The Parliament of the Commonwealth of Australia

CONNECTING AUSTRALIA!
WIRELESS BROADBAND

HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON COMMUNICATIONS, INFORMATION TECHNOLOGY AND THE ARTS

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Foreword

Wireless broadband has an important role to play in extending the reach of broadband services to all Australians. There is no one particular wireless broadband technology that can solve all telecommunications problems. The future will see a mix of various technologies and the market should be permitted to determine, over time, which ones best suit particular applications. The government should maintain a general regulatory policy of 'technology-neutrality' (not favouring any particular technology, whether it be wireless or wire-line). Specific measures should be put in place to extend the understanding and takeup of wireless broadband.

The recommendations contained in this report reflect the broad observations and statements of principle set out above. If they are adopted by the government, they would greatly facilitate the expansion of wireless broadband services in metropolitan, regional and rural areas. The Committee also has made recommendations to assist the hearing-impaired gain access to wireless broadband services, to improve the regulatory framework and to preserve the power of police and intelligence services to protect the community against illegal activities.

Many people contributed to this inquiry and, in particular, the Committee benefited from the 60 submissions and many witnesses who addressed us at our eight public hearings. Also, the Committee acknowledges the invaluable assistance of Professor Harris and Dr Borg (of the Plasma Research Laboratory of the ANU) who were contracted to produce a draft report.

Chris Pyne MP
Chair
23 October 2002

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Membership of the Committee

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Terms of Reference

To inquire and report on the current and potential use of wireless technologies to provide broadband communication services in Australia, including regional Australia, having particular regard to the following:

- The current rollout of wireless broadband technologies in Australia and overseas including wireless LAN (using the 802.11 standard), 3G (eg UMTS, W-CDMA), Bluetooth, LMDS, MMDS, wireless local loop (WLL) and satellite;

- The inter-relationship between the various types of wireless broadband technologies;

- The benefits and limitations on the use of wireless broadband technologies compared with cable and copper based broadband delivery platforms;

- The potential for wireless broadband technologies to provide a 'last mile' broadband solution, particularly in rural and regional areas, and to encourage the development and use of broadband content applications;

- The effect of the telecommunications regulatory regime, including spectrum regulation, on the development and use of wireless broadband technologies, in particular the *Radiocommunications Act (1992)* the *Telecommunications Act (1997)*, and Parts XIB and XIC of the *Trade Practices Act*:

- Whether Government should make any changes to the telecommunications regulatory regime to ensure that Australia extracts the maximum economic and social benefits from the use of wireless broadband technologies; and

- Likely future national and international trends in the development and use of wireless broadband technologies.

Executive summary

The terminology of wireless broadband is complex and there are many technologies, each of which is being continuously refined. Each has been developed for a specific role according to the type of data transmitted, the data rate required, the need for mobility, the need for long distance transmission to remote sites, or operation on dedicated or class-licensed spectrum.

No wireless broadband technology is able to handle the data rates of the best wire-line technologies but there are many situations where the latter cannot yet be used or is simply unavailable (such as in remote and regional areas, and even in some suburban metropolitan areas). Also, there are situations where wireless technologies are cheaper and / or more flexible than wire-line solutions. Nowhere is this flexibility more apparent than in mobile applications.

Given the fundamental fact that different wireless technologies serve different purposes and that they are constantly evolving, the government should take a technology-neutral approach to both wireless and wire-line services.

The Committee concludes that the solution to the 'last mile' service involves a mixture of technologies, both wire-line and wireless. Clearly, however, for regional and remote Australia where wire-line solutions are not economically viable in the short to medium term, the last mile problem could be addressed by a variety of wireless techniques. Nortel's CDMA2000 and Lucent's 450 MHz, CDMA were cited as existing technologies. These could be deemed to be underway but spectrum availability for 400-500 MHz is a problem. The possibility of allocating spectrum in that band should be examined for rural wireless links (recommendation 1).

A possible way of bringing broadband services to remote areas involves the use of analogue TV bands (especially the band I channels 0, 1 and 2) which will not be employed in the future for digital TV services in Australia. These TV bands are able to provide long distance services without the need for expensive infrastructure. They are to be abandoned at the completion of the analogue-digital simulcasts, which will occur in 2008 in urban Australia and somewhat later in regional Australia. However, in many places, these channels are not being used at all and so are already available for tests. Several groups are working on developing technologies for these low frequency bands. The ACA and ABA should develop a scheme to allow the trial use of unallocated TV channels for rural wireless broadband links with a view to such spectrum being made available if the trials are successful (also

recommendation 1). This has the potential to provide a uniquely Australian solution to the worldwide problem of long distance last mile Internet provision.

Inexpensive wireless technologies such as 802.11 and the above longer wavelength technologies could be used to “pull” broadband 3G wireless and wire-line infrastructure to customers by creating the business case for broadband. In this way, a cheap wireless rollout could later be followed by a wire-line rollout providing additional or better services.

For both urban and regional Australia, the most exciting technology for wireless broadband is 802.11. The elimination of a carrier licence on the ISM bands for both commercial and non-commercial operation would be a simple regulatory change which would unleash its potential (recommendation 2). For those areas of Australia where DSL or other broadband wire-line connections are not yet in place, the power limits for equipment using the ISM bands should be increased in order to encourage the wider availability of broadband services (recommendation 10). In view of the interest that these changes may evoke in the community, the Committee recommends that the ACA provide educational services to interested parties (carriers or non-carriers) (recommendation 3). Training programs for prospective wireless operators, in relation to the wireless market and customer requirements, should also be available (recommendation 4).

In the event that the above measures lead to a nation-wide takeup of 802.11, they may result in co-channel interference and hence the need for a conflict resolution service of some kind to be offered by the ACA (recommendation 6).

Should an organisation using 802.11 establish a business case in a certain area, then a profitable company operating on the ISM band could be given the opportunity to move to licensed spectrum. This may, for example, be a mechanism to prove a 3G-business model. Procedures should be developed by the ACA and ABA to facilitate the migration of wireless activities from ISM bands to adjacent licensed spectrum by streamlining equipment qualification procedures (recommendation 7).

Greater use of the ISM bands increases the possibility that someone might attempt to use them for illegal activities. The Committee considers that the ISM bands should be treated in the same manner as all other telecommunications with respect to the capability for police interception (recommendation 14).

In order to facilitate the provision of Internet services by small wireless service providers, the Committee recommends that the ACA and ACCC develop a mechanism to enable such providers to negotiate wholesale

prices for Internet backbone connections (recommendation 9). This is particularly important for the delivery of broadband services in areas where DSL / wire-line broadband connections do not yet exist. Impediments to the interoperation of wireless ISPs and their access to the Internet backbone should be removed (recommendation 5).

The Committee noted concern about the nature of spectrum licensing procedures. Some witnesses were worried that the cost of spectrum licences is excluding small players, and that services are not being provided to non-profitable regions that are under a spectrum licence covering a more profitable urbanised area. Some spectrum allocations have not been utilised owing to the fact that the profitability of the business operation on that spectrum does not justify the price of the spectrum licence in the first place. The ACA and the ABA should establish a spectrum bureau to examine these issues, including considering regionally adjusted spectrum auction reserve prices and financing terms (recommendation 11).

There was concern expressed about the tenure of spectrum licences. The Committee recommends that the ACA consider improving the system of licence renewal (recommendation 8).

Given the trend toward closer convergence of broadcasting, telecommunications and information technology issues, the government should consider replacing the existing regulatory bodies by just one central regulator (recommendation 13).

The benefits of new wireless broadband technology should flow to all the community. In order that the hearing-impaired are not excluded, the government may need to provide some specific encouragement to the industry to take their needs into account (recommendation 12).

List of recommendations

(The page number on which the recommendation appears is indicated.)

The Committee recommends:

— in relation to improving the general take-up of wireless broadband:

1. that the ACA and ABA develop a scheme to allow the use of unallocated VHF and low UHF TV channels for rural wireless broadband links, and that they examine the possibility of allocating spectrum in the 400-500 MHz range for CDMA-450 on, at least, an experimental basis. p. 52

2. that the requirement for carrier licences on the ISM bands be eliminated for both commercial and non-commercial operation. This will allow Australian broadband customers easier access to WLAN as a broadband alternative, and also enable Australian wireless engineers to compete with overseas entities in this burgeoning field. ISM band power limits should remain unchanged unless an exemption applies in non-metropolitan areas (see the Committee's later recommendation in this regard). p. 62

3. that the ACA provide education programs for prospective wireless operators. These programs should explain the technologies, the law and ACA services. p. 63

4. that the Minister for Communications, Information Technology and the Arts ensure training programs are in place to increase the knowledge of prospective wireless operators about the wireless market and customer requirements. p. 63

5. that the government determine whether there are legislative, regulatory and business impediments to the interoperation of wireless ISPs and their access to the Internet backbone and, if so, eliminate them. p. 67

6. that the Minister for Communications, Information Technology and the Arts ask the ACA to investigate the establishment of a conflict resolution service for users of the ISM bands. p. 71

7. that the ACA and ABA develop procedures that facilitate the migration of wireless activities from ISM bands to adjacent licensed spectrum by streamlining equipment qualification procedures. p. 77

8. that the ACA develop a system for licence renewal that evaluates the use of spectrum, utilising clear criteria established and communicated to spectrum holders well in advance of renewal dates. This could be implemented using fixed-term renewable spectrum allocations. p. 77

— in relation to improving the takeup of wireless broadband in regional areas:

9. that the ACA and the ACCC develop a mechanism whereby small wireless Internet service providers can negotiate wholesale prices for Internet backbone connections, possibly introducing appropriate conditions in the carrier Universal Service Obligation. For a service provider to be eligible under this scheme, they must demonstrate that they are serving an eligible customer base. Eligibility would be automatic where DSL / wire-line connectivity was not currently available (such as in some regions of Australia) or simply where broadband wireless takeup had not yet occurred. p. 68

10. that the Minister ask the ACA to examine the implications of raising the power limits on the ISM band to the equipment's rated values for service providers in those areas of Australia where DSL or other broadband wire-line connections are not yet in place. p. 72

11. that the ACA and ABA form a spectrum bureau to:
(1) monitor the effects of spectrum auction on local wireless use;
(2) facilitate the trading and cross-leasing of spectrum and the migration of ISM wireless activities to licensed spectrum, and
(3) recommend regionally adjusted spectrum auction reserve prices and financing terms. p. 76

— in relation to wireless broadband services for the hearing impaired:

12. that the Commonwealth develop the means to provide hearing-impaired people with mobile telephones compatible with hearing aids, portable wireless devices that can communicate through the National Relay Service, and appropriately adapted video compression and transmission technology for video communication using sign language. p. 47

— **in relation to general regulatory issues:**

13. that the Commonwealth establish an inquiry into the possible amalgamation of the ACA and the ABA. This would allow for more streamlined regulation of the dynamic and converging technologies of broadband telecommunications and broadcast transmission. p. 82

— **in relation to security issues:**

14. that the ABA, ACA and law enforcement agencies establish a standing bureau (or working party) to maintain a watching brief on the potential for Wi-Fi and other ISM networks to be used for illegal activities. p. 64

List of Abbreviations

AAD	Australian Association of the Deaf
ABA	Australian Broadcasting Authority
ABS	Australian Bureau of Statistics
ACA	Australian Communications Authority
ACCC	Australian Competition and Consumer Commission
ACE	Australian Communication Exchange
ACIF	Australian Communications Industry Forum
ADSL	asymmetric digital subscriber line
AICTEC	Australian Information and Communications Technology in Education Committee
AMPS	advanced mobile phone system
ATM	asynchronous transfer mode
ATUG	Australian Telecommunications Users Group
AUSLAN	Australian Sign Language
BDT	broadcast data transmissions
BFWA	broadband fixed wireless access
bps	bits per second
BS Act	*Broadcasting Services Act 1992*
CAN	customer access network
CDMA	code division multiple access
CPE	customer premise equipment
CRC	cooperative research centre
CSDMG	Commonwealth Spatial Data Management Group
CSG	customer service guarantee
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTs	central terminals
DCITA	(Commonwealth) Department of Communications, Information Technology and the Arts
DDA	*Disability Discrimination Act 1992*
DDSO	digital data service obligation

DECT	digitally enhanced cordless telecommunications
DMB	(satellite) digital multimedia broadcast system
DSL	digital subscriber line
DSTO	(Commonwealth) Defence Science and Technology Organisation
EDGE	enhanced data for GSM evolution
EZ	(telecommunications) extended zones
FCC	Federal Communications Commission (of the United States)
FDMA	frequency division multiple access
FWA	fixed wireless access
Gbps	gigabits per second
GEO	geostationary earth orbit (satellite)
GHz	gigahertz
GPRS	general packet radio service
GPS	global positioning system
GSM	global system for mobile
HAPS	high altitude platform stations
HDSL	high bit-rate digital subscriber line
HEDC	Hunter Economic Development Corporation
HF	high frequency (band)
HFC	hybrid fibre coaxial (cable)
Hz	hertz
IAP	Internet access provider
ICT	information and communication technology
IEEE	Institute of Electrical and Electronic Engineers
IP	Internet protocol
ISDN	integrated services digital network
ISM	industrial, scientific and medical (applications, or frequency band)
ISP	Internet service provider
ITU	International Telecommunications Union
kbps	kilobits per second
KHz	kilohertz

km	kilometre
LAN	local area network
LAS	local area switch (telephone exchange)
LEO	low earth orbit (satellite)
LMDS	local multipoint distribution system
LOS	line of sight
MB	megabyte
Mbps	megabits per second
MDS	multipoint distribution system
MEO	medium earth orbit (satellite)
MHz	megahertz
MMDS	multichannel multipoint distribution system
MPEG	motion picture expert group (video compression standards)
MSS	mobile satellite systems
NAP	neighbourhood access point
NCF	National Communications Fund
NFF	National Farmers' Federation
NOIE	National Office for the Information Economy
NRS	National Relay Service
NTN	Networking the Nation (programs)
OECD	Organisation for Economic Co-operation and Development
OFTEL	Office of Telecommunications (regulator for the telecommunication industry in the UK)
OSDM	(Commonwealth) Office of Spatial Data Management
PC	personal computer
PCS	personal communications services
PDA	personal digital assistant
PGS	pair gain systems
PMP	point to multipoint
PMTS	public mobile telecommunications service
POP	point of presence
POTS	plain old telephone service

PSTN	public switched telephone network
QoS	quality of service
RC Act	*Radiocommunications Act 1992*
RF	radio frequency
RIM	remote integrated multiplexers
RSPhysSE	Research School of Physical Sciences and Engineering (ANU)
SDR	software-defined radio
SMA	Spectrum Management Agency (until 1997)
SME	small and medium sized enterprise
SOHO	small office / home office
SPT	Soul Pattinson Telecommunications
STs	subscriber terminals
STU	standard trading unit
Tbps	terabits per second
TC Act	*Telecommunications Act 1997*
TCP	transmission control protocol
T(CPSS) Act	*Telecommunications (Consumer Protection and Service Standards) Act 1999*
TDD	time division duplex (transmission technology)
TDM	time division multiplexing
TDMA	time division multiple access
TITR	Telecommunications and Information Technology Research Institute (University of Wollongong)
TPA	*Trade Practices Act 1974*
TTY	text communication via teletypewriter
UHF	ultra high frequency (band)
UK	United Kingdom
UMTS	universal mobile telecommunications system
US	United States (of America)
USO	universal service obligation
UWB	ultra-wideband
VDSL	very high bit rate digital subscriber line
VHF	very high frequency (band)

VoIP	voice over Internet protocol
VPN	virtual private network
VSAT	very small aperture terminal
WAN	wide area network
WAP	wireless application protocol
WBT	wireless broadband technology
WCDMA	wideband code division multiple access
WDM	wave division multiplexing
WEP	wired equivalent privacy
WID	wireless information device
WISDOM	Wireless Information Services for Deaf people On the Move
WISP	wireless Internet service provider
WLAN	wireless local area network
WLL	wireless local loop
WWW	world wide web
2G	second generation (mobile)
2.5G	two and a half generation (mobile)
3G	third generation (mobile)

1. Introduction

This chapter provides a general background to wireless broadband, including defining the term.

The challenge of digital wireless communication

1.1. Wireless broadband digital communications technology brings together some of the most powerful inventions of the last century—electricity, radio and television, telephone, computer, and the Internet—to allow people to reliably send digital data without direct wire links. It promises everything from mobile telephony, e-medicine, e-business, e-education, e-mail on the run, instant stock prices, to on-line business management for farmers in rural communities. The rapidity of innovation and the diversity of wireless technology solutions—from low-power networks in offices or malls to networks of geo-synchronous satellites orbiting the Earth—provide a myriad of new opportunities for people and organisations.

1.2. The magic ingredient of wireless—information transmission on radio waves propagating invisibly through space—also greatly complicates its use on a large scale. Radio signals can be received by anyone in range, so technology standards, interference, privacy, and security issues determine whether the wireless medium is useful for communications.

1.3. Governments around the world have traditionally managed the development of the wireless medium by controlling access to spectrum segments by specific services, limiting power emissions, fostering the implementation of standards for communications protocols, and supporting research and development in communication technologies.

1.4. Stewardship of the wireless medium is becoming vastly more complicated. The demand for two-way communications bandwidth of all sorts—long range, short range, and in-between—and the development of technology that allows different users or even whole services to use parts of the same frequency band simultaneously, renders regulation of spectrum use much more difficult. Moreover, as digital wireless becomes an integral part of the communications system, there is increasing pressure on governments to ensure access to wireless communications links by the public as an essential utility for life and work.

What is broadband?

1.5. The definition of broadband is open to interpretation and therefore remains fluid. The minimum data speed that could be considered broadband is probably 64 kilobits per second (kbps) and the most common definition is 200 kbps.[1]

1.6. However, some studies and firms have set the standard much higher: ArrayComm suggests the minimum is 1 megabit per second (Mbps); a recent Canadian report suggests it is 1.5 Mbps; the CSIRO suggests that 'a definition of broadband is a baseband signal with a minimum of 2 MHz bandwidth or a digital signal with data rate greater than 2 Mbps;[2] and the Australian Communications Authority [ACA] agrees ('broadband wireless access involves connection capabilities higher than 2 Mbps').[3]

1.7. The Canadian document referred to above noted that, with new applications, the capacity of wireless broadband could increase to 4-6 Mbps.[4]

1.8. It may be more useful to define broadband by the capacity of a technology to provide specific "broadband" services of acceptable quality rather than focussing only on data speeds. In Melbourne, for example, the Committee used a video mobile telephone at Telstra over m.Net's 3G network to speak to / view someone in Adelaide. This phone provided a good service operating at 64 Kbps. This is not generally considered to be broadband speed yet video telephony is considered to be a broadband service.

1.9. Special user needs can dramatically affect the perception of what constitutes "broadband." For example, the Australian Association of the Deaf finds that for video transmission of sign language–the most natural way for many deaf people to communicate–data rates greater than 128 kbps and perhaps as much as 384 kbps are required. [5]

1.10. Rural users often have lower expectations for broadband because their existing phone service permits only limited data rates, and the arrival of a reliable service with data rates at the low end of the broadband range represents a major step forward. The

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[1] New Skies Networks Pty Ltd, submission no.59, p.5.
[2] CSIRO Telecommunications and Industrial Physics, submission no.27, p.2.
[3] ACA, submission no.19, p.28.
[4] "The New National Dream: Networking the Nation for Broadband Access", a report to Industry Canada, quoted in ACA, submission no.19, p.14.
[5] Australian Association of the Deaf Inc., submission no.8, p.8.

National Farmers' Federation has adopted the term "broaderband" to illustrate this idea.[6]

1.11. Definitions focussing on data speeds can also be misleading as they are often described in "optimal" circumstances. 802.11 WiFi can provide up to 11 Mbps, but this is dependent on the distance from transmission points and levels of congestion and interference. Other services can provide very high peak rates of data transfer, but the actual rate available to the end user on a regular basis is much lower. Other factors that can also greatly affect the apparent speed to the user include congestion and bottlenecks in the Internet and latency (the delay in response due to the time it takes for the signals to travel to and from the satellite). The standard and status of the PC or other device being used and the level of training of the person who sets it up are also important factors.[7]

1.12. A reasonable working definition of broadband for this inquiry is wireless transmission involving the following:

- data rate equal to or greater than 64 kbps;
- usage based on data volume (megabytes) rather than connect time;
- low latency;
- (preferably) always-on; and
- (preferably) symmetric data rate for both download and upload.

[6] National Farmers' Federation, submission 60, p.3
[7] Mr Bray, *Transcript*, 8 August 2002, pp.463-464.

2. The terminology of wireless broadband

This chapter defines the principal terms associated with wireless broadband, under the broad headings of: 'how it works: the physics and engineering of digital wireless'; issues affecting the choice of frequency; quality of service delivery; the meaning of the term 'the last mile'; and important legal definitions associated with digital wireless.

How it works: the physics & engineering of digital wireless

Physics

2.1. **Radio waves**: Wireless transmissions consist of electromagnetic (or radio) waves that propagate through space. Radio waves are three-dimensional oscillations of an electric field and a magnetic field. The disturbance propagates through space like sound waves through air but with several important differences. Radio waves are launched and propagate in an environment whenever an electric current in a conductor like a metal oscillates (changes direction periodically) and that conductor is exposed to the environment. Radio waves do not need air as a propagation medium; they can propagate through a vacuum such as that in outer space. The oscillating electric field can also cause currents to flow in conductors. Thus, disturbances can propagate through space and transmit messages from one location to another. Electromagnetic waves propagate at the speed of light, 300,000 km/s, which is one million times faster than the speed of sound. The direction in which a radio wave's electric field points is referred to as its polarisation.

2.2. **Frequency:** In order for radio waves to propagate, they must oscillate. An important quantity is the frequency of the oscillations. Frequency is measured in cycles per second or Hertz (Hz). It refers to how many times the electric field changes direction per second. The spectrum of radio waves is simply the range of all frequencies. Frequencies relevant for wireless communications are those above 30 MHz (million Hertz) and below about 300 GHz (GigaHertz, 1 GHz = 1000 MHz = 1 billion Hertz). Much of the spectrum from 30 MHz – 300 GHz has multiple purposes but some is not allocated.[8]

[8] See the Australian Communications Authority (ACA) spectrum plan, http://www.aca.gov.au/frequency/arsp-wc.pdf

2.3. **Wavelength:** A very important quantity is the wavelength of a radio wave. The wavelength is the distance between points along the wave train where the electric field direction goes through one cycle. If wavelength is denoted by the symbol λ and the frequency by f, then the wavelength can be calculated from the frequency by the formula $\lambda = c / f$, where λ is in metres, f is in Hz and c, the speed of light, is 300,000,000 metres / sec. As an example, radio waves used for the transmission of VHF TV channel 0 have a frequency of about 50 MHz or a wavelength of 6 metres. Radio waves used in a wireless local area network may have a frequency of 2.5 GHz or 120 mm. Wavelength is very important in determining how a radio wave responds to obstacles in the environment. Long waves (like the 6-m wavelength at 50 MHz) can diffract around hills and houses. Short wavelengths at microwave frequencies in the GHz range are limited to line-of-sight propagation.

2.4. **Band terminology:** The frequency spectrum is divided into bands with special names. The band 30 – 300 MHz is the VHF (very high frequency) band. The band from 300 MHz – 3 GHz is the UHF (ultra high frequency band) and the band from 3 – 300 GHz is microwave.

2.5. **Bandwidth:** The radiofrequency (RF) spectrum has been divided into frequency bands. For example VHF TV Channel 0 occupies the band from 45 - 52 MHz and has a bandwidth of 7 MHz. This is important because signals in any two distinct frequency bands can be filtered from one another using electronic circuits so that they do not interfere. For example, Channel 1 occupies the band from 56 – 63 MHz. It does not overlap with channel 0, and with proper filtering, it is possible to transmit and receive simultaneously at the same location on each of these bands. Because of the way that wireless has developed, generally more bandwidth has been made available to individual services operating at higher frequencies in the radio spectrum.

2.6. **Radio wave energy:** Radio waves carry energy. When an electromagnetic wave propagates it has a certain power flux or power per unit area at every location. The power flux at any given point is a measure of the signal strength at that point. Radio wave energy cannot be easily confined to any region of space unless it is completely enclosed in a metal box. Radio waves can be filtered according to frequency. Spatial filtering is more limited.

2.7. **Noise and interference:** In practice there is always some residual electromagnetic energy present in any environment. This could be

due to random noise produced by miscellaneous influences such as power lines, automobile engines and the ionosphere or it could be as a result of other (interfering) radio transmitters. Thus, if a radio wave is being used for communications purposes, its signal strength must compete with that of the background noise in the same band of frequencies at the receiver. Generally speaking, natural influences produce less noise at high frequencies than at low frequencies.

2.8. **Omnidirectional antennas:** Radio waves are launched in a controlled manner by the use of antennas. The simplest antenna is a straight wire carrying an oscillating current at the frequency of interest. The length of the wire is usually about a quarter to a half of a wavelength. These antennas are referred to as dipoles, monopoles, omnidirectional antennas or more affectionately as 'omnis', 'whips' or even 'rubber-duckies'. They launch electromagnetic waves that have electric fields polarised parallel to the wire. These antennas are very familiar on automobiles, walkie-talkies, mobile handsets and as built-ins on wireless networking cards.

A radio wave launched by one of these antennas propagates away from the antenna predominantly in the plane perpendicular to the wire. No wave is launched away from the antenna along the line of bore sight of the wire. These antennas are the most omnidirectional of all antennas. There is no such thing as an antenna that launches its energy equally in all directions (or isotropically).

Antennas have the same directional properties for reception as transmission. Thus a dipole antenna best receives radio waves that are polarised parallel to the wire and that propagate to the antenna along the plane perpendicular to the wire. Radio waves arriving along the bore sight direction are undetectable.

2.9. **Directional antennas:** During transmission, these antennas are designed to concentrate radio waves in a particular direction. During reception, these antennas are designed to receive radio waves from that same direction. Examples are the familiar microwave dishes used for satellite or Yagi antennas that have a fishbone appearance.

2.10. **Directivity or gain:** All antennas have a preferred direction or directions along which they radiate. They are also driven by a certain amount of power at their terminals by the power amplifier in the communications device that uses them. This means that the power flux radiated by an antenna along its preferred direction(s)

for a given power applied at its terminals, is always greater than the isotropic power flux. The ratio of the power flux along the maximum direction(s) to that radiated isotropically is referred to as the antenna gain.

2.11. **Equivalent Isotropically Radiated Power (EIRP):** If the antenna gain is multiplied by the terminal power, we obtain the EIRP which is always larger than the output power of the device driving the antenna. It is important because radiofrequency emission power limits are always given in terms of the EIRP. The higher the EIRP of a radio communications system, the higher is its potential for interference. The Australian Communications Authority (ACA) regulates the EIRP through three types of licence, in accord with the *Radiocommunications Act (1992)* (see later in this chapter).

The use of EIRP limits is shown by the following example. A wireless networking card may have a rated RF output power of 100 mW. Let us assume the legal EIRP to be 4 Watts. If the card is connected to a dipole antenna which has a gain of 1.64 then the EIRP is 1.64 x 100 mW = 164 mW. This is within the allowed limit. On the other hand, if a dish antenna with a gain of 100 is used, then the EIRP would be 10 Watts and the station would be illegal.

2.12. **Absorption of radio waves:** Radio waves propagate without attenuation in a vacuum. However, when propagating through matter, they can be absorbed or attenuated. Attenuation in the atmosphere as a result of oxygen absorption, humidity or precipitation becomes significant above about 15 GHz. This can be an advantage if the range of the radio waves is to be restricted in order to avoid interference, or a disaster if they are required for long distance communications.

2.13. **Propagation characteristics:** The choice of frequency (ie. wavelength) for a given application depends entirely on the environment in which the electromagnetic waves propagate. Loosely speaking, radio waves cannot escape through apertures that are less than a wavelength in dimensions.[9] By the same token, the longer their wavelength, the more radio waves can bend around obstacles. This process is referred to as diffraction. Thus radio waves at 2.5 GHz (wavelength 120 mm) and higher are suitable for indoor environments or where a line-of-sight is available outdoors. On the other hand, outdoor applications

[9] They would of course if the waves could penetrate the bounding walls of the aperture eg. most building materials at 2.5 GHz.

requiring the best one can achieve in terms of non-line-of-sight would use radio waves with the longest wavelengths or the lowest frequency. These would be the VHF waves.

Engineering

2.14. **Data bits:** All digital data are encoded as numbers in base 2. This means that all data can be represented by a string of just two binary digits (or bits).

2.15. **Data symbols:** A symbol is simply a single quantity that represents a sequence of bits. The purpose of symbols is to allow (if possible) more bits to be sent in a given bandwidth.

2.16. **Modulation:** Given that a band of frequencies is available for wireless transmission, it is customary to choose a single frequency to be the carrier frequency. This single frequency or tone has three properties: amplitude, phase and frequency. Each symbol can then be represented by any combination of any of these three properties. The following table shows examples of some common modulation schemes, the number of amplitudes, phases and frequencies used in them and the symbols that they can represent.

Table 1: Modulation schemes for digital transmission

Modulation Scheme	Amplitudes	Phases	Frequencies	Data Symbols
4- QAM (4-quadrature amplitude modulation)	2	2	1 (the carrier)	00 01 10 11 (4 symbols each representing 2 bits)
64- QAM (64-quadrature amplitude modulation)	8	8	1 (the carrier)	000000 000001… 111111 (64 symbols each representing 6 bits)
FSK (Frequency Shift Keying)	1	1	2 (very near the carrier)	0 1 (2 symbols each representing 1 bit)
BPSK (binary phase shift keying)	1	2	1 (the carrier)	0 1 (2 symbols each representing 1 bit)
QPSK (quaternary phase shift keying)	1	4	1 (the carrier)	00 01 10 11 (4 symbols each representing 2 bits)

2.17. **Data rates:** The bandwidth in MHz consumed by a modulation scheme in sending data is proportional to the number of symbols that it tries to transmit per unit time. From the table, the number of bits per unit time, and hence the data rate, is six times higher for 64-QAM than for BPSK. Thus if 1 Mbps is transmitted in a given bandwidth using BPSK, then 6 Mbps can be transmitted in the same bandwidth using 64-QAM.

2.18. **Limits to data rates:** In real wireless environments or channels, the data rate cannot always be increased arbitrarily by going to higher order schemes like 64-QAM. This is because the high order schemes are much more sensitive to channel noise and overall signal quality. Such schemes would incur large bit-error-rates (BER) and data loss in noisy channels. In this case, a lower error rate per bit would be more easily achievable with simpler schemes like BPSK or FSK. In noise free environments with good signal quality, it is better for the user to employ the highest order modulation scheme practicable. In practice, however, modern error correction techniques allow bit errors to be eliminated in noisy channels.

2.19. **Spread spectrum:** This is a manner of transmitting data so that it occupies a much larger bandwidth than the data itself. There are two types: Frequency Hopping Spread Spectrum and Direct Sequence Spread Spectrum.

(a) Frequency hopping spread spectrum (FHSS), in which the carrier frequency is hopped periodically through a set of frequencies known only to transmitter and the receiver. FHSS can either be slow or fast.

(b) Direct sequence spread spectrum (DSSS) is a technique of treating data bits so that they look like noise in the channel. The user data bits are multiplied by a sequence of bits that are randomly distributed in time that have a much higher data rate and therefore occupy a much larger bandwidth than the user data. This noisy signal can be detected at the receiver by multiplying by the same code: a process known as despreading or correlation. DSSS is useful for avoiding co-channel interference by other users and devices occupying the same bandwidth.

2.20. **Orthogonal frequency division multiplexing (OFDM)** is a modulation scheme in which data symbols are used to modulate a large number of independent subcarriers occupying the available frequency band. Each subcarrier describes its own unique set of symbols and is very slowly modulated so that it occupies minimal bandwidth.

2.21. **Transmission control protocol/Internet protocol (TCP/IP):** These protocols are responsible for error-free data transport and networking on the Internet.

2.22. **Multi-path and inter-symbol interference:** This is the greatest impediment to achieving high data rates in wireless telecommunications. In a wireless channel, signals may be reflected from obstacles so that two versions of the same signal arrive at the receiver. If paths along which these signals arrive differ sufficiently in length, their times of arrival could exceed the symbol time. In this case symbols overlap and become garbled: a phenomenon known as inter-symbol interference (ISI). DSSS and OFDM are highly resistant to ISI.

2.23. **Wireless networks:** As with wire-line, users can use wireless to connect to one another in point-to-point mode or be shared on a wireless network. In the latter case, there is a base station or access point that serves users in a neighbouring region. The base station coordinates user access to the channel. The network capacity is a direct compromise on the data rate desired per user.

The size of the network depends on its purpose. A wireless Local Area Network (LAN) for example, consists of an access point to a backbone that serves users within a 100-m radius of the access point. Much larger distances are possible and several networks may overlap and interfere. The mobile telephone network spans the nation in cells. Each cell has its own base station and the cells are independent and do not interfere with each other.

2.24. For connection to the Internet, a wireless network has to be connected to a backbone. To provide broadband connectivity to large wireless networks, numerous regular connections to the backbone must be made.

2.25. **Channel sharing:** Some methods used to share the wireless channel are:

- Frequency Division Multiple Access (FDMA). The users each have their own frequency band.

- Time Division Multiple Access (TDMA). The users access the resources of the network during designated time slots.

- Code Division Multiple Access (CDMA). Each user in the network is assigned their own DSSS code. The different DSSS codes are uncorrelated. Receivers can detect different users by correlation techniques: a process referred as despreading.

- Collision Sensing Multiple Access (CSMA). Users access the base by contention and back off in the event that a collision (co-channel interference) occurs. This is used in wireless LANs and is similar to Ethernet.

- Space Division Multiple Access (SDMA). Increasingly, more complex wireless devices will be deployed that can mitigate interference by using arrays of antennas to localise targets by angle-of-arrival of their signals.

2.26. **Signal processing:** Wireless channels are notoriously more noisy and non-ideal than wire-line channels. As a result, modern wireless equipment has quite sophisticated mathematical processing of signals to eliminate bit errors, minimise co-channel interference and optimise bandwidth efficiency. Signal processing in wireless telecommunications is a topic of very active research.

Issues affecting the choice of frequency

2.27. Different frequency bands in the radiofrequency spectrum are regulated by a system of three licences:[10]

> **Apparatus licences** authorise the operation of radiocommunications equipment for specific purposes, for example, land mobile, outpost, amateur, maritime or aeronautical communications and broadcasting. You pay a licence fee and the ACA issues you with a licence to operate the equipment.
>
> **Class licences** are open, standing authorities that allow anyone to operate particular radiocommunications equipment provided the operation and the device meet the conditions of the licence. Class licences do not have to be applied for and no licence fees are payable. Under class licensing, users may operate various types of radiocommunications equipment including citizen band radios, mobile and cordless phones and a range of other low power devices, such as remote control garage door openers. The spectrum governed by these licences are considered 'public parks'.
>
> **Spectrum licences** are a tradeable, technology-neutral (that is, the licence is not related to any particular technology, system or service) spectrum access right

[10] http://www.aca.gov.au/consumer/faq/wlans.htm

for a fixed non-renewable term. Instead of authorising the use of a specific device, spectrum licences authorise the use of spectrum-space and give licensees the freedom to deploy any device from any site within their spectrum space, provided that use is compatible with the core conditions of the licence and the technical framework.

2.28. **Industrial Scientific and Medical Bands (ISM):** These bands are used by equipment that locally employs radiofrequency energy. The best known example is the microwave oven (2.4 GHz). Radiocommunications services operating in these bands must accept any harmful interference caused by ISM equipment.

2.29. **The right frequency:** The best frequency for a given application depends on many factors, including:

- The available bandwidth and ambient noise, which affect achievable data rates.
- Whether the band is an ISM band where co-channel interference may be random, unavoidable and difficult to localise.
- The nature of the environment. Waves above 15 GHz cannot be used in humid or rainy areas if long distances transmissions are required. But they would be the best if spatial separation were employed to avoid co-channel interference. In general, waves above 1 GHz require strict line-of-sight in most terrains; however, this could still be as far as 10-30 kms.
- The cost and availability of infrastructure such as repeater towers. Hilly terrain requires expensive infrastructure for all but the VHF and low UHF frequencies.
- Cost and availability of the technology. High frequency systems (> 5 GHz) are generally more expensive.
- The cost of the spectrum, should dedicated spectrum be required and an ISM band not be employed.

Quality of Service delivery

2.30. **Speed:** Speed is mostly linked to the data rate versus network loading and the definition of broadband. This will increase significantly with the advance of technology for small-scale microwave networks.

2.31. **Security:** is a complex on-going issue in wireless networks. Users and service providers, however, can take the same precautions on a wireless network as on a wire-line network. In-built wireless security is getting better.

2.32. **Always-on connectivity:** Most wireless networks offer the possibility of a permanent connection as opposed to a dial-up connection.

2.33. **Latency:** Latency is defined as the minimum time to perform the smallest operation. In the case of networks, it is usually measured as the time it takes one packet of data to get to your destination ("trip time"). Clearly, the lower boundary of this latency is defined by the actual signals themselves, which travel at the speed of light. In practice, network latency due to the speed of the software and hardware on the network imposes its own problems but the physical latency is especially a problem for some satellite networks. For example, the most widely used scheme for two-way satellite digital wireless uses geo-synchronous satellites, which orbit the earth at exactly the earth's rotational velocity (so they appear stationary) at an orbit height of 36,000 km. The latency in this simple case, is equal to the round-trip travel time from the earth to the satellite and back, and is ~ 1/4 second (assuming no other system delays).

2.34. **Interference:** A wireless network can be rendered inoperative by co-channel interference. There is no 'quick fix' for this problem. A network on privately licensed spectrum can avoid co-channel interference by proper engineering design. In class-licensed spectrum it can only be avoided by coordination amongst users and proper, legal use of the technology.

'The Last Mile'

2.35. The 'last mile' refers to the connection linking end-users to the network backbone. Making the last mile connection is normally a difficult problem because a large number of network branches are required to connect individuals to the backbone. For carriage service providers, making the last mile connections can be very expensive.

2.36. The last mile link is a serious problem even in urbanised Australia because of the slow rollout of broadband infrastructure in general. The last mile is an even greater problem in regional Australia due to the dilapidated state of existing wire-line infrastructure.

Legal definitions important for digital wireless

2.37. The inquiry generated considerable controversy about the requirement (or perceived requirement) for a carrier licence to operate radiocommunications equipment on the ISM bands. The following definitions are relevant in this regard:

> A base station that is part of a terrestrial radiocommunications customer access network or a fixed radiocommunications link under the Act are both designated radiocommunications facilities and therefore a network unit.
>
> [According to the Act,] the owner of a network unit that is used to supply carriage services to the public must hold a carrier licence unless:
>
> - a nominated carrier declaration (NCD)[11] is in force in relation to the network unit; or
> - an exemption applies.

2.38. The following item under the *Trade Practices Act* has implications for commercial competition with major carriers supplying local loop (the connection between the home and the telephone exchange) services:

> Once a telecommunications service has been declared by the ACCC under the access regime established by Part XIC of the *Trade Practices Act 1974 (Cth)* (TPA), a provider of that service ("access provider") can satisfy its legal obligation to supply the declared service in one of three ways:
>
> - under a commercially negotiated agreement with the access seeker
> - pursuant to a determination made by the ACCC in its arbitration of an access dispute, or
> - under an access undertaking provided to the ACCC under Division 5 of Part XIC.[12]

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[11] If responsibility for a network unit is transferred from the owner of the unit to a carrier, the ACA may make a *nominated carrier declaration* that declares the carrier to be the *nominated carrie*r in relation to the unit.

[12] http://www.corrs.com.au/WebStreamer?page_id=2165

2.39. Access undertakings are effectively an agreement with the ACCC that the access provider will supply the declared service to all comers under the terms of the undertaking provided. Once an undertaking is submitted to the ACCC by the access provider, the ACCC is required to either accept or reject the undertaking and give reasons for its decision.

2.40. At the time of drafting of this report, the Parliament is debating an amendment to Part XIC of the *Trade Practices Act*.

3. The current rollout of wireless broadband technologies in Australia and overseas

This chapter describes each of the wireless technologies (and their current rollout in Australia) identified in the Committee's terms of reference, namely wireless LAN, Bluetooth, LMDS and MMDS, wireless local loop, and satellite.

Wireless LAN

3.1. Wireless LAN or WLAN stands for wireless local area network. Recent applications of WLAN range from 'Internet service providers offering WLAN "hotspots" within public locations such as coffee shops and airport lounges, to entrepreneurial hobbyists and community groups using WLANs in order to connect local residential users as a last mile alternative'.[13]

3.2. In 1997 the Institute of Electrical and Electronic Engineers Inc. (IEEE) created the IEEE 802.11 standard for WLAN technologies. The development of the IEEE 802.11 WLAN standard has been an important driver in bringing (relatively) low cost WLAN equipment into the marketplace.[14] The term 802.11 actually refers to a range of different wireless protocols.

3.3. Local area networks are isolated networks usually centred on a base station or access point. The access point is connected to a wireline network which may include the Internet.

3.4. WLANS can operate in both ad-hoc and infrastructure mode. In ad-hoc mode, users form a point-to-point computer network using an 802.11 PC card and run TCP/IP services or other networking protocols for file sharing, web services etc. There is no need for an access point. Normally only two users would connect in ad-hoc mode as there is no mechanism for sharing the channel in an organised way. At low traffic levels, however, such a network is functional for more than two users and with TCP (as used in e-mail and web services), there are repeat requests for lost data. Thus users obtain a reliable connection but may experience network congestion in multi user ad-hoc networks. In

[13] m.Net Corporation Ltd, submission no.39, p.3.
[14] ACA, submission no.19, p.23.

infrastructure mode, an access point communicates with the 802.11 PC cards to control access to the network.

3.5. In Australia, 802.11 can be deployed on the following bands:[15]

- 2400 - 2463 MHz at 4W EIRP
- 2463 -2483.5 MHz at 200mW EIRP
- 5150 – 5350 MHz at 200mW EIRP
- 5725 - 5875 MHz at 1W EIRP
- 5795 - 5815 MHz at 2W EIRP.

(Note that some are overlapping due to the actual designation of each band.)

3.6. The most popular is 802.11b which occupies 83.5 MHz from 2.4000 GHz to 2.4835 GHz, and provides 11 channels at 5 MHz intervals (beginning at 2.412 GHz and ending at 2.462 GHz).

3.7. The term WiFi (for wireless fidelity) is often used for 802.11b. 802.11b is capable of nominal data rates of 1-2 Mbps using DSSS and 5.5 and 11 Mbps in modified mode called complementary coded keying (CCK).

3.8. These all occupy 22 MHz of bandwidth (upper and lower sidebands). Three bands are therefore non-overlapping. This means that three independent wireless LANs can be co-located and operated at 11 Mbps. Evidence supporting the co-location of WLAN networks was presented by AirNet which claimed that it is possible to operate up to 70 access points in the one area with proper coordination and application of spread spectrum principles.[16] Melbourne Wireless stated that:

> We can sit three access points on the table right next to us, all three of them right next to each other operating on different channels, all of them full 11 megabit—and there would be no interference whatsoever.[17]

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[15] http://www.aca.gov.au

[16] Mr Karidis (Director, Operations), AirNet Commercial Australia Ltd, *Transcript*, 1 July 2002, p.169.

[17] Mr Haigh (President), Melbourne Wireless, *Transcript*, 2 July 2002, p.240.

3.9. Other 802.11 standards are being developed that extend the physical layer options, add quality of service (QOS) features or provide better interoperability:

- 802.11**a** (well known from RADIATA / CISCO at Macquarie University) provides eight channels using OFDM, each channel being 20 MHz wide, on the 5.3 GHz and 5.8 GHz bands. The nominal link rate is 54-Mbps per channel;
- 802.11**g** OFDM 54 Mbps 2.4 Ghz band which has higher speed and will be compatible with 802.11b;
- 802.11**d**, 802.11**e**, 802.11**f**, 802.11**h** (5 GHz) have enhancements; and
- 802.11**i** which has enhancements to provide security improvements over WEP (Wireless Encryption Protocol, the current standard built-in WLAN encryption protocol well known to be insecure).[18]

3.10. WLAN technology has a potentially enormous social impact and there was considerable input to the inquiry regarding its promises and problems. For hobbyists interested in broadband, and Internet Service Providers interested in urban and regional Australia, WLANs might provide a simple way to solve the last mile problem. Commercial operators have already entered the wireless business through WLAN in the 2.4 GHz ISM band, thus avoiding the expense of purchasing a spectrum licence.

3G

3.11. 3G stands for third generation mobile phone system which provides both voice and broadband data access. These include CDMA2000, W-CDMA, UMTS, GPRS and EDGE. GPRS and EDGE are actually 2.5G technologies because they build upon existing 2G (second generation) GSM infrastructure.

3.12. The ACA noted:

> Current international planning for 3G services has assumed operation in frequency bands around 2 GHz.[19] Within the international community, studies

[18] Mr Keighran (Chief Technical Officer), Simply Wireless, *Transcript*, 28 June 2002, p.129.

[19] In major capital cities frequencies allocated were: 1900-1920 MHz (notionally for

> are underway to determine the feasibility of operating 3G systems in existing mobile bands at 800 MHz, 900 MHz and 1800 MHz. Also at the international level, a frequency band around 2500 MHz has been identified as a potential 3G expansion band. All of these bands are subject to coordinated frequency management (spectrum licensing). 3G spectrum in Australia has been allocated by spectrum auctions and is managed under spectrum licences.[20]

3.13. 3G is a collection of more advanced technologies than the existing 2G technologies. The main examples of the latter are Qualcomm's IS95 CDMA and GSM. These are digital circuit switched technologies capable of up to 14.4 kbps and 9.6 kbp data rates respectively. The principle of CDMA has been explained in chapter 2. GSM (Global Systeme Mobile) is a European Standard based on TDMA (also see chapter 2).

3.14. **CDMA2000**: '3G technology is being supplied as an upgrade to Qualcomm's CDMAOne, IS95 systems. The service claims up to 2.4 Mbps peak rate using the HDR or 1xEV variant that overlays a data-centric network over that of the existing voice network. Actual peak data rates are expected to be comparable to other 3G systems (ie. 144 kbps for each customer).'[21]

3.15. **W-CDMA**: 'This is the International Telecommunications Union's (ITU) version of CDMA that is the upgrade path from GSM aimed at the delivery of true broadband multimedia services. W-CDMA is a service that supplies up to 144 kbps under mobile scenarios. Initial deployments in Japan and the UK will provide no more than 64 kbps.'[22]

3.16. **Universal mobile telecommunications system (UMTS):** This is a 3G, mobile communications system being developed by the European Union, intended to deliver broadband services to mobile users via fixed wireless and satellite networks with data rates up to 2 Mbps.

3.17. **General Packet Radio Service (GPRS): '**This is designed to deliver high-speed data services over existing GSM networks with data transfer rates of up to 171 kbps. In practice, speeds of

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Time Division Duplex use); and 1920-1980 paired with 2110-2170 MHz (notionally for Frequency Division Duplex use).

[20] ACA, submission no.19, p.25.

[21] ArrayComm Inc. and CKW Wireless, submission no.11, p.8.

[22] ArrayComm Inc. and CKW wireless, submission no.11, p.8.

between 20 and 50 kbps are expected for the first generation of devices.'[23]

3.18. **Enhanced Data Rates for Global (or GSM) Evolution (EDGE):** 'This is a standard that builds upon existing GSM and TDMA infrastructure to provide up to 384 kbps peak rate per user. In practice, speeds of approximately 32-64 kbps are expected. Primary alterations in air protocol to accommodate higher order modulation. EDGE will require new devices and significant upgrades to the network infrastructure.'[24]

3.19. User data rates to be provided by 3G systems 'range up to few hundred kbps for mobile applications and up to 2 Mbps for low mobility indoor applications'[25] However, some organisations consider that the broadband data rates, of the order of 2Mbps, often attributed to them can only be realised on a short-range indoor basis.[26]

3.20. 3G devices operating at ~2 GHz require a considerable number of base stations that are fairly closely spaced, thus adding to the cost of infrastructure. These must form a cellular network to provide national coverage.

3.21. In Australia, CKW Pty Ltd (a subsidiary of ArrayComm) and Hutchison have acquired spectrum licences that they intend to use for 3G services in the capital cities. Other companies with licences are Optus Mobile Pty Ltd, Vodafone Pacific Pty Ltd, 3G Investments Australia (Qualcomm) and Telstra.[27] To date, only Hutchison Telecommunications is installing a 3G network in Australia.

3.22. Nortel has proposed CDMA2000 for broadband services because it can be supported by the existing CDMA infrastructure. Nortel proposes developing a progressively modified 800 MHz CDMA system (a 3G technology) based on existing CDMA infrastructure, and expects it to be able to provide both mobile and fixed wireless data access for 97% of the Australian population.[28] Telstra has shown an interest in this solution as an add-on to their existing CDMA infrastructure.

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[23] ArrayComm Inc. and CKW wireless, submission no.11, p.8.
[24] ArrayComm Inc. and CKW Wireless, submission no.11, p.8.
[25] ACA, submission no.19, pp.26-27.
[26] Motorola Australia, submission no.12, p.3.
[27] ACA, submission no.19, p.27.
[28] Nortel Networks, submission no.21, pp.13-14 and p.20.

3.23. All of these technologies will play a role in the general uptake of wireless broadband. However, while Nortel believes that its CDMA2000 product could solve much of Australia's regional Internet problem,[29]other organisations consider that UMTS and GPRS will not provide the coverage needed to service regional Australia.

3.24. Some 3G spectrum is used for alternative technologies, eg., ArrayComm's *i-Burst* in the 2.1 GHz band, which is coming on line during 2002:

> Using *IntelliCell* technology, ArrayComm has developed *i-BURST*, which is a complete end-to-end data-only wireless system that addresses the portable broadband Internet market and has been designed to leverage the capabilities of the *IntelliCell* technology for W-CDMA base stations.[30]

Bluetooth

3.25. Bluetooth™ is 'an advanced protocol for the transmission of data at a rate of about 1.5 Mbps between portable devices in a secure and reliable manner'.[31] It uses unlicensed spectrum at 2.4 GHz over ranges of 0-10 metres.[32] Bluetooth™ 'has been driven by mobile phone manufacturers who want lower-powered implementations of greater flexibility and simplicity and with a definite need to ensure the privacy of all those who use it'.[33] Bluetooth™ 'is a recognised standard, IEEE 802.15.1'.[34]

3.26. Bluetooth™ replaces short wire connections (of a few metres) with wireless connections; its short range and very low power means that it cannot be a last mile broadband communications service.[35] It is an example of a wireless personal access network (WPAN), which may be defined as wireless technology enabling communication within 0-10m.

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[29] Dr King (Specialist, Regulation and Policy), Nortel Networks (Australia) Pty Ltd, *Transcript*, 2 July 2002, p.208.
[30] ArrayComm Inc. and CKW Wireless, submission no.11, p.12.
[31] Simply Wireless Pty Ltd, submission no.4, p.3.
[32] ArrayComm Inc and CKW Wireless, submission no.11, p.8.
[33] Simply Wireless Pty Ltd, submission no.4, p.9.
[34] ACA, submission no.19, p.25.
[35] ACA, submission no.19, pp.23-25 and m.Net Corporation Ltd, submission, p.3.

Local multipoint distribution systems (LMDS) and Multipoint distribution systems (MMDS)

3.27. **Multipoint distribution systems (MDS):** Local multipoint distribution systems (LMDS) and microwave (or multi-channel) multipoint distribution systems (MMDS) are forms of broadband Wireless Local Loop or Fixed Wireless Access (see following). The market for these systems is currently in businesses needing higher data rates than those available from telephone and ISDN connections.[36]

3.28. MMDS 'is generally used to refer to fixed microwave data distribution systems below about 10 GHz. In these bands wide area coverage (20-40 km) from the central hub station site is possible'.[37]

3.29. LMDS is generally used to refer to microwave data distribution systems operating above 10 GHz, generally in the range 24-32 GHz (10 mm wavelength) making them only useful for line-of-sight (LOS) communications. The main advantage of LMDS is that higher data rates are available from equipment in these bands.

3.30. The term 'local' derives from the limited (<5 kms) coverage provided by each hub station in these bands:.[38]

> As LMDS can be used for point-to-multipoint voice and data services, pay TV, high-speed Internet access and wireless telephony, it is the first opportunity for converged service providers, whether they are Internet service providers, fixed telecommunications service providers, cable operators or electric utilities. The technology also offers companies the ability to spread their risk in case of telecommunications disruptions.[39]
>
> Overseas experience suggests that line of sight problems and sensitivities toward the proliferation of base station towers need to be addressed before LMDS is a viable alternative to the fixed line platforms.[40]

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[36] ACA, submission no.19, p.30.
[37] ACA, submission no.19, p.29.
[38] ACA, submission no.19, p.30.
[39] Paul Budde Communication Pty Ltd, submission no.2, p.5.
[40] Optus, submission no.16, p.3.

3.31. One could use LMDS to supply high-speed voice and data over LOS links for many kilometres: 'In this instance the link would have to operate on a dedicated channel, be carefully engineered over a line of sight and utilise external antennas carefully aimed and set up. Data rates of the same order as that obtained from fibre optic links can be obtained.' The range could be up to 3 kms at data rates from 1.5 - 600 Mbps.[41]

3.32. MDS/LMDS systems:

> have been deployed, or might be deployed, in the bands listed below. Additionally, these technologies are designed in such a way that they could be implemented in other frequency bands (eg. 3.4 GHz) by changing the radiofrequency parts of the equipment.

Service	Band	Frequency range	ACA Licensing
(M)MDS	2.3 GHz	2302 MHz-2400 MHz	spectrum licensed
LMDS	27 GHz	26.5–27.5 GHz	spectrum licensed
LMDS	28 GHz	27.5–28.35 GHz	spectrum licensed
LMDS	31 GHz	31.0–31.3 GHz	spectrum licensed

These systems have a range of ~5 kms and provide high data rates with ~ 100 W of power.[42]

3.33. Using its spectrum licence in the 28/31 GHz band, AAPT 'has established LMDS facilities in various locations throughout regional Victoria. AAPT's LMDS delivers immediate coverage of services such as 2 Mbit/s data, voice and high-speed Internet to business and government users in Geelong, Bendigo, Ballarat, Shepparton, Wangaratta, Horsham and Bairnsdale. In addition, AAPT has established a small number of LMDS nodes in most State capital cities.'[43] It has been noted by m.NET that in the case of LMDS a lack of equipment availability and a high cost structure has seen limited deployment in Australia.[44]

3.34. The 27/28/31 GHz bands used by these services 'are adjacent to, or are shared with, space or satellite services. This has necessitated the development of international sharing arrangements to protect the space and satellite services.'[45] In Australia these bands have relatively few operational services at this time.

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[41] Motorola Australia, submission no.12, p.12.
[42] ACA, submission no.19, p.29.
[43] ACA, submission no.19, p.30.
[44] m.NET Corporation Ltd, submission no.39, p.3.
[45] ACA, submission no.19, p.30.

Fixed Wireless Access (FWA) and Wireless Local Loop (WLL)

3.35. **WLL**: Wireless local loop connects a customer to the local exchange by a wireless link instead of the conventional copper wire. WLL is defined as end-user radio connection to a core network, which might be a public switched telephone network (PSTN), integrated services digital network (ISDN), Internet or local / wide area network. The 'end user' could be a single user or a user accessing services on behalf of multiple users. Also, the end user could connect to the core network by equipment installed at a fixed location (fixed wireless access [FWA] or by mobile means).[46]

3.36. According to Alcatel Australia Pty Ltd:

> Fixed wireless access solutions are either terrestrial or space based. The terrestrial systems (LMDS, MMDS) are ideally suited to provide access in outer urban and rural environments where copper cable lengths are too long for DSL technologies (5-10 kms) but distances are short enough (15-25 kms) for the inherent line of sight radio systems to function at their optimum. The space-based systems are ideally suited to provide access in remote environments where neither cable-based access nor terrestrial radio systems are economic.[47]

3.37. The principal difference between FWA and LMDS is the spectrum used. As a general rule, the higher the frequency, the higher the bandwidth that can be managed for communication, but conversely the lower the operating range and the more difficult it is for the radiation to propagate. FWA systems at around 3.4 GHz present a very good compromise between the bandwidth available from the spectrum, the range able to be covered and tolerance to marginal link conditions. LMDS systems, on the other hand, present higher bandwidth capacity, but over much shorter ranges and with far less tolerance to obstructions and signal loss due to environmental conditions (rain, dust, temperature, etc). So LMDS system are typically used for high-bandwidth corporate communications over short distances, while FWA systems are able to cope with the range needed to deliver services to domestic premises but at more modest and consumer-useable bandwidth.

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[46] ACA, submission no.19, p.28.

[47] Alcatel Australia, submission no.9, pp.13-14.

3.38. Equipment for higher frequencies used by LMDS tends to be significantly more expensive than that for FWA.

3.39. All fixed systems require managed spectrum because they operate at power levels that can transmit over long distances and so they have the capability to interfere with other spectrum users over greater distances.[48]

3.40. FWA systems:

> have been deployed in many countries around the world. These range from developed countries where FWA is seen as a substitute for the copper CAN to developing countries where FWA is regarded as a simple and cost effect technology for the rapid extension of telecommunications to people who previously have not had any.[49]

3.41. Unwired Australia Pty Ltd has announced plans to develop a national fixed wireless broadband network, operating in the 3.4 GHz band, which will span more than 14 major population centres. Areas of geographic coverage will include heavily-populated metropolitan centres such as Sydney and Melbourne and selected regional areas. The company plans to launch its network progressively from late 2002.[50]

Satellite

3.42. It is recognised that satellite is particularly important for remote users.

3.43. Research by Paul Budde Communications Pty Ltd suggests that, in general, wireless broadband will not represent more than a 20% to 30% market share of the total broadband market by 2010, with satellite taking up at least 70%-80% of that share.[51]

3.44. Today's high speed satellite data services are provided by geo-synchronous satellites (GEOS). A satellite in geostationary orbit is one that follows a circular orbit in the equatorial plane at a height of 36,000 kms above the earth. At this height the satellite appears at a fixed location in the sky relative to an observer on earth. From this location almost one-third of the earth's surface is visible

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[48] Unwired Australia Pty Ltd, submission no.41, pp.20-21.
[49] Unwired Australia Pty Ltd, submission no.41, p.21.
[50] ACA, submission no.19, pp.27-28.
[51] Paul Budde Communication Pty Ltd, submission no.2, p.3.

to the satellite, so near-global coverage can be achieved with a minimum of three satellites in orbit.

3.45. GEOS returning through a hub are characterised by a 0.5 second return delay (latency), high power consumption (required by RF transmitters to launch enough signal) and usually last about 5-7 years. There are currently 198 satellites in orbit, approaching 2/3 of the maximum orbital slots. Connection to these services is made by a very small aperture terminal (VSAT) consisting of 0.65 to 2.4 metre diameter client dishes and the hub (~ 6 metre).

3.46. A non-geostationary satellite system is one using constellations of satellites, usually in a circular orbit at a constant altitude that is lower than that of a geostationary orbiting satellite. Currently, Low Earth Orbit satellites [LEOs] (200 – 3000 kms altitude) and Medium Earth Orbit satellites [MEOs] (6000 – 12000 kms altitude) are used predominantly for voice and low speed services.

3.47. Satellite-based communications:

> can carry a wide variety of communications services including: television broadcast, Internet communications, remote area telephony and data services, corporate data, videoconferencing, aggregated telecommunications data traffic, weather forecasting, and Global Navigation Satellite Systems (GNSS) such as the Global Positioning System (GPS)… Operators providing satellite services to Australia include Optus, PanAmSat, New Skies, Intelsat and Telstra. All of these systems operate in the 12/14 GHz frequency bands.[52]

3.48. The following are some examples of satellite offerings:

(a) Optus currently offers two satellite broadband access technologies.[53] 'SatWeb offers the option of either one or two-way high-speed access to the Internet, offering faster data speeds than ISDN and is an ideal solution for rural and remote communities... Customer sites can be activated quickly through the installation of the VSAT that provides a small ground earth station.' Available data speeds are up to 200 kbps and up to 400 kbps in the one or two-way option.[54]

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[52] ACA, submission no.19, p.19 and p.31.
[53] Optus, submission no.16, p.4.
[54] Optus, submission no.16, p.4.

(b) 'SatData delivers two-way point-to-point connectivity over satellite links offering reliability usually associated with dedicated 'data pipes'. The organisation can choose the pool of bandwidth necessary for its sites instead of being charged a fixed cost for bandwidth regardless of usage.'[55]

(c) 'SatData Star IP uses wireless to reticulate the service to the remote sites. 802.11 is the standard used for the service, utilising shared wireless spectrum… The high-speed data rates of 8kbps to 36Mbps ensure fast delivery of anything from multi-media presentations to e-mail and transactions based programs.'[56]

(d) The ArrayComm (CKW wireless) satellite telecommunication services involve 'a fixed wireless data service that uses 11 GHz TDMA technology. The return link limits upload speeds to 56kbps. Download data rates are about 400kbps to the user. While coverage is typically large, [the] systems only support fixed access due to the need for dish antennas and bulky receiver equipment'.[57]

3.49. Other satellite services are currently offered by Conxtel and Miraxis.

3.50. Ericsson told the Committee that:

> The ACA recently examined the costs of alternate services for providing USO services – satellite was considered the most suitable for providing services to customers 20km beyond local exchanges. It is therefore ideally suited to providing services in rural areas.
>
> As an outcome of a $150 million Commonwealth initiative, Telstra is progressively offering extended zone customers an Internet service that utilises satellite technology. Ericsson, via its relation with Hughes Network Services, is providing Telstra with the satellite equipment.[58]

3.51. Ericsson added: 'While broadband satellite is a wireless technology, it does not offer mobility to the end user. However, it

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[55] Optus, submission no.16, p.4.
[56] Optus, submission no.16, p.5.
[57] ArrayComm Inc. and CKW Wireless, submission no.11, p.9.
[58] Ericsson Australia, submission no.42, p.19.

is possible to combine satellite with wireless LAN to enhance mobility for the end user.'[59]

Conclusion

3.52. Many submissions and other inputs to the inquiry emphasised the diversity of technologies and the pace of change. The future will see a mix of various technologies and the market should be permitted to determine which ones best suit particular applications. While it is entirely appropriate for governments to set standards and allocate spectrum for particular uses, governments should remain technologically neutral with respect to developments in telecommunications.

[59] Ericsson Australia, submission no.42, p.20.

4. The inter-relationship of wireless broadband technologies

This chapter brings together information in preceding chapters to show how the various wireless broadband technologies are constrained by such effects as bandwidth, desired data rates, noise and co-channel interference, carrier frequency and propagation and mobility.

Background

4.1. Fundamentally, until more sophisticated SDMA research comes to fruition, any given band of frequencies cannot be used at the same time in the same place without suffering co-channel interference. The bandwidth capacity of radio spectrum in a clear channel is governed by the amount of spectrum available and the modulation scheme that encodes data into that spectrum. In the simplest case, if the RF power is equal to the noise power at the receiver, then the absolute maximum data rate achievable in bits per second is equal to the available bandwidth. For example, 1 MHz of bandwidth would pass 1 Mbps in this limit.

4.2. Moreover, there are limits to the data rate imposed by propagation characteristics such as multipath interference where a signal can interfere with itself. Given the existence of these major impairments which are virtually absent in wire-line systems, and the manner in which the spectrum assignments have been made, there are clear constraints on the operation of wireless systems. Moreover, the seeming advantages of wireless systems (such as mobility and free roaming) have their own technical and physical limitations. These affect the wireless broadband technologies discussed in chapter 3.

4.3. Much of the choice of wireless device for a particular application depends on the frequency band on which it is operated. This is directly affected by the ACA licensing regime. The various licences were discussed in chapter 2.

Bandwidth and data rates

4.4. The demand for bandwidth is driven by data rates and desired network capacity. Data rates generally refer to the number of bits per second achieved by the user. Of course, users connect through the network to a backbone which in turn has a capacity limit. For this discussion, we concentrate on the properties of wireless and

assume that the backbone is a wire-line connection of unlimited capacity.

4.5. Perhaps the highest data rates of all are currently enjoyed by LMDS. These have ~1 GHz of bandwidth and are suitable for short fixed LOS wireless links. These are the simplest physical conditions and just the same can employ quite high power as the system operates under a spectrum licence. The problem with handling this much bandwidth is that the channel has to be favourable. Multipath, non-LOS, humidity in the atmosphere for frequencies above 15 GHz, and co-channel interference all pose technical problems. This limits LMDS to the LOS local loop in small (generally < 5 km) areas.

4.6. 3G systems aim at using more bandwidth than 2G to provide amongst the lowest data rates in wireless broadband. These systems support large numbers of mobile users aiming to decrease cell size and maximise frequency reuse. They must not be limited to LOS (at least for man made obstacles) nor be weather dependent. Thus, their data rates are affected by a compromise on the bandwidth divided by the number of users and very sophisticated signal processing to eliminate the side-effects of the channel. They must operate under the worst conditions of multipath induced ISI (chapter 2) and serve rapidly mobile users (see further below).

4.7. Handheld mobility implies that antennas are small and suboptimal and that power levels are reduced in order improve battery life. Unwired Australia Pty Ltd urged caution about the potential of 3G systems on their own and at current bandwidths:

> …the very architecture of mobile systems and the limits on the amount of spectrum that are available to mobile systems imply that very few customers will ever really experience… [broadband] data rates with any reliability… [Further,] 3G services at 2.1 GHz are only ever likely to be provided in major urban areas because the signals are necessarily being received on low-gain mobile receivers. With such a short range, subscriber densities may not reach the levels necessary to sustain investment except in urban areas… [However, greater range can be obtained at] the 850MHz band… [and] 450MHz band.[60]

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[60] Unwired Australia Pty Ltd, submission no.41, pp.19-20.

4.8. The service provided by satellite will always be ultimately limited by footprint and the number of available (GEOS) satellites. Unlike cellular base stations and WLANs, their benefit comes from their large, rather than small, footprint. In the context of regional Australia this is not an issue. However, weather may be an issue as well as solar electrical activity induced noise.

4.9. Satellite technology has 'low capacity in terms of simultaneous circuits and data rate; long propagation delay (latency); low penetration inside buildings; high power terminal; [and] a range of standards'.[61]

4.10. The Northern Territory government submitted that satellite delivery systems display 'idiosyncratic behaviour' and are 'unpopular for voice communications because of the noticeable propagation delay'. Also, 'some business applications have proven to be difficult or impossible to run over broadband satellite services'. The most significant limitation identified by the Northern Territory government, however, is cost:

> Based on current commercial offerings, satellite broadband is almost twice the price of terrestrial services. This places those remote communities that need these services the most, but are too distant from an exchange to access terrestrial broadband, at a distinct disadvantage.[62]

4.11. Wireless LANs have over 80 MHz in the 2.4 GHz ISM band. This is adequate to produce multiple channels at T10 (10 Mbps Ethernet speeds) speeds. Thus as long as the power and the range is restricted, then with (at least) three non-interfering bands available, three networks can operate independently at the same location (chapter 3). Clearly, a large amount of ISM bandwidth is an important asset here, not just for data rates but also to minimise interference.

4.12. Other aspects of the perceived data rate are whether the connection is "always-on" and whether latency is an issue. Bandwidth will always be a limited asset. However, large bandwidth alone is not always what the customer wants. Evidence suggests that users tend to be attracted to the 'always on' character of wireless networks as well. This is especially true if one has considered upgrading to a higher data rate from a phone line that drops out many times per hour.

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[61] Alcatel Australia, submission 9, pp.9-10.

[62] Northern Territory government, submission no.38, p.3.

4.13. This has been noted by the National Farmers' Federation in its submission:

> The availability of broadband Internet access services is also becoming essential for small business including farm enterprises in rural Australia. An increasing number of small business case studies have identified instant "always on" access to information and services provided by broadband Internet access can deliver dramatic benefits to the business bottom line and also provide opportunities for farming and business practice improvements.[63]

4.14. Even for some low bandwidth applications such as voice and gaming, latency is an issue (chapter 2). For this, mobile phones are supremely adapted. On the other hand, latency effects can be quite annoying in some VoIP systems and satellite.

Noise and co-channel interference

4.15. The advantage of spectrum licences is that the band is your own private property. Given that you can operate with sufficient power and your network has been properly designed, then random noise and co-channel interference are never problems. This is mostly true of LMDS / MMDS, satellite and 3G networks.

4.16. Devices operating on the ISM bands, however, must not only avoid electromagnetic interference from industrial devices operating in their vicinity but also other communications devices. Generally, such communications networks are difficult to make absolutely reliable. By the same token, if sufficient application and research into a wide variety of devices and standards is allowed, then devices will evolve that support resilient networks in harsh environments. This is the case for Bluetooth and WLAN.

4.17. In relation to WLAN's potential, the following observation by m.Net Corporation may be appropriate:

> wireless LAN has yet to evolve into a robust carrier-grade technology and it is perhaps premature at this time to expect it to offer a viable last mile alternative.[64]

4.18. Conversely, it is clear that equipment can also mitigate interference by interoperation on the same network. It is therefore

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[63] National Farmers Federation, submission no.60, p.6.
[64] m.Net Corporation Ltd., submission no.39, p.3.

important for users to cooperate during the deployment of ISM band wireless networks.

Carrier frequency and propagation

4.19. The carrier frequency itself is not directly related to bandwidth; however,it is directly related to wavelength (chapter 2). The choice of wavelength has a strong bearing on the achievable range (distance) of wireless communications. Of course, if a Line-Of-Sight is available then virtually any distance is feasible (eg satellite). However, for terrestrial networks, the effects of the horizon and objects blocking a LOS between transmitter and receiver imply that repeaters have to be installed to repeat signals. The limitations of range are at their worst for LMDS and Ultra-Wide Band (UWB). In the latter case, communications occur in short (nanosecond range) impulses that are severely limited by dispersion in the channel.

4.20. As noted in chapter 6, however, long wavelength waves such as those in the analog TV bands (45 – 70 MHz or ~ 4.3-6.7 metres) promise long distance communications as a solution to the 'last mile' problem in remote and rural areas.

Mobility

4.21. The need to provide mobility for users introduces two problems. Firstly, a moving emitter of electromagnetic waves in general produces a change in the carrier frequency. This change is referred to as a Doppler frequency shift. 3G mobile telephone networks are designed to circumvent this effect in their signal processing. But not all wireless broadband technologies are resilient to arbitrary frequency shifts.

4.22. The second problem is network hand-off. Assuming that a network can always be found at any location of a user, there needs to be some way to hand the user off from one network to another. Again, this is an automatic requirement for 3G. Interestingly, there are software developments such as mobile IP (Internet protocol) and DHCP (Dynamic Host Configuration Protocol) that already allow roaming in IP networks such as WLAN networks.

Conclusion

4.23. The limitation of each type of technology when used on its own demonstrates that a mix of technologies is required. For example, while 3G technology may enable 'true broadband data rates in a mobile environment… [as well as to fixed locations, thus] conceivably offer[ing] last mile broadband connections, at speeds comparable to the lower end of ADSL'[65], it is just as likely that '3G mobility networks will not be able to cost effectively deliver the data rates demanded by complex Internet-based applications [and] will only be able to provide a mechanism for mobile data that is short, transaction-based and demands only low data throughput from the network'.[66]

4.24. The Committee draws two conclusions from this discussion. The first is the need for a 'horses for courses' approach to be taken in the use of spectrum and the choice of technology. It is clear that under different circumstances there is a need for high data rates, the transport of different kinds of data, mobility, long-range last-mile transmissions, low cost, a certain carrier frequency or operation on a crowded ISM band. No one wireless broadband technology will suit all these categories and there are several technology solutions in each category.

4.25. Moreover, the technologies are evolving rapidly[67] and in any evolutionary system, there must be sufficient biological diversity for natural selection to occur. It is desirable to 'let a thousand flowers bloom'.[68] Put another way, the Committee concludes that technological neutrality should be an over-riding goal for government and private enterprise.

4.26. The second conclusion drawn by the Committee is that the need to mitigate interference and to establish wider area, more profitable networking systems will lead to a constant emphasis upon network interoperability on ISM band networks.

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[65] m.Net corporation Ltd, submission no.39, pp.4-5.
[66] Cisco Systems Australia Pty Ltd, submission no.18, p.6.
[67] Motorola Australia, submission no.12, p.1.
[68] Dr Horton (Deputy Chairman), ACA, *Transcript*, 28 June 2002, p.137.

5. Comparison of wireless broadband technologies and wire-line systems

This chapter sets out key information about the performance of wireless broadband technologies compared to wire-line systems.

5.1. The two wireless technologies that can directly compete with DSL and cable for residential broadband access are wireless local loop (WLL) and satellite. Where a suitable fixed line exists, wireless broadband is not able to provide as reliable and robust a service as that fixed line. Further, 'the cost of delivering broadband bits over a fixed access network will almost always be lower than the cost of delivering those same bits over a wireless access network'.[69]

5.2. This is not true, however, for an 802.11 network where data could be transferred free of charge.[70] Usually, the rollout of wireless is always less expensive than wire-line.[71]

5.3. The following are widely recognised as key benefits of wireless technology:

- It is cheaper and faster to deploy and upgrade than a wire solution. For a wire-line solution, cabling and trenching are very expensive;
- Always connected - no tedious dial-in procedures and always faster than classical telephone dialup;
- Flexibility: the ability to connect anywhere without wires or sockets. This can promote efficiency gains in education and in the work place;
- Standardisation is much more of an issue and 802.11 is a global standard. Wi-Fi cards purchased anywhere in the world work anywhere in the world on standard networks;
- Mobile wireless technologies offer the additional functionality of access to telecommunications services while on the move. However, all IP wireless networks are mobile through mobile IP or DHCP (chapter 4);

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[69] Alcatel Australia, submission no.9, p.15.
[70] The Institute for Open Systems Technologies Pty Ltd, submission no.14.
[71] Australian Information and Communications Technology in Education Committee (AICTEC), submission no.35, p.15.

- 'Scalable architectures enable expanded coverage and services in direct relation to the level of demand'[72]; and

- Accessibility – 'Australia-wide accessibility makes broadband Internet via satellite the ideal solution for people who want high speed Internet access, but don't have access to broadband cable or ADSL services.'[73]

5.4. There are also limitations of wireless networks:

- They rely on the radio spectrum, which is a limited resource. Thus capacity has an ultimate limit;

- Interference and congestion on the ISM bands has to be avoided and latency is a problem with GEOS satellites;

- Data rates with wireless are lower than wire-line. However they are generally faster than the ubiquitous telephone line; and

- Spectrum is expensive for operators who wish to obtain unoccupied spectrum.

5.5. The view of one submitter was that:

> The reality of wireless broadband for at least the foreseeable future is that it is better suited for niche market deployment. There is absolutely nothing wrong with that. To the contrary, companies that are able to harness the customer benefits of these technologies and who are building the right customer bases around them will be very successful.[74]

5.6. The Committee concludes that, while wireless technologies are not superior to wire-line broadband, they have some specific advantages in certain circumstances. Wireless broadband should be seen as complementary to wire-line broadband, providing a service where wire-line solutions are too costly or difficult to install, providing a quick roll out of services where wire-line solutions (particularly optical fibre) may be some years away, and providing competition to wire-line services in some locations and for specific purposes.

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[72] Norlink Communications Ltd, submission no.50, p.7.
[73] Ericsson Australia, submission no.42, p.8.
[74] Paul Budde Communication Pty Ltd, submission no.2, p.2.

5.7. A key aspect is that certain wireless technologies such as 802.11 in the urban and regional networks and the VHF/UHF in the remote/rural networks have the potential to rollout with minimal cost. This is important because broadband in general has proven a difficult business case largely because of its less than impressive take-up. If, however, the business model for broadband can be made in advance at negligible base cost through a wireless rollout, then this may fund a broadband wire-line rollout with more impressive data rates and QoS in the longer term.

6. The potential of wireless broadband, including for last mile solutions

This chapter expands on the potential applications of wireless broadband in all contexts, especially for last mile solutions.

Wireless as an alternative to wire-line broadband

6.1. Commercial and business users are likely to be major early adopters of broadband, as the increased efficiencies and convenience offered by broadband can provide cost savings and improved services in many cases. Videoconferencing is an example of an application which can save on travel costs and increase efficiency for business.[75] Business and government also have requirements to transfer large amounts of data and use high bandwidth applications.

6.2. In some markets, wireless services are poised to compete directly with wire-line broadband. Unwired Australia Pty Ltd[76] and CKW Wireless / ArrayComm[77] will be deploying commercial services in the near future, starting in Sydney. Unwired Australia claims to be able to compete with Telstra in the local loop (ie the normal telephone network) as well as providing high quality broadband at competitive rates. Proponents of 802.11 also see this technology as a viable alternative to wire-line broadband. Others do not believe that wireless technologies can replace wire-line services but will always be providing niche services.[78]

6.3. There are many impressive claims made about the potential of wireless in this area, but there is limited evidence of sustained successful commercial exploitation of wireless technologies as an alternative to wire-line systems.

6.4. Despite some technical problems and the current high cost of services, in the near term, satellite appears likely to remain the only option for broadband (or narrowband in some cases) services for many locations in rural and remote Australia.

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[75] See article *Execs board virtual plane* from *The Australian* IT Section, 20 August 2002
[76] Unwired Australia Pty Ltd, submission no.41 p.2 and Mr Prins (Consultant, Network and Planning) *Transcript*, 28 June 2002, p.149.
[77] ArrayComm Inc. and CKW Wireless Pty Ltd, submission no.11 p.13 and Mr Rule (Board Director) *Transcript*, 8 August 2002, p.414.
[78] Paul Budde Communications Pty Ltd, submission no.2 p.3 and Mr Budde (Managing Director), *Transcript*, 10 July 2002, p.393.

6.5. The area of entertainment services is an area that is already driving demand for broadband and could provide the impetus for mainstream uptake. Services such as video on demand, on-line video games, video and audio streaming and interactive television are in this category, and these are mentioned in many submissions. An issue that is of concern to current users of these services is the pricing models carriers are currently using. These make high bandwidth applications such as on-line gaming more expensive in Australia than in other markets. This is one of the reasons behind the growth of interest in community wireless networks.

6.6. Broadband and wireless broadband in particular is having an impact, and has considerable potential, in the provision of education services.[79]

6.7. The most important goal for educational wireless systems is to provide Internet access everywhere on the campus with minimum infrastructure. The most common platform deployed in educational facilities is 802.11b (WiFi) because of its low cost, range, and flexibility. Some universities and schools are also experimenting with 802.11a, SMS and WAP, and some government schools in Victoria use LMDS combined with 802.11b to provide linked local and wide area networks. Individual staff at some universities and schools are reportedly using Bluetooth on their PDAs and laptops, but the penetration is hard to measure.

Wireless broadband as an advance scheme prior to extension/rollout of wire-line services

6.8. The main problem with the broadband rollout is its economic viability. If such things as spectrum licences, cable trenching, and further set up costs (eg satellite) put the technology beyond the means of the user or the margin of the provider, then rollout is bound to stall. It is clear that natural market oriented mechanisms have to be built into the regulatory system to make broadband rollout a self-starting process.

6.9. Some evidence points to the possible use of wireless technologies to bridge the gap between the current rollout status and the

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[79] Australian Information and Communications Technology in Education Committee (AICTEC), submission no .35 and Ms Parker (Executive Officer, AICTEC), *Transcript*, 2July 2002, p.269.

eventual rollout of fibre-optic, DSL or other more advanced wireless services in many areas. The philosophy is to take advantage of the very low set up costs afforded by certain kinds of terrestrial wireless: principally the ISM band devices such as 802.11.

6.10. Most wireless services have the advantage of being quick and relatively cheap to rollout once the hardware is at hand. On the ISM bands where a spectrum licence is not required, the equipment can also be inexpensive.

6.11. The workability of this mechanism for a "leading edge" role for wireless is evident in the grassroots activities already occurring. Startups such as Airnet in Adelaide and community groups like Melbourne Wireless both use the free-access 802.11b WiFi band to establish broadband data connections. This is especially important in those regional areas where wire-line has already made some in-roads and potential users are beyond the DSL / wire-line limit. WiFi can then be used to connect the user to the wire-line backbone.

6.12. In rural and remote areas, WiFi and other cheap technologies (such as those reliant on the vacant analogue VHF TV spectrum or Lucent's 450 MHz CDMA) could be deployed to create a sensible business case for establishing a proper backbone for the regional town centre. In regional Australia this backbone might be fibre, whereas in remote Australia, where the centre may be a small isolated town, it would more than likely be satellite.

6.13. The main regulatory driver for this process is to eliminate barriers to the take-up of wireless, such as the need for carrier licences on the ISM bands, if possible allow spectrum for 450 MHz CDMA and make available unused TV spectrum for rural wireless links (see later in this chapter).

6.14. It is widely accepted as well that broadband needs an application in order for the public to adopt it.[80] For example, the CSIRO proposed in its testimony that pilot studies or demonstrators could be employed to promote broadband take-up.[81] Such demonstrators could only be cheaply implemented using a wireless rollout.

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[80] Mr Simmons (General Manager), Soul Pattinson Pty Ltd, *Transcript*, 10 July 2002, p.383.

[81] Dr Bird (Sector General Manager, Information and Communication Technologies, Telecommunications and Industrial Physics Division), CSIRO, *Transcript*, 13 June 2001, pp.12-13.

6.15. It is thus possible to imagine a market scenario wherein rapid-rollout of wireless is used outside the boundaries of DSL service areas to "pull" broadband access out to fringe areas and thereby stimulate demand for the extension of DSL coverage. In some cases, after the arrival of DSL or other wire-line in the region, the use of wireless could well taper off. In a similar scenario, ISM band wireless might pave the way for a higher quality wireless service based on a spectrum licence yet still offering a viable business case due to the market share established in the ISM rollout phase.

Wireless broadband "niche" services in metropolitan areas

6.16. Paul Budde sees wireless technology as being a "niche" technology, being particularly suited to certain situations but not the main choice for broadband, which will be wire-line.[82] Specific examples of this type of service include wireless "hot spots" in airport terminals and hotels for business travellers and in Internet cafes. Mr Budde does not believe wireless can ever achieve more than 30 per cent market penetration (a minimalist view).

6.17. There is a consensus about the suitability of wireless technologies for niche market services. Telstra's recent announcement of a partnership with Skynet Global is further evidence of the suitability of wireless technology for niche services (Skynet Global specialises in wireless LAN travel hotspots).

Wireless broadband for mobile users

6.18. The development of some technologies has been driven by so-called "killer applications". The demand for these applications has led to a drop in average prices, encouraging even more demand and the development of additional applications. Whether wireless broadband technology requires a "killer application" is open to question. It might be said if wireless broadband were affordable enough there would be considerable demand. Wireless broadband for mobile users may become such a killer application", reflecting the demand for 'always-on', two-way, high-speed, voice and data communication, including for spatial information.

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[82] Paul Budde Communications Pty Ltd, submission no.2 p.1 and *Transcript*, 10 July 2002, p.399.

6.19. Although the future of 3G is uncertain (particularly in light of the extremely high prices paid for spectrum in many countries), it is possible that 3G mobile applications could prove very attractive to consumers. These include mobile videotelephony, mobile Internet and e-mail, integrated e-commerce and enhanced PDA applications. Simply Wireless provides some interesting "scenarios" which are intended to display the potential of Bluetooth technology and demonstrate the ideas for 3G mobile telephony. [83] Ericsson is very enthusiastic:

> What does 3G offer? Watching cartoons, doing the laundry, taking photos, playing with the kids, designing graphics, sitting in traffic, knowing where you are in faraway towns in the busiest of streets, chatting in the gym, starring on the small screen, enjoying mysteries, love stories, soaps and playing games, solving puzzles, glimpsing life-changing news, organising a life lived seamlessly on the move, checking shares, opening an account, walking in warm rain, just wondering aloud.[84]

6.20. Fast, always-on Internet is an obvious application but the level of demand for it has been questioned at times. However, it is significant that statistics on broadband show that once people obtain this service they tend to keep it. This contrasts with some other recent communications developments in Australia (pay-TV in particular) where the rate of "churn" (ie people not maintaining a service long term) is very high.[85]

6.21. One of the most popular wireless data applications currently in use is Global Positioning or GPS. There is considerable potential for spatial data applications to use wireless broadband technologies:[86]

> Wireless technologies applications are used by broadband hungry spatial information services… [which include] mobile location-based services, customer relationship management, environmental monitoring and the management of natural resources, assets, land and emergencies… Spatial information users are at the high end of the broadband usage

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[83] Simply Wireless Pty Ltd, submission no.4, pp.12-15.
[84] Ericsson Australia, submission no.42, p.7.
[85] Mr Budde (Managing Director, Paul Budde Communications Pty Ltd), *Transcript*, 10 July 2002, p.395.
[86] Intelligent Transport Systems Australia (ITS), submission no.24.

> spectrum, so availability of affordable bandwidth is of particular concern to spatial data users.[87]

6.22. Intelligent Transport Systems Australia (ITS) described the uses of wireless in modern transportation systems. Many of the functions, such as data and voice messages, are not strictly broadband. But intensive use of wireless broadband will become an important factor in transportation over the next 5-10 years, as is its use for navigation, safety, road toll collection, and system monitoring:

> Telematics is the application of information and communications technologies to the enhancement of safety, security and efficiency of vehicle operations. It covers the essential vehicle segment of the ITS domain.
>
> Automobile manufacturers have announced that all new cars will have ITS systems of one form or another fitted. Of these a significant proportion will rely on external communications and / or other forms of RF transmissions. There will be significant overlap between ITS and Telematics.
>
> One forecast proposes that by 2006 about 50% of new cars being sold in the US, Western Europe and Japan will be telematics-capable. In Japan alone, 8.8 million vehicles are fitted with car navigation, and five million of these are supplied with real time traffic information free of charge.
>
> Telematics applications will be based on permanent or long-duration packet-switched connection to the Internet. Wireless mobile Internet [WMI] is under active development and will be widely available in the next 2 to 3 years.[88]

6.23. For transportation uses, coverage and range are critical. The use of high-bandwidth telematic systems in Australia will track the development of 3G mobile networks.

Wireless broadband for the hearing-impaired

6.24. The Committee received evidence from several witnesses on the potential for wireless broadband, in particular 3G, to provide

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[87] Commonwealth Office of Spatial Data Management, submission no.6, p.1.
[88] Intelligent Transport Systems Australia (ITS), submission no.24, p.9.

enhanced services for the hearing impaired. Videotelephony is one application which, if provided at a high enough standard, could be of great benefit to the hearing impaired. However, compatibility with current TTY equipment and lack of planning for hearing-impaired access to these technologies is a significant issue. TTY equipment is not currently compatible with WLL and hearing-impaired people actually lost services with the move from analog to digital mobile telephones.[89]

6.25. The Committee recommends:

that the Commonwealth develop the means to provide hearing-impaired people with mobile telephones compatible with hearing aids, portable wireless devices that can communicate through the National Relay Service, and appropriately adapted video compression and transmission technology for video communication using sign language.

Wireless broadband in remote areas

6.26. Some submitters stressed the usefulness of wireless broadband to improve audio-visual communications in remote areas, eg the Northern Territory government submitted that:

> Wireless technologies may… provide an opportunity for the emergence of community or regional based organisations that could provide broadband reticulation in [remote] communities [in the Northern Territory]… Indigenous societies are non-literal and rely heavily on audio-visual means for communication. Broadband technologies will provide the necessary bandwidth to deliver better outcomes to these remote areas in a manner that is targeted to the consumer's needs and culturally appropriate.[90]

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[89] Australian Association of the Deaf Inc., submission no.8 and 8.1; Australian Communication Exchange Ltd, submission no.13, Telecommunications and Disability Consumer Representation (TEDICORE), submission no.37. Also see Mr Harper (Deaf Telecommunications Access and Networking Project Officer, Australian Association of the Deaf), *Transcript* 13 June 2002, pp.36-48 and Ms Astbrink (Policy Adviser, TEDICORE), *Transcript* 9 July 2002, pp.305-313.

[90] Northern Territory government, submission no.38, p.1.

The potential to provide a last mile solution

6.27. Wireless has the potential to replace wire-line due to the simplicity and low cost of wireless installations. Wireless could enhance the business case for broadband and so stimulate a wire-line rollout. It is at the last mile—called by one witness the "first mile" because it is the most important mile for the user[91]—that cost and technical hurdles often arise. It is likely that wireless technologies will provide a last mile solution in many cases but it is too early to tell how successful wireless will be in this area.

6.28. The National Farmers Federation is very optimistic on this point:

> Australia cannot afford to miss the opportunity to provide broadband services from a wireless perspective to offset a number of the telecommunications service inequities that exist at present.[92]

6.29. The National Farmers Federation stress that there is already a lot to be gained from 'broader band'. This is a service that would be higher speed than dialup but perhaps not up to some interpretations of broadband.

6.30. The key to the last mile problem is likely to be found in a mixture of technologies, both wire-line and wireless. With respect to wireless technologies, Unwired Australia Pty Ltd considers that:

> there are only three general classes of wireless broadband that are technically feasible and, in respect of the technology, economically viable today:
>
> - 3G mobile telecommunications system based on CDMA 2000…
>
> - fixed wireless access over the last mile; and
>
> - wireless local area networks (WLANs) and personal access networks (WPANs) based on low-powered shared use of ISM bands…
>
> [All] three technologies are very different in their attributes… [and none] can substitute for another… [S]ignificant value-adding can be achieved by

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[91] Mr Budde (Managing Director, Paul Budde Communications Pty Ltd), *Transcript*, 10 July 2002, p.410.
[92] Mr Needhan (Policy Manager, Telecommunications), National Farmers' Federation, *Transcript*, 21 August 2002, p.472.

> leveraging the synergies between them in terms of delivering broadband services any time, any place.[93]

New wireless technologies for rural last-mile links

6.31. Several organisations are experimenting with new digital wireless technologies with the potential to provide last mile connections in rural Australia, where the last mile can be 50 km long.

6.32. The National Farmers Federation has requested: 'It would be good to see the introduction of more technologies that provide [the] 64 kilobits… [required] under the current digital data service obligation.'[94]

6.33. Several technologies are being proposed as last mile solutions that had perhaps never been considered previously. These include the following:

(a) Nortel Networks proposes developing a progressively modified 800 MHz CDMA system (a 3G technology) based on existing CDMA infrastructure, and expects it to be able to provide both mobile and fixed wireless data access for 97% of the Australian population.[95] Telstra has shown an interest in this solution as an add-on to their existing CDMA infrastructure.

(b) Lucent proposes to develop 450 MHz CDMA for large area broadband coverage. Lucent 'strongly believes… [it] can provide effective and economic Internet access to under-serviced regional and remote communities.' This involves some significant redeployment of (and cost for) existing users of this spectrum:

> Throughout Australia, much of the 400-500 MHz spectrum has hosted private trunking radio systems, typically serving industries such as construction, taxis and oil, as well as government agencies. These are primarily low-capacity analogue systems providing group voice communications with minimal data capability. Globally, private trunked radio has seen relatively little innovation and growth, at the same time cellular has grown explosively. The migration

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[93] Unwired Australia Pty Ltd, submission no.41, p.15.
[94] Mr Needham (Policy Manager, Telecommunications), National Farmers Federation, *Transcript*, 21 August 2002, p.474.
[95] Nortel Networks, submission no.21.

> path for these services may be to a common, more spectrum-efficient, packet mobile solution.[96]

(c) The ANU BushLAN group is doing research on the two-way transmission of Internet data over non-line of sight paths using vacant channels in the 45-70MHz TV band. Channels within this band are allocated regionally, and there are always vacant channels in each region. The channels below channel 6 will be progressively abandoned in urban Australia in coming years. The trials have produced some impressive results. The Committee was told that this technology could also be used over digital television spectrum.[97] The ANU notes that:

> Recent Australian research suggests that low-power (<100 W), very high frequency radio waves with frequencies of 45-70 MHz could be used for the wireless transmission of Internet data over non-line of sight distances of 3-100 km in regional Australia at speeds>100 kbps…
>
> [Such] low frequency waves in the very high frequency range potentially provide an elegant solution that is not burdened with the line of sight problems of microwave or the infrastructure costs of satellite…
>
> Such alternative "last mile" links could provide a low-density population of rural users with Internet access speeds like those available to modem users in urban regions. While the data rates would be lower than those of satellite and line of sight microwave links, their infrastructure costs would be much lower.
>
> Co-operation of data communications with presently operating analogue TV transmission on channels 0,1, and 2 can be achieved by locating the data services on locally unused channels… and by using spread-spectrum techniques to reduce interference to negligible levels.[98]

(d) Baltech Pty Ltd is also researching the use of VHF channels for Internet data transmission:

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[96] Lucent Technologies Australia Pty Ltd, submission no.28, pp.8-9.
[97] Mr Bray, *Transcript*, 8 August 2002, p.465.
[98] Gerard Borg, Jeffrey Harris, Haley Jones, Anthony Cook, Andrew Cheetham, John Rayner, and John McInerny, submission no.1, pp.1-3.

> We have been developing… a new radio frequency modulation capability that is based on Orthogonal Frequency Division Multiplexing (OFDM) techniques…
>
> With access to wider VHF bandwidth we will be able to deliver very high EDT rates. For instance, with access to a redundant 5 MHz VHF broadcast channel, we will be able to deliver a 10 Mbps or more EDT rate; and again with the use of smart antenna technologies, we could increase this figure…
>
> The OFDM solution is just as apt for narrow VHF channels such as 100 KHz channels, where potential 100Kbps or more is achievable.[99]

Baltech called for government funding of these research efforts:

> To fully develop the VHF/HF modulation technology for rural, remote and regional wireless broadband communications will require $1.3 million over two-three years. Access to existing broadcast VHF/HF infrastructure would be required…[Also,] funding will be required to complete the development of the smart antenna technologies. Funding will also be required to develop the upgrade modules to modify existing customer VHF/HF transceivers and antennas and/or develop new low-cost customer receive and transmit equipment and associated customer antenna arrays.[100]

(e) ntl has conducted trials of an asymmetric system (modem uplink, fast wireless downlink) called 'Bushnet' which uses vacant VHF and lower UHF using digital TV (DVB: Digital Video Broadcast) standards and hardware, and finds they can achieve data rates near those of satellite links.[101] Ntl considers that the main barrier to commercial deployment of such a system is uncertainty about access to vacant TV spectrum.

6.34. Four of the above proposals use frequencies below 500 MHz (Lucent CDMA 450, BushLAN, Baltech and Bushnet) and so would need to use spectrum presently assigned to other uses. The CDMA 450 scheme would have to displace or co-exist with mobile radio, while the other schemes are based on using vacant channels in bands presently assigned to TV, some of which will

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[99] Baltech Pty Ltd, submission no.30, pp.2-3.
[100] Baltech Pty Ltd, submission no.30, pp.2-3.
[101] ntl Australia Pty Ltd, submission no.25.

become completely unused with the advent of digital TV. Access to spectrum is the main issue blocking further development of these technologies at this time.

6.35. **The Committee recommends:**

that the ACA and ABA develop a scheme to allow the use of unallocated VHF and low UHF TV channels for rural wireless broadband links, and that they examine the possibility of allocating spectrum in the 400-500 MHz range for CDMA-450 on, at least, an experimental basis.

7. Telecommunications regulation and wireless broadband technologies

This chapter sets out the effect of the existing telecommunications regime on the use and development of wireless broadband.

7.1. The two key pieces of legislation affecting the telecommunications regulatory regime are the *Radiocommunications Act (1992)* and the *Telecommunications Act (1997)*. Parts XIB and XIC of the *Trade Practices A*ct are also important.

7.2. Regulation of the radio spectrum is complex, and serves a multitude of needs. The ACA notes that there is a general bias in the current regulations towards wire-line communication over wireless, in spite of the tremendous growth in the use of wireless technology of recent years (indicated by the fact that the mobile phone network now carries more voice traffic than does the wire-line network). [102] Historically, wireless has been a means of broadcasting and voice communications, and interactive services have primarily developed over wire-line networks until now.

7.3. The following specific issues were raised during the inquiry:

- Requirement for a carrier licence for wireless networks connected to the Internet;
- The regulatory distinction between wireless and wire-line carriers;
- Carrier licence exemption for non-commercial carriers;
- Education about options available under the law;
- Security issues;
- Certainty with respect to access, prices and terms;
- Regulation of the local loop market and investment in wireless broadband;
- Protection of the commons;
- The spectrum auction system; and

[102] ACA, submission no.19, pp.6-7.

- The tenure of spectrum licences.

Licence fee requirement for 802.11 (and all ISM band) wireless Internet connection

7.4. At present, a carrier licence is required by any person who uses a "network unit" to provide communications services to the public. This requirement is intended to be technology-neutral and to apply equally to any means of provision of such services (whether by wire, optical fibre, satellite or radio system).[103]

7.5. An issue which is of considerable concern to groups such as Melbourne Wireless[104] and Brisbane Mesh[105] is the perceived requirement for such groups to have a carrier licence to connect to the Internet. Currently, these groups, which operate or are planning community wireless networks in the ISM bands, are able to connect to members within the network without a licence. However, to connect this network to the Internet currently requires a carrier licence to be allocated. These licences are costly and require licence holders to undertake quite significant service obligations and reporting requirements. In short, carrier licences are designed for large companies operating major networks and are not suited to community wireless operators.

7.6. The ACA suggested that the Committee consider a number of measures to improve this situation including a dual-tier licensing regime. The ACA provided the following description of the implementation of the Act:

> The Telecommunications Act does not separately treat access systems from core transmission systems. Core transmission tends to be the specialised domain of major operators that are usually carriers. However at the point of access (customer access network) conditions and arrangements are different from those of the core transmission network.[106]
>
> The phraseology and approach of the regime presumes large-scale operations and it is built around precise interpretation of the legislation. These features militate against niche operators. For example, the

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[103] ACA, submission no.19, p.8.
[104] Melbourne Wireless, submission no.3 and Mr Clugg (Treasurer), *Transcript*, 2 July 2002, p.236.
[105] Mr Leonard, speaking about Brisbane Mesh, *Transcript*, 9 July 2002, p.297.
[106] ACA, submission no.19, p.39.

> grant of a carrier licence imposes a set of obligations that is necessarily inflexibly applied…
>
> The current regime provides for only one scale of carrier operation, however, many potential new entrants are, at least initially, small scale. Businesses would wish to apply telecommunications technologies as conveniences to complement their primary business. In this, they do not see themselves as a telecommunications operator of any kind, although the regulatory regime classes them as such. A dual-tier licensing regime could be considered in order to assist entry. For example, some requirements of being a carrier under the current regime could be set aside until a threshold of scale (customer base or revenue) is reached. Requirements that could be considered for setting aside (or reduction) include:
>
> - annual licence fee and line application fee;
>
> - contribution to the USO, NRS (and associated reporting);
>
> - provision relating to aspects of telecommunications interception, number portability and pre-selection (where the latter two are relevant);
>
> - compliance with the Customer Service Guarantee…
>
> Scale and circumstance should be considerations in assessing whether… a business or enterprise should be required to hold a "full" carrier licence. Some relevant exemptions already exist as Ministerial regulations, and a devolution to the ACA would be a logical additional flexibility for the regime.[107]

7.7. The ACA noted that the carrier requirements had been represented to it as significant issues for small companies, especially in the "start-up" phase. It also pointed out that such enterprises test innovative new technologies and that 'the fostering of such start-up enterprises would result in wider testing both technologically and commercially of solutions that may be attractive to initially niche and perhaps later the broader community'.[108]

The ACA also pointed out that:

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[107] ACA, submission no.19, pp.7-8.
[108] ACA, submission no.19, p.44.

> Wireless LAN users presently would have no protection under the *Telecommunications Act* or the T(CPSS) Act if they use WLAN based services where the owner of the network units has neither a carrier licence nor an 'NCD' (nominated carrier declaration) in place. This means that as an end user they would not be covered by any of the usual consumer safeguards that apply to other licensed telecommunications services, including recourse to the Telecommunications Industry Ombudsman for complaints, and protection under the various telecommunications industry codes.[109]

7.8. Many submitters made comments in a similar vein. The CSIRO referred to the ACA requirement that a wireless Internet service provider be a carrier if it had paying customers and stated that the high carrier licence cost (from $10,000) tends to reduce the participation of small ISPs in providing broadband access. The CSIRO thought that:

> …this may be a contributory cause to the low penetration of broadband in Australia at the moment. A change in the regulatory regime may ameliorate this situation.[110]

7.9. m.Net Corporation remarked that Internet service operators using IEEE 802.11 standard WLAN technology:

> …are subjected to all of the provisions for carriers under the *Telecommunications Act*. This would include customer service guarantees, which may prove risky given the vulnerability to interference of outdoor WLAN technology.[111]

7.10. Miraxis (a company offering satellite TV and two-way data communications service) suggested that the impact on small-scale entrants could be minimised 'until the proposed system is deployed and/or revenue generation operations have commenced'.[112]

7.11. The Government of South Australia expressed concern that the 'high cost and onerous conditions' of comprehensive Telecommunications Carriers licences 'effectively preclude participation by community groups, small businesses and firms

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[109] ACA, submission no.19, p.44.
[110] CSIRO Telecommunications and Industrial Physics, submission no.27, p.8.
[111] m.Net Corporation Ltd, submission no.39, p.5.
[112] Miraxis, LLC, and Miraxis Australasia Pty Ltd, submission no.58, p.9.

for whom provision of limited wireless service is a non-core business'. The government's submission continued:

> An example of the latter is marina operators wishing to provide a practical LAN service to their floating customers. Some sort of limited low / no cost licence would seem appropriate in such cases.
>
> Such a "restricted" licence would of course have to meet all of the statutory requirements such as interception, technical standards, etc. The ACA is best placed to be able to determine these, possibly on a case-by-case basis.[113]

7.12. One solution may be for case by case exemptions to the carrier licence requirement to be granted, as is provided for in the *Telecommunications Act.* A submission by Peter Lange of Network Consultants Telecommunications (a firm based in Germany) pointed out that varying degrees of regulation are required for different technologies to prosper. He recalled that revolutionary developments always require fundamental rethinks of the legislation. He noted that in the USA there are no restrictions and licensing requirements with regard to 802.11 wireless LANs. Not so widely known is the fact that this is also the case in many European countries (including Austria and Switzerland):

> It has not come to our knowledge that users of other low power devices in the same frequency bands…have been adversely affected by this in these countries.[114]

7.13. The Committee was told that Britain recently 'decided to open up the class-licensed 2.4 GHz spectrum to commercial operation of wireless LANs (eg. 802.11), including the provision of wireless Internet access to the public, and to significantly reduce or eliminate completely the licensing barrier.'[115]

Distinction between wireless and wire-line carriers

7.14. The ACA submitted that an unforeseen effect of the telecommunications regulatory regime was to require a carrier licence to be obtained wherever a wireless connection was used, whereas no carrier licence was required for wire-line systems

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[113] Government of South Australia, submission no.52, p.1.
[114] Network Consultants Telecommunications, submission no.40, p.2.
[115] Network Consultants Telecommunications, submission no.40, p.2.

having a cable distance of 500 metres in a single section or five km in multiple sections:

> If users have migrated from cable to wireless on the basis of their misunderstanding of regulations, they would now be considered to be non-compliant with the licensing requirements of the *Telecommunications Act*. This raises significant licensing and prospective enforcement issues for the ACA and the multitude of business users who have acted on this interpretation of that Act. [116]

7.15. The ACA argued that the wireless and wire-line provisions of the *Telecommunications Act* should be aligned: 'setting range or premises-based tests provides another threshold below which regime requirements [could be] reduced'.[117] The ACA suggested an interim solution would be for the Minister to make a Determination under s51 of the Act:

> …to exempt wireless equipment from carrier licensing where the end users are on the same premises as the wireless equipment or alternatively, for alignment with cable, within 500 m or if relay radio links are involved, within maximum aggregate range of five kms.[118]

7.16. The Committee agrees that the regulatory regime should not favour wire-line technology over wireless technology. The Committee therefore welcomes the announcement, on 19 September 2002, by the Minister for Communications, Information Technology and the Arts that he had signed a Ministerial Determination to make the carrier licensing obligations of the Act operate in a technologically neutral manner:

> Prior to the Determination, wireless equipment used in Internet cafes (or Hotspots) could be subject to carrier licensing obligations, which would not apply if the same business had been using cables to network its computers.
>
> By treating wireless technologies similarly to cable-based networks, businesses using wireless technologies will not be unfairly disadvantaged by the carrier licensing obligations. This will encourage new

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[116] ACA, submission no.19, p.42.
[117] ACA, submission no.19, pp.7-8.
[118] ACA, submission no.19, p.42.

> players to enter the market and develop innovative technologies that will boost the Australian ICT sector.
>
> The Government recognises that wireless technologies offer significant benefits for consumers - with the potential to become a significant alternative broadband access technology in Australia.[119]

7.17. The Committee is pleased with the Minister's action.

Carrier licence exemption of non-commercial carriers

7.18. The ACA expressed concern about the present legislative provisions affecting the exemption of non-commercial carriers:

> [A base station] is not considered to be part of a terrestrial radio communications customer access network if the network is used, or in use, for the sole purpose of supplying carriage services on a 'non-commercial basis'.
>
> It is important to note that the non-commercial purpose for which the base station is used must be the sole purpose for its use in order to attract the exemption…
>
> Note that under this test there is no specific reference to the treatment of an incorporated not-for-profit group.[120]

7.19. The following anomalies were said to arise from this form of exemption and to require an amendment of the Telecommunications Act:

> …a business could use its telecommunications network for its own commercial purposes. Accordingly if the wireless equipment in question forms any part of the overall network of a business, it would necessarily fall outside the exemption…
>
> Similarly, where an individual has joined with others in a non-commercial arrangement for carriage services, the fact that the individual uses his or her

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[119] Media release by Senator the Hon Richard Alston headed 'Wireless regulation encourages innovation' dated 20 September 2002.
[120] ACA, submission no.19, pp.37-38.

> own equipment for a purpose other than that non-commercial supply, eg running a small business from home, is itself enough to take the equipment outside the exemption.[121]

7.20. The ACA pointed out that drawing the distinction between 'commercial' and non-commercial' is sometimes difficult and depends on the circumstances of the case. The ACA argued in favour of being allowed some discretion:

> This approach would mean that:
>
> - hobbyists and community users such as cooperatives, as long as they could meet [certain] tests, would not be considered as commercial, would be exempted from licensing and this would not dampen innovative use of the technology;
>
> - small business users such as small Internet service providers (ISPs) in regional and rural areas who meet the test as being "commercial" would require a carrier licence; and
>
> - the policy outcome is equitable in the sense that the commercial and regulatory requirements of CSPs providing Internet services using their own network units – cable or wireless – is comparable.[122]

7.21. Not surprisingly, community based wireless organisations were also deeply concerned about the present provisions, with one submitter stating that:

> The requirement for a carrier licence to interconnect a community wireless network with the public Internet is a show-stopper for nearly all communities wanting to take advantage of the WLAN explosion.[123]

7.22. Melbourne Wireless considered that any question about the legal position of non-profit, non-commercial community organisations needs to be resolved. It stated that its operations as a carrier of Internet traffic for its members may already be legal since:

- the band in which it intends to operate is already designated for industrial, scientific and medical uses; and

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[121] ACA, submission no.19, pp.39-40.
[122] ACA, submission no.19, pp.40-41.
[123] Mr Bray, submission no.31, p.3.

- it is a non-profit organisation with terms of incorporation which prevent it engaging in commercial activities.

7.23. However, it was concerned that the establishment of its wireless network could bring it within the scope of the *Telecommunications Act* and requires payment for a carrier licence:

> …the establishment of a wireless network would appear to constitute a "a designated radiocommunications facility" and under s28(1) of the *Telecommunications Act 1997* would be considered a "network unit"". Under s42 of the *Telecommunications Act 1997*, a network unit cannot be used to supply a carriage service to the public unless the owner of the network holds a carrier licence…
>
> A further problem concerns the ownership of the network unit. Since each person in the network would be using equipment (a wireless card, antenna and connecting cable) supplied and owned by that person, everyone connected would own the network. Depending on the circumstances, Melbourne Wireless may own part of the network or may own none of the network…
>
> The power that would commonly be used is about 30 mW and is generated using voltages no higher than those used in a pocket flashlight or laptop computer. At this power level, signals would be highly unlikely to cause interference to other services, whether within the frequency segment or outside it.[124]

7.24. Another submitter, Mr W J Miller, voiced similar concerns, associating public switched telephone network (PSTN) with carriers:

> Where wireless technology using equipment covered by a 'spectrum licence' such as 2.4 and 5.6 GHz (802.11) DSSS network cards operating in the associated ISM frequency bands, is used by community groups or ISPs to provide Internet services, then those groups should be exempt from registering as a Telecommunications Carrier. Such Internet services would include WWW, e-mail, messaging, video conferencing and telemetry / security services.

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[124] Melbourne Wireless, submission no.3, pp.13-14.

> The Minister could issue such an exemption in much the same way as is currently done to allow "spectrum licensed" radio equipment.
>
> Where such equipment is used to provide VOIP telephony services, and the associated telephone numbers are accessible directly from the PSTN network, then registration as a Telecommunications Carrier would still be required.[125]

7.25. **The Committee recommends:**

that the requirement for carrier licences on the ISM bands be eliminated for both commercial and non-commercial operation. This will allow Australian broadband customers easier access to WLAN as a broadband alternative, and also enable Australian wireless engineers to compete with overseas entities in this burgeoning field. ISM band power limits should remain unchanged unless an exemption applies in non-metropolitan areas (see the Committee's later recommendation in this regard).

Education about the options available under the law

7.26. Given the subject matter of the inquiry, there is a surprising lack of knowledge about some of the options available under the legislation. This is most likely the result of the large number of people now becoming involved in this area without a professional communications background. A public information campaign may be necessary to inform people about the regulatory situation in regard to wireless broadband technologies. It would be useful if both carriers and non-carriers took advantage of such programs.

7.27. For those contemplating the delivery of a service that might attract a carrier licence, one option would be that the carriage service provider obtains a trial certificate for a six month (extendable) licence for the trial of a service.

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[125] W.J.Miller, submission no.22, p.2.

7.28. **The Committee recommends:**

that the ACA provide education programs for prospective wireless operators. These programs should explain the technologies, the law and ACA services.

7.29. The Committee is aware that the provision of ACA-sponsored education programs cannot address all the business needs of prospective wireless operators, many of whom could benefit from a greater knowledge of the market and customers. It is important that the government ensure appropriate training programs are in place to meet this need.

7.30. **The Committee recommends:**

that the Minister for Communications, Information Technology and the Arts ensure training programs are in place to increase the knowledge of prospective wireless operators about the wireless market and customer requirements.

Security issues

7.31. Two types of security issues are raised by wireless broadband: data security and national security.

Data security

7.32. While the security of data over a WLAN is of general concern, it is important to be aware that the same data securitisation software is available for IP based wireless technologies (such as WLAN) as is available for wire-line. In this regard, Xone noted that:

> …while much fear, uncertainty and doubt has been spread about Wi-Fi security, Xone believes it is, in fact, a neutral issue for the following reasons: first and foremost, Wi-Fi is a layer 2 ie a link layer technology (using the OSI model), equivalent to the Ethernet protocol in corporate networks and the carrier protocol in satellite networks. Network architects have long regarded the link layer as insecure. There is nothing new in this. Being a radio network simply adds a degree of "observability". However, no network architect worth his salt would assume the link layer to be secure or even perform security at the link layer. Most network security is done at the layer above, the network layer, or even higher at the transport and session layers. Therefore the security and authentication systems that today

> protect corporate and public Internet networks and service providers are more than adequate. These include mechanisms such as Virtual Private Networks, Radius Access and Authentication (AAA) servers and Secure Socket Layer (SSL / https) used by banks to secure Internet banking. Xone allows, in fact encourages, everyone to come to our "front door", ie the wireless link. We want access to be as easy as possible. We secure the process from the front door onwards using standard IP carriage service provider security systems.[126]

National security

7.33. The Australian Security Intelligence Organisation (ASIO) expressed some concern over proposals to relax the licensing regime by amending the definitions of 'designated radio communications' facility or 'network unit', or by exempting a class of broadband access providers under s51 of the *Telecommunications Act*. ASIO noted that wireless broadband access networks would inevitably increase user anonymity, possibly adversely affecting the policy objective that 'all carriage services, unless exempted, should be interceptible'.[127]

7.34. The Committee considers that—just as with the introduction of analogue phones—detailed consideration should be given by regulatory bodies to security issues before the widespread adoption of new technologies that have the potential to be used illegally against Australians.

7.35. **The Committee recommends:**

that the ABA, ACA and law enforcement agencies establish a standing bureau (or working party) to maintain a watching brief on the potential for Wi-Fi and other ISM networks to be used for illegal activities.

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[126] Xone Pty Limited, submission no.56, p.8.
[127] ASIO submission no.55.1, p.2.

Certainty in relation to access prices, terms and conditions

7.36. There are issues about the manner in which the ACCC uses the *Trade Practices Act* to enforce the level, and possibly price, of services for the benefit of broadband end-users. One issue appears to be the retrospective nature of these rulings. Providers can devise and implement a business model and be unaware and uninformed about a pending ruling under the *Trade Practices Act.*

7.37. Telstra drew the Committee's attention to the power of the ACCC under Part XIC of the *Trade Practices Act* to declare a service to be the subject of regulated access if declaration would promote the long-term interests of end-users. Declaration causes providers of the service to be subject to 'standard access obligations'. The terms and conditions of access are to be agreed between the provider and the access seeker, with the ACCC being able to arbitrate in the absence of such agreement.

7.38. Telstra stated that Part XIC of the *Trade Practices Act* creates uncertainty for potential investors about: whether the infrastructure could become the subject of a declaration by the ACCC; and, if so, what the access terms and conditions could be. The argument was made that a number of services have been 'declared' contrary to Parliament's intentions – where the market already provided for the competitive supply of services. Telstra argued that the standards for declaration are too vague and that there is a need for legislative guidance concerning the pricing principles that the ACCC may apply:

> [Also,] regulated access regimes such as Part XIC of the Act carry with them substantial risks of regulatory error… [which can] create considerable scope for incentives for investment to be distorted from efficient outcomes… [For example, if] access prices are set too low by a regulator… new entrants into the market may be encouraged to "buy" access from another market player, rather than invest in new technologies that may be more efficient.[128]

7.39. Telstra advocated it should be possible to 'quarantine' certain new infrastructure from the effect of Part XIC of the *Trade Practices Act* and also that it should be possible to involve the ACCC in a pre or post-investment undertaking and require it to

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[128] Telstra, submission, pp.14-18.

adhere to 'reasonable time limits' in making its deliberations. Acceptance by the ACCC of the undertaking should provide immunity from any declaration during the term of the undertaking.[129]

7.40. The Committee notes that the government has introduced the Telecommunications Competition Bill 2002 to amend Parts XIB and XIC of the *Trade Practices Act*. The Bill sets time limits for the ACCC to make decisions about ordinary and special access undertakings (in relation to services that are not necessarily yet provided or exist at present only to some extent). This, and other measures in the Bill, should facilitate the involvement of regulatory bodies at the pre-investment stage of broadband ventures before business decisions are made regarding infrastructure that risks being 'declared' under the *Trade Practices Act*. The Committee supports this objective.

Regulation of the local loop market and investment in wireless broadband

7.41. One issue that is not directly related to wireless broadband but is important in relation to the commercial prospects of companies in this area generally is the regulation of the local loop market. Unwired Australia Pty Ltd specifically raised this issue, pointing to a tendency (reflected in government attitudes, according to Unwired Australia) to treat Telstra's dominance of the last mile, particularly in the standard copper telephone network (also called the copper CAN, POTS and PSTN), as a natural monopoly. Accordingly, regulation has been directed to facilitating access to the monopoly for competing services.

7.42. If the local loop is considered to be a monopoly, the ACCC can declare this service to be the subject of regulated access under Part XIC of the *Trade Practices Act*. Such mandated access in the local loop would most likely mean the imposition of low access prices, effectively removing the possibility of commercial competition.

7.43. Provision of WLL voice services is a central component of a number of WBT business plans and the possibility of regulation in this area is of concern to investors. The Productivity Commission addressed this issue in its draft report into Radiocommunications (February 2002) and recommended 'a safe-

[129] Telstra Corporation Limited, submission no.47, pp.14-18.

harbour mechanism be introduced into the Act to protect investment in wireless broadband from "unwarranted or overly-intrusive regulation".[130] A number of submissions and witnesses addressed this issue.[131]

7.44. m.Net submitted that the potential for WLAN technology to provide public telecommunications services:

> … may require positive regulatory intervention to enable (in fact encourage) local WLAN providers to inter-operate without the risk of contravening the *Trade Practices Act*. Further, such services could be considered for Declaration under the Act to enable the ACCC to arbitrate in resolving any impasse in reaching an access agreement in the event that any of the large carriers have a dominant market position in any market.
>
> [This action would follow a conclusion] that the provision of such highly inter-operable WLAN networks were desirable but are unlikely to eventuate if left to market forces alone.[132]

7.45. The new wireless ISPs are operating in a regulatory and market environment dominated by large telecommunications companies. These ISPs would have to negotiate access to the backbone to deliver their services to customers. It would also be to their benefit to make their networks interoperate. The situation presented by m.NET is untested in law. If there is a problem, a regulatory or legislative solution should be found. The Committee would not want such a problem to be an impediment to WLAN take up.

7.46. **The Committee recommends:**

that the government determine whether there are legislative, regulatory and business impediments to the interoperation of wireless ISPs and their access to the Internet backbone and, if so, eliminate them.

7.47. Small wireless connection companies (for example, those dependent on ISM bands) could well be fragile. Charges from large Internet providers to connect these services to the wire-line

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[130] Telstra Corporation Limited, submission no.47, p.13.
[131] These include submissions by Unwired Australia Pty Ltd (no.41), Telstra Corporation Limited (no.47) and the ACA (no.19).
[132] m.Net Corporation Ltd, submission no.39, p.5.

Internet backbone could become prohibitive. One submitter called for:

> a certain degree of regulatory pressure [to be] applied to the wireline high-speed Internet service providers (DSL, cable, and also satellite) which new wireless access network operators will depend on for their backhaul. Interconnections must be unrestricted, reduced wholesale prices for wireline or satellite broadband capacity must be available to wireless access providers and all restrictions with regards to reselling, redistributing or third-party sharing that are currently manifested in the terms and conditions of many of these companies must be abolished.[133]

7.48. **The Committee recommends:**

that the ACA and the ACCC develop a mechanism whereby small wireless Internet service providers can negotiate wholesale prices for Internet backbone connections, possibly introducing appropriate conditions in the carrier Universal Service Obligation. For a service provider to be eligible under this scheme, they must demonstrate that they are serving an eligible customer base. Eligibility would be automatic where DSL/wire-line connectivity was not currently available (such as in some regions of Australia) or simply where broadband wireless takeup had not yet occurred.

Protection of the commons

7.49. Several submitters expressed concern about 'high-power, spectrum-hogging applications'[134] in the class-licensed bands such as 802.11b WiFi. The use of devices with greater power than legally permitted and with higher-grade antennas was said to:

> …increase the amount of noise in the band and have in some locations meant that the band is unusable. If everyone worked within ACA's guidelines, all links should be able to co-exist due to the nature of the underlying spread spectrum transmission method.
>
> If, however, an omni-directional antenna and an amplifier are used, then anyone else trying to use the

[133] Network Consultants Telecommunications, submission no.40, p.2.
[134] Government of Western Australia, submission no.34, p.7.

> band in the same area will have their signals swamped…
>
> Any vendors or importers selling the product in Australia should undertake an accreditation process, which involves educating their channel on the class licence.
>
> All installed links should be registered with the ACA by the installer, end-user or both and must supply, as a minimum, a link budget which clearly shows the product, RF cable, and antennas used, as well as the EIRP level for the link. The ACA could then issue a certificate of compliance.[135]

7.50. Unwired Australia Pty Ltd expressed similar concerns and indicated that use of the 2.4Ghz band in the USA is being compromised by people:

> ...using specially adapted 802.11b devices with higher power levels in order to extend the applications well beyond "proximity". Unwired suspects that similar techniques may be being used in Australia and we are aware of a number of groups promoting the use of high-gain antennas to increase the effective range of 802.11 devices.[136]

7.51. Ericsson Australia also was concerned about the use of devices in the WLAN bands with high power outputs:

> [The WLAN bands] stipulate regulations relating to power output… which have been designed to be low enough to limit interference. The issue is that companies, including operators, are considering offering public services over WLAN in these unlicensed bands. It will become increasingly difficult to guarantee quality of service with regards to interference if these bands are not regulated in some way.[137]

7.52. Xone Pty. Limited stated that it 'recognises the need for a cooperative body to manage interference' upon WiFi.[138] Similarly, the Users of Wireless Networking Technologies asked the government to regulate commercial use of this spectrum because:

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[135] Integrity Data Systems Pty Ltd, submission no.26, p.6.
[136] Unwired Australia Pty Ltd, submission no.41, p.22.
[137] Ericsson Australia, submission no.42, p.18.
[138] Xone Pty Limited, submission no.56, p.9.

> …there is no other spectrum available for grass-roots community broadband development… We have no objection to commercial use of the ISM band, where commercial operators are willing to live with the limitations of a public band… We would however strenuously object to any attempt to privatise the commons, and close out community operators.[139]

7.53. AirNet was concerned that uncoordinated use of the ISM band could render the spectrum unusable with the uptake of 802.11.[140] Integrity Data Systems expressed some concern about the activities of community wireless operators and recommended more regulation of the ISM bands. They suggested registering devices used and the location of their facilities.[141]

7.54. The suggestion for such registration was opposed by Melbourne Wireless which claimed that a registry of wireless devices would be no more practicable than for CB:

> What made [regulating CB] so hard is that you can walk down to any shop, pay $99, get your radio, go home and set it up. To register that with someone and to identify who is actually using that radio is almost a nightmare in itself just to even think about.[142]

7.55. However, Melbourne Wireless was prepared to coordinate an effort to protect the ISM band:

> Melbourne Wireless is keen to operate… a low-power wireless network across Melbourne which would be used to carry digital traffic at high transfer rates… legally whereby such a network would be governed by legislation, regulations, terms and conditions that are fair and reasonable.[143]
>
> We are certainly willing to work with the ACA or any other regulatory body… to establish a set of guidelines that can be used.[144]

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[139] Users of Wireless Networking Technologies, submission no.36, pp.3-7.
[140] Mr Burgess (Technical Director) and Mr Karidis (Director, Operations) AirNet Commercial Australia Ltd, *Transcript*, 1 July 2002, p.166 and p.169.
[141] Integrity Data Systems Pty Ltd, submission no.26 p.6 and *Transcript*, 1 July, p.176 and p.179.
[142] Mr Haigh (President), Melbourne Wireless, *Transcript*, 2 July 2002, p.240.
[143] Melbourne Wireless, submission no.3, p.17.
[144] Mr Clugg (Treasurer), Melbourne Wireless, *Transcript*, 2 July 2002, p.242.

7.56. Sooner or later, ISM will become crowded (see chapter 4), and commercial operators may impinge on one another. This will give rise to the need for a mechanism to help settle conflicts over the right to use shared spectrum.[145] Such conflicts may be resolved through consultation with the ACA where priority would be given to the possibility of interoperability by the network operators.

7.57. **The Committee recommends:**

that the Minister for Communications, Information Technology and the Arts ask the ACA to investigate the establishment of a conflict resolution service for users of the ISM bands.

7.58. Integrity Data Systems expressed concern about current power restrictions on technologies using at least part of the unlicensed spectrum in rural areas:

> To maximise the commercial use and flow-on social gains from the products that operate in the 5.725 to 5.825 GHz bands, we believe there also needs to be some changes to the ACA's current power restrictions.
>
> In Australia this band is restricted to one watt EIRP, while in New Zealand it is four watts EIRP…
>
> Young second-tier carriers desperately require long distance, low cost bandwidth for use as part of a broadband infrastructure, which is exactly what these products can provide if their power restrictions are lifted…
>
> We already have a product available for the 5.8 GHz band (licence free) that is capable of 100 Mbps, full duplex true bandwidth and data rate… However, the ACA has imposed power restrictions on this band which significantly limit distances when compared with the distances the product is technically capable of and used for in other countries such as the USA (ie ACA power restrictions limit link distances to around 20 km while in the USA the same product is used over distances of 100 km or more).[146]

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[145] Cisco Systems Australia Pty Ltd, submission no.18, p.18

[146] Integrity Data Systems Pty Ltd, submission no.26, p.7 and pp.2-3.

> The power limitation on 802.11a / g transceivers limits Australia's ability to take advantage of second generation WLAN equipment.[147]

7.59. By way of contrast, Unwired Australia Pty Ltd opposed any increase of power limits even in rural Australia:

> Unwired firmly believes that 802.11 is a complementary technology to FWA [fixed wireless access] in that [it] extends the reach of an Internet connection provided by FWA to a local area network so that connection can be shared. It is not, of its own, a wide area Internet connection technology.
>
> Unwired supports the existing class-licence regime for 802.11 services. This regime imposes strict power limits that allow the technology to enjoy widespread use…[148]

7.60. **The Committee recommends:**

that the Minister ask the ACA to examine the implications of raising the power limits on the ISM band to the equipment's rated values for service providers in those areas of Australia where DSL or other broadband wire-line connections are not yet in place.

7.61. Motorola expressed the opinion that interference in an ISM band would lead to those who needed a better service, and were prepared to pay for it, moving out of the spectrum: 'Those that do not care put up with it, so it looks after itself. CB radio is a classic example of that'.[149]

7.62. A possible remedy for ameliorating interference problems if burgeoning numbers of users overload the unlicensed 802.11b WiFi band would be to facilitate local leasing or even re-sale of purchased spectrum. Users could then migrate. This would allow purchasers of 3G spectrum who have not yet deployed systems (a likely scenario, given the worldwide telecommunications industry slump and the high prices of purchasing the spectrum) to sell spectrum for use by exasperated WiFi users. The drawback here is that the change of frequency would require change of interface hardware.

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147 Mr Bray, submission no.31, p.3.
148 Unwired Australia Pty Ltd., submission no.41, pp.30-32.
149 Mr O'Shannassy (Director, Telecommunications Government Relations) Motorola Australia Pty Ltd, *Transcript*, 2 July 2002, p.228.

7.63. Open Systems Technologies proposed in their submission that all non-licensed carriers on a wireless network must join their networks to existing networks. This large resulting wireless network is referred to as the Mesh. Carriers could also join the Mesh but they could also run their own network. It is claimed that this would be self-regulating. The aim is to avoid anarchy in the ISM band and avoid rendering the band useless by interference.[150]

The spectrum auction system

7.64. Many submitters expressed concern about the effect of the current auction system, especially in relation to disadvantaging the efforts of small regional based operators to obtain suitable spectrum for their locality. ntl Australia submitted that auctions raise the entry price so that 'only very large and significant entities can afford to enter the market' and that only large markets will therefore be commercially viable: 'the smaller regional towns tend to have insufficient population to generate the required return on investment to justify rollout into those areas'.[151]

7.65. Alcatel voiced similar concern, and suggested an overall price 'cap' that would reflect the capacity of both industry and the consumer to 'pay':

> The recent LMDS spectrum auctions resulted in pricing that would be prohibitive for backhaul use… There has been virtually no rollout of LMDS equipment following the auction. Selling spectrum previously bought at auction often involves writing down the value of the purchases. Companies that do use the spectrum have to recover costs from the customers. This results in higher charges. The spectrum auctions have a good commercial basis, but a method of capping the total price should be implemented to ensure that the customer and Australia can afford to utilise the new technologies.
>
> Auctions should be limited to only spectrum that is known to be required for competitive services. This is the current regime and should be continued.[152]

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[150] Institute for Open Systems Technologies Pty Ltd, submission no.14.
[151] ntl Australia Pty Ltd, submission no.25, p.8.
[152] Alcatel Australia, submission no.9, pp.18-19.

7.66. Optus considered that the current auction system hinders 3G services.[153] Miraxis submitted that high auction prices are blocking the operation of improved satellite services:

> Spectrum auctions should be avoided with respect to satellite-based systems, in recognition of such systems' inherent abilities to provide services to rural and thinly populated areas, and given the long lead-times and tremendous upfront expenditures that must be made by satellite-based system developers prior to the generation of any revenues.[154]

7.67. Cisco Systems stated that high auction prices could lead to 'spectrum squatting' and that the Government should require that purchased spectrum be used within a specified time period (perhaps 12 months) to deliver commercial communications services. 'Failure to do so would result in the government re-auctioning the spectrum to another party without financial consideration towards the original licensee.'[155]

7.68. Soul Pattinson Telecommunications Pty Limited suggested there should be a rebate of spectrum costs where services are actually delivered to regional areas.[156]

7.69. Some state governments expressed concern about some effects of spectrum auctions, especially in relation to providing services to rural areas. The government of Western Australia stated that, 'for rural Australians, the Commonwealth should re-examine policies for access to spectrum'. In particular, the Commonwealth should provide 'initiatives… to encourage businesses and local communities to play larger roles in the expansion of wireless broadband services'.[157]

7.70. The Northern Territory government submitted that 'the cost of spectrum must be kept low or offered at no cost where delivery is into remote communities'[158] and the Tasmanian government stated:

> The current policy of treating some spectrum useful for telecommunications services essentially as a corporate asset has the potential to provide

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153 Optus, submission no.16, p.3 and p.8.
154 Miraxis, LLC, and Miraxis Australasia Pty Ltd, submission no.58, pp.9-10.
155 Cisco Systems Australia Pty Ltd, submission no.18, pp.18-19.
156 Soul Pattinson Telecommunications Pty Limited, submission no.48, p.7.
157 Government of Western Australia, submission no.34, p.2.
158 Government of the Northern Territory, submission no.38 p.3.

> competitive advantage to the licence owners, even where they have no intention to utilise the licences for the provision of services. This is in contrast to the apparatus licence approach to managing spectrum for the provision of radio and TV services.[159]

7.71. The Hunter Economic Development Corporation submitted:

> It would be an advantage if the geographic areas of footprint defined by the ACA for spectrum allocations could cater for carriers operating in rural and regional areas…
>
> It is interesting to note that telecommunications carriers that do own spectrum aren't using wireless technology in those regions to provide broadband to small communities. Therefore local telecommunication carriers are essentially locked out from competition in this market…
>
> It has been my experience working in regional development that the larger carriers tend to cherry pick in regional towns, targeting call centres, corporate and government sectors. In some of these cases infrastructure is provided for these customers, but the carrier does not seem interested in delivering to the broader community.[160]

7.72. ntl Australia Pty Ltd proposed that spectrum should be allocated by a tender process with charging based on revenue as with television broadcasting licences. This would lower the entry cost and make role out to smaller centres more commercially viable:

> ntl proposes that the Commonwealth consider a more conservative approach to pricing spectrum, eg the use of a hybrid system that incorporates both financial and non-financial criteria. Such a system could involve a system similar to the Hong Kong approach [involving 'a "beauty contest" plus fixed fee approach'] or a traditional tender process incorporating the usual quantitative and qualitative criteria. Such a process would incorporate a form of "beauty contest" which takes account of the financial strength and credibility / experience of tendering parties as well as providing for competition in the price paid. It would also allow assessment of tenders

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[159] Government of Tasmania, submission no.23, p.2.

[160] Hunter Economic Development Corporation, submission no.49, pp.2-4.

on the basis of the policy objectives of the government of the day.[161]

7.73. The rush into the use of the WiFi ISM band is testimony to what happens when the entry price for wireless is low. For various reasons—power limits, range, and (ultimately) congestion—ISM band usage is not always possible, and purchased spectrum must be used. The submissions quoted in earlier paragraphs of this chapter demonstrate that the price of spectrum—often set by reserve auction prices for the 15 year term—deters the set-up of wireless ventures, particularly in regional areas, and may also encourage spectrum squatting to block competition.

7.74. Submitters suggested a variety of means to alleviate this situation, including lowering the reserve prices for spectrum in regional areas, flexible terms based on revenues generated, rebates, or a tendering process that includes competition partly based on non-financial factors. It would appear useful to add flexibility to the system of allocating spectrum access initially and at renewal, to encourage spectrum leasing, and to facilitate migration from the ISM bands to licensed, paid spectrum. These functions are closely related.

7.75. **The Committee recommends:**

that the ACA and ABA form a spectrum bureau to:
(1) monitor the effects of spectrum auction on local wireless use;
(2) facilitate the trading and cross-leasing of spectrum and the migration of ISM wireless activities to licensed spectrum, and
(3) recommend regionally adjusted spectrum auction reserve prices and financing terms.

7.76. Use of the ISM band, especially the 2.4 GHz band, is attractive because market developments have reduced equipment prices dramatically using the economies of scale—the IEEE 802.xx standards have allowed a world-wide market of competing suppliers to develop. While the anticipated congestion of the ISM bands may make migration to neighbouring spectrum attractive, the price of changing equipment would be a deterring factor, as the equipment would have to meet Australian standards even if the only modifications are a small shift in frequency. It seems prudent to encourage the development of suppliers able to provide such equipment at competitive prices.

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[161] ntl Australia Pty Ltd, submission no.25, p.8.

7.77. **The Committee recommends:**

that the ACA and ABA develop procedures that facilitate the migration of wireless activities from ISM bands to adjacent licensed spectrum by streamlining equipment qualification procedures.

Tenure of licences

7.78. Several submissions supported changes in licence renewal procedures. Ericsson supported a presumption of renewal of licences, to assist in obtaining finance, and advocated that approaches to re-issue spectrum licences be considered at least five years prior to the expiry date.[162] Vodafone also favoured an early ACA review of the spectrum used at a fixed time before expiry of the licence. This would allow potential new entrants time to register their interest and increase certainty to the incumbents. The review would include a public benefit test. [163]

7.79. Unwired Australia Pty Ltd told the Committee that the present arrangement - whereby spectrum licences are allocated for up to 15 years, with subsequent reallocation by auction, unless the public interest favours reissuing the licence to the licensee – increases the investment risk. To cover this increased risk, expenditure on capital and maintenance might be reduced and cause a decline in service quality. Unwired advocated the licence term provisions be changed to provide perpetual tenure.[164]

7.80. **The Committee recommends:**

that the ACA develop a system for licence renewal that evaluates the use of spectrum, utilising clear criteria established and communicated to spectrum holders well in advance of renewal dates. This could be implemented using fixed-term renewable spectrum allocations.

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[162] Ericsson Australia, submission no.42, pp.23-24.
[163] Vodafone Pacific, submission no.17, p.2.
[164] Unwired Australia Pty Ltd., submission no.41, pp.32-33.

8. Future trends in the development and use of wireless broadband technologies

This chapter outlines some important trends affecting wireless broadband in the future.

The integration of different technologies into the one physical device

8.1. There is a trend toward the integration of various technologies into the one physical device, which itself is likely to be portable. For example, Unwired Australia Pty Ltd pointed to:

> …a trend to integrate different complementary technologies into common physical devices. For example, mobile phones are already being manufactured and marketed with Bluetooth capability, allowing phones enabled this way to integrate seamlessly with devices such as headsets and PDAs… [Another example concerns] an integrated FWA / 802.11 terminal and gateway. The FWA segment provides the last mile connectivity back into the Internet cloud, while the 802.11 device extends the reach of that broadband service to other computers on the local area network segment.[165]

Improved 802.11

8.2. There are several 802.11 standards to be implemented over the next few years. These will create greater security and higher data rates though probably will have lower range. As a result, the potential for interference will be a balance between the smaller sizes of the networks and their proliferation. In any case, an upgrade in backbone connectivity will have to evolve to support them. In the end, much research has to be done to get such networks to coexist without mutual interference. However, there is a long way to go before this is a serious issue.

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[165] Unwired Australia Pty Ltd, submission no.41, p.35.

Requirements for faster speed and wider pipes

8.3. It appears certain that the requirements for broadband speed and volumes of data transfer will increase dramatically over time. It will be important not to settle for an inferior solution in the long term which could ultimately harm Australia's economic prospects and prosperity. On the other hand, it would not make sense to invest billions of dollars in technology that is not needed yet or could become obsolete. In this difficult policy dilemma, wireless broadband could be a good interim solution but should not be seen as a means of avoiding necessary rollout of wire-line infrastructure in the long term.

What will happen with 3G?

8.4. The success or failure of 3G networks will be critical to the development of wireless broadband. While 3G technology may enable 'true broadband data rates in a mobile environment… [as well as to fixed locations, thus] conceivably offer[ing] last mile broadband connections, at speeds comparable to the lower end of ADSL'[166], it is just as likely that '3G mobility networks will not be able to cost effectively deliver the data rates demanded by complex Internet-based applications [and] will only be able to provide a mechanism for mobile data that is short, transaction-based and demands only low data throughput from the network.[167]

8.5. The commercial prospects of this technology internationally are far from certain, not because it is not good technology, but because of over-hyped commercial expectations. Australia may be in a reasonably good position in this area compared to other markets, but the lack of certainty and investor reluctance following the "techwreck" is a major concern. The commercial uncertainty in this area is also a significant issue.

Last mile and the potential of satellite

8.6. Existing satellite technology was criticised by one submitter in the following terms: it has 'low capacity in terms of simultaneous circuits and data rate; long propagation delay (latency); low penetration inside buildings; high power terminal; [and] a range

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[166] m.Net Corporation Ltd, submission no.39, pp.4-5.

[167] Cisco Systems Australia Pty Ltd, submission no.18, p.6.

of standards'.[168] The Northern Territory government stated that satellite delivery systems display 'idiosyncratic behaviour' and are 'unpopular for voice communications because of the noticeable propagation delay'. Also, 'some business applications have proven to be difficult or impossible to run over broadband satellite services'. The most significant limitation identified by the Northern Territory government, however, is cost:

> Based on current commercial offerings, satellite broadband is almost twice the price of terrestrial services. This places those remote communities that need these services the most, but are too distant from an exchange to access terrestrial broadband, at a distinct disadvantage.[169]

8.7. Satellite appears to remain the most likely solution for broadband access in remote regions. The key questions for the future in this area are: who will roll out what services and when; how good will these services be; and what will they cost users?

8.8. One way to bring satellite costs down for end users is to use "neighbourhood networks" to connect users to a shared satellite base station. Conxtel already offers such a product, which uses 802.11b Wi-Fi links to make the user connections. It still leaves the question about the last '50 miles' in some areas and this is perhaps where the VHF/UHF solutions can pick up the tab. Suitable relaxation of carrier licensing requirements could help encourage these developments.

8.9. In the urban local loop, Unwired Australia Pty Ltd is one company that is very confident of its ability to provide a last mile service to urban and many rural areas, but its submission states that satellite remains the only solution for more remote areas. [170]

Convergence of technologies

8.10. Convergence is another much hyped phrase but the trend in this direction is evident. Telephones, PDAs and Laptop computers are all moving towards hybrid devices that provide some of the capabilities of each other. The uncertainty in this area is in what devices and applications will prove popular and/or commercially viable and how long this process of convergence will take. This is

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[168] Alcatel Australia, submission no.9, p.10.
[169] Government of the Northern Territory, submission no.38, p.3.
[170] Unwired Australia Pty Ltd, submission no.41, p.3 and p.26

a very nervous time for manufacturers of equipment and telecommunications carriers.

Convergence of telecommunications, IT and broadcasting

8.11. Many submitters pointed to the growing convergence of telecommunications, IT and broadcasting matters, suggesting that there may come a time when the sectors should be regulated by the one set of provisions.

8.12. A suggestion was made that the government 'consider the establishment of a specialist broadband department under the auspices of the ACA that has regular contact with commercial operators and industry support groups'.[171]

8.13. **The Committee recommends:**

that the Commonwealth establish an inquiry into the possible amalgamation of the ACA and the ABA. This would allow for more streamlined regulation of the dynamic and converging technologies of broadband telecommunications and broadcast transmission.

8.14. The Committee notes the view of both Ericsson and Vodafone that the ACA should be viewed as the primary regulatory body:

> Ericsson believes responsibility for planning and licensing the broadcasting services bands of the spectrum should be transferred from the ABA to the ACA and that licence fees and access to spectrum be based on "the opportunity cost of spectrum used". Such provisions are necessary in an environment of convergence to prevent distortions of technology usage in investment decisions.[172]

8.15. Vodafone recommended that responsibility for the broadcasting services spectrum bands be transferred to the ACA, and be managed under the *Radiocommunications Act*. Differing regulatory treatment of broadcasters and telecommunications companies creates the potential for inconsistent policy outcomes and market distortions at a time of increasing convergence of technologies.

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[171] New Skies Networks Pty Ltd., submission no.59, p.12.
[172] Ericsson Australia, submission no.42, p.26.

Spectrum users should not be able to gain a competitive advantage due to differing regulatory environments.[173]

8.16. Vodafone went further, to suggest that it was time the same regulatory framework applied to the telecommunications sector as to the rest of the Australian economy.[174]

Encouraging the development and use of broadband

8.17. The Committee is aware of the lack of communication and understanding (in relation to broadband services) between small businesses, regional carriers, and owners of spectrum. Much of the development in this area is so new, and the number and variety of technologies so diverse, that businesses and investors are confused as to what is out there and what is possible.

8.18. As a result, there are calls for pilot studies and specific programs about improving broadband availability. The Committee is aware of the demonstration programs already funded by DCITA, including "Building on IT Strengths' (BITS), the Networking the Nation program, and the National Communications Fund (NCF). The Committee considers that the recommendations contained in this report will go a long way toward improving the understanding, and takeup, of wireless broadband.

The limitations of physics

8.19. Despite the limitations imposed by finite bandwidth, there is the possibility that antenna research will lead to far greater channel capacity than has been achieved to date:

> Until recently, it was thought that available wireless spectrum was limited, necessitating strict regulations to apportion a precious resource. Recent advances in space-time coding and smart antennas have shown that it is possible to resolve multiple users based on their spatial positions. This means that a number of users can each simultaneously use exactly the same wireless spectrum to full capacity. It is a bit like having a wire connecting each communicating party, only the wire isn't actually there. In other words, one

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[173] Vodafone Pacific, submission no.17, p.2.
[174] Vodafone Pacific, submission no.17, p.4.

can multiply the available data capacity, effectively multiplying the 'amount of spectrum'. As computing power increases, better methods for removing interference between users will be implemented, so the available wireless data capacity increases. Computing power is currently doubling every eighteen months, with no end in sight. These increases in capacity are not a theoretical artefact. Bell Laboratories, in the United States, have demonstrated a working prototype that multiplies available capacity by a factor of ten. Their work is available on the World Wide Web.[175] Any changes to the rules which govern radio spectrum must consider a future where there may be no limits on available wireless capacity. Does it make sense to tightly regulate an unlimited resource?[176]

Christopher Pyne MP
Chair
23 October 2002

[175] http://www.bell-labs.com/project/blast/
[176] Mr Dalton, submission no.33, p.1.

Appendix A: Conduct of the inquiry

On 15 April 2002, the Committee accepted a reference from the Minister for Communications, Information Technology and the Arts (Senator the Hon Richard Alston) for an inquiry into wireless broadband technology. The terms of reference at set out at page iv of this report.

The inquiry was advertised in major national newspapers and key stakeholders were invited by letter to provide submissions to the inquiry.

Sixty submissions were received. These are listed in Appendix B to this report. Additional material relevant to the inquiry, which was received as exhibits, is described in Appendix C. Public hearings were held in Canberra, Brisbane, Newcastle, Sydney, Melbourne and Adelaide. The dates and locations of the hearings and the names of the witnesses are listed in Appendix D of this report. A Glossary is provided at Appendix E.

The submissions and the transcripts of the hearings were made available electronically through links on the Committee's web page at http://www.aph.gov.au/house/committee/cita/Wbt/index.htm . These will remain available through that site for some time. The submissions and transcripts of hearings will be available in printed form at the National Library in Canberra.

The report of this inquiry is available electronically in pdf form at the following Internet site http://www.aph.gov.au/house/committee/cita/reports.htm . The Government's response to the report will also be made available through that site.

Appendix B: List of submissions

The names of the persons and organisations providing submissions are listed below.

Sub No.	Individual/organisation
1	Gerard Borg, Jeffrey Harris (Plasma Research Laboratory, Research School of Physical Sciences & Engineering, ANU), Haley Jones (Department of Engineering, ANU), Anthony Cook (ANUTECH Pty.Ltd), Andrew Cheetham, John Rayner (School of Electronics and Telecommunications Engineering, Uni of Canberra), John McInerny (Allstate Computers, Cowra)
2	Paul Budde Communications Pty Ltd
3	Melbourne Wireless
4	Simply Wireless Pty Ltd
5	Department of Education, WA: Facilities and Services Directorate
6	Commonwealth Office of Spatial Data Management
7	Jeremy Lunn
8	Australian Association of the Deaf Inc.
8.1	Australian Association of the Deaf Inc
9	Alcatel Australia
10	David Leonard
11	ArrayComm Inc and CKW Wireless
12	Motorola Australia
13	Australian Communication Exchange Limited
14	The Institute for Open Systems Technologies Pty Ltd
15	A / Professor Doan Hoang (Faculty of Information Technology, Uni of Technology, Sydney)
16	Optus
17	Vodafone Pacific
17.1	Vodafone Pacific
18	Cisco Systems Australia Pty Ltd

19	Australian Communications Authority
20	ACT government (Chief Ministers Department)
21	Nortel Networks
22	W.J.Miller (Miller Computing Services)
23	Tasmanian government (Jim Bacon MLA, Premier)
24	Intelligent Transport Systems Australia
25	ntl Australia Pty Ltd
26	Integrity Data Systems Pty Ltd
27	CSIRO Telecommunications & Industrial Physics
28	Lucent Technologies Australia Pty Ltd
29	Austar United Communications
30	Baltech Pty Ltd.
31	George Bray (Tech Trek - Australian Mobile Internet Survey & Showcase)
32	SR Telecom
33	John Dalton
34	Government of Western Australia (Clive Brown MLA, Minister for State Development)
35	Australian Information and Communications Technology in Education Committee (AITEC)
36	Users of Wireless Networking Technologies
37	Telecommunications and Disability Consumer Representation (TEDICORE)
38	Northern Territory Government (Peter Toyne, Minister for Corporate and Information Services)
39	m.Net Corporation Ltd
40	Network Consultants Telecommunications
41	Unwired Australia Pty Ltd
42	Ericsson Australia
43	Gold Coast City Council
43.1	Gold Coast City Council
44	AirNet Commercial Australia Ltd
45	Xtreme Business (Midac Technologies (Australia) Pty Limited)
46	New South Wales government (Cabinet Office)

47	Telstra Corporation Limited
48	Soul Pattinson Telecommunications Pty Limited
49	Hunter Economic Development Corporation
50	Norlink Communications Ltd
51	Conxtel Communications Ltd.
52	South Australian government (Jane Lomax-Smith, Minister for Science and Information Economy)
53	Ipera Communications
54	Australian Telecommunications Users Group (ATUG)
54.1	Confidential
55	Confidential
55.1	Australian Security Intelligence Organisation
56	Xone Pty. Limited
57	Telecommunication and Information Technology Research Institute (Uni of Wollongong)
58	Miraxis, LLC and Miraxis Australasia Pty Ltd
58.1	Confidential
59	New Skies Networks Pty Ltd
60	National Farmers' Federation

Appendix C: List of exhibits

Exhibit Nbr	Description of exhibit
1.	Paper by Dan Gillmore, Mercury News Technology Columnist titled “Imagine: world with unlimited airwaves” dated May 19 2002, forwarded by Mr David Leonard.
2.	Supplementary material to submission from Integrity Data Systems forwarded by Mr Ross Chiswell, Chief Executive Officer, Integrity Data Systems.
3.	Graph showing Percentage Internet Accounts Broadband presented by Dr Trevor Bird, Sector General Manager, Information & Communication Technologies, CSIRO Telecommunications & Industrial Physics.
4.	‘The Alberta Connection’, IQ Magazine Article dated Jan / Feb 2002 forwarded by Mr Chris Coughlan, Director, Mobility, Australia New Zealand, Lucent Technologies Australia Pty Ltd:
5.	Facts relating to TTY use by ACIF Disability Advisory Board presented by Mr Phil Harper Deaf Telecommunication Access & Networking Officer, Australian Association of the Deaf Inc.
6.	Tech Trek Australian Mobile Internet Survey & Showcase Final Report forwarded by Mr George Bray, Tech Trek.
7.	“Fourth Report and Order in the matter of Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems” forwarded by Mr Phil Harper, Deaf Telecommunication Access & Networking Officer, Australian Association of the Deaf Inc.
8.	“Positioning For Growth”: Spatial Information Industry Action Agenda, September 2001 forwarded by Joanne Huxley, Commonwealth Office of Spatial Data Management.
9.	AirNet Media Release dated 1 July 2002 presented by Mr Peter Karidas, Director of Operations, AirNet Commercial Australia.
10.	“Harmony Products: Access Points” presented by Mr Ross Chiswell, Chief Executive Officer Integrity Data Systems.
11.	“Microwave Link Budget: 5.8 GHz Spread Spectrum” presented by Mr Ross Chiswell, Chief Executive Officer, Integrity Data Systems
12.	“Tsunami: Wireless Gigabit Ethernet Bridge” presented by Mr Ross Chiswell, Chief Executive Officer, Integrity Data

Systems.

13. "Channel Differences Among US and Europe" presented by Mr Ross Chiswell, Chief Executive Officer, Integrity Data Systems.
14. "Radicommunications Regulations" (General User Radio Licence for Spread Spectrum) Notice 2001 presented by Mr Ross Chiswell, Chief Executive Officer, Integrity Data Systems.
15. "USA Regulations, Part 15, Radio Frequency Devices" presented by Mr Ross Chiswell, Chief Executive Officer, Integrity Data Systems.
16. "Blogging the Wireless Freenet" presented by Mr Ross Chiswell, Chief Executive Officer, Integrity Data Systems.
17. Additional printed information from Integrity Data Systems presented by Mr Ross Chiswell, Chief Executive Officer, Integrity Data Systems.
18. Supporting papers to hearing presentation from Mr Alex Gosman, General Manager, Government and Regulatory, Ericsson Australia.
19. AICTEC Organisational Chart presented by Ms Catherine Parker, Executive Officer, AICTEC.
20. Graph showing registered sites at brishmesh.org presented by Mr David Leonard.
21. "Bridging the Gap: Access to Telecommunications for all people" presented by Ms Gunela Astbrink, Policy Advisor, TEDICORE.
22. "Which Button?; Designing user interfaces for people with visual impairments" presented by Ms Gunela Astbrink, Policy Advisor, TEDICORE.
23. "Telephones-What features do disabled people need?" presented by Ms Gunela Astbrink Policy Advisor, TEDICORE.
24. "A step forward: design for all" presented by Ms Gunela Astbrink, Policy Advisor, TEDICORE.
25. "Call Barred?: Inclusive Design of Wireless Systems" presented by Ms Gunela Astbrink, Policy Advisor, TEDICORE.
26. "Telecommunications-Guidelines for Accessibility" presented by Ms Gunela Astbrink, Policy Advisor, TEDICORE26
27. Map showing the Microwave Network, Gold Coast forwarded by Ms Karen Vought, Manager, Value Management, Gold Coast City Council.
28. "Introduction to Conxtel Communications Ltd" presented by Mr Roger Mitchell, Operations Manager, Conxtel Communications Ltd.

29. Power point slides - ArrayComm to support presentation at public hearing presented by Mr Ted Rule, Board Director, CKW Wireless.

30. Presentation to the committee on MMDS by Mr Keith Lawrence, Director, Networks & Technology, Austar United Communications Frequencies.

31. Various printed information on Global Learning Services - Internet Everywhere, forwarded by Dr McDonel, Director, Information Technology Services University of Southern Queensland

32. A paper on Broadband Development dated 13 May 2002 by Mr Sam Paltridge.

33. Telecom Strategy Group, the Office of Information Technology paper on Techno Economic Assessment of Access Network Technologies Version 1.0 dated February 2002, forwarded by Mr Roger Wilkins, Director-General, New South Wales Government.

Appendix D: List of witnesses

The Committee received a number of private briefings from key stakeholders and conducted eight public hearings in various cities. A list of witnesses who appeared at these hearings follows.

Thursday 13 June 2002: Sydney

Alcatel Australia

Mr Ross Fowler, Chief Executive Officer; and
Mr Scott Nelson, Chief Technology Officer.

Australian Association of the Deaf

Mr Phil Harper, Deaf Telecommunication Access and Networking Officer

CSIRO Telecommunications and Industrial Physics

Dr Trevor Bird, Sector General Manager, Information and Communication Technologies; and
Mr Boyd Murray, Telecommunications Research Engineer

Lucent Technologies Australia

Mr Chris Coughlan, Director, Mobility, Australia New Zealand; and
Ms Luis Megale, Director, Corporate Communications

ntl Australia

Ms Linda Anderson, Manager, Strategy and Planning;
Mr David Hilliger, Business Manager – New Media; and
Mr Clive Morton, Broadcasting Services Director

Optus

Ms Judy Anderson, Manager Regulator Policy; and
Mr Nick Leake, Marketing Manager, Satellite Services

Friday 14 June 2002: Sydney

Institute for Open Systems Technologies

Mr Greg Baker

Vodafone Australia

Mr Peter Stiffe, General Manager, Regulatory, Vodafone Pacific; and
Mr Jonathan Withers, Director, Regional Technical Strategy

Friday 28 June 2002: Canberra

ANU Research School of Physical Sciences and Engineering

Mr Anthony Cooke, Technology Manager, Physical Sciences and Engineering, Anutech Pty Ltd;
Professor Jeffrey Harris, Head, Plasma Research Laboratory, Research School of Physical Sciences and Engineering;
Professor Erich Weigold, Director, Research School of Physical Sciences and Engineering; and
Professor James Williams, Associate Director, Research School of Physical Sciences and Engineering

Australian Communications Authority

Mr Murray Delahoy, Deputy Spectrum Manager, Spectrum Planning Team;
Mr John Haydon, Executive Manager, Universal Service Obligation Group; and
Dr Bob Horton, Deputy Chairman

Commonwealth Office of Spatial Data Management

Mrs Judith Huxley, General Manager; and
Mr Paul Treloar, Technical Adviser

Simply Wireless Pty Ltd

Mr Benjamin Keighran, Chief Technical Officer; and
Mr Desmond O'Geran, Chief Executive Officer

Unwired Australia Pty Ltd

Mr David Harris, Chief Executive Officer;
Mr Ian Hayne, Radiocommunications Consultant; and
Mr Hendrik Prins, Consultant, Network Planning and Development.

Monday 1 July 2002: Adelaide

AirNet Commerical Australia Ltd

Mr Colvin Burgess, Technical Director;
Mr Peter Fortunatow, Director, Sales and Marketing;
Mr Peter Karidis, Director of Operations; and
Ms Grace Taylor, Consultant, Media and Marketing Research

Integrity Data Systems
Mr Ross Chiswell

m.Net Corporation
Professor Reginald Coutts, Director;
Mr Andrew Ekiert, Chief Executive Officer; and
Professor Michael Miller, Chair, Board of Directors.

Tuesday 2 July 2002: Melbourne

Australian Information and Communications Technology in Education Committee (AICTEC)
Ms Catherine Parker, Executive Officer;
Mr Bruce Rigby, Adviser; and
Professor James Taylor, AICTEC member representing the Higher Education Sector (Australian Vice-Chancellors Committee), and Deputy Vice-Chancellor (Global Learning Services), University of Southern Queensland

Ericsson Australia
Mr Alexander Gosman, General Manager, Government and Regulatory; and
Mr Scott Moorhen, General Manager, 3GSM Solutions

Intelligent Transport Systems (ITS) Australia Incorporated
Mr Christopher Skinner, Chairperson, National Reference Architecture Working Group

Melbourne Wireless Inc.
Mr Tyson Clugg, Treasurer;
Mr Darren Dreis, Vice President;
Mr Steven Haigh, President; and
Mr James Pollock, Member

Motorola Australia Pty Ltd
Mr Bernard O'Shannassy, Director Telecommunications Government Relations

Nortel Networks (Australia) Pty Ltd
Mr Robert Inshaw, Product Manager, Wireless Internet Solutions;
Dr Graeme King, Specialist, Regulation and Policy (South Asia); and
Mr Brad McDiarmid, Senior Account Manager

SR Telecom Pty Ltd
Mr Robert Vanderslik, Regional Sales Manager

Tuesday 9 July 2002: Brisbane

Australian Communication Exchange Limited
Ms Robin Blackson, Executive Officer, Community Services;
Mr Leonard Bytheway, Chief Executive Officer; and
Dr Thomas McCaul, Research Manager

ConXtel Communications
Mr Richard McElhinney, Director;
Mr Roger Mitchell, Operations Manager;
Mr Glenn Raleigh, Technical Director; and
Mr Walter Raleigh, Chairman

Gold Coast City Council
Mr Grayson Perry, Manager, Economic Development; and
Mrs Karen Vought, Manager, Value Management Branch

Mr David Leonard

TEDICORE
Ms Gunela Astbrink, Policy Adviser

Wednesday 10 July 2002: Newcastle

Paul Budde Communications Pty Ltd
Mr Paul Budde, Managing Director

Hunter Economic Development Corporation
Mr Edouard Bernard, ICT Project Officer

Midac Technologies (Australia) Pty Ltd
Mr Kevin Johnson-Bade, Managing Director

Soul Pattinson Telecommunications (SPT)
Mr Michael Simmons, General Manager

Telstra
Mr Tony Bundrock, National General Manager, Telstra Mobile Convergence
Dr Mitchell Landrigan, Group Regulatory Manager, Telstra Mobile.

Thursday 8 August 2002: Sydney

Australian Telecommunications Users Group

Mrs Rosemary Sinclair, Managing Director; and
Mr Mark McDonnell, Adviser and member

Austar Communications

Mr Keith Lawrence, Director, Networks and Technology

Baltech Pty Ltd

Mr Peter Moon, Managing Director
Mr George Bray

CKW Wireless Pty Ltd

Mr Ted Rule, Director; and
Mr Kanwar Saluja, Manager, Strategic Planning

Norlink Communications Ltd

Mr Keith Davidson, Chief Executive Officer;
Mr Brian Stevens, Director; and
Ms Janet Scharbow, Project Manager

Appendix E: Glossary

ADSL: Asymmetric digital subscriber line. ADSL is one of a family of DSL technologies that are capable of transforming phone lines (copper networks) into high-speed digital lines. ADSL enables simultaneous voice and data transmission (for example, for voice telephony). ADSL is asymmetric in that it utilises most of a channel to transmit downstream to the user and only a small part to receive from the user.

Allocation: The division of the radio spectrum bands of frequencies dedicated to particular services, as documented in the Australian Radiofrequency Spectrum Plan

AMPS: Advanced mobile phone system. The analogue cellular mobile phone system that operated in Australia until 2000 and still operates in other countries.

Any-to-any connectivity: The ability of a customer of one network to communicate with customers of other networks (for example, on mobile phones).

Apparatus licence: A licence authorising the operation of specific devices that use radiofrequency spectrum, subject to licence conditions.

Assignment: The process of issuing the right to access spectrum to spectrum users. The method of assignment is through licences and may be administrative or market-based (principally auctions).

Backhaul: The process of transferring information to a central point from which it can be distributed over a network. Fixed links, for example, are often used to backhaul traffic for mobile communications and broadcasting.

Bandwidth: The range of frequencies, expressed in hertz (Hz), over which a spectrum user can transmit or receive radio signals. In general, the greater the bandwidth the more information that can be sent through the spectrum in a given amount of time.

Bit: A bit is the smallest possible piece of digital information and is a binary digit with a value of either one or zero. Bits are used to store data on computers and to sequence digital transmissions. A kilobit equals one thousand bits.

Bps: Bits per second. The number of bits transmitted each second. Kbps is the number of kilobits transmitted each second.

Bluetooth: A short-range (10 to 100 metres), low-power radio technology that allows wireless communication between devices such as mobile handsets and computers.

Broadband: Broadband refers to information transmission speed and capacity.

Byte: A byte is a collection of eight bits and can have one of 256 possible values ranging from '00000000' to '11111111'. Text is normally represented using one byte per alphanumeric character.

CDMA: Code Division Multiple Access. A second-generation (2G) digital cellular mobile phone technology that uses spread spectrum techniques to transmit coded signals across several channels, rather than allocating each signal to an individual channel.

CDMA 2000: Code Division Multiple Access 2000. A standard for third generation (3G) mobile phone technology that employs advanced spread spectrum techniques.

Cellular: A mobile communications service using cells that are each served by a base station transmitter, and connected to a switching exchange that is connected to the fixed network. It allows frequency re-use across the service area and greater frequency-use intensity than conventional mobile phone coverage.

Channel: A path through which communications can flow. The bandwidth of a communications channel influences the amount of information that can be carried.

Class licence: Open, standing authorities that allow anyone to operate specified devices, within the conditions of the licence (for example, CB radios, mobile phone handsets, cordless phones and remote controls). Device users do not have to apply for a class licence and do not pay a fee.

Congestion: Too many spectrum users crowding into the same frequencies in the same location. Congestion can cause interference that reduces effective communication.

Convergence: The ability of similar types of information to be transmitted using different platforms and different radiofrequencies.

Co-primary use: An allocated use in which the primary use rights to the band is shared. Secondary uses can co-exist with co-primary uses but are unable to claim protection from or cause interference with the co-primary uses.

Datacasting: A range of interactive services available through digital television, including access to the Internet, video on demand and games.

Device registration: Radiocommunications devices must be registered with the Australian Communications Authority (ACA). The ACA may refuse registration for devices that do not meet relevant technical standards and that are likely to cause undue interference with other devices.

EDGE: Enhanced data for global system for mobile (GSM) evolution. A packet-based data technology for cellular mobile phones that overlays GSM networks and supports data transmission rates of up to 384 kilobits per second.

Externality: An indirect cost or benefit resulting from a transaction that is not covered or captured by either party to the transaction. In radiocommunications, interference is an externality.

FDMA: Frequency division multiple access. An analogue technique that increases the intensity of spectrum use by splitting a single channel (allowing one signal) into a number of sub-channels (each supporting one signal).

Fixed links: See point-to-point services.

Frequency: The number of complete cycles or waves per second, as measured in cycles per second or hertz (Hz).

Frequency agile: The ability of radiocommunications devices to operate in a number of different frequency bands.

Frequency band plan: A legal instrument made under s.32, *Radiocommunications Act 1992*, that subdivides the broad spectrum allocations of the Australian Radiofrequency Spectrum Plan into specific service types.

GPRS: General packet radio service. A packet-based data technology for cellular mobile phones that overlays global system for mobile (GSM) networks and supports data transmission rates up to 114 kilobits per second.

GPS: Global positioning system. A network of 24 satellites that orbit the earth enabling people with ground receivers to pinpoint their geographic location. The GPS is provided by the United States Department of Defence but can be used by civilians in Australia and other countries.

GSM: Global system for mobile. A second-generation (2G) digital cellular mobile technology based on time division multiple access (TDMA).

HFC cable: Hybrid Fibre Coaxial cable. A network of fibre optic and coaxial cable that connects customers' premises to pay-TV services, high speed Internet access and voice services, mainly in metropolitan areas of Australia.

Hz: Hertz. A unit of frequency, equal to one cycle per second. A kilohertz (KHz) equals one thousand hertz. A megahertz (MHz) equals one million hertz. A gigahertz (GHz) equals one billion hertz.

Interference: The effect of unwanted energy colliding with transmitted signals. Interference can arise from artificial sources (for example, two or more radio signals colliding) or natural sources (for example, lightning). Interference is a negative externality.

ISDN: Integrated services digital network. A set of standards for digital transmission over copper wire and other platforms using a circuit-switched technology to allow both voice and data over the same network.

ITU: International Telecommunication Union. An organ of the United Nations, the ITU is the international forum within which governments and the private sector coordinate the operation of telecommunication networks and services, and advance the development of communications technology. The ITU is responsible for developing standards for new technologies, such as mobile telephony and the Internet, and for managing the radio-frequency spectrum. The ITU maintains the international Radio Regulations, which allocate frequency bands to various types of services.

Last mile: The last mile refers to the final stage in the connection from individual homes and businesses to broadband.

LMDS: Local multipoint distribution system. A terrestrial radio system using radio frequencies of around 25 to 40 gigahertz to provide interactive video, Internet and voice services (usually limited to customers residing within a 3 km radius of a transmission tower).

Management rights: Rights that allow a spectrum holder to sub-lease rights to use spectrum in much the same manner as the sub-leasing of a building by a licensee.

MDS: Multipoint Distribution Station. One-way radio services operating from a fixed location and generally transmitting to multiple receiving facilities at fixed locations, generally used for terrestrial broadcasting.

MMDS: Multichannel multipoint distribution system. A terrestrial radio system utilising radio frequencies between 2 and 3 gigahertz that is used for television broadcasting and increasingly for two-way, high-speed Internet access (usually limited to customers within a 50 km radius of the transmission tower).

Multiplexing: A range of techniques that enable transmission of multiple signals (voice or data) simultaneously along a single channel (for example, FDMA and TDMA).

Narrowcasting: Specialised radio and television transmissions intended for a specifically defined group.

Non-assigned licence: A licence that does not require an individual frequency assignment, but allows the licensee to operate equipment on a shared frequency basis (for example, for amateurs and some aircraft, maritime and scientific applications).

Open access resource: A resource that is non-excludable (no one can be exclude from benefiting from it) but is rivalrous (one person's benefit reduces benefits for others). In the absence of property rights, strong incentives exist for over-use of the resource and government intervention may be required.

Passive services: Services that receive radio signals but do not transmit them (for example, radioastronomy).

PCS: Personal Communications Services. A generic term for mobile phone services, including technologies such as GSM and CDMA.

Platforms: The type of system or network used to transmit communications, for example, platforms transmitted over copper wire, HFC cable, fibre optic cable, terrestrial microwave and satellites.

Point-to- multipoint services: Wide area services that transmit signals from a central distribution point to multiple fixed points (for example broadcasting transmitters, LDMS, MMDS, and mobile services).

Point-to-point services: Fixed links that transmit information between two fixed points in the form of directed beams of radio waves, and are often used to backhaul traffic for mobile communications and broadcasting.

P**rimary use**: The single use that takes precedence over others in a given frequency. Secondary uses are unable to claim protection from or cause interference with the primary use.

Propagation: The area or distance of 'service coverage' that can be achieved from a transmitting device. The propagation of radio signals depends on factors including the communications equipment, power, time of day, time of year, solar activity and topography and weather conditions.

Public good: A good or service that is both non-excludable and non-rivalrous. That is, once the good is produced, it is not possible to withhold its benefits from anyone, and the benefits for one person do not reduce the benefits available to others. This means that private producers may not supply public goods, or may produce less than is desirable.

Radio-frequency spectrum: Part of the electromagnetic spectrum, currently defined as the subset of frequencies between 3000 hertz (Hz) and 300 gigahertz.

Re-allocation: The process of changing the allocation of spectrum, as defined in the Australian Radiofrequency Spectrum Plan, from one use to another. Incumbent users who do not conform to the new allocations must be re-located to other frequencies.

Regional Australia: In the context of this Report, regional Australia may be understood as referring to rural and remote regions, in contrast to metropolitan centres and their major urban hinterland. While statistical definitions vary, the ACA defines remote localities as those with populations less than 200.

Resource rent tax: Payments to owners of natural resources are often referred to as royalties. A resource rent tax is a particular form of royalty that charges a per cent of the expected profit, rather than a fixed amount per unit used or taken.

Safety-of-life services: Emergency service providers such as police, ambulance and fire services, the Royal Flying Doctor Service and life saving associations. Other services with potential safety-of-life functions include maritime and aeronautical services.

Satellites: A wireless receiver and transmitter that orbits the earth. Satellites are used for weather forecasting, television broadcasting, amateur radio communications, Internet communications and other services.

SDR: Software-defined radio. Equipment using digital techniques and stored program controls that allows users to choose the type of service and the service mode from those stored in the device. An SDR device, for example, could incorporate a mobile phone, GPS, wireless fax, e-mail and Internet.

Secondary use: A use that shares frequencies allocated to primary and co-primary uses, but is unable to claim protection from or cause interference with the primary or co-primary uses.

Shadow pricing: A technique used by regulators that aims to mimic market-based valuations, in the absence of actual market-based methods of valuing goods, services and resources (for example, calculating apparatus licence fees based on annualised auction prices).

Spectrum: The set of all frequencies (or electromagnetic waves) produced in the electric and magnetic fields. Spectrum can be defined according to frequency, space and time.

Spectrum licence: A licence authorising the use of spectrum space for any device from any site within that space, subject to the conditions of the licence and relevant technical regulations. They are issued for a fixed, non-renewable term and may be sub-divided, combined and traded.

Spread spectrum: A digital technique that combines FDMA and TDMA technologies to allow many users to occupy several channels at the same time. Signals are distributed (or spread) over the whole range of channels and each user is assigned a unique code that differentiates it from other users simultaneously carried over the same spectrum (for example CDMA technology).

STU: Standard trading unit. The smallest unit of spectrum space for which the ACA will issue a spectrum licence or register trading. STUs are defined in terms of radiofrequency bandwidth and geographic area.

TDMA: Time division multiple access. A digital technique used to increase the intensity of spectrum use. TDMA splits a single channel (allowing one subscriber) into eight time slots (each supporting one subscriber).

UMTS: Universal mobile telecommunications system. A 'third generation' (3G) mobile communications system being developed by the European Union within the framework defined by the ITU and known as IMT-2000. UMTS will enable broadband services to be delivered to mobile users via fixed, wireless and satellite networks. Data rates of up to 2 Mbps are promised.

UWB: Ultra-wideband radio. A wireless technology that uses advanced spread spectrum techniques to transmit large amounts of data over a wide range of frequency bands. UWB operates at very low power levels, potentially allowing some UWB devices to co-exist in frequencies already occupied by radio services without causing undue levels of interference.

WCDMA: Wideband Code Division Multiple Access. A standard for third generation (3G) mobile technology that employs advanced spread spectrum techniques.

Wide area services: See point-to-multipoint services.

Wi-Fi: The standard commonly given to 802.11b devices that interoperate under testing by the Institute of Electrical and Electronic Engineers (IEEE).

Wireless LAN: Wireless local area networks (LANs) using the 802.11 standard are primarily provided in offices as an alternative or extension to a wire-line LAN. Wireless LANs can connect computers, printers, palm pilots and other equipment without the need for network cables.

WLL: Wireless local loop refers to the use of radio access technology to link a customer to a local exchange or service provider. WLL is now used interchangeably with 'wireless access', which the ITU defines simply as "End-user radio connection to a core network." A range of technologies can be used to provide WLL.

2G mobile: Second generation mobile. Mobile phone technologies that provide voice and low speed Internet access, using digital voice encoding and a mixture of circuit-switching and packet-switching techniques that support data transmission rates around 9.6 kbps (for example, GSM and CDMA).

2.5G mobile: 2.5 generation mobile. An evolutionary cellular mobile technology on the way to third generation (3G) mobile, using packet-switching techniques that can support data transmission rates up to 384 kbps (for example, GPRS and EDGE).

3G mobile: Third generation mobile. An emerging cellular mobile technology employing more advanced digital switching technologies than 2G and 2.5G mobile systems. 3G technologies include WCDMA and CDMA2000 and offer the prospect of data transmission rates up to 2 Mbps.

802.11: 802.11 is a standard which was approved in 1996 for Wireless LANs using spread-spectrum technology. Signals are transmitted across a range of frequencies using very low energy levels. Initially transmission speeds over the 802.11 standard were between 1 and 2 Mbps. However, in 1999 a new standard called IEEE 802.11b was ratified. This standard enables a rate of transmission of 11 Mbps. 802.11a and 802.11g versions of the standard also exist. The technology can be converted to use over a longer distance using directional antennas but this is not the original purpose the standard was developed for.