Valuation of public mobile spectrum at 825-845 MHz and 870-890 MHz

A report for the Department of Broadband Communications and the Digital Economy

15 September 2011

Table of Contents

1   Executive Summary

Spectrum licences at 825-845 MHz and 870-890 MHz ("800 MHz band") will be reissued upon expiry in 2013 either through renewal at an administratively determined price or through price based reallocation (e.g. auction). [1] Reissue will be subject to a price that provides an appropriate rate of return to the community and that reflects the scarcity and value of this important resource. This report seeks to value licences for the purposes of setting government expectations with regard to licence reissue prices.[2] If licensees fail to meet the government's price expectations then the spectrum will be auctioned; therefore the value of spectrum yielded by an auction sets a lower bound on value. Licensees should be prepared to pay a premium for licence reissue because this removes the costs and uncertainty of engaging in an auction.

The spectrum licences to be valued are currently used to provide public mobile services (voice and data). It is assumed that the licences will continue to be used for these applications over the next 15 year licence period as the bands are used internationally for these applications.

There are three elements to the study:

- A review of international evidence on the value of spectrum licences in the same or similar frequency bands as revealed in auctions and licence renewal processes elsewhere.

- Modelling of values based on the projected revenues and costs of a hypothetical operator. A spreadsheet business model was constructed and calibrated against data and projections for the Australian market.

- Consideration of the disruption costs that might be associated with auctioning licences and proposing a range of values for the renewal price.

International evidence

The findings from a review of international evidence on spectrum value since the original auction of the Australian spectrum licences show that the value of the 800 MHz band is now likely to exceed substantially the original auction value in Australia. More generally there appears to be a strong view within the global mobile industry that sub 1 GHz spectrum carries a value premium to reflect the flexibility that it provides with regard to rural coverage and in-building penetration.

The recent international benchmarks and the current 900 MHz apparatus licence tax[3] indicate that the range of representative auction benchmark values from \$0.5/MHz/pop to \$1.2/MHz/pop may be appropriate (i.e. \$0.5 to \$1.2 per MHz per person within the licensed geographic area).

---

[1] Media release by Senator the Hon Stephen Conroy, Minister for Broadband, Communications and the Digital Economy, 4 March 2010. See http://www.minister.dbcde.gov.au/media/media_releases/2010/020

[2] The different approaches to calculating the opportunity cost of spectrum are discussed in "Opportunity cost pricing of spectrum", ACMA, April 2009

[3] Apparatus licence fee schedule, the ACMA, April 2011. Available at http://www.acma.gov.au/WEB/STANDARD/pc=PC_1614

Modelled values

Values were calculated based on a hypothetical incumbent operator and assuming that the market continues to support three operators. The value of the spectrum for a hypothetical operator having similar characteristics to the weakest of the three operators was modelled since this would most likely determine a hypothetical auction price and the government would not want to set prices at a level that might result in further industry consolidation. We have assumed that spectrum in the 800 MHz band will be used primarily for deployment of 3G services over the licence period.

To provide bounds on the value of the spectrum licences the following two measures were modelled:

- <u>Cost reduction value</u>: This is the value arising from the use of an incremental block of spectrum to reduce infrastructure costs. The cost reduction value is calculated by modelling infrastructure costs with and without additional spectrum. In congested areas additional spectrum allows more capacity to be deployed per site (and therefore fewer sites are required). The coverage and in-building penetration advantages of lower frequency bands were valued based on differences in the number of base stations needed to provide coverage. It was assumed that the minimum block size for efficient deployment of 3G services is 2x5 MHz

- <u>Full enterprise value</u>: This is the net present value (NPV) of total business cashflows (i.e. revenues less costs) that a mobile operator earns from all of its spectrum holdings. This sets an upper bound on what might be charged on licence reissue. A price higher than this level would mean that the operator modelled would go out of business.

Licensees will be prepared to pay more than the cost reduction value for a licence renewal because renewal removes the costs and uncertainty of going to auction (see Figure 1).

Figure 1: Range of spectrum value measures
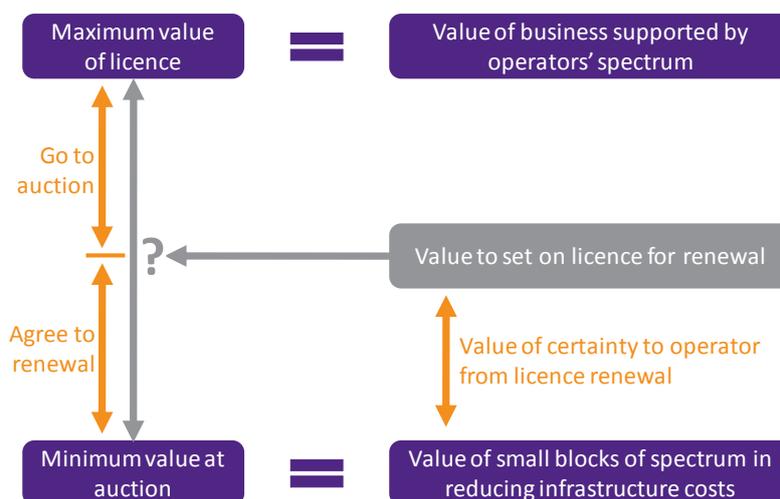
It was assumed that in future 3G services will be supplied using 800 MHz, 900 MHz and 2100 MHz spectrum and that LTE services will be supplied using 700 MHz, 1800 MHz and 2500 MHz spectrum. Values for low, medium and high market assumptions were estimated.

From the modelling it was found that the main drivers of value are:

- The forecast growth in ARPU expected across the mobile sector. Higher ARPU growth increases the full enterprise valuation but has no impact on the cost reduction valuation.

- The future growth in the data traffic that will be supported by the operators. This increases network deployment costs but is mitigated in part by the adoption of more spectrally efficient technology, namely LTE.

- The ability of sub 1 GHz spectrum to deliver deep in-building coverage at comparatively lower cost than higher frequency ranges.

The medium scenario provides our best estimate of the cost reduction value (i.e. a lower bound on the value that might be realised if there were an auction for the spectrum). The estimates of the value of 800 MHz spectrum for the medium scenario are:

- $0.97/MHz/pop for the cost reduction valuation

- $3.16/MHz/pop for the full enterprise valuation.

The cost reduction valuation includes benefits from the ability to provide more cost effective in-building coverage in urban and suburban areas. These benefits arise because, without sub 1 GHz spectrum, more sites are required to deliver enhanced in-building coverage.

Proposing a renewal price

The modelling results give a wide range of values under the different market scenarios. Values at the upper end of the range are not plausible based on international benchmarks.

From an operator's perspective there are also costs and risks associated with auctions:

- Operators may not be able to retain current spectrum holdings which can result in retuning and subscriber migration costs

- Risk of higher competitive intensity as a result of new market entry

- Disruption to investment financing as a result of uncertainty about future spectrum holdings, and the potential delays associated with an auction

- Costs of management time in preparing for and participating in the auction.

We have not attempted to quantify these individual impacts since they are specific to the individual operator's circumstances and aspirations. However, prices should be uplifted to take account of the value to an operator in avoiding these costs and risks.

Although international benchmarks do not incorporate the value of avoiding an auction, they provide an indication of the potential willingness to pay under an auction outcome. Therefore the value of spectrum to operators may be higher than the levels indicated by recent international benchmarks, where operators take account of the costs and risks associated auctions of existing spectrum holdings.

We have assumed an uplift of between 25% and 50% may be applied to the cost reduction valuation to take account of these factors and the option value that might otherwise raise auction prices above the cost reduction levels. **This gives a range of potential prices between $1.21/MHz/pop and $1.46/MHz/pop.**

The choice of spectrum price within this range is a policy decision, and DBCDE has conveyed the outcome of discussions between DBCDE and Government finance agencies, which have tended to support the adoption of a 50% premium.

In setting Government expectations with regard to licence reissue prices, the following policy objectives should be taken into account:

- Promoting efficient spectrum use

- Obtaining a fair value for the public purse.

Efficiency points towards setting values that mimic the results of an auction (i.e. at or somewhat above the cost reduction value). A fair value is one that does not take all of the benefit that an operator might gain from spectrum use (i.e. is less than the full valuation), yet takes account of the value that an operator would attribute to avoiding an auction. The choice of spectrum price within this range depends on the DBCDE's view of the relative importance of its policy objectives.

2 Introduction

Spectrum licences at 825-845 MHz and 870-890 MHz ("800 MHz band") will be reissued upon expiry in 2013 either through renewal at an administratively determined price or through price based reallocation (e.g. auction).[4] Reissue will be subject to a price that provides an appropriate rate of return to the community and that reflects the scarcity and value of this important resource. An auction remains an option if the Minister for Broadband Communications and the Digital Economy is not satisfied that renewal is in the public interest.

This report estimates the range of values for 800 MHz spectrum that might be obtained at auction and recommends an appropriate range of values for the renewal price. The spectrum licences to be valued are currently used to provide public mobile services (voice and data). We have assumed that the licences will continue to be used for these applications over the next 15 year licence period as the bands are used for these applications internationally.

This report contains our findings and recommendations. The structure of the report is as follows

- Section 3 provides context for the valuation modelling. It describes the spectrum licences we are valuing, the circumstances of the original auctions and compares the amounts paid with international benchmarks from auctions and licence tenders at the time and more recently.

- Section 4 explains our approach to modelling spectrum value and the scenarios modelled (this is supported by Appendix A which describes the modelling approach and assumptions in more detail).

- Section 5 contains the modelling results for the market scenarios, commentary on our findings and our conclusions.

---

[4] Media release by Senator the Hon Stephen Conroy, Minister for Broadband, Communications and the Digital Economy, 4 March 2010. See http://www.minister.dbcde.gov.au/media/media_releases/2010/020

3   Context

3.1   Values obtained in initial Australian auctions

In 1998 the Government sold 800MHz licences in two auctions. A total of 2x20 MHz was auctioned for regions covering all of Australia. A third auction was held in 1999 for the one remaining licence for Remote Central Australia and this sold for $20,000. The spectrum licences are due to expire in June 2013.

Auction revenues totalled $219.7m and the value of individual licences ranged from $0.1 to $1.13 per MHz per person ($/MHz/pop) with a mean of $0.29/MHz/pop.[5] The payments reflected bidders' expectations of the likely profitability of services at the time of the auctions.

The three incumbent operators also have access to 900 MHz spectrum upon which they pay an annual licence tax which currently stands at around $2.85m/2x1MHz.[6] We have expressed this value in terms of $/MHz/pop by calculating the net present value (NPV) of payments over a 15 year period. This gives a value of $0.48/MHz/pop.[7]

We note the average price per MHz/pop paid for the 800 MHz licences is around 60% of the price currently paid by 900 MHz licensees. Frequencies at 800 and 900 MHz have very similar propagation characteristics and can both be used to provide 3G services suggesting they should be valued similarly. Hence going forward higher values for the 800 MHz band could be expected.

3.2   International auction and reissue values

The international evidence given in Figure 3-1 shows a mixed pattern of values. The Australian auction results are higher than the other 800 MHz auction results in the late 1990s and early 2000s. However, the higher values for the 800/900 MHz licence reissue in New Zealand and the auctions held since early 2008 in the US, Germany, Korea, Spain, Sweden and Hong Kong show that the value of the band has increased substantially.

The highest benchmark value was for 900 MHz spectrum awarded by auction in Hong Kong in March 2011. Spectrum at 800 MHz (i.e. within the range of frequencies valued in this report) was auctioned at the same time and achieved 81% of the 900 MHz value. Although we do not consider the Hong Kong environment is directly comparable to Australia, it does illustrate how prices for the 800 MHz band can be similar to 900 MHz spectrum prices.
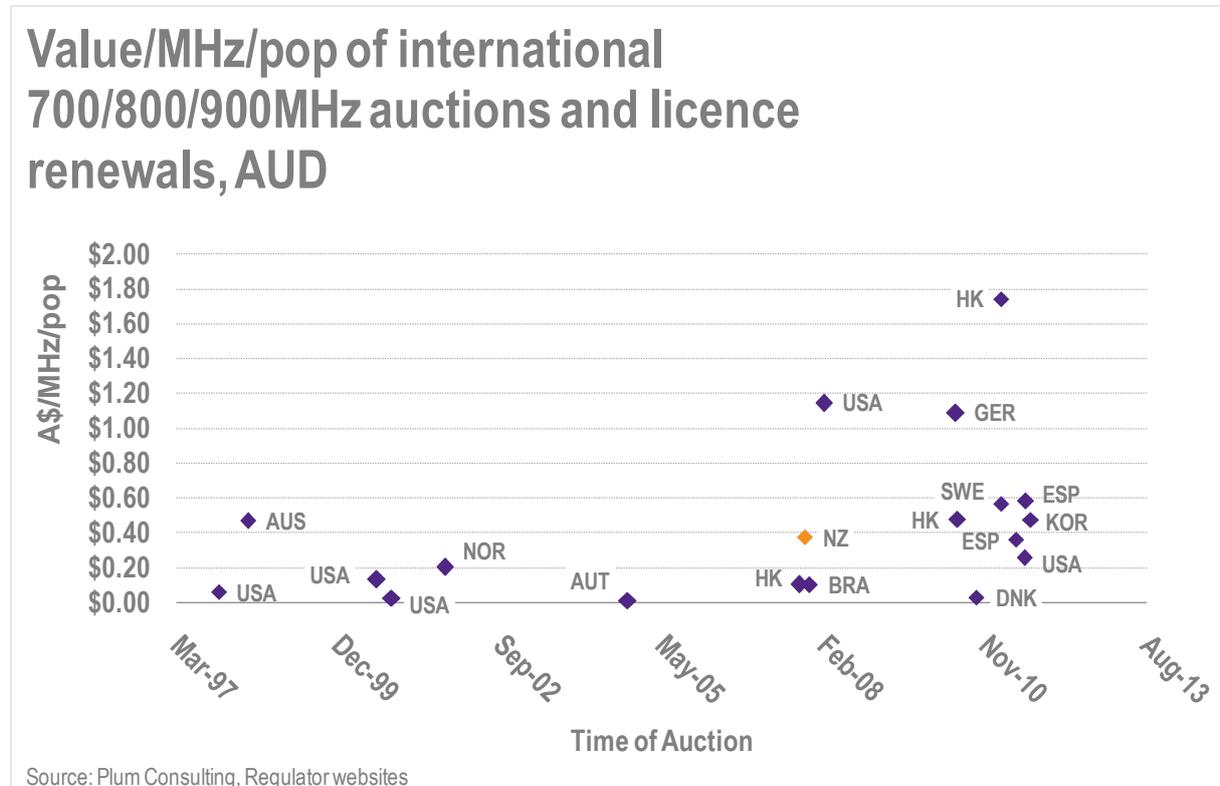
---

[5] Source: ACMA website, Productivity Commission Report 2002 and analysis by Plum Consulting

[6] Apparatus licence fee schedule, the ACMA, April 2011. Available at http://www.acma.gov.au/WEB/STANDARD/pc=PC_1614

[7] There are 2x25MHz of 900 MHz spectrum and so the total annual payment is $2.85m x25 = $71.25m. The calculations assume a population of 22.6m, 15 year licences and a 12% discount rate (based on values adopted by the Australian Competition and Consumer Commission (ACCC) for analysis of mobile termination rates).

Figure 3-1: International evidence on value per MHz pop at 700/800/900 MHz (local currencies are converted to Australian dollars using exchanges rates applicable at the time of the auction)

Value/MHz/pop of international 700/800/900MHz auctions and licence renewals, AUD

Source: Plum Consulting, Regulator websites

Reserve prices set by regulators in Europe for forthcoming auctions generally exceed the original prices paid for the 800 MHz band in Australia (see Table 3-1).

Table 3-1: Reserve prices for forthcoming 800/900 MHz auctions

Country	Spectrum to be auctioned	Total MHz	Total reserve price	Value/MHz/pop
Belgium	2x4.8 MHz (900 MHz)	9.6	€31.5m	AUD 0.4316
Hungary	2x5 MHz; 2x4.8 MHz; 2x1 MHz (900 MHz)	21.6	€19.3m	AUD 0.1219
Greece	2x35 MHz in 14 lots (900 MHz)	70	€ 298m	AUD 0.5149
Ireland	2x30 MHz (800 band); 2x35 MHz (900 MHz)	130	€ 260m	AUD 0.6116
France	2x30 MHz in 4 lots (800 MHz)	60	€1,800m	AUD 0.6334
Switzerland	2x30 MHz in 6 lots (800 MHz); 2x35 MHz in 7 lots (900 MHz)	130	€ 235m	AUD 0.3172
Netherlands	2x30 MHz in 6 lots (800 MHz); 2x35 MHz in 7 lots (900 MHz)	130	€ 414m	AUD 0.2626

Source: Plum analysis of data from regulator websites, Eurostat

There have also been some trades of spectrum in the USA for spectrum in the 700 MHz band:

- In February 2008, Aloha Spectrum Partners sold 12 MHz of spectrum at 700 MHz to AT&T for US$2.5bn, which equates to a spectrum price of US$1.06/MHz/pop (A$1.17/MHz/pop using exchange rates at the time)

- In December 2010, Qualcomm sold 12 MHz of spectrum at 700 MHz to AT&T for US$1.925bn, which equates to a spectrum price of US$0.84/MHz/pop (A$0.85/MHz/pop using exchange rates at the time).

Recent auctions have exhibited prices that arguably reflect the importance of sub-1GHz bands for the provision of data services and the provision of high bandwidth services in buildings. The prices paid for the 800 MHz spectrum in the German auction were many times higher than the 1.8, 2.1 and 2.5 GHz spectrum awarded in the same auction (6.8 times for the paired 2.1 GHz, 28 times for the 1.8 GHz and 32 times for the 2.5 GHz spectrum).[8] [9]

---

[8] See the results web page for the auction of 800 MHz, 1.8 GHz, 2GHz and 2.6 GHz spectrum in May 2010 at http://www.bundesnetzagentur.de/cln_1931/DE/Sachgebiete/Telekommunikation/RegulierungTelekommunikation/Frequenzordn ung/OeffentlicherMobilfunk/VergabeVerfahrenDrahtlosNetzzugang/vergabeVerfahrenDrahtlosNetzzugang_node.html#doc13839 2bodyText1

[9] In Denmark re-farmed 900 MHz spectrum was sold for the reserve price largely because incumbent 900 MHz spectrum holders were not permitted to bid in the auction.

The value of in-building coverage has been emphasised during debates internationally on the digital dividend spectrum and the liberalisation of spectrum at 900 MHz. In-building coverage can be achieved by deployment of indoor base stations or increasing the density of outdoor sites (to reduce the maximum range to subscribers). For the latter approach, having access to frequencies below 1 GHz provides a propagation advantage that allows enhancement of in-building coverage at lower cost.

Many regulatory authorities are taking these propagation advantages into account when setting reserve prices for upcoming auctions of digital dividend spectrum. For example:

- Ofcom has indicated its potential reserve prices for the 800 MHz digital dividend spectrum (790 to 862 MHz) at £0.05 to £0.33/MHz/pop ($A0.08/MHz/pop to A$0.5/MHz/pop). Ofcom notes that it *"... would expect to use information such as international benchmarks to identify such a value. This would involve a degree of caution reflecting the uncertainties involved in extrapolating such data and the risks that reserve prices that are too high create for participation in the auction and efficiency."* The reserve values suggested by Ofcom for the 1800 MHz and 2.5 GHz spectrum to be awarded in the same auction are half and a third of the 800 MHz value respectively.[10]

- In France, the Industry Minister has announced reserve prices for the 800 MHz digital dividend spectrum with an average value of A$0.47/MHz/pop. The reserve prices proposed for the 2.5 GHz band are around a sixth of this value.[11]

- In Ireland, ComReg intends to auction operators existing spectrum holdings at spectrum at 800, 900 and 1800 MHz. It proposes that the reserve price for the 800 and 900 MHz spectrum will be €20m per 2x5 MHz which is equivalent to €0.45/MHz/pop (A$0.61/MHz/pop) and that the reserve price for the 1800 MHz band spectrum will be half this value.[12]

The coverage benefits of digital dividend spectrum have been highlighted in the Green Paper on the Australian Digital Dividend which describes the digital dividend as *"..'waterfront property' because of its ability to carry signals over long distances, penetrate buildings and carry large amounts of data"*. Some responses to the Green Paper stress the importance of low frequency spectrum for the development of in-building coverage in urban areas as well as lower cost provision of coverage in rural areas.[13]

3.3   Implications for reissue values

Changes in technology, spectrum supply and market conditions are likely to mean that the value of licences at the time of reissue could be very different from historical auction receipts. Here we consider the implications of the international evidence and specific aspects of the Australian context for reissue values.

---

[10] "Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues", Ofcom, March 2011. See http://stakeholders.ofcom.org.uk/consultations/combined-award/

[11] Source: PolicyTracker. See www.policytracker.com

[12] Release of the 800 MHz, 900 MHz and 1800 MHz radio spectrum bands, 11/60, 24 August 2011
http://www.comreg.ie/_fileupload/publications/ComReg1160.pdf

[13] For example, see responses from Crown Castle, GSM Association and VHA.

The apparatus licence tax paid by the 900 MHz licensees (when put on an equivalent basis) could provide a floor on the average values we would expect to be paid by cellular mobile operators in future, unless there were good reasons to expect values to have fallen over time.

There appears to be a strong view within the global mobile industry that sub 1 GHz spectrum carries a value premium to reflect the flexibility that it provides with regard to rural coverage and in-building penetration. International benchmarks suggest that the value of the 800 MHz band is now likely to exceed substantially the original auction value.

The recent international benchmarks and the current 900 MHz apparatus licence tax indicate that the range of representative auction benchmark values from $0.5/MHz/pop to $1.2/MHz/pop may be appropriate. Given the range in these benchmarks, we consider that bottom-up modelling is required to help establish values for the reissue of the 800MHz licences. Our approach to the modelling and the results are addressed in the next section of this report.

4 Valuation scenarios and approach

4.1 Introduction

In this section we describe our approach to valuing spectrum licences used to deliver cellular mobile services in the 800 MHz band. We describe the scenarios and key assumptions made in the modelling. More detail is presented in Appendix A.

Spectrum is purchased by mobile operators to reduce costs and/or to increase revenues. Access to additional spectrum allows operators to reduce costs because fewer base stations are required. Additional revenues might also be earned if service quality improves or new applications and more traffic can be supported by the additional spectrum. We have assumed that spectrum in the 800 MHz band will be used primarily for deployment of 3G services over the licence period.

We are seeking to value licences for the purposes of setting government expectations with regard to licence reissue prices.[14] If licensees fail to meet the government's price expectations then the spectrum will be auctioned, therefore the value of spectrum yielded by an auction sets a lower bound on value. Licensees should be prepared to pay a premium for licence reissue because this removes the costs and uncertainty of engaging in an auction.

4.2 Range of values

At a minimum the value revealed by an auction will be the value arising from the use of an incremental block of spectrum to reduce infrastructure costs – we call this the **cost reduction value**. The cost reduction value is calculated by modelling infrastructure costs with and without additional spectrum. In congested areas additional spectrum allows more capacity to be deployed per site (and therefore fewer sites are required). However, it should be noted that if no areas have capacity limited sites then adding spectrum has no impact on costs.

Although different frequency bands are largely substitutable in terms of providing capacity, they are very different in terms of their ability to cover geographic areas. Therefore we can expect differences in value between the bands. In particular, the propagation advantages of lower bands (700 MHz, 800 MHz and 900 MHz) enable them to provide coverage with few base stations in rural areas and deeper in-building penetration in urban and suburban areas. To assess this differential valuation between bands we considered the impact on a hypothetical operator of having less spectrum in the lower frequency bands. The coverage and in-building penetration advantages of lower frequency bands were valued based on differences in the number of base stations needed to provide coverage. The difference in the lifecycle costs for the two cases provides a measure of the differential value between the high and low bands. It was assumed that the minimum block size for efficient deployment of 3G services is 2x5 MHz.

The **full enterprise value** of the spectrum is the net present value (NPV) of total business cashflows (i.e. revenues less costs) that a mobile operator enjoys from all of its assumed spectrum holdings.

---

[14] The different approaches to calculating the opportunity cost of spectrum are discussed in "Opportunity cost pricing of spectrum", ACMA, April 2009

This sets an upper bound on what might be charged for reissue. A price higher than this level would mean that the operator modelled would go out of business.

Licensees will be prepared to pay more than the cost reduction value for a licence renewal because renewal removes the costs and uncertainty of going to auction (see Figure 4-1).

Figure 4-1: Range of spectrum value measures
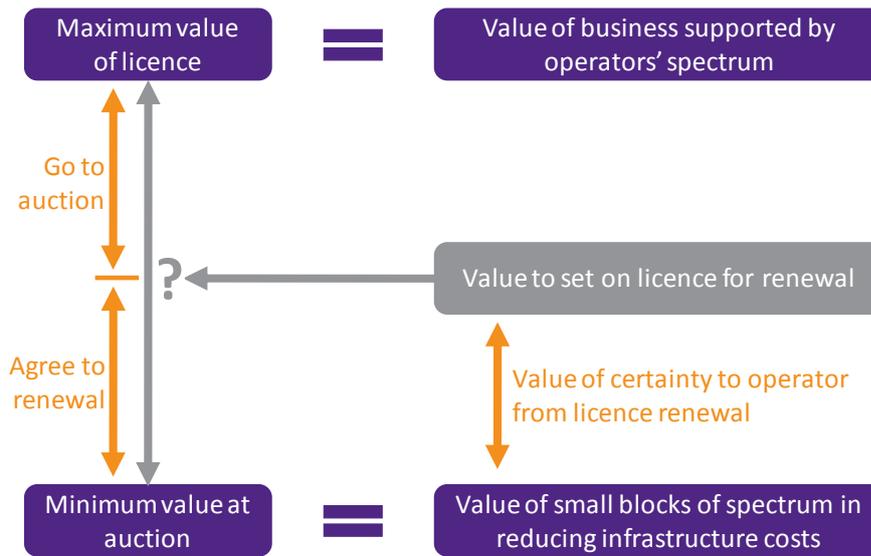
In principle mobile operators are also likely to value the investment and operating flexibility that access to additional spectrum provides when faced with uncertainty over future technology and market performance – this is often called the option value of spectrum. In practice the option value is only known by the operator and so we do not attempt to estimate its value. This means our cost reduction value estimates can be expected to be a lower bound on operators' willingness to pay for spectrum.

4.3   Major assumptions used for modelling value estimates

The 15 year licences are due to expire in 2013 hence it is necessary to construct a view of the future development of the mobile sector over the period out to 2028. For our analysis we assumed that the existing three mobile operators would continue to supply mobile services and that each operator's 3G coverage would be extended to match 2G coverage. In the longer term LTE will also extend to this level of coverage. Coexistence is assumed to be permitted for all spectrum bands.[15]

We have considered three scenarios to describe the possible evolution of the market environment as detailed in Table 4-1.

---

[15] It is assumed that this has a negligible impact on value because the process of global standards setting ensures harmful interference does not arise from allowing new devices in bands currently harmonised globally for mobile services. In this regard we note that the market benchmarks from other countries we refer to in Section 3 all permit some degree of co-existence (i.e. do not guarantee exclusivity).

| Value	Low scenario	Medium scenario	High scenario
Population growth (year on year)	1.0%	1.2%	1.6%
ARPU growth	-0.5% p.a.	0% p.a.	0.5% p.a.
Handset penetration	Linear growth to 120% in 2013, flat thereafter		
Wireless modem penetration in 2014	22%	27%	32%
GSM refarming	Linear decline in penetration (7.5% per year)		
LTE penetration	50% in 2021, 94% in 2028		
Data growth (see Figure 4-2)	Aligned with the ABI Research mobile traffic forecast (2011)[16]	Mid way between the high and low scenarios	Aligned with Cisco mobile traffic forecast (2011) [17]

A major driver of both cost reduction and full enterprise valuations is the data traffic forecast for the period of the licence. For the high scenario, we have adopted the Cisco 2011 forecast for Western Europe as being representative on a per capita basis of optimistic traffic levels in Australia. For the low scenario we have adopted the ABI Research forecast. The traffic profiles for the three market scenarios are extrapolated using a Gompertz curve as shown in Figure 4-2 which also illustrates the data forecasts made by IDATE for the UMTS Forum in May 2011[18].

---

[16] See: http://www.abiresearch.com/products/market_data

[17] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015. Dated 1 Feb 2011 and retrieved 6 June 2011. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[18] Mobile traffic forecasts 2010-2020: A report by the UMTS Forum, Executive summary. Prepared by IDATE May 2011.

Figure 4-2: Estimated total forecast mobile traffic in Australia 2010–2028
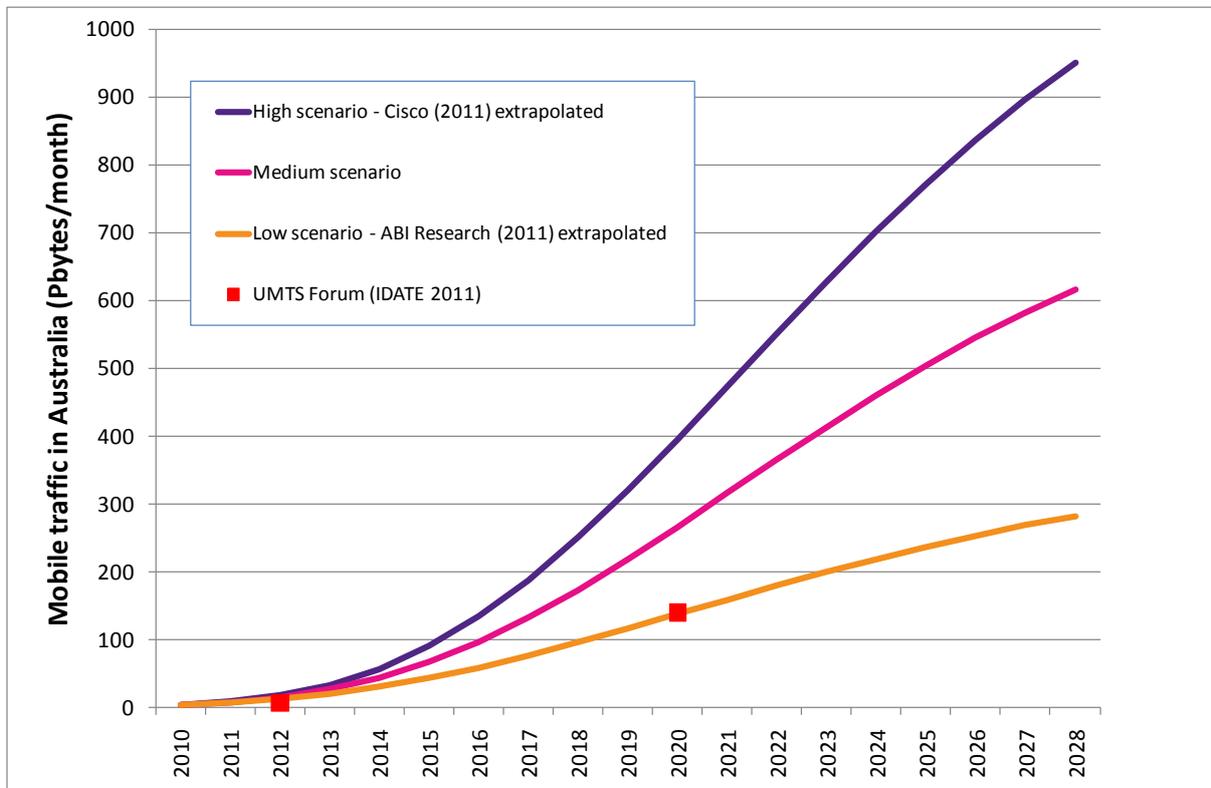
Source: Cisco, ABI Research, UMTS Forum and Plum estimates

4.4   Typical operator valuation

Spectrum is to some extent substitutable in its ability to provide 3G and LTE services. It follows that the valuation approach should consider the fact that other spectrum bands may be used to deliver the same service if an incremental amount of spectrum in one band is not obtained (i.e. the costs are spread across all bands capable of delivering the same services). To accommodate this we have modelled bands together that are likely to deliver the same services: specifically we have assumed that the 800 MHz, 900 MHz and 2.1 GHz bands will be used to deliver 3G services. For this group of spectrum bands we have assumed that the hypothetical operator will deploy a single network and that the total revenues and traffic attributed to each technology can be spread across the respective group of three bands.

Together the 800, 900 and 2100 MHz bands comprise a total 210 MHz of paired spectrum. We modelled the NPV of a hypothetical incumbent operator's business case with a third of this spectrum (70 MHz) and an incremental 10 MHz (i.e. 2x5 MHz). We consider the case where the hypothetical operator has 27% market share, based on the lowest current market share of the incumbent mobile operators.

4.5   Modelling results

4.5.1   Capacity related values

In assessing the cost reduction value where the spectrum is assumed to give only capacity enhancement we have assumed that the hypothetical operator will gain access to sufficient 800 or 900 MHz spectrum to provide long range coverage in rural areas and provide deep in-building penetration in urban and suburban areas.

All NPVs are calculated in 2013 prices for ease of comparison. Values are expressed as a value per MHz per person ($/MHz/pop) so they can be compared with the benchmarks discussed in Section 3. The results for the three market scenarios are detailed in Table 4-2.

Table 4-2: Estimates of capacity related values for the 800 MHz band

Market scenario	Cost reduction value due to capacity provision	Full enterprise valuation
Low scenario	$0.0/MHz/pop	$2.58/MHz/pop
Medium scenario	$0.42/MHz/pop	$3.16/MHz/pop
High scenario	$0.87/MHz/pop	$3.38/MHz/pop

Source: Analysis undertaken by Plum Consulting

4.5.2   Coverage related values

The results in Table 4-2 show the cost reduction value of spectrum where the value is derived from capacity enhancement alone. To understand the differences in value between the 800/900 MHz bands and higher frequency bands we also need to consider the additional value from the greater coverage and in building penetration characteristics of lower frequency bands.

The lower frequency spectrum could be used for more cost effective coverage in rural areas and the difference in propagation capability suggests that many more sites would be required to cover the rural area if an MNO were denied access to spectrum in the 700, 800 or 900 MHz bands. However, MNOs only need a modest amount of lower frequency spectrum for this purpose since traffic demands are not high in rural areas. With 2x135 MHz of harmonised spectrum available in the 700, 800 MHz and 900 MHz bands and rural sites remaining range limited, MNOs would be unlikely to have to compete at the margin for this spectrum in rural areas. Therefore we do not consider that in this case the marginal value of 800 MHz spectrum is likely to be affected by rural coverage benefits.

More significant benefits are likely to arise from the ability to provide more cost effective in-building coverage in urban and suburban areas since higher capacity is demanded in these environments. The benefits arise because, without sub 1 GHz spectrum, more sites are required to deliver enhanced in-building coverage. A comparison between the propagation characteristics of 800 MHz and 2100 MHz spectrum suggests that at least twice as many sites may be required in a given area to achieve the

same degree of in-building coverage without access to the lower bands. While this value is uncertain[19] we use it together with data on actual operator site numbers[20] and find that an average of 73% additional sites would required in urban and suburban areas for the typical operator, if they were to fail to gain access to sub 1 GHz spectrum.

Attributing this additional cost evenly across a third of the spectrum in sub 1 GHz public mobile bands results in an average coverage premium of $0.55/MHz/pop.

4.5.3   Total value

Table 4-3 summaries the modelling results for the cost reduction and full enterprise values.

Table 4-3: Estimates of coverage and capacity values for the 800 MHz band

Market scenario	Cost reduction value due to capacity provision	Cost reduction value due to coverage enhancement	Total cost reduction valuation	Full enterprise valuation
Low scenario	$0.0/MHz/pop	$0.55/MHz/pop	$0.55/MHz/pop	$2.58/MHz/pop
Medium scenario	$0.42/MHz/pop	$0.55/MHz/pop	$0.97/MHz/pop	$3.16/MHz/pop
High scenario	$0.87/MHz/pop	$0.55/MHz/pop	$1.42/MHz/pop	$3.38/MHz/pop

Source: Analysis undertaken by Plum Consulting

The medium scenario provides our best estimate of the cost reduction valuation and is a likely lower bound on values that would emerge in an auction. It should be noted that although the value related to coverage enhancement is the same across the three market scenarios, there is considerable variation in the low and high scenarios for the capacity related component of value.

In summary, our analysis suggests that incumbent MNOs would have a minimum value at auction of $0.97/MHz/pop for the 800 MHz band. The corresponding full enterprise valuation is $3.16/MHz/pop. The value of the 800 MHz band is driven by the ability of this low frequency spectrum to deliver deep in-building coverage at comparatively lower cost as well as the capacity provided.

The number of MHz x population (MHz.pop) inherent within the licences currently held in the 800 MHz totals 904,100,000 MHz.pop[21]. This suggests for a typical operator having licences covering half of the 800 MHz band, total spectrum prices could range from $438M to $1,428M. The precise values will depend on the actual MHz.pop inherent within the 800 MHz licences each operator holds. Full

---

[19]Uncertainty is caused by the fact that the operator would have an alternative of deploying indoor base stations and the possibility that the amount of traffic originating from deep in-building locations may not demand substantial amounts of capacity.

[20] Some incumbent operators already have more sites than others and there has been considerable investment in site deployments over the last couple of years.

[21] Estimates of the MHz.pop figures were provided to the project team by the ACMA.

enterprise values may also be higher than the upper end of this range depending upon the actual market share of each operator.

5   Conclusions

The results of our modelling suggest that operator valuations may lie within a range bounded by:

- A cost reduction valuation of $0.97/MHz/pop, and

- A full enterprise valuation of $3.16/MHz/pop

These results are our best estimate of operators valuations based on a medium scenario. The modelling results give a wide range of values, and those towards the high end are not plausible when compared with the experience in spectrum markets over the last 10 years. The cost reduction valuation lies within the range of recent international auction benchmarks.

There are potentially substantial disruption costs to both operators and consumers if an auction is used to licence spectrum rather than renew licences. The most quantifiable consumer costs are associated with loss of coverage in remote rural areas and the potential need for an operator to migrate users from one band to another as a result of obtaining different spectrum to that currently held. While we consider the probability of such disruption is low and could be mitigated in the auction design process, there is always a risk of unforeseen events in an auction process.

From an operator's perspective there are potential advantages and disadvantages from going to auction. On the positive side, an auction is an opportunity for operators to gain more spectrum and they may perceive that final prices will be lower than a reissue price. However there are also costs and risks associated with auctions:

- Operators may not be able to retain current spectrum holdings which can result in retuning and subscriber migration costs

- Risk of higher competitive intensity as a result of new market entry

- Disruption to investment financing as a result of uncertainty about future spectrum holdings, and the potential delays associated with an auction

- Costs of management time in preparing for and participating in the auction.

We have not attempted to quantify these individual impacts since they are specific to the individual operator's circumstances and aspirations. However, prices should be uplifted to take account of the value to an operator in avoiding these costs and risks.

Although international benchmarks do not incorporate the value of avoiding an auction, they provide an indication of the potential willingness to pay under an auction outcome. Therefore the value of spectrum to operators may be higher than the levels indicated by recent international benchmarks, where operators take account of the costs and risks associated auctions of existing spectrum holdings.

We have assumed an uplift of between 25% and 50% may be applied to the cost reduction valuation to take account of these factors and the option value that might otherwise raise auction prices above the cost reduction levels. **This gives a range of potential prices between $1.21/MHz/pop and $1.46/MHz/pop.**

The choice of spectrum price within this range is a policy decision, and DBCDE has conveyed the outcome of discussions between DBCDE and Government finance agencies, which have tended to support the adoption of a 50% premium.

In setting Government expectations with regard to licence reissue prices, the following policy objectives should be taken into account:

- Promoting efficient spectrum use
- Obtaining a fair value for the public purse.

Efficiency points towards setting values that mimic the results of an auction (i.e. at or somewhat above the cost reduction value). A fair value is one that does not take all of the benefit that an operator might gain from spectrum use (i.e. is less than the full valuation), yet takes account of the value that an operator would attribute to avoiding an auction. The choice of spectrum price within this range depends on the DBCDE's view of the relative importance of its policy objectives.

Appendix A: Modelling assumptions

A.1   Revenue forecasts

A.1.1   Population

Population forecasts are produced by the Australian Bureau of Statistics (ABS) and these are presented in the Intergenerational report 2010.[22] This predicts a single average growth rate of 1.2% per annum for the period 2010 to 2050.

The ABS's most recent population forecasts project growth rates for the period to 2030; the growth rates range from 1% p.a. (low growth scenario), 1.2% p.a. (mid growth scenario) and 1.6% p.a. (high growth scenario). The higher population growth scenario has a younger population and hence a higher share of the population of working age.

To span the range of population growth forecasts reported above we have used the following low, medium and high population growth scenarios in our work:

- Low scenario: Population growth 1.0% p.a.

- Medium scenario: Population growth 1.2% p.a.

- High scenario: population growth 1.6% p.a.

The population growth will be applied to the current population of Australia which was estimated at 22.5 million for year end 2010 based on ABS statistics.

A.1.2   Subscriber penetration rate

We considered two broad groups of subscribers that make up the subscriber base: handheld subscribers that make use of mobile service over handheld, voice-enabled devices and subscribers that only use mobile broadband data through non-voice devices such as wireless modems. At the end of 2010, population penetration of handheld subscribers was 105%, and population penetration of mobile broadband subscribers was 19%.[23] We have assumed that by 2015, aggregate mobile penetration will reach 152%.

Consistent with these forecasts we have assumed that:

- Handset penetration will rise to 120% in 2013 and be constant thereafter

- Wireless modem penetration will rise to:

    – 22% in the low scenario in 2015 and remain constant thereafter

    – 27% in the medium scenario and remain constant thereafter

    – 32% in the high scenario and remain constant thereafter

---

[22] *http://www.treasury.gov.au/igr/igr2010/report/pdf/IGR_2010.pdf*

[23] Calculated from the total number of wireless broadband customers reported by Telstra, Optus and VHA's periodic report for year-end 2010.

Both 3G and LTE technologies will support wireless modem use.

A.1.3   Split of subscribers between technologies

Over the next 15 year licence period we expect the provision of 2G services to terminate, 3G will expand and LTE services will dominate by the end of the period. Our assumed timings are as shown in Table A-1.

Table A-1: Technology timings

Technology	Timing
2G handsets	Penetration declines at 7.5% per annum until services cease in 2016
3G handsets	Penetration of services peak in 2016
LTE handsets	Launched in CBDs in 2011 with large scale take up from 2013 onwards. 50% penetration achieved in 2020
Wireless modems	Assumed to be distributed between 3G and LTE in the same proportion as handsets

Source: Plum assumptions

A.1.4   Average revenue per user

In general levels of ARPU have been relatively constant in recent years. Following two consecutive years of steady ARPU growth between 2006 and 2008, growth of market ARPU declined between 2008 and 2009, and ARPU fell between 2009 and 2010.

We have adopted the current mobile sector averages for the split between prepaid and postpaid subscriptions and we have assumed that this distribution will persist over the 15 year licence period. The sector average levels of ARPU are also adopted for the typical operator modelled. This is A$23.8/month for prepaid and A$72.4/month for postpaid ARPU. [24] For 3G mobile broadband subscriptions we have assumed that current ARPU is A$30/month which is at the lower end of the tariffs offered by 3G operators. LTE mobile broadband is assumed to command a 50% premium above the 3G mobile broadband ARPU.

We have adopted the following real growth assumptions which are assumed to apply for both prepaid and postpaid subscriptions.

- Low scenario: – 0.5% year on year growth

- Medium scenario: 0% year on year growth

---

[24] Market prepaid and postpaid ARPU numbers are calculated based prepaid and postpaid ARPU figures reported by Optus and Telstra in their periodic financial reports in 2010.

- High scenario: + 0.5% year on year growth

A.1.5   Market shares

The hypothetical incumbent operator is assumed to have a market share of 27% in each of the bands modelled throughout the period under study, based on the lowest market share of the incumbent mobile operators (VHA).

A.2   Cost assumptions

A.2.1   Capital and operating costs

Capital cost assumptions are detailed in Table A-2.

Table A-2: Capital cost assumptions

Item	Description
Site quantities	A minimum number of sites to achieve 95% population coverage in the band being considered. These site numbers are estimated for three environment categories (urban, suburban and rural)
Rollout	For LTE network rollout we have assumed that for an incumbent operator coverage of urban and suburban areas is staged over 5 years. For rural areas it is staged over 10 years.
Site establishment costs	New sites are assumed to be $110k for site establishment.
Network equipment	Network equipment and backhaul equipment is deployed at each site. Installed equipment costs per site are assumed to be $146k.
Equipment lifetime	Network equipment is assumed to have a lifetime of 10 years, therefore 10% of sites are re-equipped each year and 10% of the core network costs are incurred each year
Existing network	The 3G network is assumed to already exist and have a value of 50% of its replacement cost.
Residual value	The 3G network is assumed to have no residual value at the end of the 15 year licence period. The LTE network is assumed to have a residual value of 50% of historic deployment cost.

Source: Plum assumptions

Operating cost assumptions are detailed in Table A-3.

Table A-3: Operating cost assumptions

Item	Description
Handset subsidies	Handset subsidies of A$179 per terminal are applied to all new additions and churned subscribers.[25]
Churn	Churn was assumed to be 21% of total subscribers per annum for the purposes of analysis.[26]
Network maintenance	Network maintenance will be estimated at 12% of cumulative capital network equipment costs
Site rental	Site rental will be driven by the total number of sites and typical base station site rents for Australia. We assumed $20,000/site/year.
Core network costs	Annual core network costs were based on 155 Mbit/s leased line prices
Marketing and admin	Marketing and admin costs were assumed to be 39% of service revenues.
Interconnection	Interconnection costs were assumed to be 17% of service revenues.

Source: Plum assumptions

A.2.2   Site quantities and traffic distribution

The number of sites currently deployed by the operators is important for the study since it shows the number of sites available to each operator and an indication of the minimum number of sites required to achieve (almost) national population coverage.

The breakdown of sites by operator and environment are detailed in Table A-4. In general the Urban area category comprises the Central Business Districts of Sydney, Melbourne, Brisbane, Perth and Adelaide. Suburban areas are the metropolitan areas of these cities plus towns having a population greater than 10,000. The remaining areas having mobile coverage areas are assumed to be rural.

---

[25] Derived from the average of VHA's reported year average for 2010 ($145/sub) and Optus' average of the 4 quarterly figures for 2010 ($213.5/sub).

[26] From SingTel's quarterly MD&A reports for 2010 in which monthly churn ranges from 1.5% to 1.7%.

Table A-4: Number of sites by operator

Environment	Telstra	Optus	VHA	Typical operator
Sites				
Urban	483	369	387	369
Suburban	2662	2217	2855	2217
Rural	5723	4106	2847	2847
Notes				
Source: ACMA assignment database (June 2011)				
Derived from a list of unique site identifiers in the ACMA assignment database. "Typical" operator site numbers are based on the lowest number of sites in each environment.				

To understand the impact of traffic growth on the network, the traffic is distributed across urban, suburban and rural areas. We have assumed that traffic will be distributed according to population. The estimated population distribution across urban, suburban and rural areas is shown in Table A-5.

Table A-5: Distribution of population by area type

Area type	Estimated population	Proportion of total population
Urban	1,781,500	8.1%
Suburban	15,567,000	70.4%
Rural	4,759,000	21.5%
Note: Urban population also includes workforce and visitors Data were obtained from:		
www.citypopulation.de (based on 2006 Australian census data)..		
http://cityofsydney.nsw.gov.au/AboutSydney/CityResearch/AtAGlance.asp		
http://www.melbourne.vic.gov.au/info.cfm?top=66&pa=779&pg=900		
http://www.brisbane.qld.gov.au/bccwr/about_council/documents/sept07_context_brisbane_mass_transit_investigation_lmt.pdf		

Traffic estimates are formed by forecasting the average traffic per subscriber for 2G, 3G and LTE services and distributing the subscriber base across environments in proportion to population.

A.2.3 Traffic growth

Traffic is expected to grow substantially in the period to 2028. Voice traffic growth has declined in recent years and we have assumed that voice growth will slow from 4.4% p.a. in 2010[27] to zero growth in 2016. There is considerable uncertainty regarding mobile data volumes demanded over the next few years and growth in the longer term is even more speculative since it relies on as yet unknown

---

[27] Source: Merrill Lynch Global Wireless Matrix 3Q10

services and applications. We have taken a top down approach to modelling mobile data traffic. We start with a forecast for total mobile data traffic in Australia and then break split this total between 3G and LTE technologies.

A range of forecasts for global mobile data growth were considered. To perform the analysis we adopted the Western Europe data volumes per person, since we consider these more typical for Australia rather than the average across the Asia Pacific region. The forecasts from Cisco Systems[28], ABI Research[29] and IDATE[30] cover the period 2011 to 2015 for Western Europe.

The Cisco and ABI forecasts were projected over the licence period by fitting a Gompertz curve, then scaling to Australia by population. We have adopted the Cisco and ABI forecasts as the traffic forecast for our high and low scenarios respectively. The medium forecast is mid-way between these two forecasts.

The projected monthly traffic volume for Australia is shown in Figure A-1 for all the scenarios.

Figure A-1: Estimated total forecast mobile traffic in Australia 2010–2028
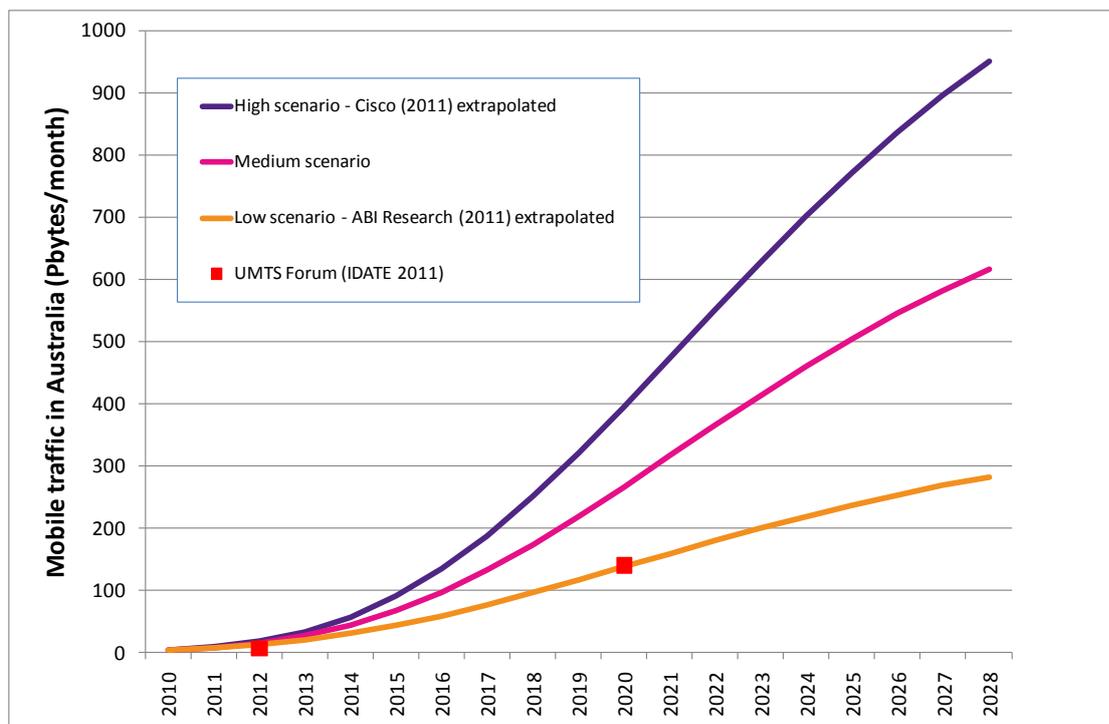
Sources: Cisco, ABI Research, UMTS Forum and Plum estimates

The monthly projections are converted to busy hour figures by assuming 30 days in each month and 7.5% of daily traffic will occur in the busy hour.

---

[28]Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015. Dated 1 Feb 2011 and retrieved 6 June 2011. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[29] http://www.abiresearch.com/products/market_data

[30] Mobile traffic forecasts 2010-2020: A report by the UMTS Forum, Executive summary. Prepared by IDATE May 2011.

A.3   Network efficiency

The traffic demand is converted into infrastructure demand using a set of spectral efficiency assumptions and network efficiency assumptions. These are detailed in Table A-6 and Table A-7 respectively.

Table A-6: Spectral efficiency assumptions

Service	Spectral efficiency in bits/Hz/cell	Comments
GSM voice	0.032	Throughout the licence period
WCDMA voice	0.114	Throughout the licence period
LTE voice	0.114	Throughout the licence period
3G data	0.48 – 1.1 *	Spectral efficiency rises linearly to 2021. Level thereafter
LTE data	1.36 – 2.2 *	Spectral efficiency rises linearly between 2013 and 2032.
* Values sourced from the FCC National Broadband Plan. See http://www.broadband.gov/plan/ and ITU-R Recommendation M.2134		

Table A-7: Network efficiency assumptions

Aspect of deployment	Efficiency factor	Comments
Utilisation factor	60%	Caters for imperfect matching of traffic demand to network capacity and build ahead.
Asymmetry factor	63% to 56%	Represents the effective loading given that traffic is highly asymmetric with heavy bias in the downlink direction.
Multiple operator factor	80%	Allows for the misalignment in spectrum holdings between operators relative to market shares.
QoS loading factor	100% to 74%	Usable capacity for mean traffic so that high bandwidth services can be provided with adequate QoS. Factor reduces linearly from 2013 to 2016.

Source: Plum assumptions

These spectral efficiencies defined in Table A-6 are multiplied by the network efficiency factors in Table A-7 to form an estimate of overall network efficiency.

A.4   Discount rate

We have used a commercial nominal pre-tax discount rate of 12 % for the analysis, which is based on values adopted by Australian Competition and Consumer Commission (ACCC) for analysis of mobile termination rates.

A.3   Inflation

All modelling is in nominal terms. An inflation rate of 2.5% has been adopted as predicted in the Intergenerational report 2010 for the period 2015 to 2046. [31]

---

[31] http://www.treasury.gov.au/igr/igr2010/ Appendix D: IGR 2007 Projections