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Land of White Space Opportunity: Channel Planning and DTV Restack in Australia

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1. Introduction

Ever increasing demand for broadband wireless access (BWA) services is stretching spectrum capacity in Australia and around the world. A regulatory response that has emerged in other countries in recent years is to allow or ‘tolerate’ productive usage of the buffer bands between TV channels (known as white spaces) by wireless devices that are more sophisticated and capable than the low power and short range devices that have long shared the UHF band with high power terrestrial television services.

White spaces are channels that have been allocated for terrestrial television broadcasting but which have not been assigned to the provision of television services in a particular licence area. These unused channels have traditionally served a variety of purposes, arising from (i) the need for guard spaces between analog TV services in the same licence area, (ii) the need for geographic separation between TV services that are in different licence areas but are broadcasting on the same channel, and (iii) usage opportunities in areas where channels are not allocated to broadcasters due to supply constraints (small number of authorised or deployed services) or demand weakness (e.g. low population density or alternative transmission technologies).

In an age of acute spectrum scarcity, allocated but unused ‘beachfront’ spectrum always presents an efficiency puzzle to regulatory agencies such as the Federal Communications Commission (FCC), the UK’s Ofcom, and the Australian Communications and Media

Authority (Peha 2008; Freyens and Yerokhin 2009; Mullane 2009; Cave 2010; Levy and Freyens 2010). Although the white spaces serve a legitimate and useful purpose in the planning and delivery of high quality terrestrial television services, new technologies have emerged that promise significant (if not exponential) increases in the productive and allocative-efficient usage of white spaces while minimising the potential for interference to the reception of terrestrial television services. A device, which opportunistically uses these available channels, is commonly referred to as a ‘white-space device’.

White space devices (WSD) have so far adopted two types of profiles (Freyens and Loney 2010): (i) low power and short range ‘symbiotic’ WSD, such as wireless microphones and biomedical telemetry monitors, which broadcasters have long tolerated, and (ii) ‘invasive species’, such as a emerging higher power WSD based on advanced technologies that are proposed to exploit white spaces on a much larger scale and in a more dynamic fashion -typically to provide broadband wireless access services. In the US, invasive WSD have recently acquired secondary (unlicensed) rights against the wishes of broadcasters through controversial regulatory decisions such as adopted by the FCC in November 2008 (FCC 2008). As we will discuss in later sections, the regulatory context is less controversial in Australia, but similarly to the evolution in the US, the usage rights of white space users have been expanding over time.

It is therefore apparent that regulatory agencies in many jurisdictions recognise the important economic role played by WSD. In this article, we examine the threats and opportunities in Australia for symbiotic and invasive WSD as the UHF spectrum allocated to broadcasting shrinks from 300 MHz (520-820 MHz) to 174 MHz (520-694 MHz) and as the share of this spectrum held by telecommunications companies expands? Will invasive

WSD be able to survive and thrive in a smaller environment that may well be more densely populated by high power digital terrestrial television services? Can symbiotic WSD survive in a changed environment with less available resources and more advanced competitors? With these questions in mind, we first present the regulatory context for white space usage in Australia. We then present current plans for UHF reallocation, and discuss the nature of the opportunities and challenges confronting invasive and symbiotic WSD at different stages of the reallocation process.

2. Regulating white space usage

Whereas in the US pre-2008 white space arrangements rested on tolerance for symbiotic WSD and regulatory enforcement for invasive species, a different evolution took place in Australia. Here, secondary usage rights for symbiotic WSD have long been authorised by class licences (such as the LIPD class licence for low interference potential devices). The Australian regulator has typically (but not always) used its class licensing powers to establish open access regimes that are similar to the ‘unlicensed’ approach used in other countries.

This open access class licensing approach has long been used to authorise the operation of symbiotic white space devices in the broadcasting services bands in Australia. The broadcasting services bands are those bands that have been designated by the Minister as primarily for broadcasting services (and thus subject to planning under the Broadcasting Services Act). Importantly, secondary usage of the broadcasting services bands is subject to the over-riding requirement to protect their utility for broadcasting services. In practice, the long term nature of available white spaces – a consequence of the essentially static use

of the broadcasting bands for television services – meant that usage rights for symbiotic WSD were relatively easy to define, well understood by industry and straightforward to implement.

As a result, usage rights for symbiotic WSD in Australia are well specified and have proved less controversial than in some other countries. However, it is the case that the introduction of digital terrestrial television services on a simulcast basis from 1 January 2001 significantly reduced the availability of white spaces for use by symbiotic WSD in Australia – because previously unallocated channels available as white spaces were allocated to the new digital terrestrial television services. This effect was particularly pronounced in major metropolitan areas where symbiotic use of white space was highest.

A decade after the introduction of digital terrestrial television services, 2010 was a watershed year for the use of the UHF band in Australia. The progressive switch off of analog terrestrial television services started on 1 July 2010 with the move to digital only services in the Mildura / Sunraysia licence area in western Victoria and New South Wales. In June, the Australian Government announced that there would be a “digital dividend” of 126 MHz of high value spectrum in the UHF band. The digital dividend encompassed the entire 700 MHz band – from 694 MHz to 820 MHz – and would become available for next generation networks after the completion of digital switchover in 2013 and the subsequent “restacking” that is required to accommodate digital terrestrial television services in the lower part of the UHF band from 520 MHz to 694 MHz.

These developments mean that there will be substantial changes to usage rights in the UHF band in Australia over the next 3-5 years. The government decision to use of the lower part of the UHF band from 520 MHz to 694 MHz to provide digital terrestrial

television services, and the planning approach adopted to restacking all digital services into this reduced frequency range, means that 520-694 MHz will be of high interest to – and presents a significant opportunity for – proponents of invasive WSD.

The digital dividend and the restacking of digital terrestrial television services required to achieve it also have significant implications for symbiotic WSD that have long inhabited the white spaces between 520 MHz and 820 MHz. The future use of 520-694 MHz for digital terrestrial television services presents an opportunity – albeit one that invasive WSD will also be competing for – while the reallocation of 694-820 MHz to other services, most likely under spectrum licensing arrangements, presents a significant threat. In contrast to the regime flexibility available to the regulator in areas where apparatus licences predominate, spectrum licences have provided exclusive access to their licensee since they were first issued in 1997. A spectrum licence is for a large ‘spectrum space’ defined by frequency and geographic boundaries rather than for the operation of specific devices at specific locations (the typical authorisation characteristics of an apparatus licence). Spectrum licences effectively confer exclusive leasehold property rights to their holders and are commonly used to assign spectrum usage rights to telecommunications services provided by technologies such as 3G and WiMAX (spectrum licences are typically service neutral and technology flexible but their predominant use since 1997 has been for mobile telecommunications services).

Because the majority of the digital dividend will be reallocated by issuing spectrum licences, these regulatory constraints would have effectively denied symbiotic WSD access to the 694-820 MHz frequency range once the spectrum licences came into effect. However, after a consultation process that commenced in 2006 when the regulator released

a discussion paper about a proposal to amend the Radiocommunications Act (ACMA 2010a) the recent changes to that Act by the Parliament of Australia will allow ‘co-existence’ between class and spectrum licences, subject to the regulator being satisfied that a class licence is in the public interest and will not result in unacceptable interference to spectrum licensees. This legislative development is an important milestone in the a decade-and-a-half long property right vs. shared access debate, which has been particularly virulent in the US (Freyens 2010).

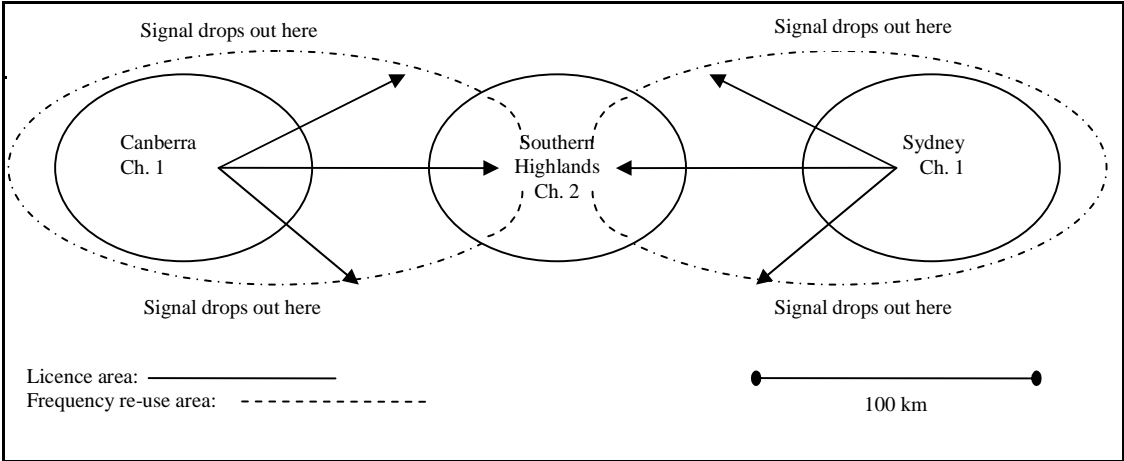
Regardless, while a significant regulatory impediment has now been removed, the regulator and industry will still need to consider whether the operation of symbiotic WSD will be technically viable and economically efficient between 694 MHz and 820 MHz after the clearance of high power terrestrial television services and the widespread deployment of advanced telecommunications services (the regulator, of course, will also need to specifically consider the legislative requirements identified above) (Freyens and Loney 2010).

3. White spaces and channel planning

Future white space opportunities in Australia are within the 520-694 MHz frequency range. What will this segment of the UHF band look like after digital dividend and digital restack? Most licences areas, and particularly metropolitan areas, require at least 6 main transmitter channels (one for each of the 6 broadcasting services; 2 public broadcaster services (PBS), 3 commercial broadcasters (CBS) and one unallocated channel used by community service channels in some locations). Because of its large size and low

population (albeit concentrated in metropolitan areas), Australia typically plans its channels on a noise-limited basis rather than the interference-limited basis (which is often necessary in more densely populated countries such as the US or the UK). This is essentially a reflection of the discretion afforded by the much smaller number of metropolitan areas in Australia, relative to most other industrialised countries. Table I below illustrates the white space opportunities offered by noise-limited channel planning.

Table I. Channel planning on noise-limited basis



Consider a specific service broadcast on notional channels 1 and 2 across three adjacent licence areas, such as Canberra, Southern Highlands and Sydney. Each licence area may, for instance, have a radius of 100km. Within each licence area, the object of the planning process will be to ensure reliable reception of high quality services. However, it will not be possible to reuse a channel until the frequency reuse distance is exceeded (that is, the distance at which the strength of the radiated signal drops below a level where it is not expected to interfere with reception of another service using the same channel). This will

typically be much larger than the radius of the licence area. For the purposes of this example, we assume that the reuse distance is 200km.

Although audiences in Canberra and Sydney will experience reliable reception in their respective licence areas, households in the Southern Highlands cannot expect reliable reception of channel 1 programs transmitted from either city (although reception may be of adequate quality in some areas). This is because their televisions would be attempting to receive a lower strength signal that may be interfered with by a competing signal originating from a different licence area. This also explains why Southern Highland area would typically be assigned a different channel (say channel 2) for the service transmitted on channel 1 in Sydney and Canberra.

This means that channel 1 will be a vacant TV white space for the Southern Highland area. For the same reasons, channel 2 becomes a white space for the adjacent cities of Sydney and Canberra. Although the same general principle applies to both noise limited and interference limited planning models, noise limited channel planning create much larger white spaces because the frequency reuse distances are larger than those used in an interference-limited approach.

4. White spaces arrangements in Australia

Australia has long established arrangements that have enabled the co-existence of broadcast services (authorised by apparatus licences) and symbiotic WSD (authorised by class licences) in the UHF spectrum from 520-820 MHz used for terrestrial television services. This coexistence arrangement only requires the mildest type of regulatory

interventions: a standard secondary usage easement for class licensed (unlicensed) usage is all that is necessary. These arrangements are commonly provided for in ITU-R allocations and then implemented in different countries through national licensing regimes. Such easements can also be crafted in such a way as to specify the rules establishing settlement area for invasive WSDs. Another possibility is for regulators to specifically reallocate white spaces, either in whole or in part, from broadcasting to unlicensed services as was done on ISM and UNII micro-wave bands. If broadcast spectrum is indeed large enough to accommodate both types of services or tolerate these kinds of subdivisions then the regulatory choices are relatively simple. However, the age of large spectrum allocations to terrestrial broadcasters is quickly receding, constraining regulatory choices for white space usage.

The need for regulatory decisions of this nature is rapidly approaching in Australia now that the size and location of the digital dividend has been determined. The government has also announced its intention to auction the digital dividend in 2012 – while digital switchover is still in progress. This is intended to allow incoming licensees to plan and deploy (but not operate) networks before the restack process is complete and minimise the time that the digital dividend spectrum is idle (that is, not used by a primary service such as broadcasting or telecommunications).

Key parameters for the restack of digital terrestrial television services were revealed in July 2010 when the Minister formally directed the regulator to take a number of government policy objectives into account as it realised the digital dividend (ACMA 2010b). For white space proponents, the most important of those parameters is the requirement for the regulator to preferentially use VHF Band III (174-230 MHz) for digital

terrestrial television services in metropolitan areas (that is, in the capital cities of each Australian state and territory). The use of VHF Band III for main transmitter sites will not entirely prevent the need to use channels in the UHF band (520-694 MHz) for terrestrial television services in metropolitan areas. This is because channels in the reduced UHF band (520-694 MHz) will be needed for secondary transmission sites for translators or in-fill purposes. In some case they may also be needed to provide main transmitter services to separate licence areas in conurbations such as Newcastle-Sydney-Wollongong). However, the preferential use of VHF Band III will significantly diminish the requirement for channels in the reduced UHF band in metropolitan areas.

The significance of the use of VHF Band III to provide digital terrestrial television services to metropolitan Australia is best seen by considering the white space capacity that is available in the United States – a country of similar geographic size to Australia but with a much larger population - 310m and 21.5m respectively in July 2010 (CIA 2010). The results of a semi-empirical analysis presented to IEEE DySPAN in Singapore in April 2010 indicate that white space availability is relatively poor in metropolitan areas in the United States because of the extensive use of channels in the UHF band to provide digital terrestrial television services to populated areas (Harrison et al. 2010). Nonetheless, the authors concluded that the benefit to urban and suburban areas in the United States from the deployment of white space devices and networks in the UHF band (470-698 MHz) could be of the same order as the benefits expected from the allocation of 62 MHz in the 700 MHz band as part of the US digital dividend.

5. The Guard bands

High level band planning arrangements for the spectrum identified as the Australia digital dividend (698-820 MHz) are also of interest to white space proponents. The regulator set out its preferred approach to configuring the digital dividend spectrum in a discussion paper that it released in October 2010 (ACMA 2010c). That approach is based on alignment with regionally harmonised arrangements in Asia Pacific that are the result of decisions made by the International Telecommunication Union – most notably by the World Radiocommunication Conference held in 2007 – and work by the Asia-Pacific Telecommunity Wireless Forum (AWF) that subsequently commenced in 2008. The AWF adopted harmonised arrangements for use of the digital dividend across the Asia Pacific region in September 2010, including both paired and unpaired arrangements. Adoption of either of the AWF arrangements in Australia would result in a 9 MHz guard band from 694-703 MHz to prevent interference between high power broadcasting services below 694 MHz and the mobile telecommunications networks most likely to be deployed above 703 MHz.

This 9 MHz guard band will clearly be of interest to proponents of symbiotic WSD such as wireless microphones. While the regulator has indicated that use of symbiotic WSD will continue to be supported in the 520-694 MHz frequency range through the LIPD Class Licence, it has also acknowledged that the restack of digital terrestrial television services will impact on the availability of white spaces for such devices. As guard bands are generally suitable (and made available by regulators) for low interference potential devices, 694-703 MHz could become an important frequency range for use by symbiotic

WSD because of it would be available in all geographic areas across Australia (although, strictly speaking, it will not be a white space).

For the same reason – its availability in all geographic areas – the 694-703 MHz guard band will likely be attractive to invasive WSD. However, because invasive WSD can be expected to operate at higher powers and wider bandwidths than symbiotic WSD, there will be legitimate concerns about the potential for invasive WSD to interfere with the reception of digital terrestrial television services below 694 MHz and the operation of mobile telecommunications networks above 703 MHz. Technical issues associated with the use of 694-703 MHz will need to be closely examined and carefully considered by industry and the regulator with possible outcomes including operation of invasive WSD on a restricted segment in the guard band – perhaps centred on 698.5 MHz – and for limited purposes – such as determining white space availability in the vicinity of the WSD, link establishment or network optimisation.

However, although perhaps counter-intuitive, it would seem prudent for symbiotic and invasive WSD to minimise their reliance on the use of 694-703 MHz in Australia. On the one hand, use of the guard band will be heavily constrained near the band edges to protect broadcasting services below 694 MHz and mobile telecommunications networks above 703 MHz. On the other hand, 9 MHz of (most likely) open access spectrum in the UHF band can be expected to attract a large number of devices providing a wide range of applications and services. Additionally, the likely high availability of white spaces in metropolitan Australia means that significantly more spectrum (and thus more capacity) will be available to both symbiotic and invasive WSD than the 9 MHz that will be ubiquitously available but on a more contested basis.

Differences between the AWF and Australian arrangements should also be taken into account to exploit the economies of scale that a harmonised Asia Pacific digital dividend is intended to enable. The AWF arrangements provide for a guard band of 5 MHz – from 698 to 703 MHz – rather than the 9 MHz guard band that seems likely in Australia. This is because the internationally harmonised digital dividend in the Asia Pacific region encompasses the 698-806 MHz frequency range – a total of 108 MHz – rather than the 126 MHz digital dividend in Australia that will reclaim 694-820 MHz from broadcasting use.

The AWF arrangements establish an additional two guard bands for the harmonised digital dividend in the Asia Pacific region. Those guard bands are a mid-band gap of 10 MHz (748-758 MHz) and an upper guard band of 3 MHz (803-806 MHz). Either or both of these guard bands may be of interest to WSD proponents for reasons similar to those surveyed above in the discussion of the lower guard band of 694-703 MHz. While there are additional factors that need to be taken into account in each case (for example, the small size of the upper guard band and the declared intention of the regulator to commence a consultation process about future arrangements for the adjacent 900 MHz band), they are not further identified or discussed in this article.

6. Digital Dividend 1.0. : switchover and restack

The process of switching-off analog signals commenced in regional Australia in 2010 and is to be completed by the end of 2013. Table II below provides an indicative representation of the transition process, including digital switchover (where analog services are switched off) and then digital restack (where digital services are consolidated

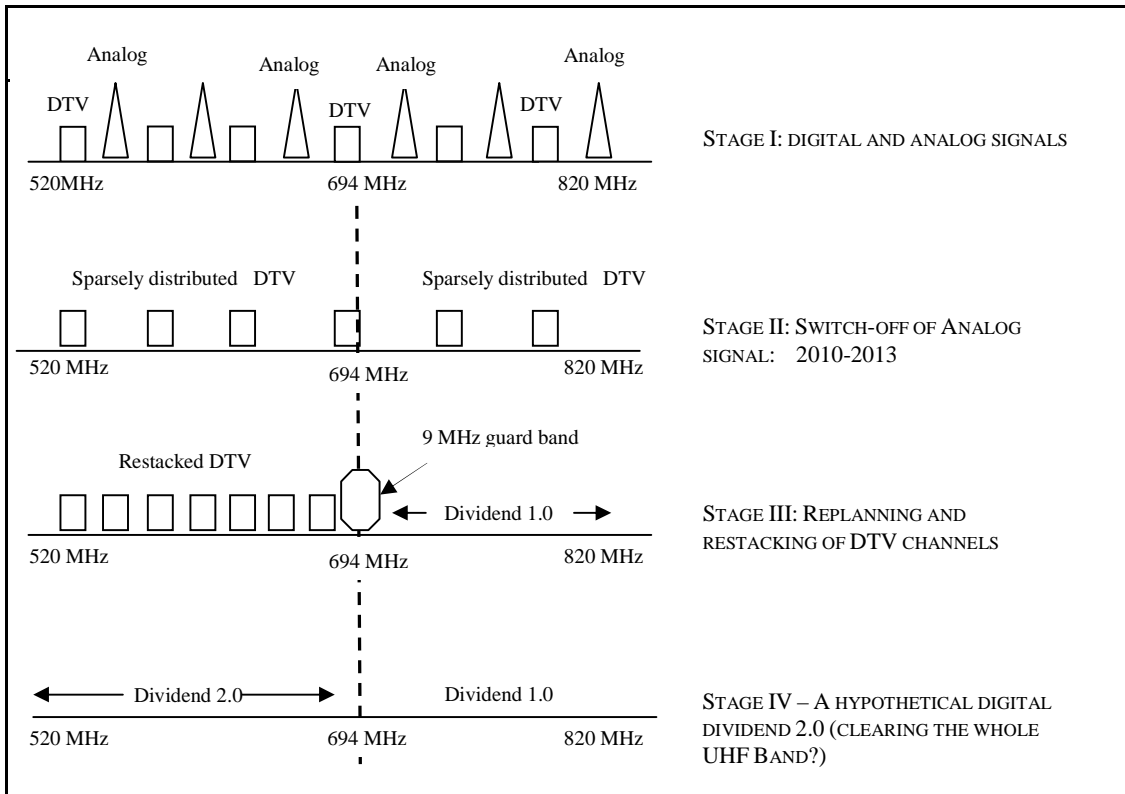
into channels between 520-694 MHz). Table II also indicates the potential for the complete clearance of broadcasting services from the UHF band – a longer term option that we have described elsewhere as Digital Dividend 2.0 and canvas briefly later in this article).

Stage I shows the current interweaved layout of analog and digital channels in the UHF Band, separated by white spaces. Stage II represents the situation after wholesale analog switch-off by the end of 2013. Throughout this relatively short process (2010-2013), the white spaces available in Australia will progressively and significantly increase. However, the increase in white spaces during digital switchover is essentially only a theoretical opportunity for WSD (although it will provide some welcome additional capacity for established symbiotic WSD such as wireless microphones). This is because the government and the regulator are focussed on establishing arrangements for the services that will be the primary users of the UHF band from 2014 (broadcasting from 520-694 MHz and, most likely, telecommunications networks from 694-820 MHz).

Prior to auctioning and issuing new licences for the digital dividend, the band will need to be re-planned. This will involve clearing the 700 MHz band (694-820 MHz) and restacking (consolidating) all digital terrestrial television services in the reduced 520-694 MHz band. This process is shown in stage III of Table II. By stage III, if no other factors were taken into account, the potential availability of white spaces would seem to fall significantly, and particularly by comparison with stage II. However, given the preference discussed earlier for main transmitter sites in metropolitan areas to use VHF Band III and the much higher performance of digital terrestrial television (which performs robustly in interference environments that disrupt analog services), the potential availability of white

spaces in Australia would seem to be much higher than the availability of white spaces in the United States.

Table II. Australia’s digital switchover and re-planning of the UHF Band



7. Opportunities & Challenges

Conditional on the exact design of the re-planning and re-stacking process, the digital dividend in Australia should present at least two important opportunities for a class licensed open access regime for WSD: (i) the likely high availability of white spaces in the restacked 520-694 MHz segment of the UHF Band; and (ii) up to 22 MHz of guard band spectrum, including a 9 MHz guard band from 694-703 MHz, a 10 MHz guard band from

748-758 MHz and a 3 MHz guard band from 803-806 MHz. The opportunities provide WSD proponents with significant incentives to engage in the consultation processes that the Australian regulator commenced in 2010 – with the release of a discussion paper in October 2010 and a one day conference at the National Maritime Museum in Sydney in November 2010. WSD proponents now have a window of opportunity to seek regulatory outcomes that (i) maximise the availability of white spaces in 520-694 MHz – and particularly in metropolitan Australia where demand for white space devices can be expected to be highest, (ii) secure class licensed open access rights to these white spaces that will optimally enable their extensive colonisation by invasive WSD without jeopardising digital terrestrial television services, and (iii) best exploit the opportunities presented by guard bands to maximise the performance of WSD – at both the device and network level.

Given the long term trend of increasing competition for spectrum and contestability about its highest value use, WSD proponents should not be surprised at the emergence of challenges to their interest to intensively use white spaces for non-broadcasting services. We expect that there will be challenges from broadcasters as well as from operators of telecommunications networks. An obvious challenge will be to address the long standing of concern of broadcasters that WSD will interfere with the reception of digital terrestrial televisions. Another challenge that WSD proponents should consider is the likely interest of broadcasters in accessing unallocated channels in the UHF band for emerging spectrum intensive broadcasting services such as 3D television. If the latter challenge does eventuate, then broadcasters may seek to completely prevent invasive WSD from colonising the reduced UHF band (520-694 MHz). Alternatively, broadcasters could seek

to limit the intensity of use of white spaces by invasive WSD (while limiting device numbers would seem impractical, the sophisticated nature of invasive WSD may well allow operational constraints to be imposed at both the device and network level). The rationale for a strategy of this kind would be to minimise consumer disruption if white space availability in a particular area is reduced because of the allocation of a vacant channel to a new digital terrestrial television service.

Operators of telecommunications networks – both fixed and wireless and in established frequency ranges as well as the digital dividend spectrum – may become the unlikely allies of the broadcasters if concerns of this nature are pursued with the regulator. Much will depend on how established operators view invasive WSD: if invasive WSD are seen to be *complementary* to traditional business models and their associated network infrastructure, established operators are likely to argue for regulatory arrangements compatible with invasive WSD. However, if established operators see invasive WSD as a *disruptive* threat to their businesses – perhaps if WSD proponents adopt business models akin to that pursued by Meraki when it first released the Mini in 2007¹ – then they would most likely oppose the development of regulatory arrangements favourable to the intensive use of white spaces by invasive WSD.

¹ Meraki is a provider of low-cost, centrally-managed, large scale WLAN services e.g. for multiple sites business applications or for ‘main street’ internet services (e.g. city hotspots). The Meraki Mini is an IEEE 802.11b/g based mesh repeater allowing users to build a wireless mesh network and control it via web-hosted interface. The hardware was developed with an open-access platform (Linux) and the software provided with quasi open access licensing agreements (e.g. freedom to re-write the device’s main code). Meraki has since moved away from its open access roots, imposing restrictive software licensing agreements in 2008.

8. Digital Dividend 2.0

Although the focus of many WSD proponents is understandably on the digital dividends that are being or have already been achieved around the world, we propose that the strategy of WSD proponents could usefully be informed by a longer term (10-15 year) perspective. While the situation for DTV (and thus WSD, both symbiotic and invasive) seems likely to stabilise after digital restack and the reallocation of the digital dividend, there is emerging interest in the potential for further reallocation of UHF spectrum from broadcasting to other services – which we describe as a ‘digital dividend 2.0’. The first intimation of a digital dividend 2.0 occurred in 2008 when the Finnish national plan of action identified that the achievement of high speed broadband by 2015 would justify reconsidering the future of terrestrial DTV by 2017 (MTC Finland 2008).

In August 2009, the European Commission followed suit, identifying two options for making more spectrum available for wireless broadband or other non-broadcasting purposes in the European Union. One option was to reallocate the segment 694-790 MHz – a dividend 2.0 which would be more consistent with digital dividend now being achieved in Australia and across the Asia Pacific. The second option was to completely clear DTV from the UHF band to realise a digital dividend from 470-790 MHz. While the report indicates that neither of these options is realistic in the short term, it identifies that they may well be achievable in the medium (beyond 2015) to long (beyond 2020) term. Finally, in December 2009 the FCC issued a public notice that sought data on future use of spectrum used for terrestrial television broadcasting, including the impact of reallocating more spectrum – again, a digital dividend 2.0 – away from DTV (FCC 2009).

Any further reallocation of UHF spectrum away from broadcasters and into other uses would clearly have major implications for WSD proponents – not least because it may call into question the viability of enabling intensive use of white spaces by invasive WSD. Any regulatory framework that allowed the use of invasive WSD must be considered very carefully (Freyens and Loney 2010). The second implication is that highly functional invasive WSD that have operated flawlessly in a broadcasting environment for many years will no longer be tolerated after further reallocation of the UHF band in a digital dividend 2.0 scenario. As shown in stage IV of Table II, the availability of spectrum for wireless telecommunications networks access is expanded by relocating broadcasting services, most likely to high capacity geostationary satellites operating in the Ka band (20-30 GHz). Crucially, this implies that the long term viability of symbiotic WSD may well depend on their ability to operate effectively in spectrum used by telecommunications networks as well as in the broadcasting environment in which they are currently evolving. We suggest that WSD proponents take pre-adaptive steps to ensure that the design and development of symbiotic WSD takes into account the likely need for those devices to be able to survive the transition from a broadcasting environment (characterised by a small number of high power sites and stable licence areas) to a telecommunications environment (characterised by a large number of lower power sites and ongoing growth in base station deployments). Accordingly, we claim that the prospects for long term success of symbiotic WSD will be enhanced if WSD proponents develop devices, network architectures and application models that are *complementary* to established operators and business models rather than *disruptive*.

Interestingly, there are at least two reasons why the longer term interests of terrestrial broadcasters may also align with the development of invasive WSD that are complementary to the business models and network architectures of telecommunications operators. The first is the medium term potential for terrestrial broadcasters to establish tradable property rights to the channels that they use to provide digital television services to their licence areas (spectrum licences in the Australian regulatory framework). In this scenario, a financial incentive would be created for broadcasters that chose to trade their UHF spectrum for higher value uses (such as telecommunications) and move to another delivery technology (such as geostationary satellites operating in the Ka band or perhaps the ubiquitous fibre to the premises national broadband network that is being established by the Australian Government). Alternatively, intensive use of the reduced UHF band using advanced technologies may be of such high value that the threshold is never reached where the benefits of a Digital Dividend 2.0 outweigh the costs of completely clearing terrestrial digital television services from the UHF band. In this scenario, broadcasters and invasive WSD would combine to create a diverse ecosystem that was robustly impervious to demands for more spectrum for traditional telecommunications infrastructure – because that ecosystem was able to satisfy demand for wireless access that could never be met by the monoculture of exclusive broadcasting use.

Less optimistically, if the emerging scenario of a digital dividend 2.0 is combined with the fact that suitable arrangements for invasive WSD have yet to be finalised in the process of implementing “digital dividend 1.0”, we can only wonder what would happen if regulatory authorities did not have to deal with a relatively small PMSE community using symbiotic

WSD but a host of citizens enamoured of the invasive WSD that provide them with crucial connectivity to, and improve the functionality of nationally deployed high speed broadband networks. How would a regulatory agency keep the necessary flexibility to prioritise the rights of new licensees and enable invasive WSD to successfully adapt and contribute an environment that is making a step change from high power broadcasting services to lower power telecommunications services with a more pervasive network infrastructure?

One approach to this challenge would be for the regulator to determine that the use of invasive WSD will not be allowed to continue to operate once broadcasting ceases to be the primary service and it is reallocated for other purposes. While this approach may have some appeal, it is unlikely to be attractive to WSD proponents and suffers from some significant limitations. Consumer devices that are not tightly bound to particular networks and technologies will tend to continue in use even if the regulatory permission to operate them is withdrawn. If invasive WSD are able to flourish and thrive in TV white spaces, then they may prove to be a persistent feature of the spectrum landscape. Secondly, as identified above, this risk may lead regulators to decide against authorising invasive WSD or to place stringent limitations on their use with consequential reductions of total economic welfare. Finally, and most importantly, this approach would forego the opportunity to create regulatory arrangements that maximised total welfare by developing technical frameworks that would allow invasive WSD to flourish and thrive in both broadcasting and telecommunications environments.

We suggest that an alternative approach would be for regulators and industry to identify the technical and operating characteristics that would allow invasive WSD to successfully transition from broadcasting environments where there are a small number of high powered transmitters and where technology changes little over time, to telecommunications environments where there are large numbers of low powered transmitters and rapid technological change over time. Ideally, invasive WSD would be able to adaptively collaborate with telecommunications networks using advanced technologies.

Importantly, there is time for regulators and industry to develop an understanding of the technical and operating characteristics that are required for optimal invasive WSD. This is because it seems likely that it will be 10 to 15 years before a digital dividend 2.0 is realised – and that period of time is sufficient for the development of increasingly sophisticated invasive WSD and the consequential retirement of earlier generations of WSD that will become sub-optimal over time.

9. Conclusions

Digital switchover, and the consequential realisation of a digital dividend, has been an important focus of governments and regulators over the last decade. Digital switchover has either been achieved or is underway in a majority of advanced economies with significant economic, commercial and social benefits expected to result from the reallocation of valuable spectrum in the UHF band from broadcasting to telecommunications. The last decade has also seen increasing advocacy for, and interest in the use of white space in the UHF band – spectrum that has been allocated to the

broadcasting service but not assigned to a particular broadcaster – by new generation white space devices – invasive WSD – that are intended to be deployed on a large scale but operate without affecting the reception of broadcast services because of their intrinsic ability to automatically adapt to their specific local spectrum environment.

2010 was a watershed year for broadcasters, telecommunications companies and WSD proponents in Australia. The Federal Government announced in June that the Australian digital dividend would be a contiguous 126 MHz from 694 to 820 MHz. Digital switchover commenced in regional Australia in July and is to be completed by the end of 2013. The regulator commenced a consultation process about reallocating the digital dividend ahead of the auction of licences for spectrum from the digital dividend spectrum in 2012 (with new networks able to commence operations once the restack of digital television services into the reduced UHF band of 520-694 MHz is complete). Importantly, as planning for the restack is now underway, the Minister has directed the regulator that VHF Band III (174-230 MHz) should be used for main transmitter services in metropolitan Australia – which should have a major and positive impact on the availability of white spaces in Australia.

We identified the opportunities and the challenges for WSD proponents in Australia that are the results of these developments, both in terms of new slots of standard UHF (or even VHF) white space on broadcast spectrum, and in terms of guard bands with future telecommunications services. There is now a window of opportunity for WSD proponents to optimise the availability of white spaces in Australia and establish regulatory arrangements that will allow intensive use of those white spaces by symbiotic WSD. We argue that the success of symbiotic WSD will be enhanced if WSD proponents take into

account the emerging likelihood of a digital dividend 2.0 in the 10-15 year time frame. This is despite the potential for the widespread deployment of invasive WSD to impact adversely on the realisation of any additional digital dividend – a consequence of the very different technical characteristics of the broadcasting and telecommunications environments. Instead, for this scenario, we conclude that the potentially conflicting objectives of broadcasters, telecommunications companies and WSD proponents may be able to be reconciled by the development of invasive WSD that are *complementary* – both technically and commercially – with established telecommunications operators and business models (rather than *disruptive* for these models). Most optimistically, we identify that intensive use of UHF spectrum by invasive WSD may well be to the long term benefit of both broadcasters and telecommunications operators.

Finally, we emphasise that the imminent debate in Australia about white space and white space devices would usefully be informed by an analysis of the likely availability of white space given the parameters established for the restack of digital terrestrial television services. To that end, WSD proponents would be well inspired to seriously consider undertaking an analysis of possible outcomes and preferred options for white space availability in Australia that draws on the approach developed by (Harrison et al. 2010) to identify white space capacity in the United States.

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