS 1.1 can achieve shared speeds of 10 Mbps. This means that individual customers' bandwidth may be 256 Kbps or less. HFC upgraded to DOCSIS 3.0 will be capable of voice and data delivery at 30 Mbps upstream and downstream in at least four frequency pairs, and so will be able to deliver a total capacity of 120 Mbps upstream and downstream shared by the users on that network segment.

HFC has a range of up to 100 kilometres on the fibre component fibre and 2 kilometres on the coaxial cable component.

7.11.5 Scalability

HFC requires the installation of a fibre terminating node for every 200-500 users, depending upon the bandwidth offered to each user. It is therefore modular and scalable.

7.11.6 Deployment, operational and maintenance costs

To enable voice services over the cable connection, the network has to be upgraded for the delivery of voice-over-IP. This means significant additional investment in telephony infrastructure. Operators need softswitch and gateway components and users need to be connected through DOCSIS 1.1 or DOCSIS 2.0 compliant equipment.

Some operators (such as in the UK and Spain), have deployed combined HFC and twisted copper pair access networks, with voice services carried over the copper pair.

The cost of deploying HFC can only be justified in areas of high population density in which a reasonably high proportion of homes passed (>30%-40%) are expected to take service. The business case is based on cost recovery from TV revenues, rather than from voice and Internet access.

Convergent Consulting's September 2005 study, Metropolitan Broadband Blackspots Program (MBBP) Cost Consultancy, stated that Telstra's HFC deployment in the mid-to-late 1990s cost $4 billion, equating to $1,900 per home passed.

As with ADSL, the initial start up cost of HFC is high, with a low marginal cost per subscriber. Maintenance costs can be higher than other technologies as the coaxial cable needs to be properly and regularly maintained.

7.11.7 Existing base of infrastructure

HFC is an upgrade of the existing CATV network. Optus and Telstra have rolled out cable networks in Sydney, Melbourne and Brisbane. Telstra has also begun but not completed cable networks in Adelaide and Perth. Austar has a cable network in Darwin. Neighbourhood Cable has rolled out a cable network in Mildura, Ballarat and Geelong in Victoria. All these deployments are in urban areas, and it is not expected that HFC can be cost-effectively deployed in rural or remote areas.

7.11.8 Competition, demand and applications

There is demand for cable in Australia, supply has been fixed, but Telstra has upgraded its network while the negotiations relating to its FTTN rollout unfold. It would be unlikely that Telstra would extend the HFC network further given it preference for FTTN systems in the announcement of 15 November 2005. Additionally the shared nature of the technology will constrain the addressable market that will be defined in terms of distance

7.12 Fibre

7.12.1 Overview

Fibre can be used in both the access and the backhaul network. This sections considers fibre in the access network, refer to section 8.2 for an assessment for fibre as a backhaul medium.

Fibre is very expensive to deploy but can deliver up to 100 Mbps to the end-user.

7.12.2 Technology

Optical fibre can be deployed in access networks and as backhaul from a local node (such as a local exchange or point-of-presence) to the core network.

At the access level, there are alternate configurations (and terminologies) which can be used:

- **Fibre to the premises (FTTP)** or **fibre to the building (FTTB)** - a fibre connection terminating at a shared residence commonly known as a multi-dwelling unit or multi-tenant unit (MDU/MTU). FTTP also includes business use of fibre access.
- **Fibre to the home (FTTH) -** commonly taken to mean a fibre connection terminating at - or immediately adjacent to - the customer premises. The FTTH market is a subset of the FTTP market.
- **Fibre to the node** or **fibre to the neighbourhood (FTTN)** - a fibre connection taken to a cross-connection point that services up to several hundred individual premises. A multiplexer device at the cross-connection point converts the signal to a different medium type (commonly a twisted-pair copper connection) to the individual subscribers. A digital subscriber line (DSL) technology such as ADSL2+ or VDSL is used to provide final service to the customer over distances of up to approximately 1.5 kilometres. **Fibre to the cabinet (FTTC)** is equivalent to FTTN.
- **Fibre to the kerb (FTTK)** is similar to FTTN except that the cross-connection point is typically within 200 metres of the customer and therefore serves fewer premises. Higher-bandwidth services are possible because the copper loop length is considerably shorter.
- **Fibre to anything (FTTx)** is the term used to collectively refer to all of the above variants.

7.12.3 Maturity and open standards

FTTx is being deployed in many advanced trials and commercial deployments around the world. In nearly all cases it is installed in urban areas, and for some operators it is the technology of choice when developing green field sites. TransACT has a significant pole-mounted fibre network in Canberra that is used to deliver high bandwidth DSL services.

Optical networking standards are well established but are continually evolving with work being undertaken by such organisations as the international and national standards bodies, the cross-industry forums and others. Many vendors and industry interest groups promote their particular strengths to try and establish standards in particular areas. Unless the development and build of a network is solely under the responsibility and ownership of a single operator, it is important that the technology selection ensures interoperability.

7.12.4 Bandwidth and range limitations

In the access network fibre is the enabler of very high bandwidth services. Its limitations are primarily cost related.

7.12.5 Scalability

Fibre is scalable, but the extent to which it is scalable is dependent upon network design and breakout levels. Scalability, in supporting the deployment in remote and rural areas, is dominated by cost and issues related to fibre routing and laying the fibre in inhospitable environments.

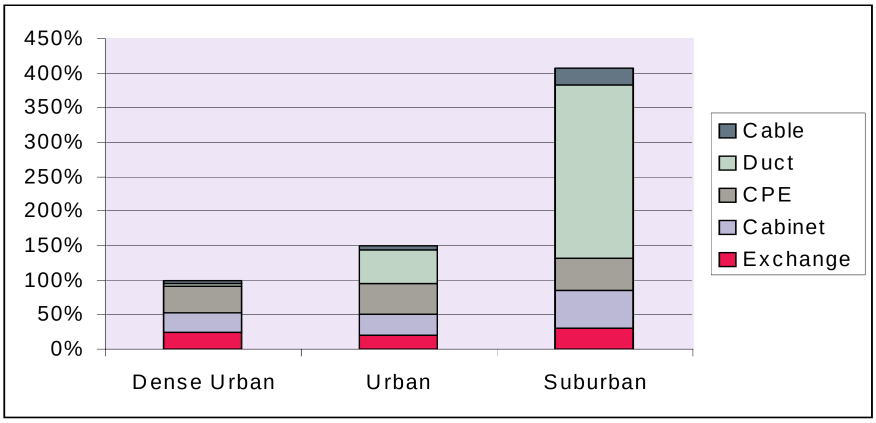
7.12.6 Deployment, operational and maintenance cost

Fibre is expensive to install, relative to copper and wireless systems. One stakeholder estimated that fibre is approximately $1,500 more expensive to install per house than copper. The nature of the routing / terrain where fibre is to be installed have a significant impact on costs. In an urban area, the costs of laying ducts and fibre can vary by up to 3 to 4 times, depending on the type of pavement and ground being dug. Costs of up to $500 per metre may be incurred, although this is at the extreme end of the range. The cost of obtaining way leaves also varies considerably, and local government involvement in the deployment may reduce the associated problems and costs. If existing ducts are available in which to run fibre cables, significant cost savings can be achieved. In some areas, subject to planning conditions, fibre can be run above ground using existing telegraph or electricity poles. This allows considerable savings to be made, but has the down-side of higher vulnerability to accidental or malicious damage.

It is not expected that the high deployment costs will fall in the short term, mainly due to the labour intensity involved in a fibre rollout. The cost per subscriber will therefore remain high.

Figure 7.11 shows the relative costs (derived from a European study) for fibre deployment in different urban environments. It shows that direct burying of the fibre can reduce costs significantly.

Figure 7.11 **Relative costs of Ethernet over VDSL with fibre deployment in different environments**



Fibre-to-the-kerb requires reliable and environmentally hardened cabinets to ensure low maintenance demands in the field. Vendors can provide FTTx nodes that are environmentally hardened and some small nodes are designed to be pole-mounted. The cost of maintaining active components in the field is higher than supporting a passive copper network. This will particularly be the case where long journeys are needed to provide technical support.

7.12.7 Existing base of infrastructure

There has been very limited deployment of end-user fibre networks here.

7.12.8 Competition, demand and applications

Fibre can be installed in remote and rural access networks to provide high-speed Internet connectivity. However to deliver applications such as IPTV and video-on demand, which need such bandwidth, will also require significant investment in the video distribution servers and associated systems required for content delivery.

7.13 Broadband over powerline

7.13.1 Overview

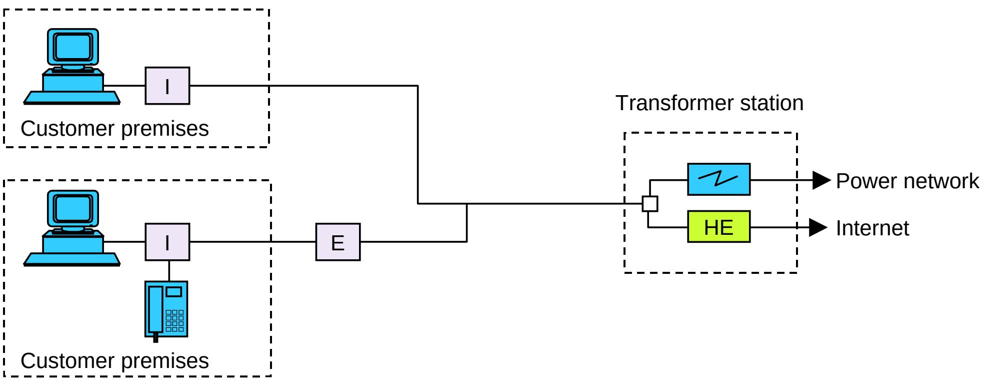
Broadband over powerline (BPL) is a developing technology which is currently under trial by a number of utility operators. Additionally, there is strong interest in the outcomes of these trials from telecoms operators. BPL promises to deliver up to 20 Mbps to the customer via the ubiquitous power connections to each household. However, the technology is as yet unproven.

7.13.2 Technology

Powerline communications (PLC), sometimes also called broadband over powerline (BPL) has been around for many years as a concept. After a flurry of excitement in the late 1990s, there have been a number of trials of different technologies but still relatively few commercial deployments. Unfortunately most of the recent news is of setbacks.

The principle of the technology is to combine communications signals and electric power delivery on a single transport medium - the existing electric power cable networks. The architecture is illustrated in Figure 7.12.

Figure 7.12 **Powerline network**



HE = head-end equipment
E = external termination equipment
I = internal termination equipment

Source: Ovum

The network is split into two parts: the outside network and the indoor network. These two parts can be combined, as in Figure 7.12 or can work separately - that is, with the powerline feeding a conventional LAN, or a conventional broadband access network feeding an indoor powerline LAN.

7.13.3 Maturity and open standards

PLC has yet to achieve mainstream market adoption in any country and cannot be considered to be proven as a commercial solution for use in rural and remote areas.

The power distribution network is not regulated in the same way as telecommunications networks, and as such, there has been far less drive to develop harmonised standards for PLC than other forms of broadband access. There are no internationally agreed standards for PLC. Work is under way in various industry forums, the IEEE's BPL Study Group and in the EU Opera initiative, which is an Open

PLC European Research Alliance for new generation PLC integrated network with a budget of about $32 Million including a funding of $14.5 Million from the European Commission.

7.13.4 Bandwidth and range limitations

Whilst solutions can be offered at speeds up to 45 Mbps in aggregate, as higher bandwidth is offered, so there will be increasing demands on the backhaul.

Like cable modem technology, powerline is a shared medium, in that the useable bandwidth is shared between users. Noise ingress, signal egress and signal attenuation are also major problems because the broadband operator is using electric power cables - very inefficient signal cables - as its access network. Without repeaters, the distance between the transformer station and the customers can be as short as 200-300 metres. Using repeaters adds complication and expense.

Serious doubt has been expressed by the ACA (Australian Communications Authority, now ACMA) over the level of interference emanating from largely unshielded and overhead power cables. The same report also cites Japanese telecoms ministry reservations regarding PLC if it is used on a widespread basis.

7.13.5 Scalability

It is a problem to make solutions based on PLC technology scalable, and trials still struggle with this problem. A large number of sub-station transformer nodes need to be powerline-equipped to provide any acceptable level of broadband availability in an area. This is because the PLC head-end system has to connect into the powerline on the consumer side of the transformer – a problem that will be particularly relevant to rural areas. There is therefore no head end scale benefit. The problems of scalability are compounded by interference issues and costs, which are not being reduced through economies of scale.

7.13.6 Deployment, operational and maintenance cost

Broadband through the powerline uses part of the existing power wiring and so has less civil works requirements than other broadband solutions. Clear Advantage and Associates estimates that the capital cost of deploying PLC FTTK to a community with 100,000 inhabitants in Australia is A$109 million based on an 80% aerial network. This equates to a total capital cost per house connected of A$5,463 based on a 20% take-up rate. For a PLC FTTN deployment in a community of the same size in Australia, the total capital cost is estimated to be A$96 million. This equates to a total capital cost per house connected of A$4,796.

As BPL is an unproven technology, there is very little information on costs. With any PLC installation running in low commercial volumes or trials, the maintenance costs are expected to be high in the short term. Costs will improve if the technology stabilises and is deployed in high volumes.

7.13.7 Existing base of infrastructure

Aurora Energy in Tasmania started a commercial deployment of PLC in 2005, offering 12 Mbps services in Hobart.

Singapore Power announced in July 2003 that it had cut support for its PLC service to skeleton levels and was not looking for further deployment of PLC after less than two years in service. Lack of scalability has been mooted as the likely reason for the decision.

Many other trials and services have been withdrawn or limited to the initial deployments.

7.13.8 Competition, demand and applications

As well as being considered as a technology for providing broadband access, products are also available to make use of the home's internal wiring as a broadband local network.

7.14 Satellite

7.14.1 Technology

Satellite broadband has been available for many years by using one-way satellite services. The downlink connects the Internet to the customer and allows content and communications at broadband speeds. The return path is normally made through a dial-up connection. Whilst services like this have enjoyed some market penetration, the split connectivity and narrow-band return path has meant that take-up has been very limited.

The introduction in recent years of DVB-RCS (Digital Video Broadband – Return Channel by Satellite), which was standardised in 1999 has meant that 2 way satellite services have started to make inroads as a means of providing remote users with broadband services.

Satellite services can play an important role in the provision of broadband in remote areas:

- services direct to consumers and enterprises
- as a means of backhaul for fixed wireless access services.

7.14.2 Maturity and open standards

Satellite broadband services are in use world-wide. Service may be subject to problems during heavy rain, but is generally reliable. The use of common standards helps keep equipment costs down a little, but the lack of volume means that reasonable economies are not achieved.

The majority of satellite operators and service providers now offer DVB-RCS services. In future, the implementation of the new transmission standard Adaptive DVB-RCS S2 has been shown by trials to achieve a theoretical improvement in capacity of almost 75% over existing DVB-RCS systems, even using existing Ku-band satellites. With Ka-band the improvement is 125%. In practice, an improvement of between 30% and 60% is expected by service providers on their current satellites.

Combined with the use of MPEG2 (and in future MPEG4) encoding and compression, these developments have the effect of increasing throughput per 36 MHz transponder as follows:

- QPSK – 45 Mbps
- 8PSK – 60 Mbps
- 16QAM – 90 Mbps
- Adaptive DVB-RCS S2 – 150 Mbps

7.14.3 Bandwidth and range limitations

The bandwidth of broadband satellite services currently ranges from around 128 Kbps downstream with 64 Kbps upstream to 1 Mbps / 256 Kbps. In all cases, it is normal to have a monthly cap on downloaded data after which a per MB charge is applied. Services are offered at varying contention ratios, which will also influence the charges. It is possible to extend the access speed to higher rates, but the charges would make these prohibitively expensive.

7.14.4 Scalability

Satellite service provision may be scaled in line with demand. This is subject to transponder capacity. The capacity of a satellite depends upon the following factors, among other things:

- the number of users per satellite beam/transponder,
- the average bandwidth per user,
- the maximum bandwidth per satellite, and
- the total available spectrum.

For example, a contention ratio of 50:1 would be required to achieve 5,000 low bandwidth users per transponder and this is at the outer margins of the QoS levels generally considered acceptable for traditional Internet use.

7.14.5 Deployment, operational and maintenance cost

The economics of providing satellite broadband services are complex. Apart from the general and administrative costs of running a service provider business, there are three main components:

- Capacity on satellites is shared between a number of different communications services, eg. broadcast television, content collection and distribution (in the TV and media industries) and broadband services. Satellite broadband service providers lease transponder bandwidth capacity (each with 36 MHz bandwidth) from satellite operators. The geographically dispersed customers communicate through the satellite to teleport earth stations, from which they connect to the Internet backbone. The modulation and coding techniques used, and the contention ratio provided for customers influence the efficiency with which the leased transponder bandwidth is used, and hence the share of the transponder lease cost which is attributed to each customer. Because the broadband service provider is using a resource, which can be used by TV and media companies who can afford to pay high tariffs, similarly high tariffs for transponder capacity also apply to broadband service providers.

The service charging profile rises steeply for customers willing and able to pay for services above the basic level of 256 Kbps or 512 Kbps downstream. Service agreements usually have a monthly cap on traffic levels to discourage excess use of the shared resource.

- The customer premises equipment comprises a receiver dish, which may be from 60cm to 1.8m diameter or more, and associated termination device, housed with the PC. Manufactured volumes of these components are modest and as such there are no major economies of scale to be enjoyed. Ovum's research indicates that satellite CPE costs in the order of $1,400 –$2,000 for the consumer and SoHo market.
- The cost of sale is the third major cost component. A site survey may be required to establish whether line of sight is available and to assess the installation costs. A further site visit is needed to install and align the equipment. Support costs may also be incurred due to the complexity of the systems operating in an open environment. These costs may be $1,000 –$1,600, depending on location. An additional first year help desk support cost (including some set up costs) may be of the order of $600.

Once installed, there should be quite low operating costs. A major cost may be incurred by the service provider if there is a change in terrestrial service provision and a broadband fixed wireless operator enter a region, or if the local exchange is enabled with ADSL. In these cases, the prospects for the satellite service provider may be poor, as many consumers may be able get better service deals from the terrestrial broadband service provider.

7.14.6 Existing base of infrastructure

There are many satellites serving Australia. Operators of the satellites include Telstra, Optus, Intelsat and iPSTAR. The opportunities for satellite broadband service providers are limited however. The high costs of service provision mean that demand is suppressed, although public sector rural broadband subsidies of up to $6,600, if the subscriber is eligible, can cover the majority of the initial installation charges. Service providers may have to work through local resellers with limited geographic area coverage. The volumes of sales are often insufficient to sustain a dedicated direct sales and support team of the service provider. There are currently around twenty satellite broadband providers in Australia.

7.14.7 Competition, demand and applications

Some users find the additional delay inherent in satellite transmission noticeable. Whilst this is not a significant problem for web browsing or e-mail, it does make voice services or other interactive broadband applications, such as gaming, noticeably slower. However, the problem of slight voice delay may be acceptable when the consumer gets open access to the PSTN, rather than having to use two-way radio.

8 Backhaul technologies

8.1 Overview

Backhaul services available in rural and regional Australia include fibre, microwave point to point, satellite and HCRCS. Of these, HCRCS is not a suitable technology for backhaul of mobile or broadband services. Fibre is the most robust choice. The availability and pricing of backhaul services in rural and regional Australia is a major limitation for the provision of mobile and broadband services.

8.2 Fibre

8.2.1 Technology

Fibre is an established technology choice for provision of backhaul services.

As a medium for backhaul or backbone, the type of network operator or owner involved may influence the installation of optic fibre. For example, an electricity company may run fibre using existing pylons in the grid system; rail operators may run fibre alongside the track. Rights of way may be negotiated alongside roads.

8.2.2 Maturity and open standards

As for fibre in the access network. Refer to section 7.12

8.2.3 Backhaul and bandwidth limitations

Once installed in the backbone or backhaul network, fibre is able to provide huge bandwidth, and in most cases the demand and the optical transmission systems selected will determine the capacity. Long backhaul and backbone fibre networks will require repeater systems, the spacing depending on the architecture and deployment decisions of the operator.

8.2.4 Scalability

As for fibre in the access network. Refer to section 7.12

8.2.5 Deployment, operational and maintenance costs

For backhaul the costs of deploying fibre are very dependent on the method used. Rural installation of fibre could be: overhead, using existing poles; buried in soft ground using a mole plough, at a cost of around $5 per metre; buried in denser ground, with the use of chain digging equipment at a cost of approximately $15 per metre[4]. Such costs (between $5,000 and $15,000 per kilometre) make fibre deployment over long distances very costly.

New approaches to utilisation of fibre for backhaul services promise to achieve major cost savings for carriers. For example, DWDM-Lite is a set of sub-systems, which permits add-drop of bandwidth in the optical domain in channels of less than a full wavelength. This means that less lit fibre is required to serve a certain number of towns and this is particularly important for rural towns where the capacity required is low. DWDM-Lite is in prototype phase in the Monash University Centre of Telecommunications and Information Engineering. It could result in major cost savings for operators of fibre backhaul.

8.2.6 Existing base of infrastructure

There are fibre backbone networks in Australia. There are fibre networks for the corporate market that are primarily used for backhaul. The rollouts have all focussed on either CBD loops or long-haul east-coast networks. Fibre network owner operators in Australia include:

- **PowerTel** provides data, voice and Internet services to corporate, government and wholesale customers through its owned and operated 100% fibre optic network, the third largest in Australia.
- **Uecomm** is owned by Optus. The operator owns a fibre-optic network providing dark fibre services and converged solutions such as voice over IP (VoIP).
- **AAPT** has a fibre optic backbone network that extends across Australia. AAPT also has a fibre optic network within the CBDs of major cities.

8.3 Point to point microwave

8.3.1 Technology

Point to point microwave / radio systems are designed to cover a very wide range of applications in core network backbone or backhaul situations. These range from long haul very high capacity SDH links, which can cover many hundreds of kilometres, to campus systems for use within a private network. Systems are designed to carry SDH, PDH, ATM or Ethernet / IP structured traffic. The capacity of a link may range from 1.5 Mbps up to 622 Mbps or more SDH or Fast Ethernet.

Depending on the application, distance, traffic, terrain microwave systems operate in frequency bands from 1.5GHz up to 38GHz. Some bands are regulated and these will be used for backbone services, which require the protection that regulated used

[4] Derived from: Development Of A Terrain Evaluation Method To Assess Trenching Difficulty For Telecommunication Services In New Zealand, Aug 2004

provides. Other services will choose the frequency band that best suits the needs of the service.

8.3.2 Maturity and open standards

Point to point radio systems are a well proven technology. Innovation continues at both ends of the scale, with very high capacity, very long haul systems coming to market and pre-packaged, integrated systems being offered at the low end of the market.

It is usual practice to implement the same vendor systems within any point to point link. Interfaces to associated network systems are standardised to SDH, PDH, ATM, IP, Ethernet and others.

8.3.3 Bandwidth and range limitations

Point to point radio can achieve speeds from 1.5 Mbps to 622 Mbps or more (conveyed as n x 155 Mbps). Links with a capacity of 155 Mbps is more usual in the backbone. The practical range is limited to 30-50 kilometres because of signal path loss and the need to operate without any obstruction, such as high rise buildings, to the physical path.

With recent designs of SDH radio being capable of reaching well over 100kilometres (eg. Spain to the Canaries – 170 kilometres, single hop), being able to support up to 10 STM-1 (10 x 155 Mbps) with automatic standby of spare channels and being able to support frequency diversity, space diversity and angle diversity, systems operating in the range 3GHz to 13GHz (ie. below the frequency bands which suffer from precipitation interference) are able to meet exacting criteria for performance and can be designed to meet the ITU recommendations for 99.995% availability and threshold bit error rates of 10^{-6}.

8.3.4 Scalability

Subject to careful radio planning, point to point services are, within limits, scalable to increase the capacity of the link, however, many operators will over-provision links at the time of initial installation in order to ensure a long operating life without interference. The costs of manpower and equipment to upgrade a link can be quite significant compared to the overall capital expenditure of the link. Existing towers and mast can be used for capacity network coverage through the provision of additional point to point links. However, the potential for this expansion needs to be taken into consideration when the initial tower and installation is designed, in order to allow smooth integration of any future upgrades.

8.3.5 Deployment, operational and maintenance cost

Point-to-point radio is already used in fixed and mobile communication infrastructure. It can be very effective in some rural locations such as crossing mountain ranges or bridging water. The main drawbacks are reach and line of sight. Even though solutions are more than capable of spanning more than 50 kilometres between antennae, obstacles such as trees and hills can significantly reduce this, which may be avoided through the use of mast-mounted antennae. However the costs of large / powerful antennae needed to cover long links may then outweigh any advantage of having fewer hops. If relay stations are required to create a multi-hop link, these add to the both the capital expenditure and the operating costs.

The cost of deploying point to point radio depends upon the distance covered by the link and site costs, such as site lease, and transmission systems. One stakeholder estimated that the cost to construct a licensed long haul backhaul link via an average of two longhaul microwave hops to connect the town to another, already backhauled township, is around $150,000 per microwave hop. Short links can be deployed cost effectively, long-hop point to point routes may require repeater stations: to overcome limitations on operating range due to cost / power trade-offs; to reduce the need to expensive high tower for antenna mounting; or to overcome the lack of line of sight due to building or unfavourable terrain. The costs vary hugely. A high capacity communications backbone operating at 155 Mbps or more will be designed for high levels of availability, may have standby capacity and warrant fewer, higher towers in the network. Links in such a network could run to millions of dollars to install. At the other end of the range, systems designed for short links designed to for 10 Mbps IP traffic over 5 kilometres may be installed for around $15,000 –$20,000.

Point-to-point wireless systems can be configured and installed more quickly and cheaply than fibre and is the preferred option for many operators for rural areas with dispersed centres of population.

Once installed and operational, the ongoing operations costs of running a point to point network are modest. If the network is designed around common components, then the operating costs for spares holdings and staff training can be minimised.

8.3.6 Existing base of infrastructure

Point to point microwave is widely used in Australia and service providers are well aware of the capabilities and issues that arise from network and link planning. It is well suited to much of the terrain.

Following is an example from South Australia. Internode owns wireless and ADSL2+ networks in the Yorke Peninsula. For this project build of new microwave point to point backhaul was required in order to avoid use of high cost Telstra fibre backhaul.

Yorke Peninsula

A wireless and ADSL2+ network rollout in the Yorke Peninsula was funded partly from the Broadband Development Fund, other government bodies and Agile Communications for a total cost of $1.3 million. The Broadband Development Fund contributed $250,000 towards this cost.

The network structure is made up of:

- Wireless point-to-multi-point broadband services. Agile Communications installed microwave towers at the four business and population centres (Maitland, Minlaton, Warooka, Yorketown) as well as a repeater. There is a 10 kilometre radial access wireless local loop around the major regional towns.
- ADSL and ADSL2+ connections to business, government and residential users. Ericsson's DSLAMs were installed by Internode (sister company to Agile) at two of the business centres in the region.
- Microwave point-to-point backbone links.
- VPN connections to the four major business centres in the region.
- VoIP gateways allowing untimed calls to Australian capital cities using a calling card arrangement from the PSTN. Previously callers were charged national call rates.

The Agile/Internode joint submission states that the main reason that they were able (and willing) to build out this network was because the government funding allowed them to build a new backhaul network. They believe that the build-out of a new network is financially untenable without a subsidised backhaul.

8.3.7 Competition, demand and applications

Radio network planning and design is needed to ensure that many factors are taken into account: transmission cost, timely development, capacity flexibility, distance, typical weather conditions, possible interference, attenuation, line of sight etc.

8.4 Satellite as backhaul for BFWA and WiFi community broadband

The opportunities provided by using WiFi or BFWA with satellite backhaul is a powerful combination for use in community networks. These will play an important role in the future provision of rural and remote broadband services. The use of such combinations of technology will means that satellite services for direct access will be limited to areas with very sparse user populations and to individual users with high bandwidth requirements, mostly SMEs and public entities such as schools and local councils. Combined services will be able to economically serve communities of 8 users upwards within a radius of 5-15 kms. If the number of users, or bandwidth demands grow, then satellite capacity can be increased. The demands on the satellite transponder may be offset to some extent by improvements to the multiplexing and compression techniques used, as discussed in the Maturity section above.(The costs of deploying WiFi and BFWA nodes vary depending on the number of users, average bandwidth offered, dispersion of customers and services offered. As well as offering broadband, such configurations can also offer VoIP telephony, which can be a great advantage to communities using radio or High Capacity Radio Concentrator (HCRC) system for telephony services.

A typical WiFi broadband access node can be installed, with antenna, for a system cost of around $8,000 upwards. Antenna and CPE prices for the consumer are falling and are estimated at $750. An installation can serve up to about 15 users for basic broadband and VoIP service over a typical area of 20 square kilometres. WiFi broadband solutions are not designed to be scalable, and nodes lack the capability to be built into a wide area network management system.

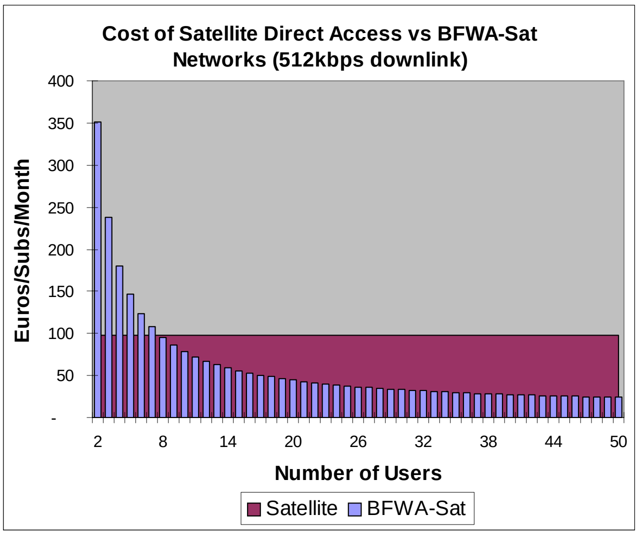
A BFWA solution serving 50 users upwards, might cost $50,000 to deploy, with CPE and antenna costs of around $750. Customers close to the base station and with line-of sight, may be able to use internal antenna, costing around $300.

The cost of satellite backhaul depends very much on the number of users served by the base station, the average bandwidth offered and the contention ratios that the service provider and the satellite operator use. A typical 2 Mbps service suitable for serving a WiFi node might cost the SP $10,000 pa plus set up charges for the antenna and installation. The charges rise as bandwidth requirements increase.

An assessment of the economic advantage of BFWA networks with satellite backhaul compared to the costs of individual satellite direct access, is shown in Figure 8.1. This was derived from a study undertaken by Ovum in Europe. The crossover comes at about 10 users within a community, but the actual figure will vary depending on distance and topography.

Satellite direct access appears to remain the optimum solution where there are fewer than eight users within the potential coverage radius of a BFWA system. In practice the figure is fewer than 15 for WiFi and less than 20 for WiMAX, because most BFWA operators regard these as the trigger points at which it is financially worthwhile to set up a network.

Figure 8.1 **Costs of satellite access compared to BFWA/ Satellite solutions**



SOURCE: OPERATOR DATA AND OVUM ASSESSMENT

8.5 Summary

An overview of the technologies according to the criteria is provided below. It should be remembered that key criteria, such as cost, bandwidth and range, vary widely according to deployment location, coverage, population size, equipment chosen and other factors. These tables only provide a generalised idea of the technologies rather than specific details on performance or cost in any location.

Cellular

Criteria	**CDMA**	**GSM**	**UMTS (FDD)**	**UMTS (TDD)**	**HSDPA**	**TD-SCDMA**
Description	2G cellular	2G cellular	3G cellular	3G cellular	3G cellular	3G cellular
Deployment/ OPEX costs	Middle	Middle	Middle	Middle	Middle – high	Not available
Download bandwidth and range (Max range requires trade off in bandwidth)	Up to 14.4 (EV-DO- 600) Kbps Varies. Can go to 150 kilometres (rural)	Up to 9.6 (EDGE-384) Kbps Varies. 1 - 15 kilometres	Around 200 Kbps. Around 50 kilometres (rural)	Up to 12 Mbps Up to 30 kilometres (LOS, rural)	Currently – up to 1.8 Mbps Around 50 kilometres (rural)	Theoretical - Up to 2 Mbps
Scalability	High	High	Middle	Middle	Middle	Low
Infrastructure	98% of Australia.	96% of Australia.	Rolling out in Australia.	Limited deployment.	Rolling out in Australia	None
Maturity	Commercially established	Commercially established	Commercially available	Commercially available	Data cards available	China approved January 2006
Fully proven	Yes	Yes	Yes	Yes	No	Yes
Maintenance costs	Middle	Middle	Middle	Middle	Middle	Not available
Timing	Available	Available	Available	Available	Data cards available.	Not yet available
Open standards	Yes	Yes	Yes	Yes	Yes	Yes
NGN issues	None	None	None	None	None	None
Competitive issues	Competes with GSM	Competes with CDMA	Competes with CDMA2000 and TD-SCDMA	Lack of industry support and roaming opportunities	Competes with wireless broadband services.	Competes with CDMA2000 and WCDMA
Issues with demand and applications			-	Does support mobile VoIP services.	Supports mobile VoIP and gaming	Good for uplink heavy applications

Wireless broadband

Criteria	WiMAX	WiFi	iBurst	Flash OFDM
Physical description	Radio frequency technology	Radio frequency technology	Radio frequency technology	Radio frequency technology
Deployment and OPEX Costs	Middle	Low	Middle	Middle
Download bandwidth and range (Max range requires trade off in bandwidth)	Typically up to 11 Mbps in a rural 10 kilometre range	From shared 6 Mbps to potentially 54 Mbps. (Most suited to 256 Kbps per customer) Up to 50 metres	Up to 16 Mbps (1 Mbps in practice) 12 km+ (suburban)	Up to 5.3 Mbps (15.9 Mbps in 5 MHz multi-carrier system)
Scalability	Middle/Low	Low	Middle/Low	Middle
Existing base of infrastructure	Not yet deployed	Worldwide	Sydney and overseas	Finland, Slovakia and US
Maturity	New technology	Commercially available	Commercially available	Commercially available
Fully proven	Fixed – yes Mobile – no	Yes	Yes	Yes
Maintenance costs	Medium	Low	Medium	Low
Timing	Fixed available now Mobile available mid 2006	Available	Available	Available
Open standards	Yes	Yes	Yes	No (proprietary)
Issues for NGN	None	None	None	None
Competitive issues	Mobile WiMAX will compete with 3G, Flash OFDM and iBurst.	Limited coverage results in limited potential use.	Limited equipment providers and few commercial deployments.	Limited industry support.
Issues with demand and applications	CPE may be too expensive	-	Equipment and CPE costs may remain high.	-

Fixed broadband

Criteria	ADSL/2+	SHDSL	VDSL	HFC

Physical description	Run over copper loop	Run over copper loop	Run over copper loop	Hybrid Fibre Co-axial Cable
Deployment and OPEX Costs	Low	Middle	Middle	High
Download bandwidth and range (Max range requires trade off in bandwidth)	Typically 2 Mbps (ADSL2+ - 4 Mbps) within 4 kilometres	Up to 2.3 Mbps a pair within 3 kilometres	Up to 52 Mbps (within 300 metres) Up to 13 Mbps (within 1 kilometre)	Up to 10 Mbps shared (DOCSIS 1.1) Up to 100 kilometre on fibre and 2 kilometre on coaxial cable
Scalability	High	High	High	Middle
Existing base of infrastructure	Large proportion of Australia. Most of the world.	Niche. Small deployments in Australia and internationally	Small deployments, such as TransACT in Canberra	Capital cities in Australia. In Europe and the US.
Maturity	Commercially established	Commercially available	Commercially available	Commercially established
Fully proven	Yes	Yes	Yes	Yes
Maintenance costs	Middle	Middle	Middle	Middle
Timing	Available	Available	Available	Available
Open standards	Yes	Yes	Yes	Yes
Issues for NGN	None	None	None	None
Competitive issues	Compete with cable.	Small presence	Cost and uncertain demand	Limited coverage compared to DSL.
Issues with demand and applications	-	Key technology for applications with high upstream requirements	-	-

Criteria	Fibre	Satellite	Powerline	Point to Point Radio
Physical description	Optical fibre	Satellite	Powerline	Radio system
Deployment and OPEX costs	High	High	High (unproven)	Middle (compared to fibre systems)
Bandwidth and range	Bandwidth and reach determined by system, network structure and demand.	Up to 1 Mbps. Higher range than any other technology,	Up to 45 Mbps in aggregate Up to 300 metres	Up to 622 Mbps (usually 155 Mbps) Up to 50 kilometre
Scalability	High	High	Low	Middle
Existing base of infrastructure	Fibre backbone in Australia. Fibre end-user networks launched overseas including Japan and US.	Many satellites serving Australia and internationally	Small trials. Aurora Energy commercially deployed in Tasmania.	Widely used in Australia and internationally
Maturity	Commercially available	Commercially established	New	Commercially established
Fully proven	Yes	Yes	No	Yes
Maintenance costs	Low	Low	High	Low
Timing	Available	Available	Available	Available
Open standards	Yes	Yes	No	Yes
Issues for NGN	None	None	None	None
Competitive issues	Competes with DSL and cable	Expensive for end-users	Limited support.	Requires careful network planning
Issues with demand and applications	-	May not support some interactive applications	-	-

9 Scenario Analysis

9.1 Approach to scenario analysis

The scenario analysis was undertaken as set out in Section 3, including assessment of the technology options, and costing for each technology in each scenario.

Calculation of backhaul requirements in each town has been undertaken on a town by town basis. It should be noted that this would an unlikely approach in practice, it is more likely backhaul build would be undertaken to service all the towns in a region, rather than one town at a time. For each scenario, the backhaul required was calculated based on the number of customers and their usage at an assumed contention ratio of 50 to 1. For each scenario the cost to build and lease based on the available choices was calculated.

It should be remembered that all access technologies, subject to being proven, appear to be capable of being used in at least some of the scenarios. We have not made absolute judgements on the suitability of each technology. Rather these are contingent assessments based on the individual factors present in each scenario.

Some technology choices (for example, ADSL and its variants) require existing access infrastructure in order for services to be available based on that technology choice. A number of the scenarios do not have exchanges in the town, and in those cases we have assumed that there is not adequate copper reticulation systems available for delivery of ADSL/ADSL2+/VDSL.

For mobile and wireless broadband technology options, the number of base stations required in each scenario was assumed based on the coverage achievable by the technology and the size of each town estimated from maps.

9.2 Approach to costing

Costing analysis has been undertaken to provide an estimation of the cost to deploy each technology in each scenario. Due to the timeframes of this project, focus has been on the major cost elements, and the costs should therefore be considered on this basis. Costing has been undertaken by estimating the deployment costs and operating costs of each technology option in each scenario, and calculating the backhaul lease and build costs for each scenario. A detailed description of the assumptions made for the costing analysis is set out in Annex 2.

Costing has been carried out, for the purposes of this analysis, on the basis that the backhaul requirements are established for each town individually, and the operator deploying infrastructure to each town does not have the benefit of traffic volumes from elsewhere. In addition, we have assumed that backhaul will be leased where backhaul services are available. Elements of the costing such as backhaul lease pricing and equipment pricing particularly will vary significantly depending on size and scale of the operator engaged in deploying services to rural and regional towns. We have not considered this factor in our costing.

9.2.1 Access

Deployment costs for each access technology has been based on three major cost elements:

- Capital cost of the access technology
- Operating costs to operate the network
- Backhaul leasing or build cost (including operating costs)

In order to generate costing analysis which is comparable across scenarios and technology deployment choices, operating costs have been calculated at their net present value over 5 years of operation. In these calculations, discount rate of 12% across all scenarios and technologies was assumed for simplicity[5].

For each technology, the capital costs of deployment were estimated based on[6]:

- Network and CPE equipment costs
- Build costs
- Installation costs of the network equipment and the CPE
- Telstra based administration costs required.

Operating costs for each technology where calculated based on:

- Site leasing costs
- Maintenance costs
- Power costs
- Customer sales and market costs

9.2.2 Backhaul

For each scenario it was assumed that the nearest point of presence (POP) for backhaul is the nearest capital city. This is except in the case of Christmas Creek, where Broome was used. Backhaul distances were calculated based on the road distances between the town and the POP.

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[5] We have made no provision for depreciation in our costs.

[6] We have examined the results in terms of asset lives associated with different technologies and have confirmed that the results are sufficiently clear cut and would not have been affected.

Telstra's published backhaul prices were used where fibre or microwave point to point infrastructure is available. It was assumed that the operator in question does not have volumes that enable it to negotiate better prices from Telstra. Telstra's prices are not technology dependant (ie. whether it is a fibre or a microwave system), and are available at the following capacity levels and prices:

- 2 Mbps link: $23,056 per 100 km per annum
- 8 Mbps link: $84,298 per 100 km per annum
- 34 Mbps link: $384,265 per 100 km per annum
- 155 Mbps link: $900,620 per 100 km per annum

In order to generate costing analysis which can be compared across scenarios and technology deployment choices, operating costs for network operation, backhaul leasing costs, and operating costs of new build backhaul systems have been calculated at their net present value over 5 years of operation. This was using a discount rate of 12% across all scenarios and technology for simplicity. We have assumed that over the 5 years of this cost assessment, there will be no requirement to replace any existing systems, and therefore depreciation of existing assets has not been considered.

9.2.3 Technologies not costed

Costing analysis was undertaken for most technology choices. There were a number of technology choices which were not costed as follows:

SHDSL/VDSL

SHDSL and VDSL can provide much higher speeds to broadband users but only within 2km of an enabled exchange. From 2km from the exchange, SHDSL and VDSL provide speeds in line with those deliverable by ADSL2+. Additionally, SHDSL and VDSL require higher backhaul capacity, more expensive DSLAMs and higher proportion of fibre in the CAN. SHDSL and VDSL have been included in this report and scenario analysis as an option but not costed.

Broadband over powerline

BPL is a new technology that is under trial in a number of areas in Australia and is as yet unproven commercially. Ovum cannot comment on the costs of deployment at this stage.

Flash-OFDM

Flash-OFDM is a proprietary fixed wireless technology, with similar costs and cost structure to WiMAX and iBurst. Ovum has not interviewed Flarion (the equipment provider of Flash-OFDM) as part of this project, and Ovum does not have any comprehensive costs for this technology.

Satellite broadband

Satellite broadband services are available all over Australia. We have assumed for the purposes of the costing that the capacity available currently is sufficient to service the deployments that follow distribution of Connect Australia funding. Therefore the deployment cost of satellite broadband has not been costed in detail. We have included a discussion of terrestrial network system costs earlier in this section of the report.

9.2.4 Deployment considerations

Across the analysis, the in-built deployment assumption made is that where no infrastructure exists, deployment will be undertaken as though it was a green field site.

WCDMA

WCDMA is typically deployed as an upgrade to existing GSM infrastructure. The GSM service is left in place as it utilises a separate spectrum band and is required to service customers with GSM only handsets. Assumptions in this report are based on WCDMA deployments as planned by Telstra at 850 MHz. That is assuming the same coverage map as currently achieved by the CDMA network, and use of existing CDMA towers for WCDMA equipment.

HFC

Internationally HFC is most typically deployed where there are legacy cable television network that can be utilised to gain access to the home. Fibre is then deployed in a ring around the area of service to connect the existing cable home connections. However, in Australia, Optus and Telstra have deployed HFC in urban areas as a new deployment. This is an unlikely choice compared to simply deploying fibre. Fibre is more cost effective for small deployments than HFC, which does not scale down well.

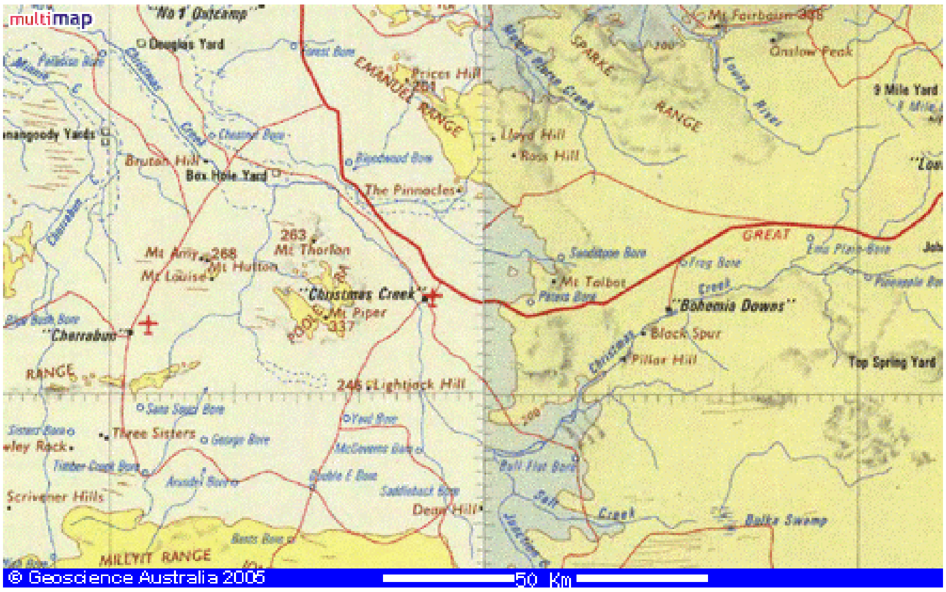
9.3 Scenario 1 - Christmas Creek Aboriginal Community, Western Australia

9.3.1 Locality

Christmas Creek Aboriginal Community is a very small town with an estimated population of 150 people. It is located in an extremely remote region of north westerly Western Australia, around 150km south east of Fitzroy Crossing. The town itself is very small with few facilities; it has an estimated radius of less than 2km.

Figure 9.1 shows the location of Christmas Creek.

Figure 9.1 **Location of Christmas Creek**



Source: www.multimap.com

9.3.2 Available infrastructure

At Christmas Creek, existing infrastructure enables provision of the following services:

- Satellite services
- HCRCS backhaul services

There are no CDMA, GSM, DSL, or wireless services available and there is no Telstra exchange in the town.

9.3.3 Costing analysis

For each of the technologies the costs calculated are as follows on a whole-of-community basis (refer to Annex 3 for a detailed costing):

- FTTH $0.74 million
- HFC $0.77 million
- WiFi $0.10 million
- WiMAX $0.23 million
- iBurst $0.32 million
- GSM $0.32 million

- CDMA $0.30 million
- WCDMA $0.44 million

In Christmas Creek the only suitable backhaul service which can be leased is satellite. The net present value over 5 years of the lease cost of a 2 Mbps and 8 Mbps satellite link, and the build costs (including operating costs of the system) of fibre and microwave backhaul systems are as follows:

- Lease: Satellite 2 Mbps link $1,147,000
- Lease: Satellite 8 Mbps link $4,586,000
- Build: Fibre $9,517,000
- Build: Microwave $2,969,000

9.3.4 Technology choice

Christmas Creek is a very small town both physically, and in terms of population size. Christmas Creek represents the following scenario:

- Population density: Low
- Existing infrastructure: Low
- Usage level: 256 Kbps

The major consideration in Christmas creek is backhaul. To deliver 256 Kbps broadband services, a 2 Mbps link is required in Christmas Creek. A 2 Mbps could also be sufficient to deliver 1.5 Mbps to Christmas Creek as demand for services increase. An 8 Mbps service may be required to ensure all customers receive a 1.5 Mbps service at peak times.

Satellite is the only existing backhaul available in the town. Satellite is technically capable of delivering backhaul for broadband and mobile services but is the desirable choice only when it is the only option. This is due to the delay effect of satellite and cost increases as demand scales upwards. Assessment of the backhaul options shows that at current population levels, and likely takeup levels, building a microwave link from Broome could not be justified unless speeds of 10 Mbps are required in Christmas Creek. Therefore the preferred backhaul choice for Christmas Creek is to lease satellite backhaul.

ADSL is not available in Christmas Creek because there is no exchange and we have assumed that if there is copper reticulation in the town, the configuration will not be appropriate for ADSL services. Due to the small size of Christmas Creek, and low speed requirements of the scenario, there are a number of possible options. Each has different limitations. WiFi can be cheaply deployed to provide services in the town at 256 Kbps, but only for a range up to 5km with line of sight. Given the small size of Christmas Creek, at this range WiFi could reach all the customers in the town and those in the immediate outlying areas. WiMAX and iBurst are more expensive options which can provide much greater coverage to the areas surrounding the town than

WiFi is capable of. This would mean that the town and a wide surrounding areas could be served by this technology choice. Performance of WiMAX and iBurst in rural environments is as yet unproven, however the range is likely to be around 15km. iBurst are developing equipment which could provide services up to 90km at 650 Kbps. Lastly, satellite broadband is a possibility, but not a preferred option due to cost and reliability.

Scaling the scenario to 1.5 Mbps, WiFi is no longer a deployment choice. WiMAX and iBurst are likely to be capable of delivering 1.5 Mbps in a deployment at Christmas Creek. Typically the maximum bandwidth of WiMAX for urban deployments is 1 Mbps per customer, so 1.5 Mbps is the upper limit of the technology's capability. At these speeds, a likely range of around 15km would be achievable. FTTH and HFC are capable of delivering 10 Mbps but are much too expensive for a town as small as Christmas Creek.

There are no mobile services available in Christmas Creek. Deployment of either CDMA or GSM would be a desirable improvement of services in the town. However, given Telstra's plans to close the CDMA network, deployment of CDMA would be a poor choice. GSM could be an option, but given the remoteness of Christmas Creek, it is unclear whether there would be any other nearby areas where GSM networks are available, thereby making GSM network services much less value to residents in Christmas Creek. Telstra plans to deploy WCDMA across Australia, however with no CDMA or GSM deployments in Christmas Creek, WCDMA deployment in Christmas Creek by Telstra is unlikely. Targeted funding for WCDMA in Christmas Creek would be required for deployment to this location.

Figure 9.2 shows a comparative assessment of all of the technologies considered in this study are possible options.

Figure 9.2 **Comparison of technology deployment options at Christmas Creek**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 1	**Town: Christmas Creek Aboriginal Community, Western Australia**															
Suitability																
Does it meet the range requirements of the scenario? (yes or no)	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Does it meet current bandwidth capacity requirements? (yes or no)	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable? (highly, medium or no)	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost? (high, medium or low)	n/a	medium	medium	medium	medium	low	low	high	n/a	low	low	low	low	low	low	low
Maturity																
Has it been proven in operation elsewhere? (yes or no)	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia? (yes or no)	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve? (beginning, middle or end)	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology? (yes or no)	yes	yes	yes	yes	No	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements? (yes or no)	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

Estimated population of 150

CDMA and GSM wireless coverage

No ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology,

Assumed that CDMA towers can be used for high speed broadband access.

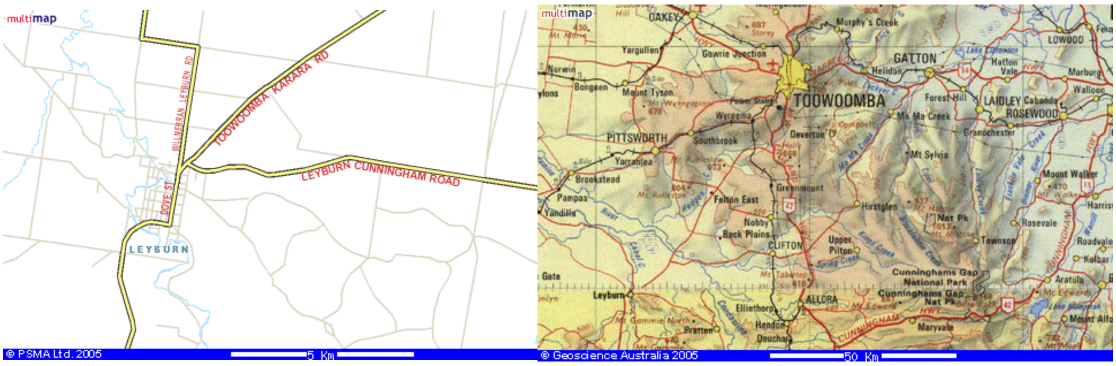
Assumed that GSM towers can be used for 3G

9.4 Scenario 2 - Leyburn, Queensland

9.4.1 Locality

Leyburn is a small town with a population of 150 people located 200 west of Brisbane. Figure 9.3 shows the size of the main town and the surrounding areas. The town itself is small, with a maximum radius of about 2km, outer lying areas are more extensive to a radius of about 5 km from the edge of the town.

Figure 9.3 **Leyburn**



Source: Multimap

9.4.2 Available infrastructure

At Leyburn, existing infrastructure enables provision of the following services:

- GSM carkit services, but not handheld
- CDMA services, but not handheld
- Satellite services
- Wireless services from Halenet
- Telstra fibre backhaul services

There is no DSL available but there is a Telstra exchange.

9.4.3 Costing Analysis

For each of the technologies the costs calculated to deploy mobile and broadband services are as follows (refer to Annex 3 for more detailed costing analysis):

- ADSL/ADSL2+ $0.13 million
- FTTH $0.82 million

- HFC $0.84million
- WCDMA $0.44 million
- WiFi $0.10 million
- WiMAX $0.23 million
- iBurst $0.32 million
- GSM $0.32 million
- CDMA $0.30 million

In Leyburn fibre backhaul and satellite services connected to Telstra's inter-capital fibre can be leased. The net present value over 5 years of the lease costs of a 2 Mbps and 8 Mbps fibre link, 2 Mbps and 8 Mbps satellite link and the build costs (including operating costs of the system) of fibre and microwave backhaul systems are as follows:

- Lease: Fibre 2 Mbps link $203,500
- Lease: Fibre 8 Mbps link $744,000
- Lease: Satellite 2 Mbps link $1,147,000
- Lease: Satellite 8 Mbps link $4,586,000
- Build: Fibre $4,063,000
- Build: Microwave $1,213,000

9.4.4 Technology choice

Leyburn is a small town both in terms of geography and population. Leyburn represents the following scenario:

- Population density: Low
- Existing infrastructure: Low
- Usage level: 1.5 Mbps

Satellite and fibre backhaul services can be leased in Leyburn. Due to the very small size of the town, a 2 Mbps link would be sufficient to deliver 1.5 Mbps to Leyburn. An 8 Mbps link would be required to scale to 10 Mbps. Higher capacity backhaul links may be required to absolutely ensure that all customers receive these speeds at the peak. Fibre is the preferred choice based on quality of service and reliability, and due to Leyburn's proximity to Brisbane fibre backhaul is the much more cost effective choice as well. Leasing backhaul allows capacity to be upgraded as takeup and demand for capacity increases in the future. Comparison of fibre leasing costs and build costs for fibre and microwave backhaul systems to Leyburn shows that it is much more cost effective over 5 years to lease fibre backhaul.

There is an exchange in Leyburn, so ADSL or ADSL2+ are good choices for delivery of 1.5 Mbps services, subject to the condition of the copper infrastructure. Both ADSL and ADSL 2+ are capable of delivering 1.5 Mbps, although speeds will be much faster for customers closer to the exchange, and services will not be available for customers 5km or more from the exchange. Therefore depending on the location of the exchange, ADSL/ADSL2+ will be able to cover the town itself but not all its outlying areas. Range extenders could be used in Leyburn to further extend the reach of DSL to surrounding areas. Leyburn does have pair-gain systems in the area, so some customers will not be able to access ADSL services.

WiFi is currently provided in Leyburn by Halenet. Halenet services are available at 256 Kbps or 512 Kbps. WiFi can deliver 1.5 Mbps but it is more suitable choice for entry level broadband services, such as those provided by Halenet. Deployment of a WiMAX or iBurst base station would enable coverage to the whole town including the outlying areas at a maximum bandwidth of 1.5 Mbps. However, this is the upper limit of the capability of this technology and quality of service will not be as reliable as ADSL. A combination of ADSL, ADSL2+ and WiMAX/iBurst is a good choice for delivering 1.5 Mbps to Leyburn.

ADSL and ADSL2+ cannot provide 10 Mbps at 4km but these speeds are possible for end-users located closer to the exchange. VDSL can deliver well in excess of these speeds but only to households located near to the exchange. Wireless broadband is unlikely to be capable of delivering 10 Mbps. FTTH and HFC are capable of providing 10 Mbps broadband services to town on an extremely reliable and robust basis, FTTH is also scalable further to much higher speeds, however both FTTH and HFC are extremely expensive options for a town of this size and aggregate demand of Leyburn. BPL claims to be capable of delivering up to 20 Mbps but this is as yet unproven.

There are GSM and CDMA carkit services available in Leyburn. The availability of carkit services only, suggests that the nearest GSM and CDMA towers are not in the town of Leyburn, but at a location nearby. Therefore it may be suitable to make handheld services available in Leyburn by extending backhaul services from the nearest mobile towers and building a new tower in Leyburn. Given the proximity of Toowoomba to Leyburn, the closest base stations are not likely to be far away. Telstra’s plans to shut down their CDMA network make further deployment of CDMA not viable. Additionally, GSM is a more widely used technology, so may be the preferred choice of the town. Telstra plans to deploy WCDMA across Australia, and are planning to deliver a similar footprint as achieved with CDMA. In order to deliver WCDMA services to Leyburn an additional tower would be required.

Figure 9.4 shows a comparative assessment of all of the technologies considered in this study.

Figure 9.4 **Technology options for Leyburn, Queensland**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 2	**Town: Leyburn Queensland**															
Suitability																
Does it meet the range requirements of the scenario?	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	no	yes	yes	yes
Does it meet current bandwidth capacity requirements?	no	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	high	medium	medium	medium	medium	low	low	low	n/a	n/a	n/a	n/a	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA wireless coverage, no GSM coverage

No ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

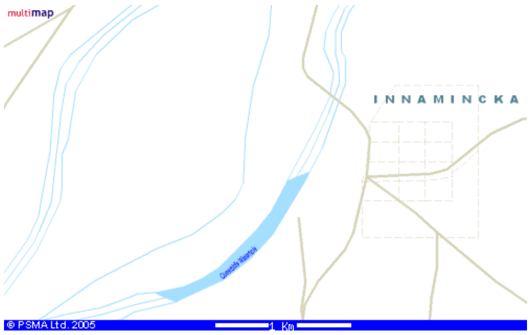
Assumed that CDMA towers can be used for high speed wireless broadband.

9.5 Scenario 3 – Innamincka, South Australia

9.5.1 Locality

Innamincka is a very tiny isolated town with an estimated population of around 15 people. It is located in a remote region of north easterly South Australia, near the border with New South Wales. The town itself is extremely small with few facilities, it has an estimated radius less than 2km, and from the map there are no obvious outlying areas extending from the town. Figure 9.5 shows the location of Innamincka

Figure 9.5 **Innamincka**



Source: www.multimap.com.au

9.5.2 Available infrastructure

At Innamincka, existing infrastructure enables provision of the following services:

- Satellite services
- Telstra microwave backhaul services

There are no CDMA or GSM services, DSL, or wireless broadband services available in Innamincka. There is no exchange in Innamincka.

9.5.3 Costing analysis

For each of the technologies the costs calculated are as follows (refer to Annex 3 for a detailed costing assessment):

- FTTH[7] $0.20 million
- HFC $0.20 million
- WCDMA $0.39 million
- WiFi $0.079 million
- WiMAX $0.18 million
- iBurst $0.27 million
- GSM $0.26 million
- CDMA $0.26 million

In Innamincka Telstra microwave backhaul and satellite services can be leased. The net present value over 5 years of the lease cost of a 2 Mbps and 8 Mbps link, 2 Mbps and 8 Mbps satellite link and the build costs (including operating costs of the system) of fibre and microwave backhaul systems are as follows:

- Lease: Microwave 2 Mbps link $990,500
- Lease: Microwave 8 Mbps link $3,621,500
- Lease: Satellite 2 Mbps link $1,146,500
- Lease: Satellite 8 Mbps link $4,586,000
- Build: Fibre $19,989,000
- Build: Microwave $6,355,000

9.5.4 Technology choice

Innamincka is a tiny town. It is represents the following scenario:

- Population density: Low
- Existing infrastructure: Medium
- Usage level: 256 Kbps

Due to the small size of Innamincka, a 2 Mbps backhaul link would be sufficient to deliver 256 Kbps broadband services to the town. 2 Mbps would also be sufficient to deliver 1.5 Mbps to Innamincka, however all customers may not be able to receive these speeds at the peak at the same time. The capacity of the microwave link in Innamincka is unknown, but assuming sufficient capacity is available, this would be a

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[7] The cost to deploy FTTH in Innamincka is $0.2 million. This is low compared to the cost to deploy the mobile technology options in the town. Due to the very small population size of Innamincka, the assumptions we have made for FTTH and HFC do not apply very well. Deployment of FTTH in Innamincka would be a very unusual choice, and we would not recommend it.

more cost effective choice than leasing satellite services or building a new backhaul system for Innamincka. For the purposes of this analysis, we have assumed that the microwave link is capable of delivering this capacity.

DSL is not an option for Innamincka because there is no exchange and we have therefore assumed that if there is copper reticulation in the town, it does not have an appropriate configuration for DSL services. Given the small size and population of the town, all broadband technology choices are capable of delivering 256 Kbps to Innamincka. WiFi is a very cost effective option for delivery of 256 Kbps to a small isolated town like Innamincka with no other options, but less reliable and resilient than other choices. However, it could provide services to 5km with line of sight. Given the small size of Innamincka, this would mean that WiFi broadband access could enable the whole town and some outlying areas to be served. Satellite broadband is a possibility, but it can become very expensive if the download limits are exceeded. Both these options are reasonable choices for entry level broadband services. WiMAX and iBurst are more expensive options that can provide greater reach for a greater number of customers than WiFi, however there does not appear to be populated outlying areas spreading from the town.

Scaling up to 1.5 Mbps, WiFi is no longer an option. WiMAX and iBurst are able to deliver speeds in this range, but this would be the maximum limit of their technical capacity. HFC and Fibre are exceedingly expensive options for a town like Innamincka with very low aggregate demand. BPL is a possibility, but is as yet unproven.

GSM and CDMA are not available in Innamincka. Deployment of CDMA, given the announced Telstra shutdown of the network is not viable. Given the expensive cost of deploying GSM for such a small town, utilisation of mobile satellite services may be a sensible option for provision of mobile services in Innamincka. Expectations would be that Telstra’s WCDMA plans do not include deployment in Innamincka. Targeted funding for WCDMA in Innamincka would be required for deployment to this location.

Figure 9.6 shows a comparative assessment of all of the technologies considered in this study are possible options.

Figure 9.6 **Innamincka technology choices**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 4	**Town: Tobooburra, New South Wales**															
Suitability																
Does it meet the range requirements of the scenario?	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	no	yes	yes	yes
Does it meet current bandwidth capacity requirements?	no	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	high	medium	medium	medium	medium	low	low	low	n/a	n/a	n/a	n/a	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA wireless coverage, no GSM coverage

No ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

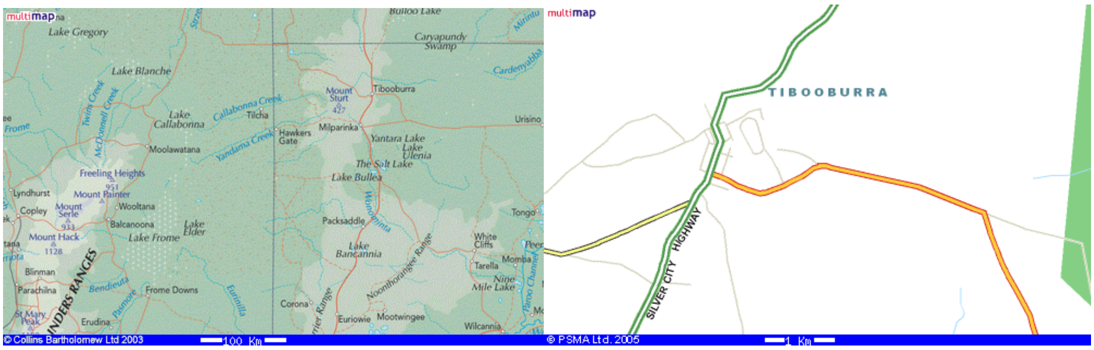
Assumed that CDMA towers can be used for high speed wireless broadband.

9.6 Scenario 4 – Tibooburra, New South Wales

9.6.1 Locality

Tibooburra is a very small isolated town with an estimated population of around 150 people. It is located in a remote region of north western New South Wales, near the borders with Queensland and South Australia. The town has few facilities. It has an estimated radius less than 2km. Figure 9.7 shows the location of Tibooburra.

Figure 9.7 **Tibooburra**



Source: www.multimap.com.au

9.6.2 Available infrastructure

At Tibooburra, existing infrastructure enables provision of the following services:

- Satellite services
- CDMA services
- Telstra microwave backhaul services

There is no GSM service, DSL, or wireless broadband available. However, there is an exchange in the town.

9.6.3 Costing analysis

For each of the technologies the costs calculated are as follows (refer to Annex 3 for a more detailed assessment of costs):

- ADSL/ADSL 2+ $0.13 million
- FTTH $0.74 million

- HFC $0.77 million
- WCDMA $0.37 million
- WiFi $0.10 million
- WiMAX $0.23 million
- iBurst $0.32 million
- GSM $0.25 million

In Tibooburra Telstra microwave backhaul and satellite services can be leased. The net present value over 5 years of the leased cost of a 2 Mbps and 8 Mbps link, 2 Mbps and 8 Mbps satellite link and the build costs (including operating costs of the system) of fibre and microwave backhaul systems are as follows:

- Lease: Microwave 2 Mbps $1,292,000
- Lease: Microwave 8 Mbps $4,723,000
- Lease: Satellite 2 Mbps $1,147,000
- Lease Satellite 8 Mbps $4,586,000
- Build: Fibre $26,084,000
- Build: Microwave $8,324,000

9.6.4 Technology choice

Tibooburra is a very small town in terms of geographical size and population. Tibooburra represents the following scenario:

- Population density: Low
- Existing infrastructure: Medium
- Usage level: 1.5 Mbps

To deliver a 1.5 Mbps service in Tibooburra, a 2 Mbps backhaul link is required. An 8 Mbps backhaul link would be the minimum required to deliver 10 Mbps to end-users in Tibooburra, however this may not allow all customers to obtain full speed at peak times. Due to the distance of Tibooburra to Sydney, satellite services are slightly more cost effective than leasing microwave point to point services. The cost of deploying a new backhaul system for backhaul capacity requirements up to 8 Mbps cannot be justified, however it can be if 34 Mbps is required. At current levels of population and takeup, this is unlikely in Tibooburra. Satellite has technical limitations as a backhaul service, so leasing the microwave point to point link may be the preferred option.

There is an exchange in Tibooburra, so ADSL or ADSL2+ are possibilities, subject to the condition of the copper infrastructure. This is the preferred choice as DSL is more cost effective, reliable and resilient than wireless broadband technologies for delivery of 1.5 Mbps. We know there are pairgain systems in Tibooburra, and this will limit the number of customers who can obtain services from ADSL. Both ADSL and ADSL 2+ are capable of delivering 1.5 Mbps up to 5 kms from the enabled exchange. As Tibooburra is a very small town geographically, ADSL and ADSL2+ will be able to deliver services to the whole town, however there may be customers outside of the town it cannot reach. Wireless technology options such as WiFi, WiMAX and iBurst are options to deliver broadband to customers outside the reach of ADSL in Tibooburra. At 1.5 Mbps, WiFi is not feasible. WiMAX and iBurst will provide coverage to the town and large areas around the town. HFC and FTTH are extremely expensive options for a town with low aggregate demand like Tibooburra.

ADSL and ADSL2+ can also deliver 10 Mbps broadband services, although customers over 2 km from the exchange may not be able to obtain these speeds. VDSL is capable of delivering speeds far in excess of 10 Mbps, but only to households located near to the exchange. Given the size of Tibooburra, VDSL services for example could cover most of the town. Wireless broadband technologies such as iBurst and WiMAX cannot deliver 10 Mbps, and nor can WiFi. FTTH and HFC are capable of providing 10 Mbps broadband services to the town on an extremely reliable and robust basis, these technologies are also scalable further to much higher speeds, however both FTTH and HFC are extremely expensive options for a town of this size and aggregate demand. BPL may be an option for delivery of 10 Mbps, however, as yet the technology is unproven.

CDMA services are available in Tibooburra. Deployment of a GSM network for such a small town is likely to be a poor use of available resources. Given the availability of CDMA in the town, we expect Telstra would replace the CDMA equipment with WCDMA through the course of the network upgrade program.

Shown in Figure 9.8 is a comparative assessment of all of the technologies considered in this study that are possible options.

Figure 9.8 **Tibooburra technology choices**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 4	**Town: Tobooburra, New South Wales**															
Suitability																
Does it meet the range requirements of the scenario?	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	no	yes	yes	yes
Does it meet current bandwidth capacity requirements?	no	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	high	medium	medium	medium	medium	low	low	low	n/a	n/a	n/a	n/a	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA wireless coverage, no GSM coverage

No ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

Assumed that CDMA towers can be used for high speed wireless broadband.

9.7 Scenario 5 – Warburton, Victoria

9.7.1 Locality

Warburton is a small regional town located 80 km east of Melbourne. It is in a very hilly area, on the edge of the Yarra Ranges National Park, which has lots of trees. Warburton has a population of around 2000 people. The town itself has an estimated radius of around 5km, with outlying areas beyond this distance to approximately another 5 km. Warburton is in an areas where there is a greater density of population in between towns than in many other rural locations considered in this study.

Figure 9.9 shows the location and scale of Warburton.

Figure 9.9 **Warburton**

Source: www.multimap.com.au

9.7.2 Available infrastructure

At Warburton, existing infrastructure enables provision of the following services:

- Satellite services
- ADSL
- Wireless broadband services from Megalink
- CDMA services
- GSM services
- Telstra fibre backhaul services

9.7.3 Costing analysis

For each of the technologies the costs calculated are as follows (refer to Annex 3 for a more detailed costing assessment):

- ADSL 2+ $0.67 million
- FTTH $9.892 million
- HFC $10.259 million
- WCDMA $1.09 million
- WiFi $0.62 million
- WiMAX $1.19 million
- iBurst $1.44 million

In Warburton Telstra fibre backhaul and satellite services can be leased. The net present value over 5 years of the leased cost of a 2 Mbps, 8 Mbps and 34 Mbps links, 2 Mbps, 8 Mbps and 34 Mbps satellite links and the build costs (including operating costs of the system) of fibre and microwave backhaul systems are as follows:

- Lease: fibre 2 Mbps $82,000
- Lease: fibre 8 Mbps $300,000
- Lease: fibre 34 Mbps $1,366,000
- Lease: Satellite 2 Mbps $1,147,000
- Lease: Satellite 8 Mbps $4,586,000
- Lease: Satellite 34 Mbps $19,110,000
- Build: fibre $1,615,000
- Build: microwave $419,000

9.7.4 Technology Choice

Warburton is a fairly spread out town with a medium sized population. Warburton represents the following scenario:

- Population density: Medium
- Existing infrastructure: Medium
- Usage level: 1.5 Mbps

A 2 Mbps backhaul link may be sufficient to deliver 1.5 Mbps services to Warburton for a residential grade broadband service. However, Warburton has a higher number of businesses and professional workers than other towns included in this study, and therefore a 1.5 Mbps service over an 8 Mbps link is likely to be required due to the lower contention ratio these customers require. To deliver a 10 Mbps broadband service to Warburton, a 34 Mbps backhaul service would be required in Warburton.

Lease of a fibre link is the most cost effective choice for Warburton and is likely to be the preferred choice compared to building a new microwave system because of the superiority of fibre as a backhaul medium.

ADSL and WiFi services are already available in Warburton. ADSL is capable of providing 1.5 Mbps up to 5 km from the exchange. Assuming there is only one exchange in Warburton, ADSL would not be able to provide services to the whole town and its surrounding areas. ADSL range extenders could be used in Warburton to extend existing ADSL range, however range extenders may not be able to deliver 1.5 Mbps. Upgrade of ADSL to ADSL 2+ would mean 1.5 Mbps services could be delivered to more end-users. There are pairgain systems in Warburton, therefore some end-users would not be able to obtain services from ADSL.

Wireless services are also available in Warburton, these are provided by Megalink. Megalink provides services up to 1 Mbps, which is likely to be WiFi. WiFi performs particularly well at 256 Kbps or 512 Kbps but is not a good choice for 1.5 Mbps services. To fill in the gaps where ADSL coverage is not available, WiMAX and iBurst could provide services up to 1.5 Mbps up to a range of 15km, which is the upper limit of their capability. Due to the layout of Warburton, the hilly nature of the area, and the number of trees, Ovum estimates that deployment of WiMAX or iBurst to the whole town would be expensive and may require at least 3 further base stations located on hills around the town.

Scaling the scenario up to 10 Mbps, ADSL 2+ can provide 10 Mbps services 2 km from the exchange. Upgrading to VDSL will allow speeds far in excess of 10 Mbps but only for end-users close to the exchange. FTTH and HFC are capable of delivering 10 Mbps with no limitations and FTTH is totally scalable, but this is a very expensive option. FTTH is an unlikely choice, but it may be more feasible in a town like Warburton where there are a greater number of businesses and government buildings and where a greater level of demand can be aggregated.

GSM and CDMA are already available in Warburton. Telstra is expected to replace CDMA services in Warburton with WCDMA as part of their network program.

Shown in Figure 9.10 is a comparative assessment of all of the technologies considered in this study are possible options.

Figure 9.10 **Warburton technology choices**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 5	**Town: Warburton, Victoria**															
Suitability																
Does it meet the range requirements of the scenario?	yes	no	no	no	no	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Does it meet current bandwidth capacity requirements?	no	no	yes	yes	yes	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	high	medium	medium	medium	medium	low	low	low	n/a	n/a	n/a	n/a	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	no	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA and GSM wireless coverage

ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

Assumed that CDMA towers can be used for high speed wireless broadband.

Assumed that GSM towers can be used for 3G

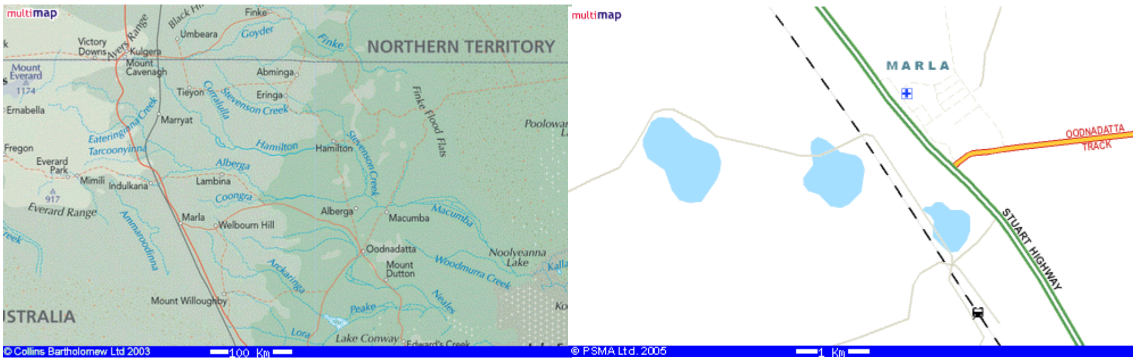
Assumed that there is one exchange in each town and it is located in the centre of town

9.8 Scenario 6 – Marla, South Australia

9.8.1 Locality

Marla is a very small isolated town located in mid northern South Australia near the border with the Northern Territory. It has a population of around 250 people. The town itself is very small and has an estimated radius of less than 2km. From available maps, the town does not appear to spread to outlying areas, however it is located on a major highway through northern South Australia to Adelaide. Figure 9.11 shows the location and scale of Marla.

Figure 9.11 **Marla, South Australia**



Source: www.multimap.com.au

9.8.2 Available infrastructure

At Marla, existing infrastructure enables provision of the following services:

- Satellite services
- CDMA services
- Telstra fibre backhaul services

There is no GSM service or wireless broadband available. There is no DSL service although there is an exchange.

11.6.2 Costing analysis

For each of the technologies the costs calculated are as follows (A detailed costing analysis is shown in Annex 3):

- ADSL/ADSL 2+ $0.15 million
- FTTH $1.08 million

- HFC $1.12 million
- WCDMA $0.41 million
- WiFi $0.14 million
- WiMAX $0.27 million
- iBurst $0.35 million
- GSM $0.29 million

In Marla Telstra fibre backhaul and satellite services can be leased. The net present value over 5 years of the leased cost of a 2 Mbps, 8 Mbps and 34 Mbps links, 2 Mbps, 8 Mbps and 34 Mbps satellite links and the build costs (including operating costs of the system) of fibre and microwave backhaul systems are as follows:

- Lease: 2 Mbps fibre $1,117,000
- Lease: 8 Mbps fibre $4,303,000
- Lease: 2 Mbps satellite $1,147,000
- Lease: 8 Mbps satellite $4,586,000
- Build: Fibre $23,772,000
- Build: Microwave $7,574,000

9.8.3 Technology Choice

Marla is a small town physically with a relatively small population. Marla represents the following scenario:

- Population density: Medium
- Existing infrastructure: Medium
- Usage level: 256 Kbps

To deliver 256 Kbps to Marla, a 2 Mbps backhaul link would be sufficient. Additionally, this would be the minimum capacity required to deliver 1.5 Mbps to Marla, although all customers may not receive 1.5 Mbps at the peak time, and therefore an 8 Mbps backhaul link may be required. At this capacity, leasing of a fibre backhaul link is by far the most cost effective option.

We know that Marla has an exchange and we therefore assume it has appropriate copper reticulation for DSL deployments. If this is the case, ADSL is an excellent choice in Marla for delivery of 256 Kbps. Marla is geographically small so deployment of ADSL could deliver services to the whole town, depending on the location of the exchange. There are pairgain systems in Marla, this may reduce the number of end-users who can access broadband services via DSL. At 256 Kbps, as well as ADSL, WiFi would be a good choice and this would allow provision of services to any areas which ADSL cannot reach. WiFi can provide range of around 5km with line of sight. Depending on the location of the base station, and due to the small size of Marla, end-users both residing in Marla, and those in the immediate rural areas around the town could be in range. WiMAX and iBurst are other options which could provide even greater coverage to Marla and its outlying areas, but these technologies are more expensive. Further, iBurst claim to be developing technology which can deliver 650 Kbps up to 90 km from the base station, and this would be a good choice for a town like Marla.

Scaling the scenario up to 1.5 Mbps, ADSL is still a suitable option in Marla. Upgrade to ADSL2+ would ensure that more end-users are able to obtain faster speeds more reliably. However, customers further than 5km from the exchange would be unlikely to receive these speeds. Delivery of 1.5 Mbps would be the upper limit of WiMAX and iBurst technology capability (up to 15 km from the base station), but it is likely that these speeds would be possible in a small town like Marla. WiFi is not a suitable choice for delivery of 1.5 Mbps. FTTH and HFC are much too expensive deployment choices for a small town like Marla. BPL is unproven.

Marla has CDMA coverage. Deployment of GSM services would in general be unnecessary addition given that Marla has CDMA access. However the Stuart Highway, a major South Australian freeway, runs through Marla and there may be an opportunity to extend the GSM network up the freeway from the last point of coverage. As Marla has CDMA access, Telstra would be expected to replace the CDMA with WCDMA equipment as part of their network upgrade program.

Shown in Figure 9.12 is a comparative assessment of all of the technologies considered in this study are possible options.

Figure 9.12 **Marla technology choices**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 6	**Town: Marla, South Australia**															
Suitability																
Does it meet the range requirements of the scenario?	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	no	yes	yes	yes
Does it meet current bandwidth capacity requirements?	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	high	medium	medium	medium	medium	low	low	high	n/a	low	low	low	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	no	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA wireless coverage, no GSM coverage

ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

Assumed that CDMA towers can be used for high speed wireless broadband.

Assumed that there is one exchange in each town and it is located in the centre of town

9.9 Scenario 7 – Marysville, Victoria

9.9.1 Locality

Marysville is a medium sized regional town located 100 km north east of Melbourne. It has a population of around 650 people. It is located in a fairly hilly area, surrounded by national parks. The town itself has an estimated radius of around 4km, and surrounding areas spread about 4km again around the town. Figure 9.13 shows the location and scale of Marysville.

Figure 9.13 **Marysville, Victoria**

Source: www.multimap.com.au

9.9.2 Available infrastructure

At Marysville, existing infrastructure enables provision of the following services:

- Satellite services
- ADSL services
- Wireless services provided by Megalink
- CDMA services
- GSM services
- Telstra microwave or possibly fibre backhaul services

9.9.3 Costing analysis

For each of the technologies the costs calculated are as follows (a detailed costing analysis is attached in Annex 3):

- ADSL 2+ $0.26 million
- FTTH $2.2 million
- HFC $2.2 million
- WCDMA $0.56 million
- WiFi $0.26 million
- WiMAX $0.43 million
- iBurst $0.51 million

Backhaul services can be leased in Marysville from Telstra. Satellite, microwave and fibre services are available, Telstra charges the same price for a particular backhaul capacity regardless of technology. Due to the proximity of Maryville to Melbourne, satellite services are much less cost effective than leasing backhaul from Telstra. The net present value of the leasing prices over 5 years and the cost to build fibre and backhaul systems to Marysville are as follows:

- Lease: 2 Mbps fibre/microwave $107,000
- Lease: 8 Mbps fibre/microwave $392,000
- Lease: 34 Mbps fibre/microwave $1,786,000
- Lease: 2 Mbps satellite $1,147,000
- Lease: 8 Mbps satellite $4,586,000
- Lease: 34 Mbps satellite $19,110,000
- Build: Fibre $2,164,000
- Build: Microwave $583,000

9.9.4 Technology Choice

Marysville is a medium sized town with an approximate radius of 8 km including the main town and outlying areas. Marysville represents the following scenario:

- Population density: High
- Existing infrastructure: Medium
- Usage level: 1.5 Mbps

To deliver 1.5 Mbps to Marysville an 8 Mbps backhaul link is required. As demand for services increase, to deliver 10 Mbps to Marysville a 34 Mbps backhaul link would be required. Leasing Telstra's fibre or microwave link is by far the most cost effective backhaul choice for Marysville. At 34 Mbps it becomes feasible to build a microwave point to point system to Marysville, however fibre remains the preferred choice in terms of service quality.

In Marysville ADSL and wireless services are already available. Assuming the ADSL is basic ADSL, 1.5 Mbps can be delivered up to 5km from the exchange. We do not know how many exchanges there are in Marysville. Assuming there is one exchange, ADSL coverage could not provide services to the whole town and its outlying areas. Range extenders could be used to increase the reach of ADSL. Additionally upgrade of ADSL to ADSL 2+ will ensure a higher quality broadband service and fast speeds to more end-users in Marysville. Some customers in the town would not be able to access ADSL services due to pairgain systems in the town.

The wireless services in Marysville are provided Megalink. Megalink offer services up to 1 Mbps, and these are likely to be WiFi services. WiFi is a suitable choice at lower bandwidth, but is not a good choice for 1.5 Mbps. In order to deliver 1.5 Mbps services to areas where the DSL cannot reach, options include WiMAX or iBurst wireless broadband deployments within the gaps. At 1.5 Mbps WiMAX can achieve a range of around 15 km in a rural environment. The greater reach achievable by iBurst and WiMAX could enable delivery of broadband access to customers outside the town itself and in the surrounding areas. Similarly to Warburton, Marysville is in a reasonably hilly area and therefore a deployment of wireless broadband would require more base stations than required in flatter scenarios.

Scaling the scenario up to delivery of 10 Mbps, ADSL2+ is capable of delivering 10 Mbps services to Marysville, but only to customers within a few km of the exchange. It is possible to upgrade the exchange in Marysville with VDSL which can deliver well over 10 Mbps but only within 2 km of the exchange. DSL cannot therefore cover the whole town of Marysville and its outlying areas. WiMAX and iBurst are not capable of delivering 10 Mbps in Marysville. Given the huge investment required for FTTH, and the relatively small population of Marysville, this is an unlikely option, however FTTH is fully scalable. BPL could deliver 10 Mbps per second but is currently unproven.

Marysville has CDMA and GSM coverage. Telstra’s plans to upgrade CDMA with WCDMA would be likely to include Marysville.

Shown in Figure 9.14 is a comparative assessment of all of the technologies considered in this study.

Figure 9.14 **Marysville technology choices**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 7	**Town: Marysville, Victoria**															
Suitability																
Does it meet the range requirements of the scenario?	yes	no	no	no	no	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Does it meet current bandwidth capacity requirements?	no	no	yes	yes	yes	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	high	medium	medium	medium	medium	low	low	low	n/a	n/a	n/a	n/a	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	no	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA and GSM wireless coverage

ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

Assumed that CDMA towers can be used for high speed wireless broadband.

Assumed that GSM towers can be used for 3G

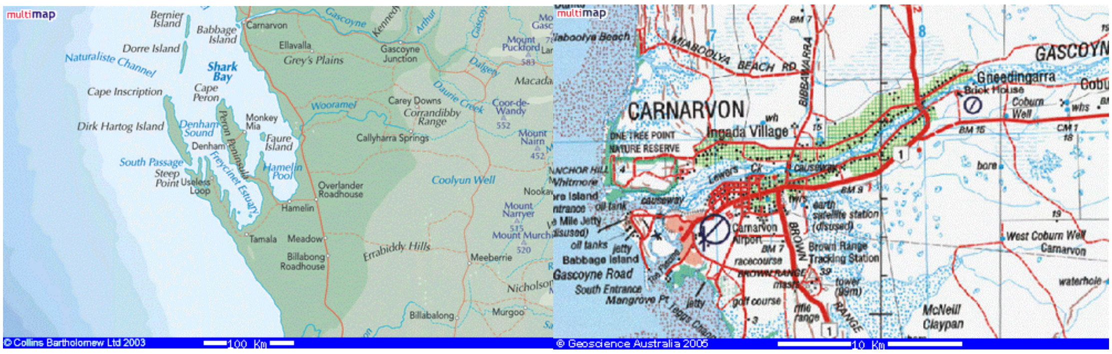
Assumed that there is one exchange in each town and it is located in the centre of town

9.10 Scenario 8 – Carnarvon, Western Australia

9.10.1 Locality

Carnarvon is a regional town located on the coast about 900 km north of Perth. It is reasonable sized town with a population of around 7,000 people. The town itself has an estimated radius of around 10km, and surrounding areas spread about 4km around the town. Figure 9.15 shows the location and scale of Carnarvon.

Figure 9.15 **Carnarvon, Western Australia**



Source: www.multimap.com.au

9.10.2 Available infrastructure

At Carnarvon, existing infrastructure enables provision of the following services:

- Satellite services
- ADSL services
- CDMA services
- GSM services
- Telstra inter-capital fibre and coaxial cable backhaul services

9.10.3 Costing analysis

For each of the technologies the costs calculated are as follows (a more detailed costing analysis is attached in Annex 3):

- ADSL 2+ $1.24 million
- FTTH $23.2 million
- HFC $24.1 million

- WCDMA $3.0 million
- WiFi $2.2 million
- WiMAX $3.5 million
- iBurst $3.6 million

In Carnarvon, satellite and fibre backhaul services can be leased. The net present value of the leasing prices and the build costs of fibre and microwave backhaul systems (including operating costs) over 5 years are as follows:

- Lease: 8 Mbps fibre $ 3,520,000
- Lease: 34 Mbps fibre $16,045,000
- Lease: 8 Mbps satellite $4,586,000
- Lease: 34 Mbps satellite $19,110,000
- Build: Fibre $19,442,000
- Build: Microwave $6,173,000

9.10.4 Technology Choice

Carnarvon is a large town. It is physically long and narrow, with areas of population spreading out near the coast an estimated radius of approximately 14 km. Carnarvon represents the following scenario:

- Population density: High
- Existing infrastructure: Medium
- Usage level: 256 Kbps

To deliver a 256 Kbps broadband service, Carnarvon requires an 8 Mbps backhaul link. In order to respond to increases in demand for bandwidth and deliver a 1.5 Mbps service a 34 Mbps backhaul service is required. Leasing fibre in Carnarvon is most cost effective option to deliver 8 Mbps backhaul capacity to Carnarvon. For 34 Mbps backhaul capacity it may be cost effective to build a microwave system, however leasing fibre would still be the preferred choice in terms of quality of service and reliability.

ADSL is already available in Carnarvon, and this is an excellent technology choice for delivery of 256 Kbps. However, given the physical dimensions of the town and depending on the number of enabled exchanges in Carnarvon, it is likely that ADSL is not available to all of Carnarvon and its surrounding areas. For the purposes of this study we have assumed that half of the population of the town can be serviced by ADSL. Extension of ADSL outside of 5 km from the exchange could be achieved by deployment of range extenders. Another option could be the deployment of wireless broadband technologies in the gaps where ADSL is not available. Due to the large population and size of Carnarvon compared to other towns considered in this study WiFi is not a cost effective option for Carnarvon. Wireless broadband such as WiMAX and iBurst are better options, for delivery of 256 Kbps and existing CDMA and GSM towers may be able to be utilised to deliver wireless broadband to Carnarvon. These technologies will reach areas well outside the town itself. The best choice would be a combination of ADSL, ADSL range extenders and wireless broadband to service the whole town and its surrounding areas.

To deliver 1.5 Mbps to Carnarvon ADSL is still a good choice and services will be available up to 5km from the exchange. Additionally, upgrading ADSL to ADSL 2+ will ensure higher speeds to more end-users in Carnarvon. Further increases in demand for bandwidth can be serviced by more advanced DSL technologies, but only very close to the exchange. Wireless broadband can also deliver speeds of 1.5 Mbps which is on the upper limit of its capability up to a range of 15km. Fibre and HFC are extremely expensive options for Carnarvon and over engineered for deliver of 1.5 Mbps. However, these technologies would allow full scalability for future increases in demand.

Carnarvon has CDMA and GSM coverage. Telstra’s plans to upgrade CDMA with WCDMA are likely to include Carnarvon.

Shown in Figure 9.16 is a comparative assessment of all of the technologies considered in this study.

Figure 9.16 **Carnarvon technology choices**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 8	**Town: Carnarvon, Western Australia**															
Suitability																
Does it meet the range requirements of the scenario?	yes	no	no	no	no	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Does it meet current bandwidth capacity requirements?	yes	yes	yes	yes	yes	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	n/a	medium	medium	medium	medium	low	low	high	n/a	low	low	low	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	no	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA and GSM wireless coverage

ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

Assumed that CDMA towers can be used for high speed wireless broadband.

Assumed that GSM towers can be used for 3G

Assumed that there is one exchange in each town and it is located in the centre of town

9.11 Scenario 9 – Wadeye, Northern Territory

9.11.1 Locality

Wadeye is an aboriginal township located on the coast south west of Darwin. It is the largest township in the Northern Territory with a population of 2200. The town itself is quite spread out and has an estimated radius of around 10km, and surrounding areas spread about 4km around the town. Figure 9.17 shows the location and scale of Wadeye.

Figure 9.17 **Wadeye, Northern Territory**

Source: www.multimap.com.au

9.11.2 Available infrastructure

There is very limited existing infrastructure at Wadeye. Satellite services and HCRCS services are available.

9.11.3 Costing analysis

For each of the technologies the costs calculated are as follows (a detailed analysis of each costing is attached in Annex 3):

- FTTH $7.36 million
- HFC $7.62 million
- WCDMA $1.24 million
- WiFi $0.77 million
- WiMAX $1.28 million

- iBurst $1.35 million
- GSM $1.32 million
- CDMA $0.90 million

In Wadeye, satellite in the only backhaul option available to be leased. The net present value of the leasing prices and the build costs of fibre and microwave backhaul systems (including operating costs) over 5 years are as follows:

- Lease: Satellite 8 Mbps link $4,586,000
- Lease: Satellite 34 Mbps link $19,110,000
- Build: fibre $8,996,000
- Build: radio point to point $2,800,000

9.11.4 Technology choice

Wadeye is a medium sized town that is fairly spread out. Analysis of technology choice for Wadeye has been undertaken for delivery of 1.5 Mbps.

The major consideration for delivery of broadband and mobile services to Wadeye is availability of backhaul services. To deliver 1.5 Mbps broadband services to Wadeye, an 8 Mbps backhaul link would be required. As demand for capacity increases, to delivery 10 Mbps, a 34 Mbps backhaul link could be suitable, but a 155 Mbps link is more likely to be required. Satellite is the only backhaul infrastructure available to deliver services. Use of satellite backhaul for broadband or mobile services is technically possible and a possible choice where there are no other options, but is undesirable. Satellite introduces latency and does not support high download levels cost effectively.

The only alternative to using Satellite is to build backhaul services from Darwin. For this scenario, delivering 1.5 Mbps to Wadeye, the more cost effective backhaul option for Wadeye is to build a microwave point to point system rather than lease satellite backhaul services. This would be the preferred choice. However, deployment of a fibre based backhaul system becomes feasible if 10 Mbps broadband services are required in Wadeye. The superiority of fibre as a backhaul medium may make fibre deployment for Wadeye a real choice.

Wadeye does not have an exchange and we have assumed that even if there is copper reticulation in the town it is not appropriate for DSL. Therefore deployment of DSL is not an option. For a town the size of Wadeye, WiFi is not cost effective, therefore Ovum believe in this case WiMAX and iBurst would be good choices for delivery of 1.5 Mbps, although this would be the upper limit of the technologies capability. Delivery of 10 Mbps to Wadeye is going to be very difficult. The only real options are FTTH or BPL, and since BPL is not a proven technology, and FTTH would cost over $9m before the cost of backhaul, this will not be feasible.

Wadeye has no terrestrial mobile coverage. Deployment of CDMA in Wadeye is not a viable choice due to Telstra’s plans to shutdown the CDMA network. GSM may be a reasonable choice for Wadeye depending on the proximity of other GSM networks. If there are not GSM networks in any town in the region of Wadeye, GSM will have only limited value for customers in Wadeye. As there is no GSM or CDMA network in Wadeye, we do not anticipate that Telstra will provide WCDMA services to the town. Targeted funding for WCDMA in Wadeye would be required for deployment to this location.

Shown in Figure 9.18 is a comparative assessment of all of the technologies considered in this study.

Figure 9.18 **Wadeye technology choices**

	Satellite	ADSL	ADSL2+	SDSL	VDSL	Fibre	HFC	Powerline	WiFi	Flash OFDM	WiMAX	iBurst	GSM	CDMA	HSDPA	WCDMA
Scenario 9	**Town: Wadeye, Northern Territory**															
Suitability																
Does it meet the range requirements of the scenario?	yes	possible	possible	possible	possible	yes	yes	yes	possible	no	no	no	no	no	no	no
Does it meet current bandwidth capacity requirements?	yes	possible	possible	possible	possible	yes	yes	yes	possible	yes	yes	yes	yes	yes	yes	yes
Is it scalable?	no	highly	highly	highly	highly	highly	medium	medium	no	medium	medium	medium	medium	medium	medium	medium
What is the scaling cost?	high	medium	medium	medium	medium	low	low	high	n/a	low	low	low	low	low	low	low
Maturity																
Has it been proven in operation elsewhere?	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	no	yes	yes	yes	yes
Are there reference cases in rural and regional Australia?	yes	yes	yes	yes	yes	yes	no	no	yes	no	no	no	yes	yes	no	no
Where is it placed on the cost/volume curve?	middle	end	end	end	end	end	middle	beginning	middle	beginning	beginning	beginning	end	middle	beginning	beginning
Timing																
Is it available for deployment this year as an operating technology?	yes	yes	yes	yes	No	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
Is it available in sufficient quantities to meet likely requirements?	Yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes
Issues for NGN investment																
Is the technology likely to be forward compatible with the requirements of an NGN (IP based network)?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demand and competitive pressure																
Are the customers locked into one provider?	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no
Is there a wide range of customer handsets?	no	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	yes	no	yes	yes

Notes

CDMA and GSM wireless coverage

ADSL exchange

Handset question for satellite technology applies to mobile satellite only.

Assumptions

Assumed that range requirements are to service the whole town

Assumed that there will be two potential providers for each technology.

Assumed that CDMA towers can be used for high speed wireless broadband.

Assumed that GSM towers can be used for 3G

Assumed that there is one exchange in each town and it is located in the centre of town

10 Findings

10.1 Access technology choices

10.1.1 DSL – ADSL/ADSL2+/SHDSL/VDSL

ADSL is the most cost effective technology choice where appropriate copper infrastructure is available. It provides high quality, reliable and robust broadband services.

The major limiting factor of DSL technology is its reach. ADSL can deliver broadband services within 5 km of the exchange (by cable route), which makes it a good choice for services within rural and regional towns. For households on the outskirts of towns or in rural areas, ADSL is often unable to provide a broadband service. Additionally, the DSL technologies capable of delivering very fast speeds, SHDSL and VDSL, can only deliver these speeds within 2km of the exchange, after which the performance of these technologies equate to that of ADSL and ADSL2+. Therefore SHDSL and VDSL are not good choices for deployment of DSL in rural and regional areas of Australia in order to increase coverage of services. VDSL can be used to provide faster speed broadband to households in the centre of towns.

The physical condition of the copper reticulation in rural and regional areas will affect the success of a DSL deployment. In many rural and regional towns longer loop lengths and pair gain systems make deployment via copper difficult and impossible to some customers.

Range extenders can be used to extend the reach of ADSL to end-users up to 20km from the exchange.

10.1.2 Fibre and HFC

Fibre and HFC are unsuitable deployment choices for rural and regional areas with low aggregate demand. This is due to extremely high deployment costs. However, both these technologies have low maintenance costs and can offer very high speed access that is easily scalable for growth in demand.

10.1.3 Wireless broadband (WiMAX and iBurst)

In general, wireless broadband technologies such as WiMAX and iBurst are not a direct competitor with terrestrial based technologies such as DSL and fibre where they are available. DSL offers more reliable services at higher speeds which are more cost effective. However, where DSL is not available, wireless technologies are usually the next choice.

In rural and regional areas, wireless broadband technologies have the capacity to fill gaps between areas where DSL is available. Wireless broadband can be deployed quickly and relatively cheaply to provide coverage where services are not available. A limitation of wireless broadband is that it becomes significantly more expensive to scale the technology once demand for services takes off. Additionally there is limited bandwidth available through wireless broadband, with around 1 to 1.5 Mbps per customers and an upper limit of the base station capacity of the current systems of around 11 Mbps. It is a shared system so as the number of customers per base station and usage levels increase, the individual customer speeds the system is capable of delivering decrease very quickly.

The requirement for spectrum puts a limitation on wireless broadband. Obtaining spectrum can be difficult for smaller providers looking to deploy rural and regional networks. Additionally, spectrum is a scarce resource, and this puts a limitation on the speeds and number of end-users that wireless broadband can serve.

10.1.4 WiFi

WiFi has been used in rural and regional areas in Australia and internationally to provide basic broadband access to very rural and remote areas on a best effort basis. WiFi deployments are cheap, and for small numbers of users can provide adequate broadband services. For very remote areas, it has been used in combination with satellite backhaul to make some kind of broadband service available.

WiFi is only really an option for very small towns in very remote locations where there is no other alternative apart from broadband via satellite. ACMA has allocated spectrum bands for WiFi that allow non-exclusive use (licence free) so spectrum access is not an issue for WiFi.

10.1.5 Broadband over powerline

Broadband over powerline (BPL) is a new technology which has been used internationally on a very limited basis and trialed in many countries with indifferent success. Trials are being conducted in Australia by a number of utility operators who are interested in the possibilities BPL offers as a ubiquitous access technology which could compete directly with Telstra’s CAN. A number of operators in Australia have expressed interest in BPL as a possible option for the same reason on interview.

Across regional and rural Australia, utility companies provide power into households, thereby suggesting that BPL has potential. However, the technology is still under trial and there is uncertainly whether the technology and commercial models work. For example, as it is a shared technology, trials have not yet shown what effect lower contention ratios have on the speeds which are deliverable through the network.

BPL may offer very high speeds (40 Mbps to the home) which are scalable, but like fibre and HFC, this is limited by the backhaul which is available at any particular location.

Ovum is unable to comment further at this point whether BPL would be a suitable long term technology choice. It is still yet to be seen whether BPL becomes a mainstream technology option.

10.1.6 Satellite broadband

Satellite broadband is a possible choice for broadband service delivery to very remote areas where no other broadband services are available and there are very small numbers of customers. As with satellite backhaul services, satellite broadband is capped heavily for higher usage levels comparable with broadband speeds available in many urban areas, which makes it not cost effective for broadband services delivering speeds above 256 Kbps.

10.1.7 GSM , CDMA and WCDMA

As set out in Section 3 of this report, GSM and CDMA networks are available across many regional and remote parts of Australia.

Both technologies are primarily suitable for voice services, but are capable of delivering data services through utilising GPRS. GPRS does not have the capacity to deliver the range of data services available from WCDMA, but can provide cost effective services in applications for which time sensitive streaming applications are not required.

10.1.8 Mobile Satellite

Mobile satellite appears to be a good choice for delivering mobile services where GSM and CDMA networks have not been deployed, but there are some limitations. For example, Globalstar operate their satellite services through a collection of satellites in Low Earth Orbit. Low earth orbit allows mobile services to be provided with a shorter delay than other services provided by satellites in orbits further from the earth's surface. Low earth orbit satellites are expensive to deploy. Global star was able to obtain these satellites from Vodafone for a reasonable price because the satellite business was heavily loss making. Whether Globalstar can afford to deploy another satellite at current revenue rates when the useful life of the current satellites are reached is uncertain.

10.2 Backhaul technology choices

Consideration of future demands on backhaul in the locality are key to decide what type of backhaul is required to provide broadband and mobile services scalable for future demand. Backhaul requirements depend on the number of customers and their required usage levels.

In Australia High Capacity Radio Concentrator systems (HCRCS), satellite, fibre and microwave point to point systems have been deployed and can be leased. Where there are limited backhaul services available, the alternatives are leasing satellite services and building a new backhaul system.

High Capacity Radio Concentrator systems (HCRCS) can deliver speeds between 14.4 and 28.8 Kbps, which makes it an unsuitable choice for backhaul for any kind of broadband or mobile service. In such cases, Satellite is a possible choice for backhaul services where nothing else is available. Satellite backhaul links at low broadband speeds such as 256 Kbps are possible at annual lease prices which make it a feasible option particularly for locations a great distance from the nearest POP. Capacity limitations are enforced and penalties for over use are high. This is because there is only limited bandwidth on a 36 MHz transponder and the bandwidth is shared. Prices for satellite backhaul at speeds equivalent to broadband services available in urban areas are very high, relative to other technologies.

For locations where it is available, fibre is by far the preferred option. This is due to the superior quality of service, and resilience of fibre backhaul systems. Where fibre is not available, microwave point to point is the next choice.

Build costs for new backhaul systems to remote areas are extremely high. Microwave point to point systems are relatively less expensive at around one third of the cost, but they have a higher operating cost and are much less scalable than fibre backhaul systems.

10.3 Scenario analysis conclusions

10.3.1 Access technologies

The suitability of a particular technology choice for rural and regional Australia comes down to cost, existing infrastructure availability and capacity requirements now and into the future.

Figure 10.1 shows which technology choices are possible in each town included in the scenario analysis. This shows that for any particular scenario, there are in general a range of options which may be suitable.

Figure 10.1 **Technology suitability**

Town	**Usage**	**ADSL/ ADSL2+**	**SHDSL/ VDSL**	**WiFi**	**WiMAX /iBurst**	**Sat.**	**FTTH/ HFC**	**BPL**
Christmas Creek, WA	256 Kbps	□		✔	✔	✔		✔
Leyburn, QLD	1.5 Mbps	✔	✔	✔	✔			✔
Innamincka, SA	256 Kbps			✔	✔	✔		✔
Tibooburra, NSW	1.5 Mbps	✔	✔	✔	✔			✔
Warburton, VIC	1.5 Mbps	✔	✔		✔		✔	✔
Marla, SA	256 Kbps	✔	✔	✔	✔			✔
Marysville, VIC	1.5 Mbps	✔	✔		✔		✔	✔
Carnarvon, WA	256 Kbps	✔	✔		✔		✔	✔
Wadeye, NT	1.5 Mbps				✔			✔

In Figure 10.2 is a matrix showing the breakdown of optimum technology choices by town size and capacity required.

Figure 10.2 **Technology choice matrix**

		Town size		
Capacity required	**Preference order**	Small Pop: 200 or less	Medium Pop: 200 to 1000	Large Pop: Over 1000
256 Kbps	Preferred choice	ADSL	ADSL	ADSL
	Second choice	WiFi	WiMAX/iBurst	WiMAX/iBurst
	Third choice	WiMAX/iBurst		
1.5 Mbps	Preferred choice	ADSL/ADSL 2+	ADSL/ADSL 2+	ADSL/ADSL 2+
	Second choice	WiMAX/iBurst	WiMAX/iBurst	WiMAX/iBurst
	Third choice			
10 Mbps	Preferred choice	ADSL 2+	ADSL 2+	ADSL 2+
	Second choice	BPL[8]	BPL[8]	Fibre
	Third choice			BPL[8]

In general, ADSL/ADSL2+/VDSL are the preferred choices where they are available. Where ADSL is available, WiMAX can be usefully deployed as a complimentary

[8] We have included BPL as a choice in Figure11.2 as it is a technology option considered by this study. However, it is currently unproven so it cannot be recommended ahead of other proven technology options

technology, providing service to customers connected to unsuitable copper services or past the reach of ADSL from the exchange.

For delivery of 256 Kbps it should be noted that:

- 256 Kbps is an entry level service, and as such it would be reasonable to expect end-users to seek faster speed broadband fairly rapidly after receiving a 256 Kbps service.
- Where ADSL is not available, WiFi is the best choice for small towns for delivery of 256 Kbps, and WiMAX/iBurst for medium and larger towns. However WiFi cannot be scaled well to higher speeds.

For delivery of 1.5 Mbps it should be noted that:

- ADSL/ADSL2+ and WiMAX/iBurst are both suitable and are likely to be deployed in combination where there is a big enough town to justify the capital expense.

For delivery of 10 Mbps it should be noted that:

- ADSL2+ is by far the preferred choice for delivery for 10 Mbps.
- Where ADSL2+ is not available, the options are limited. For small towns, it is near impossible to deliver 10 Mbps where ADSL is not available. For larger towns FTTH is a possibility but extremely expensive. BPL is a possibility but is as yet unproven.

10.3.2 Backhaul technologies

From a technical perspective, fibre is by far the preferred backhaul option, and satellite the least preferred. This is due to its greater reliability, resilience and quality of service.

Where there are backhaul choices, the preferred option for each town depends on its distance from the nearest POP and the relative cost of leasing satellite services. Where there is a choice of backhaul options, for towns more than 1,200 kilometres away from the nearest point of presence, it is generally more cost effective to lease satellite services rather than fibre or microwave.

In most cases, when considering lease costs over a 5 year period, it becomes viable to build a new fibre system only when very high usage levels are reached requiring a 155 Mbps backhaul link. It is most unlikely that this level of usage and takeup will be achieved in medium and small rural towns in Australia. It is typically viable to build a microwave point to point link to a town in cases where a 34 Mbps backhaul link is required. While this is a much more likely case, microwave is a less effective medium for backhaul and has significantly higher operating costs than fibre, which makes it a much less desirable choice.

10.4 Market considerations

10.4.1 Backhaul

Backhaul availability

Fibre or microwave point to point backhaul are available across much of Australia. The cost of satellite at higher bandwidth requirements makes it a poor choice as demand for higher speed broadband services is likely to increase. Therefore in areas where satellite is the only choice targeted programs to provide backhaul infrastructure to isolated areas would be desirable.

Backhaul pricing and competition

Where fibre or microwave point to point backhaul are available, it is typically available at prices that are not viewed as commercially acceptable by smaller operators and new entrants. This is particularly the case where Telstra is the only backhaul provider in areas that are considerable distance from the nearest POP. Without more cost related backhaul pricing, more dynamic competition and therefore lower prices to end-users will not be achievable in rural and regional areas in Australia.

10.4.2 Access technologies

Roaming issues

As 3G and 2G networks develop in Australia, the issues for roaming between networks are becoming more complicated. WCDMA was designed as the evolution of GSM and roaming between GSM and WCDMA networks is a design feature of the WCDMA standard. An operator can even design their network architecture to attach the GSM and WCDMA base stations to a common core network. It is technically possible to hand over an active call between GSM and WCDMA even between different operators.

The handsets used by consumers are a major constraint to this. Clearly a GSM only handset will not be able to roam onto WCDMA. The majority of WCDMA handsets being sold in Australia provide for WCDMA at 2100MHz and GSM at 900, 1800 and 1900MHz, and can therefore roam onto any of the GSM spectrum in use in Australia (and all or most spectrum used for GSM globally). So technically, the handsets could roam onto any GSM or WCDMA currently in Australia.

Two issues complicate this. First, roaming can only occur where there is a commercial agreement in place allowing the customers of one operator to roam onto the network of another operator. Even where there is an obligation to provide roaming to other operators as part of the requirements of public funding, unless the rates are commercially attractive the other operators will not take up their roaming rights.

Second, Telstra is planning to rollout WCDMA at 850MHz. This is primarily to achieve the better coverage possible from the lower spectrum band. Handsets that can roam onto WCDMA at 850MHz will be limited to Telstra for at least the next 2 - 3 years. The handsets that are currently being supplied by Cingular to their customers for use with their 850MHz WCDMA network are designed to work with GSM at 900 and 1800MHz and WCDMA at 1900MHz. Telstra will need to source handsets that can roam onto WCDMA at 2100MHz rather than 1900MHz. Currently all the handsets that Cingular are providing are high end (expensive) handsets and there is only a limited range available to choose from, and this is likely to be the same for the handsets that Telstra supplies.

So while Telstra customers with the special handsets will be able to roam onto GSM at 900 and 1800MHz, the customers of the other operators will not be able to roam onto WCDMA at 850MHz unless there is a roaming agreement in place and they have purchased one of the special handsets.

Broadband delivery over mobile networks

GSM upgraded to GPRS and EDGE are able to provide basic data applications such as email and graphics. These technologies are widely deployed and used.

Cellular network technologies currently in development are capable of delivering broadband speed data to mobile devices. Mobile equipment vendors are expecting to develop technology soon which can compare comparably with wireless broadband technologies such as WiMAX and iBurst.

HSDPA deployments in the USA, for example, can deliver 400 to 700 Kbps to the handset. Telstra’s deployments of HSDPA are capable of 3.6 Mbps, however this is based on a laboratory testing environment, the actual speeds achievable are much lower. HSUPA developments are expected to be capable of delivering 5.8 Mbps (uplink). The availability of handsets that can deliver these speeds is a key limitation currently. However, vendors are expecting that the speeds deliverable from cellular network technology will continue to improve.

WCDMA coverage

Telstra’s vendor, claims that the WCDMA equipment that will be used at 850Mhz will be able to provide the same coverage footprint across Australia as the current CDMA system. Telstra’s vendor claims that reach from the new WCDMA equipment will exceed the current CDMA base stations that deliver 183 km.

Achievement of this coverage will require a number of changes to standard equipment and thereby extra cost to Telstra. If the same coverage footprint is not possible, than extra WCDMA towers will be required at additional cost.

A car kit versus a handheld provides a fixed signal strength boost regardless of the underlying technology. The range differential between handheld and car kit should be very similar between GSM, CDMA and WCDMA.

Issues for NGN investment

Telstra has announced plans to implement an NGN network incorporating fibre to the node. Deployment dates for these plans beyond the five mainland capitals were not specified originally and the plans have now been put on hold. Regardless of the time deployment start, Ovum anticipates that capital cities and major regional centres will be the main focus originally. Ovum does not anticipate that rural and regional areas outside of the main centres will be targets for deployment for some time. Having said this, it is important that any new deployments in rural and regional areas enable flexibility so that they can be forward compatible with NGN networking in the instance that Telstra rolls out its plans.

In principle compatibility of any access technology with a IP based next generation network (NGN) build depends on whether the network traffic is managed through the network on IP standards or not. In general, all the technologies considered in this study, except for GSM and CDMA can be made compatible with future NGN network builds. In some cases it will require some specific approaches in network design.

The reason for singling out GSM and CDMA is that the voice networks are circuit switched, and therefore do not operate under protocols compatible with NGN operation.

10.5 Funding considerations

10.5.1 Backhaul

The issues for backhaul in Australia are a result of market failure. Backhaul providers such as Telstra and Optus are able to charge prices that are not directly cost related. The impact of competition on backhaul pricing is clear from the relative discounts large operators with volume purchases are able to obtain.

This analysis has been undertaken on the basis of providing backhaul to each new town on an individual basis. This is not the way that it would be carried out in practice. Backhaul should be provided to regional areas so that each town along the leg of the backhaul from the pop can be provided services, and a group of towns located across a region can be provided services at the backhaul destination.

Additionally, in general, backhaul costs for small operators are an operating cost that takes the form of an annual operating cost. Government funding tends to focus on providing one off capital funding contributions. Funding procedures need to explicitly address ongoing costs such as backhaul.

10.5.2 Mobile and broadband access

The funding structure chosen can affect the technology choices made by operators deploying infrastructure. The focus of the funding structure must be on ensuring the optimum outcome for end-users, rather than the operator, and to be as flexible as possible. For example, the funding criteria that is only structured on a per user deployment cost may result in biasing technology choice and lead to failure to adopt technologies which are capable of catering for additional users and increased capacity.

The opportunity offered by the Connect Australia funding program for Australia is to provide a step change in the scale of government funded programs in rural and regional Australia. We believe that the most effective way to make access services available for mobile and broadband services is to consider delivery of services on a town by town basis.

Experience internationally in delivery of services to new areas shows that the most efficient way to provide services to a new area is to target the highest users first. These are the users which provide a basis for the infrastructure required. Examples of high users in rural and regional areas could include government agencies, welfare agencies, hospitals, general practitioners, and small businesses such as veterinary surgeons for example. Implementation of programs which are concerned with capturing and aggregating the demand for services in these groups is key to the most efficient and cost effective use of funding. Once the basic level of demand in a town has been targeted in this way, services will be available for residential customers and smaller businesses on a more cost effective basis.

In addition to aggregation of demand for high users first, community organisations can be a key factor in successful deployment in rural and regional towns. Particularly if care is taken with the approach. Local councils for example, have the ability to coordinate access to infrastructure dig projects in towns and well organised council led projects with access to state and federal government funding, input from telecoms operators and major local business organisations can result in leveraging more funds and experience.

Annexes

A1 Service availability

Figure A.1 **Service availability**

Scenario	1	2	3	4	5	6	7	8	9
Fixed telephone services	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Exchange in town	No	yes	no	yes	yes	yes	yes	yes	no
ADSL broadband	No	No	No	No	Telstra	No	Westnet/TSN Internet	Telstra	No
Wireless broadband	No	Halenet	No	No	Megalink	No	Megalink	No	No
CDMA services	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No
GSM handheld services	No	No	No	No	Telstra and Optus	No	Telstra and Optus	Telstra, Optus and Vodafone	No
GSM carkit services	No	Telstra and Optus	No	No	Telstra and Vodafone	No	Telstra	Telstra	No
Satellite services	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Backhaul services	HCRCS	Telstra fibre to inter-cap. fibre	Telstra microwave	Telstra microwave	Telstra fibre	Telstra inter-capital fibre	Telstra microwave and possibly fibre	Telstra inter-capital fibre and coax cable	HCRCS

Source: DCITA

A2 Cost analysis assumptions

A2.1 Population assumptions

To estimate the cost of deployment for each technology in each town, the number of connections required has been calculated. This is based on the population in each town, which was used to estimate the number of households (applicable to broadband services) and the number of customers (applicable to mobile services). Of the total number of addressable households or customers, likely takeup of services was assumed to establish the final number of connections or end-users.

Figure A.2 shows the populations used for each scenario, and its source. Christmas Creek's population was assumed due to no information on its population being available.

Figure A.2 **Population assumptions**

Scenario	Town	Population	Source
1	Christmas Creek	150	assumed
2	Leyburn	150	Internet
3	Innamincka	15	DCITA
4	Tibooburra	150	Internet
5	Warburton	2000	DCITA
6	Marla	243	Internet
7	Marysville	650	DCITA
8	Carnarvon	7000	Internet
9	Wadeye	2215	Internet

Estimated take up levels for each scenario are representative of those likely in the first 5 years following deployment. For simplicity, flat takeup levels across the 5 years have been assumed.

- *For broadband services* – To calculate the number of end-users in each town, we have estimated the number of households based on the population of each town. An average of three people per household was assumed. In rural and regional towns, there are typically a mix of households, ranging from those with large families and those with elderly people living on their own. There are fewer households of 3 or 4 people than in city areas. We have seen no evidence to suggest that take up of services in rural and regional towns is different to that in urban areas, and therefore based on Ovum's experience in similar infrastructure projects, take up of broadband services in 30% of households has been assumed.

- *For mobile services* – In the case of mobile services, a similar approach was taken to estimate the number of customers. The number of customers were estimated from the population of the town, and from this assuming an addressable market and then assuming the take up of mobile services amongst the addressable market. Based on our experience in mobile service take up internationally, 70% of the population of the town has been estimated to form the addressable market, and of those 80% are assumed to take up services.

A2.2 Financing Assumptions

In order to establish comparable costs for each scenario and technology, we have undertaken costing analysis over 5 years. The net present value of operating costs and leasing costs in year 1 for each technology deployment have been calculated. A discount rate of 12% was used across all scenarios and all technology deployments.

All costs are shown in Australian dollars. Equipment costs obtained in Euros and US dollars have been converted using the following exchange rates:

- Euro to AU$: 1.35
- US$ to AU$: 1.66

A2.3 Backhaul assumptions

DCITA has provided Ovum with details of backhaul services available in the scenario towns. All the towns have backhaul services of some type available. For simplicity we have assumed that the backhaul infrastructure is available at the location where it is required for interconnection.The following assumptions were made for satellite, HCRCS, microwave point to point and fibre services available in each town:

- *Satellite and HCRCS services:* HCRCS does not provide enough backhaul capacity for broadband or mobile services and therefore cannot be used for backhaul. Satellite services are available everywhere, but is only used for backhaul where nothing else is available. This is because satellite usage prices do not scale well as usage increases past 2 Mbps for a backhaul link, and there are harsh penalties for exceeding download limits.
- *Microwave point to point*: Where microwave point to point services are available, it has been assumed the capacity it can deliver is enough to provide the bandwidth required in the scenario.
- *Fibre:* Where fibre is available it is assumed that the fibre capacity is enough to deliver services at any capacity into the future and that the backhaul system is fully scalable.

Where appropriate backhaul services are not available the option to build new backhaul infrastructure has been considered. Two options have been considered in each scenario, fibre or microwave point to point links.

For each scenario an estimation of the backhaul requirements was calculated assuming a contention ratio of 50 to 1[9].

Figure A.3 shows leasing costs used in the costing analysis. Satellite costs were based on Ovum's experience[10] and fibre or microwave costs were assumed based on Telstra's charges. Telstra charges the same leasing price regardless of the technology of the system used.

Figure A.3 **Leasing costs**

Type of lease	**Satellite (per annum)**	**Fibre/Microwave (per 100 km per annum)**
2 Mbps	$249,000	$23,056
8 Mbps	$996,000	$84,298
24 Mbps	$4,150.000	$384,265
155 Mbps	$8,300,000	$900,620

The cost to build a new backhaul system was calculated for each scenario. Calculation of the cost to deploy backhaul in each scenario was based on the distance to the nearest point of presence in the capital city in that State. The backhaul system length was assumed based on the most direct travel distance. Road distances between the scenario town and the nearest capital city (and in the case of scenario 1, Broome) were taken from www.whereis.com.au.

Deployment costs for fibre and microwave point to point backhaul systems were provided by Internode. Assumptions made are as follows.

- *Fibre deployment costs*: The cost of the fibre together with the laying cost was assumed at $20/m. We have assumed repeaters are required every 100 km, at a cost of $50,000 each[11].

[9] The minimum backhaul capacity required for each scenario depends on the contention ratio assumed, the number of customers in the town and the usage levels of the scenario.

[10] Due to the difficulty of obtaining satellite backhaul quotes in Australia

[11] This is the worst case scenario, as Gigabit Ethernet switches at $30,000 can be used if there are townships being served along the length of the fibre.

- *Microwave deployment costs*: The cost of building each tower was assumed to be $80,000, and the cost of each radio system $40,000. Each tower (apart from the end ones) requires two radio systems, and each end tower one system each. We have assumed that a microwave tower is required about every 40 km for a long haul chain in flat terrain. Power costs of $30,000 were assumed for each tower, this is based on using solar systems.

The total build costs are based on the cost to build the system and the net present value of the operational costs of the backhaul system over 5 years. These costs for each scenario are shown in Figure A4.

Figure A.4 **Cost to build backhaul system**

Town	**Fibre**	**Microwave**
Christmas Creek	$9,516,524	$2,969,414
Leyburn	$4,062,850	$1,213,036
Innamincka	$19,989,136	$6,355,356
Tibooburra	$26,083,619	$8,324,222
Warburton	$1,614,679	$418,580
Marla	$23,771,645	$7,574,928
Marysville	$2,164,273	$583,479
Carnarvon	$19,441,634	$6,173,808
Wadeye	$8.996,011	$2,796,815

A2.4 ADSL Cost Assumptions

DCITA has provided information on the ADSL availability for each of the towns in the study to Ovum. It is assumed in each case that the ADSL is basic ADSL, rather than ADSL2+.

The capital cost of deployment of ADSL is based on the following elements:

- *Administration and negotiation costs with Telstra* – This element is based on the work required for another operator to reach an agreement with Telstra to use the Telstra exchange. We have assumed this will require one individual undertaking 40 man days of work at an annual salary of $50,000.

- *Exchange installation costs* – This element is based on the work required to install the other operators' equipment in the Telstra exchange. We have assumed this will require 5 man days of work and the calculation is based on work by one staff member on an annual salary of $50,000.

- *DSLAM costs* – The cost and type of DSLAM deployed varies depending on the number of lines required. For deployments serving very small numbers of end-users it is more cost effective to purchase small standardised units which have a fixed number of ports. Therefore in the scenarios where there are 24 or less lines are required, we have assumed that a standardised 24 line DSLAM unit will be deployed. Based on current equipment provider costs, a standardised DSLAM of this type costs US$5000. For the larger towns where more than 24 lines are required, a different type of customised DSLAM will be more cost effective to deploy, these are purchased on a per port basis. Based on Ovum's current advice from equipment providers, DSLAMs of this type cost 160 Euros per port. Therefore for the larger towns with 25 or more end-users, it has been assumed the customised per port DSLAM will be deployed
- *CPE equipment costs* –The cost of ADSL CPEs has been assumed at $80 per connection[12].

The operating cost of ADSL is based on the following elements:

- *Site leasing costs* – Site leasing costs of $12,000 have been used across the costing analysis. This is based on the Telstra exchange access fee taken from Metropolitan Blackspots Program Cost Consultancy. This is in line with information obtained from stakeholder interviews conducted as part of this consultancy study. For example, Austar quoted site rental costs per base station of $15000 to $25,000.
- *ULL leasing costs* – Telstra's averaged ULL leasing charges of $30 per month per line, agreed with the ACCC in 2006, are used in the model.
- *Maintenance costs* – Maintenance costs for ADSL were assumed at 20% of capital costs. This is based on Ovum's experience.
- *Backup power costs* – The DSLAM costs used in this model include the cost of power. However, it has been assumed that a source of backup power will be required. Based on Ovum's experience, the cost of a backup power source is US$1000 per year for each exchange site.
- *Customer sales and marketing costs* – Customer sales and marketing costs per customer of $150 were assumed.
- *Backhaul leasing costs* – This has been covered in the previous section.

A2.5 ADSL 2+ Cost Assumptions

The same structure of costing was used for ADSL 2+ as in the case of ADSL. The only difference in costing between ADSL and ADSL2+ is the type of backhaul required to deliver the higher speeds ADSL2+ can provide. It is assumed that for

[12] Based on Ovum's experience of current CPE prices

those towns where ADSL is already available, there is no cost of negotiation with Telstra to upgrade to ADSL2+.

A2.6 SHDSL and VDSL Assumptions

SHDSL and VDSL can provide much higher speeds to the customer than ADSL and ADSL2+ however they can only achieve this for customers located very close to the exchange. The cost structure for deployment of SHDSL and VDSL is similar to ADSL and ADSL2+, but deployment is more expensive, This is due to the cost of upgrading the DSLAMs, higher backhaul capacity required to deliver higher broadband speeds and the requirement for a greater proportion of fibre required in the system. Ovum has not costed these technologies.

A2.7 Fibre Assumptions

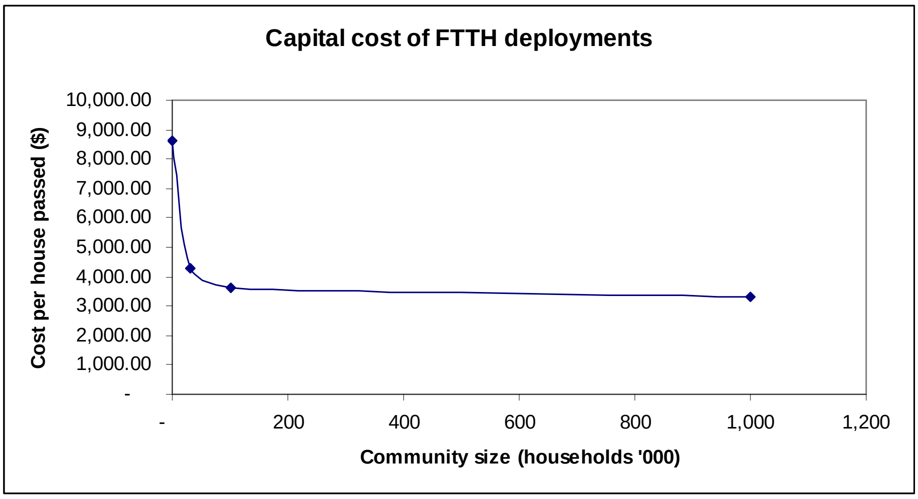
For the purposes of the costing analysis, Ovum has chosen the Fibre to the Home (FTTH) deployment model. In this case, fibre is deployed up to the point of interconnection in the home. This is the most expensive type of fibre deployment which can provide the highest potential speeds, up to 100 Mbps.

In order to calculate the capital cost for deployment of FTTH in each scenario, Ovum has used figures compiled by Clear Advantage and Associates in their 2003 consultancy report to DCITA. Ovum has reviewed these figures and found they are in line with costing assessments undertaken by Ovum for previous studies. Differences in unit costs between Australian terrain and overseas terrain mean that these costs are a better estimation than could be made by Ovum by other means without more detailed analysis. Clear Advantage and Associates found that it cost $3.337m to deploy PON[13] FTTH for a community of 1m people, $360 m to deploy FTTH for a community of 100,000 people, $73m to deploy FTTH for a community of 30,000 people and $6.5m to deploy FTTH for a community of 1000 people.

Figure A.5 shows the cost per household passed to deploy FTTH based on this data.

[13] Passive optical network

Figure A.5 **Cost to deploy FTTH**



Source: Clear Advantage and Associates

Based on the analysis above, the cost per household passed more than doubled between communities of 30,000 and 1,000 households. We have therefore, that for the larger towns in this study a deployment cost per household passed of $6,679, and for the smaller towns we have taken into account the lower benefits of scale with very small towns and applied a factor of 1.5, which gives us a deployment cost per household passed of $10,018 per town. Additionally costing analysis by Clear Advantage and Associates was undertaken in 2003, we have assumed that these costs have reduced by 7.5% per annum between 2003 and 2006.

The cost elements of the operating costs for FTTH include:

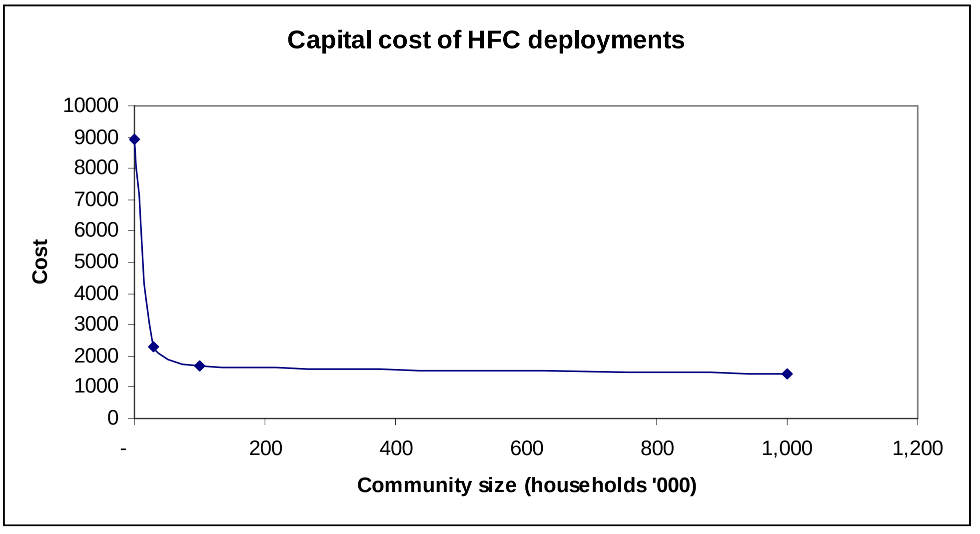
- *Maintenance costs* – Maintenance costs of FTTH are low. And have been assumed to be 10% of capital costs. This is based on Ovum's experience.
- *Customer sales and marketing costs* – Customer sales and marketing costs per customer of $150 are assumed.
- *Backhaul leasing costs* – Delivery of services up to 100 Mbps require very high backhaul capacity. This has been covered in an earlier section.

A2.8 HFC Assumptions

HFC costs are similar to FTTH, and a similar approach has been taken in estimating a cost using Clear Advantage and Associate costing from their 2003 consultancy report to DCITA.

Clear Advantage and Associates found that it cost $865.9m for a community of 1 million households, $111.6m for a community of 100,000 households, $51.8m for a community of 30,000 households, and $8.4m to deploy HFC to a community of 1,000 households. Figure A.6 shows the cost per household passed to deploy HFC based on this data. This chart figure shows that for small deployments of HFC the costs are very similar to FTTH.

Figure A.6 **Cost to deploy HFC**



Source: Clear Advantage and Associates

As in the case of FTTH, a factor of 1.5 was applied to the Clear Advantage figures for the very small towns in this study. Since costing analysis by Clear Advantage and Associates was undertaken in 2003, we have assumed that these costs have reduced by 7.5% per annum between 2003 and 2006.

A2.9 Broadband over powerline Assumptions

Broadband over powerline (BPL) is a new technology which is being trialed by a number of utilities in Australia. The technology used in the trials is new, and therefore Ovum does not have estimates of its cost. However, feedback from the stakeholder interviews and experience internationally indicate that BPL would be an expensive broadband deployment choice.

A2.10 GSM Assumptions

DCITA has provided information to Ovum detailing which of the scenario towns already have GSM services available. It is assumed for simplicity that if GSM is available, coverage is available in the whole town and no further deployment in those towns is required.

There are two broad approaches to deploying GSM in a new town. If GSM is available within reasonable distance of the town, services can be made available by making a backhaul link to the edge of the existing GSM network, and building a new tower in the town where there is no GSM coverage. This much more cost effective than building backhaul all the way back to the nearest point of presence. Where there is no GSM network nearby, backhaul to the nearest capital city has been assumed to deliver traffic to the rest of the network. In the case of Leyburn, GSM carkit access is available, but not handheld coverage. We have therefore assumed that the carkit coverage is provided from a tower in a town nearby. Leyburn is not far from Toowoomba where there is GSM, and we have assumed that backhaul will be built between Toowoomba and Leyburn, rather than all the way to Brisbane. In all other scenarios, backhaul has been assumed to the nearest capital city. This may be an over estimation of the backhaul cost, however without more detailed knowledge of GSM coverage it is difficult to make a better assumption.

The capital cost of deployment of GSM to a town is based on the following elements:

- *Base station cost* – The base station cost of GSM deployment represents a very high proportion of the totals costs of the network. Based on Ovum's experience internationally, the cost of building one base station is $40,200.
- *Equipment cost* – The equipment cost for one base station is based on experience of Ovum internationally. It is assumed to be $80,400.
- *Coverage required* – Based on performance of 900 GHz GSM technology used in Australia, the coverage which can be achieved by GSM base station equipment is 9 to 10 km radius from the base station. For each scenario, maps of the towns were used to estimate the distance from the centre of the town to the town's extremities. The maps show where the main town area is and whether there are significant outlying areas spreading from the town. Figure A.7 shows the town radius assumptions estimated on this basis.

Figure A.7 **Town radii**

Scenario	**Town Radius**	**Outlying area radius**	**Total**
Scenario 1 – Christmas Creek, WA	2	0	2
Scenario 2 – Leyburn, Queensland	2	5	7
Scenario 3 – Innamincka, SA	2	0	2
Scenario 4 - Tibooburra, New South Wales	2	0	2
Scenario 5 - Warburton, Victoria	5	5	10
Scenario 6 - Marla, South Australia	2	0	2
Scenario 7 - Marysville, Victoria	4	4	8
Scenario 8 -- Carnarvon, Western Australia	10	4	14
Scenario 9 - Wadeye, Northern Territory	10	4	14

Source: www.mulitmap.com.au

- *Number of base stations* - The number of base stations required depends on the coverage required and the number of customers served. For the number of customers involved in each of the scenarios of this analysis, coverage is a much greater consideration than customer numbers in determining how many base stations are required.

  We have assumed that the GSM deployment would involve a base station somewhere near to the centre of town. Based on the radii shown in Figure A.7, and assuming coverage from one base station up to 5 km.

The costs of operating a GSM network include:

- *Site leasing costs* – Ovum has assumed a site leasing cost of $12,000 per annum
- *Maintenance* – Maintenance charges for GSM were assumed to be 15% of capital costs. This is based on Ovum's experience.
- *Customer sales and marketing* – Customer sales and marketing costs per customer are assumed to be $150.
- *Backhaul leasing costs* – This is covered in an earlier section

A2.11 CDMA Assumptions

As in the case of GSM, DCITA has provided Ovum with those scenario towns where CDMA is already available. It has been assumed for simplicity that for those towns where CDMA is available, coverage is available in the whole town and therefore there will be no further deployment in those towns.

Based on Ovum's experience it has been assumed that the capital costs and operating costs of CDMA are about the same as those for GSM.

A2.12 WCDMA Assumptions

WCDMA infrastructure is not available in any of the towns included in this analysis. Typically, a W-CDMA is not deployed in a green field site. The approach of network operators internationally is to upgrade GSM sites with WCDMA equipment.

Telstra plans to deploy WCDMA operating in the 850MHz band. Deployment in this lower band allows for much greater range than deployments in other bands internationally. We have assumed that the range achieved by Telstra's WCDMA deployments will result in the same footprint as that achieved by the current CDMA network. This is the promise made by Telstra's vendor.

The capital costs of deploying WCDMA include:

- *Base station cost* – It has been assumed that for towns where CDMA and/or GSM are available the existing tower will be used for a WCDMA deployment. Where there is no GSM or CDMA available, the build cost of the tower has been included in the cost estimate at the same level as GSM.
- *Equipment cost* – Based on Ovum's experience, equipment cost was assumed to be 2.5 times more expensive than GSM. There are a number of reasons for this:
    - WCDMA access and core infrastructure support much more sophisticated modulation and coding techniques than the 2G ones.
    - Vendors have not really enjoyed economies of scale for WCDMA infrastructure. This is because the takeup of deployed infrastructure has been slower than expected.

The costs of operating a WCDMA network include:

- *Site leasing costs* – Ovum has assumed a site leasing cost of $12,000 per annum
- *Maintenance* – GSM maintenance costs have been assumed
- *Customer sales and marketing* – Customer sales and marketing costs per customer are assumed to be $150.
- *Backhaul leasing costs* – these has been covered in an earlier section.

A2.13 WiFi Assumptions

The number of WiFi base stations was calculated assuming that each base station can serve 15 customers. This is in line with Ovum's experience.

The capital costs of deploying WiFi include:

- *Base station and equipment cost* – It has been assumed that a WiFi station can be set up for $14110. It was assumed in each scenario that one WiFi base station can serve 15 customers. This is based on Ovum's experience.
- *CPE cost* – Based on experience from Ovum, WiFi CPE cost of 450 Euros was assumed.
- *CPE installation cost* – CPE installation in the small towns was assumed to involve 5 man days for an individual on an annual salary of $50,000. This figure was scaled up by the number of customers requiring installation.

The costs of operating a WiFi include:

- *Site leasing costs* – Ovum has assumed a site leasing cost of $12,000 per annum
- *Maintenance* – Maintenance charges for WiFi were assumed to be 10% of capital costs. This is based on Ovum's experience.
- *Customer sales and marketing* – Customer sales and marketing costs per customer are assumed to be $150.
- *Backhaul leasing costs* – these has been covered in an earlier section.

A2.14 WiMAX Assumptions

The capital costs of deploying WiMAX include:

- *Base station and equipment cost* – Cost of WiMAX equipment in the market varies very significantly. Additionally, there are a variety of sizes and types of base stations. Based on interviews held with equipment providers, Ovum's experience and information provided by DCITA, it has been assumed that for the very small towns in this study a 3 sector base station has been used, and in the case of the larger towns, a larger 6 sector base station has been assumed.
- *CPE cost – Equipment cost assumptions are* based on costs of the Unwired deployment of Navini technology in Sydney. Unwired provided a PC card and a modem to every customer. The PC card cost $320, and the modem cost $189.
- *CPE installation cost* – CPE installation in the small towns was assumed to involve 5 man days for an individual on an annual salary of $50,000. The number of days required for the larger towns was scaled up by number of customers requiring installation.

The costs of operating a WiMAX include:

- *Site leasing costs* – Ovum has assumed a site leasing cost of $12,000 per annum
- *Maintenance* – Maintenance charges for WiMAX were assumed to be 10% of capital costs. This is based on Ovum's experience.

- *Customer sales and marketing* – Customer sales and marketing costs per customer are assumed to be $150.
- *Backhaul leasing costs* – these has been covered in an earlier section.

A2.15 iBurst Assumptions

iBurst is a proprietary WiMAX solution, and therefore the elements of cost for iBurst are very similar to that of WiMAX. The major difference between the two is the base station and equipment costs. The WiMAX base station is a little cheaper to account for greater volume resulting from applications of the standards solution.

The capital costs of deploying iBurst include:

- *Base station and equipment cost* – Based on interviews held with iBurst in Sydney, Ovum's experience and information provided by DCITA, there are two types of base stations used in the model. For the very small towns, the minimum base station costing $140,000 was assumed, and for the larger towns the boomer base station was assumed costing $300,000.
- *CPE cost* – Equipment cost assumptions are based on figured provided by iBurst. The PC card cost $299, and the modem cost $199.
- *CPE installation cost* – CPE installation for the small towns was assumed to involve 5 man days for an individual on an annual salary of $50,000. This was scaled up for the larger towns by the number of customers requiring CPE installation.

The costs of operating a WiMAX include:

- *Site leasing costs* – Ovum has assumed a site leasing cost of $12,000 per annum
- *Maintenance* – Maintenance charges for iBurst were assumed to be 10% of capital costs. This is based on Ovum's experience.
- *Customer sales and marketing* – Customer sales and marketing costs per customer are assumed to be $150.
- *Backhaul leasing costs* – these has been covered in an earlier section.

A2.16 Flarion

A cost estimate for Flarion was not undertaken. Ovum did not interview Flarion as part of this project, and therefore does not have appropriately detailed cost to provide a calculation. Additionally, Flarion is another example of a proprietary WiMAX solution.

A2.17 Number of base stations

Figure A.8 shows the number of base stations which were assumed across all the scenarios and technologies apart from WCDMA in the costing analysis. WCDMA will be dealt with separately following Figure A.8. These assumptions were made based on the physical characteristics of each scenario, the reach of each technology and Ovum's experience of deployment of each technology in practice.

Figure A.8 **Number of base stations**

Scenario	**WiFi**	**WiMAX**		**iBurst**		**GSM**	**CDMA**
		Min.	Boomer	Min.	Boomer		
Christmas Creek	1	1		1		1	1
Leyburn	1	1		1		1	1
Innamincka	1	1		1		1	1
Tibooburra	1	1		1			
Warburton	10	3		3			
Marla	2	1		1			
Marysville	4	1		1			
Carnarvon	45		2		2		
Wadeye	15		3		1	2	1

Figure A.9 shows the WCDMA base stations and equipment required in each scenario.

Figure A.9 WCDMA base station and equipment assumptions

Scenario	**WCDMA base stations required**	**WCDMA equipment required**
Christmas Creek	1	1
Leyburn	1	1
Innamincka	1	1
Tibooburra		1
Warburton		1
Marla		1
Marysville		1
Carnarvon		1
Wadeye	1	1

A3 Cost calculations

Figure A3.1 **Scenario 1 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 1	**Town: Christmas Creek Aboriginal Community, Western Australia**									
Capital Costs										
Telstra access negotiation										
Installation costs			500,921	519,405						
DSLAM equipment costs										
Tower costs								40,200	40,200	40,200
Base station equipment					14,110	81,000	140,000	80,400	80,400	201,000
CPE Equipment					11,205	32,535	32,370			
CPE installation					1,042	1,042	1,042			
Total capital costs			**500,921**	**519,405**	**26,357**	**114,577**	**173,412**	**120,600**	**120,600**	**241,200**
Operational Costs										
Site leasing					12,000	12,000	12,000	12,000	12,000	12,000
ULL leasing										
Maintenance			50,092	51,941	2,636	11,458	17,341	18,090	18,090	18,090
Power costs										
Sales and marketing			2,250	2,250	2,250	2,250	2,250	12,600	9,450	12,600
Total operational costs			**52,342**	**54,191**	**16,886**	**25,708**	**31,591**	**42,690**	**39,540**	**42,690**
NPV of operating costs over 5 yrs			**241,024**	**249,535**	**77,755**	**118,378**	**145,470**	**196,578**	**182,073**	**196,578**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link										
Leasing cost - 8 Mbps link										
Satellite 2 Mbps link			249,000	249,000	249,000	249,000	249,000	249,000	249,000	249,000
NPV of leasing cost over 5 yrs			**1,146,589**	**1,146,589**	**1,146,589**	**1,146,589**	**1,146,589**	**1,146,589**	**1,146,589**	**1,146,589**
Backhaul Build Cost										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL			**1,888,534**	**1,915,529**	**1,250,701**	**1,379,544**	**1,465,471**	**1,463,767**	**1,449,262**	**1,584,367**
Total without backhaul costs			741,945	768,940	104,111	232,955	318,882	317,178	302,673	437,778

Note 1: Christmas Creek does not have an exchange or copper reticulation in the town. Therefore ADSL is not possible without laying copper
Note 2:GSM and CDMA are already available in Christmas Creek

Figure A3.2 **Scenario 2 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 2	**Town: Leyburn, Queensland**									
Capital Costs										
Telstra access negotiation	8,333	8,333								
Installation costs	1,042	1,042	551,013	571,346						
DSLAM equipment costs	6,700	6,700								
Tower costs					14,110	81,000	140,000	40,200	40,200	40,200
Base station equipment								80,400	80,400	201,000
CPE Equipment	1,200	1,200			11,205	32,535	32,370			
CPE installation					1,042	1,042	1,042			
Total capital costs	**17,275**	**17,275**	**551,013**	**571,346**	**26,357**	**114,577**	**173,412**	**120,600**	**120,600**	**241,200**
Operational Cost										
Site leasing	12,000	12,000			12,000	12,000	12,000	12,000	12,000	12,000
ULL leasing	5,400	5,400								
Maintenance	3,455	3,455	55,101	57,135	2,636	11,458	17,341	18,090	18,090	18,090
Power costs	1,350	1,350								
Sales and marketing	2,250	2,250	2,250	2,250	2,250	2,250	2,250	12,600	9,450	12,600
Total operational costs	**24,455**	**24,455**	**57,351**	**59,385**	**16,886**	**25,708**	**31,591**	**42,690**	**39,540**	**42,690**
NPV of operating costs over 5 yrs	**112,610**	**112,610**	**264,090**	**273,453**	**77,755**	**118,378**	**145,470**	**196,578**	**182,073**	**196,578**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link	44,198	44,198	44,198	44,198	44,198	44,198	44,198	15,581	15,581	15,581
Leasing cost - 8 Mbps link										
Satellite 2mb link										
NPV of leasing cost over 5 yrs	**203,524**	**203,524**	**203,524**	**203,524**	**203,524**	**203,524**	**203,524**	**71,748**	**71,748**	**71,748**
Backhaul Build Cost										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL	**333,408**	**333,408**	**1,018,627**	**1,048,322**	**307,635**	**436,478**	**522,405**	**388,926**	**374,421**	**509,526**
Total without backhaul costs	129,885	129,885	815,103	844,798	104,111	232,955	318,882	317,178	302,673	437,778

Note 1: CDMA is already available in Leyburn

Note 2: Carkit GSM services, but not handheld services are available in Leyburn

Figure A3.3 **Scenario 3 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 3	**Town: Innamincka, South Australia**									
Capital Costs										
Telstra access negotiation										
Installation costs			133,579	138,508						
DSLAM equipment costs										
Tower costs					14,110	81,000	140,000	40,200	40,200	40,200
Base station equipment								80,400	80,400	201,000
CPE Equipment					1,121	3,254	3,237			
CPE installation					208	208	208			
Total capital costs			**133,579**	**138,508**	**15,439**	**84,462**	**143,445**	**120,600**	**120,600**	**241,200**
Operational Cost										
Site leasing					12,000	12,000	12,000	12,000	12,000	12,000
ULL leasing										
Maintenance			13,358	13,851	1,544	8,446	14,345	18,090	18,090	18,090
Power costs										
Sales and marketing			225	225	225	225	225	1,260	945	1,260
Total operational costs			**13,583**	**14,076**	**13,769**	**20,671**	**26,570**	**31,350**	**31,035**	**31,350**
NPV of operating costs over 5 yrs			**62,546**	**64,816**	**63,403**	**95,186**	**122,347**	**144,360**	**142,909**	**144,360**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link			215,103	215,103	215,103	215,103	215,103	215,103	215,103	215,103
Leasing cost - 8 Mbps link										
Satellite 2mb link										
NPV of leasing cost over 5 yrs			**990,502**	**990,502**	**990,502**	**990,502**	**990,502**	**990,502**	**990,502**	**990,502**
Backhaul Build Cost										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL			**1,186,628**	**1,193,826**	**1,069,344**	**1,170,150**	**1,256,294**	**1,255,462**	**1,254,012**	**1,376,062**
Total without backhaul costs			196,125	203,324	78,841	179,648	265,792	264,960	263,509	385,560

Note 1: Innamincka does not have an exchange or copper reticulation in the town. Therefore ADSL is not possible without laying copper

Figure A3.4 **Scenario 4 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 4	**Town: Tibooburra, New South Wales**									
Capital Costs										
Telstra access negotiation	8,333	8,333								
Installation costs	1,042	1,042	500,921	519,405						
DSLAM equipment costs	6,700	6,700								
Tower costs					14,110	81,000	140,000			
Base station equipment								80,400		201,000
CPE Equipment	1,200	1,200			11,205	32,535	32,370			
CPE installation					1,042	1,042	1,042			
Total capital costs	**17,275**	**17,275**	**500,921**	**519,405**	**26,357**	**114,577**	**173,412**	**80,400**		**201,000**
Operational Cost										
Site leasing	12,000	12,000			12,000	12,000	12,000	12,000		12,000
ULL leasing	5,400	5,400								
Maintenance	3,455	3,455	50,092	51,941	2,636	11,458	17,341	12,060		12,060
Power costs	1,350	1,350								
Sales and marketing	2,250	2,250	2,250	2,250	2,250	2,250	2,250	12,600		12,600
Total operational costs	**24,455**	**24,455**	**52,342**	**54,191**	**16,886**	**25,708**	**31,591**	**36,660**		**36,660**
NPV of operating costs over 5 yrs	**112,610**	**112,610**	**241,024**	**249,535**	**77,755**	**118,378**	**145,470**	**168,811**		**168,811**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link	280,538	280,538	280,538	280,538		280,538	280,538	280,538		280,538
Leasing cost - 8 Mbps link										
Satellite 2mb link					249,000					
NPV of leasing cost over 5 yrs	**1,291,817**	**1,291,817**	**1,291,817**	**1,291,817**	**1,146,589**	**1,291,817**	**1,291,817**	**1,291,817**		**1,291,817**
Backhaul Build Costs										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL	**1,421,702**	**1,421,702**	**2,033,762**	**2,060,757**	**1,250,701**	**1,524,772**	**1,610,699**	**1,541,028**		**1,661,628**
Total without backhaul costs	129,885	129,885	741,945	768,940	104,111	232,955	318,882	249,211		369,811

Note 1: CDMA is available in Tibooburra

Figure A3.5 **Scenario 5 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 5	**Town: Warburton, Victoria**									
Capital Costs										
Telstra access negotiation										
Installation costs		1,042	6,678,950	6,925,400						
DSLAM equipment costs		53,120								
Tower costs					141,100	243,000	420,000			
Base station equipment										201,000
CPE Equipment		16,000			149,400	433,800	431,600			
CPE installation					4,167	4,167	4,167			
Total capital costs		**70,162**	**6,678,950**	**6,925,400**	**294,667**	**680,967**	**855,767**			**201,000**
Operational Cost										
Site leasing		12,000			12,000	12,000	12,000			12,000
ULL leasing		72,000								
Maintenance		14,032	667,895	692,540	29,467	68,097	85,577			12,060
Power costs		1,350								
Sales and marketing		30,000	30,000	30,000	30,000	30,000	30,000			168,000
Total operational costs		**129,382**	**697,895**	**722,540**	**71,467**	**110,097**	**127,577**			**192,060**
NPV of operating costs over 5 yrs		**595,777**	**3,213,650**	**3,327,135**	**329,088**	**506,971**	**587,462**			**884,393**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link										
Leasing cost - 8 Mbps link		65,061	65,061	65,061	65,061	65,061	65,061			65,061
Satellite 2mb link										
NPV of leasing cost over 5 yrs		**299,592**	**299,592**	**299,592**	**299,592**	**299,592**	**299,592**			**299,592**
Backhaul Build Costs										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL		**965,531**	**10,192,193**	**10,552,127**	**923,347**	**1,487,529**	**1,742,821**			**1,384,986**
Total without backhaul costs		665,938	9,892,600	10,252,535	623,755	1,187,937	1,443,229			1,085,393

Note 1: ADSL is already available in Warburton

Note 2: GSM and CDMA are available in Warburton

Figure A3.6 **Scenario 6 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 6	**Town: Marla, South Australia**									
Capital Costs										
Telstra access negotiation	8,333	8,333								
Installation costs	1,042	1,042	730,343	757,292						
DSLAM equipment costs	6,700	6,700								
Tower costs					28,220	81,000	140,000			
Base station equipment								80,400		201,000
CPE Equipment	1,944	1,944			18,152	52,707	52,439			
CPE installation					1,042	1,042	1,042			
Total capital costs	**18,019**	**18,019**	**730,343**	**757,292**	**47,414**	**134,748**	**193,481**	**80,400**		**201,000**
Operational Cost										
Site leasing	12,000	12,000			12,000	12,000	12,000	12,000		12,000
ULL leasing	8,748	8,748								
Maintenance	3,604	3,604	73,034	75,729	4,741	13,475	19,348	12,060		12,060
Power costs	1,350	1,350								
Sales and marketing	3,645	3,645	3,645	3,645	3,645	3,645	3,645	20,412		20,412
Total operational costs	**29,347**	**29,347**	**76,679**	**79,374**	**20,386**	**29,120**	**34,993**	**44,472**		**44,472**
NPV of operating costs over 5 yrs	**135,135**	**135,135**	**353,091**	**365,501**	**93,875**	**134,090**	**161,135**	**204,784**		**204,784**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link	255,636	255,636	255,636	255,636		255,636	255,636	255,636		255,636
Leasing cost - 8 Mbps link										
Satellite 2mb link					249,000					
NPV of leasing cost over 5 yrs	**1,177,145**	**1,177,145**	**1,177,145**	**1,177,145**	**1,146,589**	**1,177,145**	**1,177,145**	**1,177,145**		**1,177,145**
Backhaul Build Costs										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL	**1,330,300**	**1,330,300**	**2,260,579**	**2,299,938**	**1,287,878**	**1,445,984**	**1,531,762**	**1,462,329**		**1,582,929**
Total without backhaul costs	153,154	153,154	1,083,434	1,122,793	141,288	268,839	354,616	285,184		405,784

Note 1: CDMA is available in Marla

Figure A3.7 **Scenario 7 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 7	**Town: Marysville, Victoria**									
Capital Costs										
Telstra access negotiation										
Installation costs		1,042	1,447,106	1,500,503						
DSLAM equipment costs		17,264								
Tower costs					56,440	81,000	140,000			
Base station equipment										201,000
CPE Equipment		5,200			48,555	140,985	140,985			
CPE installation					2,083	2,083	2,083			
Total capital costs		**23,506**	**1,447,106**	**1,500,503**	**107,078**	**224,068**	**283,068**			**201,000**
Operational Cost										
Site leasing		12,000			12,000	12,000	12,000			12,000
ULL leasing		23,400								
Maintenance		4,701	144,711	150,050	10,708	22,407	28,235			12,060
Power costs		1,350								
Sales and marketing		9,750	9,750	9,750	9,750	9,750	9,750			54,600
Total operational costs		**51,201**	**154,461**	**159,800**	**32,458**	**44,157**	**49,985**			**78,660**
NPV of operating costs over 5 yrs		**235,770**	**711,256**	**735,845**	**149,461**	**203,332**	**230,171**			**362,212**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link										
Leasing cost - 8 Mbps link		85,099	85,099	85,099	85,099	85,099	85,099			85,099
Satellite 2mb link										
NPV of leasing cost over 5 yrs		**391,861**	**391,861**	**391,861**	**1,146,589**	**391,861**	**391,861**			**391,861**
Backhaul Build Costs										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL		**651,136**	**2,550,223**	**2,628,209**	**1,403,129**	**819,262**	**905,101**			**955,073**
Total without backhaul costs		259,275	2,158,362	2,236,348	256,539	427,401	513,240			563,212

Note 1: ADSL is already available in Marysville

Note 2: GSM and CDMA are already available in Marysville

FIGURE A3.8 SCENARIO 8 COST ANALYSIS

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 8	**Town: Carnarvon, Western Australia**									
Capital Costs										
Telstra access negotiation										
Installation costs		1,042	15,584,217	16,159,267						
DSLAM equipment costs		185,920								
Tower costs					634,950	500,000	600,000			
Base station equipment										201,000
CPE Equipment		56,000			522,900	1,518,300	1,510,600			
CPE installation					10,417	10,417	10,417			
Total capital costs		**242,962**	**15,584,217**	**16,159,267**	**1,168,267**	**2,028,717**	**2,121,017**			**201,000**
Operational Cost										
Site leasing		12,000			12,000	12,000	12,000			12,000
ULL leasing		126,000								
Maintenance		24,296	1,558,422	1,615,927	116,827	202,872	212,102			12,060
Power costs		1,350								
Sales and marketing		52,500	105,000	105,000	105,000	105,000	105,000			588,000
Total operational costs		**216,146**	**1,663,422**	**1,720,927**	**233,827**	**319,872**	**329,102**			**612,060**
NPV of operating costs over 5 yrs		**995,305**	**7,659,685**	**7,924,482**	**1,076,719**	**1,472,937**	**1,515,440**			**2,818,399**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link										
Leasing cost - 8 Mbps link		764,406	764,406	764,406	764,406	764,406	764,406			764,406
Satellite 2mb link										
NPV of leasing cost over 5 yrs		**3,519,918**	**3,519,918**	**3,519,918**	**19,109,821**	**3,519,918**	**3,519,918**			**3,519,918**
Backhaul Build Costs										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL		**4,758,184**	**26,763,819**	**27,603,667**	**21,354,807**	**7,021,572**	**7,156,374**			**6,539,317**
Total without backhaul costs		1,238,266	23,243,901	24,083,749	2,244,986	3,501,654	3,636,456			3,019,399

Note 1: ADSL is already available in Carnarvon

Note 2: GSM and CDMA are already available in Carnarvon

Figure A3.9 **Scenario 9 cost analysis**

	ADSL	ADSL2+	FTTH	HFC	WiFi	WiMAX	iBurst	GSM	CDMA	WCDMA
Scenario 9	**Town: Wadeye, Northern Territory**									
Capital Costs										
Telstra access negotiation										
Installation costs			4,931,291	5,113,254						
DSLAM equipment costs										
Tower costs					211,650	250,000	300,000	80,400	40,200	40,200
Base station equipment								160,800	80,400	201,000
CPE Equipment					165,461	480,434	477,997			
CPE installation					4,167	4,167	4,167			
Total capital costs			**4,931,291**	**5,113,254**	**381,277**	**734,600**	**782,164**	**241,200**	**120,600**	**241,200**
Operational Costs										
Site leasing					12,000	12,000	12,000	12,000	12,000	12,000
ULL leasing										
Maintenance			493,129	511,325	38,128	73,460	78,216	36,180	18,090	18,090
Power costs										
Sales and marketing			33,225	33,225	33,225	33,225	33,225	186,060	139,545	186,060
Total operational costs			**526,354**	**544,550**	**83,353**	**118,685**	**123,441**	**234,240**	**169,635**	**216,150**
NPV of operating costs over 5 yrs			**2,423,743**	**2,507,533**	**383,821**	**546,518**	**568,420**	**1,078,623**	**781,131**	**995,322**
Backhaul Leasing Cost										
Leasing cost - 2 Mbps link										
Leasing cost - 8 Mbps link										
Satellite 8mb link			996,000	996,000	996,000	996,000	996,000	996,000	996,000	996,000
NPV of leasing cost over 5 yrs			**4,586,357**	**4,586,357**	**4,586,357**	**4,586,357**	**4,586,357**	**4,586,357**	4,586,357	4,586,357
Backhaul Build Costs										
radio point to point										
fibre link										
NPV of operating cost of backhaul build over 5 yrs										
TOTAL			**11,941,392**	**12,207,143**	**5,351,455**	**5,867,475**	**5,936,941**	**5,906,180**	**5,488,088**	**5,822,879**
Total without backhaul costs			7,355,034	7,620,786	765,098	1,281,118	1,350,584	1,319,823	901,731	1,236,522

Note 1: Wadeye does not have an exchange or copper reticulation in the town. Therefore ADSL is not possible without laying copper

A4 IEEE Standards for WiFi

A4.1 Standards ratified to date

- **802.11a**. Ratified in July 1999, this standard operates in the 5GHz frequency band, and can deliver speeds of up to 54 Mbps at a range of 10 metres. This standard requires more complex installation and due to its shorter range has seen relatively little interest from vendors and service providers
- **802.11b**. This standard was also ratified in July 1999, operates in the 2.4GHz band and offers data speeds of up to 11 Mbps in a 50 metre range
- **802.11g.** Ratified in June 2003, 802.11g, also operates in the 2.4GHz band but due to its orthogonal frequency division multiplexing (OFDM) modulation it can offer speeds of up to 54 Mbps, albeit at a shorter range of 25 metres. This standard is compatible with 802.11b
- **802.11i** was ratified in June 2004 with the aim of resolving WLAN security weaknesses for both authentication and encryption protocols and includes 802.1x temporal key integrity protocol (TKIP) and advanced encryption standard (AES).

A4.2 Standards under development

There are several other 802.11x standards that are currently under development within the IEEE:

- **802.11e**, which is addressing quality of service (QoS) mechanisms to 802.11 in order to support real time applications such as voice and video. The standard was ratified in 2005
- **802.11n,** which is aimed to provide over 100 Mbps throughput speeds, and is expected to be ratified in 2006
- **802.11r,** which is addressing seamless roaming between WiFi access points
- **802.11s**, which is developing mechanisms for standardised self-healing/self-configuring mesh networks.

A5 Glossary

Word/Acronym	Meaning
3GPP	3rd Generation Partnership Project. A collaboration agreement bringing together a number of telecommunications standards bodies including ETSI. The scope of this agreement includes producing globally applicable Technical Specifications and Technical Reports for a 3rd Generation Mobile System as well as the maintenance and development of GSM Technical Specifications and Technical Reports including GPRS and EDGE.
ANSI	American National Standards Institute
ATM	Asynchronous Transfer Mode
BFWA	Broadband Fixed Wireless Access
BPL	Broadband over Powerline
BSC	Base Station Controllers
BSS	Base Station Subsystem
BTS	Base Transceiver Stations
CDMA	Code Division Multiple Access
CPE	Customer Premise Equipment
CSD	Circuit Switched Data
DLC	Digital Loop Carrier
DOCSIS	Data over Cable Service Interface Specification
DSL	Digital Subscriber Line
DVB-RCS	Digital Video Broadcast – Return Channel Satellite
EDGE	Enhanced Data rates for GSM Evolution
ETSI	European Telecommunications Standards Institute
Eurescom	European Institute for Research and Strategic Studies in Telecommunications
EV-DO	Evolution-Data Only
FDD	Frequency Division Duplex

Word/Acronym	Meaning
FFT	Fast Fourier Transform
FHSS	Frequency Hopping Spread System
Flash-OFDM	Fast Low Latency Access with Seamless Handoff – Orthogonal Frequency Division Multiplexing
FTTC	Fibre to the Cabinet
FTTH	Fibre To The Home
FTTK	Fibre To The Kerb
FTTN	Fibre To The Node
FTTP/B	Fibre To The Premises/Building
FTTx	Fibre To Anything (includes all the above variants)
GGSN	Gateway GPRS Support Node
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HDTV	High Definition Television
HLR	Home Location Register
HCRC	High Capacity Radio Concentrator
HC-SDMA	High Capacity Spatial Division Multiple Access
HSCSD	High Speed Circuit Switched Data
HSDPA	High Speed Downlink Packet Access
HS-DSCH	High Speed Downlink Share Channel
HSUPA	High Speed Uplink Packet Access
IEEE	Institute of Electrical and Electronics Engineers
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LOS	Line of sight
LDPC	Low Density Parity Check
MAN	Metropolitan Area Network

Word/Acronym	Meaning
MSC	Mobile Switching Centre
MPEG	Moving Picture Experts Group
NLOS	Non line of sight
OEM	Original Equipment Manufacturer
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
PHY	Physical
PLC	Powerline Communications
PSK	Phase Shift Keying
RNC	Radio Network Controller
Scalable	In terms of this report, scalable means the ability to increase the capacity per user rather than increasing the capacity to serve an increased number of users. This is defined as a continuum rather than a binary concept. That is, a technology is not either scalable or not scalable. Rather, the technologies differ in terms of scalability. Highly scalable technologies do not have to replicate much of the network in order to increase the capacity per user. Less scalable technologies do have to replicate much of the network in order to increase capacity.
SDSL	Symmetrical Digital Subscriber Line
SGSN	Serving GPRS Support Node
SHDSL	Symmetrical High-speed Digital Subscriber Line
Smart antenna	This means that signals are directed to intended target rather than broadcast throughout the cell area.
SME	Small to Medium Enterprise
SMS	Short Message Service
SoHo	Small Office Home Office
TDD	Time Division Duplex

Word/Acronym	Meaning
TD-CDMA	Time Division – Code Division Multiple Access (aka UMTS TDD)
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division – Synchronous Code Division Multiple Access
UMTS	Universal Mobile Telecommunication System
UMTS FDD	Universal Mobile Telecommunication System Frequency Division Duplex
UMTS TDD	Universal Mobile Telecommunication System Time Division Duplex
UTRAN	UMTS Terrestrial Radio Access Network
VDSL	Very high bit-rate Digital Subscriber Line
VLR	Visitor Location Register
VoIP	Voice Over Internet Protocol
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access

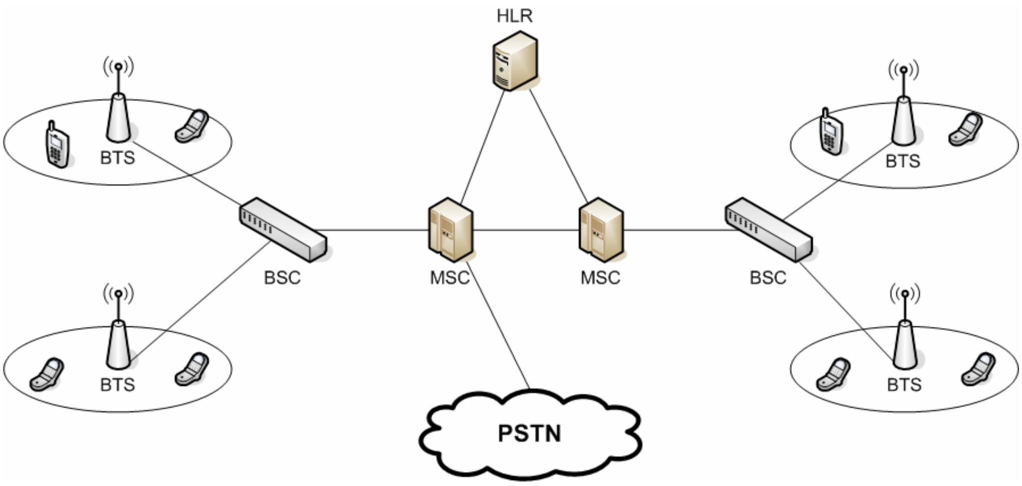
A6 Mobile networks structure

A6.1 GSM

GSM is a 2G cellular technology that is used in several frequency bands: 450 MHz, 900 MHz, 1800 MHz and 1900 MHz. The separation between adjacent carrier frequencies is 200 kHz while the distance between the uplink and downlink frequencies is 80 MHz.

Based on Time Division Multiple Access (TDMA) technique, GSM is a circuit-switched system that divides each 200 kHz channel into eight 25kHz time-slots. The GSM standard describes the relations between all the equipment needed to set up a GSM network. The key elements are represented in the Figure A6.1.

Figure A6.1 **Architecture of a GSM cellular network**



Source: Ovum

The Base Transceiver Stations (BTS) and Base Station Controllers (BSC) compose the Base Station Subsystem (BSS). The BTS supplies the mobile service within a cell and a BSC manages several BTS. The BSC provides all the control functions and physical links between the MSC and BTS.

The Mobile Switching Centre (MSC) is responsible of switching functions in the mobile network and performs the call control function to and from other networks. A MSC manages several BSCs.

The Home Location Register (HLR) is a database used for storage and management of subscriptions.

Visitor Location Register (VLR), a database that contains temporary information about subscribers that is needed by the MSC in order to provide services for visiting subscribers. The VLR is always integrated with the MSC.

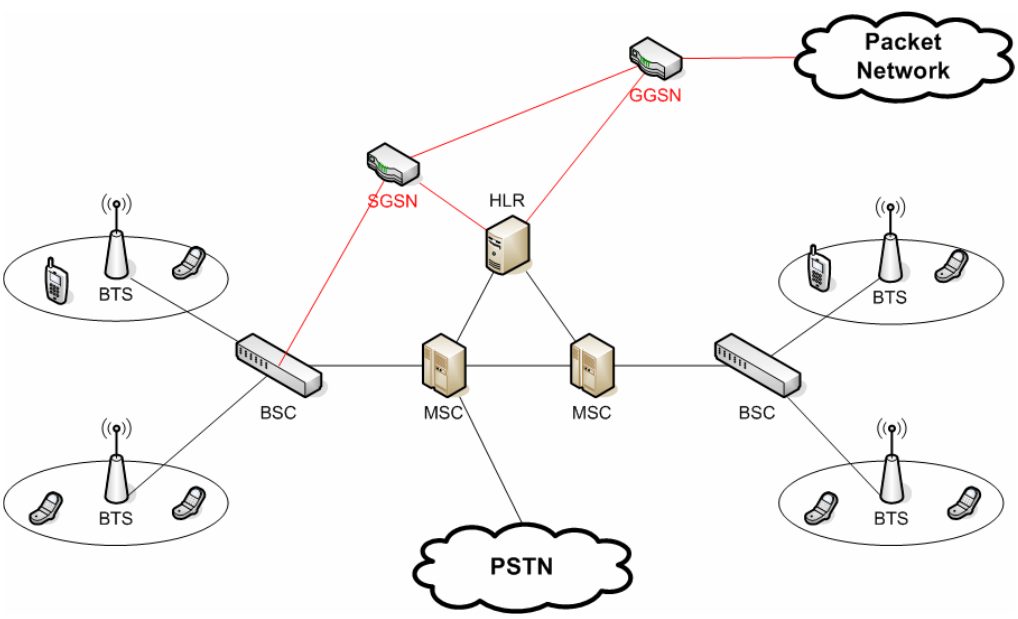
A6.2 GPRS and EDGE

The rollout of a GPRS overlay network increases the bandwidth of the core network to allow high-speed data transfer with an "always-on" connection. This requires the addition of key core IP network equipment that constitute the GPRS core network:

- The Gateway GPRS Support Node(GGSN) is a router connecting the mobile core network with external packet networks, such as IP networks.
- The Serving GPRS Support Node (SGSN) is a router connected to one or several BSC. It is responsible for the packet delivery to users located in the cells managed by the BSC connected to it.

HLRs also need to be upgraded with the addition of new interfaces connecting it to both GGSN and SGSN. The HLR will be able to accommodate new user profiles with a software upgrade. Figure A6.2 shows the GPRS network architecture.

Figure A6.2 **GSM/GPRS network architecture**



Source: Ovum

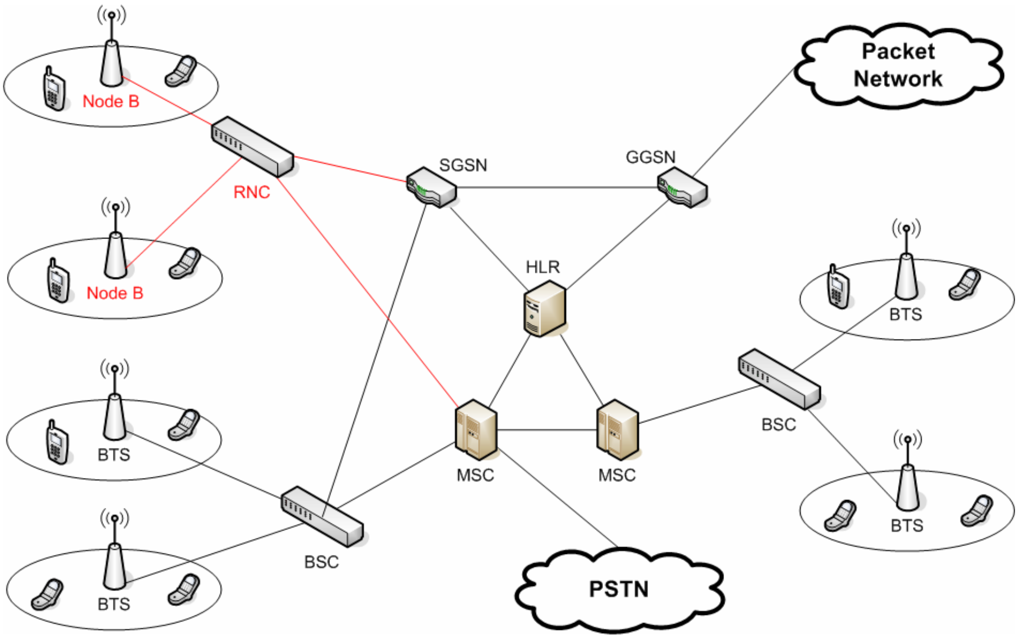
*** IN RED, THE NEW ELEMENTS NEEDED FOR GPRS**

EDGE higher speeds are enabled by the introduction of new modulation technique based on 8- Phase Shift Keying (PSK) both for uplink and downlink while GSM uses Gaussian Minimum-Shift Keying (GMSK). As a consequence, base stations need to be upgraded and be equipped with a compatible transceiver unit. The rollout of EDGE generally requires a software only upgrade of the radio access network as most of base stations sold for the past several years are EDGE-ready.

A6.3 UMTS network structure

An UMTS base station, called Node B, is connected to a RNC, which manages the link to the core network being connected to MSC (circuit) and SGSN (packet). One RNC controls multiple Node Bs. Compared to BSCs in GSM/GPRS networks, RNC are more “intelligent”, being able to manage handover involving MSCs and SGSNs for instance. UMTS network architecture is shown in Figure A6.3

Figure A6.3 UMTS Rel99 network architecture



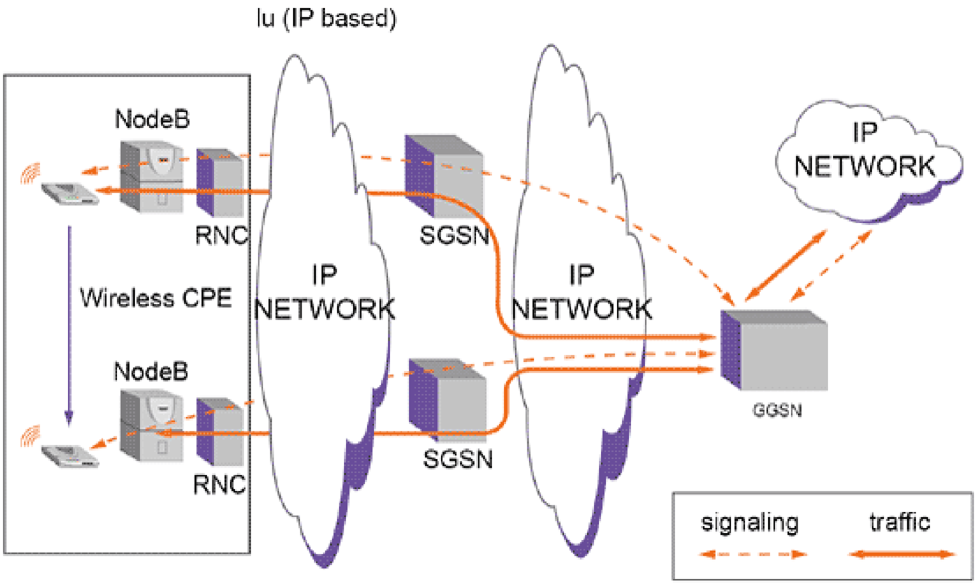
Source: Ovum, from 3GPP

*** IN RED, THE NEW ELEMENTS NEEDED FOR UMTS**

A6.4 UMTS TDD

Figure A6.4 shows UMTS TDD network architecture.

Figure A6.4 **UMTS TDD Network Architecture**



Source: UTStarcom

Operators acquiring a UMTS license are generally granted both TDD and FDD spectrum. If, up to now, mobile operators have deployed UMTS FDD, they can easily deploy a TDD network as an overlay to their existing network. The radio network part of a UMTS TDD network inter-works with both all IP core infrastructures and legacy mobile core networks (GSM/GPRS).