Valuing mission critical radio services: A study of the economic value of land mobile radio spectrum in Australia

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Overview

The radio communications industry is a vital and essential part of daily life in Australia, but as it happens without people realising or seeing radio in action, it is often overlooked in importance. When you consider that every major resource project in Australia relies heavily on radio communications for their daily operations, that the emergency services must have radio communications to protect life and property, and these are just two of the critical applications.

Many believe that mobile phones have replaced the need for radio communications, in some instances this may be the case, but in most radio applications there is a need for multiple parties to be involved in the communications and mobile phones are only designed for one–to–one communications. When you add the levels of redundancy that 'mission–critical' and 'business–critical' applications require, they are well beyond the normal mobile phone operating parameters.

As the voice of the radio communications industry, ARCIA members are heavily involved in providing these essential communications, from safety communications for school excursions and local swimming pool lifeguards, through the wide range of recreational and industrial users, the major resource projects and mining industry and on into Government and emergency service areas. It is our members who supply, design, install and maintain these communications links; we are the vital support network behind the essential services.

There is no doubt that the radio communications industry is like most other industries—it is the people who work in the industry that make it all happen. From engineers to technical apprentices, from management and consultants through to clerical support staff, our industry comprises highly skilled people from all walks of life. The radio industry offers many different working environments and we offer many essential services to our clients, by giving good support and providing benefits to our clients, we are a vital part of Australia's economy.

We encourage people to learn more about our industry, as we are now one of the leading proponents of 'converged communications' where the communications world merges with the Information Technology (IT) sector. It is the radio communications industry that is moving into the IT world and leading the way with equipment that is IP connected. Radio communications is an exciting and innovative industry, which is growing stronger each year.

ARCIA is continually striving to improve our industry and to enable rewarding careers for the thousands of people who work in the radio communications industry.

CONTENTS

1 EXECUTIVE SUMMARY

The objective of this study is to estimate the economic benefits of spectrum allocated to land mobile radio (LMR) in Australia and to offer other assessments of the value proposition of spectrum allocated to LMR.

Spectrum allocated to LMR services, primarily in the 400MHz and 500MHz range, is a key input for a wide array of public and private sector organisations. In the private sector LMR is used, for example, by mining companies, taxi services, and transport and utilities companies. As the general public is broadly aware, radio services play a vital role in a range of services provided by the public sector including police, ambulance, firefighting and other emergency and first-responder services.

The efficient allocation and management of spectrum resources is becoming of increasing economic significance in a world of Smartphone's and other mobile Internet-connected devices. The economic significance of spectrum and the competition for spectrum resources can be expected to increase as consumers' expectations of wireless services continue to increase and the demand for spectrum for machine-to-machine communications also grows.

The rise of mobile Internet-connected computing devices has not only increased demand for spectrum but also led to significant increases in personal and corporate productivity. The increasing sophistication of digital services provided over public cellular networks leads naturally to the question of to what extent these services now constitute a viable and effective substitute for traditional LMR services from the perspective of efficient spectrum use. The related question from the spectrum allocation perspective is: should spectrum currently allocated to LMR services be, at some time, allocated to mobile cellular services and to what extent should mobile be favored over radio in future spectrum allocation decisions?

From the economic perspective the central question is: to what extent is mobile cellular a close substitute for LMR? For this study we conducted two surveys, met with industry representatives, and conducted structured face-to-face and telephone interviews. We wanted to investigate the importance that users, particularly users 'in the field', attached to LMR services and the extent to which (hypothetical) increases in costs of such services would lead to decreases in use. In economic jargon, we were interested in the price elasticity of demand for LMR services.

We found that users were highly committed to traditional LMR technologies and services, and their associated characteristics. In particular, the immediacy of establishing communications using LMR was emphasised as well as its 'one-to-many' characteristic, which is regarded as indispensable in creating 'shared situational awareness' in emergency scenarios. This was contrasted with the characteristics of mobile cellular systems: a one-to-one communications channel that requires significant user time and focus before a communications channel can be established. This gap between the intent to communicate and the establishment of communication was seen as a key disadvantage of cellular mobile as a substitute for LMR.

In addition to these intrinsic characteristics of the alternative technologies, LMR has several other characteristics that are particularly relevant in emergency scenarios. Although LMR systems make use of trunk systems and repeater units to connect them to broader networks and/or extend their range, individual LMR units are nonetheless independently capable of effective communication without any such infrastructure. Mobile phones are not. Natural disasters such as bushfires and floods can and do destroy mobile cellular infrastructure and/or disrupt power supplies. Thus, LMR technologies offer robustness and resilience in the face of emergency scenarios that are commonly faced in Australia.

This focus on LMR as the core communications system for the emergency and first responder services should not, however, presume to be indicative of a conservative attitude towards new digital technologies. Emergency services organisations are making innovative use of mobile broadband, social media and messaging services to provide information to and receive information from the public. In addition, public cellular services are being used to augment emergency services, creating productivity gains and improving performance (including saving lives).

New digital radio services and the increasing availability of digital dividend spectrum in the 700 MHz range offer new possibilities for emergency service providers. In the face of these technological changes and with the growing competition for spectrum in general, the challenges and opportunities faced by these organisations need to be carefully considered.

Australia's population is growing and it is also becoming more aged. These factors alone will lead to growing demand on emergency services. But community expectations of emergency services are also increasing. In the context of these growing expectations, emergency services will increasingly come to rely on various types of digital services delivered over multiple channels to augment and enhance traditional radio voice channels to enable them to deliver superior services and outcomes. Such digital services should be seen as additional to core radio services, which should constitute the robust and resilient backbone of emergence communications services and represent the 'fallback communications resource' when other services become disabled in emergency and disaster scenarios.

These considerations will be increasingly pressing in the near future. This study, however, focuses on the economic contribution of LMR spectrum today. We use a relatively standard social welfare analysis based on consumer surplus concepts to estimate the economic value of spectrum allocated to LMR.

We have generated two sets of estimates of economic benefits: one based on LMR equipment costs and one based on associated time costs. We believe the former estimate of economic benefit is demonstrably conservative. The equipment valuation method yields an economic benefit estimate of $1.99 billion per annum while the time valuation method yields $3.72 billion.

Compared with this is the opportunity cost of the spectrum used for LMR which is estimated to be $39.7 million per annum. Set against these benefit estimates, the estimated opportunity cost is relatively tiny, almost *de minimis.* In order for this estimate to be comparable with the benefit estimate, however, it needs multiplied by the consumer surplus ratio that would be created were new service provided over this spectrum. Even if we use the highest value consumer surplus ratio used in our benefits estimates (see Section 6), the benefit associated with this next best use of spectrum would be in the order of $200 million per year.

Thus, the allocation of spectrum to the current set of uses (including, critical, emergency and first responder services) generates an economic benefit at least 10 times greater than the benefits that would be generate by its allocation via a market-based processes to the next best use. This indicates that the current use is strongly preferable from a social welfare perspective to a market-based alternative use of the spectrum.

2 INTRODUCTION AND BACKGROUND

2.1 THIS REPORT

The Australian Radio Communications Industry Association (ARCIA) commissioned Windsor Place Consulting (WPC) to conduct a study on the economic benefits of spectrum allocated to Land Mobile Radio (LMR) in Australia.

LMR services (also referred to as two-way radio services) play a critical role in a wide range of public and private sector activities. Public services that depend on LMR include emergency services, police, ambulance, firefighters and many other government service providers. Private sector users include mines, utilities, commercial transport, taxis and recreational radio users.

This diverse set of users, as well as equipment manufacturers, importers/exporters, distributors, wholesalers and retailers are represented by ARCIA.

A primary requisite for the operation of the LMR-dependent organisations is the availability of suitable electromagnetic spectrum, a resource managed by the Commonwealth Government through the Australian Communications and Media Authority (ACMA). ACMA's decisions concerning spectrum allocation are guided by the high-level objective of promoting the public benefit.

Technological change and shifting consumer behaviour mean that determining the optimal allocation of spectrum to competing uses is an ongoing task. This report seeks to contribute to this process by providing estimates of the national economic benefits associated with the use of spectrum for LMR.

2.2 USE OF LMR AND TECHNOLOGICAL CHANGE

The enormous benefits created by mobile communications are amply demonstrated by the rapid rise of mobile telephony and mobile broadband over the past 20 years. These technologies and associated devices – Smartphone and tablets – have driven a revolution in consumer behaviours. These changes marked a sharp departure from almost 100 years of landline fixed telecommunications. Today, the idea of calling a place rather than a person in the world of consumer-to-consumer communications is rapidly becoming as obsolete as the telegram.

This experience is instructive in relation to the use of LMR (traditional 2-way radio) in the corporate world. There is a significant set of organisations that are highly dependent on mobile communications in general but, critically, on LMR in particular. LMR is said to be 'mission critical' for these organisations. According to the TETRA and Critical Communications Association the term 'mission critical' refers to:

> *A function whose failure leads to catastrophic degradation of service that places public order or public safety and security at immediate risk. These systems are paramount to the operation of a nation's public safety and critical infrastructure services and are therefore specified to have particular and adequate inbuilt functionality, availability, security and interoperability.*[1]

This emphasises the role of LMR services in the critical areas of policing, ambulance, firefighting and other emergency services. The expanding and increasingly sophisticated communications options being developed in public mobile cellular and digital radio are relevant to the communications strategies of the organisations that provide these services but, at this point in time and for the foreseeable future, most of these organisations are still deeply embedded in a communications environment that are based on traditional LMR. Thus, in a sense, the radio communications sector has not advanced down the path of digitisation as fast or as far as consumer cellular communications. There are good reasons for this.

Technical characteristics of radio and mobile cellular communication systems

The first set of reasons why organisations are cautious about new and alternative communications technologies has to do with the particular technical and performance characteristics of traditional LMR which make it particularly well suited to its role in many organisations, especially those delivering time-critical emergency services. These include:

- one-to-many communications on open channels
- immediate initiation of communications link – 'push to talk'
- robustness and resilience
- LMR can operate independently – in many critical contexts LMR can operate effectively independent of any central infrastructure.

These technical characteristics of LMR are a key to understanding its particular suitability to emergency services and first responders. The essence of LMR is that it is *a broadcast technology adapted to a communications role*. Cellular mobile, on the other hand, entails establishing a closed *one-to-one circuit* between caller and receiver (see Figure 1). Each approach embodies a position on a range of technical trade-offs. By establishing a dedicated 'circuit' (and by using various time and frequency division technologies) mobile cellular communications make efficient use of spectrum in the sense that it can support more simultaneous one-to-one

[1] *Socioeconomic Value of Mission Critical Mobile, Applications for Public Safety in the UK: 2x10MHz in 700MHz*, Dr Alexander Grous, Centre for Economic Performance, London School of Economics and Political Science, November, 2013.

communications channels than can radio systems. However, the drawback of this approach is that each circuit has to be established before communication can begin. In addition, the caller must first designate the destination or recipient of the call before attempting to establish the circuit. This takes time and user focus – the duration between forming the intent to communicate and beginning a conversation is in the range 15 to 30 seconds or more, although this is improving with LTE. In contrast, the radio user simply 'pushes to talk' – that is, pushes a single button to achieve the access to the communications channel. By accessing the communications channel, a radio user accesses all users that are listening to that channel or frequency.

Figure 1: Characteristics of radio and mobile cellular communications

LMR characteristics

- One-to-many
- Always open, always 'on'
- Instant connection
- Very low user effort/focus require to establish connection – 'push-to-talk'
- Shared situational awareness

Cellular mobile characteristics

- One-to-one
- Circuit must be established
- Latency in establishing connection
- Greater user effort required to establish connection
- Communication is not shared beyond the two parties

Whereas these characteristics and their importance are obvious to industry participants, politicians and some policymakers may be less aware of the extent to which mobile cellular communications are a very poor substitute for radio systems, particularly in emergency and first responder scenarios. The user focus and extra time required to establish communications using a mobile cellular device compared with radio devices could alone mean the difference between life and death in emergency scenarios. In addition, the shared situational awareness that is facilitated by radio technologies is a critical requirement for the effective management and coordination of large distributed teams in emergency situations.

This lack of "substitutability" of mobile for radio systems is further exacerbated by the relative susceptibility of mobile systems to degradation and failure in emergency scenarios. Emergencies of all kinds generate increased mobile traffic leading to congestion and loss of services. Bushfires and floods can destroy mobile communications infrastructure and/or interrupt power supplies. In effect, the time at which systems are most needed is when they are most likely to fail. LMR infrastructure is also threatened by natural disasters but individual radio units can continue to operate effectively without central infrastructure. Under congestion, radio systems tend to be characterized by 'graceful degradation' rather than complete failure.

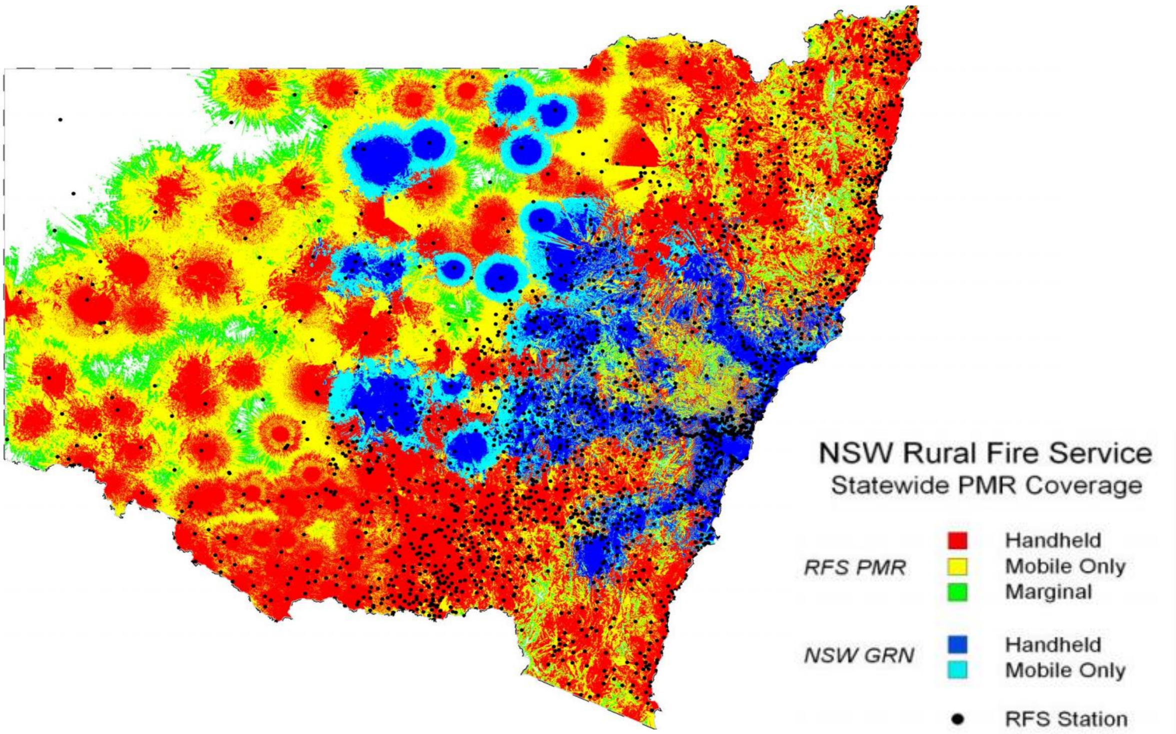
It should also be said that improvements in mobile cellular technologies and the advent of digital radio technologies will, over time, reduce these difference between the two communications modalities. The key point is that, at this point in time, the differences remain material and the costs of change are high.

Organisational factors

A second set of reasons why adoption of technological change has not been as rapid as in the consumer case is that often the organisations that use LMR undertake critical and emergency services in which procedures and practices are highly evolved and refined to ensure that they can be delivered even in highly adverse circumstances. The managers of these organisations are rightly cautious about introducing new technologies into such environments.

Additionally, some of these organisations are very large operations: New South Wales Rural Fire Service, for example, is the world's largest volunteer fire service with around 70,000 volunteers and uses more than 20,000 radio terminals. Figure 2 provides an appreciation of the size and complexity of the Service's radio systems. The costs of implementing technological change in terms of capital expenditure and training are substantial.

Figure 2: NSW Rural Fire Service: Statewide PMR coverage



Source: NSW Rural Fire Service presentation Comms Connect Conference 2014

Another consideration is that organisations that use LMR represent a diverse group with quite different characteristics and communications needs and this means that particular communications technologies have significantly different levels of suitability across these organisations.

For example, a rail management company's operational footprint is restricted to a relatively small area along the rail corridor it manages. In contrast, an emergency services operation may have a footprint that extends not only over an entire state but, in fact, beyond its borders. An example of the latter is state-based ambulance services which, in emergency situations, needs to take patients to the nearest suitable hospital irrespective of state borders. Thus, whereas it would be technically feasible for such a rail company to deploy a cellular based mobile phone network across its whole footprint, this would be never economically sensible for ambulance services.

Thus, new technological solutions that might eventually replace or augment LMR will generally not be able achieve the scale that is achieved in the consumer domain and they may, in any case, require significant customisation for use by particular organisations – suitable off-the-shelf solutions may not be available. All these factors limit the capacity of large LMR-using organisations to rapidly adopt new technologies. Therefore, it cannot be assumed that consumer grade mobile communications technologies are a close substitute for LMR systems now or any time soon.

3 PREVIOUS STUDIES

A number of reports and studies have been undertaken in the area the economic benefits of spectrum use by government departments, industry representative groups and academics. This section discusses some of the literature relevant to the current study.

Analysys Mason in 2012 undertook a study for the UK Government[2] on the value of spectrum use to the economy and the relative importance to the constituent parts of the mobile communications industry. This report was a follow-up to a similar 2006 study. The report found that the key sectors of the wireless industry generated revenue of £37.3 billion. Economic value of spectrum use for 2011 was estimated at £52 billion pounds with public mobile (cellular) communications being significantly the dominant component at £30.2 billion. The private mobile radio component was estimated at £2.3 billion, an increase of 55% on the 2006 figure with a 10 year NPV for 2012-2021 of £19.2 billion.

Table 1: Economic benefits of spectrum use in the UK

Spectrum use	2006 (£ billion)	2011 (£ billion)	Real % change 2006–2011	10-year NPV 2012–2021 (£ billion)
Public mobile communications	21.8	**30.2**	16%	273
Wi-Fi	–	**1.8**	–	25.6
TV broadcasting	3.6	**7.7**	79%	86.0
Radio broadcasting	1.9	**3.1**	35%	28.6
Microwave links	3.9	**3.3**	-29%	22.1
Satellite links	2.8	**3.6**	7%	31.3
Private mobile radio	1.2	**2.3**	55%	19.2
Total	**35.2**	**52.0**	**25%**	**486**

The UK Federation of Communication Services (FCS) published in 2010 a strategic review on the professional use of radio communications in the UK. The review emphasises the role of radio communications as a critical input in the provision of a wide array of services by private and public organisations. This review was not quantitative in nature but rather was 'research into the views of the professional radio industry'.

2 *Impact of radio spectrum on the UK economy and factors influencing future spectrum demand*, Analysys Mason for Department for Business, Innovation and Skills and Department for Culture, Media and Sport, 5 November 2012

The reviews high-level conclusions included:

- The value to the UK of the use of professional radio is very large.
- Professional radio is not easily substituted by other schemes
- There is a strong expectation of future growth if key issues can be resolved
- Flexible regulation will, for the future ensure the UK is well positioned to enjoy the benefits of the new efficiencies and improved safety schemes.

These qualitative conclusions reinforce the findings of this report and we have attempted to develop quantitative estimate of economic benefit to provide a more definitive guide to policy making.

Dr Alexander Grous of the Centre for Economic Performance produced a 2013 quantitative study titled *Socioeconomic Value of Mission Critical Mobile, Applications for Public Safety in the UK*. This study estimates the socioeconomic value of two 10MHz channels in the 700 MHz band that are to be used for mobile broadband services. The analysis is noteworthy in that it is a 'bottom-up' estimation of the benefits based on the activity of police and ambulance services using this spectrum. It is therefore narrow in focus but relatively detailed. It estimates not only the benefits to citizens to improve services such as reduced loss of life and injury, but also estimates productivity benefits in police and ambulance operations. Grous states that 'efficiency-enhancing tools such as mobile broadband have been increasingly used by these agencies to obtain productivity benefits and enhance the performance of fewer resources'[3]

It should be emphasised that this analysis applies only to the 700 MHz spectrum allocated to emergency services for broadband and voice use and not to traditional radio services.

Grous finds that the value of these two 10 MHz bands allocated to public safety in the UK to be a present value of £5 billion, compared with an opportunity cost from sale at auction of the spectrum at an estimated value of £300 million to £1.1 billion (this estimate based on international and UK auctions of 700 MHz and 800 MHz spectrum). As Grous points out, the socioeconomic benefits of the use of this portion of spectrum exceeds the opportunity cost by a significant factor.

> *The estimated socioeconomic benefit exceeds the potential alternative benefit of this portion of the spectrum: amortised over a 15 year license, the annual socioeconomic benefit equates to £333 million, versus £20 million-£73.3million for the amortised potential alternative sale of the spectrum at auction. These estimates indicate that the socioeconomic benefits of the*

3 *Socioeconomic Value of Mission Critical Mobile, Applications for Public Safety in the UK: 2x10MHz in 700MHz*, Dr Alexander Grous, Centre for Economic Performance, London School of Economics and Political Science, November, 2013

> *use of this portion of spectrum by PPDR agencies exceeds the opportunity cost for its alternative sale at auction. In addition to any review of the alternative use of this 20MHz block of the 700MHz band, consideration must occur for the appropriate technical and implementation model in order to fulfill key mission critical broadband and voice requirements for public safety whilst maximising the potential that this bandwidth offers. Only by aligning a number of such critical parameters will the maximisation of socioeconomic benefits ensue and continue to occur.*[4]

This is an important point that reinforces the conclusions of this study. In essence, the economic benefits associated with spectrum use for emergency and first responders are significantly higher than the next best use according to the estimated value the market would be willing to pay for the spectrum. It is worth emphasising that this result is for broadband spectrum and, on the basis of interviews for this study, the valuation of LMR spectrum is likely to be substantially higher.

Grous goes on to consider in detail the case of dedicated spectrum for the emergency sector, meaning that if emergency organisations have control of the spectrum, negative social welfare outcomes are more likely to be avoided.

> *For optimised social benefits to be derived from PPDR activities, a congruent operational delivery mode is required that addresses the unique characteristics of this sector such as the requirement to be 'always available': the inability of safety and mission critical voice traffic to be transmitted due to traffic 'overload' may result in fatal consequences or the impediment of communication at times of emergencies. Equally, as mobile broadband becomes operationalised over time into a more mission critical function, a reduction in service availability can result in the inability of medical, fire, or police teams to utilise situational enhancing information, patient data, intelligence, or other information that can result in loss of life, serious injury, property damage and other negative outcomes, that cause distress and costs to ensue. The socioeconomic cost of a 5 per cent degradation of service availability in the UK in times of mission critical dependency could result in a socioeconomic cost of over £5 billion, whilst a one per cent decrease could yield a socioeconomic cost of £1 billion. Such a reduction in service could occur in a large scale emergency where spectrum is not available in a dedicated manner for public safety. Optimised socioeconomic benefits are more likely to occur when PPDR organisations have greater control over their activity chain and can incorporate and directly manage elements required, such as service availability, security, and other features.*[5]

This type of analysis is useful input to the similar debates in Australia concerning spectrum allocations.

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4 ibid

5 ibid

4 SURVEY AND INTERVIEW RESULTS

For this project two surveys and a series of interviews were conducted. The general user survey drew around 400 responses and a specialist management survey was completed by around 10 respondents. Around 6person-to-person and telephone interviews of major user organisations such as NSW Rural Fire Service and Queensland Rail were conducted. In this section we report results of these surveys and interviews.

4.1 RESULTS OF GENERAL USER SURVEY

Table 2 shows the distribution of respondents to the general user survey by industry and sector. The responses have been reviewed and businesses that were equipment or service providers to a sector entitled Communications Services and Equipment. This sector was the largest in terms of proportions, but as observed later generally were smaller businesses. In addition there were in cases multiple respondents who were employed by the same business or entity. The number of responses is then adjusted down for the number of respondents on average from the same firm to provide an estimate of the number of entities in the category.

Table 2: Which industry/market segment do you work in?

Industry or Segment	No. of Respondents	Ave no. of respondents per entity	Estimate of no. of entities	Proportion
Comm services and equip	164	1.1	149	41.3%
Other	47	1.0	46	12.6%
Emergency services	60	1.8	34	9.5%
Mining	27	1.0	27	7.5%
Transport	31	1.3	24	6.7%
Utilities provider	25	1.2	21	6.0%
Manufacturing	21	1.0	21	5.8%
Not identified	16	1.0	16	4.4%
Other government user	17	1.1	15	4.3%
Construction	7	1.0	7	1.9%
Total	**415**	**1.2**	**360**	**100.0%**

Respondents were streamed in the surveys on the basis of a question in which they were asked to identify their type of organisation or whether they were a private recreational user. Those who represented an industry or corporate user also identified the number of employees and volunteers involved in the organisation, and this was used to provide estimates of aggregate employment by sector. These averages from the survey in Table 3 are then multiplied by the number of entities in the segment to provide an estimate of the aggregate outcomes for the segment (provided in Table 4).

In conclusion, the 340 entities represented by the respondents (excluding recreational users) are estimated to employ 565,000 people, with an additional 800,000 volunteers involved. Emergency services are the strongest represented user group (and would be even more so if volunteers were included). This calculation gives an indication of the magnitude of LMR use, by identifying the number of employees and volunteers in each sector, and the number of employees who use LMR. This can be used as a cross-check of LMR uses relative to the other sources of information available (and in so doing affirms the order of magnitudes in this study).

Table 3: Which of the following best describes the context in which you use radio communications devices: averages?

				Averages from survey				
	No of Respondents	Ave no. of respondents per entity	Estimate of no. of entities	Employees	Employees plus volunteers	Propn of employees who use LMR	Propn in Highly comms dependant activities	Propn of in Normal activities
Emergency services user	82	1.8	47	5157	16351	67%	68%	42%
Large enterprise user	76	1.0	76	978	980	62%	47%	43%
Other	85	1.0	85	410	424	46%	46%	36%
Other government user	32	1.0	32	1080	1121	46%	48%	51%
Private recreational user	33	1.0	33					
Single prop/small business (< 20 emp)	64	1.0	62	23	23	63%	56%	42%
Utilities provider	28	1.2	24	1540	1540	39%	49%	54%
Not identified	15	1.0	15					
Grand Total	415	1.1	373	1513	3665	56%	54%	43%

Table 4: Which of the following best describes the context in which you use radio communications devices: aggregates?

				Estimated Aggregates		
	No of Respondents	Ave no. of respondents per entity	Estimate of no. of entities	Employees	Employees plus volunteers	Employees who use LMR
Emergency services user	82	1.8	47	240,025	760,997	161,152
Large enterprise user	76	1.0	76	74,350	74,450	45,956
Other	85	1.0	85	34,879	36,049	15,941
Other government user	32	1.0	32	34,564	35,884	15,956
Private recreational user	33	1.0	33			
Single prop/small business user (< 20 emp)	64	1.0	62	1,392	1,392	883
Utilities provider	28	1.2	24	36,962	36,962	14,441
Not identified	15	1.0	15			
Grand Total	415	1.1	373	565,091	1,368,449	316,457

Although the number of private recreational respondents was only 31 the following charts provide useful information about their use characteristics. Figure 3 illustrates the importance of LMR to private recreational users with 77.69% rating LMR between 'extremely important' and 'important'.

Figure 3: Which of the following best describes the importance of LMR to you (private and recreational users)?

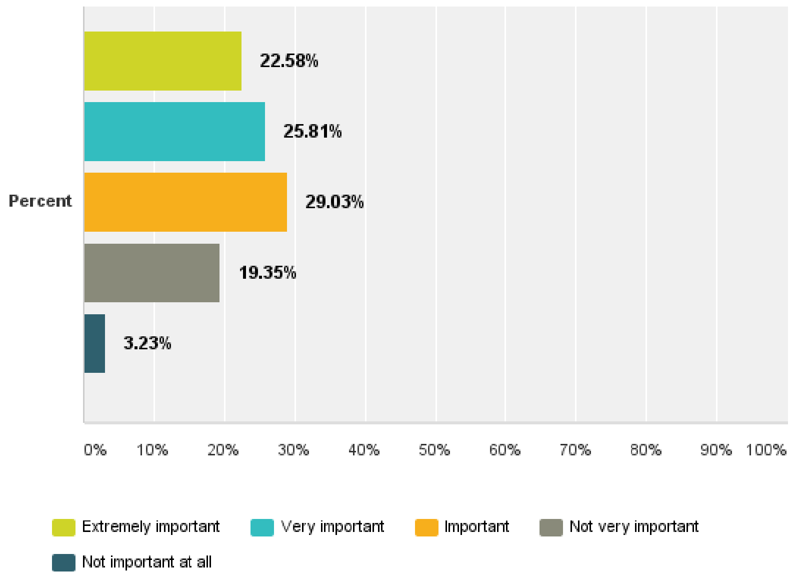
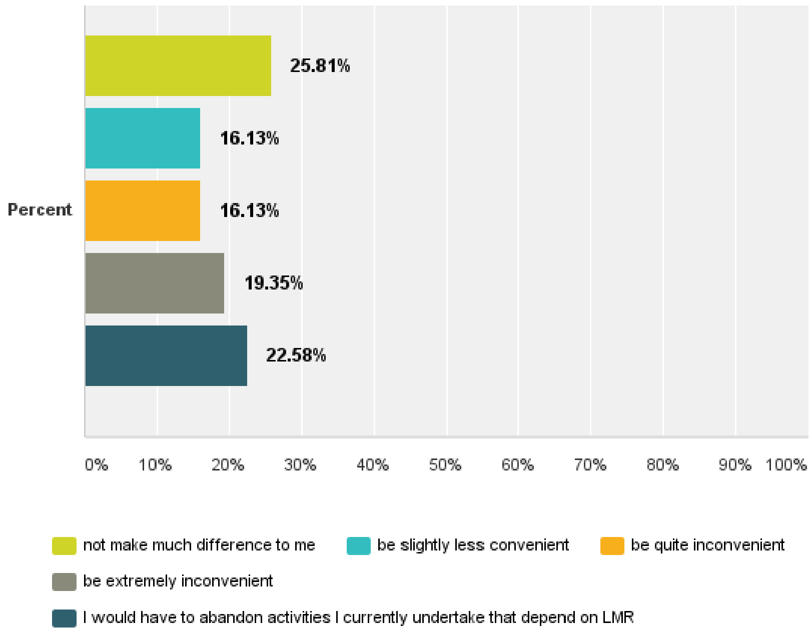


Figure 4 shows responses to a question regarding the substitutability of LMR services for mobile phone services. A total of 41.93% indicated this would be either 'extremely inconvenient' or that they would have to abandon the activities they currently undertake are dependent on LMR.

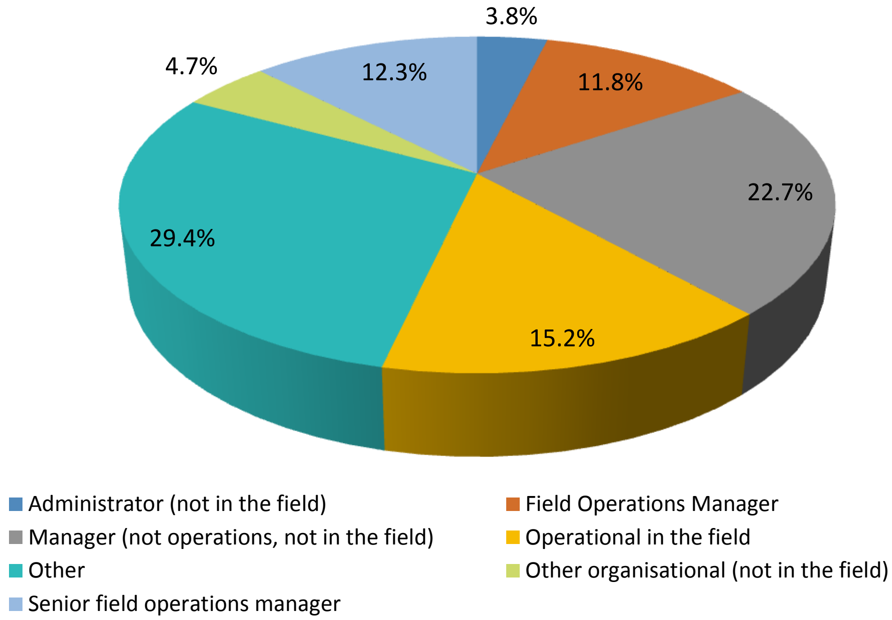
Figure 4: If you (private and recreational users) were forced to use a mobile phone instead of LMR it would:



4.2 CORPORATE USERS

Users who described themselves as belonging to large corporate entities, or as being sole proprietors or small business operators, made up the distinct majority of respondents with just under 400 responding to questions designed for these users. The distribution of these respondents between in-the-field and not-in-the-field roles was 37% and 63% respectively.

Figure 5: Organisational roles



Within large organisations there will typically be employees who make little or no use of LMR services and those for whom LMR is a critical input for achieving their day-to-day activities. An example of this distinction would be administration personnel in a large emergency services organisation and the employees who undertake field operations that are highly LMR dependent. In the survey, respondents were asked to consider their organisations' activities in terms 'highly comms dependent activities' and 'less comms dependent activities'. This distinction was emphasised because we were focused on that subset of organisational employees who were involved in highly comms dependent activities.

Figure 6 shows the responses to the importance of mobile communications in general for highly comms dependent activities. The use of four options here is based on the reasonable assumption that mobile communications are at least 'important' for highly comms dependent activities. Given this obvious point, the distribution of responses demonstrates the critical nature of communications for undertaking these kinds of activities.

Figure 6: Please rate how important mobile communications (in general) are to 'highly comms dependent activities'.

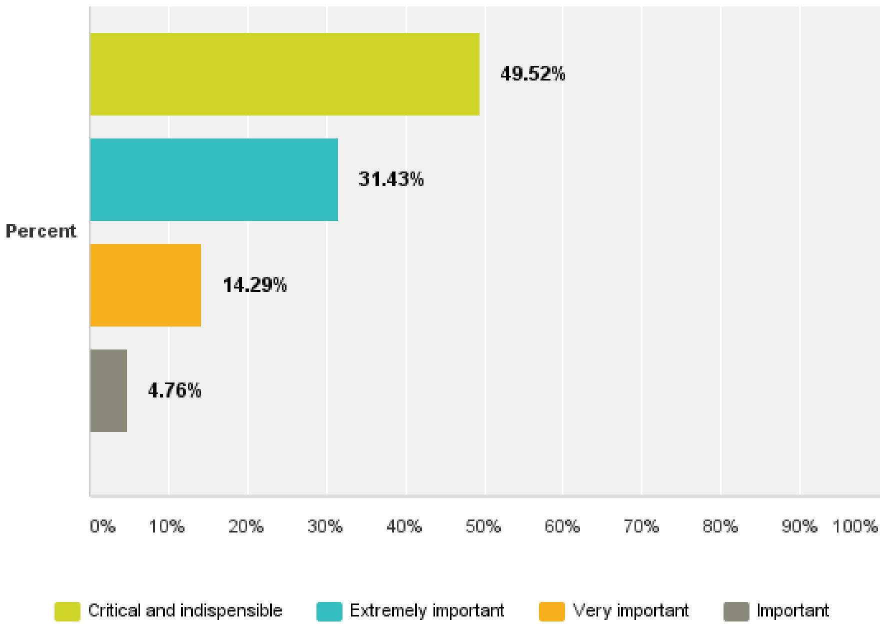


Figure 7 shows responses to the same question in relation to LMR specifically rather than mobile communications in general. The option 'not important' is included in this case because it is possible that mobile communications in general are important but LMR is not. It can be seen that 87.75% of respondents regard LMR as between 'critical and indispensable' and 'very important'. For emphasis, this pair of questions establishes the ongoing important of LMR in the organisations surveyed, notwithstanding the even greater importance of mobile communications in general.

Figure 7: Please rate how important is LMR to 'highly comms dependent activities'.

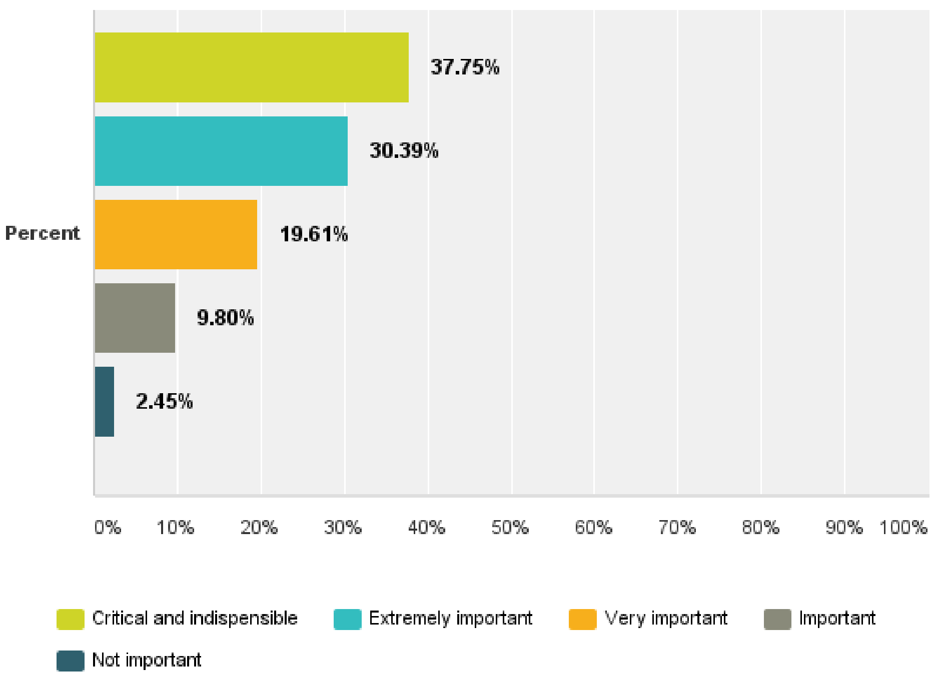


Figure 8 provides responses regarding the importance of LMR in the organisational context with 56.31% of respondents rating LMR as 'by far the most critical' or 'the most important'.

Figure 8: Importance of LMR compared with mobile communications in general.

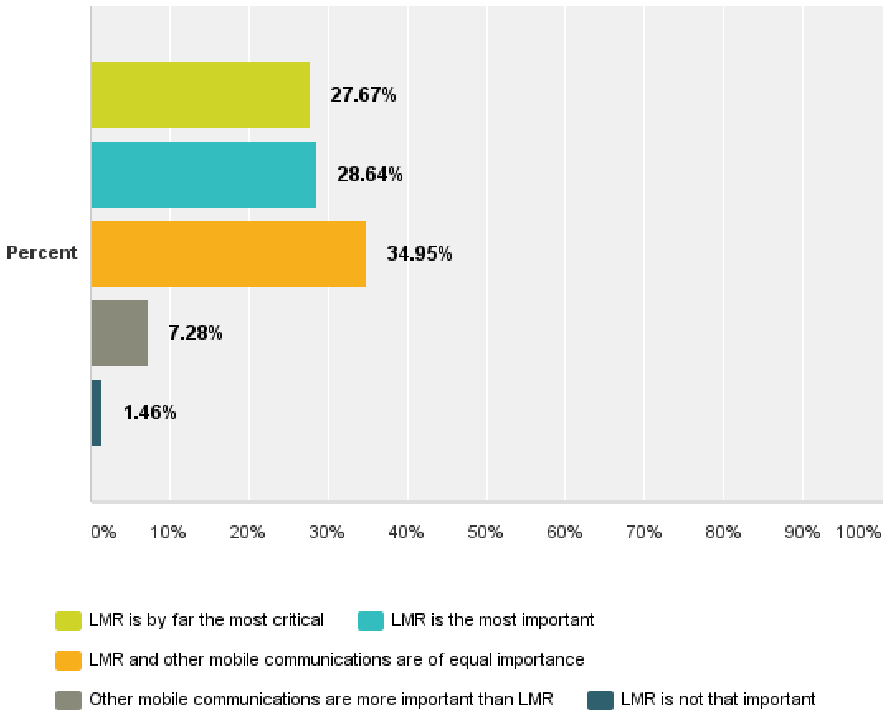


Figure 9 indicates that spectrum allocated to LMR is regarded as insufficient on balance and limiting the extent to which organisations are prepared to invest in LMR.

Figure 9: A lack of spectrum availability limits my organisation's investment in LMR technology.

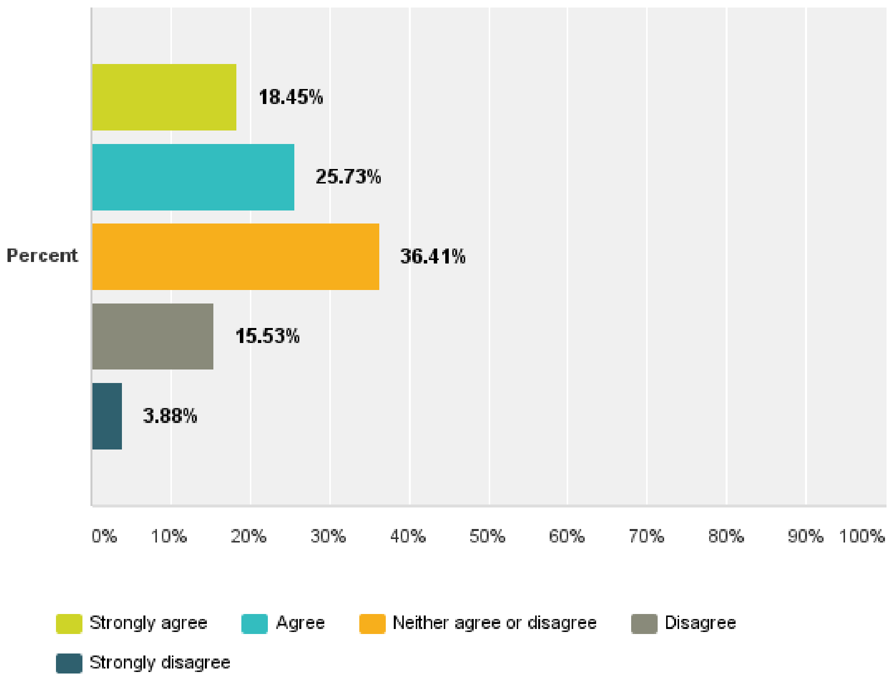


Figure 10 provides an illustration of the expected importance of digital technologies in organisations' future LMR use. It can quickly be seen that the significant majority of respondents regard digital as being important in the future.

Figure 10: Digital technologies will form an important part of my organisation's future LMR requirements.

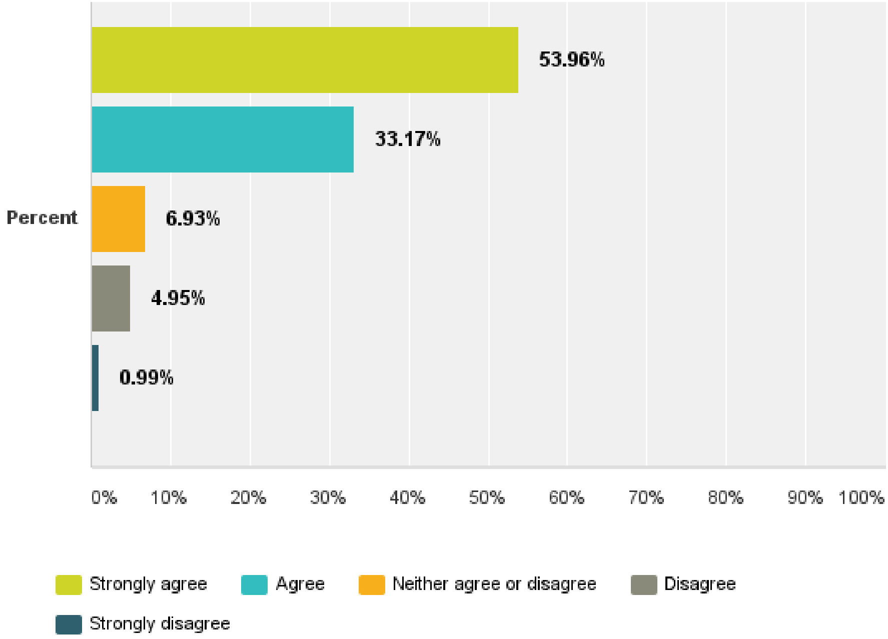
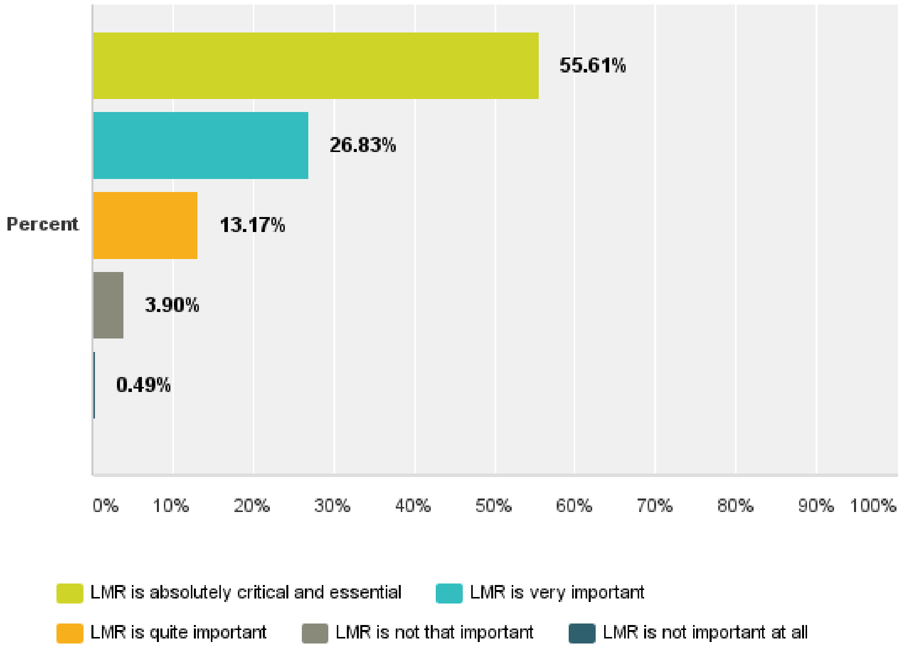


Figure 11 shows that 55.61% of respondents regard LMR as 'absolutely critical and essential' for the delivery of services with only 4.39% regarding LMR as 'not that important' or 'not important at all'.

Figure 11: How would you describe the 'criticality' of LMR services for the ability of your organisation to deliver its services overall?



A critical part of estimating the value in use of LMR services is to attempt to estimate the extent of consumer surplus in the context of corporate users. The survey provides an indication of the level of use of LMR systems. During operational events, respondents used LMR on an average of 46.6 times per day. In non-operational event periods the average was 22.1 times.

Figure 12: Frequency of use operational periods

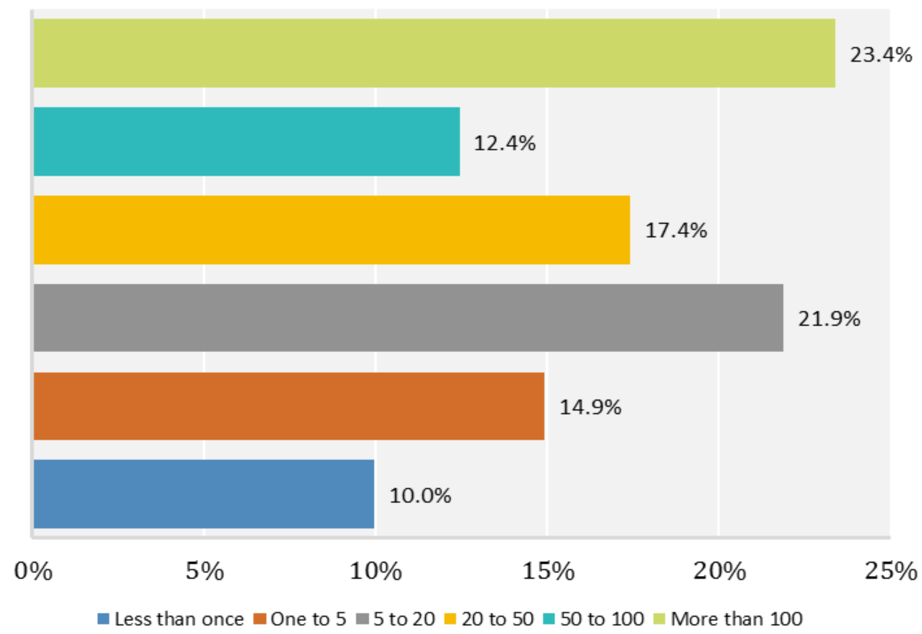
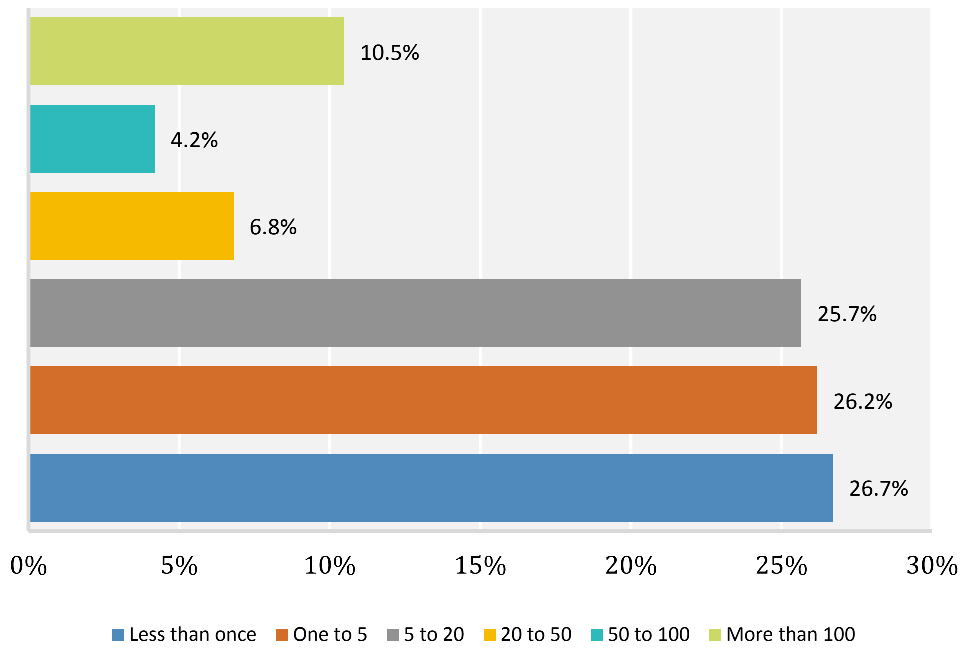


Figure 13: Frequency of usenon-operational periods



Emergency service users and large enterprises have much higher frequency of use, as do other government users – both at times of events and non-operational times.

A critical part of estimating the value in use of LMR services is to attempt to estimate the extent of consumer surplus in the context of corporate users. The extent of consumer surplus is related to the elasticity of demand – the more inelastic is demand, the greater will be consumer surplus.

Table 5 and Figure 14 report the results of a survey question designed to elicit responses to organisational use of LMR services in the face of various hypothetical cost increases: 30% more costly, double the cost and 5 times the cost. Although respondents were asked for 'gut-feel' responses and, to this extent, the method can be regarded as somewhat unscientific, the responses are nonetheless instructive.

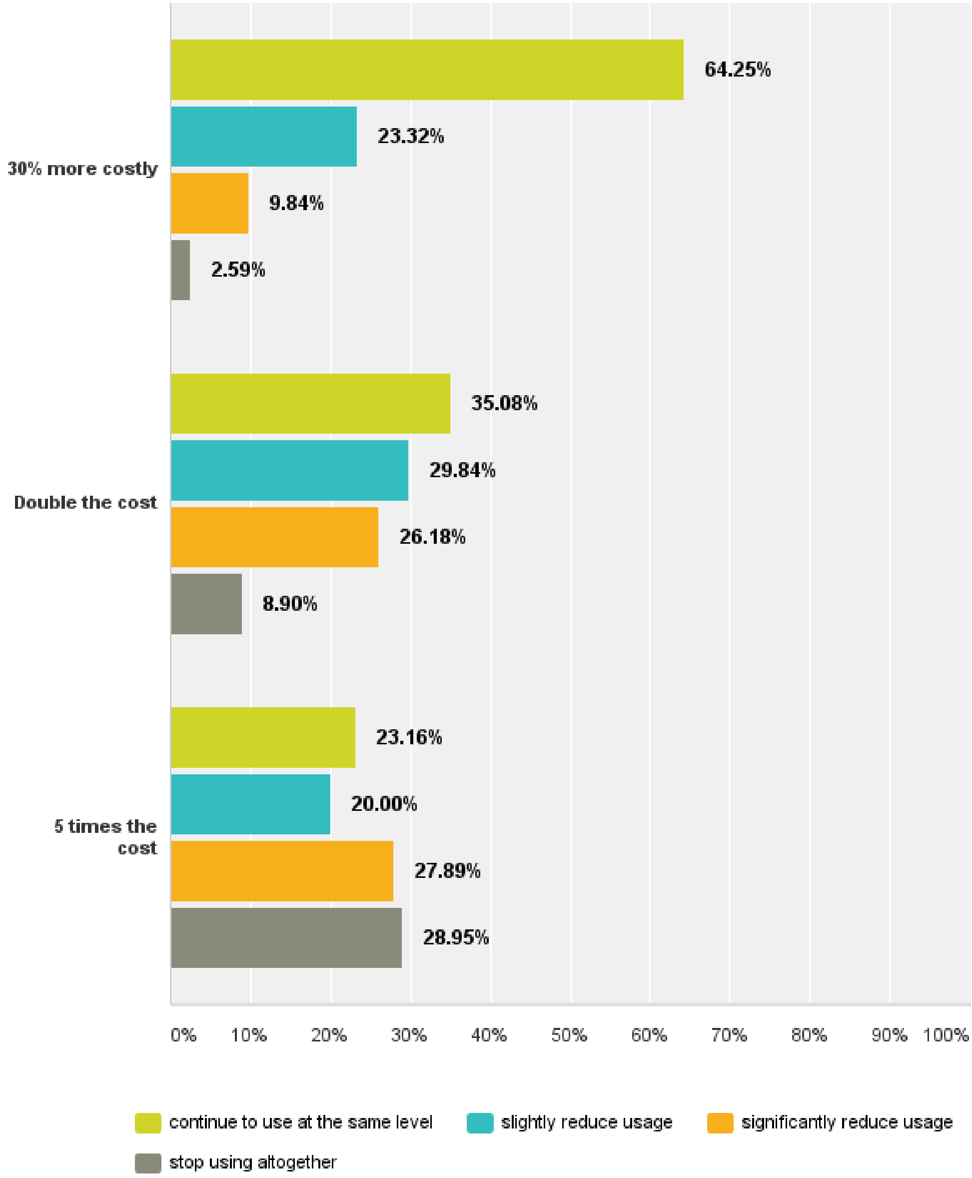
For a 30% increase 64.25% respondents predicted no change in organizational use of LMR, with 35.08% and 23.16% predicting no change for a cost doubling and a cost increase of 5 times respectively.

Percentages predicting slightly reduced usage in the three cases were 23.32%, 29.84% and 20%. These responses indicate strongly that a large to very large consumer surplus is associated with the use of LMR by the organisations surveyed.

Table 5: How do you think your organisation would respond in terms of its future use of LMR in relation to the provision of 'highly comms dependent activities' in the face of the following hypothetical cost increased for LMR services?

		Increase in LMR cost		
		30%	**Double**	**5 times**
Change to service provision level	No change	64%	35%	23%
	Slightly reduce	23%	30%	20%
	Significantly reduce	10%	26%	28%
	Stop using	3%	9%	29%

Figure 14: How do you think your organisation would respond in terms of its future use of LMR in relation to the provision of 'highly comms dependent activities' in the face of the following hypothetical cost increases for LMR services?



4.3 INTERVIEWS

Interviews were conducted in confidence and specific comments cited in this section are therefore not attributed. In general, communications or infrastructure managers were interviewed.

Organisational of mobile communications and LMR: interviewees were asked to comment on the significance of LMR systems and mobile communications in general for our organisations. Responses generally indicated that both mobile communications and LMR were indispensable for current operations. The key benefits of LMR included in its capacity to create shared situational awareness by providing open channel and instantaneous communications. LMR-based procedures and processes are deeply embedded into training and operations of these large organisations, in particular, emergency services providers. LMR is critical for providing not only information exchange in relation to time critical events that impact on community and operator safety but also have a key role in prosecuting crosschecking processes that are critical to ensuring operational effectiveness and operator safety. An example of the embedding of LMR in standard practice relates to the training given to operators in relation to succinctly and accurately describing emergency situations to base and other operators in the field. On-site operators are expected to 'paint a picture' and keep this updated to ensure operational effectiveness in a highly time critical environment. The expression 'mission-critical' was often used. The robustness of end user equipment, the resilience of LMR systems, the capacity for LMR terminals to operate on a peer-to-peer basis without central infrastructure, and the geographical range of LMR were all cited as key advantages.

'Substitutability' of public mobile systems for LMR: interviewees were questioned about the capacity of public mobile cellular communications systems to be used as substitutes for LMR. Responses repeatedly emphasised the need for organisations to 'manage their own destiny' and avoid 'putting all their eggs in one basket' that was not within their control. The high availability of LMR systems was seen as critical particularly where safety issues were paramount and for emergency services providers. Public mobile systems were most likely to be overwhelmed by demand in emergency situations, just when they are needed most. There was skepticism about current technologies for capacity privatisation on public networks although there was a willingness to consider such options in the future. Nonetheless, given the public safety aspects of many of the services delivered by these organisations, such solutions need to be adopted with a high degree of caution and require widespread consensus. Some interviewees saw a role for public mobile systems in offloading non-critical functions at the margin and to potentially carry data relating to enhanced service delivery.

Sensitivity of LMR use to cost changes: interviewees were asked hypothetical questions about the likely response of those organisations to various LMR cost changes. It was emphasised in questioning that responses should take account of all costs associated with LMR including capital and ongoing service charges. Interviewees were asked to consider hypothetical cost increase of 10%, 25% and 100%. It was pointed out that this line of questioning presented some conceptual difficulties particularly in that much of the cost of LMR is fixed in nature and so smooth variations in use level are generally not made in response to these costs. Interviewees were asked to consider these costs being advertised and consider how the organisation might respond to the cost changes described. In general, the responses to the 10% and 25% cost increases were that this would have no impact or 'very little' impact on use of LMR services and some means would need to be found to fund the additional cost. Even considering a 100% cost increase, interviewees responded that changes in use would be minimal given mission criticality of LMR and the absence of suitable substitutes.

Response to reduced access to spectrum: interviewees were asked to consider the impact on their organisations of a hypothetical reduction in availability of spectrum and capacity. One respondent emphasised the need for reliability and capacity by observing that his organisation receives a call (by phone) for assistance, on average every 27 seconds and receives around 3200 calls a day. Responding to this level of demand for services entails ongoing 'in time critical dispatch' by LMR. Any congestion or loss of functionality of radio systems would result in a degradation of service delivery and reduced public safety and care. Another interviewee responded that a loss of capacity might accelerate the movement to more spectrum-efficient digital services but this would imply significant capital costs and training costs. Most interviewees believed that their current spectrum allocations were sufficient but that they were almost fully utilised. One respondent commented that his organisation would like to acquire spectrum in the 1800 MHz range in order to build a private cellular network. This was an organisation with a relatively limited geographic operational footprint.

Other characteristics of LMR: interviewees were asked to freely describe the characteristics of LMR that make it useful in a particular organisational context. The open channel and instantaneous nature of LMR and its capacity to generate an 'all aware' communications modality was repeatedly emphasised. Interviewees repeatedly emphasised the functionality of LMR in emergency situations when publicly provided mobile cellular systems failed.

5 A LITTLE THEORY: INTRODUCTION TO THE MODELLING CONCEPTS

The economic contribution of an industry or sector is often measured in terms of the absolute size and share of income and employment that it generates in the broader economy – a 'value-added' approach. This approach is based on the national accounting framework that is used at the aggregate national level to identify GDP and other macroeconomic variables. Measures based on this framework are relevant and pertinent to a range of policy issues and economic analysis.

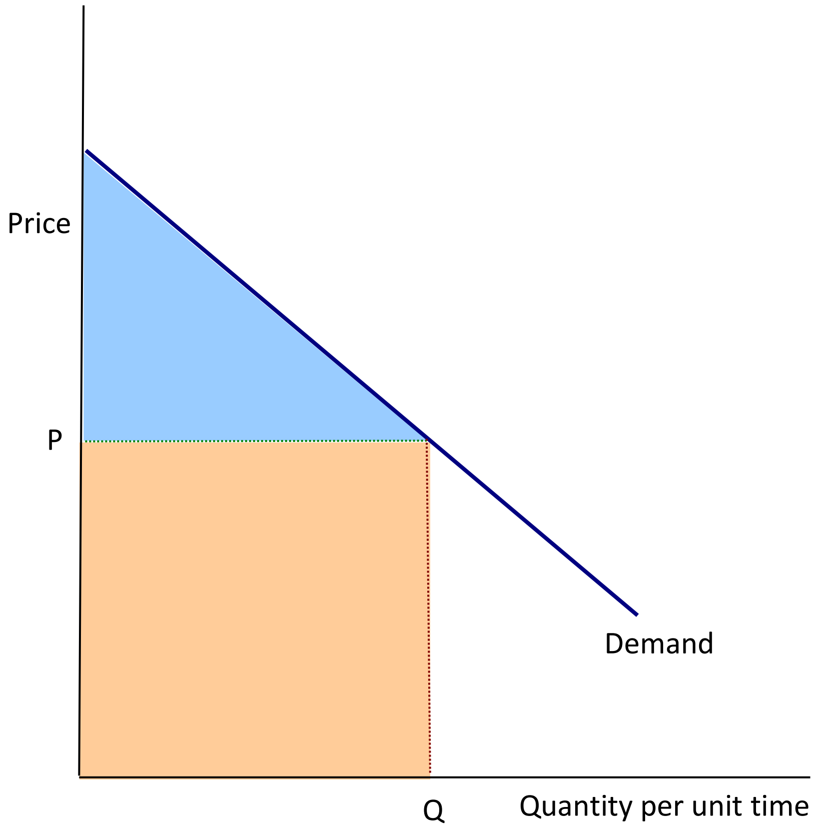
The focus of this project, however, as discussed in the previous section, is the economic benefit associated with the allocation of spectrum to LMR services. This is not measured by a simple value-added approach – in fact, the value-added approach would significantly underestimate economic benefit. A more comprehensive approach to determine the economic benefit of any product or service is necessary to give regard to the consumer surplus created in its consumption. Consumer surplus is defined as the benefit that the consumer enjoys in the act of consumption that is over and above the purchase price.

The difficulty of executing an empirical analysis based on consumer surplus is that such surpluses are not directly observable in market transactions. All that we can observe in examining market data (if, in fact, that data is available) is the market price which represents 'a floor' to consumers' evaluation of the benefit associated with consuming a particular product or service. What we cannot observe is the extent to which any particular consumer's evaluation is higher than the market price. It is on this additional surplus benefit that 'willingness-to-pay' analysis is based. Willingness-to-pay investigations attempt to establish the maximum prices consumers are willing to pay and thereby enable an estimation of associated consumer surpluses. Therefore, it is necessary to have information about market transactions and average willingness-to-pay in order to estimate the value of consumer surplus for a particular market. Figure 15 illustrates this visually with the region in orange representing total revenue in the market and the consumer surplus indicated in blue.

In the analysis in the next section we will employ the idea of a 'consumer surplus ratio' (CSR) which is simply the total value of consumer surplus divided by the total value of revenue in the market. In the case of the market represented in Figure 15 the CSR has a value of approximately 0.5 (by simple visual inspection).

It is important to emphasise the relationship between the existence of close substitutes, the elasticity of demand and the consequent value of CSR. If a particular product or service has no close substitutes, it will have a relatively low elasticity of demand. This means that even relatively large price changes elicit only relatively small changes in demand from consumers. The CSR will tend to be larger the lower is the elasticity of demand. This is illustrated in Figure 16.

Figure 15: The demand curve and consumer surplus



These relationships between substitutability, elasticity and consumer surplus are important for the economic modelling that follows. To presage the modelling: if LMR is judged to be 'indispensable' in some critical activities then this suggests that relatively high values of CSR should be used in the modelling.

In terms of economic theory, all of this is relatively straightforward (theoretically, if not empirically). But this discussion is based on goods and services that are transacted in a marketplace and for which are least some market variables can be observed (price, quantity traded per unit time, revenue). There are, however, two problems in applying this theoretical framework to the objective of estimating the economic benefit of spectrum allocated to LMR.

The first is that a significant proportion of LMR services are consumed by organisations and not final consumers. Economic theory does not ascribe 'utility' to organisations in the way it does to final consumers (while recognising that organisations are making choices on behalf of the needs of final consumers). Economists are concerned with maximizing the utility of end consumers, not businesses – economic benefits are defined as those benefits that flow to consumers or citizens, not to private for government organisations.

The second problem in applying consumer surplus analysis is that many of the organisations that use LMR provide public services which are not transacted directly with consumers.

Consumers determine the level of provision of the various emergency and first-responder services via political rather than market processes, and therefore there are no transactions or prices to observe.

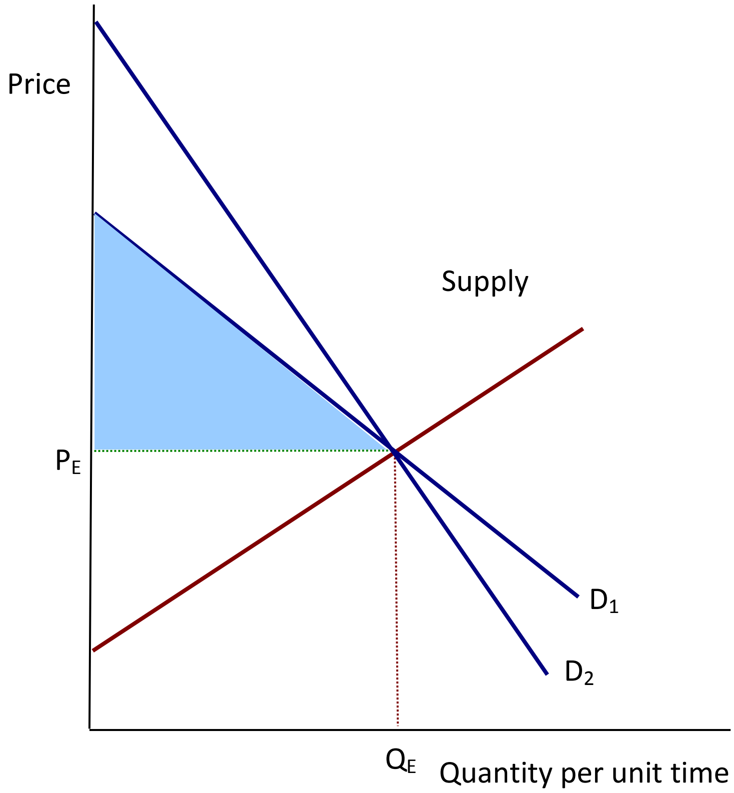


Figure 16: Elasticity of demand and consumer surplus

Our approach to dealing with these two problems is as follows. To begin with, we apply the logic of consumer surplus to LMR-using organisations. Even though LMR-using organisations are not final consumers, they are consumers of LMR equipment and services. Therefore their willingness-to-pay for LMR services can be legitimately estimated. Along with estimates of current levels of expenditure, consumer surplus for the organisation can therefore be estimated and an implied net benefit calculated. For those organisations that provide a public service that is not transacted, the traditional practice for calculating value-added is to value the services at their cost of provision. We argue that valuing these services at cost of provision substantially underestimates the economic benefit they produce. The basis for this position is that senior managers in a range of these organisations asserted strongly in interviews, even in the face of very large cost increases, that their organisations would continue to provide services at their current levels using LMR services at basically the same level as current. We believe that the correct interpretation of this view is that these services are so valuable to the community, that even at significantly higher costs they would still be provided at current levels through the same political process that currently determine their levels of provision. Another way of interpreting this position is that there are very large ‘consumer’ (or ‘citizen’) surpluses associated with the provision of emergency and first-responder services and that these surpluses flow through into surpluses in the demand for critical inputs to these services such as LMR. We believe that estimates of the consumer surplus of organisations in the LMR market are representative of the value created for final consumers of their services. We believe that the senior managers of publicly provided services are assuming additional budget resources would be provided to their organisations to cover the hypothetical LMR cost increases because the political processes that determine service provision levels would make these resources available. An interesting topic for further study would be to estimate (probably by willingness-to-pay survey) the consumer surplus in the final 'market' for emergency and first responder services.

This approach is in line with the core objective of communications regulators. The economic analysis used by communications regulators is directed at allocating resources (in particular, spectrum) and designing policy such that the sum total of economic benefits to society is maximised. This is obvious enough at a high level, but the practical application of this approach in specific circumstances is very difficult and requires data that is usually not available. This is especially the case where some of the services facilitated by spectrum users are public goods, are not transacted in a marketplace and where levels of provision are determined via political processes.

Estimating economic benefits in such cases requires making many assumptions that need to be explicit and transparent in the analysis. Nonetheless, there is a well-developed body of practice in the area of cost benefit analysis that provides a rich toolkit of techniques.

Given the primary focus is the estimation of economic benefits to end users, the core research question for this project is: what are the economic benefits that flow to end users/consumers/citizens for the allocation of spectrum to LMR services over and above the allocation of that spectrum to it next best possible use?

The methodological approach discussed below is essentially a 'top-down' approach in which we make use of the estimated aggregate cost of LMR services and add estimated consumer surpluses to this. A 'bottom-up' approach would also be hypothetically be possible. This would entail identifying the impacts on social welfare of the use of LMR in the provision of the various publicly and privately provided goods and services for which it is an input. While possible, this would be an enormously complex and expensive approach and nonetheless be subject to many data deficiencies and therefore require making many assumptions.

The methodology used in this study we believe is an effective and tractable means by which to estimate the economic value of the contribution of LMR spectrum to the services that it facilitates.

6 ECONOMIC BENEFIT MODELLING

6.1 PROJECT METHODOLOGY

The high-level description of the project methodology consists of the following elements:

1. Literature search and review of previous studies
2. Development and execution of two surveys: one for general users and one for senior management
3. Meetings and discussions with senior managers in significant LMR-using organisations
4. Collection of relevant published data and estimates of key industry data from industry participants
5. Development of economic modelling framework, using two approaches – a cost of equipment-based approach and a time-based approach
6. Incorporation of data and assumptions into modelling framework
7. Comparisons of data from other sources and studies to triangulate model results.

The modelling framework is a standard neoclassical economic approach using consumer surplus as the measure of economic benefit.

6.2 INTRODUCTION TO THE MODELLING

In this section we describe the modelling undertaken to estimate the economic benefit of LMR services. In general, the data is poor in relation to this objective. Ideally, it is preferable to have accurate information on the total annual capital and recurrent expenditure on all LMR equipment and services in Australia. This is not available in any central and coherent form and we have used several sources to approximate this value. In addition, as discussed in Section 4, we have undertaken two surveys and face-to-face interviews to assist in developing estimates of willingness-to-pay for LMR services. Below we describe the data sources and methods used to derive our estimates.

Table 6: Estimates of the number of LMR licences in Australia

Count of Active Licences*							
* Licences counted (not devices). *Cancelled*, *Surrendered* and *Not-Issued licences* have been excluded.							
			Number of Licences By Fee Density Area				
Licence Type	Coverage	Band	Australia	High Density Area	Low Density Areas	Medium Density Area	Remote Density Area
Land Mobile	Australia Wide	066-088 MHz	1		1		
Land Mobile	Australia Wide	148-174 MHz	58		5		
Land Mobile	Australia Wide	403-520 MHz	209		7		
50 radios/licence			**268**	**0**	**13**	**0**	**0**
Land Mobile	Local	066-088 MHz	68	302	2927	132	1004
Land Mobile	Local	148-174 MHz	66	2306	9023	487	2915
Land Mobile	Local	403-520 MHz	114	5694	10936	1857	6013
Land Mobile	Local	850-930 MHz		597	460	157	101
50 radios/licence			**248**	**8899**	**23346**	**2633**	**10033**
Land Mobile	Regional	066-088 MHz		36	27	10	
Land Mobile	Regional	148-174 MHz	2	150	42	31	14
Land Mobile	Regional	403-520 MHz	2	406	122	73	12
Land Mobile	Regional	850-930 MHz		3			
50 radios/licence			**4**	**595**	**191**	**114**	**26**
Land Mobile	Sub-Local	066-088 MHz	3	5	18	2	1
Land Mobile	Sub-Local	148-174 MHz	124	583	712	226	963
Land Mobile	Sub-Local	403-520 MHz	973	6867	4659	2503	2081
Land Mobile	Sub-Local	850-930 MHz		42	17	10	19
10 radios/licence			**1100**	**7497**	**5406**	**2741**	**3064**

6.3 IDENTIFYING THE NUMBER OF USERS/SERVICES DEPENDENT ON LMR

We begin by developing estimates of the number of users of LMR in Australia based on the recorded data on licence allocations. Table 6 provides estimates supplied by ARCIA of licences in various frequency bands and classified by ACMA 'Fee Density Areas'.

Based on this estimate of the number of licences allocated (around 65,000), we have estimated that there would be in the order of 2.5 million radios in use. It is likely, however, that only half of the channels are actually in use with dedicated radios loaded to them (particularly the smaller ones), and that a further quarter are only lightly loaded. Therefore, we estimate that there are around 1.5 million users on the 'licenced' channels. As a verification of this order of magnitude we note that:

— The IMS reports that there are approximately 1 million radios installed and in active use. As this is taken on equipment shipments over a period of time, it should be increased to take account of new sales, existing radios (and discontinued use).Therefore this data is supportive of the 1.5 million users estimated above.

- As discussed earlier (see Table 2 and Table 3), based on the general user survey undertaken for this report there are an estimated 500,000 employees[6]and a total of 1.4 million employees and volunteers in the organisations that responded to the survey. Based on the proportion of radio users, around 300,000 of the employees are LMR users and therefore it can be concluded that around 750,000-900,000 of the total number of users (including volunteers) use LMR. We would expect that the survey respondents cover most of the major LMR-using organisations, but not all, and therefore 750,000 to 900,000 is a lower end estimate of individuals involved, and this supports the estimate as above there are of the order of 1.5 million active radios.

In addition to the licences as estimated above, there is the use of the CB on UHF spectrum to consider. This is mostly for to lower-level recreational and private use. Users within this segment are covered by 'class licence', and as such do not have to pay individual licence fees, as all equipment is licenced when authorised for use in the band. The major uses within this segment include:

- Grey nomads and other casual users who travel and use it for communication with other similar users

- Long distance transport, although the use is not as prevalent as it was several years ago. There is very little use amongst 'local transport' operators.

- Agricultural operators such as farmers who use the low-cost communications as a business tool on their properties

- Quasi-business users in rural areas who use the UHF CB radio to talk to farmers as they coordinate local deliveries (fuel, fertiliser, etc) and civil construction projects where radio is used for coordinating small contractors

- Rural Fire Brigades, SES and other localised emergency support services who use the UHF CB as another communications tier in addition to their professional communications networks

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6 Note that employment in Emergency Services in total around Australia is estimated from their web sites at around 225,000 – and they survey would have captured around 90% of this number. The employment estimates by category are:

1. Police – combined Australian numbers from Police Federation Association web site – approximately 58,000
2. Fire - NSW – RFS 72,000; Vic – CFA 33,000, MFB 2500; SA – CFS 13,500, urban 1000; WA – FEAS 30,000; Qld – Rural 34,000, urban 4,000
3. Ambulance – NSW – 4,000; WA – 1,000; Vic – 1,000; Qld – 4,000; SA – 1,300; NT/ACT/Tas – 850
4. SES – Qld – 6,000; Vic – 5,000; SA – 1,600; NSW – 10,000

- Casual users who are be private operators that may talk to truck drivers, other private operators, organised groups, etc.

We estimate there are tens of thousands of units in private recreational or small business use. Many of them, however (with the exception of agricultural and quasi-business), will be used at lower rates than by other mainstream LMR users.

6.4 MODELLING APPROACHES

The following model has been developed to estimate the economic value of the LMR-using sector. There are two valuation frameworks employed as follows:

- The first approach is based on the value of the equipment used in providing the service. This is expected to provide a more conservative estimate, that is, to provide a lower-end estimate of benefit. This approach is based on the premise that organisations and individuals buy radio equipment because it generates the value, and that the value must be at least as great from that perspective as the cost of acquiring and using it. Therefore the costs associated with establishing and using LMR services is a 'floor' or minimum to the underlying surplus value from use. As described in the discussion above, however, the actual value will be greater for some users (where the value in use substantially exceeds the price paid) than for others, depending on the context in which the equipment is used.

- The second approach is an alternative method that assigns a value to each instance of use of radio equipment. This measure is based on how LMR is used, the type and quantity of use, and assigns value to this use based on the opportunity cost of the time taken for the use. The use of LMR enables the user to perform their role, and provides information about the relationship between this value creation and the characteristics of users. An average value is assigned for categories of user, and the number of uses multiplied by that value to give an aggregate value (per year).

The modelling identifies five separate user groups, as follows:

- General Recreation/Private

- Business Commercial – smaller business, including retail and wholesale, small transport (such as taxis), event operators

- Business Enterprise – larger corporate including mining companies, rail and large transport operations, large manufacturing businesses

- General Government and Utilities

- Emergency Services

In this model each user group is split into two – a more intensive user, for which the services provided are more critical, and a less intensive user.

6.4.1 EQUIPMENT VALUATION APPROACH

The method for estimating total value of equipment (see Table 7) begins with an average equipment value per user and this is multiplied by an estimated number of users to give an aggregate value of equipment. We assume that each piece of equipment has an 8 year life, and determine an annualised value using a 6% real discount rate. This annual value represents the 'floor' value related to the LMR services provided by the equipment (which, as described, is equal to the cost of the equipment).

The next step in the method is to apply a consumer surplus ratio to the annualised equipment value – the value-in-use over and above the cost. A ratio of zero would suggest that the value of service provided by LMR is exactly equal to the cost of providing the service across all uses. A ratio of one implies the service has additional value equal to the equipment cost. The consumer surplus ratio specified is multiplied by the equipment value to provide an estimate of the net value of the services based on the equipment.

The number of licences assumed is calibrated against the overall number of licences and radios in use as described above. The number of users as assumed in the table, and therefore the modelling, is 'matched' against the alternative estimates above giving a conservative estimate of 1.25 million users (relative to the other information that suggests the numbers could be as high as 1.5 million users) again, suggesting the modeling is on the conservative side.

The distribution across the type of user is based on information obtained from the survey, and also from public data, and can be taken as indicative.

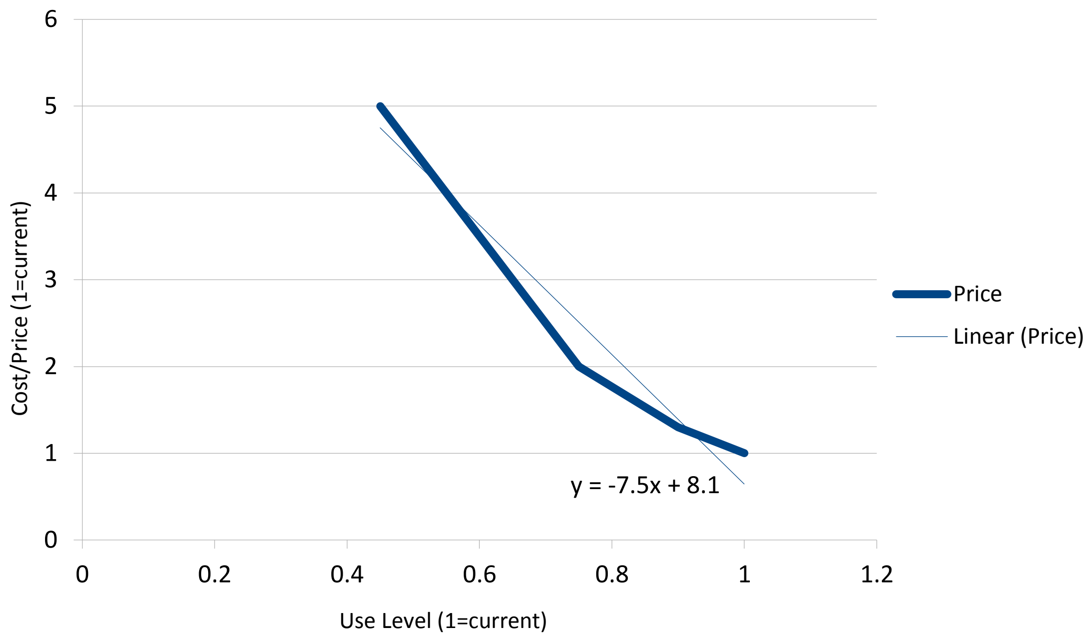
With respect to the underlying value of equipment value:

- The general survey indicates that private recreational users have equipment with an average value of $800. This is used as a base for the value in that user group.
- The management survey was focused on senior managers in a few larger entities and entailed more detailed questions about equipment value. Responses to this survey indicated an equipment value of around $20,000 replacement value per employee, or around $10,000 in book value. There would be a lower value per user if volunteers are taken into account although, on an ongoing average basis, their intensity of use is likely to be significantly lower than that of full-time employees. Thus, the values above are taken as an upper end of equipment value per user, as it is assumed that 'higher end' users (as have responded to the survey) have more complex systems and therefore have more comprehensive base systems and better individual radio units.

The Consumer Surplus Ratio (CSR) used in the analysis should be dependent on the underlying elasticity of demand. The elasticity of demand will be higher if there are few substitutes for LMR services. A CSR of less than one suggests that the demand is highly elastic and a value slightly greater than one indicates that the demand is somewhat elastic (more substitutes or less mission critical). A CSR much higher than one suggests that demand is inelastic.

The survey included a question on the anticipated implications of cost increases for corporate use of LMR. Using the responses, an indicative demand curve has been developed as shown in Figure 17.

Figure 17: Implied Demand Curve for LMR Use



This demand curve standardizes the current price/cost at an index value of '1' on the vertical axis, and the use level of '1' on the horizontal axis. The demand curve thus indicates the impact of use-level in response to various cost increases. This demand curve supports the observation that demand or use of LMR is relatively inelastic and, as such, assuming the demand curve was linear, would imply a CSR at the current point of use of around 4. The model uses slightly higher CSRs for users such as emergency services and lower for others (noting that emergency service users, large enterprises and other government in the survey make more extensive use of LMR).The values used for each type of use are shown in the 'CSR Ratio' column of Table 7. Some of the thinking on the value of these CSRs is informed by earlier work undertaken by the authors[7] in which CSRs were estimated from survey data.

6.4.2 TIME VALUATION METHOD

A value-in-use estimation approach employs a different perspective, and provides an estimate of value applied to each instance of equipment use.

The survey also asked respondents to identify their average levels of use. Responses indicated that users on average used equipment 47 times a day during operational events, and 22 times a

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7 *Creating new markets: broadband adoption and economic benefits on the Yorke Peninsula*, Simon Molloy, Barry Burgan and Sally Rao, 2008.

day in ‘non-operational or event’ periods. Emergency service users were close to double this average, while small business and other users were somewhat less. Based on these responses, the assumptions used for estimation purposes are that:

- General recreational users use a piece of equipment on average 6.75 times per week (based on the survey result that indicated that such users used LMR 2.7 times a day on average, and this is likely to be sporadic), while semi-business use was reported to be 20 times per week on average

- Business commercial uses each individual unit 20 times per day (average) for high end users and 10 times per day for other users

- Business enterprise use (including the mining industry and large manufacturing) is assumed to be similar to business commercial.

- General government and utilities are assumed to have a higher level of use per user (30 times per day for high end users and 20 for others)

- Emergency service use in the survey was indicated as being an average of 70 times a day during an event and 40 times on other days. The modelling is slightly more conservative with an average of 40 for high end users and 20 for other.

Every time radio is used it provides some value to users and this value will be based on the extent to which it enables them to do their job effectively, or to save time etc. The value per use will be higher the more critical is the context in which radio is used. The survey indicates that, in the view of users, LMR is highly critical, and more critical at time of greater ‘operational intensity’. Approximately 38% of respondents asserted that LMR was ‘critical and indispensable’ for ‘highly comms dependent activities’, while 30% said it was ‘extremely important’.

If we assume that an average radio call is 2 minutes in duration, then the implied wages value involved per use would be a little over $1 (based on a wage of $60,000). In the survey, respondents were asked how *not* having access to LMR would impact on organisational costs (if the current level of service provision were to be maintained), and the median response was ‘double the cost’. Therefore, the value of accessing LMR can be considered to be at least equal to the wage value per use, although it is noted that 40% of respondents said that it would not be possible to provide the service without LMR, and, accordingly, this assumption should be considered conservative. The modelling uses this value only for the more high-end users in the LMR intensive categories.

6.5 ESTIMATION RESULTS

The results of this applying this modelling framework, with the application of the assumptions as discussed are presented in Table 7.The equipment valuation method yields an economic benefit estimate of $1.99 billion per annum while the time valuation method yields $3.72 billion.

Thus, the core conclusion is that the economic benefits of allocating spectrum to LMR are of a significant value. The modelling suggests, on a conservative basis, that the annual value is between $2 billion and $4 billion. Almost 40% of the value is derived in the Emergency Services sector.

6.6 TRIANGULATING THE ESTIMATION RESULTS

The Queensland government has developed a statewide plan for managed radio services for all first responders and emergency services. The estimated cost to implement the system outlined in this plan over the 15 year period 2016 to 2031 was $2 billion, and this included all capital and ongoing service charges. If we take a simple approach and pro rata this up on a population basis, the cost of a similar system nationwide would be $9.95 billion over the same 15 year period. This is an average spend of $663 million per year. Using a discounted present value figure would give a cost figure of $1.03 billion per year (discount rate of 6%). Note that this is for emergency and first responder services only and so the fact that this figure is around half of our aggregate economic benefit is further order-of-magnitude confirmation of the model's performance.

Another point of reference for triangulation purposes is the 2012 study by Analysys Mason mentioned in Section 3 this study found that the economic value of 'private mobile radio' was £2.3 billion or around $4.26 billion. Given that the UK's population is around three times Australia's, this seems a little low but it needs to be recalled that Australia's much larger area means that coverage cost are much higher. In any case, this figure provides further order-of-magnitude validation of the model estimates.

Table 7: Economic benefits of land mobile radio: equipment and time based methods

	Est. Number of Users		Equipment Valuation					Time/usage Valuation			
	Licences	Individuals	Ave Equipment Value ($)	Aggregate Equip Value ($m)	Annualised Value ($m)	CS Ratio	Adjusted Annual Value ($m)	Ave Number of Uses	Total Annual Uses (m)	Value per Use	Total Annual Value ($m)
RECREATIONAL/PRIVATE											
General Recreation	na	30,000	$600	$18.0	$2.90	0.5	$1.4	351	10.53	$0.20	$2.1
Private -semi Business	na	30,000	$1,000	$30.0	$7.12	1	$7.1	1053	31.59	$0.25	$7.9
Total	*na*	*60,000*	*$800*	*$48.0*	*$10.02*	*0.86*	*$8.6*	*1404*	*42.12*	*0.45*	*$10.0*
BUSINESS COMMERCIAL											
High end	13,000	296,400	$3,000	$889.2	$143.19	1.5	$214.8	5200	1541.28	$0.50	$770.6
Other	25,000	570,000	$1,000	$570.0	$135.32	1.2	$162.4	2600	1482	$0.25	$370.5
Total	*38,000*	*866,400*	*$1,684*	*$1,459.2*	*$278.51*	*1.35*	*$377.2*	*3489.4*	*3023.28*	*$7.00*	*$1,141.1*
BUSINESS ENTERPRISE											
High end	5,000	114,000	$7,000	$798.0	$128.51	2	$257.0	5200	592.8	$1.00	$592.8
Other	5,000	114,000	$1,500	$171.0	$40.59	1.5	$60.9	2600	296.4	$0.50	$148.2
Total	*10,000*	*228,000*	*$4,250*	*$969.0*	*$169.10*	*1.88*	*$317.9*	*3900*	*889.2*	*$0.83*	*$741.0*
GENERAL GOVERNMENT AND UTILITIES											
High end	2,000	45,600	$7,000	$319	$51.40	5	$257.0	7800	355.68	$1.00	$355.7
Other	2,000	45,600	$1,500	$68	$16.24	2.5	$40.6	5200	237.12	$0.50	$118.6
Total	*4,000*	*91,200*	*$4,250*	*$387.6*	*$67.64*	*4.40*	*$297.6*	*6500*	*592.8*	*$0.80*	*$474.2*
EMERGENCY SERVICES											
High end	5,000	114,000	$10,000	$1,140	$183.58	5	$917.9	10400	1185.6	$1.00	$1,185.6
Other	3,000	68,400	$2,000	$137	$32.48	2.5	$81.2	5200	355.68	$0.50	$177.8
Total	*8,000*	*182,400*	*$7,000*	*$1,276.8*	*$216.06*	*4.62*	*$999.1*	*8450*	*1541.28*	*$0.88*	*$1,363.4*
TOTAL											
LMR	**60,000**	**1,254,000**	**$3,264**	**$4,093**	**$731.31**	**2.72**	**$1,991.8**	**4822**	**6047**	**$0.62**	**$3,719.8**
UHF-CB	**na**	**60,000**	**$800**	**$48**	**$10.02**	**0.86**	**$8.6**	**1404**	**42.12**	**$0.24**	**$10.0**

6.7 POTENTIAL FOR FUTURE RESEARCH AND EXTENSIONS TO THE MODEL

The research and modelling could potentially be extended in the following ways:

- Additional sources of value: commercial use has impacts on business costs and business productivity. An alternative/additional perspective would be to align estimated consumer surplus values with business cost increases should the current use of LMR become not possible in the future, and to investigate productivity and competitiveness impacts.

- An alternative view on public safety value: the perspective is that LMR is a critical factor in the delivery of public safety, and emergency services. Public sector spending on safety in Australia is estimated at $26.4 billion in 2012/13 or almost 5% of government expenditure[8]. This is seen in the literature as a under-estimate of the total value, with, for example, a range of studies indicating that, in addition to this, there is significant volunteer time involved, with studies of the volunteer time in the SES indicating that this time would be worth $120 million in Victoria and NSW in 2006[9]representing around $200 million for Australia as a whole. Therefore if use of LMR was considered in its role in these organisations as reducing costs of operation by (say) 5%, this would suggest that the value is of the order of $1 billion annually. This does not consider the impact of access to LMR in terms of response times, and therefore effectiveness.

- Estimation of direct consumer surplus in the provision of emergency and first responder services. A methodology could be devised to estimate 'consumer' surplus for these services. This would be another source of triangulation for the estimates in this study but would also shed light on the economic value of these services in their own right. This has emerged as a critical question in the current research. Over and above spectrum allocations, society devotes significant resources to such services. What is the social value proposition of these services and how should changing communication expectations influence future policy decisions?

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8 5512.0 - Government Finance Statistics, Australia, 2012-13

9 Aust Council of State Emergency Services, *The Value of Volunteers in State Emergency Services*, October 2007

7 ESTIMATING THE VALUEOF SPECTRUM FOR LMR

7.1 CHALLENGES IN VALUING SPECTRUM FOR LAND MOBILE SERVICES

In the previous section we generated estimates of the economic benefits of LMR spectrum use. In this section we develop estimates of the value of this spectrum in the next best possible use. We assume that this value would be realised in an unconstrained auction of the spectrum. This requires a benchmarking and estimation of what the auction price(s) would hypothetically be.

Spectrum bands for land mobile services are difficult to value due to their largely non-commercial nature. Land mobile stations typically provide one-to-many or one-to-one communication services for many government services including law enforcement, defense, security and first-responder organisations as well as for a range of commercial and community uses.

While there is significant commercial use, for example throughout the transportation, rail and utilities sectors, the lack of market-based spectrum assignments poses another challenge to valuation. In order to deal with increasing congestion, regulators have begun implementing opportunity cost (OC) pricing for certain spectrum bands. In Australia, ACMA has begun imposing OC-based taxes on apparatus licences in the 400 MHz band in high-density areas.

While there are no current examples of market-based spectrum prices for land mobile services, previous auctions of 400 and 500 MHz spectrum in Australia and overseas may provide a reasonable indication of the value of land mobile spectrum in these bands. This includes Australia's auction of 500 MHz spectrum in 1997, and a limited number of auctions in the United Kingdom and Europe.

7.1.1 AUSTRALIA'S 500 MHZ AUCTION (1997)

The 500 MHz auction conducted in 1997 was the first allocation by simultaneous ascending auction in Australia. According to ACMA it was the first allocation of technology flexible spectrum licences in the world. The 500 MHz band spectrum licences were allocated by auction with 838 lots offered, ranging in bandwidth from 12.5 kHz to 1 MHz.

The total spectrum auctioned was 2x4 MHz, suitable for pairing but sold unpaired. The duration of the licences was 10 years, with all but four licences extended to 15 years in 2000. The spectrum bands auctioned were:

- Lower band: 500.99375 - 504.99375 MHz
- Upper band: 510.99375 - 514.99375 MHz

The auction concluded after 64 rounds on 25 March 1997 and all but one of the 13 participants in the auction were successful in acquiring licences. At the close of the allocation some of the auction lots remained. The total amount raised in the auction was $1,062,077. Applications for the residual lots were then invited quarterly, commencing in January 2004.

As shown in Table 8, the average annualised price per kHz per 1 million population was approximately $0.82. However, there were a range of prices paid across the 838 lots depending on demand in each area.

Table 8: Average spectrum price per kHz per population in Australia's 500 MHz auction

Spectrum auctioned	Amount raised	Population (1997)	Original licence duration	Average annualised price / kHz / population
2x4 MHz	$1,062,077	16,135,100	10 years	$0.82

Some 500 MHz spectrum licences that expired on 31 May 2007 were subsequently also re-offered for sale with duration of 5 years. An outcome of ACMA's 400 MHz band review was that spectrum licensing in the 500 MHz band would cease when licences expired on 31 May 2012. Spectrum in this band is now subject to apparatus licensing.

7.1.2 OTHER SPECTRUM VALUE BENCHMARKS

A limited number of spectrum auctions have taken place overseas, including in the United Kingdom, Ireland and Sweden. Table 9 shows a comparison of auction results published as part of an ACMA-commissioned study of Administrative Incentive Pricing (AIP) in the 400 MHz band. The comparison includes Australia's subsequent auctions of 500 MHz spectrum in 2007.

Table 9: International comparison of 400 and 500 MHz land mobile spectrum auction prices10

Country	Auction	Bandwidth	Duration	Coverage	Equivalent annualised cost / kHz (AUD)	Equivalent annualised cost / million pop / kHz (AUD)
Australia	Residual 500 MHz (2007)	(2x12.5 kHz) + (2x25 kHz) + (2x37.5 kHz)	5 years	Sydney	14.4	3.34
Australia	Reallocated 500 MHz (2007)	12.5 kHz to 1 MHz	5 years	Sydney	2.3 to 16.3	0.53 - 3.79
UK	413 / 423 MHz	2x2 MHz	15 years	National	94.8	1.56
Ireland	413 / 423 MHz	2x2 MHz	10 years	National	13.3	3.24
Ireland	411 / 421 MHz	2x2 MHz	10 years	National	6.8	1.66
Sweden	454 / 464 MHz	2x18 MHz	15 years	National	510	56.7

[10] http://www.acma.gov.au/webwr/_assets/main/lib310867/ifc12-9_app_a_1_plum_report_to_acma.pdf

ACMA noted that the Swedish auction was skewed by a winning bid that was significantly higher than others and so this result was excluded as an outlier. It also noted the UK spectrum was significantly constrained by the need to protect a military early warning radar at Fylingdales, which would have depressed the UK values.

Table 10 provides a comparison of these results with 700 and 800 MHz auction results held in the same countries (excluding Sweden), with values expressed as an annualised price per MHz per 1 million population.

Table 10: Comparison of 400/500 MHz and 700/800 MHz auction results

Country	Auction	Annualised price / MHz / population (AUD)	Auction	Annualised price / MHz / population (AUD)
Australia	Residual 500 MHz (2007)	0.00334	700 MHz (2013)	1.36 (reserve price)
Australia	Reallocated 500 MHz (2007)	0.00053 - 0.00379		
United Kingdom	413 / 423 MHz	0.00156	800 MHz (2013)	0.29
Ireland	413 / 423 MHz	0.00324	800 MHz (2012)	0.28
Ireland	454 / 464 MHz	0.00166		

Source: ACMA (2008), WPC (2014)

7.2 OPPORTUNITY COST PRICING IN THE 400 MHz BAND

In January 2010, the ACMA announced an in-principle decision to use opportunity cost ('OC') pricing for certain bands in order to manage spectrum more efficiently. In August 2012, the ACMA introduced OC pricing for the 400 MHz band in high-density areas. ACMA determined that an OC price of $199 per kHz was appropriate, with this price to be achieved through a series of 15 per cent increments in the licence tax rate (plus an annual CPI escalation).

This staged implementation reflects uncertainty about the 'true' market-clearing price and provides flexibility to ACMA to discontinue tax increases if congestion is eventually removed. The remaining increments towards the full OC-based tax rate are yet to be made, and will only be implemented after monitoring the impact on demand and congestion of the tax increase and other regulatory changes. Table 11below shows the current licence taxes, with the current tax rate for high-density areas for the 400 MHz band (403 - 520 MHz) being $121.7524 per kHz.

Table 11: Current annual apparatus licence taxes for land mobile (per kHz)[11]

Country	Auction	Bandwidth	Duration	Coverage	Equivalent annualised cost / kHz (AUD)	Equivalent annualised cost / million pop / kHz (AUD)
Australia	Residual 500 MHz (2007)	(2x12.5 kHz) + (2x25 kHz) + (2x37.5 kHz)	5 years	Sydney	14.4	3.34
Australia	Reallocated 500 MHz (2007)	12.5 kHz to 1 MHz	5 years	Sydney	2.3 to 16.3	0.53 - 3.79
UK	413 / 423 MHz	2x2 MHz	15 years	National	94.8	1.56
Ireland	413 / 423 MHz	2x2 MHz	10 years	National	13.3	3.24
Ireland	411 / 421 MHz	2x2 MHz	10 years	National	6.8	1.66
Sweden	454 / 464 MHz	2x18 MHz	15 years	National	510	56.7

Using Plumb's estimate for the 'typical' user ($269) as an upper bound and the existing price, $90, as a lower bound, a mid-point was considered a prudent price target to encourage a movement to higher value use/users. The purpose of the price increments is to observe whether demand equalises with supply at one of the interim increments. If so, the price would be kept at that level until demand once again started to outstrip supply.[12]

In the calculations for the 400 MHz in Sydney, the average user was assumed to be a land-mobile user with 25 mobiles. In the less dense region of Perth the average user may be assumed to be a land-mobile user with a need for less than 25 mobiles.

7.3 VALUATIONS MORE BROADLY

It is difficult to determine the amount paid for LMR apparatus fees as currently ACMA only report on the total aggregated apparatus fees paid in any year. However, from ARCIA's estimates of the count of active licences, the total estimated annual licence fee is over $33 million per annum. This estimate is reduced to just under $19 million if spectrum allocated 'free of cost' for government use is taken into account. Table 12 below shows ARCIA's estimate of the number of licences issued for LMR by area of coverage and density area, Table 12 shows the licence rates and total licence fees paid.

[11] www.acma.gov.au/~/media/Economic%20Research%20and%20Spectrum%20Pricing/Information/pdf/Apparatus%20licence%20fee%20schedule.pdf

[12] www.acma.gov.au/webwr/_assets/main/lib310867/ifc12-09_final_opportunity_cost_pricing_of_spectrum.pdf

Table 12: ARCIA's estimate of active LMR licences[13]

Coverage	Band	Australia	High-density area	Low-density area	Medium-density area	Remote-density area
Australia-wide	066 – 088 MHz	1	-	1	-	-
	148-174 MHz	58	-	5	-	-
	403-520 MHz	209	-	7	-	-
	Total licences	**268**	**-**	**13**	**-**	**-**
Local	066 – 088 MHz	68	302	2,927	132	1,004
	148-174 MHz	66	2,306	9,023	487	2,915
	403-520 MHz	114	5,694	10,936	1,857	6,013
	850-930 MHz	-	597	460	157	101
	Total licences	**248**	**8,899**	**23,346**	**2,633**	**10,033**
Regional	066 – 088 MHz	-	36	27	10	-
	148-174 MHz	2	150	42	31	14
	403-520 MHz	2	406	122	73	12
	850-930 MHz	-	3	-	-	-
	Total licences	**4**	**595**	**191**	**114**	**26**
Sub-local	066 – 088 MHz	3	5	18	2	1
	148-174 MHz	124	583	712	226	963
	403-520 MHz	973	6,867	4,659	2,503	2,081
	850-930 MHz	-	42	17	10	19
	Total licences	**1,100**	**7,497**	**5,406**	**2,741**	**3,064**

Table 13: ARCIA's estimate of licence fees based on density area

	Australia	High-density area	Low-density area	Medium-density area	Remote-density area	Total
Australia-wide coverage						
No. of licences	268	-	13	-	-	281
Licence fee rate	$2,362	-	$236	-	-	-
Total licence fees	**$633,016**	**-**	**$3,068**	**-**	**-**	**$636,084**
Local coverage						
No. of licences	248	8,899	23,346	2,633	10,033	45,159
Licence fee rate	$2,362	$1,522	$0	$0	$0	-
Total licence fees	**$585,776**	**$13,544,278**	**$0**	**$0**	**$0**	**$14,130,054**
Regional coverage						
No. of licences	4	595	191	114	26	930
Licence fee rate	$4,724	$3,044	$1,210	$210	$210	-
Total licence fees	**$18,896**	**$1,811,180**	**$231,110**	**$23,940**	**$5,460**	**$2,090,586**
Sub-local coverage						
No. of licences	1,100	7,497	5,406	2,741	3,064	19,808
Licence fee rate	$236	$152	$61	$37	$37	-
Total licence fees	**$259,600**	**$1,139,544**	**$329,766**	**$101,417**	**$113,368**	**$1,943,695**
All coverage areas						
Total licence fees	**$1,497,288**	**$16,495,002**	**$563,944**	**$125,357**	**$118,828**	**$18,800,419**

Another estimate of value can be achieved based on the annual opportunity cost-based fees assigned by ACMA for licences based on the four density areas. There are three high-density areas (Sydney/Wollongong, Melbourne/Geelong and Brisbane/Gold Coast), three medium density areas (Perth, Adelaide and Newcastle) and four low-density areas (East Australia low-

13 Cancelled, surrendered and non-issued licences excluded.

density area, Western Australia low-density area, Tasmania low-density area and Darwin low-density area). All other areas are categorized as remote density.

We can estimate a total nationwide licence value of $775 per kHz or $775,249 per MHz per annum. An estimated 120 MHz is used for LMR in Australia. An estimated 50 percent of high-density spectrum is in use, along with 20 percent of medium-density and 10 percent of low-density spectrum. Based on these assumptions, the estimated spectrum value for LMR (ignoring discounted value for government use) is estimated at $39.7 million per annum.

The final consideration is to attach some consumer surplus value to the estimate of spectrum value. The logic for this step is essentially the same as that applied to the estimation of benefits arising from use of spectrum for LMR. If, for example, a telecommunications paid $40 million for the spectrum in question it would provide services on a commercial basis using this spectrum and the consumers of these services would enjoy some associated consumer surplus.

The obvious next question that arises is what value of CSR to use? As discussed earlier, if products and services have numerous close substitutes, they tend to have higher elasticity's of demand and lower consumer surpluses. We could argue that a telecommunications company would use spectrum in the 400 to 500 MHz range to provide telephony and wireless broadband services, that is, to provide additional service to those it already provides. It may also be that the lower capital costs required to deliver services in this spectrum frequency could lead to lower prices for consumers leading to greater consumer surpluses. The general point, however, is that there are substitutes for these new hypothetical services and this would suggest a lower value CSR is appropriate– around 1.0 or 0.5.

A counter argument for a higher CSR value might be that spectrum for mobile services in this frequency range might lead to services being made available in more remote regions and these services would have fewer substitutes. While this is true, the population numbers would be small and the absolute size of the benefit would likewise be small. Nonetheless, a CSR vale of 2.72 – the average value used for the 'equipment-based method' in Section 6 might be justifiable (see Table 7) on this logic.

In the absence of better data about appropriate CSR values, this discussion is largely speculative. But even if we used the highest value CSR used in the benefit estimates above – a value of 5 – the benefit value of the spectrum in its next best use would be around $200 million (39.7 x 5). This is only one tenth of the lower bound estimate of benefit in the current use ($1.99 billion) and around one-twentieth the upper bound estimate ($3.73 billion).

In other words, the allocation of spectrum to the current set of uses (including, critically, emergency and first responder services) generate an economic benefit *at least 10 times greater* that the benefits that would be generated by its allocation via a market-based processes to the next best use.

8. CONCLUSIONS

As described above, the core research question of this project is to answer the question: what is the economic benefit that arises from allocating spectrum to LMR services in Australia.

We have discussed the paucity of detail data available for answering this question and the project itself has gone some way to addressing this problem by undertaking a general user survey and other data gathering exercises.

We have generated two sets of estimates of economic benefits: one based on LMR equipment costs and one based on associated time costs. We believe the former is demonstrably conservative. The equipment valuation method yields an economic benefit estimate of $1.99 billion per annum while the time valuation method yields $3.72 billion.

Compared with this is the opportunity cost of the spectrum used for LMR is estimated to be $39.7 million per annum.

Table 14: Economic benefit estimates from modelling

Method	Economic benefit estimate
Equipment valuation method	$1.99 billion per annum
Time valuation method	$3.72 billion per annum

Set against these benefit estimates the estimated opportunity cost of $39.7 million per annum is relatively tiny, almost *de minimis.*

Even if this value is factored up using the highest value of consumer surplus ratio used in the benefit estimate analysis, the allocation of spectrum to the current set of uses (including, critically, emergency and first responder services) generates an economic benefit at least 10 times greater that the benefits that would be generate by its allocation via a market-based processes to the next best use.

Although rapid technology-driven changes appear set to rapidly transform services through the introduction of digital radio and mobile cellular broadband communications, the organisations that use LMR, particularly emergency service and first responder services, are deeply dependent on mission critical radio to delivery on their various missions. Radio is fundamentally embedded into their operations and procedures and radio delivers a level and type of connectivity and resilience that is not available from alternative technologies.

In this context, assertions about the substitutability of alternatives to radio need to be carefully considered and the community's rising expectations of emergency services also need to be factored into such evaluations.

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