Getting the most out of the digital dividend in Australia

Allocating UHF spectrum to maximise the economic benefits for Australia

April 2009

1 Executive summary

1.1 Introduction

The Australian Mobile Telecommunication Association (AMTA) engaged Spectrum Value Partners[1] and Venture Consulting (referred to throughout as "Value Partners") to determine the net economic benefit generated by redeploying the UHF (700MHz) spectrum freed up by the switch-off of analogue television (ASO). This is usually referred to as the 'digital dividend'.

Specifically, the study provides policy makers with a clear indication of the expected economic benefit that would be generated by allocating a portion of this digital dividend UHF spectrum to mobile services rather than to digital TV services.

It identifies the optimal UHF spectrum allocation between mobile and broadcasting services such that net economic benefit to Australia is maximised on a 'whole-of-market' basis. The study takes account of the current and future spectrum environment as well as expected developments in mobile and broadcast technology.

AMTA's members have assisted us through the provision of proprietary data on a confidential basis. However, the assumptions and analysis contained within this report represent Value Partners' independent view.

1.2 Key findings

The study concludes that significant incremental economic benefit would be generated by allocating a portion of the digital dividend UHF spectrum to mobile services under each of four different overall market scenarios:

- Allocating the optimal mix of UHF spectrum to mobile operators is forecast to generate a net benefit to the economy of between $7bn and $10bn[2], depending on which overall market scenario is realised
- Where mobile broadband is a ubiquitous part of the broadband access mix, the maximum net economic benefit to society will be realised if 120MHz of usable UHF spectrum is allocated to mobile services
- In rural areas, where population density is lower, the propagation characteristics of the 700MHz spectrum are more critical for mobile coverage. As a result, the maximum net economic benefit under the same scenario will be realised with an allocation to mobile of 140MHz of usable spectrum

1.3 Key assumptions

A number of key assumptions underpin the Cost-Benefit Analysis:

- Mobile operators are assumed to continue to have access to their existing spectrum allocations and to gain access to the 2.6GHz spectrum band as planned globally
- The mobile broadband market is assumed to remain competitive such that economic benefit will be efficiently allocated between producers and consumers. For example, if only one or two mobile operators are awarded UHF spectrum, price levels might be higher than if three or four operators are awarded spectrum
- Over time it is assumed that new broadcast technologies will be deployed to ensure spectrum allocated to broadcast services is used efficiently

[1] Spectrum Value Partners, formerly known as Spectrum Strategy Consultants and now part of the Value Partners Group
[2] Throughout this study, all benefits are measured over a 20-year period between 2008 and 2028 with a terminal value applied. The Net Present Value (NPV) represents the sum of the annual benefits, discounted to current prices

- A conscious effort has been made to ensure that the study does not favour the mobile industry. Therefore, when in doubt, the study deliberately favours broadcasters when defining assumptions and methodologies. As a result, we believe that the study results are conservative from the perspective of mobile operators.

1.4 Our approach

Our analysis is based on a Cost-Benefit Analysis (CBA), which is a well established approach employed by governments in guiding policy. The CBA compares the net economic benefit generated by allocating different combinations of digital dividend UHF spectrum to mobile and broadcast services.

1.4.1 Mobile analysis

For the purpose of this study, we have defined mobile broadband as broadband services delivered wirelessly via the mobile network to laptops, mobile phones and other mobile devices.

The demand for mobile broadband services is calculated at a market level. The optimal market structure is not something that we seek to establish in this study. The CBA assumes that the market is competitive and that reductions in costs are passed on to consumers as reductions in price.

To forecast customer demand for mobile broadband services, we have drawn on existing research, proprietary data from stakeholders, and internal Value Partners analysis. We have benchmarked our results against existing studies forecasting future mobile broadband demand.

We have developed three mobile scenarios. The following exhibit summarises the key characteristics of the scenarios.

Exhibit 1: Mobile scenarios

Trend	Mobile ubiquitous	Mobile complementary	Mobile supplementary
Consumer behaviour	• Mobile broadband usage is widespread. It is a ubiquitous service, with an increasing number of consumers accessing broadband primarily through mobile networks[3]. However, fixed networks remain important for on-site use (e.g. for IPTV)	• Consumers use mobile broadband as a complementary service to fixed, recognising the benefits of mobility.	• Consumer continues to use fixed broadband as the primary mode of access. Mobile broadband is emerging as an option for supplementary use
Technology	• Peak speeds improve dramatically • Vast majority of portable devices are mobile broadband enabled • Desirable mobile broadband applications generate boom in mass market adoption.	• Peak speeds improve quickly • Handsets converge with ultra-portable laptops in functionality • Mobile broadband applications becoming more widespread	• Peak speeds improve steadily • Handsets evolve to facilitate increased data usage • Mobile broadband applications emerging and only used by early adopters
Commercial plans	• Generous unlimited data bundles are standard	• Unlimited data bundles introduced in the near term	• Tariffs remain on per MB basis in the short term, before moving to bundles

We have to make assumptions about industry structure when we consider the supply-side issue of how spectrum is utilised. We take a representative industry structure across Australia, based on the current market.

The net economic benefit generated by allocating digital dividend UHF spectrum to mobile is calculated by determining the difference between the total benefit generated under each of the mobile scenarios and the benefit if no UHF spectrum is allocated to mobile.

1.4.2 Broadcast analysis

The broadcast component of the CBA assumes that a maximum of 300MHz UHF spectrum is available to digital TV (from 520MHz to 820MHz) and that a further 20MHz of VHF is also allocated to digital TV services[4]. We modelled a range of different digital terrestrial television (DTT) service mixes, taking account of spectrum availability and the likely evolution of broadcasting technology. The net economic benefit generated by broadcast services is based on the different costs and benefits to broadcasters and to viewers of providing a broader range of services via DTT.

We developed two broadcast scenarios based on variations in the assumptions that underpin much of the net benefit generated by broadcast services: advertising revenue as a proxy for the producer benefits enjoyed by advertisers and 'willingness to pay' (WTP) as a proxy for the consumer benefits enjoyed by viewers. For advertising revenue, we have assumed it will be correlated with overall Australia economic growth. For willingness-to-pay, we have benchmarked our assumptions based on both local and overseas surveys conducted.

[3] Note: While it is expected that there will be some mobile-fixed substitution from a consumer perspective, fixed networks remain critical for ubiquitous consistent quality of service and scalability

[4] It is possible that DAB might also share a portion of the VHF Band III. However, as this is not confirmed by government policy at this time, we cannot assume allocation of the entire 58MHz of VHF Band III for Digital TV use. We take a conservative approach to mobile and hence allocate 20MHz of VHF Band III spectrum to broadcasting in our modelling.

The exhibit below shows our assumptions for the two potential broadcast scenarios: 'Free-to-air (FTA) market conservative' and 'FTA market aggressive'. In the conservative scenario, FTA advertising is expected to grow at 75% of historic levels and consumer's willingness to pay for free to air services is estimated to be lower than in our European study, based on available data. Our FTA market conservative scenario illustrates what we expect to be the more likely outcome whereas the FTA market aggressive scenario seeks to model the best outcome for broadcasters in Australia.

Exhibit 2: Broadcast scenarios

Trend	FTA market conservative	FTA market aggressive
Advertising revenue growth	• Taken to be 75% of Australian GDP growth forecast, which is forecast to be 5%pa. We believe this forecast is aggressive especially give the current economic climate	• Taken to be in-line with Australian GDP growth
Willingness-to-Pay[5]	• Taken to be 47.5% of Value Partners' European analysis[6], on the basis of Australian survey data[7,8]	• Taken to be the same as used in the equivalent Value Partners' European CBA study

The net economic benefit generated by allocating incremental digital dividend UHF spectrum to digital TV services is calculated by comparing the net benefit generated by additional services over and above those already planned.

1.5 Overall Results

The CBA forecasts that under four overall market scenarios (combining the mobile and broadcast scenarios) the net benefit to the Australian economy of allocating the optimal UHF spectrum to mobile services will be between $7bn and $10bn.

Under the overall market scenarios based on the 'mobile ubiquitous' scenario, the optimal allocation of digital dividend UHF spectrum to mobile services is 120MHz of usable spectrum, regardless of the broadcasting scenario selected. Under the reduced mobile scenarios ('mobile complementary' and 'mobile supplementary'), the CBA suggests an optimal allocation of between 80MHz and 100MHz to mobile services, so long as this does not result in any overall lessening in competition.

If each of the four overall market scenarios considered is equally likely to occur, the risk-weighted optimal allocation of digital dividend UHF spectrum to mobile services is 120MHz of usable spectrum.

The exhibit below illustrates the net value added to the Australian economy by allocating a varied amount of the digital dividend UHF spectrum for mobile broadband services under different overall market scenarios.

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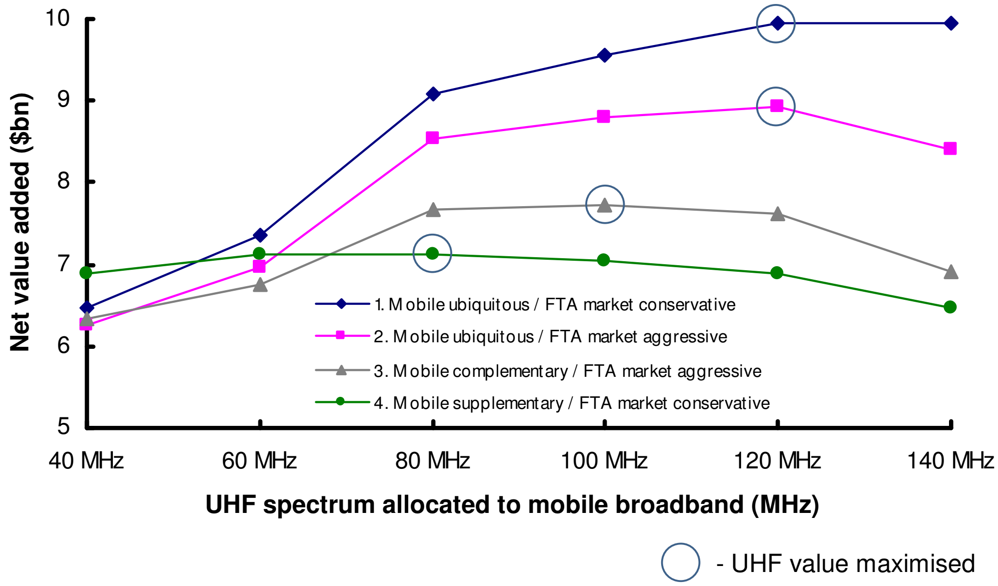
[5] Willingness-to-pay is the theoretical price a consumer is willing to pay for a service or product, which in this case is FTA television
[6] *Getting the most out of the digital dividend*, March 2008, Value Partners
[7] Empirical evidence on willingness-to-pay for public broadcasting is in Glenn Withers, David Throsby and Kaye Johnston, Public Expenditure in Australia, EPAC Commission Paper No. 4, Canberra
[8] The National Social Science Survey, carried out in 1999 and made available to Professor Glenn Withers of the ANU in March 2000

Exhibit 3: Net value added – national ($bn)



The CBA also considered the optimal allocation of spectrum on a rural and metropolitan basis given the current broadcast licence allocations. For rural, due to lower population density, the propagation properties of 700MHz spectrum is more significant. As a result, the optimal allocation of digital dividend to mobile is higher, ranging from 80MHz to 140MHz, and the net economic benefit is $4bn to $5bn, depending on the overall market scenario.

2 Introduction

Venture Consulting[9] and Spectrum Value Partners (referred to throughout as “Value Partners”) were asked by the Australian Mobile Telecommunication Association (AMTA) to model the benefits to the Australian economy that would arise if the UHF spectrum released by Analogue Switch-off (ASO) was allocated between mobile operators and broadcasters in an optimal manner. The model allows us to determine how much spectrum should be allocated to each sector in order to achieve maximum benefits. Our analysis builds on previous studies, but looks to analyse a wider selection of scenarios to identify the best mix for broadcasters, operators and to Australian society as a whole.

The challenge is to find where the right balance may lie so as to maximise overall economic value. There is a need to allocate broadcasters enough spectrum to provide consumers with services such as high definition television (HDTV), as well as to drive digital take-up; for Australian operators to be able to stay at the forefront of mobile developments in offering a more affordable mobile broadband experience; and most importantly, for as many consumers as possible to have access to a wide range of broadcast and broadband services that can enrich and enliven personal lives, and enhance and enable work productivity.

Finding this balance involves looking at the trade-offs between broadcast and mobile services at the margins. Our modelling allows us to do this, and to consider the impact of various scenarios.

This report outlines Value Partners’ approach within the cost-benefit analysis (CBA) framework, and has been compiled in consultation with a team of economists in London and Milan. We have based our approach on the work Value Partners performed for the Mobile Broadband Alliance in Europe, published in the report ‘*Getting the most out of the digital dividend*’ in March 2008. The economic methodology used in this project was verified by an independent third party.

Our broadcast assumptions are derived from conversations with broadcast (and broadcast technology) experts from industry, industry organisations and regulators, and are agreed to be within a likely future range by an independent broadcast engineer.

For our mobile assumptions, we have been assisted by the fact that the sponsors of the project are themselves either major developers of wireless technologies or operators present in many of the markets that we wish to study. The sponsors have provided proprietary data to us on a confidential basis.

All assumptions contained within this report represent Spectrum’s independent views and have been sense-checked both internally and externally, through sources such as Analysys, Ovum, Yankee, Informa and Screen Digest.

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[9] Venture Consulting was formed by the management buyout of Spectrum Value Partners’ Australia and NZ business in January 2009

3 Methodology

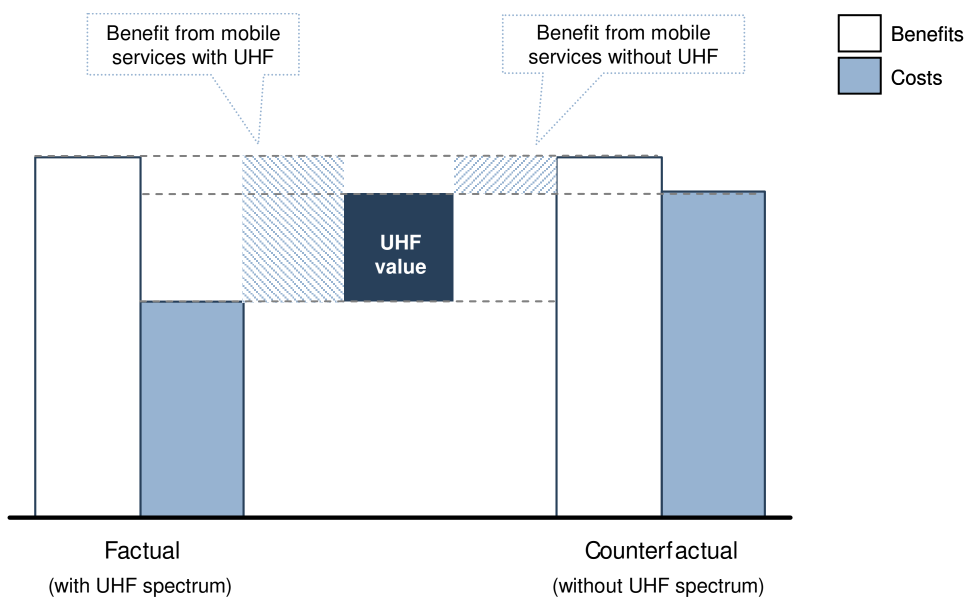
3.1 Overview

To estimate the benefits to the Australian economy of optimally allocating UHF spectrum released by digital switch-over between mobile operators and broadcasters, Value Partners chose to use a cost-benefit analysis (or surplus model) rather than an economic impact assessment. The former method allows us to identify easily the *incremental* benefits of having UHF spectrum available to meet mobile broadband demands (in addition to other frequencies), by employing a counterfactual case in which operators do not have UHF available. As the mobile industry could and will use alternative frequencies for the provision of mobile broadband services, this ensures that any benefits (or costs) that would have existed without the use of UHF are excluded. A cost-benefit analysis (CBA) is the preferred method employed by governments in setting policy.

3.2 Incremental value from UHF for mobile

Our network model calculates the capital expenditure and operating expenditure necessary to fulfil the coverage requirements and the capacity requirements of the demand model. In the factual case, UHF spectrum is available to mobile operators and in the counterfactual case, it is not. Thus we will measure the incremental cost and benefits of UHF spectrum for mobile as shown in the exhibit below.

Exhibit 4: Assessing the value of UHF spectrum for mobile services



3.3 Total valuation of UHF spectrum for broadcast

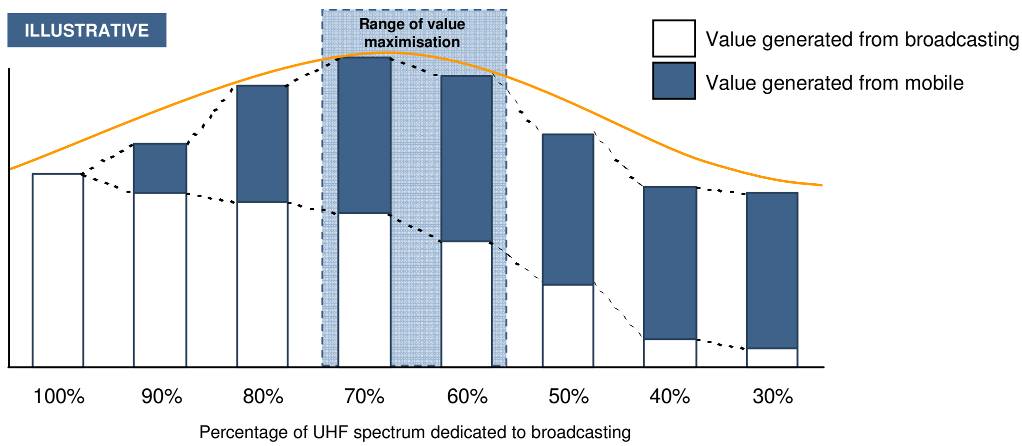
This analysis aims to quantify the costs and benefits of using UHF spectrum for broadcast services and to assess how these services vary with the amount of spectrum allocated to broadcasting.

Our assessment is based on the different costs and benefits to broadcasters of providing a broader range of broadcast services via digital terrestrial television (DTT) and the ensuing benefits to society of such a service.

3.4 Finding the optimal mix

To find the optimal mix of mobile and broadcasting services, we have developed several scenarios, each with a different allocation of spectrum for mobile broadband and broadcasting. The exhibit below illustrates a possible comparison of overall value from different allocations of spectrum.

Exhibit 5: Illustrative comparison of overall value generated for different allocations of spectrum



The exact sizes of the blocks that separate the scenarios are based on realistic allocations of spectrum. For broadcast services it is most appropriate to allocate spectrum by multiplexes. The amount of spectrum needed per multiplex depends on factors such as interleaving and interference. For mobile, spectrum is broken down in 20MHz blocks. In our modelling, we separate the scenarios by mobile blocks and therefore, necessarily, we have had to allocate 'partial multiplexes' in some scenarios.

3.5 Conservative assumptions

A conscious effort has been made to ensure that the study does not favour the mobile industry. When in doubt, the study deliberately favours broadcasters when defining assumptions.

The elements that we feel have made our results conservative can be categorised as:

- Demand assumptions
- Network assumptions
- Cost-benefit assumptions
- Technology assumptions

As explained below, a less conservative approach would lead to an increase in the optimal spectrum allocation to mobile.

3.5.1 Demand assumptions

Modelling demand for a new service twenty years into the future is necessarily an uncertain exercise. Our methodology for developing demand forecasts focuses on extending and extrapolating current usage figures in a manner considered feasible and reasonable, given our analysis of changing consumer behaviour and corporate business models. The results of this mobile model are based on a present-day understanding of the future evolution of the industry and there could be significant upside should conditions prove amenable to more explosive development of mobile broadband services.

3.5.2 Network assumptions

Value Partners has elected to be conservative in terms of the availability and technical capabilities of future network developments.

The use of existing spectrum for Universal Mobile Telecommunication System (UMTS) services has an impact on the value of UHF spectrum for the mobile industry. Currently, there are roll-out programs in the industry to deploy Wideband Code Division Multiple Access (WCDMA) services on 900MHz in rural Australia. However, metro WCDMA deployments on 900MHz are expected to be possible from 2012 onwards as GSM 900MHz traffic loads reduce to levels sufficient to clear 5MHz of spectrum for 3G technologies.

The evolution path of International Mobile Telecommunications (IMT) Advanced technologies anticipates that High Speed Packet Access (HSPA) networks will be upgraded to LTE networks, which will offer higher speeds to users and greater economies to network operators. The LTE upgrade is modelled as a full network upgrade, which immediately impacts the capacity of the network. Vendor representatives in our sponsor group have indicated that LTE could be market ready in Australia around 2010/11. In addition, Australian mobile operators have been consistently positive regarding early LTE deployment. However, for the purposes of the model, we have defined 2015 as the date for widespread market adoption, national implementation and commercial use of the technology. This is a conservative assumption since our modelling shows that an earlier date for widespread market adoption would lead to an increase in the optimal spectrum allocation to mobile. We expect real world LTE deployment to begin long before 2015.

Value Partners has not considered future advancements beyond LTE. It is probable that these will be developed and implemented within the twenty year time frame of this model; however, we are currently unable to make robust projections on the impact of these technologies.

3.5.3 Cost-benefit assumptions

a) Handset ecosystem

On our mobile broadband demand curve, we have chosen to use usage (MB) rather than users (subscribers). As there is, technically, no change in subscribers between the factual and the counterfactual, no change in handsets is created. This removes the handset ecosystem from the surplus calculation and, thereby, ignores the benefits to handset manufacturers and to consumers of having a new handset.

b) Price elasticity

As exemplified above, we have benchmarked our price elasticity against that of mobile voice. It is likely that price elasticity of mobile broadband would be higher as there are more substitutes for mobile broadband services (such as fixed broadband, watching television at home) than for mobile voice (the need for calling on the move). A higher elasticity increases consumer surplus and, therefore, overall surplus.

3.5.4 Technology assumptions

For this analysis, we have assumed that with each increment in UHF spectrum allocated to mobile, the improvement in capacity is the same. That is, we have assumed the throughput per MHz is constant for different size spectrum blocks (e.g. a 20MHz block has the same throughput per MHz as a 10MHz block).

However, this is a conservative assumption as larger blocks of spectrum allow for considerable improvements in throughput per MHz.

4 Mobile modelling

The mobile modelling analysis endeavours to quantify the *incremental* economic value generated through making UHF spectrum available for mobile broadband services, in addition to other frequencies, such as 2.1GHz, 2.6GHz and the re-farming of 850/900/1800MHz where available.

It is important to note that, in our model, the demand for mobile broadband services is calculated on a market level as we make no particular assumptions with regards to the market structure or the number of operators that will service the demand. However, we do assume that the mobile market is competitive so a portion of cost savings are passed through to consumers as reductions in prices. The exact number of operators in a market will affect the overall utilisation of spectrum, but the optimal mobile market structure is not something that we seek to establish in this study or upon which we advance a view.

We must however make assumptions about industry structure when we come to consider the 'supply-side' and how spectrum will be utilised. Our assumptions about, for example, the possibilities of re-farming existing spectrum and the use of LTE require that we take a view about industry structure and the division of spectrum amongst operators. In this respect, we take a 'representative industry structure' across Australia, based on the current market structure.

This analysis has required us to project the demand for mobile broadband services in Australia over the next 20 years. Demand for mobile broadband services drives the coverage and capacity requirements for mobile networks. The incremental value of the UHF spectrum assigned to mobile is derived from the increase in quantitative value for both the suppliers and consumers of mobile broadband services.

For this project, our sponsors have assisted us by providing proprietary data on a confidential basis. However, assumptions contained within this report represent Value Partners' independent views and no individual assumption can be attributed to any one sponsor.

This section presents an overview of the methodology, in which we seek to quantify these matters, as well as the key results for mobile.

4.1 Mobile model overview

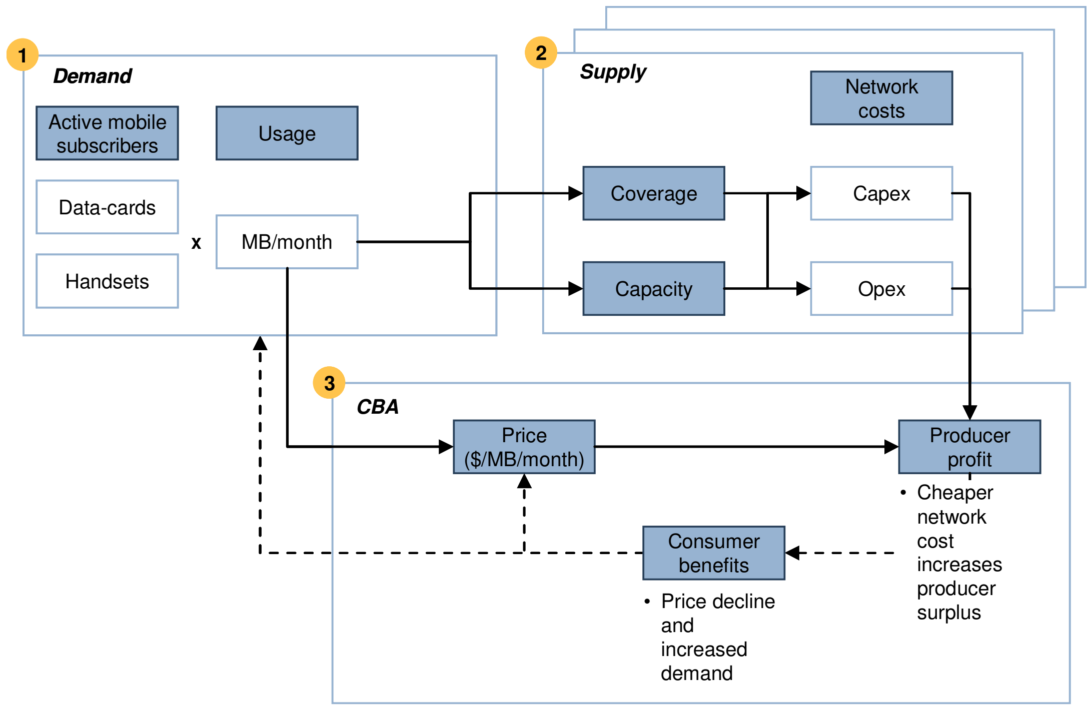
The mobile model can be divided into three distinct modules, each inter-related. The demand module estimates the total data usage of consumers on both datacards and handsets. The total data usage is calculated by projecting monthly usage per user and active subscriber numbers. The demand for mobile services drives the network requirements, determining the capital expenditure and operating expenditure of rolling out infrastructure for coverage and capacity.

This structure is replicated for both a factual case, where the UHF spectrum is taken into account for mobile services, and a counterfactual case, where it is assumed UHF spectrum is not available. In addition, we have modelled metro and rural as two separate regions, accounting for the particularity of Australian broadcasting licence areas as well as differences in mobile signal propagation properties.

The difference between the factual and counterfactual cases is the value generated through the use of UHF spectrum. This additional value is allocated between producers and consumers, assuming savings in network costs will be passed on to consumers in price reductions.

The exhibit below illustrates the logic of the model schematically.

Exhibit 6: Simplified mobile model structure



4.2 Mobile model sensitivities

The mobile model is built with a flexible structure, which allows key assumptions to be adjusted easily to perform sensitivity analysis. The key sensitivities tested in this model are the level of demand for mobile broadband services, and the amount of UHF spectrum that is allocated for mobile broadband.

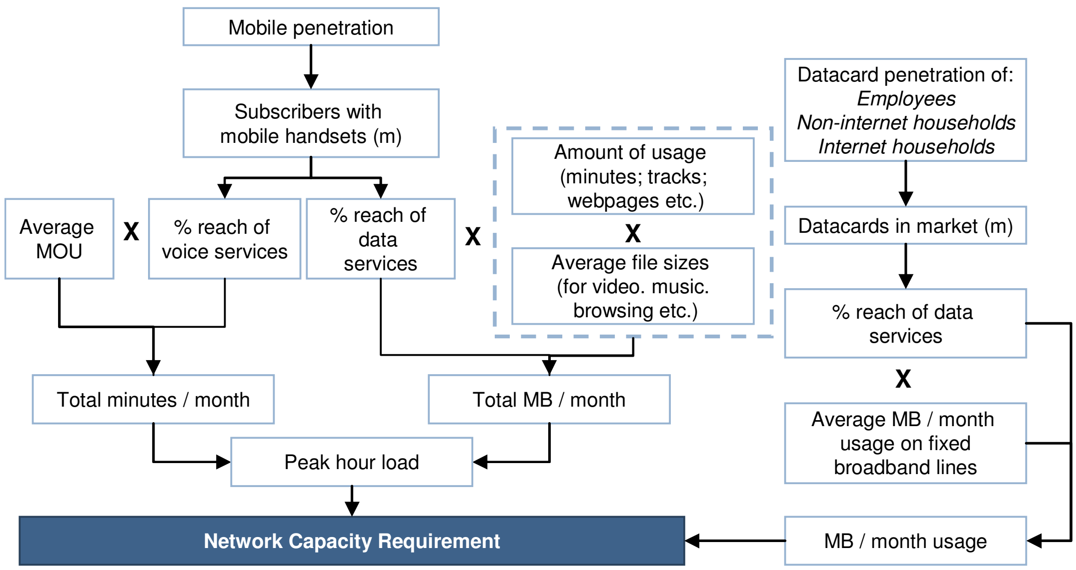
Exhibit 7: Mobile broadband model sensitivities

Area	Sensitivity	Description
Demand	**Demand scenarios**	• Variations in usage and penetration for both data-cards and handsets
UHF network	**Amount of UHF spectrum allocated**	• Size of UHF spectrum allocation to mobile (in 40 MHz chunks)
	Delay of UHF network availability	• Timing of availability of UHF spectrum
Alternative frequencies	**Timing of other frequency and technology availability**	• Timing of spectrum re-farming • Timing of LTE
General network	**Coverage requirements**	• Extent of coverage requirements for operators
	Network costs	• Variation in the capex and opex of base stations
CBA	**Price elasticity**	• Variation in the elasticity of mobile broadband

4.3 Demand for mobile broadband services

In forecasting demand for mobile broadband services, we drew on existing third party research, proprietary data from stakeholders and internal Value Partners analysis on the future development of consumer behaviour. We have benchmarked our projections against existing studies forecasting future mobile broadband demand in Australia.

Exhibit 8: Mobile demand model structure



We have developed three mobile scenarios, which incorporate a series of supporting assumptions regarding fundamental trends in consumer behaviour, technology and commercial plans. The differences between the scenarios represent step-changes in all three of these elements.

The following exhibit summarises the key characteristics of the scenarios and the consequential take up and usage assumptions:

Exhibit 9: Mobile scenario characteristics

Trend	Mobile ubiquitous	Mobile complementary	Mobile supplementary
Consumer behaviour	• Mobile broadband usage is widespread. It is a ubiquitous service, with an increasing number of consumers accessing broadband primarily through mobile networks[10]. However, fixed networks remain important for on-site use (e.g. for IPTV)	• Consumers use mobile broadband as a complementary service to fixed, recognising the benefits of mobility	• Consumers continue to use fixed broadband as the primary mode of access. Mobile broadband is emerging as an option for supplementary use

[10] Note: While it is expected that there will be some mobile-fixed substitution from a consumer perspective, fixed networks remain critical for ubiquitous consistent quality of service and scalability

Technology	• Peak speeds improve dramatically • Vast majority of portable devices are mobile broadband enabled • Desirable mobile broadband applications generate boom in mass market adoption	• Peak speeds improve quickly • Handsets converge with ultra-portable laptops in functionality • Mobile broadband applications become more widespread	• Peak speeds improve steadily • Handsets evolve to facilitate increased data usage • Mobile broadband applications emerge and are only used by early adopters
Commercial plans	• Generous unlimited data bundles are standard	• Unlimited data bundles introduced in the near term	• Tariffs remain on per MB basis in the short term, before moving to bundles

4.3.1 Handsets

a) Take-up

To project future take-up of mobile handsets for the demand module, we have forecast the population penetrations of 3G and 4G[11] technology handsets. This has enabled us to determine the number of users with the capability to access the services we have modelled and display the usage behaviour described in our demand scenarios.

To forecast 3G and 4G population penetrations, we have forecast the overall mobile penetration, and the penetration of 2G. We have assumed a flat 114% mobile population penetration in Australia from 2010 onwards. Although Australia has a highly penetrated mobile market, we do expect that mobile penetration will continue to increase rather than to remain flat; therefore, our assumption is conservative for mobile. We have also assumed GSM (2G) will be switched off by 2020, and using historical progression of 3G penetration as a proxy for future 4G take-up, we have projected the population penetration of all mobile technologies for the period of our forecast.

b) Penetration

The key handset data services we have modelled in this cost-benefit analysis include:

- Video (streaming and downloading)
- Browsing (mobile web pages)
- Music downloads
- Email
- Mobile TV
- Other (including business applications)

For each of these activities, we have estimated the penetration amongst subscribers (i.e. active users), utilising benchmarks provided by the members of AMTA.

Penetrations of mobile handset data services are assumed to remain constant across different mobile scenarios. This is in line with our view that subscribers' access to, and use of data services are largely driven by actions of mobile operators, and is therefore unlikely to vary significantly by scenario. In contrast, usage is more sensitive to the commercial and behavioural factors that define the differences between our scenarios.

[11] For this exercise, we have defined 4G services as LTE-enabled mobile services with broadband capability

The table below details our model's assumptions on the penetration of the selected services in Australia. Note that penetration is the percentage of mobile subscriber base that are actively subscribed to the service and that penetration figures across services are not additive, as users of some services will overlap.

Exhibit 10: Forecast take-up of mobile handset data services

	2010	2015	2020
Video	16%	50%	63%
Browsing	14%	27%	69%
Music	5%	12%	31%
Email	15%	35%	69%
Mobile TV	2%	10%	34%
Other	3%	14%	42%

The 'Mobile TV' category refers to Mobile TV services carried over IMT networks, as opposed to DVB-H broadcasting.

c) Usage

The total usage of mobile data services is driven by two major factors:

- Changes in the average file sizes / data rates of different data services
- Changes in average consumption (files per months / minutes per months etc) of different data services

The former is expected to reflect the trend in fixed internet usage that, as speeds and capabilities increase, file sizes / data rates of services and applications increase correspondingly. Our forecasts of usage are based on current figures provided by our stakeholder group and internal Value Partners analysis, which are projected forward using online usage benchmarks.

Exhibit 11: Forecast average data service usage per active user, by mobile scenario

	Unit	Mobile ubiquitous			Mobile complementary			Mobile supplementary		
		2010	2015	2020	2010	2015	2020	2010	2015	2020
Video	(min/mth)	26	135	334	22	63	144	21	30	55
Browsing	(pages/mth)	43	174	444	43	174	444	43	167	310
Music	(tracks/mth)	2	6	17	2	6	17	2	6	10
Email	(emails/mth)	279	665	873	279	665	873	279	611	771
Mobile TV	(min/mth)	30	92	201	19	54	136	18	48	65
Other	(unit/mth)	1	10	496	1	2	195	1	2	33

Using the projections for data service penetrations, average consumption rate and file size per 'use', we have calculated the average and total data usage per active user on mobile handsets. This is illustrated in the exhibit below.

Exhibit 12: Average usage of data on handsets

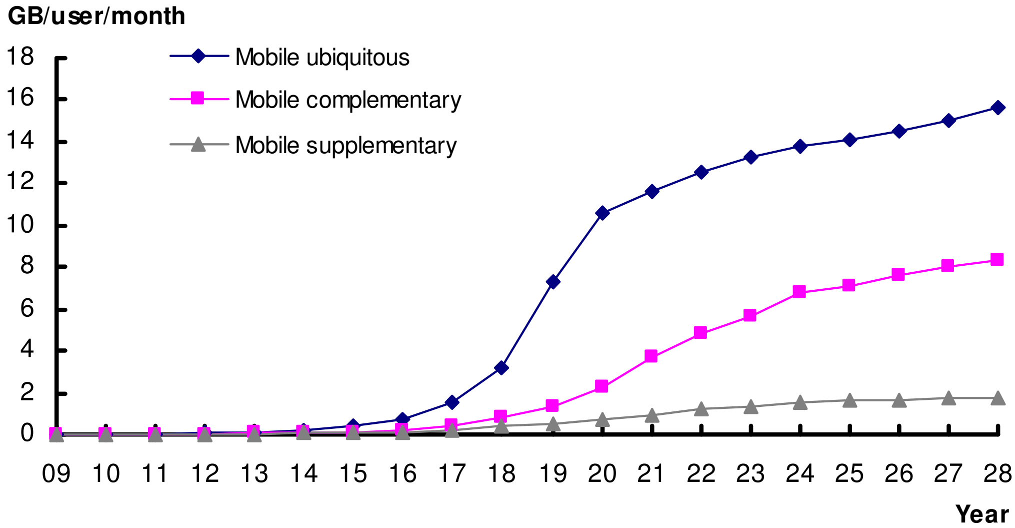
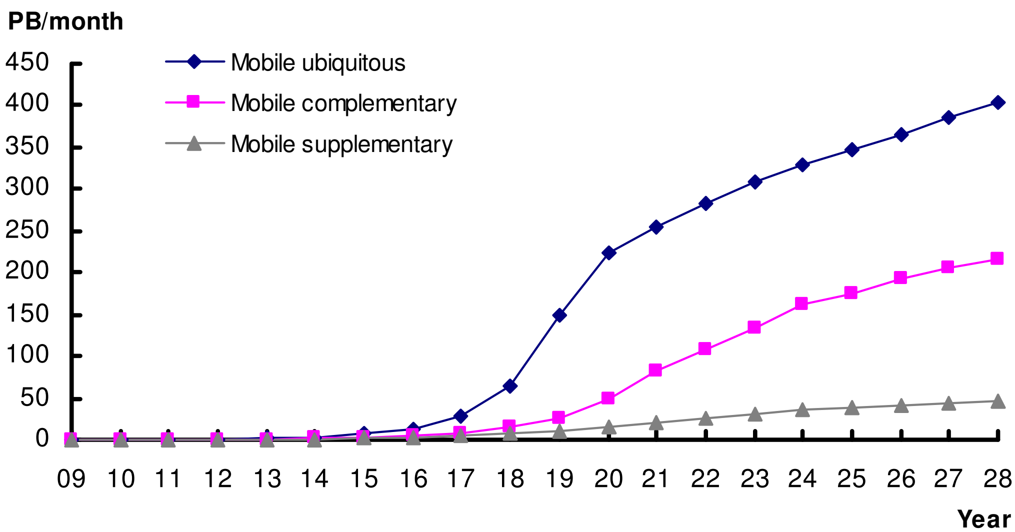


Exhibit 13: Total usage of data on handsets



4.3.2 Datacards

a) Take-up

To forecast the take-up of datacards, we have taken into consideration the future growth in penetration of laptops and other portable devices, as well as the availability of fixed broadband infrastructure. Growth in datacard penetration is based on the assumption that such cards will be widely included in portable entertainment and business devices, analogous to the historical development with WiFi. Datacard take-up can be broadly split into three elements:

- Business use/applications such as sales force automation and remote working

- Demand for datacards driven by coverage where fixed broadband is not a viable option or otherwise as an alternative to fixed broadband
- Extension of fixed broadband on the move (i.e. ownership of both a fixed line and a datacard)

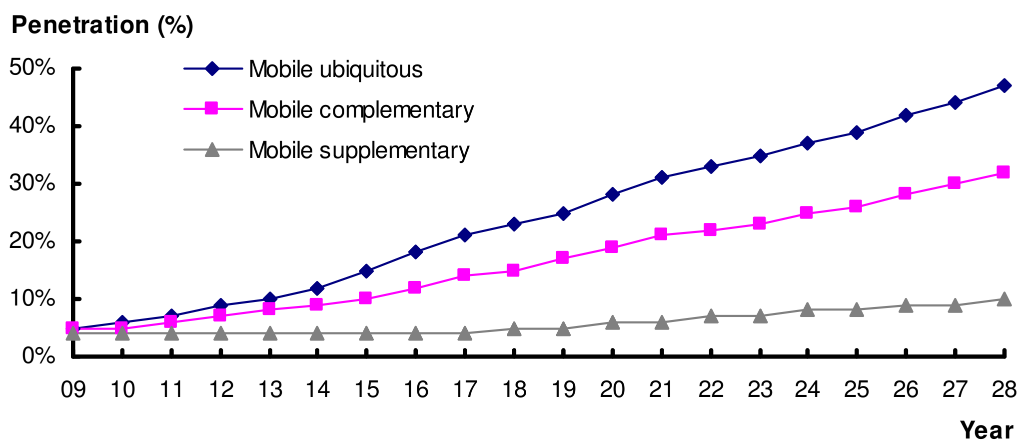
For each element, we have forecast the level of datacard take-up.

Exhibit 14: Percentage of broadband connections that are datacards

	2010	2015	2020
Mobile ubiquitous	17%	29%	39%
Mobile complementary	15%	23%	30%
Mobile supplementary	12%	11%	12%

From this analysis, we have derived the datacard penetration projections, shown in the exhibit below.

Exhibit 15: Population penetration of datacards



b) Usage

We have assumed that, given the right commercial incentives (i.e. similar pricing for data), users will not differentiate between fixed or mobile broadband. Therefore, the broadband usage on mobile is expected to increase, and converge with fixed broadband usage levels. Our projected average and overall datacard usage is shown in the following two exhibits.

Exhibit 16: Average data traffic per datacard

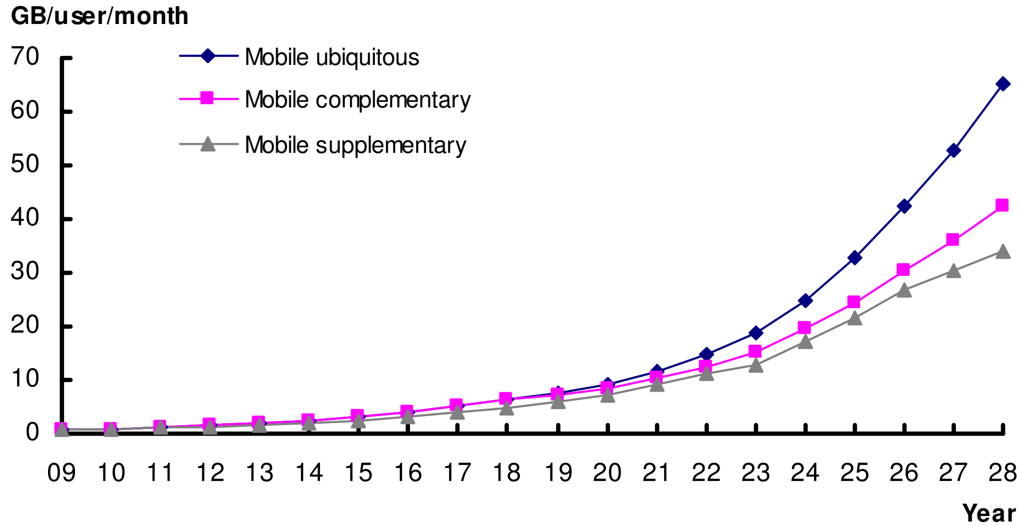
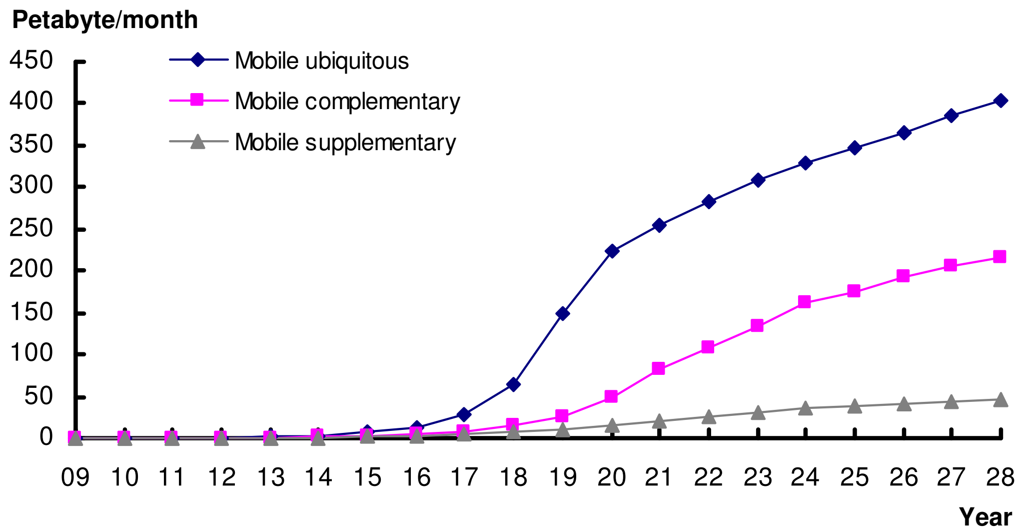


Exhibit 17: Total usage of data on datacards



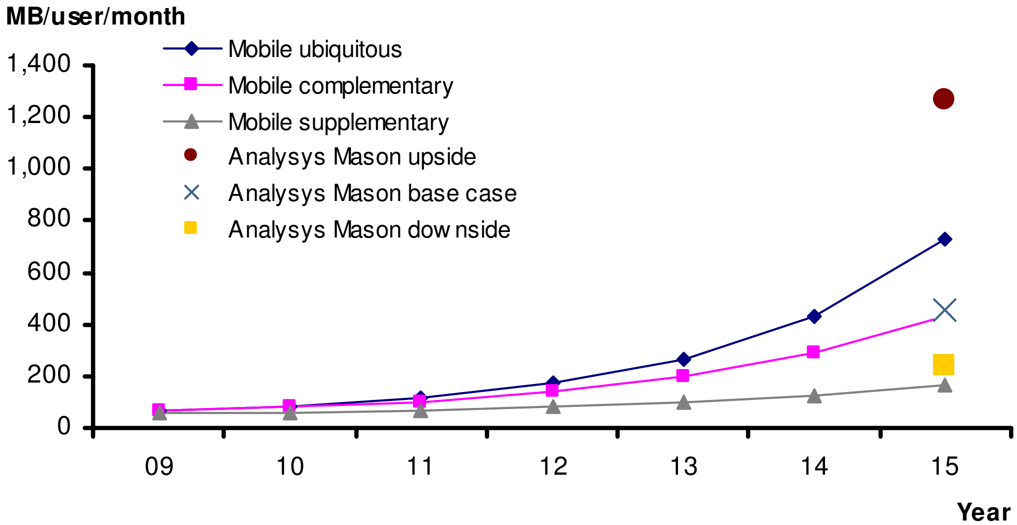
4.3.3 Total traffic

Given projected data usage on handsets and datacards, we were able to project the average data usage in Australia. Comparing against Analysys Mason's projections[12] for developed countries, our projections are in line with the downside and base cases; however, the upside case is more aggressive than our estimate. The reason for Analysys' more aggressive upside case is substantial mobile penetration growth, whereas we have conservatively forecast flat population penetration of 114% from 2010 onwards. Under more aggressive

[12] Wireless network traffic 2008-2015: forecasts and analysis, Analysys Mason, October 2008

scenarios than we have modelled, the optimal allocation to mobile in the mobile ubiquitous case would be higher than this study suggests.

Exhibit 18: Average data usage on all devices



4.4 Supply of mobile broadband

4.4.1 Overview

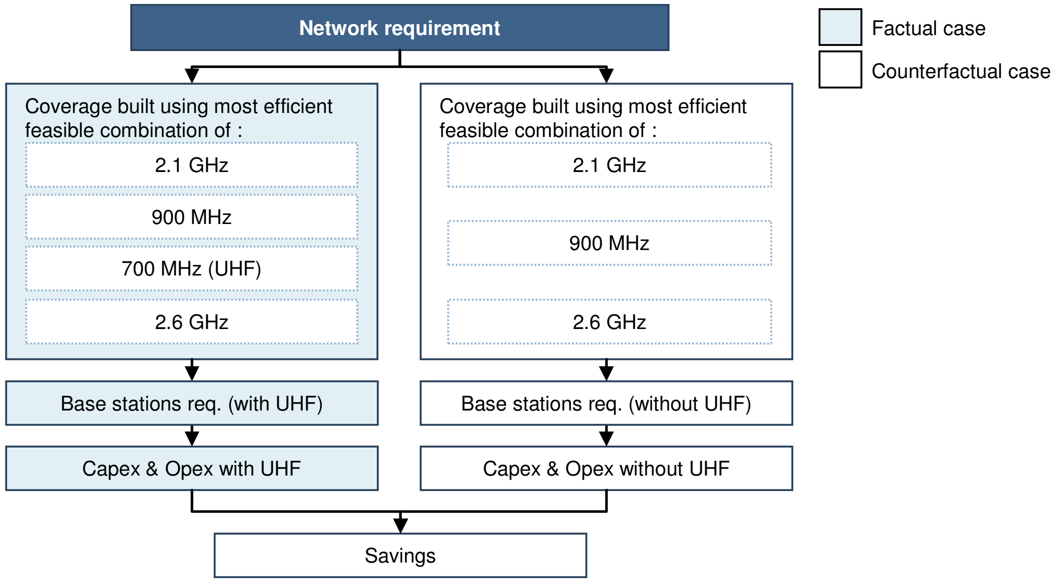
Our supply model for mobile calculates the capital expenditure and operating expenditure necessary to satisfy the coverage and the capacity requirements, which are derived from the demand module of the model. The model is further divided into two separate cases: in the factual case, UHF spectrum is available for mobile broadband use; and in the counterfactual case, it is not. From the differences between the factual case and counterfactual case, we are therefore able to measure the *incremental* costs and benefits of allocating UHF spectrum for mobile use.

In addition, for each factual and counterfactual case, we have analysed Australia in two separate regions – metro and rural – repeating the methodology in each region. Our metro and rural division is defined by the metro and rural broadcast regions, to ensure the mobile model is in line with the broadcast analysis. This also allows us to identify any differences that may exist between metro and rural regions in terms of optimal allocation of UHF for mobile purposes for each of the mobile demand scenarios.

The cost differentials between the factual and counterfactual cases are derived from the difference in capital and operating expenditure to mobile operators in rolling out a nationwide 3G/4G network and meeting forecast mobile broadband demand.

The exhibit below illustrates the structure and logic of the network cost model for coverage. A similar structure has been utilised to determine the network costs to satisfy capacity requirements, with the addition of existing spectrum bands for use.

Exhibit 19: Schematic outlining structure of network cost model for coverage



Network cost savings calculated using this cost model drive our calculations of producer and consumer surplus, to derive our final valuation in the CBA module of our mobile model.

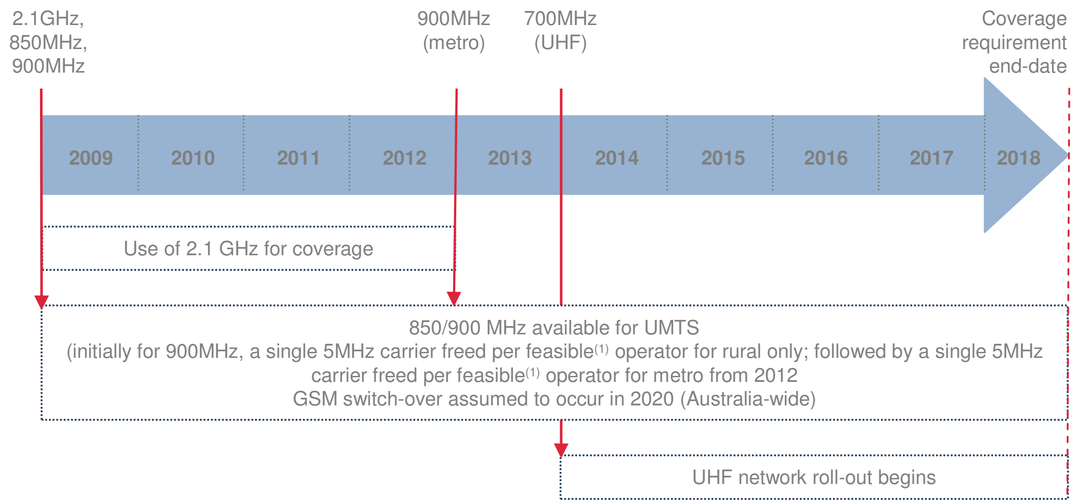
A key assumption of the network cost model is unit cost of each base station site rolled out. We have made assumptions regarding each element of capital and operating costs, as well as price trends over time. These assumptions have been benchmarked against proprietary information from vendors as well as public sources[13].

4.4.2 General assumptions

To capture the benefit of UHF in the model, operators are assumed to have to meet 100% of current 2G (GSM) geographic coverage with 3G services by 2018. This also assumes that mobile operators decommission their 2G networks in 2020. The order in which spectrum bands become available for use to meet the coverage requirements is illustrated in the exhibit below.

[13] http://www.ofcom.org.uk/research/technology/archive/cet/uwb/uwbpans/ (p75)
http://www.ofcom.org.uk/consult/condocs/liberalisation/lib_annex.pdf (p30)

Exhibit 20: Spectrum timing assumptions for coverage

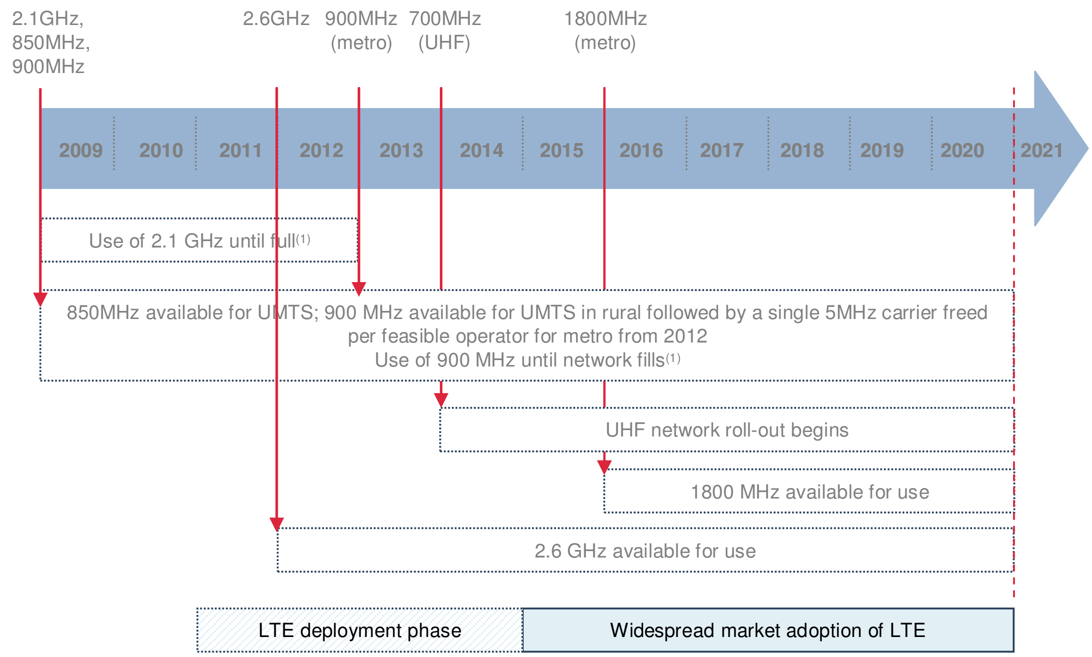


- We assume that operators are required to build out a certain amount of coverage per year
  - operators will do this on the lowest available frequency network
  - 2600 MHz is available from 2012, but is unlikely to be used for coverage

Note: (1) Feasibility refers to operator's current spectrum holdings

Network capacity requirements are driven by the projected level of mobile voice and data demand. Operators are assumed to roll out infrastructure to meet forecast demand levels, extending the capacity of their networks until the current spectrum is full and then alternative spectrum will be utilised. Where forecast levels of demand are such that existing 2.1GHz, 850MHz and 900MHz frequencies are insufficient to provide the required capacity, operators will utilise 700MHz (UHF), 1800MHz or 2600MHz. The order in which these spectrum bands become available for mobile use, as assumed in our model, is illustrated in the following exhibit.

Exhibit 21: Spectrum timing assumptions for capacity



- We assume that operators move on to a new frequency as existing frequencies fill
- Where spectrum allocations render this feasible, we assume that operators upgrade cells to multi-carrier cells and install LTE
- Our timing of LTE does not reflect its initial deployment, but the point at which widespread market adoption is likely to occur

Note: (1) We have assumed that operators will not retire their existing holdings but complete their 2.1GHz and 900MHz networks before building out on UHF

For capacity, we have incorporated the introduction of LTE and have assumed 2015 as the year of widespread market adoption, although actual deployment is expected to begin long before then.

Costs of accommodating both coverage and capacity requirements are assessed for both the factual and counterfactual cases, and the difference between the two is then valued on a net present value basis using the cost-benefit discount rate of 7%[14] to obtain the incremental value of UHF spectrum for mobile operators.

These assumptions on availability of spectrum have been based on publicly available sources, as well as information provided by stakeholders. Previous feedback on these assumptions has led us to have several points of clarification:

- We understand that 2012 may be considered early for the availability of 2.6GHz spectrum. However, the timing of 2.6GHz spectrum makes little difference to the results as it is the last frequency to be used for both capacity and coverage
- Our 900MHz re-farming scenario assumes that 25MHz is available now in the rural region and will become available in 2012 for the metro region. In addition, due to only slight difference in properties, an additional 10MHz of the currently unused 850MHz band is also added to the 900MHz spectrum pool

[14] Valuing the future: Choosing the discount rate in Cost-Benefit analysis, Mark Harrison, 2007

- LTE is assumed to achieve widespread market adoption from 2015. In assuming this date, we have taken into consideration the likely commercial feasibility of this technology, and the capacity demands of operators' networks. In addition, based on past experience with 3G, *full scale* commercial deployment is typically delayed from the first availability of the technology. We recognise that operators in the market may be in a position to launch initial LTE services prior to our current assumptions and in currently existing spectrum bands e.g. 850/900/1800/2100MHz, where feasible[15]. Therefore, the assumed date for widespread market adoption date for LTE is conservative. If the assumed date is moved earlier, the optimal allocation of UHF spectrum for mobile broadband increases.

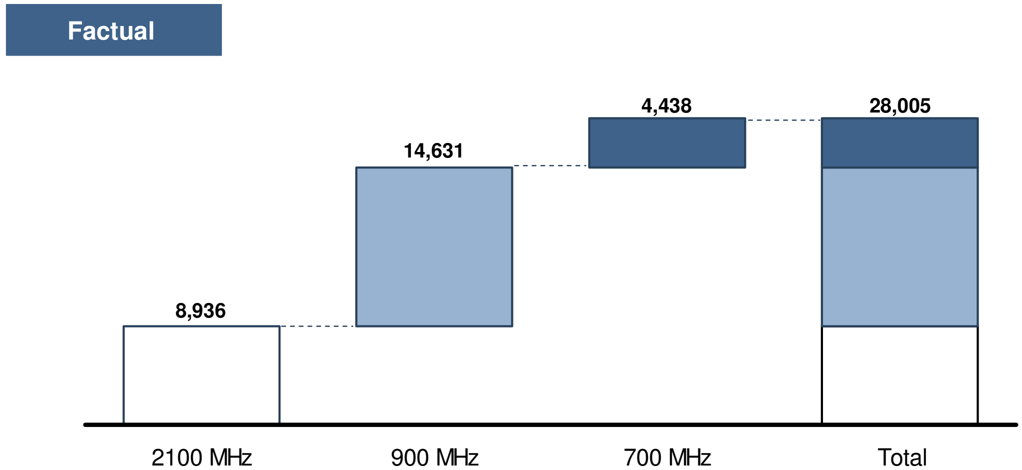
4.4.3 Calculations for coverage

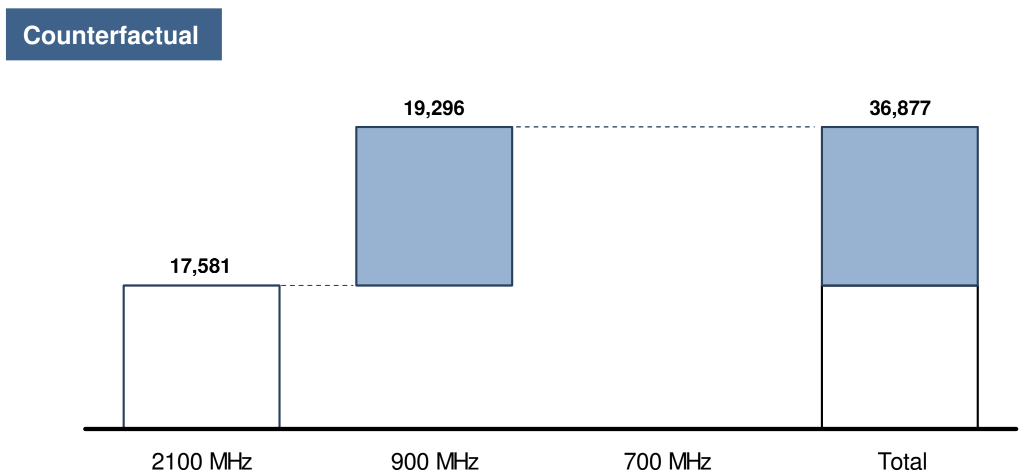
Coverage requirement assumptions are fixed in this model – we assume coverage of 97% of the Australian population will be required by 2018. The coverage is further divided into metro and rural, in which we have assumed 100% land coverage in the metro region, which is approximately 90,000 km^2, and 800,000 km^2 land coverage in rural region. We have performed a sensitivity analysis to model 99% population coverage, which would imply 1,900,000 km^2 land coverage; however, this has no material affect on our overall result for optimal allocation of UHF spectrum.

Our coverage requirement was determined based on current GSM coverage in Australia. This enables us to only take into consideration those areas where it is commercially feasible for operators to roll out mobile services. We have assumed that operators will roll out their nationwide networks in the most cost efficient frequency available, to meet their coverage requirements. The exhibit below details the results from the model for roll-out of base stations for coverage.

[15] Feasible refers to the operator's current spectrum holdings and ability for that operator to successfully refarm existing spectrum bands for LTE

Exhibit 22: Total number of base stations rolled out for nationwide coverage





Base station roll-out in the factual case is less than roll-out in the counterfactual case, as 700MHz UHF spectrum possess superior propagation characteristics, enabling greater coverage with fewer base stations. Each base station will incur capital expenditure in the year it is rolled out. However, some base stations can be co-located, which will reduce the cost of roll-out. Therefore, significant network capital expenditure savings can be achieved with the access of 700MHz UHF spectrum for coverage roll-out. Additional savings would be generated from lower operating costs, as there are fewer base stations.

4.4.4 Calculations for capacity

The total amount of spectrum required to fulfil the capacity projected in our mobile demand model is independent of the Australian market structure. However, we recognise that it is possible that the distribution of spectrum will not match actual capacity demand of each operator. But, we take the view that with higher demand commanded, an operator will acquire additional spectrum to satisfy the demand.

The demand model projects capacity demand in terms of minutes of voice traffic and terabytes of data traffic use per month in Australia. These figures represent capacity requirements for the Australian mobile networks.

Additional considerations are then made to allow for fluctuations in traffic volume using our stakeholders' historical peak hour traffic data.

We have assumed that each base station will provide the same capacity, given the same technology, independent of frequency. Our model considers two technologies, HSDPA and LTE, and therefore there are two potential capacity levels for base stations. HSDPA is the technology in use today and the near future – all base stations built until 2015 are assumed to provide HSDPA capacity. As before, we have assumed 2015 as the date for widespread market adoption of LTE, and existing 3G networks will be upgraded to provide capacity at LTE levels.

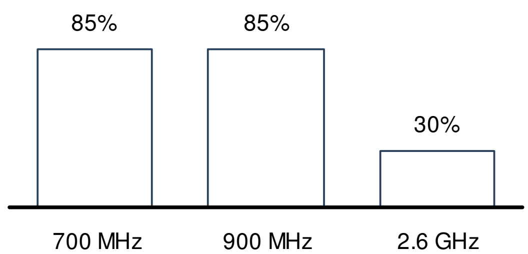
After 2015, new LTE deployments begin once there is sufficient spectrum available for at least one LTE channel, which is assumed to be 2 x 10MHz. Vendors advise that the LTE specification will support channel bandwidths from 2 x 1.4MHz up to 2 x 20MHz. Globally, many operators are promoting 2 x 20MHz spectrum allocations if the full benefits of LTE are to be realised. However, in order to ensure flexibility in the model, a 'base unit' channel size of 2 x 10MHz has been assumed. As the available spectrum increases, so will the number of LTE channels, in 10MHz increments. It should be noted that with a wider channel, throughput will be higher, and additional capacity gains can be achieved. This is another area where our valuation of UHF spectrum for mobile usage is on the conservative side.

In modelling network required for capacity, we have assumed that operators will meet year-end capacity requirements as determined by our demand model. In addition, operators are assumed to fill existing spectrum bands before moving onto new frequencies.

A key assumption is the extent to which existing frequency networks are able to 'cell-split' (i.e. roll out new base stations), which determines when a spectrum band is full. This assumption will drive the extent to which current spectrum bands are used in meeting capacity requirements, and therefore potentially delay the use of UHF spectrum. There is a technical limit to the degree that cell-splitting can be achieved for a mobile network as smaller cells increase the level of interference. We have benchmarked our limits for cell-splitting on current cell-site numbers, limiting roll-out on each network to approximate current total roll-out of base stations on GSM.

Another key assumption, which will influence costs, is the level of co-location of sites that can be achieved. Each base station rolled out is, where possible, co-located on an existing site as it reduces the capital expenditure and operating costs. We have assumed that the proportion of base stations of lower frequencies that are co-located on existing infrastructure is higher than that achieved with base stations of higher frequencies. As such, more base stations are built as 'greenfield' sites at higher frequencies as co-location with the existing base station site density may be insufficient to provide contiguous coverage. Our co-location assumptions are detailed in the following exhibit.

Exhibit 23: Co-location assumptions by frequency (% of 2100MHz / 900MHz sites)



4.5 Cost-benefit analysis

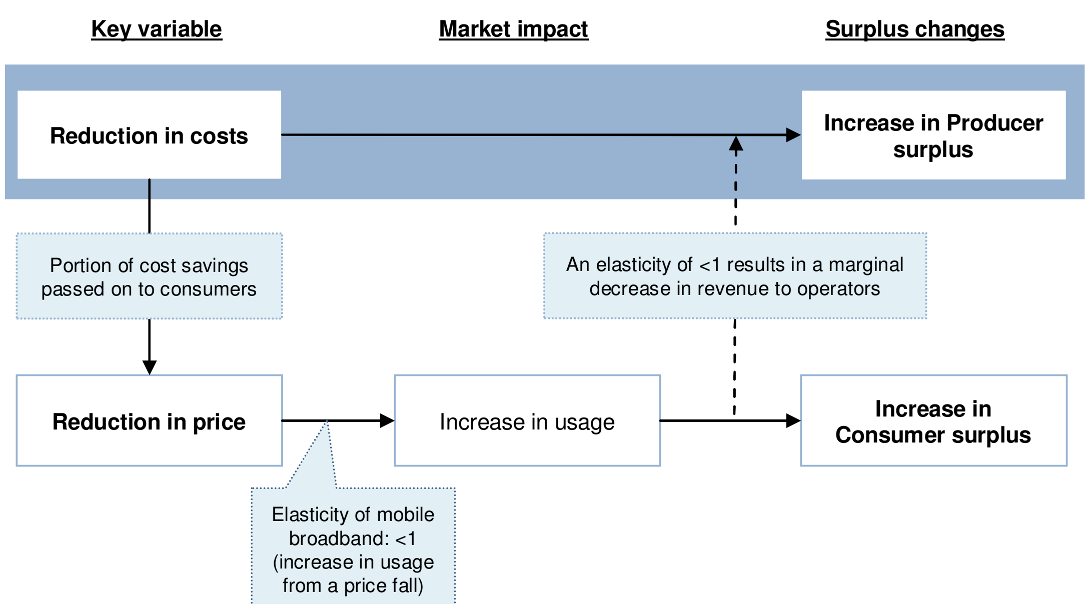
The costs and benefits are split into three areas: direct benefits, indirect benefits and externalities.

4.5.1 Direct benefits

Direct benefits are those arising from the direct consumption of mobile broadband services and are split into the cost/benefits (or surplus) due to the producers and those due to the consumers. For producers of mobile broadband services, direct benefits primarily accrue as a result of a reduction in network costs.

If these cost savings were retained by the operators or their shareholders, this would add to the producer surplus. However, in our model, we have assumed that a portion of the cost-savings are ultimately passed on in price changes, based on the competitiveness of Australian mobile services markets and historic trends in mobile operator margins. Reduced prices for mobile broadband will facilitate increased consumer usage of the service and the incremental benefit to consumers or consumer surplus is this additional usage, combined with lower prices for existing usage. This is illustrated in the following exhibit.

Exhibit 24: Direct consumer surplus



4.5.2 *Indirect benefits*

Indirect benefits result from indirect effects that the market for these services has on other product markets and, as a result, can further increase total consumer and producer surplus. For example, some of the incremental revenues from a mobile broadband service could be generated by advertisements and not by subscribers. However, advertising revenues do not represent an economic benefit but a financial flow or an expense by the advertiser as part of its marketing strategy, which results in higher sales and profits for the producers in other markets. Advertising revenue, therefore, represents the minimum additional surplus/profit that the producer in the adjacent market (i.e. the advertiser) is expecting to make through increased sales. Sensitivity testing indicates that the 'indirect benefits' do not significantly affect our results.

4.5.3 *Externalities*

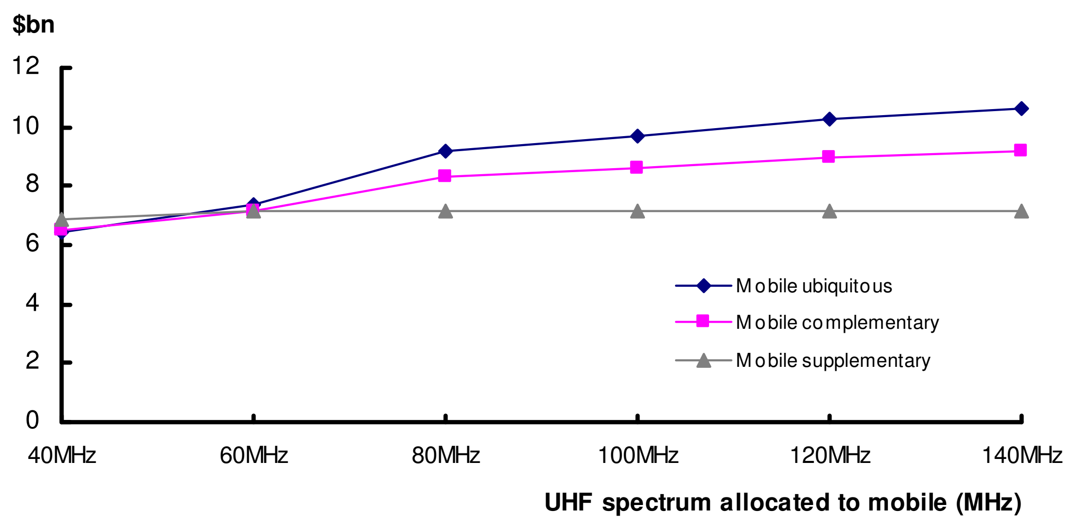
Externalities are wider economic benefits to society as a whole which are not taken into account by the consumer or the producer when selling the product or service. These would include increased productivity of workers, additional job generation, boosting of related industries etc, and would largely accrue to citizens and society as a whole. Sensitivity testing indicates that 'externalities' have a limited affect our results.

4.6 Mobile results

4.6.1 *National*

The total value of UHF spectrum allocated to mobile in Australia is between $6.5bn and $10.7bn. This value depends on the allocation of spectrum and the mobile demand levels. The exhibit below details the results for each mobile scenario modelled and allocation of UHF spectrum to mobile operators for the national case.

Exhibit 25: Total value of UHF spectrum for mobile - national ($bn)



The total value generated by UHF spectrum allocated to mobile increases for every additional 20MHz of UHF spectrum allocated. For example, assuming the mobile complementary scenario, an allocation of 80MHz generates $8.3bn, as compared to $8.6bn of value when the allocation is 100MHz. Of particular note is the increase from 60MHz to 80MHz in the mobile ubiquitous and mobile complementary scenarios. With four operators in the market, an allocation of 80MHz is the minimum to allow each operator one 2x10MHz LTE block. With LTE, base station throughputs are increased which leads to increased cost savings for operators that build out a mobile broadband network utilising the UHF spectrum band. This effect is not evident in the mobile supplementary scenario as sufficient capacity exists to support this data demand due to the coverage that has been rolled out.

One particular point to note is that at low frequency allocations, higher demand generates lower value for the spectrum utilised. This is because the value generated is driven mainly by the benefits from coverage using UHF spectrum rather than other higher frequencies. However, with higher capacity demands, there is higher capital expenditure initially in the factual case than in the counterfactual case, reducing the overall benefit generated. This is because in the counterfactual case, the base stations are denser at higher frequencies, and therefore account for any additional capacity requirements, unlike the factual case. Once both the factual and counterfactual are equally limited and require network build out for capacity, the factual, with its lower roll-out costs, becomes the cheaper option once again. This effect is best conceptualised by a hockey stick: benefits for coverage, followed by a net loss for meeting initial capacity, followed by a net gain at high capacity requirements.

For the mobile ubiquitous and mobile complementary scenarios, the incremental value is largely driven by coverage, such that incremental values decline slightly between 100MHz and 140MHz. However, there is a sharp increase in the value generated by UHF spectrum between 60MHz and 80MHz due to the addition of spectrum for LTE, as described previously. The following two exhibits illustrate the value of each additional 20MHz block of UHF spectrum allocated for mobile broadband use for mobile ubiquitous and mobile complementary scenarios.

Exhibit 26: Value of UHF to mobile for mobile ubiquitous scenario – national ($m)

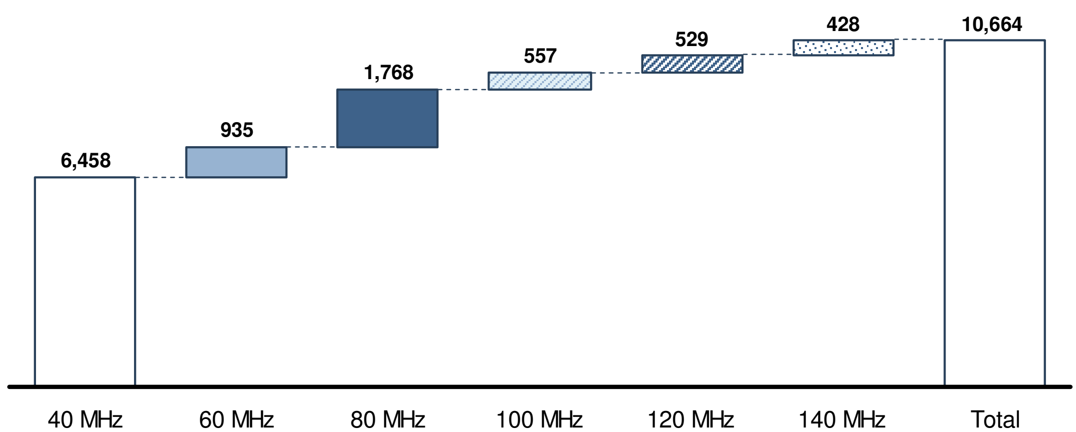
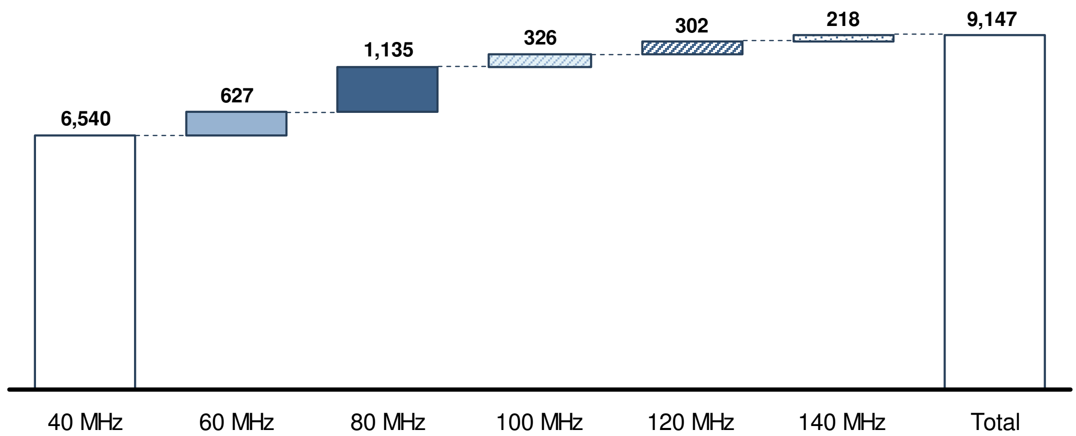
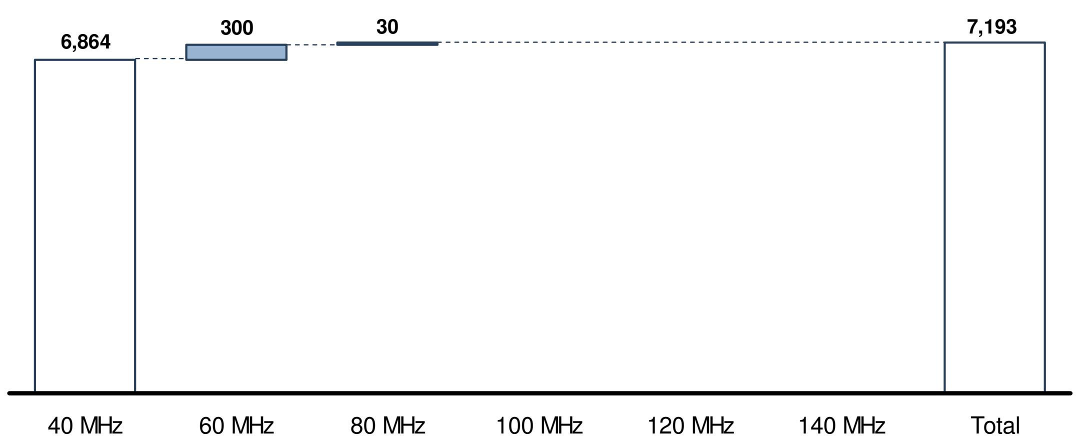


Exhibit 27: Value of UHF to mobile for mobile complementary scenario – national ($m)



For the mobile supplementary scenario, the incremental value is driven by the benefits from coverage using UHF spectrum rather than other, higher frequencies. Base stations rolled out to cover the active area are generally sufficient to meet capacity demanded. Hence, the incremental value of UHF in the mobile supplementary scenario is independent of the amount of UHF allocation and valuations do not increase between 80MHz and 140MHz allocation of UHF spectrum to mobile. This is shown in the exhibit below.

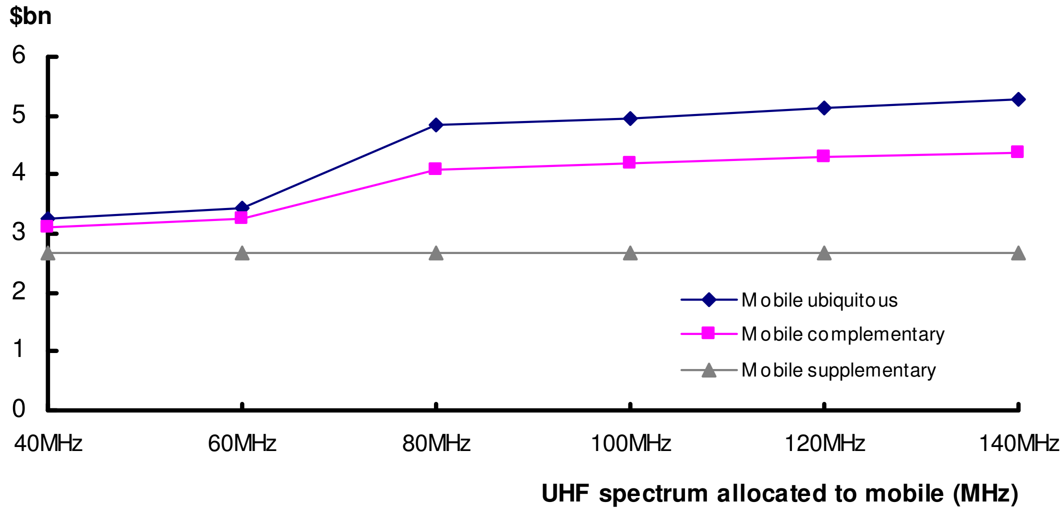
Exhibit 28: Value of UHF to mobile for mobile supplementary scenario – national ($m)



4.6.2 Metro

The total value of UHF spectrum allocated to mobile in the metro region is between $2.7bn and $5.3bn, depending on demand and size of allocation. The exhibit below details the results for each demand level and allocation of UHF spectrum to mobile operators in the metro region.

Exhibit 29: Total value of UHF spectrum for mobile – metro ($bn)



As previously, the value generated by UHF spectrum allocated to mobile increases for every additional 20MHz of UHF spectrum allocated for mobile ubiquitous and mobile complementary cases. However, the value generated remains constant in the mobile supplementary scenario regardless of the allocation of spectrum as sufficient capacity exists from the rollout for coverage to support the level of demand in this scenario. The value of each additional block of spectrum allocated for mobile broadband use in the metro region under each mobile scenario is illustrated in the three exhibits below.

Exhibit 30: Value of UHF to mobile for mobile ubiquitous scenario – metro ($m)

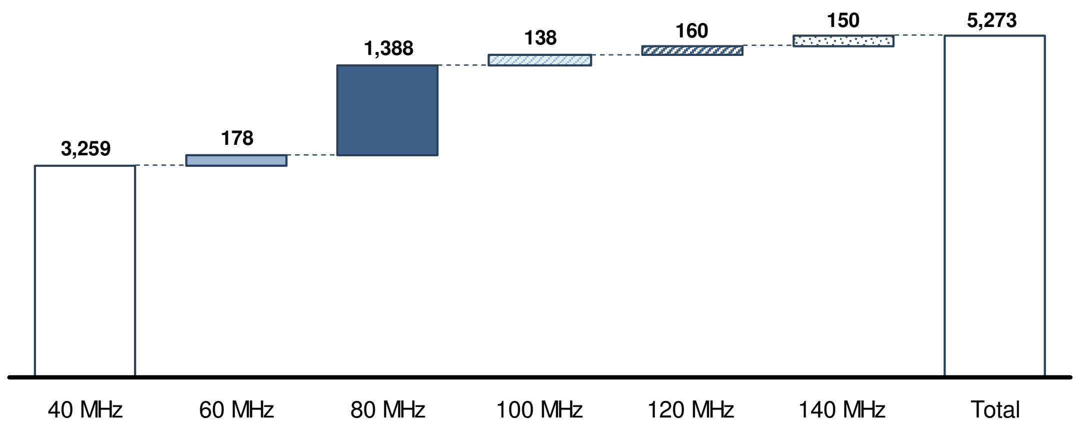


Exhibit 31: Value of UHF to mobile for mobile complementary scenario – metro ($m)

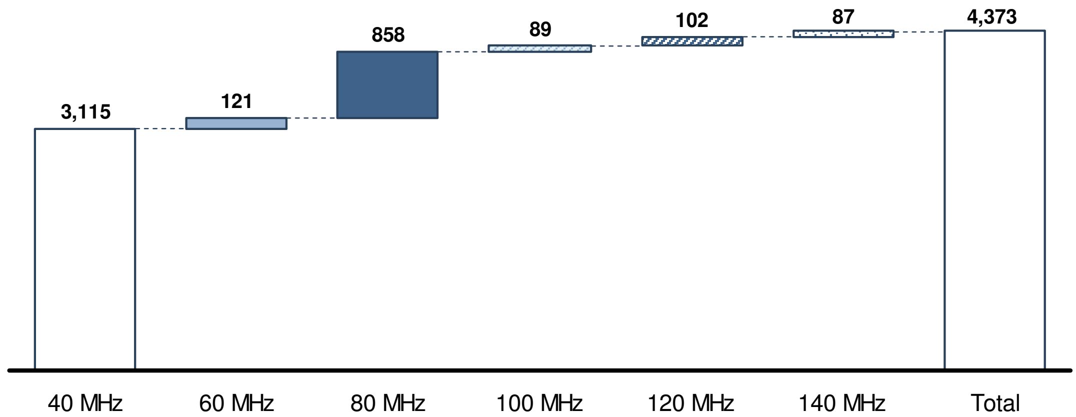
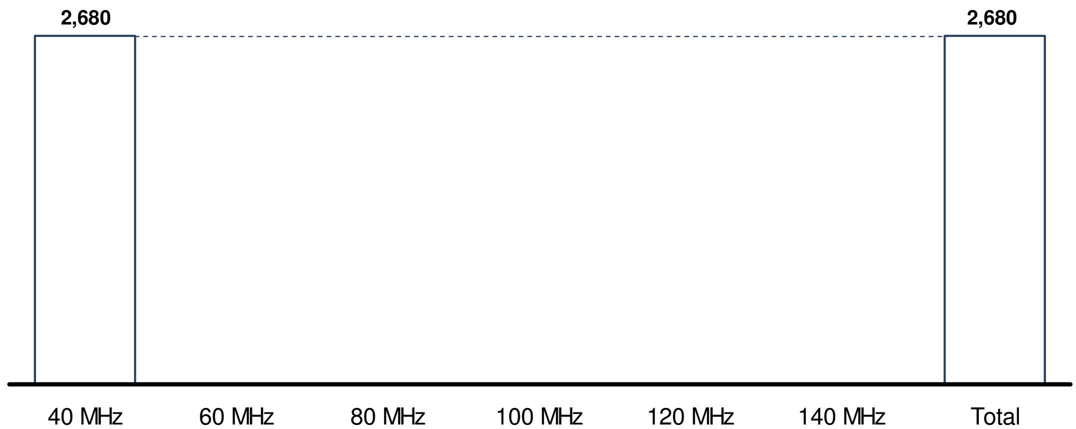


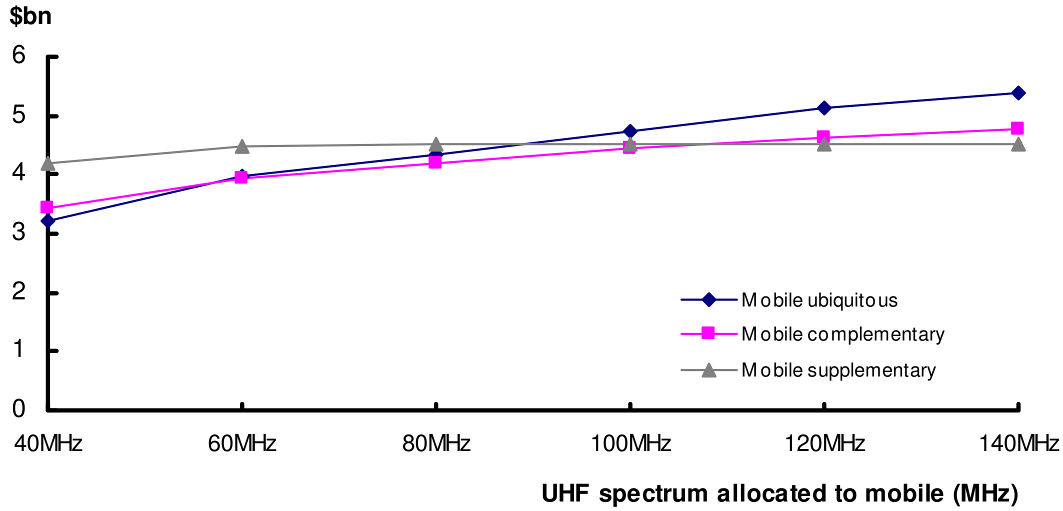
Exhibit 32: Value of UHF to mobile for mobile supplementary scenario – metro ($m)



4.6.3 Rural

The total value of UHF spectrum allocated to mobile in rural Australia is between $3.2bn and $5.4bn, depending on demand and size of allocation. The exhibit below details the results for each mobile scenario and allocation of UHF spectrum to mobile operators in the rural region.

Exhibit 33: Total value of UHF spectrum for mobile – rural ($bn)



The results show that, even in the mobile supplementary scenario, there is additional value gained with spectrum allocations higher than 40MHz, as distinct from the metro case. This is due to larger cell coverage area in the rural region and therefore less base stations than metro per unit of area, which means with increased spectrum allocation benefits can be gained from improved capacity of the network.

The value of each additional block of spectrum allocated for mobile broadband use in the rural region under each mobile scenario is illustrated in the three exhibits below.

Exhibit 34: Value of UHF to mobile for mobile ubiquitous scenario – rural ($m)

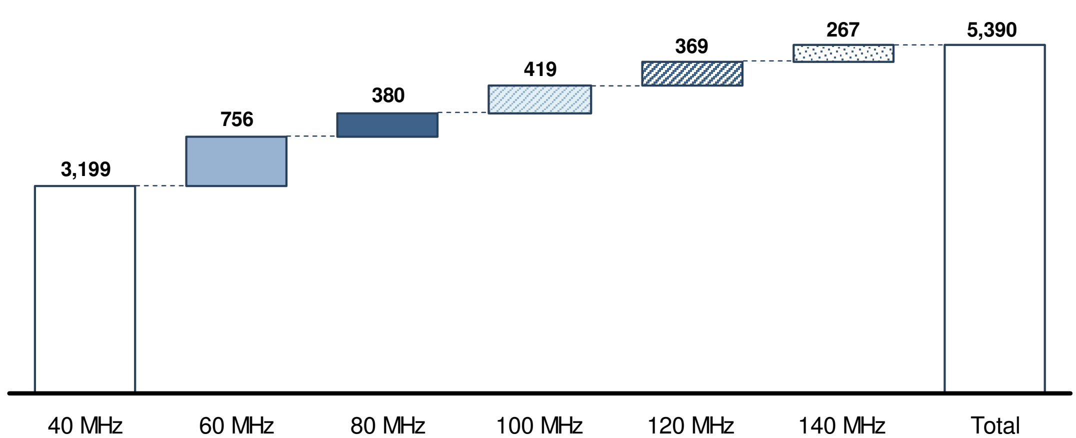


Exhibit 35: Value of UHF to mobile for mobile complementary scenario – rural ($m)

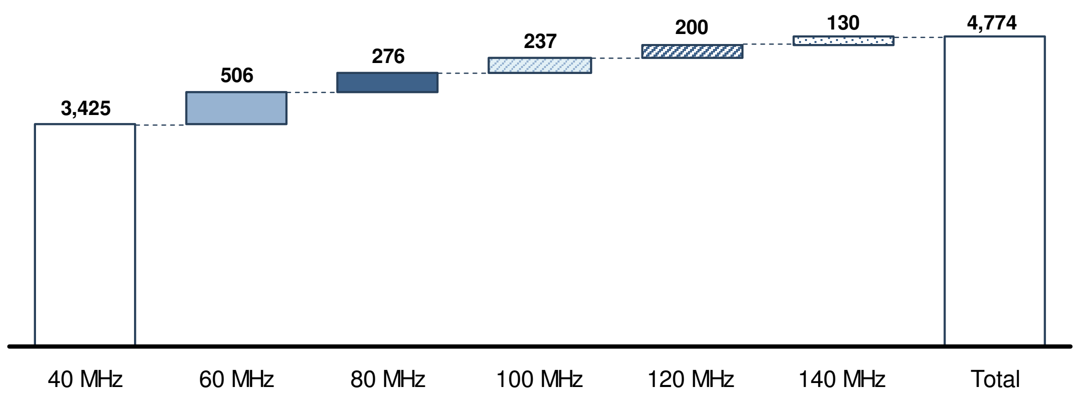
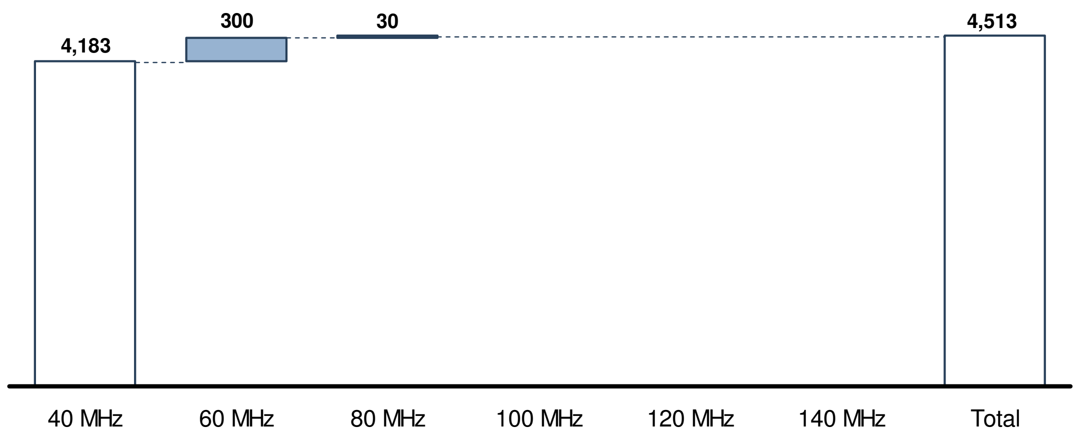


Exhibit 36: Value of UHF to mobile for mobile supplementary scenario – rural ($m)



4.7 Key takeaways from mobile analysis

Key takeaways from the mobile results are:

- The size of the initial 40MHz block in our model allows for at least one 2x5MHz block per operator, which is technically feasible for running UMTS services with HSDPA. However, there could be higher allocation thresholds than this to ensure commercial feasibility for operators
- When demand is high, significant value can be created through additional spectrum allocations beyond this initial 40MHz. This is illustrated by the jump in economic value when the mobile allocation is increased from 60MHz to 80MHz as it allows operators to utilise 2 x 10MHz spectrum blocks and upgrade to LTE. However, the full benefit of LTE has not been achieved as allocations of spectrum beyond 2 x 10MHz will allow operators to significantly lower technology overheads. For example, 2 x 20MHz compared to 2 x 10MHz will enable a doubling of network capacity at virtually no additional costs. This benefit is reflected in the results of our modelling as the value for mobile increases by up to $1.1bn if 120MHz is allocated instead of 80MHz. Furthermore, we

have assumed no improvement in capacity per MHz with larger blocks of spectrum, making our valuation for mobile more conservative.

5 Broadcasting modelling

The following sections outline the methodology of the broadcast case in detail. The broadcast model aims to quantify the costs and benefits of using UHF spectrum for broadcast services in Australia, and to assess how these costs and benefits vary with the amount of spectrum allocated for broadcasting. The current UHF spectrum allocated for television broadcast services totals 300MHz, ranging from 520MHz to 820MHz.

We have modelled the supply of different DTT service mixes, which are determined by the chosen broadcasting technology, availability of spectrum and market dynamics. A service mix is the channel supply of the platform, which can vary in terms of quality (standard definition or 'SD' vs. high-definition or 'HD'), as well as in the number of channels.

In addition, we have modelled the metro broadcasting and rural broadcasting services separately, each as an autonomous region. The reasoning behind this division is to align with legacy broadcasting licence coverage divisions, and also to address the differences in market dynamics between metro and rural regions.

As a result of this division, we have made different assumptions for each region where applicable. For the base case (or counterfactual) service mix, we have assumed:

- For the metro region, all digital FTA channels that have been launched or will be launched will make up the metro base case service mix. This translates to 10 SD channels and 5 HD channels
- For the rural region, all current analogue channels that are simulcasted in a SD/HD mix before ASO, will be broadcasted in HD thereafter
- If there is any spare capacity in the base case multiplexes, additional multichannels are added in SD, to fill up the multiplexes.

Beyond the base case, we have considered additional UHF spectrum allocated to broadcasting in metro and rural regions and the value generated from the additional channels launched with this spectrum. For each scenario, our model assumes that the UHF spectrum is efficiently used and there is no underutilisation.

For both metro and rural, we have assessed the different DTT services mixes (the 'supply'). This is affected by chosen broadcasting technology (e.g. compression and modulation), market dynamics (e.g. quality: SD vs. HD) and the amount of UHF spectrum available for broadcasting.

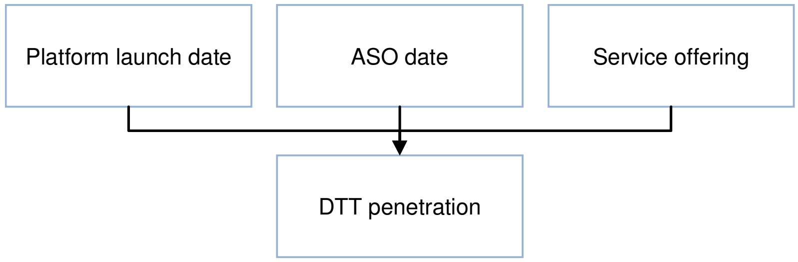
Given the supply of DTT services in metro and rural regions, we have then forecast the future penetration for the DTT platform (the 'demand'), taking into account of market dynamics (e.g. pay vs. free).

Through a cost-benefit analysis, we have identified the economic effects of the various broadcasting service mixes, taking into consideration the costs and benefits, both direct and indirect.

5.1 Broadcast demand

Demand for DTT affects the penetration of the FTA DTT platform over time. The model assumes that DTT penetration will vary depending on the date of platform launch, the date of analogue switch-off, and the service offering in terms of DTT multiplexes launched.

Exhibit 37: Key components of the demand model



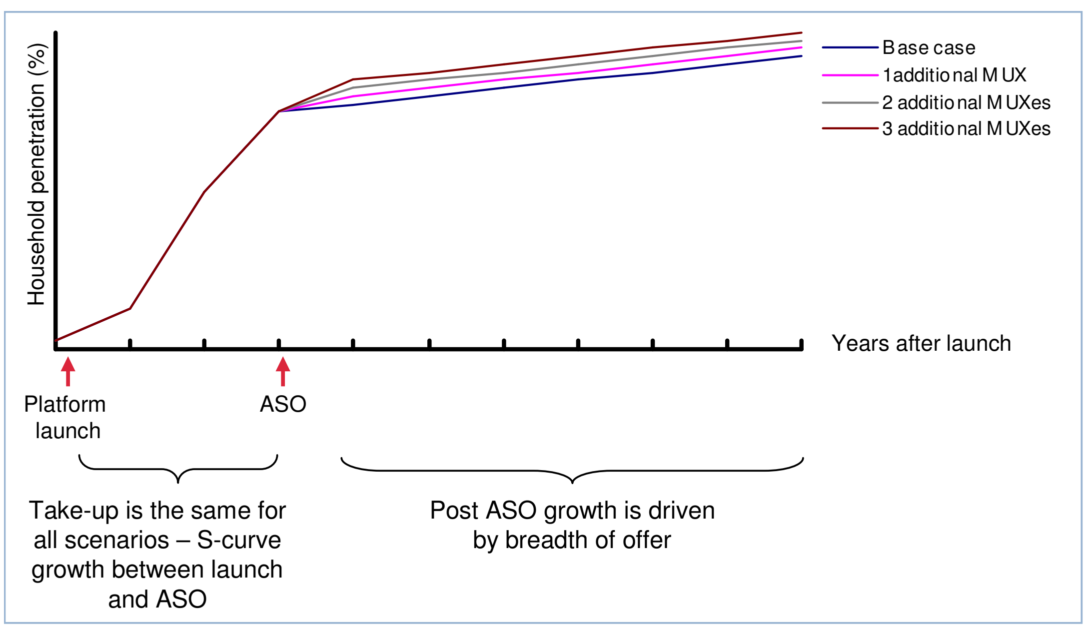
We have modelled the penetration of DTT using actual data to 2007. Beyond 2007, we have assumed a level of primary TV set penetration at analogue switch-off based on third party forecasts, such as those by Screen Digest and Informa Telecoms and Media. We then modelled the growth in penetration through to ASO, using an S-curve. We believe that an S-curve represents a realistic model of adoption.

Take-up until ASO is the same for all scenarios, as the channel offer is identical. The pre-ASO offer is identical for two reasons:

- The way in which analogue and digital services are interleaved prior to ASO makes it difficult to accurately model the standalone capacity of the digital platform
- Incremental spectrum for the high scenarios only becomes available after ASO

Beyond ASO, the scenarios diverge as additional multiplexes (MUXes) and channels are introduced, as shown in the exhibit below.

Exhibit 38: Primary TV set penetration methodology (illustrative)

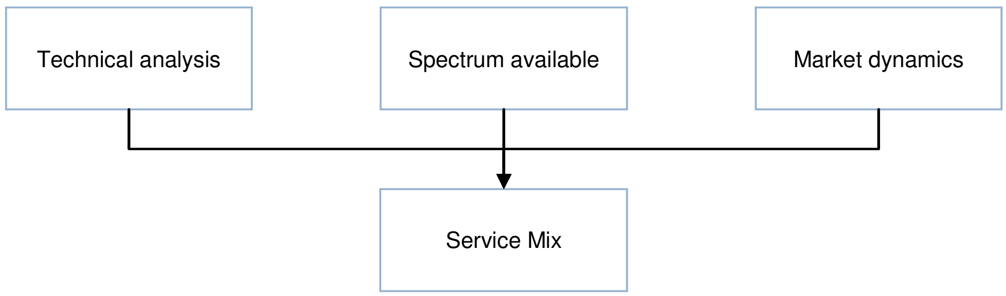


5.2 Broadcast supply

5.2.1 Overview

The DTT service mix, which is provided in the Australian television broadcasting market, is determined based on the technologies deployed to improve spectrum efficiency, the spectrum available and the market dynamics.

Exhibit 39: Factors impacting the modelled DTT service mix



The **technical analysis** models the different technological levers that can affect spectrum efficiency of the platform (e.g. the bitrate of channels and the modulation of multiplexes), taking into account of specific Australia broadcasting conditions (e.g. likely delay of DVB-T2 implementation compared to Europe).

The **spectrum available** for broadcasting is varied in each scenario, beginning with the base case (the spectrum required for the provision of current and already planned digital broadcasting services), with additional 20MHz spectrum added in each scenario until the broadcasting UHF spectrum is exhausted.

The **market dynamics** impact the chosen mix of SD and HD channels on each multiplex and the ratio of pay to free-to-air channels.

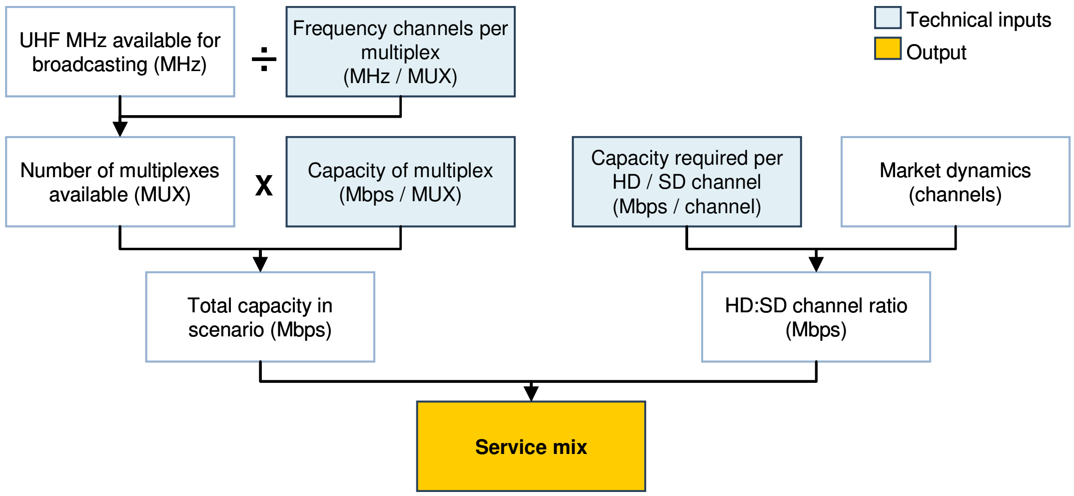
5.2.2 Technical analysis

Since the model projects forward over 20 years, it takes account of the broadcasting technical innovations that are expected during this time frame. Specifically, over time the spectrum efficiency of the DTT platform will improve. Changes in technology will affect:

- The number of frequency channels required per multiplex (e.g. multi-frequency network (MFN) vs. single frequency network (SFN))
- The capacity of a multiplex (e.g. DVB-T vs. DVB-T2), and
- The capacity required per television channel (e.g. MPEG2 vs. MPEG4)

In this section, we discuss the technical inputs in more detail.

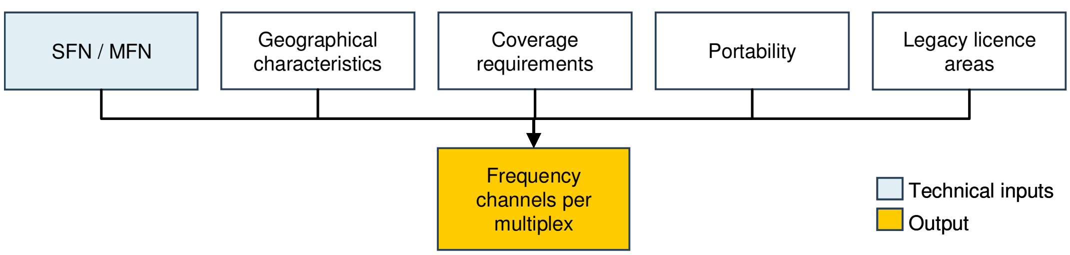
Exhibit 40: Overview of technical analysis



a) Frequency channels per multiplex

The number of frequency channels required per multiplex, will vary depending on technical, geographical and regulatory factors.

Exhibit 41: Factors affecting the number of frequency channels required per multiplex



The decision to keep the current MFN, which is currently deployed in most of Australia, or to move to a SFN, is both a technical and regulatory decision that will impact the number of frequency channels required per multiplex.

As more than one transmitter is needed to provide widespread coverage of DTT, interference between broadcasts from different towers must be avoided. In a MFN, this is done by broadcasting in different frequency channels for adjacent interfering towers, where as in a SFN, the same frequency is used across the country to broadcast each multiplex and is therefore more spectrum efficient than a MFN.

However, SFN would require synchronisation of transmissions across all transmitters, which can be difficult and costly to achieve. In theory, only one frequency channel is required per multiplex with SFN, but in Australia, as relay stations are needed to fill coverage gaps more frequencies will be required. Relay stations use different frequencies to the main transmitters to avoid interference and the actual number required varies, depending on the topography, size and shape of the country, as well as coverage requirements.

The coverage and the level of portability[16] required by the multiplex also affect the number of channel frequencies required per multiplex. However, these are regulatory rather than technological decisions. For example, a high level of coverage may be required to ensure universal access to public service programming, or portability may be required to ensure DTT reception on secondary sets, without external aerials.

Portable reception and increased land coverage require additional channel frequencies per multiplex. Portability requires additional frequencies, as a higher powered signal is required to ensure reception on smaller, indoor aerials. Higher coverage requires greater overlap between adjacent frequencies to ensure areas on the edge of the range of a broadcast tower have adequate reception. Therefore, to ensure there is no interference between adjacent towers, a greater number of different frequencies are required. Also, additional relay towers are required to cover 'black spots' due to topographical reasons. These may also need to be on different frequencies to the adjacent broadcast towers.

Furthermore, unique to Australia, due to legacy broadcasting licence coverage issues, metro and regional licences often overlap, and therefore to prevent interference, additional spectrum is required. This is especially the case in coastal New South Wales and Queensland regions.

b) Capacity of a multiplex

Modulation techniques can be used to translate channel data into the carrier signal that is broadcast. The efficiency of these techniques will affect the capacity of a multiplex. The two most commonly deployed types of modulation globally, are 16QAM and 64QAM. All Australian broadcasters utilise 64QAM, which is one-third more efficient than 16QAM.

In addition, DVB released its framework structure for DVB-T2 in June 2008, an evolution of the current DVB-T standard. The standard has not yet been finalised, but is expected to offer between 30% and 50% improvement in capacity over DVB-T. However, equipment manufacturers have indicated that it may not be available until 2011. DVB-T2 is likely to require the installed base of set top boxes to be upgraded and therefore, the transition may be difficult. In Australia, DVB-T2 is likely to be further delayed, as historically, Australia is later at adopting new technologies when compared to European countries.

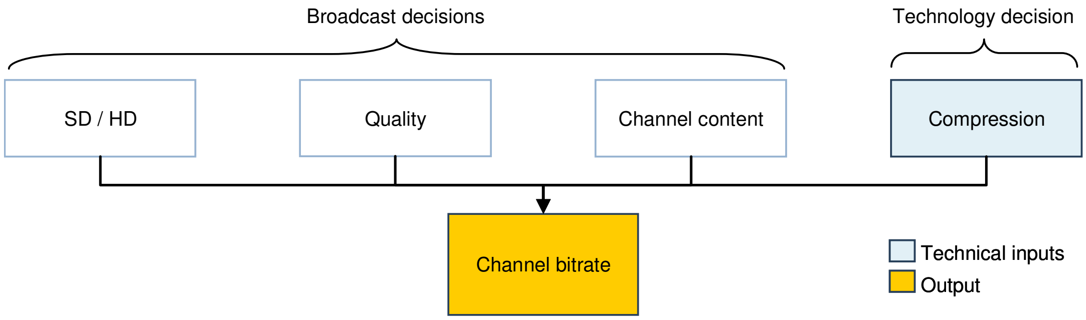
Other technology improvements that impact the capacity of a multiplex include the Forward Error Correction (FEC) coding rate, the guard interval and the number of carriers utilised for Orthogonal Frequency Division Multiplexing (OFDM) modulation. However, we do not expect that these changes will significantly impact the capacity of a multiplex.

c) Capacity required per HD / SD channel

The amount of data that is required to be broadcast per television channel varies, depending on whether the channel is broadcast in standard definition or high definition, the chosen quality of broadcasts, the channel content and the compression technology used.

[16] Portability refers to the type of aerial required to receive a signal. Typically, either a fixed external aerial is required for reception, or a smaller, indoor aerial can be used to pick up the signal

Exhibit 42: Factors affecting channel bitrate



We have modelled service mixes using a combination of SD and HD channels, taking into account the different capacity requirements of these options. High definition channels have a higher bitrate, as a greater amount of data is required to deliver the increased number of pixels in the higher quality picture. Even within SD and HD standards, different bitrates are evident as broadcasters will often vary the quality of the channel.

The channel content also impacts bitrate. Digital technology allows only the pixels that alter from frame-to-frame to be broadcast, reducing the capacity required. Therefore a news channel, in which the shot is often static, can send relatively few pixels after the first frame. However a sports channel, in which each frame alters very significantly, requires a higher bitrate.

Beyond the broadcast factors, the compression technology implemented will also affect the capacity required per channel. Data is compressed before it is broadcast and the efficiency of this compression technique affects the amount of capacity required per channel. The two current compression standards available are MPEG2 and MPEG4. MPEG4 is more efficient than MPEG2 as it reduces the capacity required by approximately 33% compared to MPEG2 broadcasts; this is expected to improve to 50% over time.

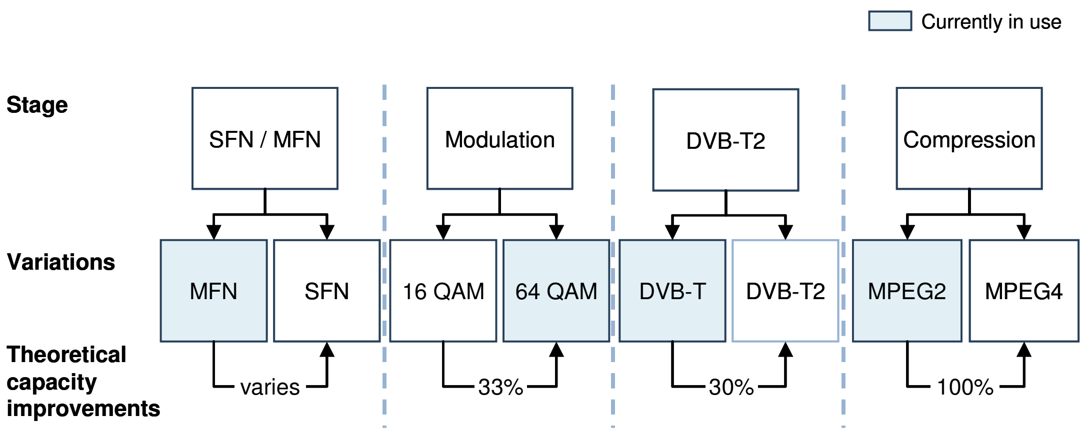
MPEG2 is currently in use in Australia, and to switch to the more efficient MPEG4, will require all installed set top boxes to be upgraded. The transition could be expensive and difficult, requiring a transition period during which a mix of MPEG4 and MPEG2 services are transmitted. In addition, dual MPEG2/MPEG4 boxes would be required to ease migration.

The chosen bitrate for an SD or HD channel also takes into account the average quality of channels currently broadcast and an average bitrate requirement based on a broad range of channel content types.

d) Summary of technical levers

A summary of the modelled technical levers that improve efficiency is given below. The model also includes potential for uplifts in capacity from as yet unforeseen (or less well defined) technologies, such as multiple input multiple output (MIMO) antennas.

Exhibit 43: Technical levers modelled

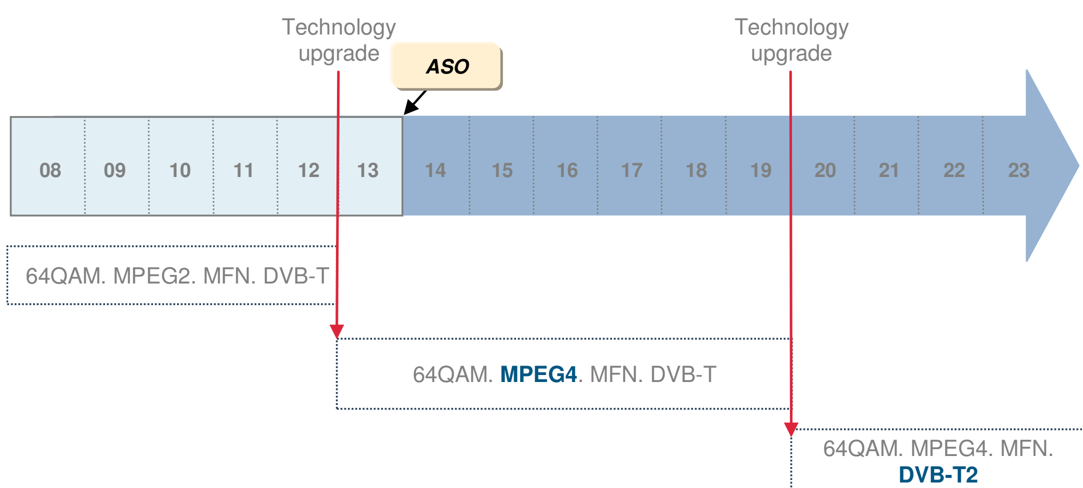


Whilst different technologies may be applied to different multiplexes, we have assumed the same configuration across all multiplexes.

e) Timing of technical implementation

In Australia, the DTT platform was launched in 2001, using 64QAM, MPEG2 and DVB-T technology. We have assumed that Australia will introduce MPEG4 from 2013 to improve spectrum efficiency. However, transitioning to MPEG4 will require a change in the installed base of set top boxes, which can potentially delay the upgrade to MPEG4. We have modelled the potential delay in the switch to MPEG2 to MPEG4 after ASO in our sensitivity analysis with no material difference to our overall result. As such, we assume that the switch from MPEG2 to MPEG4 occurs at ASO. Additionally, we do not believe that Australian broadcasters will be ready to move to DVB-T2 from 2013, as at present the standard is yet to be finalised and equipment manufacturing will be further delayed. In addition, moving to DVB-T2 will also require a change in the installed base of set top boxes, which we think is unlikely to occur in quick succession following a change to MPEG4. Therefore, our model assumes a move to DVB-T2 in 2020.

Exhibit 44: Technical levers timing assumptions



5.2.3 Spectrum available

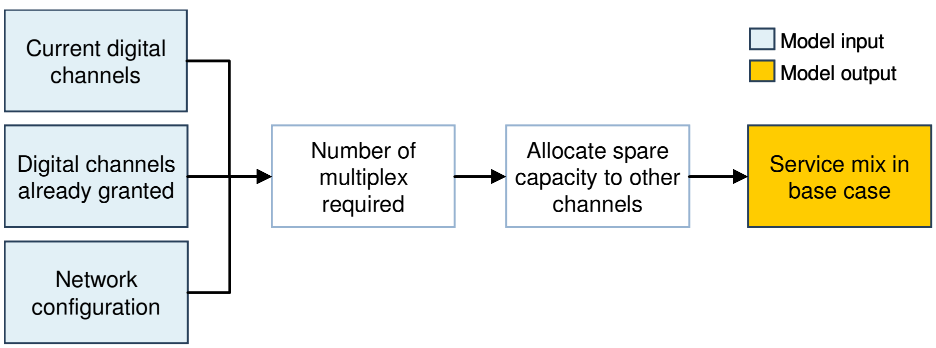
For each different allocation of UHF spectrum broadcasting, we have assumed that prior to ASO all UHF spectrum[17] is used for broadcasting because of the heavy spectrum demands resulting from simulcasting. We have also assumed that 20MHz of VHF is used for digital TV services[18]. Beyond ASO, the spectrum allocation varies depending on amount of spectrum allocated for mobile services.

The base case assumes:

- Enough DTT spectrum to broadcast all digital FTA channels that have been launched or will be launched in the metro region, which translates to 10 SD channels and 5 HD channels
- That all current analogue channels that are simulcasted in a SD/HD mix before ASO, will be broadcasted in HD thereafter
- That if there is any spare capacity in the base case multiplexes, additional multichannels are added in SD, to fill up the multiplexes.

Due to changes to technology, the spectrum required for the base case is expected to decline.

Exhibit 45: Methodology for determining spectrum required for base case after ASO



Beyond the base case, we have modelled 160MHz to 300MHz of spectrum being allocated for broadcasting, at intervals of 20MHz.

5.3 Cost-benefit analysis

The cost-benefit analysis is performed to identify the net economic benefit of assigning spectrum for digital broadcasting, given the supply and demand of services estimated in each scenario previously. This analysis has taken into consideration the direct producer, direct consumer and other indirect producer costs and benefits, as well as made provisions for any externalities.

5.3.1 Direct producer surplus

The direct producer surplus is measured by the difference between the revenue gained from supplying the goods or services, and the costs associated with supplying the goods or services, i.e. the profit. In this

[17] 520MHz to 820MHz

[18] We assume 28MHz (4 channels of 7MHz each) of VHF Band III (174-230MHz) is likely to be used post-ASO for Digital TV. It is possible that DAB might also share a portion of the VHF Band III. However, as this is not confirmed by government policy at this time we cannot assume allocation of the entire 58MHz of VHF Band III for Digital TV use. We take a conservative approach to mobile and hence allocate 20MHz of VHF Band III spectrum to broadcasting in our modelling.

broadcasting analysis, the key producers are the broadcasters, and consumer premise equipment (CPE) vendors. Direct producer benefits include CPE sales and installation revenues for vendors.

a) Calculating direct producer costs

All broadcasters incur costs of the platform such as transmission, and for new channels, other costs such as programming and marketing must also be included. Transmission costs are based on local as well as international benchmarks. As the effects of various technology upgrades have on transmission costs are uncertain, Value Partners has opted to use sensitivities to test the impact.

For programming, marketing and other administrative costs, Value Partners has completed projections based on local and international percentages of revenue and total costs benchmarks.

b) Calculating direct producer benefits

The majority of direct producer benefits are expected to be realised from the sale and installation of digital CPEs. Incremental broadcaster revenue generated from advertisements is not included as a direct benefit, but as an indirect benefit. Advertising revenue is a financial flow, an expense for advertisers, which is expected to translate into increased sales, and thus increased benefits for the economy.

The total sale of CPEs is an output from the market modelling exercise. With assumptions on average selling prices and margins applied by vendors, Value Partners is able to estimate the direct benefits gained. The average selling price and margin assumptions are based on benchmarks from previous Value Partners studies and input from operators

5.3.2 Direct consumer surplus

Direct consumer surplus is the difference between how much consumers value the consumption of the good or service, and the costs incurred in consuming it.

a) Calculating direct consumer costs

For consumers, the costs incurred in consuming digital broadcasting services are the cost of purchasing, and the cost of installing set-top boxes and aerials. Given previously projected set-top box and aerial sales, the cost to consumers is simply calculated using the assumed margins and Goods and Services Tax (GST) of 10%.

b) Calculating direct consumer benefits

The key benefit for consumers is the value they place on the digital broadcasting services, measured by their willingness-to-pay (WTP). Our methodology for measuring WTP – where the most appropriate discount for the value of broadcast services would apply – is based on a review of both local[19,20] and international survey data[21] and studies. Because the local studies are slightly outdated, we have used the available international data, which is higher than the inflation adjusted Australian WTP. We have then constructed a WTP curve based on viewing shares of the channels, which was used to estimate WTP for each additional channel provided by broadcasters. However, we have also defined a scenario that uses the local WTP data.

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[19] Empirical evidence on willingness-to-pay for public broadcasting is in Glenn Withers, David Throsby and Kaye Johnston, Public Expenditure in Australia, EPAC Commission Paper No. 4, Canberra

[20] The National Social Science Survey, carried out in 1999 and made available to Professor Glenn Withers of the ANU in March 2000

[21] UK CBA study, dti/DCMS, 2005; Radicommunications Agency study, 2001

5.3.3 *Indirect producer surplus*

As mentioned previously, advertising revenue is taken as an indirect benefit in our analysis. Incremental broadcaster revenues will be generated from advertisements and by subscribers.

Our working assumption is that the proportion of TV advertising that is viewed on DTT would increase as more households switch over to the platform, which is the result of additional services launched on the platform. Advertising revenues for different scenarios have been calculated by measuring the increase in penetration of DTT and the subsequent increase in the percentage of TV advertising revenues that can be attributed to the DTT platform. TV advertising revenue is assumed to increase at the same pace as Australian GDP[22], which, along with corporate profits and consumer expenditure, is a relatively good proxy for year-on-year changes in TV advertising revenues. We recognise that new advertising platforms such as the internet are rapidly emerging and that they are likely to reduce TV advertising revenue growth in the future. However, in line with our conservative modelling approach, we have assumed that they do not materially impact the growth of TV advertising revenue. For this reason, we have also included a scenario in which TV advertising growth is lower than it has been historically.

5.3.4 *Externalities*

While a significant selection of externalities apply to broadcasting as a whole, it is important to capture only the incremental benefits that apply to the allocations of additional spectrum. For example, the current national channels (and some local channels) are already accounted for in our base case, against which each scenario is measured. Therefore, some social benefits from public service broadcasting do not apply in these scenarios as they remain in our base case. However, it is universally recognised that multichannels do have some public value – particularly in diversity, reach, access and inclusion.

Ofcom, the UK broadcasting regulator, applies a figure of 5% for HDTV and 10% for SD[23]. HD provides very little additional social value above SD, as having the channels is more important than watching them in HD. We have elected to use the full 10% value, given that it would be difficult to split this value between different channels and in order not to underestimate the broadcast case. In addition, we have performed sensitivity analysis in case the local Australian situation differs from this international based assumption, and found externalities had minimal impact on optimal allocation of UHF spectrum.

5.4 Broadcast scenarios

We developed two broadcast scenarios based upon variations in the assumptions that underpin much of the net benefit generated by broadcast services: advertising revenue as a proxy for the producer benefits enjoyed by advertisers and 'willingness-to-pay' as a proxy for the consumer benefits enjoyed by viewers. For the advertising revenue, we have assumed it will be correlated with overall Australia economic growth. For willingness-to-pay, we have benchmarked our assumptions based on both local and overseas surveys conducted.

The exhibit below shows our assumptions for two potential broadcast scenarios: FTA market conservative and FTA market aggressive. In the conservative scenario, advertising growth is expected to decline to 75% of historic levels and consumer's WTP for free-to-air services is estimated at a reduced point compared to our European study. Our FTA market conservative scenario illustrates what we expect to be the more likely

[22] GDP growth forecasts sourced from EIU
[23] Ofcom does not reveal how the multipliers were calculated or from where they are sourced. Ofcom, 2006, *Digital Dividend Review – Annexes*, p.p. 134-5

outcome whereas the FTA market aggressive scenario seeks to model the best outcome for broadcasters in Australia.

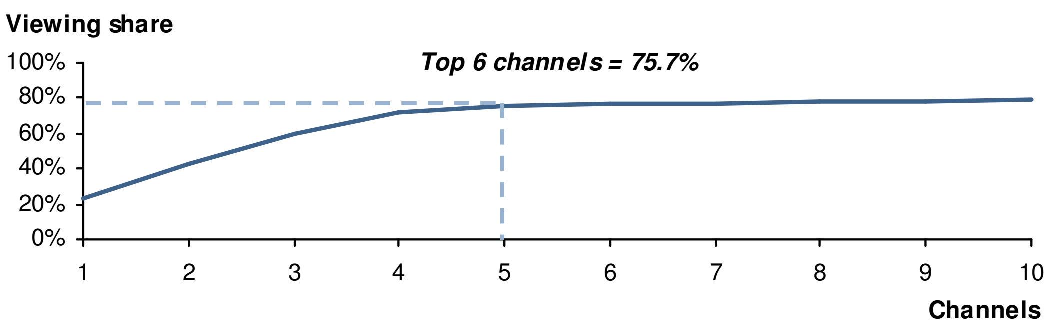
Exhibit 46: Broadcast scenarios

Trend	FTA market conservative	FTA market aggressive
Advertising revenue growth	• Taken to be 75% of Australian GDP growth forecast, which is forecast to be 5%pa. We believe this forecast is aggressive especially give the current economic climate	• Taken to be in-line with Australian GDP growth
Willingness-to-Pay[24]	• Taken to be 47.5% of Value Partners' European analysis[25], on the basis of Australian survey data[26,27]	• Taken to be the same as used in the equivalent Value Partners' European CBA study

5.5 Broadcasting results

The UHF spectrum creates significant value for broadcasting in Australia as the primary method of audiovisual content for a large proportion of Australia. However, most of this value resides with the main channels as consumers value ex-analogue channels most, as reflected in their viewing shares (in Australia the top 5 analogue terrestrial channels account for 76% of viewing, as shown in the exhibit below). Adding additional channels does create some value for consumers (notably through reach rather than simply audience share), although this value is limited.

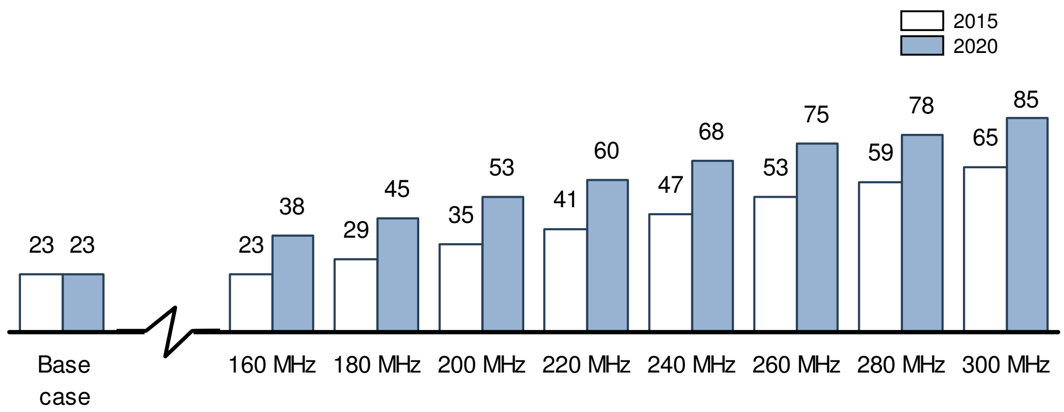
Exhibit 47: Viewing shares in Australia on all TV platforms[28], 2007



The following exhibit shows the results of the number of SD and HD channels that are possible within the allocated UHF spectrum for broadcast in 20MHz increments.

[24] Willingness-to-pay is the theoretical price a consumer is willing to pay for a service or product, which in this case is FTA television
[25] *Getting the most out of the digital dividend*, March 2008, Value Partners
[26] Empirical evidence on willingness-to-pay for public broadcasting is in Glenn Withers, David Throsby and Kaye Johnston, Public Expenditure in Australia, EPAC Commission Paper No. 4, Canberra
[27] The National Social Science Survey, carried out in 1999 and made available to Professor Glenn Withers of the ANU in March 2000
[28] OzTAM

Exhibit 48: Number of SD and HD channels launched with UHF spectrum

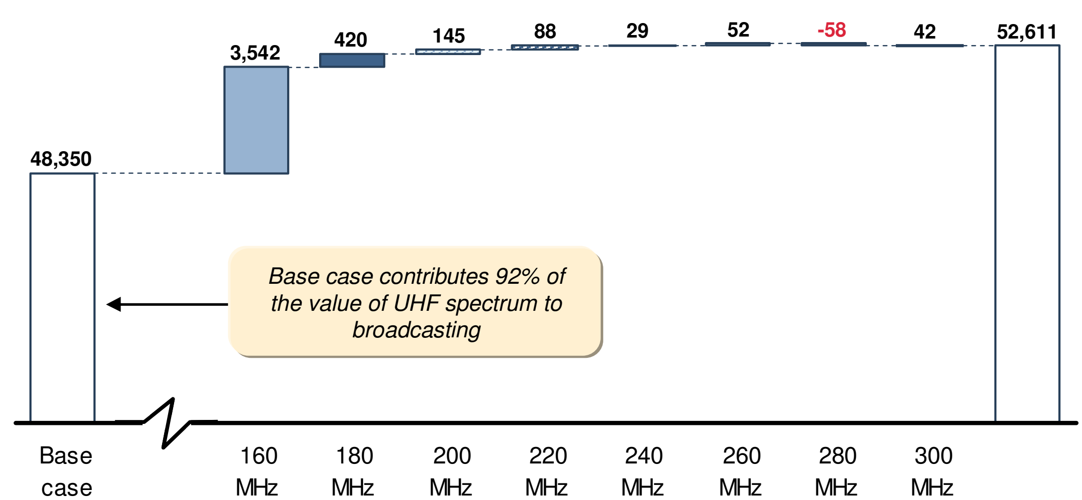


In the FTA market conservative scenario, the value generated for the economy ranges from $48bn in the base case to $53bn if all UHF spectrum is allocated to broadcasting services. Similar to the FTA market aggressive scenario, a significant portion of the total value is generated in the base case.

One particular point of note is that with a spectrum allocation increment from 280MHz to 300MHz, the overall value generated by broadcasting is reduced. This is because as the number of channels increase, the amount consumers are willing to pay for extra channels declines. Once the amount consumers are willing to pay is lower than the costs of the additional channels, the value of the incremental spectrum becomes negative.

The value of additional UHF spectrum allocated for broadcasting under the FTA market conservative scenario is illustrated in the exhibit below.

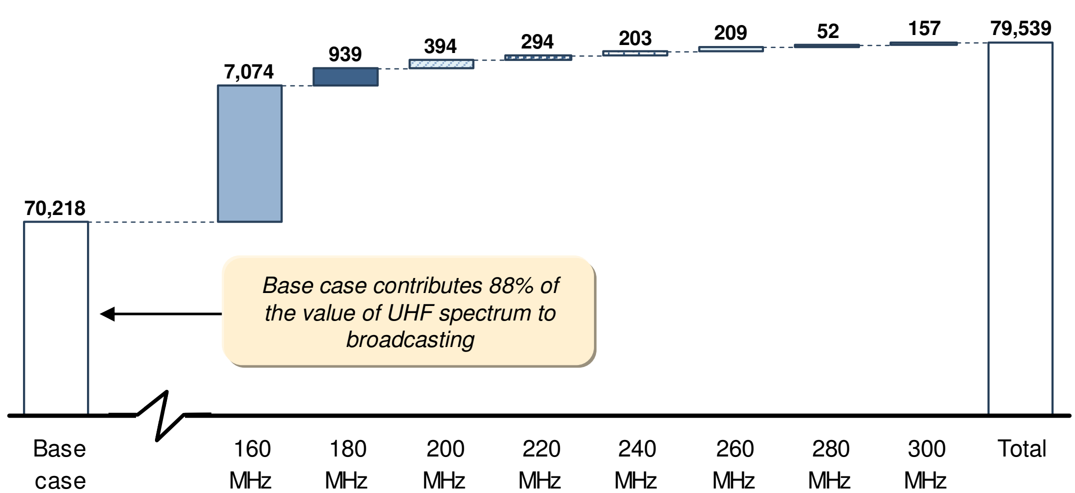
Exhibit 49: Value of UHF to broadcasting in FTA market conservative scenario – national ($m)



For the FTA market aggressive scenario, a net present value (NPV) of $70bn is generated in the base case, rising to $80bn if broadcasting is allocated the entire UHF spectrum. The majority of the total value generated from broadcasting in the UHF spectrum is the result of the few higher rating TV channels. This is shown as the base case generates 88% of the total value of the UHF spectrum.

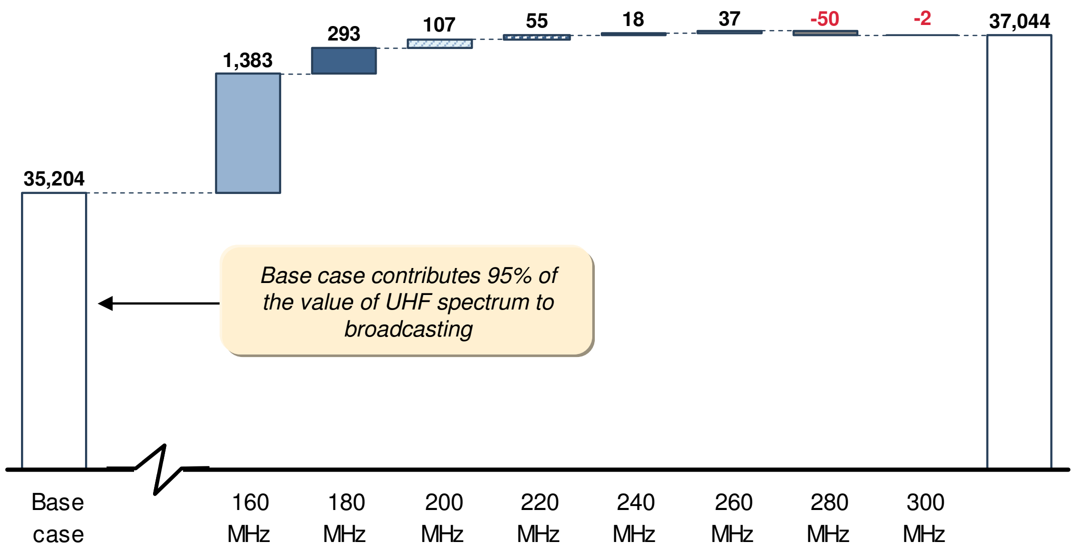
The value of additional UHF spectrum allocated for broadcasting under the FTA market aggressive scenario is illustrated in the exhibit below.

Exhibit 50: Value of UHF to broadcasting in FTA market aggressive scenario – national ($m)



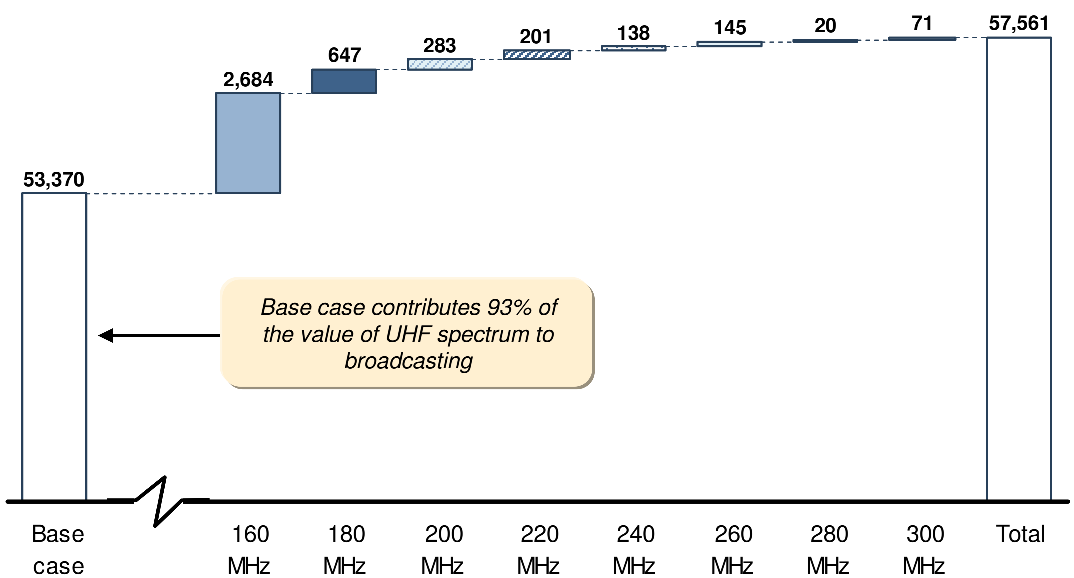
For the metro region, in the FTA market conservative scenario, the value generated ranges from $35bn to $37bn, with the base case representing nearly 95% of the total value of UHF spectrum. Similar to the national case, the increment from 280MHz allocation to 300MHz allocation actually reduced the overall value of the spectrum for broadcasting due to declining consumer willingness-to-pay.

Exhibit 51: Value of UHF to broadcasting in FTA market conservative scenario – metro ($m)



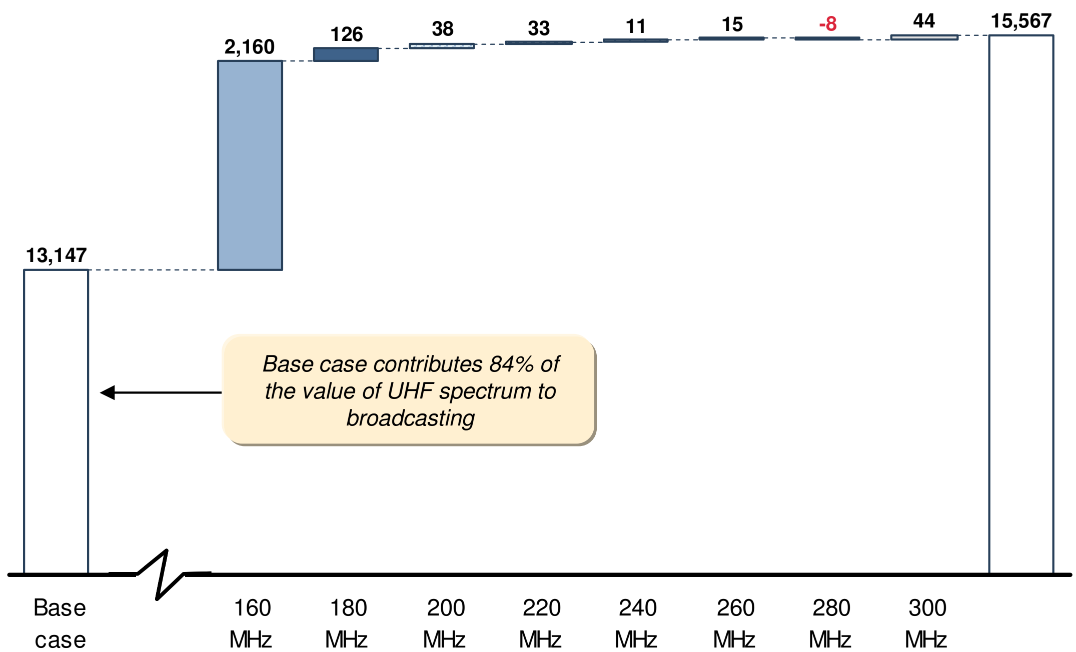
For the metro region, an NPV of $53bn is generated in the FTA market aggressive scenario, rising to $58bn if broadcasting is allocated the entire UHF spectrum, as shown in the exhibit below.

Exhibit 52: Value of UHF to broadcasting in FTA market aggressive scenario – metro ($m)



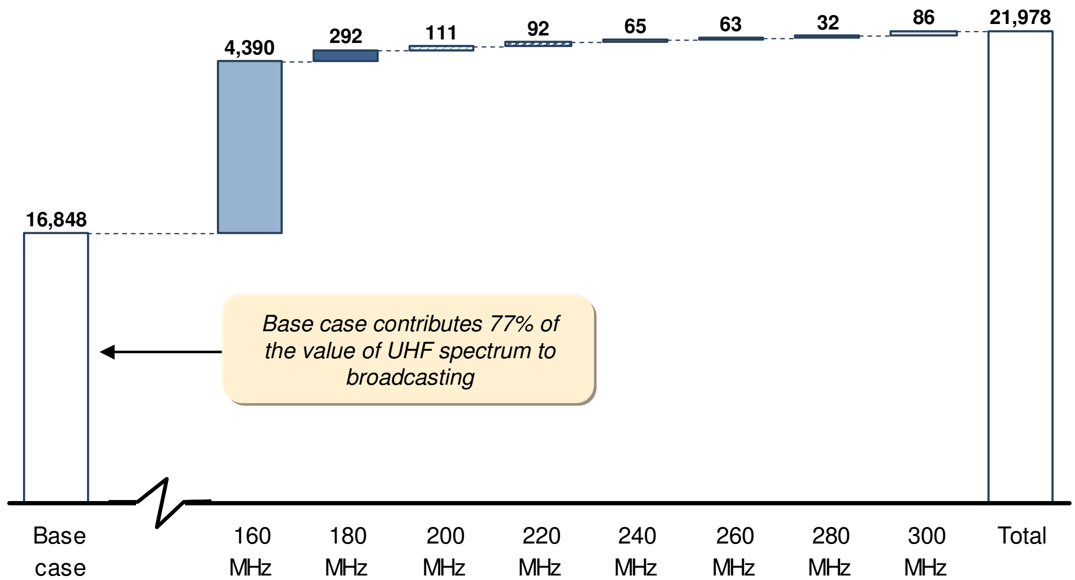
For the rural region, the value of the UHF spectrum is estimated to range from $13bn to $16bn for broadcasting under the FTA market conservative scenario. The base case contributes approximately 84% of the total value of UHF spectrum to broadcasting services, as shown in the following exhibit.

Exhibit 53: Value of UHF spectrum allocated to broadcasting in FTA market conservative – rural ($m)



For the rural region, under the FTA market aggressive scenario, $17bn of value is generated by broadcasting in the base case, rising to $22bn if broadcasting is allocated the entire UHF spectrum in the rural region. Unlike the metro case, the incremental value broadcasting generates in the rural region if 160MHz is allocated is significantly higher. This is because, for rural, we have assumed there are fewer channels in the base case.

Exhibit 54: Value of UHF to broadcasting in FTA market aggressive scenario – rural ($m)



5.6 Key takeaways from broadcasting analysis

The key takeaways for broadcasting are:

- The value generated from broadcasting is significantly higher in the metro region than in the rural region, due to higher population, leading to higher total WTP and advertising revenue
- The majority of value for UHF spectrum is concentrated in the first few channels as they account for the majority of the viewing share and therefore the majority of the value consumers place on FTA TV. The economic benefit generated by additional DTT channels, and hence by allocating incremental UHF spectrum to broadcasting, quickly diminishes

6 Results of the study: The optimal allocation of UHF spectrum

6.1 Mobile and broadcasting results summed

The incremental value of UHF spectrum under different mobile broadband demand scenarios can now be compared against the incremental value of broadcasting being allocated the same spectrum. It is optimal to allocate spectrum to mobile operators if the value from their use exceeds the value from use by broadcasters.

In order to assess the incremental value of spectrum we must define an increment. We have used the mobile increment of 20MHz block as the basis for this part of the analysis. We recognise that 20MHz is not equivalent to one broadcast multiplex, and to ensure mobile and broadcast cases are comparable, we have made provisions for partial multiplex when required.

We have combined the three mobile scenarios and the two broadcast scenarios to create four key overall market scenarios as defined below:

- **Overall market scenario 1:** Mobile ubiquitous / FTA market conservative
- **Overall market scenario 2:** Mobile ubiquitous / FTA market aggressive
- **Overall market scenario 3:** Mobile complementary / FTA market aggressive
- **Overall market scenario 4:** Mobile supplementary / FTA market conservative

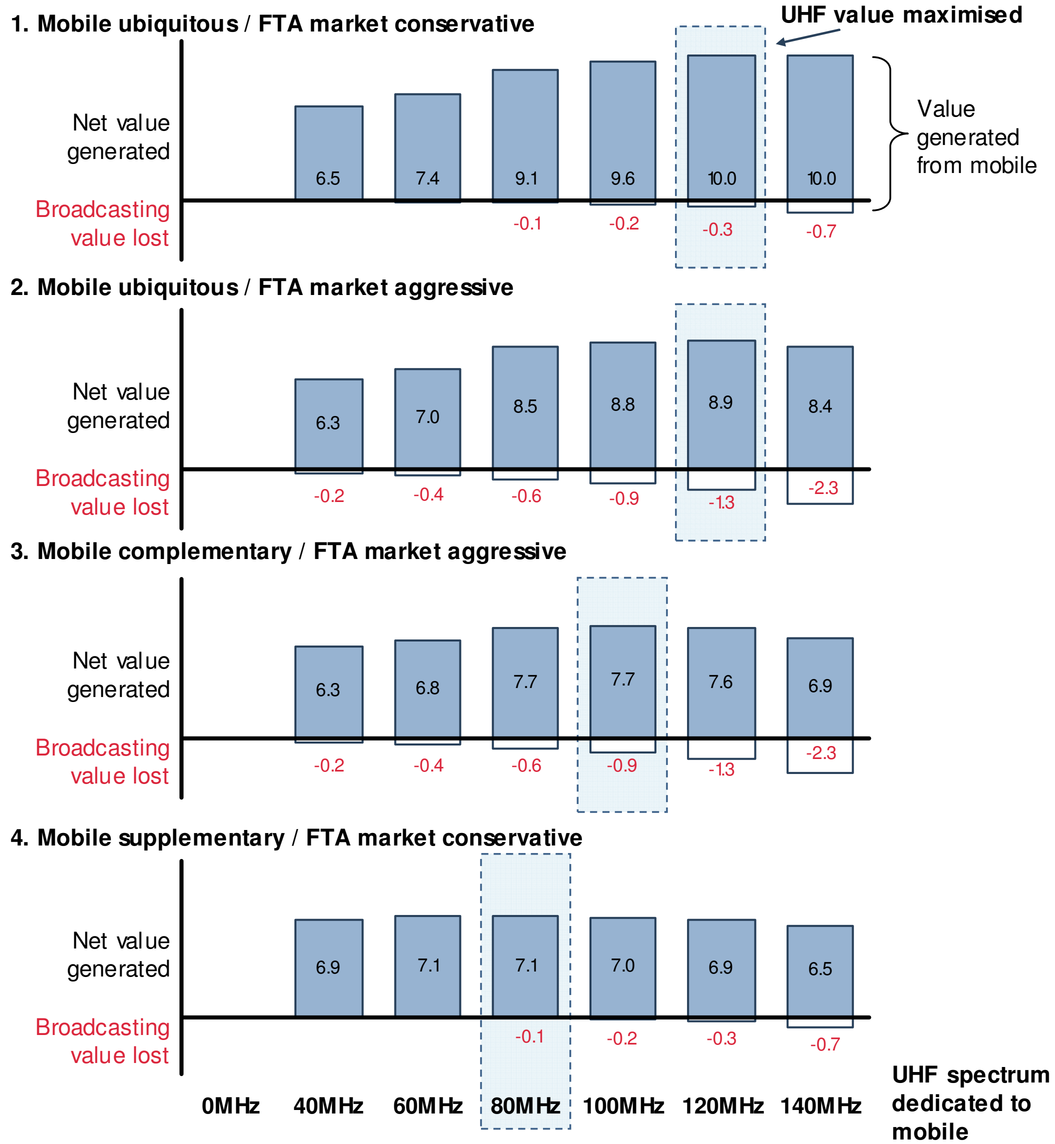
We have modelled these four scenarios using the methodology as described in Sections 3-5. The optimal allocation of UHF spectrum between mobile and broadcast services varies by demand for mobile broadband.

6.2 National

To derive the optimal spectrum allocation under each scenario, we have compared the value generated from spectrum allocated to mobile with the value from spectrum allocated to broadcasting. The following exhibits show the increasing value generated by mobile as more UHF spectrum is allocated to mobile. However, as more spectrum is allocated to mobile, less spectrum is allocated to broadcasting and this results in the value generated by broadcasting declining: this is the value below the x-axis in each case. Therefore, the net value generated under each spectrum allocation is the incremental mobile value less the decline in broadcasting value: this is the value above the x-axis.

The optimal allocation occurs where the net value generated is maximised. For example, in the first national market scenario below (mobile ubiquitous / FTA market conservative), the maximum net value is $10.0bn and is achieved when 120MHz is allocated to mobile. Under both mobile ubiquitous scenarios, the optimal allocation is 120MHz.

Exhibit 55: Net value generated – national ($bn)



The table below summarises the net value generated under each of the overall market scenarios on a national basis. If each of the scenarios is assumed to have an equal chance of occurring (i.e. a 25% probability), then a 120MHz allocation to mobile will yield the greatest risk-weighted net value generated.

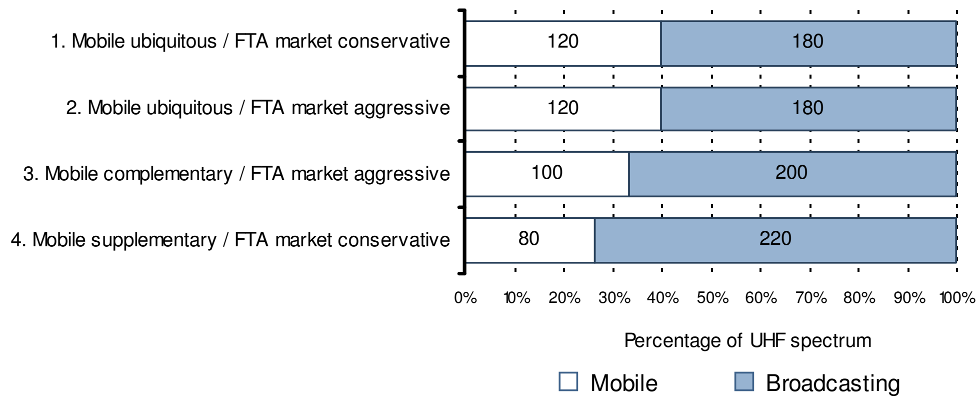
Exhibit 56: Net value added – national ($m)

National	40 MHz	60 MHz	80 MHz	100 MHz	120 MHz	140 MHz
1. Mobile ubiquitous / FTA market conservative	6,473	7,356	9,094	9,563	9,947	9,945
2. Mobile ubiquitous / FTA market aggressive	6,249	6,975	8,539	8,802	8,937	8,416
3. Mobile complementary / FTA market aggressive	6,331	6,749	7,680	7,712	7,620	6,899
4. Mobile supplementary / FTA market conservative	6,879	7,127	7,128	7,040	6,895	6,475

Within the combinations of mobile and broadcast scenario we have considered, if UHF spectrum is optimally allocated between mobile and broadcast, we calculate the net value added for the Australian economy ranges between $7bn and $10bn.

The optimal spectrum allocation for each outcome is summarised in the exhibit below.

Exhibit 57: Percentage allocation to maximise UHF band value - National (MHz[29])

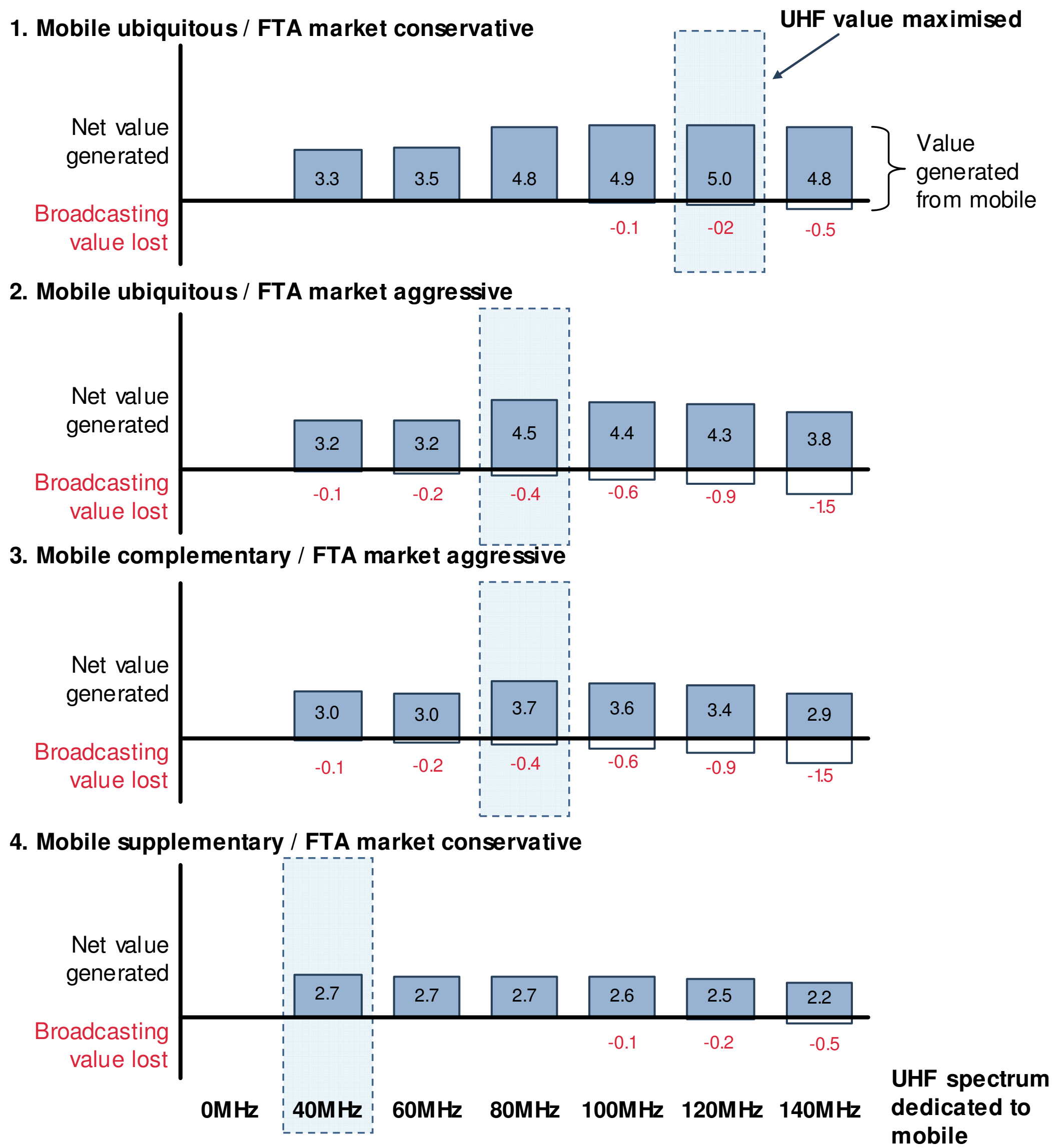


6.3 Metro

The following exhibits show the same calculations for the metro region. The results are similar although the variation is greater. However, in the mobile ubiquitous market scenarios, the forecast optional allocation is 100MHz or 120MHz. In most scenarios, the value generate by broadcasting that is at risk is negligible if 120MHz or less is allocated to mobile.

[29] All spectrum bands are assumed to be paired; i.e. 40MHz implies 2x20MHz paired

Exhibit 58: Net value generated – metro ($bn)



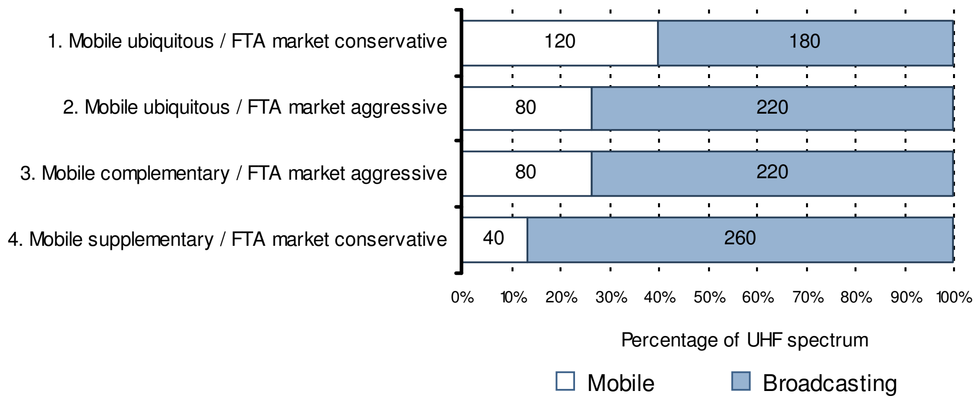
The net value generated for the metro region ranges between $2.7bn and $5.0bn depending on the market scenario.

Exhibit 59: Net value added – metro ($m)

Metro	40 MHz	60 MHz	80 MHz	100 MHz	120 MHz	140 MHz
1. Mobile ubiquitous / FTA market conservative	3,311	3,452	4,823	4,906	4,959	4,816
2. Mobile ubiquitous / FTA market aggressive	3,167	3,200	4,450	4,386	4,263	3,766
3. Mobile complementary / FTA market aggressive	3,024	2,999	3,719	3,607	3,425	2,865
4. Mobile supplementary / FTA market conservative	2,733	2,696	2,678	2,623	2,516	2,223

The optimal UHF spectrum allocation to mobile in the metro region ranges from 40MHz to 120MHz.

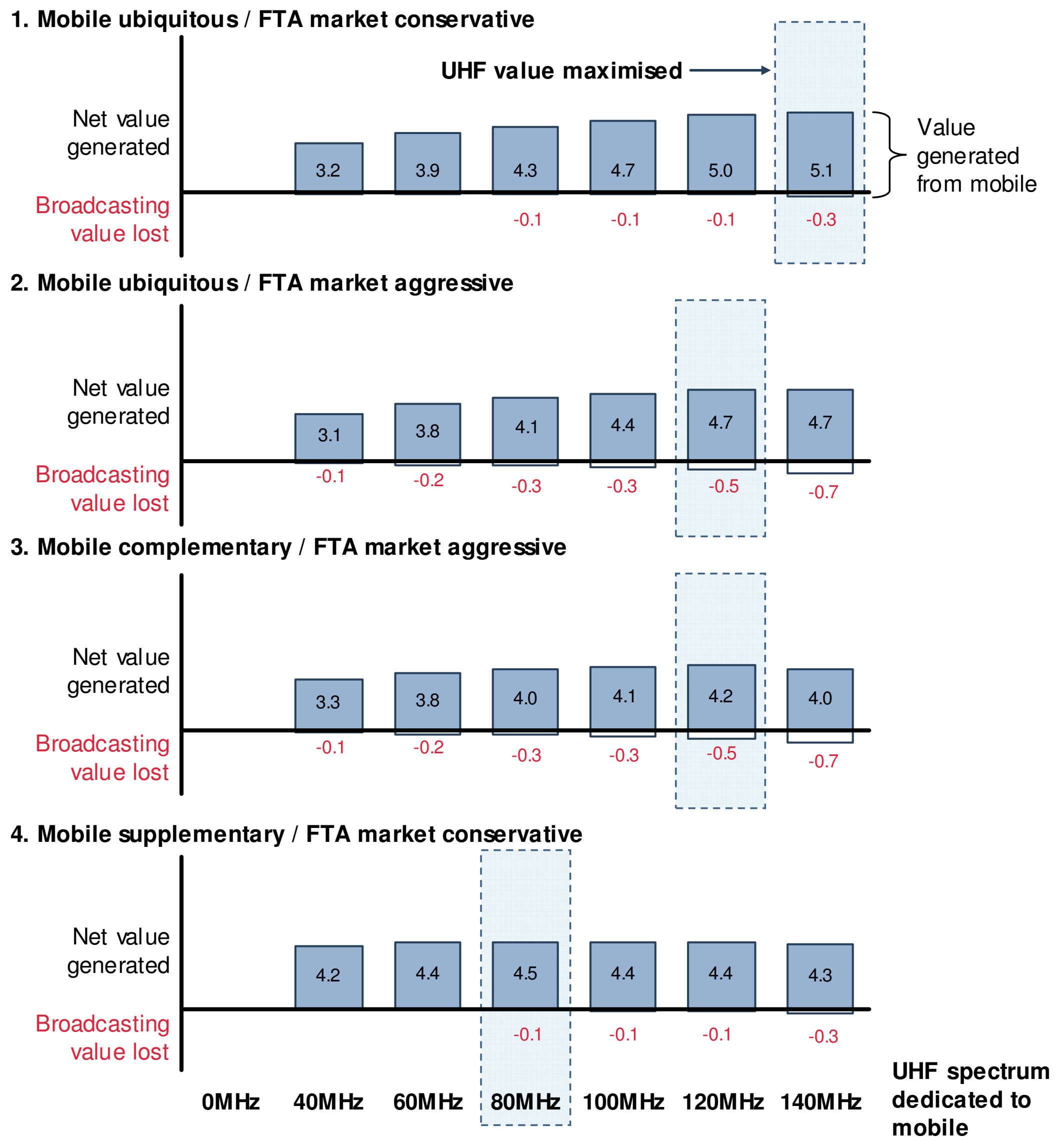
Exhibit 60: Percentage allocation to maximise UHF band value – metro (MHz)



6.4 Rural

In the rural region, the optimal allocation to mobile is greater due to the excellent propagation characteristics of the 700MHz band. In three of the four market scenarios, the optimal allocation is 120MHz or greater, with the optimal allocation in the first market scenario (mobile ubiquitous / FTA market conservative) being 140MHz.

Exhibit 61: Net value generated – rural ($bn)



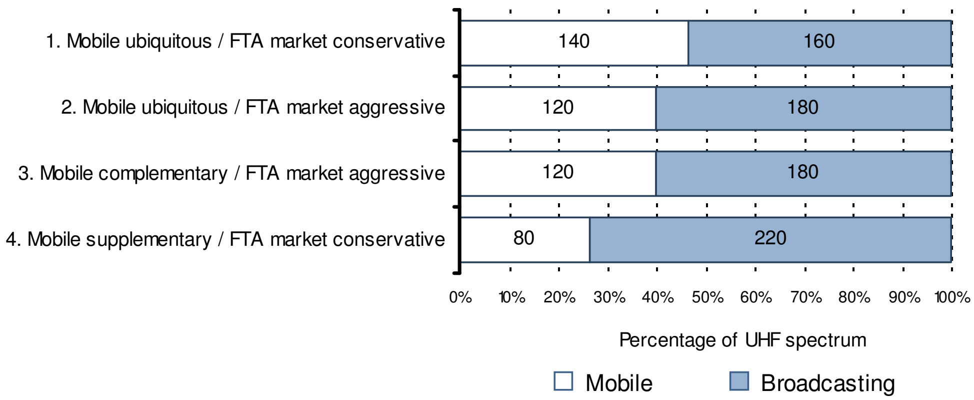
The net value generated for the rural region ranges between $4.2bn and $5.1bn depending on the market scenario.

Exhibit 62: Net value added – rural ($m)

Rural	40 MHz	60 MHz	80 MHz	100 MHz	120 MHz	140 MHz
1. Mobile ubiquitous / FTA market conservative	3,162	3,903	4,271	4,657	4,988	5,129
2. Mobile ubiquitous / FTA market aggressive	3,082	3,775	4,089	4,416	4,674	4,650
3. Mobile complementary / FTA market aggressive	3,307	3,750	3,961	4,106	4,195	4,034
4. Mobile supplementary / FTA market conservative	4,147	4,431	4,450	4,417	4,378	4,252

The optimal UHF spectrum allocation to mobile in the rural region ranges from 80MHz to 140MHz.

Exhibit 63: Percentage allocation to maximise UHF band value – rural (MHz)



6.5 Summary of the results of the study

The results show that significant incremental economic benefits would be generated by allocating a portion of the digital dividend UHF spectrum to mobile services under each of four different overall market scenarios:

- Allocating the optimal mix of UHF spectrum to mobile operators is forecast to generate a net benefit to the economy of between $7bn and $10bn, depending on overall market scenario
- Under overall market scenarios where mobile broadband is ubiquitous (i.e. is a fundamental part of the broadband access mix), the maximum net economic benefit to society will be realised if 120MHz of useable UHF spectrum is allocated to mobile services
- In rural areas, where population density is lower, the propagation characteristics of the 700MHz spectrum are more critical for mobile coverage. As a result, the maximum net economic benefit will be realised with an allocation to mobile of 140MHz of usable spectrum

The modelling approach takes full account of other spectrum bands currently allocated to mobile, and those likely to be allocated to mobile, and is conservative in favour of the broadcasting industry. Value Partners therefore considers that the optimal spectrum allocations forecast by the study could reasonably be taken as a minimum range.

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7 Appendix A: Detailed review of US Digital Dividend allocation process

7.1 Introduction

The US approach to the reallocation of digital dividend spectrum has been under consideration since 1998. The auction of the released spectrum (700MHz band) was finally completed in February 2008. This section provides an overview of the key issues that have arisen as part of this process. First, it will consider the debate regarding the allocation of 700MHz spectrum for mobile use; secondly, it will assess the 'open access' debate and the auction process; and, finally, it will consider the ongoing 'white spaces' debate.

7.2 Allocation of 700MHz spectrum for mobile use

The US Congress legislated in 2006 that US broadcasters are required to clear the 700MHz spectrum band by February 2009, and that the vacated spectrum would be reallocated. Based on the ITU ruling at the WRC-07 conference, the mobile services allocation was unconditionally extended down to 698MHz with immediate effect for all Region 2 countries (including the US). This ruling was in line with the preferences of the FCC – in the US, telecommunications services have historically taken priority as the primary service, while terrestrial FTA TV has been seen as a secondary service due to the proliferation of cable pay TV. The outcome of the allocation was underpinned by ongoing stakeholder lobbying, where telecoms companies were one of the major forces.

Exhibit 64: Key stakeholder positions in the debate

Broadcasters' position (1)	• FTA broadcasters need to launch HDTV, which provides higher picture and sound quality • This will allow them to compete on equal grounds with pay TV - Neil Braun, president of NBC, likens not having HDTV to not having colour TV • Ensuring the success of FTA broadcasters is important: - consumers will be quicker to take up digital sets - promotional power of broadcasting allows the launch of new consumer products and services and thus critical to the economy - FTA success crucial for continued investment in entertainment programming which is one of the US' biggest exports
Telcos' position	• International Table of Frequency Allocations elevates mobile services to primary status in US for 700MHz spectrum band • This recognises the telcos' need for lower frequency spectrum that will allow cheaper services and greater coverage • The FCC should not allow broadcasting services in the 700 MHz spectrum band in accordance with ITU allocations, as it will interfere with mobile services(2)
Public safety position (2)	• Final Report of the Public Safety Wireless Advisory Committee (PSWAC) determined that 24 to 25 MHz of new spectrum would be needed for: - more communications - new capabilities and technologies • More spectrum for public safety would also allow public safety organisations to: - mitigate current spectrum overcrowding - enhance interoperability among public safety agencies - allow the development of cost effective advanced communications systems

Source: Spectrum Value Partners analysis; (1) Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, Neil Braun, EN BANC Hearing, 1995; (2) Report & Order, FCC 97-421: Reallocation of Television Channels 60-69 to Other Services, 1997

Broadcasters' arguments carried significantly less weight than telecom operators due to the low penetration of FTA TV in the US as a high proportion of households receive cable pay TV. This is distinct from the Australian market where FTA channels are strong relative to mobile operators. This position is protected through the ‘Anti-Siphoning List’, which gives Australian FTA channels first pick of over 1000 programmes to prevent pay TV channels acquiring all prime time content.

In the US, in line with the Congress’ decision, the FCC allocated 24MHz to public safety uses and attempted to design the allocation process for remaining spectrum as technologically neutral as possible, but even with high power restrictions, it effectively ruled out use for broadcasting purposes. The regulatory decisions taken are set out below.

Exhibit 65: FCC regulation regarding the allocation of the digital dividend

	FCC Decision	Rationale
‘Public safety’ spectrum	• 24 MHz of spectrum ‘ring fenced’ for public safety uses	• Currently, spectrum allocation is insufficient to meet the needs of many public safety organisations • Spectrum required to facilitate interoperability and new types of communications capabilities, to strength and enhance public safety
Spectrum allocated for other usage	• 84 MHz of spectrum will be allocated for fixed, mobile or broadcasting services • Actions taken to ensure limited interference with the primary use: - 6 MHz of the 84 MHz will be guard bands - upper 700 MHz band will have a power limit of 1 kW - lower 700 MHz band will have a power limit of 50 kW	• Provide the broadest allocation possible without creating any threat of interference issues with the primary services (telco) - consistency with Region 2 allocations, which identifies mobile services as the primary use of 700MHz band • Market-based approach (highest bidder); however, technical specifications which are aimed at protecting the primary service, in effect, ruled out any sustainable terrestrial TV service

Allocation methodology mandated by Budget Act (1997): allocation made through competitive bidding process

7.3 700MHz auction process

The 700MHz auction took place in three stages: the guard band auction, the auction of lower 700MHz spectrum, and auction of upper 700MHz spectrum. This final stage was completed in February 2008. The auction occurred 18 months after the Advanced Wireless Services (AWS) auction of 90MHz of paired spectrum in the 1.7 and 2.1 GHz bands.

The FCC also announced innovative auction rules. For the first time, bidders were able to place package bids (for block C) and submit their bids anonymously. The FCC also released reserve pricing figures for the spectrum blocks for the first time.

Exhibit 66: 700MHz band reserve prices

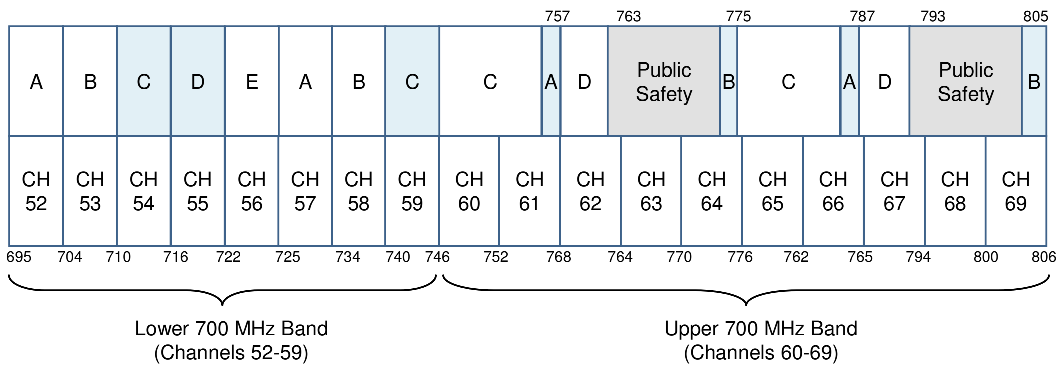
700MHz Block	Estimated Market Value (Based on AWS-1 bids)	Commission Guidance on D Block Reserve Price	Proposed 700MHz band reserve prices
A	US$1,789,485,600	_	US$1,807,380,000
B	US$1,360,817,520	_	US$1,374,426,000
C	US$4,591,934,600	_	US$4,637,854,000
D	US$1,749,031,000	US$1,330,000,000	US$1,330,000,000
E	US$894,742,800	–	US$903,690,000
Total	US$10,386,011,520	_	US$10,053,350,000

Source: FCC

7.3.1 *700MHz band plan*

The FCC's 700MHz band plan was finalised in July 2007. The map of the available spectrum for auction in the January 2008 round is set out below. This shows the spectrum already auctioned, the intended structure of the spectrum divisions within the band, and the spectrum reserved for a national public safety network.

Exhibit 67: FCC's 700MHz band plan



Block	Frequencies	Bandwidth	Pairing	Area Type	Licenses
A	698-704, 728-734	12 MHz	2 x 6 MHz	EA	176
B	704-710, 734-740	12 MHz	2 x 6 MHz	CMA	734
C	710-716, 740-746	12 MHz	2 x 6 MHz	CMA	734*
D	716-722	6 MHz	unpaired	EAG	6*
E	722-728	6 MHz	unpaired	EA	176
C	746-757, 776-787	22 MHz	2 x 11 MHz	REAG	12
D	758-763, 788-793	10 MHz	2 x 5 MHz	Nationwide	1*
A	757-758, 787-788	2 MHz	2 x 1 MHz	MEA	52***
B	775-776,805-806	2 MHz	2 x 1 MHz	MEA	52***

* Blocks have been auctioned.
** Block is associate with the 700 MHz Public/Private Partnership.
*** Guard Bands blocks have been auctioned, but are being relocated.

Source: FCC

The 700MHz band was split into five blocks based on a geographic licensing scheme that enables spectrum access to a range of national and regional players. These parameters are outlined below.

a) Economic Areas (EAs): A and E blocks

There are 176 Economic Areas in which the FCC will offer 2x6MHz and 1x6MHz unpaired licences. These offer opportunities for regional and smaller players to secure spectrum in their local markets.

b) Cellular Market Areas (CMAs): B block

The US has been split into 734 CMAs contained within the B block (frequencies 704MHz – 710MHz, and 734MHz – 740MHz). These areas, slightly smaller than EAs, were intended to allow bidders to choose specific geographic areas to offer a localised service. However, as indeed occurred, there is nothing to prevent large companies from bidding in order to gain national coverage by rolling up CMA licenses. These local licences will come with the build-out requirements FCC put on both EAs and CMAs licences. Wireless operators are required to cover at least 35 percent of the territory within their licence area covered by their license in four years, and 70 percent of the licence area within 10 years.

c) Regional Economic Area Groupings (REAGs): C block

The FCC has created 12 REAGs that provide national coverage across the US. Bidders were able to bid for all 12 licenses simultaneously so it was easier to gain national coverage. C block includes a paired 11MHz band, making 22MHz of spectrum available for national commercial use. It was the most highly sought after spectrum block and as such incited a high degree of controversy (see later). The FCC has also imposed rollout requirements on 22MHz C block: operators are required to achieve 40 percent coverage within four years and 75 percent coverage within 10 years. The FCC will automatically reclaim "unserved portions of the licence area" from companies that do not meet the build-out requirements.

d) Nationwide public / private partnership: D block

The D block offers two 5MHz sections for a total of 10MHz, and it is available nationwide. The bidder for this section must purchase it as part of the Public Safety/Private Partnership established by the FCC. This means that the licence holder is required to build out a nationwide wireless network can meet public safety specifications for coverage and redundancy. The licensee will receive the two (grey) public safety portions of the spectrum and will have the (white) 10MHz band to operate as a commercial network. Commercial traffic can also be carried over the public safety portion of the network so long as it is not being utilised.

7.4 Open access debate

The most controversial aspect of the 700MHz auction process was the FCC's inclusion of open access conditions on the flagship C block spectrum. This was a result of the high profile lobbying campaign led by Google and its partners in the Coalition for 4G in America.

Google ran a high profile campaign arguing that American interests would be best served if the following four conditions of open access were mandated by the FCC:

- Open applications: Consumers should be able to download and utilize any software applications, content, or services they desire;
- Open devices: Consumers should be able to utilize a handheld communications device with whichever wireless network they prefer;

- Open services: Third parties (resellers) should be able to acquire wireless services from a 700MHz licensee on a wholesale basis, based on reasonably non-discriminatory commercial terms; and,
- Open networks: Third parties (like internet service providers) should be able to interconnect at any technically feasible point in a 700MHz licensee's wireless network.

The FCC bowed to the pressure of this high profile lobby group and adopted the first two conditions applied to C block only. The FCC's exact wording is below:

'we will require… C block licensees to allow customers, device manufacturers, third party application developers, and others to use or develop the devices and applications of their choosing in C block networks, so long as they meet all applicable regulatory requirements and comply with the reasonable conditions related to management of the wireless network (i.e. do not cause harm to the network). Specifically, a C block licensee may not block, degrade or interfere with the ability of end users to download and utilise applications of their choosing on the licensee's C Block network, subject to reasonable network management… We intend to vigorously enforce the requirement adopted in this section'

Verizon Wireless responded to this decision in September 2007, initiating legal action against the FCC. They sought to have the rules dismissed on the grounds that the open access requirements exceeded the FCC's authority under the Communications Act of 1934, as amended, violated the US Constitution and the Administrative Procedure Act, and were 'arbitrary, capricious, unsupported by substantial evidence and otherwise contrary to law'.

Verizon Wireless filed to withdraw its suit against the FCC in October 2007 following the denial of its emergency motion for expedited treatment of its open access appeal. However, the cellphone association, CTIA, stepped into the void immediately by challenging the same open access ruling in a suite filed at the District Court of Appeals, District of Columbia circuit. This action also failed and the open access regulation stands for C block spectrum.

It should be noted that these open access regulations only apply to spectrum in the C block (frequencies 710MHz – 716MHz, 740MHz – 746MHz). Additionally, Skype filed a petition in February 2007 requesting the FCC apply the open access regulations across the wireless industry. FCC Chairman Kevin Martin has circulated an order to dismiss the petition, which he said was unnecessary because of the wireless industry's voluntary actions to promote "open access". The FCC was due to vote on this decision in June 2008, but the consideration was postponed and has yet to return to the agenda.

7.5 Auction results

Telecoms operators won the entire available commercial spectrum in the 700MHz auction, which generated approximately US$20bn in revenues for the Government. This exceeded the reserve prices for the spectrum by approximately US$5bn.

Exhibit 68: Auction results

700MHz Block	Bid winner	Winning bid amount	Reserve price	Comments
A and B	AT&T / Verizon	AT&T: US$6.6bn Verizon: US$4.6bn	US$2.2bn	• Fierce battle between AT&T and Verizon to secure the spectrum
C	Verizon	US$4.7bn	US$4.6bn	• Google bid to ensure that bidding reached the reserve price so that the open access regulations would remain in place
D	Incomplete	-	US$1.3bn	• QCOM bid $0.5bn; this did not meet the minimum bid requirement • FCC likely to re-evaluate the rules and re-auction at later stage • Unpopularity largely due to public-private partnership obligations for this block
E	QCOM / Echostar	QCOM: US$0.6bn Echostar: US$0.7bn	US$0.9bn	• QCOM bought the spectrum in NYC, Philly, Boston, SF, LA to add to their MediaFlo capacity • Echostar bought the rest of the US

Source: FCC

There are two main points of interest from these results: first, the dominance of the telecom companies; and secondly, Google's strategy for block C spectrum. Firstly, the telcos' success is not surprising given the elevated position of telecoms companies within the US market. This position was supported by the conditions for the auction which were tailored towards telecom services. The 'highest bidder' auction favours telecom players, as their business model allows them to generate higher returns from spectrum than broadcasting model, leaving more funds to bid for spectrum. The technical specifications made the business model for any TV services in this spectrum even more unsustainable, as broadcasting within the given restrictions would only cover very small areas.

The other point of note is the strategy deployed by Google to protect the open access conditions mandated by the FCC. In the event that the reserve price was not met, the FCC could have re-auctioned the spectrum without the conditions in place. Google bid $4.6bn (the reserve price) but lost to Verizon. However, industry reports suggest that Google remained uncommitted to securing the spectrum and rolling out a full wireless network; rather, that this was a tactic to achieve the open access conditions. Google remains concerned about Verizon's plans to abide by the Open Access regulation. They have submitted a letter to the FCC requesting that Verizon's winning bid for the C block spectrum be revoked if Verizon do not dismiss statements suggesting that it will apply different network rules to customers with open access devices.

7.6 White space debate

Significant debate surrounds the use of unlicensed "white space" spectrum. This section defines "white space", sets out the stakeholder positions in the debate and the current regulatory status in the US.

7.6.1 Definition of white space

"White space" is the interleaved, unused spectrum that exists between broadcast TV channels from 512MHz to 698MHz. This white space occurs because, in a multiple frequency network, any TV channel is carried on a number of different frequency channels around the country. On a given frequency there is a geographic band where high power broadcasting is not possible due to interference, but low power applications are.

Proponents of white space usage propose to use the white space in two ways:

- Ad hoc networking – white space enabled devices would be able to communicate with each other on a low power, small geographic network. This would enable a wireless world where devices could seamlessly communicate
- WiFi usage – device manufacturers will develop white space enabled devices that can be connected to white space WiFi networks. It is unclear at this stage who would build and operate these networks as it is unlikely that any of the incumbent telecoms operators would be tempted to do this due to the cannibalising effect that it could have on their existing mobile broadband services

7.6.2 Arguments against white space usage

Broadcasters are not in favour of permitting unlicensed white space usage. The central pillar of their argument is that unlicensed use of white space spectrum will cause detrimental interference to digital TV broadcasting, wireless microphones and other users that broadcast on adjacent channels. Their argument gained strength following prototype device testing that was unable to effectively use white space spectrum without causing interference with other channels. They also argue that, even if the white space usage could guarantee no interference, the investment in enabling it to be used was not warranted. Unlicensed spectrum usage could spur innovation for low power, short range systems but the white space was overqualified for such applications. In a study submitted to the FCC, underwritten by QualComm, the Brattle Group said *'devoting TV spectrum to low power, short range systems is like using land in downtown Tokyo to grow rice*[30].

7.6.3 Arguments in favour of white space usage

The lobby group in the US is spearheaded by two organisations: the White Space Coalition (Google, Intel, HP, Microsoft and Dell) and the Wireless Innovation Alliance. These have lobbied the FCC to authorise the use of unlicensed white space spectrum. The crux of their argument is that a large amount of viable spectrum is unused or grossly underutilised, and that this spectrum is too valuable to lie fallow. They have committed significant resource to developing rebuttal to the concerns raised by the opposed broadcasters.

The main rebuttal offered is that white space devices will utilise two technologies to ensure that there is no disruption of adjacent channels: spectrum sensing and geolocation. Both of these technologies are designed to prevent signals interfering with each other. Further to this, research has shown that a properly designed white space device "transmission mast" can operate at low power on the channel immediately adjacent to an occupied channel, just as two high powered DTV stations operate today without interference on immediately adjacent channels.

There is a second group of white space advocates that support licensing the white space spectrum. This lobby group argue that white space spectrum could create significant value for the Government, and so it ought to be licensed. The White Spaces Coalition argue that white space spectrum is ill suited for licensed services because it would need to operate at a low power on a secondary basis to DTV and wireless microphone licences. Lack of geographic scope and low power levels would dramatically lower the profitability of each channel.

7.6.4 Current regulatory status

In November 2008, the FCC unanimously approved the development of wireless devices that use white space spectrum. Manufactures can begin to design and certify their devices in the next few months, but they cannot

[30] Press articles: Dow Jones Newswires, Associated Press, EDN

go on sale until February 18, 2009. In order to prevent interference, the FCC will require that white space devices must:

"...include a geolocation capability and provisions to access over the Internet a data base of the incumbent services, such as full power and low power TV stations and cable system headends, in addition to spectrum-sensing technology. The data base will tell the white space device what spectrum may be used at that location"[31]

Locations that use wireless microphones will be listed in the database, and white space devices will be required to "listen" for wireless microphones as further protection against interference.

[31] Press reports: ARS Technica et al

8 Appendix B: Broadcast technology migration study

8.1 Introduction

Broadcast technology migration studies have one central aim: to increase multiplex (MUX) capacity to alleviate spectrum capacity constraints. This study will consider two mechanisms, which are currently being discussed to achieve this goal[32]:

- Improving the channel bit rate: migrating from MPEG2 to MPEG4
- Improving MUX capacity: implementing DVB-T2 (a new transmission standard), and migration to MIMO

8.2 Improving the channel bit rate: migrating from MPEG2 to MPEG4

The amount of data that is required to broadcast each television channel depends on: the channel content; the standard which the channel is produced and broadcast in (SD or HD); the chosen quality of broadcasts (given the broadcast standard); and the compression technology used. By reducing the channel bit rate, the capacity required for each channel is reduced as well freeing up additional spectrum.

a) Upgrading from MPEG2 to MPEG4

i) Description and gain

The two current compression standards used are MPEG2 and MPEG4. MPEG4 is more efficient than MPEG2, but the actual improvement is a matter of some discussion. Both technologies continue to improve so that a channel can be compressed into a lower bit-rate stream without any loss of quality. At launch in 2002, MUX D, in the UK, only carried four 24x7 DTV channels, but due to improvements in MPEG2 since then, MUX D now carries six 24x7 DTV channels without any change in the standards used or the modulation. This 50% increase in capacity was achieved without any degradation of quality. Today, using the same generation of equipment, MPEG4 offers 30% improvement over MPEG2, but this is expected to improve over time (to perhaps 50%). The exhibit below shows forecast bit rate reductions for HD broadcasting with a migration to MPEG4 compression technology.

[32] Note on sources: throughout this study, information and analysis is sourced from DVB.org and regulator interviews previously conducted by Value Partners

Exhibit 69: Examples of HD bit rates

Country	Status	Year	Compression	Video/All*	MBit/s
Japan	Active	2007	MPEG2	All	14
USA	Active	2007	MPEG2	All	19
BBC Trial	Trial	2007-8	MPEG4	All	19.5/14.3
BBC HD	Advocated	2009	MPEG4	All	15, then 12**
Ofcom	Advocated	2009	MPEG4	All	8
France	Advocated	2008	MPEG4	All	12, then 8
Germany	Trial	2007-8	MPEG4	All	6-10
Norway	Advocated	2009	MPEG4	All	12-15

* Bit-rate includes video, audio and SI; service standard (720p, 1080p, 1080i) unknown
** BBC Executive expect s the service to launch at 15MBit/s and then to reduce with technical efficiencies
Source: Sagentia, 23 August, 2007

A number of global markets have begun to deploy MPEG4 compression standards, but adoption has yet to become widespread.

In Europe, France has been one of the earliest and most aggressive adopters of MPEG4 compression standards. In June 2005, MPEG4 was made compulsory for all HDTV services on any terrestrial channel both pay and public in addition to it being compulsory for Pay TV operators. Public service operators can continue to use MPEG-2 for standard definition digital terrestrial services. Recently, pressure from the CSA (French regulator) has declined, with the mandate for manufacturers to include an MPEG4 AVC HD tuner in all HD displays delayed from December 2008 to December 2009.

In Australia, there has yet to be any migration to MPEG4, with broadcasters continuing to broadcast in MPEG2. By contrast, in New Zealand, three MUXes are in operation delivering a mixture of SD and HD FTA services all coded in MPEG4.

Exhibit 70: MPEG4 DTT deployments globally (selected countries)

	Country	Launch date	Description
Deployed	• Hungary	• Q4, 2008	• Antenna Hungaria selected to operate 5 MUXes (3 running currently; remaining available post ASP). All DVB-T services broadcast using MPEG4 compression technology
	• Ireland	• Q3, 2008	• DTT national rollout began in August 2008 using MPEG4, H.264 Audio Visual Coding
	• Sweden	• Q2, 2008	• DTT operator, Boxer, began six year project to migrate from MPEG2 visual coding to MPEG4. From April 1, Boxer no longer approved MPEG2 receivers; all new STBs are required to be backwards compatible
	• Norway	• Q3, 2007 • Q3, 2008	• DTT service launched by Riks TV using MPEG4 compression. • PSB NRK launched HD services in time for the Olympics using MPEG4 compression
	• Brazil	• Q4,2007	• Initial launch of DTT services by Rede Globo in Sao Paulo, other regions followed
	• New Zealand	• Q2, 2008	• Three multiplexes, TVNZ, TVWorks and Kordia are in operation delivering a mixture of SD and HD free-to-air services, all coded in MPEG4
Planned	• UK	• Q4,2009	• Multiplex B cleared and upgraded to DVB-T2 and MPEG4 to allow BBC HD and two other HD services to be broadcast
	• France	• Q1, 2010 • Q4, 2009	• DTT services to be launched in French Overseas Territories. 10 initial channels will use MPEG4, HD channels planned for later in 2010 • All HD DTT services will be broadcast as MPEG4; manufacturers required to include an MPEG4 AVC HD tuner in all HD displays by Dec 2009

ii) *Impact*

For countries that have already launched MPEG2, upgrading all existing multiplexes to the more efficient MPEG4 will require the installed base of set-top boxes to be replaced with MPEG4 compatible STBs.

A feasible alternative, currently under consideration in the UK and France, is to phase the transition to MPEG4 on a multiplex by multiplex basis by reorganising channels between multiplexes and converting an existing multiplex to MPEG4. This process could also take place through the addition of new MPEG4 multiplexes to sit alongside existing MPEG2 ones. Overall, MPEG4 and MPEG2 multiplexes could coincide and, therefore, minimise consumer impact.

The timing of the phasing-out of older-generation receivers is generally made on a commercial basis – i.e. a pay DTT operator may decide that it is financially viable to swap-out its boxes in order to increase its channel offering and subsequent revenues – although regulators may want to protect customers who rely on existing technologies and are unable or unwilling to change. The swap-out of any reception equipment is dependent on a number of factors:

- The size of the installed base: the larger the installed base of receivers, the more difficult and costly the swap-out. In particular, many customers may use an integrated TV and therefore be required to purchase a box for the first time

- The make-up of the installed base: with two compression standards in use today, several set-top box manufacturers are considering using dual or hybrid MPEG2/MPEG4 boxes. For future sales, this makes the platform more future proof
- The set-top box business model: in countries with a free DTT model, boxes are typically purchased by the consumer, meaning that the onus of any swap-out is on the consumer; in Pay DTT models, boxes may be offered under both a purchase and a rental model. With the latter, the onus of swap-out is with the operators, making it easier and with no additional cost to the customer
- Timing: some countries may opt to wait to implement together with other improvements that require new decoder equipment such as DVB-T2. Although it is likely that a full transition will be made at some point, many countries may only migrate after ASO has occurred.

iii) Likelihood

Value Partners has conducted extensive regulator interviews internationally and has found that MPEG4 is likely to be phased in on existing platforms as soon as feasible and that new launches will all be MPEG4.

iv) The future of compression

Given ongoing technology innovation, it is more than likely that over the next few years a new technology will emerge to supersede MPEG4. The European Broadcast Union (EBU) noted, in a recent technical report, that the lifetime of a video code is about ten years – i.e. commercial implementation of a new codec is possible ten years after the launch of the existing standard. This suggests that, when many countries are on the brink of a full MPEG2 swap-out, MPEG4 may already have been superseded, and most likely by a technology unrelated to the MPEG family.

8.3 Improving MUX capacity

The ability of a multiplex to carry TV channels is dependent on the throughput of the multiplexes (in MBit/s) and the percentage of this throughput that is reserved for non-TV services, such as the operation of the multiplex or radio and data services. There are two potential technology upgrades that can improve the throughput of a multiplex in Australia, and therefore increase its capacity: implement DVB-T2 (a new transmission standard) or / and migrate to MIMO.

a) Upgrading to DVB-T2

i) Description and gain

In June 2008, DVB released its framework structure for DVB-T2, an evolution of the current DVB-T standard. The standard has not yet been finalised, but is expected to offer between 30% and 50% improvement in capacity over DVB-T.

ii) Impact

With the DVB-T2 standard specification to be finalised soon, full implementation is possible towards the end of 2009 / early 2010 – Ofcom expects to be able to implement DVB-T2 by the end of 2009 in the UK. For broadcasters, a swap to DVB-T2 would require new modulation equipment on each main transmitter.

Despite the development of the standard from a transmission point of view, equipment manufacturers have suggested that new receivers – which will definitely be required to receive DVB-T2 signals – may not be available until 2011. This means that Australian broadcasters will not be able to take advantage of DVB-T2 in the short term to improve spectrum efficiency.

In addition, a DVB-T2 launch may come together with a shift to MPEG4 technology – offering consumers a mix of DVB-T/MPEG2 and DVB-T2/MPEG4 multiplexes. This approach will reduce the disruption of services to consumers, and limit the required STB upgrade to once only.

iii) *Likelihood*

Converting all multiplexes to DVB-T2 is possible but is only feasible in the long term. This needs to be done with a well managed set-top box strategy, most likely involving mandates by the Australian regulators for technology components.

b) Implementing MIMO

i) *Description and gain*

Multiple-Input-Multiple-Output, or MIMO, is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It does so without additional bandwidth or transmitter power.

MIMO effectively doubles the throughput of DTT networks by transmitting two signals via antennas on different polarisations (vertically and horizontally) over the same single 7MHz channel.

ii) *Impact*

In order to achieve such spectrum efficiency gains, customers would need to buy new dual-polarised antennas and set-top boxes. The horizontal polarisation could be made backward compatible with existing DTT receivers but the coverage footprint might be reduced because of higher interference. In field trials, a MIMO network provided virtually the same coverage footprint as a conventional DVB-T network[33].

iii) *Likelihood*

Currently, broadcasters seem either not to have considered MIMO or to be reluctant to implement it and therefore timescales for implementation are unclear. As with any network re-planning, it is unlikely to happen in the short to medium term, due to the significant inconvenience and service disruptions to viewers to replace broadcasting antennas, transmission equipment, and receiving antennas.

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[33] J. Boyer, P. G. Brown, K. Hayler, M. Lopez Garcia, J. D. Mitchell, P. N. Moss, M. J. Thorp, "MIMO for broadcast – results from a high power UK trial", BBC white paper, WHP 157, Oct 2007

9 Appendix C: Glossary

16QAM – a modulation format or scheme used to transmit data over a communications medium

2.5G – "Two and a half G": Term used to describe the enhanced data facilities within 2G digital networks known as GPRS and EDGE.

2G – "Two G": Second generation of mobile telephony systems using digital encoding. 2G networks support voice, limited data communications

3G – "Three G": Third generation of mobile telephony systems, providing data speeds generally higher than that used in 2G or 2.5G which supports multimedia applications such as full motion video, video conferencing and Internet access.

4G – "Four G": Fourth generation of mobile telephony systems that are still under development currently

64QAM – an improved modulation scheme over 16 QAM

ASO – Analogue switch-off

Band – A defined range of frequencies that may be allocated for a particular radio service, or shared between radio services

Base Station – A radio transmitter with or without a receiver installed to provide a communications service, typically used in mobile or broadcasting radio systems.

Capex – Capital expenditure

Carrier – in FDD refers to twin spectrum blocks required for uplink and downlink, expressed as 2 x size of required block. For example, 2 x 2.5MHz is required for GSM services (5MHz of spectrum in total); 2 x 5MHz is required for HSDPA (10MHz in total). Spectrum chunks wider than the required size of the carrier are able to support multiple carriers, allowing a doubling up of capacity on that network

CBA – Cost-benefit analysis

Compression – the reduction in size of data in order to save space or transmission time

Consumer surplus – the amount that consumers benefit by being able to purchase a product for a price that is less than they would be willing to pay

Counterfactual Case – in a CBA, the case against which the Factual Case is measure (i.e. the next best alternative for the use of resources in question

CPE – Consumer Premises Equipment

Datacards - Data-only lines registered for wireless (connected to mobile networks) modems connected to a personal device such as a laptop or PDA that require human intervention for use

DTT – Digital Terrestrial Television, see DVB-T

DTV – Digital Television

DVB – Digital Video Broadcasting: suite of internationally accepted open standards for digital television

DVB-H – Digital Video Broadcasting Handheld

DVB-T – Digital Video Broadcasting over Terrestrial networks

DVB-T2 – Theoretical new DVB-T standard scoped by Ofcom in 2007

EDGE – Enhanced Data Rates for Global Evolution: is a an access technology that delivers broadband-like data speeds to mobile devices at data speeds faster than is possible with GSM/GPRS

EIA – Economic Impact Assessment

Elasticity – measures the nature and degree of the relationship between changes in quantity demanded of a good and changes in its price

Externality – occurs when a decision causes costs or benefits to third party stakeholders

Factual Case – in a CBA, the case which is being measured (similar in concept to a 'Base Case'

FCC – Federal Communications Commission: the US telecommunications and media regulatory body

FTA – Free-to-air

GDP – Gross Domestic Product

GHz – Gigahertz: a unit of frequency, represented in 1000 million (1 x 109) cycles per second, where 1Hz is one cycle per second, e.g. 1GHz = 1,000,000,000Hz

GPRS – General Packet Radio Service a method to increase the data capacity of 2G or voice based digital networks to enable data services such as; internet browsing, e-mail, visual communications etc.

GSM – Global System for Mobile communications; a 2G mobile phone technology. This is the technology behind the vast majority of 2G mobile phones used across Europe and is used by approximately 80% of 2G operators worldwide. Also sometimes referred to under its French interpretation of "Groupe Spécial Mobile"

GSM 1800 – term used to describe GSM used in the 1800MHz frequency band, see GSM

GSM 900 – term used to describe GSM used in the 900MHz frequency band, see GSM

Guard band – band of spectrum that is unused between mobile and broadcasting services and between uplinks and downlinks in the mobile spectrum (in frequency division duplex, the "centre gap").

Handsets – Mobile communications terminals (mobile phones, Blackberry^{TM} etc) with UMTS connectivity and data-capable interfaces

HD – see HDTV

HDTV – High definition television

HSDPA – High-Speed Downlink Packet Access: an add-on access component used to enhance the data speed to the end user on 3G/UMTS networks

HSPA – High-Speed Package Access: refers to both Uplink and Downlink traffic, see HSDPA and HSUPA

HSUPA – High-Speed Uplink Packet Access: an add-on access component used to enhance the data speed from the end user to the base station on 3G/UMTS networks.

IMT – International Mobile Telecommunications

Interference – The effect of unwanted signals upon the reception of a wanted signal in a radio system, resulting in degradation of performance, misinterpretation or loss of information compared with that which would have been received in the absence of the unwanted signal

IPTV – Internet protocol television (television delivered via a broadband connection as an IP stream)

ITU – International Telecommunications Union: is an international organization within the United Nations System where governments and the private sector coordinate, discuss and agree the logistically nature of global telecom networks and services

kHz: Kilohertz: a unit of frequency, represented in thousands (1 x 103) of cycles per second, where 1Hz is one cycle per second, e.g. 1kHz = 1,000Hz

LTE – Long Term Evolution: Project within the Third Generation Partnership Project (3GPP) to improve the UMTS mobile phone standard. Features include, for example, higher download and upload speeds and greater channel flexibility. Technically able to be implemented

MB – Megabyte: a unit of information or computer data storage, not to be confused with Megabit per second (a unit of data transfer)

Mbps – Megabit Per Second (also Mbit/s): a unit of data transfer rate equal to 1,000,000 bits per second. Because there are 8 bits in a byte, a transfer speed of 8 megabits per second (8 Mbps) is equivalent to 1,000,000 bytes per second, not to be confused with Megabyte (a unit of computer data storage)

MFN – Multi-Frequency Network: a type of radio network that operates several transmitters on a number of different frequencies, as opposed to SFN (Single Frequency Network)

MHz – Megahertz: a unit of frequency, represented in millions (10^6) of cycles per second, where 1Hz is one cycle per second, e.g. 1MHz = 1,000,000Hz

MIMO – Multiple-Input and Multiple-Output: the use of multiple antennas at both the transmitter and receiver to improve communication performance. MIMO technology offers significant increases in data throughput and link range without additional bandwidth or transmit power

Modulation – Translation of digital data into a carrier signal for broadcast

MOU – minutes of use

MPEG2 – the standard for the generic coding of moving pictures and associated audio information: MPEG2 is widely used as the format of digital television signals that are broadcast by terrestrial (over-the-air), cable, and direct broadcast satellite TV

MPEG4 – differs from MPEG2 in that it has lower data rates, as well as smaller file sizes due to its improved compression

MUX – Multiplex (block of spectrum used to transmit a number of channels that have been statistically multiplexed - literally the digital transmission streams of each channel have been mixed together)

Net present value – Net present value is the standard method of valuing future cash flows, taking into consideration of time value of money

Ofcom – Office of Communications: the UK’s Media and Telecoms regulator with the responsibility for spectrum management

Opex – Operational expenditure

Petabyte – Equals to one million gigabytes

Price elasticity – see Elasticity

Producer surplus – the amount that producers benefit by selling at a market price that is higher than they would be willing to sell for

Propagation – The transmission of radio waves. Propagation characteristics depend on frequency and are affected by the environmental conditions, such as terrain and atmospheric conditions, encountered on the path

SD – Standard definition

SFN – Single Frequency Network: a broadcast network where several transmitters simultaneously send the same signal over the same frequency channel, as opposed to MFN (Multi-Frequency Network)

STB – Set-top box

Terrestrial – On the ground only

Topography – the study of landforms, i.e. Earth's surface

UHF – Ultra High Frequency: Term used to describe frequencies in the range 300MHz to 3GHz

UMTS – Universal Mobile Telecommunications System – a 3G mobile phone standard built on W-CDMA technology. See WCDMA. One of the IMT-2000 family of standards. This is the standard being deployed by the vast majority of European mobile phone operators to offer 3G services

VHF – Very High Frequency: Term used to describe frequencies in the range 30MHz to 300MHz

WCDMA – Wideband Code Division Multiple Access: a type of 3G wireless technology

WiFi – a wireless local area network technology

WiMAX – a wireless technology aimed at providing data access over long distances

WRC – World Radiocommunications Conference: an ITU convened conference, held approximately every three or four years, which makes decisions on the way in which radio spectrum is considered in a global context

WTP – Willingness-To-Pay: economic term for the theoretical price a consumer is willing to pay for a service or product

10 Appendix D: Disclaimer

10.1 Approach

Value Partners has exercised all reasonable endeavours in performing the work relating to this assignment. Any assumptions, projections, findings, conclusions and recommendations and any written material provided represent our best professional judgement based on the information available to us during the project.

In authoring this study, we have been assisted by the fact that the sponsors of the project are themselves either major developers of wireless technologies or operators present in many of the markets that we wish to study. The sponsors have provided proprietary data to us on a confidential basis; however, assumptions contained within this report represent Value Partners' independent views. No individual assumption can be attributed to any one sponsor.

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11 Appendix E: About the authors

This report was written by Justin Jameson and Dan Kirk supported by their combined project team. It represents our own independent analysis, views and opinions.

Justin Jameson is the CEO of Venture Consulting, the leading specialist media and telecoms strategy consultancy in Australia and New Zealand. He was previously the lead Partner of Value Partners' Sydney office. He has over seventeen years global experience in the media, telecommunications, and digital media industries. He specialises in corporate strategy, commercial business development, operational support and regulatory strategy. Justin has been based in Sydney for the last five years, and prior to that was based in Singapore and London. Over the last few years, he has advised broadcast, mobile, financial and government clients in Australia, New Zealand and Asia on the likely impact of Analogue Switch-Off (ASO) from a commercial, regulatory and policy perspective.

Dan Kirk leads Value Partners' European telecoms practice. Dan's practice covers all aspects of the mobile and fixed telecoms sector with projects from regulation to strategy and operations. Dan has over nine years experience in the telecoms and media sectors. Dan was a key advisor on Value Partners' European Digital Dividend Review (DDR) project undertaken during 2007.

During the production of this report, the Australian business of Value Partners underwent a management buy-out leading to the formation of Venture Consulting. Venture Consulting provides strategic advice and analysis to media and telecoms industry operators, regulators and policy makers, vendors and investors.

Value Partners and Venture Consulting continue to collaborate closely, including on this report.

Spectrum Value Partners is the global telecoms and media consultancy practice of the Value Partners Group. The company was formed in 2007 following the merger of Spectrum Strategy Consultants, a leading international strategy consultancy focused on the converging industries of telecommunications, media and technology and the management consultancy practice of Value Partners. Following the merger, Value Partners comprises over 250 specialised TMT management consultants – one of the largest dedicated TMT practices globally.

Value Partners assists its commercial clients with a wide range of strategy and implementation advice, including strategic planning, business plan development, market forecasting, feasibility studies, economic and financial analysis, business modelling, policy development, commercial strategy, product definition, consumer trend analysis and technology evaluation and selection.

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