Report regarding Wireless Networks

08 October 2009

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List of Appendices

List of Terms and Abbreviations

ACCC – Australian Competition & Consumer Commission

ACMA – Australian Communications and Media Authority

BWA – Broadband Wireless Access

Band 2 ESA – means an Exchange Service Area with more than 108.4 services in operation in a square kilometre which is not a Band 1 area.[1]

BTS – Base Transmitter Station

DRCS – Digital Radio Concentrator System

HCRC – High Capacity Radio Concentrator

HSPA – High Speed Packet Access

ISM – Instrument, Scientific and Medical

LOS – Line of Sight

LTE – Long Term Evolution

IP – Internet Protocol

OFDM – Orthogonal Frequency Division Multiplexing

POI – Point of Interconnection

PoP – Point of Presence

SOB – Sound Outside Broadcast

STL – Studio to Transmitter Link

ULLS – Unconditioned Local Loop Service

UMTS – Universal Mobile Telecommunications System

WAS – Wireless Access Service

[1] Telstra Service Quality Strategy 23 June 06

1 INTRODUCTION

1.1 This report sets out my opinion in regard to the questions contained in a Mallesons Stephen Jaques brief dated 13 August 2009.

1.2 The questions I have been asked to address are included within Appendix 4 and summarised within section 3 of this document.

1.3 This report does not provide any opinion on the economics or unit costs relating to the delivery of customer access network infrastructure.

1.4 My opinions, set out in this document, are based on the material supplied, independent research and my experience in the delivery of telecommunication networks.

2 AUTHORSHIP

2.1 I, Craig Lordan, have compiled this document in response to the brief. I am an Electrical Engineer, having graduated from Central Queensland University in 1988. I have 20 years experience within the Australian telecommunications industry and my CV is at Appendix 3. Prior to becoming a consultant, I was engaged in a number of Access Network roles within Telstra commencing in 1989 until I resigned in 2001.

2.2 During that period with Telstra, I specialised in urban and rural Customer Access Network infrastructure, including the planning, design and construction of copper, fibre and radio networks. My experience extended from hands on responsibility for individual construction projects through to long term strategic planning and budgeting.

2.3 I also completed international roles while with Telstra. These included the planning and development of customer access networks within Vietnam. Later roles with Telstra included national responsibility for the development and application of Access Network design and construction practices.

2.4 During the past seven years as a consultant, I have provided advice and support to many organisations in relation to the development and implementation of telecommunication networks. Organisations that have received and implemented my advice include existing telecommunication carriers, electricity utilities and government organisations. Recently I have spent a high proportion of my time working to plan and build alternative telecommunication infrastructure within non-carrier organisations.

2.5 I have provided advice to both Queensland electricity organisations which have successfully enabled and commercialised telecommunication infrastructure which provides competition to the existing carrier networks. Other major projects have included the completion of technical feasibility reports for the implementation of very high speed access, fibre based, networks on behalf of State and Local Governments.

3 SUMMARY AND CONCLUSIONS

3.1 My responses to the questions posed are summarised in the following paragraphs.

"What factors are relevant to determining whether or not wireless technologies could be deployed in Band 2 in Australia as a replacement for Telstra's copper Customer Access Network ("CAN") (providing both voice and broadband services akin to those provided over the copper CAN). In your view, does the presence, or absence, of any of the above factors preclude the deployment of wireless technologies in Band 2 in Australia capable of providing the services described above?"

3.2 Although wireless technology is capable of delivering broadband and voice services, I do not believe it is a viable 100 % alternative to the fixed cable network within a Band 2 Exchange Service Area (ESA).

3.3 My conclusion is based on a number of factors including consideration of the potential service density in Band 2 ESAs, the limited availability of spectrum and the variability of performance of wireless systems due to design, atmospheric and weather limitations. In my opinion, to provide a wireless solution rather than a cable network would require significant investment in infrastructure and spectrum, with ongoing expenditure to accommodate increasing demand through the use of more spectrum and equipment capacity.

3.4 Due to the potential required bandwidth of spectrum to satisfy the demand for broadband in a dense environment, the spectrum, in my opinion, which is likely to be used, will be in direct competition to the spectrum available for the delivery of higher value mobile services.

3.5 The current National Broadband Network (NBN) strategy supports the principle that the only viable solution for providing telecommunication services in a Band 2 type environment is cable, promoting the installation of optic fibre, with wireless being only considered in low density environments.

"What constraints exist to the deployment of wireless technologies in Bands 3 and 4 in Australia as a replacement for Telstra's copper CAN (providing both voice and broadband services akin to those provided over the copper CAN), to end-users within a 25 km radius of a fixed point? In light of those constraints, is a 25 km radius a reasonable radius to adopt? If it is not, what radius would, in your view, be reasonable?"

3.6 The accurate prediction of wireless system coverage is difficult and dependent on the quality of the available information. Performance is dependent on multiple factors including the frequency used for the system, type of equipment, distance over which the signal is transmitted, environment and topography. Software based predictions of coverage can be developed, but results are dependent on the quality of topographical information with variations often apparent in field measurements. In many cases, it is necessary to 'over engineer' a wireless design to allow for adequate performance in unfavourable circumstances.

3.7 In my opinion, the assumed average radius of 25 km[2] from a Base Transmitter Station (BTS) is likely to represent the extremity of the capability the wireless system to deliver services equivalent to those which could be delivered on ULLS. If only voice services were to be delivered, I believe a radius of 25 km is most likely suitable.

3.8 I have reviewed published system vendor[3] information and I have been unable to find documented evidence of broadband wireless access services with a proposed coverage radius in excess of 12.5 km.

3.9 In ideal conditions a distance of 25 km from a BTS may be viable for the delivery of voice and broadband services, but when the impacts of the environment, topography and multiple users are considered, it is my opinion that an average BTS radius of 15 km represents the result that would be achieved in the real world if a system was implemented.

[2] Annexes to Fixed LRIC LRIC model documentation | E-3
[3] Vendors reviewed include – Airspan, Alvarion, Nokia-Siemens, Motorola, Redline, Qualcomm, Telsima and Vecima.

4 BACKGROUND

4.1 Before addressing the specific questions, I provide the following comments as background information.

4.2 ULLS is used by telecommunications access seekers to provide competitive telephony and high-speed broadband services to consumers and businesses.

4.3 For the purposes of this paper, any infrastructure considered as an alternative to ULLS must be capable of supporting the two services defined as a minimum of:

(a) **Telephone calls** are calls for the carriage of communications at 3.1 kHz bandwidth solely by means of a public switched telephone network[4] (Voice Telephony).

(b) **Broadband –** is an 'always on' high data rate connection. The data rate is not universally agreed but for the purposes of this report, considering potential future customer expectations, I have assumed an average rate of 10 Mb/s[5].

4.4 The two issues that I have been asked to address relate to the use of wireless solutions as an alternative to a fixed (wireline) cable access network.

Radio Spectrum

4.5 Radio spectrum is a limited resource and to successfully deliver wireless services, devices must operate on different frequencies in a manner that does not cause interference between two applications of the same frequency.

4.6 Radio spectrum in Australia is a sovereign asset with the ACMA being responsible for its usage. The resource is described by the ACMA as:

"Spectrum is described in economic terms as being a finite, instantly renewable, natural resource. Because the spectrum has the attributes of a limited resource, it has significant economic value and must be managed to maximise its overall benefit."[6]

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[4] Declared Service Definition – Local Carriage Service
[5] ADSL2 services offer greater than 12 Mb/s within 1.5km of an exchange.
[6] ACMA Why is there a need for planning of Spectrum-
http://www.acma.gov.au/WEB/STANDARD/pc=PC_2612

4.7 Within Australia spectrum is allocated to specific uses and any assignment to new applications typically requires use of an existing suitable and available allocation, or removal of other users from an existing allocation. Wireless Access Services are one of many uses of radio spectrum.

4.8 The ACMA includes a description of various access network solutions for the delivery of internet services. For wireless, the description is:

"Wireless internet services do not have a dedicated transmission pathway (for last mile access) as do cable or twisted copper lines. Since wireless last mile access is transmitted through the atmosphere and the condition of the atmosphere is variable, variability in service performance is also expected. Impediments to optimum wireless service include poor radio conditions in the atmosphere and local interference from other devices using similar frequency bands.

Some wireless technology such as microwave links require 'line of sight' between transmitters and receivers. 'Shadows' occur when objects and landscapes such as hills obstruct the line of sight which can impede or completely obstruct data transmission.

For nomadic or mobile wireless access, the speed at which an end user is moving may also affect the data rates."[7]

[7] http://www.acma.gov.au/WEB/STANDARD/pc=PC_100093 (Internet FAQs)

4.9 ACMA manages the Spectrum within Australia via three categories of License which are:

(a) Apparatus licences – specific to a category of service and location. Includes conditions on power output, frequency of operation and emission type.

(b) Spectrum licences – area based licences with no requirement to specify the technology or service delivered. Typical applications include spectrum used for mobile telephony network services.

(c) Class licences – umbrella licences which allow multiple low powered devices to be operated with the expectation of minimal interference, because power levels are limited to minimise interference. Individual licences are not required and interference may occur if devices are operated within close proximity. There is no guarantee that the spectrum is available for any particular user.

4.10 The limited availability and often considerable commercial value of spectrum is typically reflected in the cost assigned to it.

4.11 ACMA has developed a view on the current and future spectrum allocations that may be used for the delivery of Wireless Access Services (WAS) which includes Cellular Mobile Telephony (3G and beyond), Broadband Wireless Access[8] (BWA), and Mobile Television solutions.

4.12 In my opinion, and for the purposes of this report, discussion regarding the modelling of wireless system coverage should be restricted to Spectrum Licence bands as the permitted transmit output power is much higher than Class Licence bands permit. I have not considered Class Licences as there is no guarantee of usage of the spectrum and service delivery results cannot be reliably predicted. By no guarantee of usage of spectrum, I mean that the use of Class Licence spectrum is not restricted to any one license holder and therefore multiple users may be attempt to use the radio spectrum

[8] ACMA WAS Discussion Paper Feb 06

simultaneously causing interference to each other and degradation of performance.

Spectral Efficiency

4.13 Spectral efficiency is a measure of how effectively data is carried within a radio system. A higher spectral efficiency enables more data to be transported over the same allocation of spectrum.

4.14 Spectral efficiency is measured in terms of the number of bits (1 or 0) of data which can be carried for each single Hz. For example if a system has a spectral efficiency of 3 bits/sec, for every 1 MHz of spectrum used, 3 Mb/s can be carried. The total available data capacity is often referred to as system capacity.

Modulation

4.15 Due to the limited available spectrum, high level modulation techniques are employed to enable greater spectral efficiency and to deliver greater capacity from the same amount of bandwidth.

4.16 Modulation is used to encode the base radio signal with the information (data) to be carried between the transmitter and receiver. Modulation is the process of varying a carrier signal, either in amplitude, frequency, phase or a combination of these, to convey the required message or data.

4.17 For a higher level of modulation, the same amount of frequency can carry a greater amount of data capacity.

4.18 Typically systems with high level modulation schemes require a higher quality signal between transmitter and receiver, and if signal propagation is not satisfactory, the system will often reduce the level of modulation and less data can be carried.

4.19 Adaptive modulation is a feature of many modern wireless systems which allow the system to maintain service whilst adjusting the modulation scheme depending on the conditions. If the system detects that a connection to a remote device is not able to operate correctly at the current modulation it will reduce the modulation level until the connection works. Reducing the modulation level will reduce the speed of the data connection to the device.

System and Carriage Capacity

4.20 The capacity available for carriage of customer data is lower than the total capacity as the total includes overhead data required to manage the network such as framing and error correction data. The capacity available for the transport of customer information is normally referred to as carriage capacity.

4.21 The overhead data within a system is used for control functions such as addressing and error correction. The overhead information contains additional address information to allow a system to direct the data to the correct location. Most systems also include additional data with a package which enables the system to confirm the quality of the data and correct some errors if they occur.

4.22 Various factors impact the ratio of system capacity to carriage capacity including packet size and system configuration. Typically 75 - 80% of the system capacity is available for transport of customer data with the remainder consumed in system overheads.

Point to Multi-Point Systems

4.23 Rather than allocating spectrum to a single link, point to multi-point systems allow the sharing of spectrum between multiple users.

4.24 A wireless system can normally be categorised into two main categories, either point to point or a point to multi-point system. A point to point system is used to link two discrete locations whilst a point to multi-point system typically has a one or many Base Transmitter Station (BTS) which multiple devices can receive and send information.

4.25 The mobile telephony networks within Australia are examples of point to multi-point systems.

4.26 Wireless Access Systems (WAS) is a common term used for point to multi-point wireless systems which provide connection from a carrier BTS to a customer device.

4.27 Broadband Wireless Access is another common term which is used to denote a WAS which is capable of delivering broadband data services.

4.28 A wireless system provides a finite capacity dictated by the channel bandwidth allocated to the BTS. As discussed in paragraphs 4.4 to 4.7, spectrum is a constrained resource.

4.29 The bandwidth allocated to each BTS must be able to supply the customer requirements of the area served by the BTS.

4.30 As multiple BTSs are established, the bandwidth required for the total system implementation increases. The area serviced by a BTS is commonly referred to as a cell.

4.31 Typically the same frequency cannot be reused for an adjacent BTS as the two transmitters would interfere with each other. A separation of a number of BTSs (described in a cell plan) may be required depending on the system design and implementation.

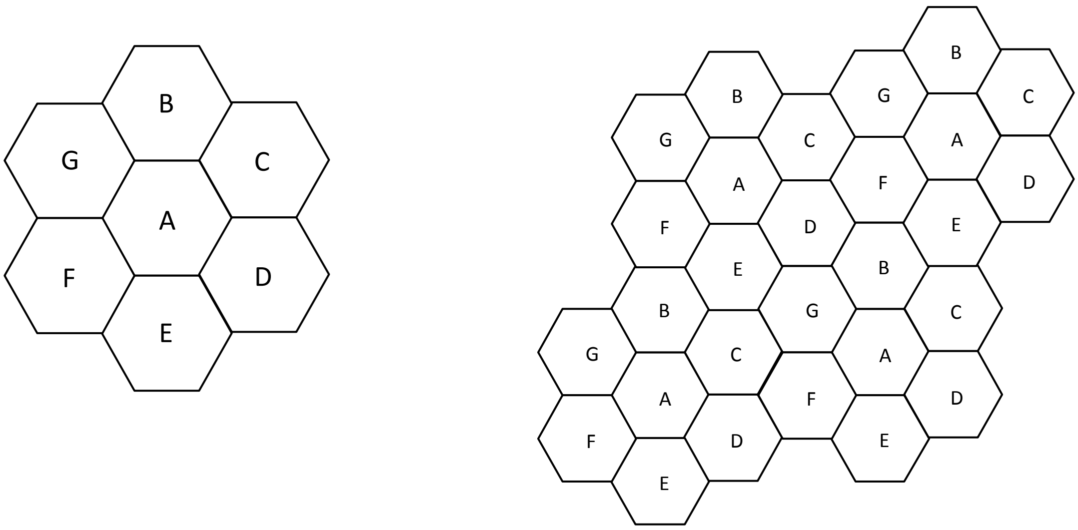

Figure 1 - Example Cell Plan

4.32 Figure 1 demonstrates a seven cell frequency reuse plan. Each cell is assigned unique frequencies. The pattern ensures that even when repeated multiple times, any one frequency group (cell) is always separated from the next occurrence by two intermediate cells. Within a wireless point to multi-point “last mile network” the system capacity is shared between the connected services. Typically the capacity provided at a BTS is not sufficient to satisfy the requirements of every customer simultaneously.

4.33 Based on statistical models of usage patterns the capacity available at a BTS is normally much lower than the sum of the customers' requirement. This approach is called contention and is used to maximise the usage of available bandwidth. Contention is not a constraint for wireline access networks where in most cases; every customer has their own physical connection to the 'exchange'.

4.34 A contention ratio of 40:1 or higher may be used within a telecommunication system. For example, 40 customers, each with 10 Mb/s each, can share a total system capacity of 10 Mb/s and statistically receive access at 10 Mb/s as users share the available capacity at different times. The statistical models are more effective when the number of customers is significantly higher than the contention ratio, for example 400 customers sharing 100 Mb/s at a contention ratio of 40:1.

4.35 The contention ratio which can be used is highly dependent on the level and usage patterns of the customers and does not guarantee specific service quality outcomes for customers using this type of contended wireless network.

4.36 When wireless is considered for the delivery of voice and data services, the dominant contributing factor to bandwidth requirements is the level of data capacity to be provided. Although capacity must be reserved for the delivery of voice services, the bandwidth required for voice is a fraction of the general data requirements for the delivery of broadband services.

Spread Spectrum

4.37 To improve the use of limited spectrum, techniques are employed to increase the data which can be carried on a unit of frequency.

4.38 Spread spectrum is a technique employed for high capacity wireless services, which rather than using a single frequency, spreads the information across a band of frequencies.

4.39 UMTS (discussed below) or WiMax technology employs spread spectrum techniques to increase the data throughput of the system within the available spectrum.

4.40 Whilst still being dependent on the fundamental principles of radio wave propagation, spread spectrum solutions can demonstrate different transmission characteristics, often better, in terms of multipath (reflection) impacts. However, within spread spectrum systems the maximum BTS transmit power is shared between users.

4.41 The sharing of BTS transmit power between users means that the range of area covered by a BTS changes continuously with relation to the amount of traffic currently delivered. When demand is greater, for example due to users downloading files, the range of the BTS decreases. The maximum performance of a spread spectrum solution is when only one service is in use.

System Standards

4.42 Global System for Mobile Communication (GSM) is a second generation (2G) mobile phone system used in most countries worldwide. Global roaming, worldwide common emergency number, and the addition of packet data capabilities of up to 56 kb/s (GPRS) are some of the features of this popular standard. Further development (EDGE) has increased the data rates to typically 400 kb/s with EDGE being considered 2.75G or even 3G in some forums.

4.43 Universal Mode Telecommunications System (UMTS) is a third generation (3G) mobile phone system rapidly developing into a (4G) system. UMTS builds on features of GSM/EDGE with the benefit of many handsets supporting both GSM and UTMS (dual mode). UMTS originally offered base data rates of up to 384 kb/s.

4.44 High Speed Packet Access (HSPA) is commonly used to refer to upgraded UMTS networks that support enhanced data rates provided by HSDPA (High Speed Data Packet Access), HSUPA (High Speed Uplink Packet Access), and HSPA+ (also known as HSPA Evolution or evolved HSPA). HSPA+ currently supports downlink rates of up to 42 Mb/s and upload rates up to 22 Mb/s close to a BTS.

4.45 Long Term Evolution (LTE) is a further upgrade to the UTMS/HSPA family offering enhanced radio throughput and the adoption of an all IP core. Theoretical data rates are 300 Mb/s download and 75 Mb/s upload with a 20 MHz channel close to a BTS.

4.46 The performance of wireless systems is variable as a result of design, transmitter power and environmental constraints. By contrast, wireline systems tend to offer more predictable capacity and reliability of performance. Both means of delivering communications services have applications where one is preferred over the other for economic and performance reasons, and there are areas of application where wireless or wireline may offer similar performance and cost.

Radio Propagation

4.47 Irrespective of system type, the delivery of any signal by radio waves depends on the propagation of the radio waves through the atmosphere and any obstructions. Obstructions include items such as, vegetation, buildings and topographical features such as hills.

4.48 The quality of service delivered via radio waves (wireless) is dependent on the received signal strength exceeding that of other radio signals within the environment so it can be interpreted and decoded by the receiving device.

4.49 Wireless services rely on the received signal strength exceeding other wireless signals, including interference, by a sufficient margin to enable the device to interpret and process the content of the signal.

4.50 The propagation of radio waves is dependent on two fundamental attributes, the distance between the transmitter and receiver, and any obstacles on the radio path. The strength of the received signal is affected by transmitter power, distance to the receiver, intermediate obstacles and the effect of changing atmospheric conditions all of which can reduce the signal level received.

4.51 Transmitter power is the amount of power transmitted, measured in watts, from the wireless device either at the base station or the customer's device. Typically the allowable transmitter power with a customer device is much lower than a base station for health and safety reasons.

4.52 The loss in radio signal between a transmitter and receiver is typically described in terms of decibels (dB). Decibel is a logarithmic unit of measurement that expresses a ratio of two quantities of the same unit. In simple terms, ignoring antennas etc, a 3 dB loss means that the strength of the signal received is half of the signal transmitted. For a loss of 6 dB the received signal is 25%.

Radio Paths

4.53 The performance of a radio system is dependent on the environment in which it operates. The ideal conditions for a radio signal are a short distance with no obstructions between the transmitter and receiver. Most systems however are designed to operate in conditions which do not satisfy the ideal requirements.

4.54 The best possible performance for a radio service is where a direct line of sight, with no obstructions impacting the signal, can be achieved between the transmitter and receiver. The level of the radio signal is still impacted by distance as the variability of atmospheric and weather conditions degrade the signal. For example temperature, barometric pressure and humidity may alter the refraction characteristics of the atmosphere.

4.55 Due to the physical attributes of the earth, in a flat terrain environment, the curvature of the earth limits the distance over which line of sight can be achieved. From a 30 m point above flat ground, the theoretical maximum distance visible to the horizon, neglecting refraction, is approximately 19.5 km.

4.56 Refraction of the radio signal is a variable dependent on atmospheric conditions including temperature and contaminants but the the effective earth radius is 4/3 (1.33) that of the actual earth radius in normal atmospheric conditions when estimating the effect of refraction on wireless performance. This means that radio signals tend to be pulled slightly towards the earth’s surface, leading to a longer ‘line of sight’ path than a calculation based on distance alone will suggest. Including the impact of refraction, the theoretical distance achievable in a level environment with no obstacles is approximately 26 km before the curvature of the earth impacts sight. This may vary considerably with changing atmospheric conditions as described in paragraph 4.62.

Fresnel Zone

4.57 A radio signal propagates with a circular radiation pattern. The zone which encompasses the signal transmitting between two points is called the Fresnel Zone. The Fresnel zone (microwave propagation) is defined as an ellipsoid between the antennas along the microwave link path. The Fresnel zone concept is used to determine whether a microwave link will suffer from attenuation of the signal due to obstruction. For a longer radio path, the affect of obstructions within the Fresnel Zone are greater.

4.58 The First Fresnel Zone is where the sum of the distance from each antenna to a point intercepting the ellipsoid is exactly one half of a wavelength further than the direct path between the antennas.

4.59 No obstruction and therefore no additional attenuation will occur when 100% of the First Fresnel zone is unobstructed in standard atmosphere (standard k-factor). Depending on the climate (tropical or temperate) and the distance of the link, a percentage of the first Fresnel zone must remain unobstructed with minimum k-factor conditions before obstruction losses may impact performance.

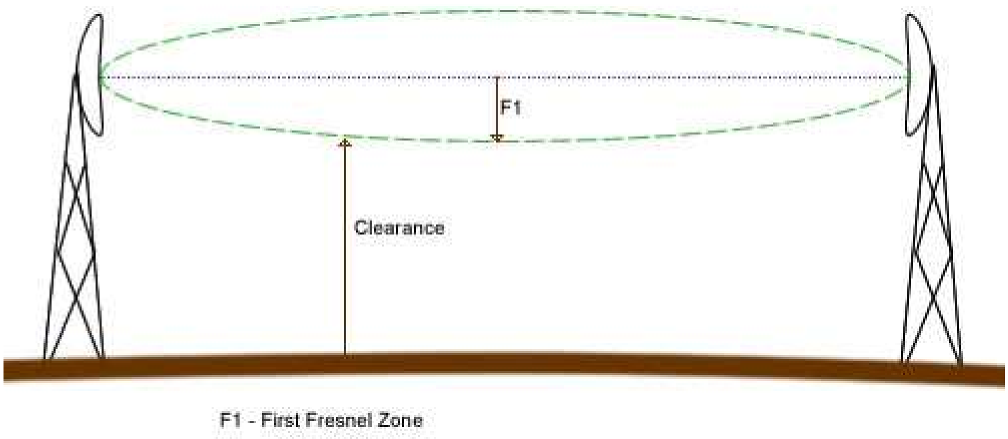

Figure 2 Fresnel Zone

4.60 The size of the Fresnel zone radius is related to the path length, the frequency, and the distance from the antenna. At the middle point of the link path the Fresnel zone radius is greatest. The Fresnel zone radius decreases with frequency of the carrier signal.

k-factor:

4.61 The k-factor is used to describe the refractivity of the atmosphere due to humidity, temperature, and pressure. Standard atmosphere has a k-factor of 4/3 meaning that the radio wave is bent downwards at a rate of 4/3 the earth's circumference.

4.62 Radio line-of-sight in standard atmosphere is 4/3 or 1.33 x visual line of sight due to refractivity of the atmosphere. In non standard atmospheric conditions – temperature inversions, very high evaporation or humidity, sub-refractive conditions may occur where the radio wave is not refracted as much, or may even be refracted in an upwards direction.

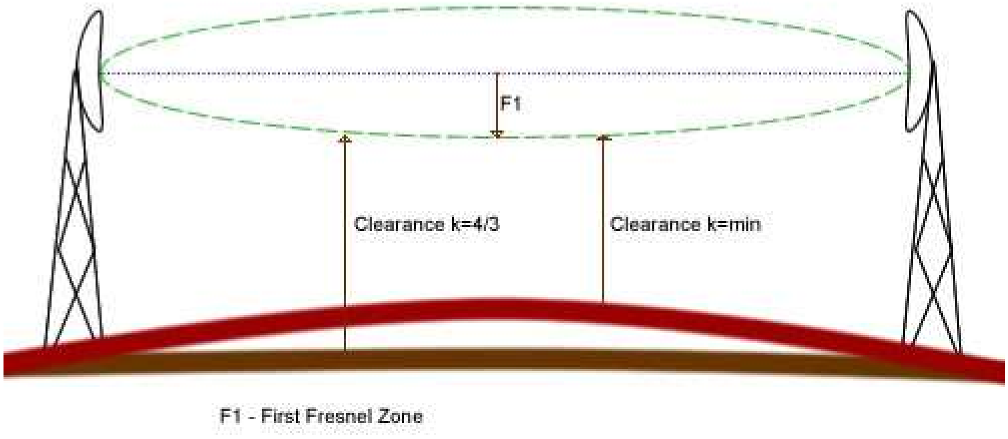

Figure 3 Impact of k Factor

4.63 The effect is to reduce the clearance of obstacles including the earth's surface. These conditions are known as minimum k-factor conditions and must be taken into consideration during the microwave link planning phase.

4.64 As an example of good engineering practice a First Fresnel zone clearance of 60% at k-factor of 0.6 (minimum) is required for an unobstructed microwave link in a tropical climate.

4.65 The impact of the Fresnel zone is further discussed in Appendix 1.

5 WIRELESS ALTERNATIVE IN BAND 2

5.1 I have been asked:

5.2 **What factors are relevant to determining whether or not wireless technologies could be deployed in Band 2 in Australia as a replacement for Telstra's copper Customer Access Network ("CAN") (providing both voice and broadband services akin to those provided over the copper CAN). In your view, does the presence, or absence, of any of the above factors preclude the deployment of wireless technologies in Band 2 in Australia capable of providing the services described above?**

5.3 Although wireless technology is capable of delivering broadband and voice services, I do not believe it is a viable 100 % alternative to the fixed cable network within a Band 2 ESA.

5.4 My conclusion is based on a number of factors including consideration of the potential service density in Band 2 ESAs, the limited availability of spectrum and the variability of performance of wireless systems due to design, atmospheric and weather limitations. In my opinion, to provide a wireless solution rather than a cable network would require significant investment in infrastructure and spectrum, with ongoing expenditure to accommodate increasing demand through the use of more spectrum and equipment capacity.

5.5 Due to the potential required bandwidth of spectrum to satisfy the demand for broadband in a dense environment, the spectrum, in my opinion, which is likely to be used, will be in direct competition to the spectrum available for the delivery of higher value mobile services.

5.6 The current National Broadband Network (NBN) strategy supports the principle that the only viable solution for providing telecommunication services in a Band 2 type environment is cable, promoting the installation of optic fibre with wireless only being considered in low density environments.

5.7 The reasons for my conclusion are provided in the following paragraphs.

5.8 I have interpreted the question in paragraph 5.1 as whether wireless may be used as an alternative to a fixed access network (the CAN) providing 100% of voice and broadband services within a Band 2 ESA.

5.9 A typical approach is to use wireless solutions for the provision of mobile services, services in low density areas and bypass and niche services where the expected market share or take-up rate is low. Smaller operators may target localised or niche markets using wireless as a delivery mechanism, but the benefits are likely to be outweighed in high density areas where the economies of scale for cable networks is effective. Wireless technology is normally chosen for service delivery because it can be more cost effective in low density areas than the use of cable networks.

5.10 In my opinion it is unlikely that any operator would consider it viable to provide all services within a service environment equivalent to a Band 2 ESA by implementing a wireless solution. Because wireless spectrum is a finite resource, the need to reuse spectrum in areas of dense demand for services forces construction of many wireless nodes, raising costs to a point where high capacity wireline infrastructure is most likely to perform better and have similar or lower costs.

5.11 The discussion within this section considers the viability of a wireless solution to provide all voice and broadband services within a Band 2 ESA.

5.12 Although the minimum density for an entire Band 2 ESA is defined as 108.4 services in operation per km^2 (or 1.084 services per hectare), in my opinion this average figure, does not accurately reflect the density likely to be encountered within a typical urban environment.

5.13 The recently published South East Queensland Regional Plan, which I have assumed is typical of urban development within Australia, requires minimum densities of 15 residences per hectare but encourages much higher densities. For a conservative approach and to allow for variations in development rules and existing urban areas, I have assumed an average density of 10 residences per hectare in the following discussion.

5.14 In my opinion, considering the supply of service in medium to high density areas, distance is unlikely to be a limiting factor in any potential Band 2 ESA wireless access network solution.

5.15 BTS capacity, in my opinion, would be the dominant factor which would limit the opportunity to use wireless as a replacement for a fixed access network within a Band 2 ESA.

5.16 As noted in the ACMA review[9], fixed networks (wireline) offer higher download rates at cheaper prices for medium to high density areas, and the growth in wireless fixed and mobile broadband services is expected in regional and remote areas where they offer more economic deployment compared to long run wireline infrastructure that may have impaired performance as a result of the long cable runs.

5.17 For the purpose of this discussion I have assumed that the service requirements to be satisfied are the reliable provision of a high quality voice grade service, and broadband service of 10 Mb/s. In my opinion a minimum broadband download speed of 10 Mb/s is conservative when future market expectations are considered.

5.18 In order to deliver 100% coverage in a Band 2 ESA, it is likely that many small wireless cells will be required.

5.19 To deliver a wireless alternative to a fixed wireline network, all service requirements within a BTS cell coverage area must be able to be supplied. For example, a cell covering a radius of 0.5 km with a density of 10 residences per hectare can have a potential of 780 services.

5.20 A fixed access (wireline) network does not share any capacity between the local access switch and the customer and therefore any wireless solution proposed as a substitute would also need to exhibit performance equivalent to an access network which does not at any time constrain access. This requirement will significantly limit the level of contention[10] which can be applied to a wireless network, and in effect means wireless capacity must be over provided to give reasonable (but not guaranteed) assurance of acceptable service when many customers are contending for wireless capacity.

5.21 For a contention ratio of 40:1 the example wireless access system BTS in Paragraph 5.19 will need an available capacity of ((780 * 10) / 40) = 195

[9] ACMA Five Year Spectrum Outlook 2009 - 2013

[10] Contention described in paragraphs 4.34 to 4.36.

Mb/s. If it was possible to maintain the same service level and double the contention ratio to 80:1, approximately 98 Mb/s would be required.

5.22 The total bandwidth to a BTS dictates the digital data capacity that can be transported. WiMax and other 4G technologies have high spectral efficiency with throughput dependent on the quality of the received signal. Adaptive modulation schemes adjust the amount of data transported in response to changes in the performance of the radio signal.

5.23 For this discussion of Band 2 ESA wireless coverage, I have assumed a very high spectral efficiency of 4.8 bits/sec even though the systems delivering this performance may not be currently available. This level of spectral efficiency is expected to be commercially available within the next five years.

5.24 If ideal conditions exist, the above spectral efficiency means that for every 1 MHz (1,000,000 Hz), a total of 4.8 Mb/s of digital information can be transported.

5.25 In simplistic terms a cell serving an area covered by a 0.5 km radius from a base station will require 40.6 MHz for 195 Mb/s whilst the 80:1 contention ratio would require 20.3 MHz allocated to it. The bandwidth required for each BTS is likely to be higher depending on the actual spectral efficiency achieved and the system overhead losses. As discussed in paragraph 4.22 an additional 20 % of spectrum may be required to service a carriage capacity of 20.3 MHz when system overheads are considered.

5.26 In my opinion, the allocation of 20.3 MHz at each BTS in a system is a very significant use of spectrum.

5.27 It is my expectation that the implementation of a system in any Band 2 ESA will require multiple BTSs with the carriage requirements calculated in paragraph 5.25. Due to interference constraints, frequencies cannot be immediately reused at an adjacent BTS. Therefore, in my opinion, the total capacity required for the system will be multiples of the bandwidth required for a single BTS.

5.28 If this system was to be implemented, the actual size of cells implemented will vary from the example size of 0.5 km radius, subject to the topography of an area, capability of the chosen equipment and the availability of suitable sites for BTS. Reducing the radius will introduce a corresponding increase in base stations required, including associated backhaul infrastructure requirements. Increasing the cell size increases the number of customers which share spectrum from the site. By way of example, if a seven cell[11] plan was adopted the total frequency capacity which would be needed would be seven times the bandwidth listed in Paragraph 5.25. The total bandwidth for a seven cell plan in the theoretical example represented in the preceding paragraphs is approximately 142 MHz.

5.29 This quantity of bandwidth is not currently available for use. To demonstrate how much additional bandwidth would need to be available, the total bandwidth currently assigned to WAS fixed and nomadic wireless access in Australia is 213 MHz[12]. Another 380 MHz is currently allocated for all Australian carriers mobile telephony services.

5.30 The use of spectrum for fixed BWA would be in competition with other requirements for spectrum such as premium services including mobile data and voice. The limited spectrum resource and multiple requirements for the spectrum will increase the cost of suitable spectrum for the delivery of BWA services.

5.31 In relation to fixed broadband services, it is my opinion that market expectations for increasing connection speeds will continue to increase and in the near future 10 Mb per customer will be exceeded. Broadband usage continues to evolve with video applications such as streaming video and online gaming which will increase capacity accordingly.

5.32 It is my opinion, due to the limited resource, that spectrum of sufficient capacity to provide this type of service would have a significant cost. The competition for and hence the cost of accessing suitable spectrum reduces the likelihood of fixed BWA being a viable replacement for a wireline network in a reasonably dense area.

5.33 Unlike the implementation of fixed access network infrastructure many, of the capital and ongoing costs of a wireless network are directly linked to the data

[11] Described in Paragraph 4.30

[12] Page 113 ACMA Five year Spectrum Outlook

volume to be carried. For example as demand grows, more spectrum must be provided and/or more BTSs added to accommodate demand.

5.34 Due to the infrastructure and implementation costs, in my opinion it is unlikely that a commercially viable business model exists to substitute wireless service provision for a fixed access network solution in the majority of areas within a Band 2 ESA.

5.35 Wireless is likely to remain as a solution for higher value services of voice, mobile data services, low density areas and possibly niche applications bypassing fixed networks for competitive reasons.

6 25 KM RADIUS MODELING

6.1 I have been asked:

6.2 **What constraints exist to the deployment of wireless technologies in Bands 3 and 4 in Australia as a replacement for Telstra's copper CAN (providing both voice and broadband services akin to those provided over the copper CAN), to end-users within a 25 km radius of a fixed point? In light of those constraints, is a 25 km radius a reasonable radius to adopt? If it is not, what radius would, in your view, be reasonable?**

6.3 The accurate prediction of wireless system coverage is difficult and dependent on the quality of the available information. Performance is dependent on multiple factors including system frequency, the type of equipment used, distance over which the signal is transmitted, environment and topography. Software based predictions of coverage can be developed, but results are dependent on the quality of topographical information with variations often apparent in field measurements. In many cases, it is necessary to 'over engineer' a wireless design to allow for adequate performance in unfavourable circumstances.

6.4 In my opinion, the assumed distance of 25 km average radius from a BTS is likely to represent the extremity of the capability of a wireless system to deliver services equivalent to those which could be delivered on ULLS. If only voice services were to be delivered, I believe a radius of 25 km is most likely suitable.

6.5 I have reviewed published system vendor[13] information and I have been unable to find documented evidence of broadband wireless access services with a proposed coverage radius in excess of 12.5 km.

6.6 In ideal conditions a distance of 25 km from a BTS may be viable for the delivery of voice and broadband services, but when the impacts of the environment, topography and multiple users are considered, it is my opinion that an average BTS radius of 15 km represents the result that would be achieved in the real world if a system was implemented.

6.7 The reasons for my conclusion are provided in the following paragraphs.

6.8 The coverage radius is an assumed figure used within the Analysys costing model when clustering locations which are to be serviced by a wireless BTS.

6.9 Based on my review of the supplied material[14], the 25 km coverage radius has been based on the use of 900 MHz GSM technology. The band commonly known as 900 MHz is 820 – 960 MHz.

6.10 The ACMA WAS discussion paper[15] views the 900 MHz band as a long term limited opportunity band for the provision of WAS in rural areas. My review of the discussion paper indicates that the current allocation for WAS in regional areas is 1785-1805 MHz for fixed and mobile services. The 900 MHz band is currently allocated for mobile services, ISM, STL and SOB fixed links, radio location and various fixed services.

6.11 I assume, that the use of wireless technology, as it is included within the model for lower density areas, is proposed to provide equivalent services which could be delivered on ULLS. This implies that a voice grade telephony service and a high speed broadband service can be provided.

6.12 I have assumed that the customer density to be serviced by a BTS in the model may vary between small township communities to single properties in isolated locations.

6.13 My interpretation, based on the supplied information of the current application of wireless services within the Analysys model is that it is unlikely, due to the relatively low density of customers to be serviced, that capacity demands will impact the potential cell size.

6.14 It is likely that in ideal radio propagation conditions services may be provided at a distance of 25 km, or greater, from a BTS. The following analysis considers whether it is valid to model a solution which assumes that a 25 km

[13] Vendors reviewed include – Airspan, Alvarion, Nokia-Siemens, Motorola, Redline, Qualcomm, Telsima and Vecima.
[14] FLRIC Report for stakeholders-Workshop
[15] Clause 7.3.2 WAS Discussion Paper Feb 06

average radius would deliver satisfactory performance to all customers within the coverage area.

6.15 The discussion within this section excludes reference to specific equipment standards with the knowledge that several manufacturers produce suitable equipment.

6.16 For the purposes of analysing the validity of choosing an average radius of 25km for modelling the provision of wireless services in Band 3 and Band 4 environments I have made a number of assumptions which are described in Paragraphs 6.17 to 6.19.

6.17 I have assumed antenna heights at a BTS of 30 m based on typical installations for cellular or wireless base stations normally being in the range of 20 to 30 m. Any structure which exceeds this height substantially increases the initial construction costs.

6.18 My interpretation is that the Analysys cost model selects the BTS position based on the location of services to be connected. I have also assumed that the BTS sites are located in the same general elevation as the customer locations. To place the BTS in an elevated location would require specific position independent of the customer locations.

6.19 I have assumed that at locations where customer services are to be provided a fixed external antenna may be mounted on the exterior of the building or roof line. With the exception of building a new antenna structure, this approach, I believe, will provide the highest possible performance for a customer service. For the purposes of this analysis, I have assumed the external customer site antenna is an average height of four metres above the ground. If alternative frequency bands are considered, any height greater than four metres may lead to interference from other systems[16].

6.20 The limitation of signal output at the customer terminal will be an important performance constraint.

6.21 In my opinion, 900 MHz is likely to have been selected as the frequency band to model as it is expected to deliver better coverage results than higher frequencies such as 2100 MHz.

6.22 As a general rule the lower the frequency selected, the greater distance which the radio signal propagates. The selection of 900 MHz aligns with this rationale.

6.23 The majority of the 900 MHz[17] band is currently allocated for mobile services. Although it is not currently assigned to BWA, I have included discussion on the presumption that it may be used for that purpose in the future. As all other likely frequencies identified for use in providing BWA services are higher than 900 MHz, the 900 MHz band is still considered as it represents the best case scenario for maximising low density rural coverage.

6.24 Standard GSM mobile telephony systems operate to a maximum operating radius of approximately 30 km. The maximum radius is a system limitation relating to the time taken for a signal to be sent to the remote device and return, which is fixed even in ideal radio conditions. Typically actual cell sizes are smaller due to geographic limits such as hills preventing transmission to all areas within a defined radius. In higher customer density areas, cell size is further reduced to enable the greater volumes of traffic to be accommodated.

6.25 In my opinion, it may be valid to select a 25 km radius for modelling the delivery of only voice services in rural areas. Voice services require a much lower level of data carriage capacity.

6.26 The use of 900 MHz UMTS is widely proposed technology for the delivery of mobile data services in a rural environment due to better coverage performance than higher bands such as 2100 MHz, although evidence of widespread implementation of the band for fixed services is not apparent.

6.27 Based on my review of available literature[18], worldwide implementations of 900 MHz UMTS appear to have been restricted to mobile data services involving the conversion of spectrum currently used for GSM voice services.

6.28 As the distance of a radio service increases, the impact of the curvature of the earth and obstructions becomes more pronounced. The impact is

[16] Clause 7.4.2.2 RALI FX 14- Jan 2000

[17] ACMA Five Year Spectrum Outlook 2009 – 2013

[18] Market Study for UMTS 900 – Ovum Feb 2007 (Report to GSMA)

demonstrated in the Figure 5 and Figure 6 in Appendix 2. The figures demonstrate the path profiles for a radio service at 15 km and 25 km.

6.29 By extending the extra 10 km, the maximum received signal is 8.8 dB less than at 15 km. This represents a reduction in received signal of 13.2% of the power received at 15km. It also increases the effect of any obstruction or undulation in the earth's surface. The figures in Appendix 1 show the first Fresnel zone during normal and minimum conditions. The majority of the transmitted signal is within the centre 60% of the Fresnel zone. Radio paths with 60% Fresnel zone clearance are considered to have a clear path and therefore suffer no attenuation due to obstructions. The curves on the figures within Appendix 1 show the 60% boundary on the first Fresnel zone for normal and minimum atmospheric refraction conditions. The result of increasing the path length by additional 10 km is significant in terms of the reduced received signal, which in this example ignores the potential impact of obstructions such as buildings, hills and vegetation.

6.30 If the only consideration was for voice (telephony) services, the issue of traffic loading is not a major factor and therefore cell radii can be relatively easily predicted and extended further than when voice <u>and</u> broadband services are jointly considered.

6.31 When considering the use of wireless as proposed in the Analysis model, I have assumed that the BTS is delivering voice and broadband services equivalent to the services available using an ULLS.

6.32 The available transmit power of a spread spectrum system is dependent on the traffic being delivered as described in Paragraph 4.41, which makes the sustainable coverage radius of spread spectrum solutions more difficult to predict. It is however, in my opinion, a valid assertion that the coverage performance of a spread spectrum solution delivering broadband services over an extensive area will be significantly less than that of a voice only system using the same frequency band. In the selection of an appropriate radius for modelling coverage, the delivery of broadband services should be the dominant criteria and, in my opinion, will limit the path length from transmitter to receiver as described above.

6.33 The use of 900 MHz UMTS in lieu of 2100 MHz is promoted by manufacturers such as Qualcomm[19] as a solution to provide greater coverage in rural areas. The Qualcomm information describes effective cell performance of a maximum of 1 Mb/s at a distance up to 7.2 km from the transmitter.

6.34 The use of lower 900 MHz frequencies for mobile broadband data services is also included in the 2007 OVUM report[20] which indicated a maximum rural coverage radius of 12.5 km for mobile data services.

6.35 I have reviewed equipment vendor[21] information and have not identified any available devices in the 900 MHz band suitable for use as customer premise equipment with an external antenna.

6.36 The implementation of external antennas at customer premises will, in my opinion, improve the potential distance to customer sites from the BTS. The reduction in losses due to building walls and the increased line of sight range will improve the signal quality at the customer premises. Increasing antenna gain[22] may offer some improvement in signal especially from customer device to BTS although the resultant increase in system interference from overshoot (where the signal from one customer device is received by a BTS within another cell) and subsequent reduction in signal to noise ratio (the ratio between wanted and unwanted signals) may, in my opinion, have a negative effect on throughput of data and degrade the cell as a whole due to the sharing of BTS transmit power.

Higher Bands

6.37 An alternative frequency band for analysis in the regional areas of Band 3 and Band 4 is the licensed band of 3.425 GHz to 3.4925 GHz. This band is recommended for Regional Wireless Local Loop services in RALI FX 14 – October 2000.

6.38 The ACMA have assumed a 20 km radius in cell planning documentation, assuming a 7 cell reuse pattern[23]. This assumption does not dictate the structure height and in my opinion allows for the possibility of significantly

[19] Qualcomm – Dubai GSM Coverage Comparison.
[20] Market Study for UMTS900 – Feb 2007
[21] Vendors include Sony-Ericsson, Nokia-Siemens and HTC
[22] Antenna gain increases the effective transmit power.

higher structures and may understate the impact of traffic load on the cell performance. The construction cost of significantly higher BTS structures is much greater than a typical height of 30 m.

6.39 The requirement for line of sight wireless connection is a key success factor for distance services and is supported by the Internode media release of 25-01-2008. The media release confirmed that a high speed broadband service could deliver 6 Mb/s data rate if "Good Line of Sight[24]" was available. I have not identified any evidence that this data rate made any consideration of multiple concurrent users of the BTS which will is likely to diminish the performance of a spread spectrum system as discussed in Paragraph 4.41.

6.40 As discussed in Paragraph 4.56 a good line of sight is only achievable at 25 km if the customer site is at the same elevation as the BTS and there are no obstructions in the path. In my opinion this is the best case scenario and not likely to be achieved in a high proportion of connections at the extremities of the 25 km radius coverage area.

6.41 There is greater loss for a wireless signal over the same distance for a signal at 3.4 GHz compared to 900 MHz. The effect of extending the distance from 15km to 25 km results in an additional loss of 7.1 dB. The additional loss, for a path over flat terrain, with no interfering trees or buildings obstructing the signal in ideal conditions, due to the earth curvature is 8.7 dB for a total of 15.8 dB loss attributable to the extra 10 km.

Conclusion

6.42 My interpretation of the aim of the Analysys model is that it is to provide a reasonable basis for the modelling the BTS infrastructure requirements to provide coverage to areas not viably serviced by fixed networks.

6.43 If a network was implemented to service rural areas, cell sizes are likely to vary depending on the availability of suitable sites for a BTS and the expected traffic demand.

6.44 For a network cost model, it is unlikely that an average of 25 km radius cells will provide voice and broadband services equivalent to an ULLS. Although

[23] Annexure B – RALI FX14 – Jan 2000
[24] http://www.internode.on.net/news/2008/01/71.php#MainContent

connectivity may be achievable at a distance of 25 km, the provision of high capacity throughput at a standard equivalent to a wireline access network is in all circumstances unlikely.

6.45 Due to the additional signal loss from distance and the impact of the curvature of the Earth, the margin in signal strength available to overcome obstructions and interference is diminished and the ability to provide a predictable high quality service is reduced.

6.46 Considering the experience of Internode (6.39), Qualcomm (6.33), Ovum (6.34) and the impact of distance on radio propagation, a more viable model, based on the available international experience at 900 MHz and the impact of distance on the services, is a maximum coverage radius of 15 km.

6.47 Past experience of delivering rural services using wireless technology such as Telstra's Digital Radio Concentrator Systems (DRCS) and High Capacity Radio Concentrator (HCRC) systems have achieved radius coverage in the range of 25 km. Both of these systems provided voice and lower data rates and used significantly larger antenna structures for each BTS, up to 100m in height and normally a separate customer site structure of at least 15 m.

6.48 Additional consideration should be given to the likely available spectrum for regional fixed BWA services which may be significantly higher than the 900 MHz band which will further restrict the viable cell radius. This in my opinion further supports the position that a viable BTS radius for analysis would be 15 km rather than 25 km.

6.49 Furthermore the impact of topography on the potential BTS coverage has not been explored, with ideal conditions presumed during discussion within this report. The implementation of a system would also be impacted by topography of the area to be serviced, with hills and mountain ranges further diminishing the potential coverage performance in actual installations. In my opinion this means that in many situations, a generic BTS design of tower height, transmit power, propagation constraints and demand density will mean there are many exceptions even to an assumed radius of 15km.

7 DECLARATION

7.1 I have made all the inquiries that I believe are desirable and appropriate and that no matters that I regard as relevant have, to my knowledge, been withheld from the Commission.

Craig Lordan
Senior Consultant
Gravelroad

8 LIST OF REFERENCES

ACMA Five Year Spectrum Outlook 2009-2013 – March 2009

ACMA WAS Discussion Paper Feb 06

ACMA Why is there a need for planning of Spectrum-
http://www.acma.gov.au/WEB/STANDARD/pc=PC_2612

Declared Service Definition – Local Carriage Service

FLRIC Report for stakeholders-Workshop Version

FLRIC user guide for stakeholders_Workshop Version

Geoanalysis user guide_Workshop Version

http://www.acma.gov.au/WEB/STANDARD/pc=PC_100093 (Internet FAQs)

http://www.internode.on.net/news/2008/01/71.php#MainContent

Market Study for UMTS900 – Feb 2007

Qualcomm – Dubai GSM Coverage Comparison

RALI FX 14- Jan 2000

Appendix 1 Path Profiles

Path Profiles Description

8.1 The diagrams in Figure 5 and Figure 6 show two Fresnel Zones for the sample path of a 30 m tower and 4 m customer terminal installation

8.2 Calculation of the Fresnel zone is dependent on k factors, 1.33 represents the typical circumstances which may occur and 0.66 depicts the normal poor conditions.

8.3 Clear line of sight is when the expected receive level based on free space loss is received at the far end. Clear line of sight is considered to be achieved when the first Fresnel zone has 60% clearance of obstructions such as terrain, trees, and other clutter. Refraction due to atmospheric conditions i.e. pressure, humidity, and temperature gradients is variable but in normal conditions is considered to bend the radio waves so as to increase the line of sight to 1.33 (k-factor) x visual line of sight.

8.4 In abnormal conditions caused by inversions of gradients (layering of the atmosphere), k may reduce to 0.6 (or any other value) and ITU[25]-R Recommendation P530 provides the minimum value based on the climate and length of the path and frequency. For the purposes of this discussion I have chosen to set minimum k at 0.6 and the percentage of intrusion to 60% (tropical climates). The minimum k-factor changes with distance as refraction of the entire path is the result of refraction at every point along the path.

8.5 The attached profiles show three curves of 60% intrusion with one at normal k (1.33) and the second at minimum k (0.66). The profiles show that with a frequency band of 900 MHz has a large Fresnel zone due to the long wavelength. The Fresnel zone size requires more height than a higher frequency to clear obstructions (or even the earth) and the customer antenna height would need to be considerably higher than 4 m to provide clearance. While the lower frequency of 900 MHz has better free path loss and clutter penetration, the intrusion of the earth occurs earlier and therefore reduces some of the gains of the lower frequency.

8.6 Figure 3 demonstrates the Fresnel Zones for a path, over level terrain, of 5 km, Figure 4 a path of 15 km and Figure 5 shows a path of 25 km.

8.7 For the path length of 5 km, for flat terrain, there is no intrusion into the Fresnel Zone and no estimated obstruction loss.

8.8 For a path length of 15 km the curvature of the earth intrudes into the Fresnel Zone and the estimated obstruction loss is 7.2 dB.

8.9 The final example is a path of 25 km which demonstrates the greater intrusion of the earth into the Fresnel zone and the increased estimated obstruction loss of 11.6 dB.

8.10 All estimated obstruction losses described above do not include any impact from obstructions such as trees or buildings are included.

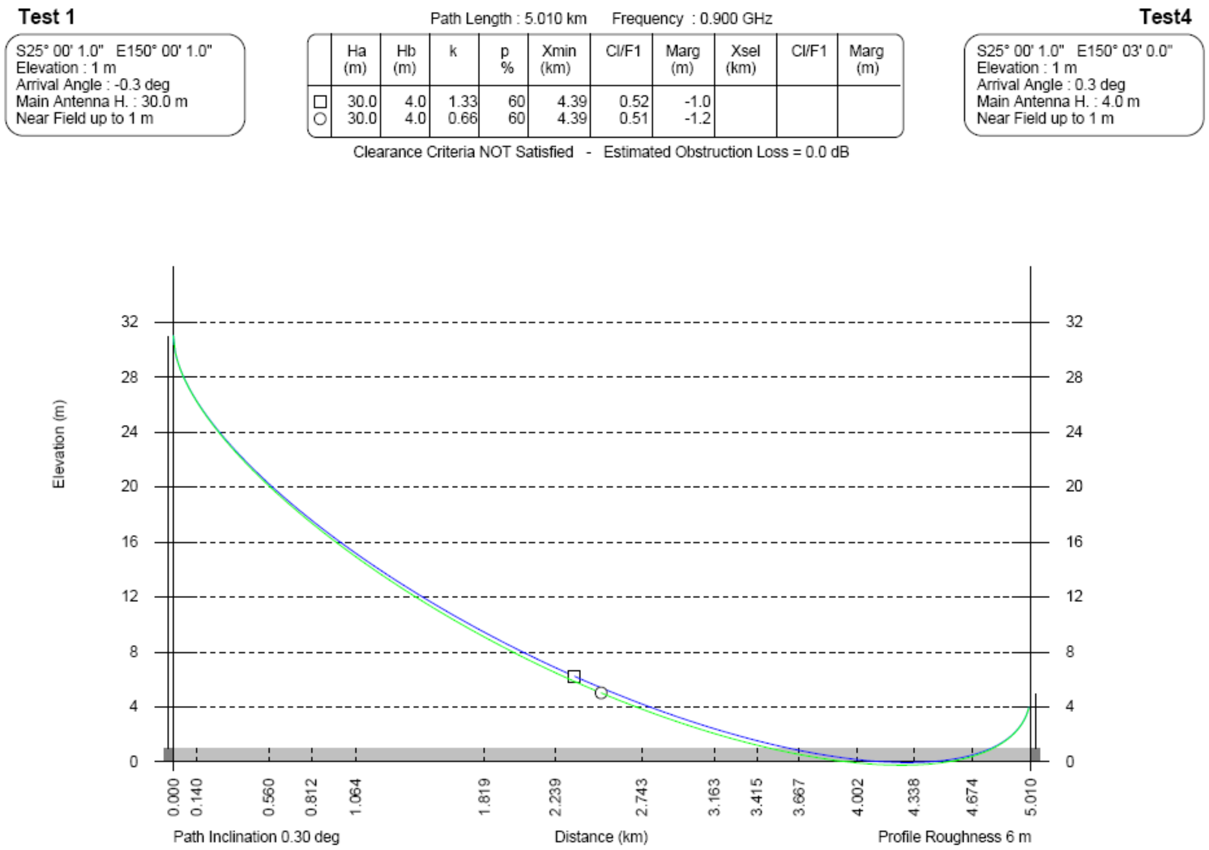

Figure 4 Path Profile 900 MHz 5 km

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[25] ITU – International Telecommunication Union

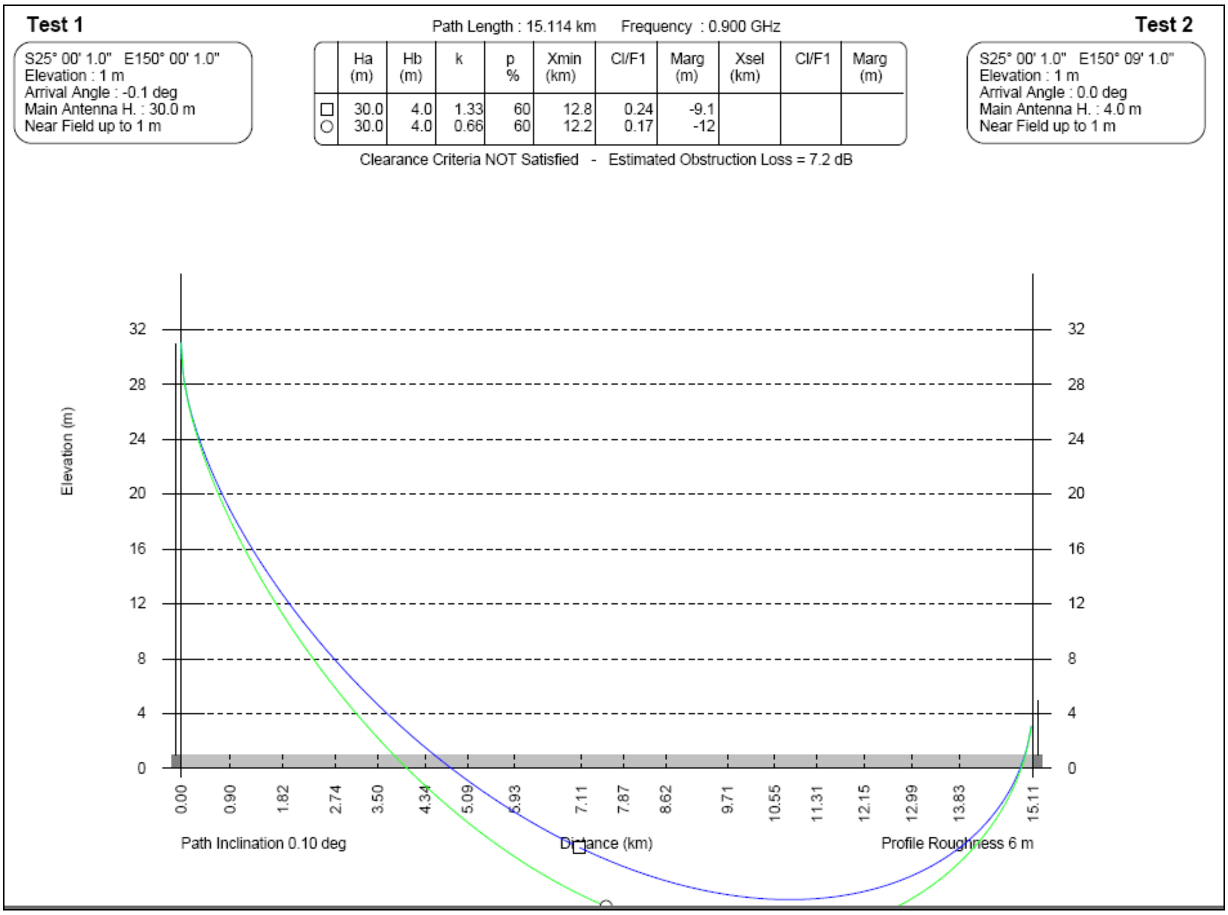

Figure 5 Path Profile 900 MHz 15 km

8.11 The graphs are the output of a professional microwave path design tool used to predict performance of a microwave link.

- x-axis represents distance between antennas at each end of the radio path. The x-axis also represents the earth surface. The earth surface is shown as flat for graphing purposes with the curvature factored into the graph results.
- y-axis represents height above ground of the antennas at each end of the radio path
- The blue line represents the 60% boundary of the first Fresnel zone in normal atmospheric conditions (k-factor = 1.33). Obstructions above the blue line in normal conditions will result in attenuation of the signal on the radio path.
- The green graph represents the 60% boundary of the first Fresnel zone during times of minimum atmospheric refraction (k-factor = 0.66) caused by changes in temperature, humidity, or barometric pressure. Obstructions above the green line in these conditions will result in attenuation of the signal on the radio path.

8.12 The graph shows that there is obstruction due to the curvature of the earth in normal conditions due to the antenna heights, frequency, and distance of 15 km.

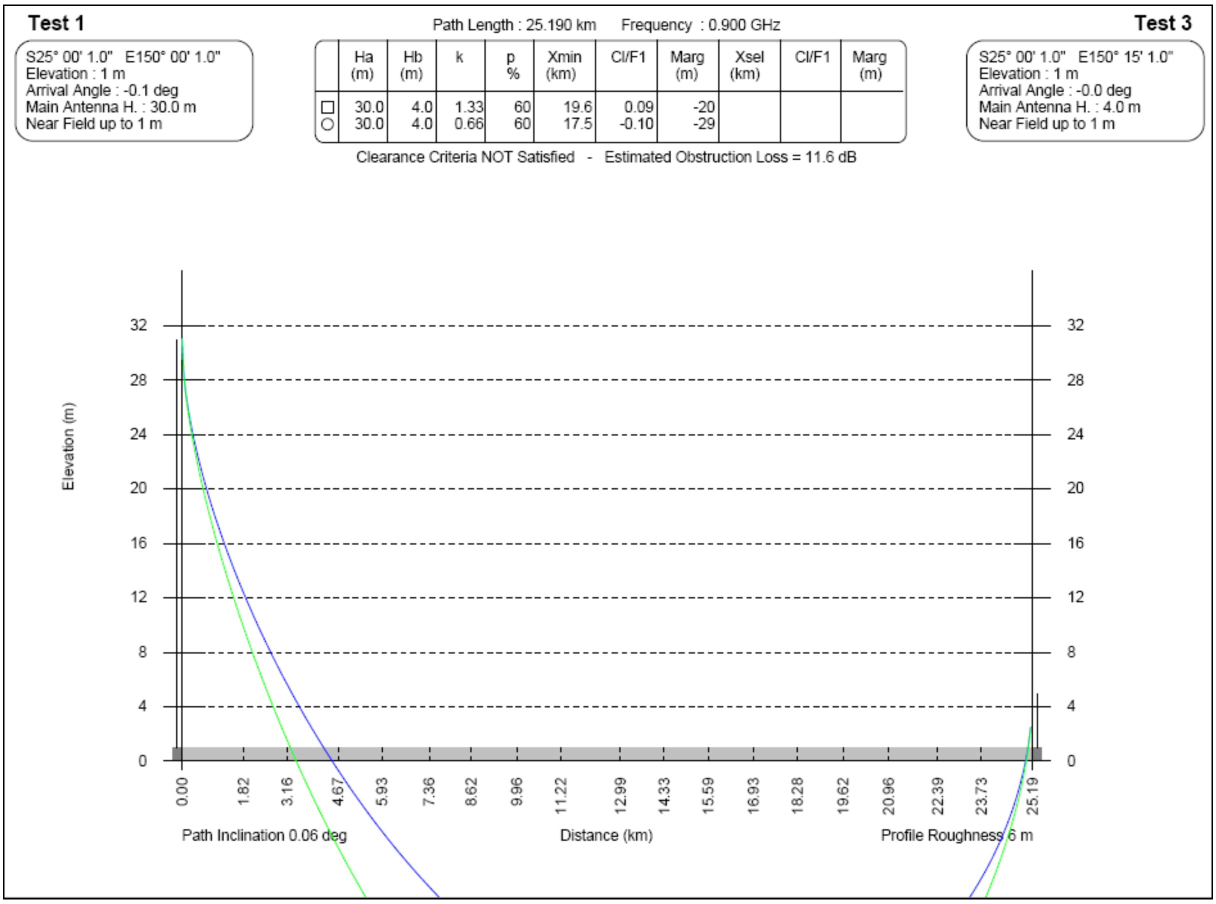

Figure 6 Path Profile 900 MHz 25 km

8.13 The graph shows that there is obstruction due to the curvature of the earth in normal conditions due to the antenna heights, frequency, and distance of 25 km.

8.14 The first Fresnel zone 60% boundary is 9 meters below ground level during normal conditions at 15km and 20 meters below ground at 25km. During times of k-factor = minimum, the obstruction becomes worse. The graphs assume obstruction from earth curvature only and do not consider trees, man-made structures, hills or other clutter.

Appendix 2 Craig Lordan Curriculum Vitae

EXPERIENCE SUMMARY

Craig Lordan is an Electrical Engineer who graduated from Central Queensland University in 1988, and now has 20 years of experience in the telecommunications industry and procurement strategy development. Prior to consulting roles, Craig was engaged in a number of roles within Telstra from 1989 through to 2001.

During his career in Telstra, he completed a number of roles which generally specialised in network construction, project management and contract management. His experience extends from hands on responsibility for individual construction projects through to long term strategic planning and budgeting.

Craig also completed international roles with Telstra, including the planning and development of networks within Vietnam. Later roles with Telstra included national responsibility for the development and application of network design and construction practices.

During the past eight years as a consultant, he has provided advice, expert opinion and support in the development and implementation of telecommunication networks to many organisations. Craig has also provided expert support in the development and implementation of procurement strategies. Organisations that have received and implemented advice include existing telecommunication carriers, electricity utilities, and Local and State Government organisations.

Recently he has contributed to the Queensland electricity industries' successful implementation of commercial telecommunication service supply, delivered Expert Witness Statements in relation to specific matters, assumed responsibility for the delivery of telecommunication and other infrastructure projects and the completion of technical feasibility reports for the implementation of very high speed access networks on behalf of State and Local Governments.

QUALIFICATIONS:

B.Eng. (Electrical) Central Queensland University
GCM Southern Cross University

EXPERIENCE HISTORY:

2001 – Present **Position:** <u>Senior Consultant</u>

Role: Specialist consulting assignments in the Telecommunications and Infrastructure fields including assessment of commercial issues, procurement, bidding strategies, project management and strategic advice.

Highlights:

Project Cost Estimation and Feasibility Analysis for the construction of a capital city wide very high-speed open access telecommunication network.
Project management of procurement of major items (long lead time) for Geothermal Power Station.
Published Expert Witness Statements in relation to DSLAM installation and optic fibre cable installation.
Development of procurement strategies for major corporate users within Queensland.
Project management of major customer telecommunication network installation and commissioning.
Advice on the establishment of Telecommunication Networks and Commercial Operation for Queensland Government Owned Corporations.
Technology application strategy advice and customer engagement policy formulation for major local government body.
Cause Analysis of failed Mobile Network Rollout for legal proceedings.
Activity pricing analysis for prominent Telecommunications Constructor during contract negotiation.
Facilitation of Post Implementation Review for a major Intelligent Traffic System installation project.
Strategic advice to a Queensland Government GOC Utility regarding the commercial opportunity to enter the telecommunications industry.

TELSTRA

2000 – 2001	**Position:**	National Operation Improvement Manager
	Role:	Leadership of the National Operations team responsible for high level analysis and improvement of existing process, contractor relationships, tender submissions, IT System Strategy and performance measurement for Global Connects Contracts
	Highlights:	Introduction of an improved work management and scheduling system, increased linkage between capital investment plan and daily operations. Tender analysis, including ongoing price negotiations and the redevelopment of Business Unit Communication Process.
1999	**Position:**	National Strategy Development Manager
	Role:	The primary responsibility of this position was, with a small team, to develop strategies improving the efficiency of capital expenditure within the Telstra Access Network and manage IT System improvements.
	Highlights:	Development of an innovative, efficient National System to identify substandard network, either due to maintenance or insufficient capacity, to facilitate a $250M capital investment program.
1998 - 1999	**Position:**	National Reporting Manager CAN2001 Project
	Role:	The initial requirement of this position was to contribute to the development of the business case for submission to the Telstra Board for additional funding ($500M) to rehabilitate Telstra's Customer Access Network. After approval of the project, responsibility for the national reporting of progress against the Business Case to Telstra Executive.
	Highlights:	Development of dynamic solutions for capturing contractor performance information.
1997 – 1998	**Position:**	Expert Decision System Development
	Role:	Through analysis of a number of Telstra Customer Access Design centres a high degree of variation in network build solutions was identified as a major issue for the company. A software solution was developed and implemented to provide a universally consistent design decision and outcome.
1994 – 1997	**Position:**	Central Vietnam Plan and West HCMC Business Plan
	Role:	As part of a three person team, a 10 Year Telecommunication Network Development Plan for the Central Vietnam Region was developed and presented to the Vietnam Telecommunication Department (VNPT).
	Highlights:	10 Year Telecommunication Network Development Plan for the Central Vietnam Region. Customer Access Network plan and costing of submission by Telstra to build the network for half of Ho Chi Minh City. Representation of Telstra and International Telecommunication Conferences in Asia.
1989 – 1994	**Position:**	Engineer and Senior Engineer Area Planning and Development (N&ITI)
	Role:	Responsibilities included the planning and project management of the Customer Access and Local Switch Network for Central Queensland. This involved the planning of conduit, copper, optic fibre and both internal and external switch technology.

Appendix 3 – Received Questions

MALLESONS STEPHEN JAQUES

13 August 2009

Mr Craig Lordan
Senior Consultant
Gravelroad Consulting
201 Wickham Terrace
SPRING HILL QLD 4004
By email:
Craig.Lordan@gravelroad.com.au

Dear Mr Lordan

Telstra Corporation Limited

We refer to our letter dated 10 July 2009.

1 Report

We are instructed to request that you prepare a report for use by Telstra in the Joint Arbitrations, expressing your opinion as to:

(a) what factors are relevant to determining whether or not wireless technologies could be deployed in Band 2 in Australia as a replacement for Telstra's copper Customer Access Network ("**CAN**") (providing both voice and broadband services akin to those provided over the copper CAN). In your view, does the presence, or absence, of any of the above factors preclude the deployment of wireless technologies in Band 2 in Australia capable of providing the services described above?

(b) what constraints exist to the deployment of wireless technologies in Bands 3 and 4 in Australia as a replacement for Telstra's copper CAN (providing both voice and broadband services akin to those provided over the copper CAN), to end-users within a 25 km radius of a fixed point? In light of those constraints, is a 25 km radius a reasonable radius to adopt? If it is not, what radius would, in your view, be reasonable?

2 Assumptions

In preparing your response to question (b) above, you should assume that more densely populated areas within Bands 3 and 4 (such as townships) may be serviced by the wireless technology.

3 Background

Pricing methodology for the ULLS: TSLRIC+

The ACCC has favoured prices set in line with TSLRIC+ for the supply of services which are "declared" under Part XIC, such as ULLS.

The ACCC's views on how costs (and specifically TSLRIC+) should be calculated are set out in *Access Pricing Principles - Telecommunications 1997*, particularly at pages 14, 27, 38 and following. Some more recent observations by the ACCC as to how those principles apply specifically to ULLS can be found in the *ULLS Final Pricing Principles - November 2007*, in particular in section 3.3.

In summary, TSLRIC+ is an estimate of what would be the least cost that a hypothetical firm would incur to replace Telstra's copper CAN in today's conditions, in a very short period of time, using the best technology currently in use.

Analysys cost model's use of 25 kilometre coverage radius for wireless

The Analysys cost model assumes a coverage radius of 25 kilometres for a wireless base station. This means that all end-users within a 25 kilometre radius of a base station are serviced by that base station. End-users outside the 25 kilometre radius of that base station are serviced by something else (for example, by another base station, or by a copper fixed network). We refer you to section 5.4.2 and Annexure E, section E.2 of the document entitled "Fixed LRIC model documentation - Workshop Version" dated 8 June 2009, which was included in the materials enclosed with our letter dated 10 July 2009.

The input is entered into the Analysys cost model in the "Access-DATA-XXX.xls" file, in cell U8 of the ESA Worksheets.

We also enclose spreadsheets and images of the exchange service area ("**ESA**") ADLE-2 in New South Wales. The Analysys cost model assumes that this ESA is serviced partially by copper, and partially by wireless as shown on these spreadsheets.

References to wireless technologies in the ACCC's ULLS Final Decision

As outlined in our letter dated 10 July 2009, in the ULLS Final Decision the ACCC observed that, in its view, wireless technology is a viable alternative to providing services over Telstra's CAN (in Band 2). We refer you to pages 50, 53, 59, 94, 104, 133, 143, 165, 219, 228, 258 and 272 of the ULLS Final Decision which include specific reference to wireless technologies.

Quality of voice and broadband services provided over a copper fixed network

In relation to the quality of voice and broadband services to be provided over a copper fixed network, we refer you to the Worksheet entitled "Pillar" in the file entitled "Cable Gauge Determination.xls" in the Analysys cost model.

4 Materials

Please find enclosed the following:

(a) ACCC, Access Pricing Principles - Telecommunications 1997;

(b) ACCC, ULLS Final Pricing Principles - November 2007; and

(c) spreadsheets and images of ESA ADLE-2 in New South Wales.

5 Guidelines for Expert Witnesses

Enclosed with our letter dated 10 July 2009 was a copy of the Federal Court of Australia's *Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia* ("**Guidelines**"). Please read it carefully and have regard to the requirements of the Guidelines in preparing your report. In particular, please have regard to the requirements in Item 2 of the Guidelines which concerns the form of the report and other matters which your report should address. If you rely on any facts beyond those stated above or make any assumptions in forming the opinions expressed in your report, please ensure that these are clearly stated to enable the reader to understand the basis for the opinions which you are expressing.

6 Confidentiality

This document and all other communications between us and you and our client are confidential.

Yours faithfully

Mallesons Stephen Jaques