# Cambium Networks

## Response to Discussion Paper on 1.5GHz and 3.6GHz Spectrum - Cambium Networks November 2016

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## 2. EXECUTIVE SUMMARY

The Cambium Networks team in Australia, appreciates the opportunity to submit comment to the discussion paper.

Cambium Networks, is a leading vendor of Fixed Wireless products, that currently ships Point to Multipoint and Point to Point products that support the 3.3 GHz to 3.9 GHz band. Current products are all TDD based. Cambium Networks has no products supporting the 1.5 GHz band, and so the scope of our response will be limited to the 3.6 GHz band.

Our response to this Discussion Paper is based on our knowledge and experience gained over the past seven years working with network operators and enterprise customers building networks in the 3.6 GHz band. We have seen the significant and positive impact that those services have had. We have actively promoted the availability and use of the spectrum; and the use of Fixed Wireless network architectures to deliver broadband services to underserved areas and to provide reliable connectively for mission critical applications. Our response is hence based on our domain knowledge of the industry on a global basis, and specifically Fixed Wireless technology and how it can be effectively used to connect the unconnected – people, places and things. Our response also contains some personal and emotional feelings as regards the impact that the current extended embargoes and contemplated re-farming is having on our business, the businesses of our customers, and the lives of those currently receiving broadband services.

The discussion paper is entitled: **Future use of the 1.5 GHz and 3.6 GHz bands, Initial investigation of the 1427–1518 MHz and 3575–3700 MHz bands for mobile broadband services discussion paper**

Cambium Networks highlights that the band is currently allocated and used for Fixed Wireless (Broadband Wireless Access (BWA) or Fixed Wireless Access (FWA)) and not mobile applications. Whilst the document states “for mobile broadband service discussion paper” and refers to mobile broadband as MBB, it also states on page 6, that MBB also refers to Fixed Wireless. We also highlight that the ITU has identified this band for IMT, which include both mobile and fixed services. The title of the Discussion Paper, as such, is misleading and exacerbates the significant lack of understanding as to the value of Fixed Wireless and the difference between Fixed Wireless and Mobile Wireless Broadband and both their BEST VALUE applications.

We will discuss and highlight that the 3.575 GHz – 3.7 GHz band is currently only used for Fixed Wireless applications (BWA). We propose that the 3.4 GHz -3.6 GHz band is also not ideal for mobile services, especially in rural and regional areas, but is rather ideal and proven for Fixed Wireless applications. To contemplate the re-allocation of the current 3.575 GHz to 3.7 GHz band by the WiSP Community and allocate it to others to deliver the same Fixed Wireless services is surely a matter for the ACCC to review and consider?

The contemplated use for 5G, may assume mobile services, but this is as yet unclear and there is contemplation that in fact initial 5G services may be deployed as Fixed Wireless and not mobile.

Perhaps, the use of 3 GHz for small cells in high density areas like stadiums is possible, but mmWave options being defined for 5G are more applicable.

The ITU has also identified the 3.3 to 3.4 GHz band for IMT and whilst the ACMA has indicated this band is in monitor mode, we strongly suggest that this band be included in this discussion and consideration for allocation for Fixed Wireless be given sooner than later

Fixed Wireless currently plays a significant and important role in delivering value to the Australian economy. We will spend some time explaining what Fixed Wireless is, why it is so important and hope that this helps with an understanding of current use, its value and importantly best future value use.

There are a number of products manufactured in this band, some standards based LTE (based on TDD and not FDD) and some like our PMP 450 range based on our proven Canopy MAC layer TDMA protocol, that lends itself to the use of this band for Fixed Wireless Point to Multipoint services.

Cambium Networks, continues to innovate and recently started shipping a Massive MU-MIMO product in the 5GHz ISM band, that will provide the best spectral efficiency in the market, delivering up to 400Mbps+ in a 20MHz channel. (Appendix C) This product will support the 3.3 GHz to 3.9 GHz band by late-2017 and hence offer significant opportunity and value to deliver business grade broadband services to many under-served areas.

Whilst the NBN is building an effective Fixed Wireless Service, its regional coverage areas have gaps. It is also taking longer to build than was initially planned (See Appendix A). In the past six years, since 3.6 GHz band was allocated by the ACMA for Point to Multipoint Fixed Wireless services(BWA), a significant number of Wireless Service Providers (WiSPs) have invested in and built infrastructure to deliver broadband services to communities and businesses in underserved areas in good faith.

It is encouraging to see that the New Zealand Government has recognised the role of Fixed Wireless service providers, and instead of trying to discourage then with embargoes and re-farming, a recent tender issued by Crown Fiber will support their ability to serve underserved areas.

Many industries have evaluated, tested and proven this band to be effective for delivering secure and reliable services for Industrial Internet of Things (IIoT) and Intelligent Transportation System (ITS) applications. This band can and will continue to be important for innovation and IIoT applications. We note that in the US, the FCC has allocated the 3.5 GHz to 3.75 GHz as the Citizens Broadband Radio Service (CBRS) band. This is also being called the Innovation band and will be available for multi-use purposes. A set of standards are being developed to support this and Cambium Networks is actively participating in this process.

This raised the topic of 5G. Whilst some call for the 3 GHz band to be allocated for 5G, we point out that in the US the FCC has allocated this as CRBS band for shared use. What 5G actually encompasses and is, is yet to be determined, but based on simple evolution, it will mean higher speed wireless, high capacity small cells but will most definitely extend to include Fixed Wireless.

In the US, rather than looking at the 3 GHz band for 5G, the FCC has allocated bands above 24 GHz for 5G and proposed those for inclusion in the 5G standards back in September at WRC15. The specific bands that will be studied for 5G services include the 27.5 to 28.35 GHz, also known as the 28 GHz band; the 37 to 38.6 GHz band, also known as the 37 GHz band; from 38.6 to 40 GHz, known as the 39 GHz band; and the 64-71 GHz band.

We hope that through this submission we will demonstrate that best use of the 3.6 GHz spectrum is for Fixed Wireless and should be continued to be allocated in remote and regional areas as an Apparatus License. Thought should be given to removing Embargo 42 and allocating some of this band ITS and IOT applications in metro areas. Consideration should also be given to expanding the available band down to 3.3 GHz, especially in the regional and rural areas.

Careful consideration should be given to re-farming of current unused and underutilized bands, rather than the re-farming or reallocation of the 3.575 GHz to 3.7 GHz band. A good example of this, is the legacy spectrum with FDD arrangements defined for the 3425–3442.5/3575–3492.5 MHz frequency ranges that is unused or very effective as an FDD allocation and should be re-farmed as TDD spectrum for BWA.

In summary we propose:

- Best use of the 3 GHz band is for Fixed Wireless.
- Current use by WiSPs, Mining Industry, and State Governments should be maintained.
- Allocation should be done based on apparatus licenses.
- Additional spectrum in the 3.3 GHz band should be allocated for Fixed Wireless.
- Fixed Wireless in the 3 GHz band is important for ITS and IIoT applications.
- Allocation of TDD apparatus licenses should be allowed in Metro areas to support ITS and other IoT applications.
- Current embargoes in regional areas be removed and first alternate band options identified.

# 3. INTRODUCTION

## 3.1. INTRODUCTION TO CAMBIUM NETWORKS

At Cambium Networks, we support the communications of life for millions of people around the world and connect enterprise networks where other radios cannot. No matter what the conditions or locations, wherever people or networks need to be connected, our wireless broadband solutions deliver clear voice, data and video communications people and networks can rely on.

Cambium Networks provide professional grade fixed wireless broadband, microwave solutions and more recently WLAN. Our solutions are deployed in thousands of networks in over 150 countries, with our innovative technologies providing reliable, secure, cost-effective connectivity that's easy to deploy and proven to deliver outstanding performance metrics. To date Cambium Networks has delivered over six million radio devices, a count that continues to accelerate year-over-year.

Cambium Networks are proven, respected leaders in the wireless broadband industry. We design, deploy and deliver innovative data, voice, and video connectivity solutions that enable and ensure the communications of life, empowering personal, commercial, and community growth virtually everywhere in the world.

Following ten-years as a business unit within Motorola Solutions, Inc. Cambium Networks was formed in 2011 following divesture from Motorola Solutions.

## 3.2. WHAT IS FIXED WIRELESS?

Key to understanding the value of Fixed Wireless, is understanding how it is different from and should not be confused with Mobile Broadband (MBB).

Mobile Broadband is synonymous with the networks that support mobile phones and are designed and built with that in mind.

Whilst similar in many respects, Fixed Wireless Broadband, does not support mobility and is optimised to provide the best results for delivery of fixed data services using radio frequency. (RF). The typical application for Fixed Wireless is to provide a fixed data service using RF, when fiber or copper are not possible, suitable, available or affordable.

Fixed Wireless is not slower than fiber! The often forgotten fact about data transmission using RF, is that it is in-fact quicker than transmitting data using light signals over glass (i.e. fiber optic) and whilst fiber has the benefit of being able to support more capacity and is less prone to interference, it is sometimes just not cost effective or practical to deploy; as recently recognized by Google's fiber deployment efforts which have been halted due to economic hurdles. Fixed Wireless is not a replacement for fiber, but rather an excellent technology for achieving broader fixed service coverage.

Advances in RF and modulation techniques, over the past 5-10 years have now made RF an effective option for last mile FIXED SERVICES, or proving reliable and secure fixed data connections for enterprise, Internet of Things (IoT), Industrial IoT (IIoT) and ITS applications. Examples of these are backhaul for WiFi or LTE networks supporting autonomous trucks in open pit mining; and Backhaul of CCTV and Traffic Information to the traffic control room and broadband internet in regional and rural areas. Today in many places fixed wireless is a viable last mile solution in metro areas, where legacy copper cannot support the required bandwidth and fiber is not available.

Mobile Broadband technology, like TDD LTE, has been adapted to support Fixed Wireless and is effectively used today for Fixed Wireless by nbn. There is no specific standard for fixed wireless and many vendors like Cambium Networks, have developed the required Layer 2 protocols to support reliable Point to Point (PTP) and Point to Multipoint (PMP) services.

So fixed wireless should not be confused with mobile broadband and WiFi services.

Some key attributes of Fixed Wireless:

- Low latency
- Layer 2
- Ability to be implemented with variable symmetry i.e.,. Asymmetric to emulate ADSL and LTE, symmetric to support business grade services or even with reverse asymmetry to support CCTV (Safe City initiatives) and other backhaul needs.
- Secure

## 3.3. WHY THE NEED FOR FIXED WIRELESS.

Fixed Wireless allows service providers to build backhaul (PTP) and last mile access (PMP) infrastructure in difficult to reach, remote or rural locations that do not have access to fixed line broadband.

Fixed Wireless is a proven solution for connecting the unconnected, when fiber or copper are not available, cost effective or feasible due to geography or cost.

Fixed Wireless is vital for helping to bridge the digital divide and this is gaining greater recognition and acceptance. See Appendix B – Google to Trial Fixed Wireless is 24 US Cities.

## 3.4. WHY IS THERE NOT MORE FIXED WIRELESS?

Fixed Wireless has been largely ignored by Tier 1 carriers as they focused on high revenue services delivered by mobile broadband, and hence the focus has been on building the best possible 2G, 3G, 4G and perhaps soon 5G infrastructure.

There is no specific standard for Fixed Wireless, but for some time WiMAX (IEEE 802.16) was considered the standard for Fixed Wireless. It was actually developed for both fixed and mobile

broadband, but when LTE won the technology battle for mobile broadband, the drive and focus was to build mobile networks.

We suggest that the poor mobile experience and high latency of WiMAX stalled the deployment of Fixed Wireless.

Some reasons we believe why WiMAX was not a greater success:

- High latency of >30ms
- Limited bandwidth, as services were typically limited by paired FDD spectrum of 3.5MHz, 7MHz or at most but not often10MHz channels
- So called WiMAX spectrum, was allocated in the 2.3 GHz and 3.3- 3.6 GHz bands, both of which are not ideal for having indoor CPE. So when WiMAX modems were placed indoor the service often suffered from poor performance and this coupled with high latency lead to the demise of many fixed wireless solutions in tier 1 carriers

Now also the bandwidth in many places was not coordinated for more suitable TDD solutions. Instead fixed wireless solution grew in leaps and bound in the 2.4 GHz and even more so in the 5 GHz ISM bands, driven by cost effective technology and entrepreneurial Wireless Services Providers (WiSPs) that grasped the opportunity to build networks to deliver broadband services in areas and regions that were not effectively served by Tier 1 Service providers.

With the end of life of WiMAX chipsets, other more suitable TDD, Fixed Wireless Solutions and technology, able to make use of the small amount of licensed spectrum available in the 3 GHz bands emerged.

In Australia the NBN was built with Fixed TTD LTE in the 2.3 GHz initially and perhaps 3.4 GHz more recently. (See Appendix A)

Enterprises like some of the larger mining companies, and TMR QLD found value in the solution and started to build what were effectively early IoT networks.

## 3.5. LTE AND FIXED WIRELESS

We have seen proprietary dedicated Fixed Wireless solutions emerge from vendors like Cambium Networks, but the large telco equipment vendors, recognised the market opportunity to sell LTE as a standards base fixed wireless solution and we have seen TDD LTE emerge.

LTE is however layer 3 by design, requires a more complex enterprise packet core that adds cost, asymmetric by design and hence has some limitations vs lower cost more flexible non standards based solutions.

## 3.6. WHY THE NEED FOR LICENSED SPECTRUM FOR FIXED WIRELESS.

Almost all service providers prefer the certainty provided by licensed spectrum to be able to justify the investment in Fixed Wireless Infrastructure.

The remote and regional WiSPs were OK to deploy Fixed Wireless in unlicensed bands, typically 5.8GHz band. For the most part it has proven to be reliable and secure, but as some areas become more popular and more networks were built, congestion resulted and the need for licensed band for Fixed Wireless started to grow. Certain enterprise and industrial applications also cannot risk possible interference, so when the ACMA allocated the 3.55 GHz to 3.7 GHz band in 2009/10 the opportunities in the market started to grow due to the ability to build and invest with confidence

More and more the need for licensed spectrum has grown.

Fixed Wireless is now a proven and well respected solution for bridging the digital divide, but small service providers' just as large ones need the certainty and comfort offered by licensed spectrum for delivering interference free broadband services.

It is important, however, that the licensed spectrum for regional and rural areas remains cost effective to enable networks to be built and deliver the required services in underserved areas. Spectrum for IIoT and ITS services in metro areas is also now required and so too does this spectrum need to be priced affordably as it is now in regional towns.

## 3.7. IN SUMMARY.

Fixed Wireless is playing an important role in bridging the Digital Divide all over Australia, as well as enabling key connectivity (IIoT and ITS) solutions for enterprise, government and industry.

Everyone agrees that effective broadband is vital for a growing economy. Licensed spectrum for Fixed Wireless, whilst important, also needs to be cost effective to continue to drive broader acceptance.

It is important for Fixed Wireless to be treated separately from mobile broadband and Wi-Fi and that any desire to re-farm spectrum should take this into account. Special care and thought is specifically required for broadband internet in regional and remote areas. The opportunity to remove Embargo 42 and provide some licensed spectrum for ITS applications is now more necessary than ever.

The re-farming of the 3.6 GHz spectrum provides this opportunity. It is vital for industry, government and regional communities. The key role that WiSPS play in Australia, should be recognised and supported, just as they are being supported and recognised in New Zealand.

The overall social benefit of effectively used 3.6 GHz spectrum for BWA, massively overshadows a stringent carrier based spectrum licensing model.

# 4. RESPONSE TO QUESTIONS SPECIFIC TO 3.6GHZ

## 4.1. THE ACMA SEEKS COMMENT ON EXPECTED FUTURE USE OF THE 3.6 GHZ BAND BY FIXED, FIXED-SATELLITE, AMATEUR AND RADIOLOCATION SERVICES IN AUSTRALIA:

## 4.2. IF THE 3.6 GHZ BAND IS RE-FARMED FOR MBB SERVICES

Based on Rali FX19, 3.6 GHz BWA (TDD Fixed Wireless) is already actively and extensively used by Wireless Service providers, Mining, Oil and Gas, SMART Grid and for ITS application by Transport and Main Roads and Maritime Services. Since the band was allocated in 2010, many businesses have done planning, understood business opportunity and made investments in this band to deliver services or communications solutions that are now either very important or vital.

Bands supporting the economic and social benefits of delivering critical internet and communication services Australians need to be protected. Access to these bands should be made available under apparatus license.

### 4.2.1. DO YOU AGREE THAT A TIME DIVISION DUPLEX (TDD) ARRANGEMENT SHOULD BE ADOPTED? WHY/WHY NOT?

Yes, definitely. This allows the most efficient and effective use of the spectrum. Since only one channel is required. Cambium Networks GPS Sync enables spectral efficiency by allowing channel reuse and zero adjacent channel spacing.

TDD-based Equipment is cheaper to develop and supports flexible symmetry. Asymmetric data capability in both directions, making it ideal for CCTV backhaul and also Symmetric for business grade services. The best applications for this band are all based on Fixed Wireless and TDD offers the best utility to support a range of applications considered and currently in use.

### 4.2.2. SHOULD ALL OR ONLY PART OF THE BAND BE CONSIDERED FOR RE-FARMING?

No, the existing 3.575 to 3.7 GHz band should not be re-farmed, but the broader 3.4 GHz to 3.7 GHz band should be reviewed and more bandwidth allocated for Fixed Wireless and IIoT applications. We also advocate for consideration to be given for the 3.3 GHz to 3.4 GHz band as well as the bands from 3.7 GHz to 3.8 GHz. This spectrum is ideal for Fixed Wireless applications that serve key underserved areas and allow Wireless Service Providers to invest with confidence. The number of Wireless Service providers, making use of the Fixed 3.6 GHz TDD band is significant and is making a massive difference to so many

people's lives already. CCTV, IoT and ITS applications in metro areas would also make effective use of the embargoed spectrum in metro areas.

### 4.2.3. SHOULD DIFFERENT AMOUNTS OF SPECTRUM BE RE-FARMED IN DIFFERENT AREAS?

There is clearly a different need or application for the spectrum in different areas. The current applications in mining, rural and regional broadband services and ITS are regional specific and application specific and well suited to apparatus licensing at a cost effective price point. There is also a need for the band where it is currently embargoed for additional Fixed Wireless broadband services and it is also vital for ITS (IIoT) applications. The mobile application for this spectrum is not proven or clear, but it is well proven and suited for Fixed Wireless. Current BWA allocations should not be re-farmed, but differential farming in other areas makes sense.

It is a good idea to consider differential re-farming of the 3.55 to 3.7 GHz band, as well as the broader 3 GHz band. This has proven to be vital for regional and rural WiSPs supporting local communities with effective broadband and should not be changed. The removal of the current embargo 42 and allocation of differential amounts of spectrum for different applications is strongly recommended. ITS is the one metro application that stands out most at this stage and has the greatest immediate need. The entire 3.4 to 3.7 band needs a national review as in some cases spectrum is owned but not used. Apparatus licensing vs spectrum licensing should also be considered for all of the band.

## 4.3.IF THE 3.6 GHZ BAND IS RE-FARMED FOR MBB SERVICES, WHAT GEOGRAPHICAL AREAS SHOULD BE CONSIDERED?

We highlight, that when referring to MBB, we are also referring to Fixed Wireless (BWA) services and not only mobile services. We strongly advocate, that all areas be given consideration, including the areas in Embargo 42. This does not mean taking away current use services, but rather exploring effective best use sharing of spectrum.

The CBRS model in the US is a good example how some of this band can be used. The Cambium Networks technology is designed to ensure effective use of spectrum and also to build large networks of adjacent cells. This is demonstrated by network operators like Eolo in Italy, and Rise Broadband in the US, each with greater than 150,000 subscribers on their networks. Both operators leverage 3GHz and 5GHz to provide enterprise and residential access using FWA. In the Philippines SMART Communications built a network across Manila of adjacent cells using TDD technology on the 5 GHz band. This network operated in the 5 GHz band, which was allocated as "licensed" spectrum for outdoor use and the use case is no different from the BWA use case with 3.6 GHz. A combination of GPS Sync and Automatic Transmit Power control, as well as spectrum planning ensured an effective and dense network, which at its peak supported over 400,000 customers. Appropriate planning, coordination and allocating on an apparatus license basis is required.

The blanket re-farming and possible sale as a Spectrum License is not best use value for this spectrum. We also highlight that consideration to BEST Value Use of the entire 3.4-3.6 GHz band be considered and not just how can we "take away" the 3.55 GHz to 3.7 GHz band from the WiSP community and other enterprises and allocate it to one of the large service providers for exclusive use. We note, Nbn and Optus already have considerable spectrum in the 3.4 GHz band (See Appendix A)

By MBB Services some may be thinking 5G. We note that in the US, this band is allocated for mixed used under the CBRS model and that rather other bands are being thought of for 5G, which is still really being defined and worked out. Rather than there being a specific 5G standard, various ideas and higher speed wireless technologies are being grouped under the 5G banner. See Appendix D for bands plans in the US for 5G. We note the 3 GHz band is not contemplated.

### 4.4. IF THE 3.6 GHZ BAND IS RE-FARMED FOR MBB SERVICES, SHOULD EXISTING USERS (SOME OR ALL) BE ALLOWED TO CONTINUE OPERATION WITHIN THE BAND, EITHER TEMPORARILY OR ON AN ONGOING BASIS? SHOULD/COULD SHARING ARRANGEMENTS BE DEVELOPED? SHOULD SHARING ONLY BE CONSIDERED FOR SOME SERVICES OR SPECIFIC LICENCES? IF YES, WHAT KIND OF ARRANGEMENTS WOULD BE SUITABLE TO SUPPORT THE ONGOING OPERATION OF INCUMBENT SERVICES OR SPECIFIC LICENCES? IF NO, WHY?

As per previous question, we highlight the Fixed Wireless (BWA) use case, rather than mobile broadband only. Fixed Wireless IS an MBB service and the 3.55 GHz to the 3.7 GHz band is being well used. Sharing arrangements along the lines of the CBRS Alliance in the US should be explored. and no single Spectrum License allocation should be given. Those Wireless Service Providers and Enterprise customers using the 3.6 GHz covered by Rali FX19 should most definitely be allowed to continue to use the spectrum. Significant investment has been made and business developed to make use of this only recently allocated spectrum. In many cases the planned ROI is yet to be realised. Those that own spectrum but are not using their current apparatus licenses in 3.6 GHz or plan to use it should be consulted about surrendering the spectrum for others to use. Those with spectrum licenses should be required to demonstrate a suitable business case and reason to be allowed to hold on to the licenses they have. The spectrum should be shared amongst the current apparatus license holders and the remainder of the spectrum should be shared/allocated only on an apparatus license basis or done on an LSA model, as is contemplated for the CBRS band in the US.

### 4.5. IF THE 3.6 GHZ BAND IS RE-FARMED FOR MBB SERVICES, AND MIGRATION OF INCUMBENT SERVICES IS REQUIRED, ARE THERE ALTERNATIVE SPECTRUM OR DELIVERY OPTIONS?

The current technology and products used by the Wireless Service Providers and Enterprise customers in Australia, supports the bands from 3.55 GHz to 3.8 GHz and new versions in the future support the full 3.3 to 3.9 GHz band. It is quite conceivable that those operating in 3.6 GHz could, if required, move up the 3.7 GHz band or down to the 3.3 GHz band for example. This however does not suggest that we agree with the re-farming of incumbent users or maintaining the new embargo for too long. In fact the current embargo and regional areas is already having significant negative impact on business and the resultant services to end customers. Very serious consideration to the process needs to be given. It's just not in the Australian psyche or spirit about giving the underdog a fair go! Nor is it reflective on any consideration for small business and the communities being served. Is the motivation to create a monopoly and remove all competition? No re-farming or embargoes should be imposed until consideration first for alternative bands is provided.

### 4.6. IN DETERMINING WHETHER TO RE-FARM THE 3.6 GHZ BAND FOR MBB, ARE THERE ANY ADJACENT BAND ISSUES THAT SHOULD BE CONSIDERED? THIS INCLUDES:

#### 4.6.1. THE EFFECT SUCH USE MAY HAVE ON ADJACENT BAND SERVICES

None from a Cambium Networks perspective. The products currently operate effectively without any such issues. The Cambium Networks Fixed Wireless 3 GHz products have low and acceptable out-of-band emissions. The Cambium PMP 450 allows a network to be built using no channel spacing between adjacent bands. All products should conform to appropriate power spectral densities and out of band emissions as is currently required for the 900MHz ISM band as an example. This capability is also supported by the effective use of TDD GPS Sync and Automatic Transmit Power Control (ATPC).

#### 4.6.2. THE EFFECT ADJACENT BAND SERVICES MAY HAVE ON THE UTILITY OF THE 3.6 GHZ BAND FOR MBB SERVICES.

With appropriate coordination and also designed products this will not be an issue. Also terrestrial Fixed Wireless service directivity vs Terrestrial Satellite service directivity should allow effective co-existence.

### 4.7. IF THE 3.6 GHZ BAND IS RE-FARMED FOR MBB SERVICES, SHOULD THE ACMA REVIEW ARRANGEMENTS IN THE BROADER 3400–3700 MHZ BAND? WHY/WHY NOT?

Yes, this broad consideration for the entire band should be given and should include the 3.3 to 3.4 GHz band as well. Cambium and other industry products, support the bands from 3.3 GHz to 3.8 GHz. New models will support the full 3.3 GHz to 3.9 GHz band. Should a strong case be made to re-farm the current 3.6 GHz band, then alternate options in the 3.7 GHz band must be made available for incumbents' migration. In our view the 3 GHz band is best suited for Fixed Services with outdoor CPE,

and not mobile, MBB Services as the frequency does not effectively support indoor CPE or mobile user devices indoors. At best nomadic operation is possible, but only when devices are outdoors.

### 4.8. WOULD SUCH A REVIEW BE FACILITATED THROUGH THE ALIGNMENT OF GEOGRAPHICAL BOUNDARIES IN THE 3.6 GHZ BAND WITH EXISTING BOUNDARIES DEFINED FOR SPECTRUM AND APPARATUS LICENSING IN THE 3400–3575 MHZ BAND (THAT IS, TO FACILITATE TRADING)?

This is a tough question, for effective use, we proposed that all spectrum should be allocated on an apparatus license basis in this band. This is to ensure best use and best value for all. Cost models for high density, medium and low density can be created, BUT important consideration MUST be given for IIoT and ITS use in all regions including current Embargo 42, even if it is only 40MHz or 60MHz.

### 4.9. IS THERE ANYTHING ELSE THAT COULD BE CONSIDERED AS PART OF THE 3.6 GHZ BAND PROCESS THAT MAY FACILITATE A FUTURE REVIEW OF THE BROADER 3400–3700 MHZ FREQUENCY RANGE?

There are a number of Fixed Wireless Technologies emerging with greater spectral efficiency. (See Appendix C- Massive MU-MIMO) Current systems provide 6.5 -10bps/Hz and new Massive MU-MIMO will offer greater than 40 bps/Hz with frequency re-use, enabling over 400Mbps in a single 20MHz channel. This will give the allocation of the limited spectrum i.e., 20MHz or 30MHz channels much greater utility.

### 4.10. COMMENT IS SOUGHT ON THE ACMA'S PROPOSAL TO PROGRESS THE 3.6 GHZ BAND TO THE PRELIMINARY RE-PLANNING STAGE OF ITS PROCESS FOR CONSIDERATION OF ADDITIONAL SPECTRUM FOR MBB SERVICES, AS DETAILED IN THE ACMA'S MOBILE BROADBAND STRATEGY.

We note that the ACMA's mobile broadband strategy makes no specific mention of Fixed Wireless. Given however MBB, encompasses Fixed Wireless, we agree, that there is a significant and important opportunity to re-farm current legacy spectrum with FDD arrangements defined for the 3425–3442.5/3575–3492.5 MHz frequency ranges and make that available for practical BWA use. Also there is an important opportunity to make available some spectrum for BWA and ITS services as apparatus licenses in the current Embargo 42 areas.

### 4.11. TO ASSIST THE ACMA IN CONDUCTING A COMPREHENSIVE ASSESSMENT OF THE HIGHEST-VALUE USE FOR THE 3.6 GHZ BAND, RESPONSES TO THE FOLLOWING QUESTIONS ARE REQUESTED:

#### 4.11.1. DO YOU SEE INCREASING DEMAND FOR FIXED BROADBAND/MBB SERVICES IN THE 3.6 GHZ BAND? WHAT BENEFITS DO YOU ENVISION FROM USING THE BAND FOR FIXED BROADBAND/MBB SERVICES?

Yes, we definitely see increasing demand in rural and regional areas as there are many underserved areas. Business customers and farmers (Agriculture) need low latency symmetric broadband services currently not available from others. The 3.6 GHz band is key to encourage investment without fear of interference as is the case in unlicensed bands. The Wireless Service Provider (WiSP) industry are playing a vital role in the economy of the country and for their own communities. WiSPs should be encouraged to add value, as is happening now in New Zealand. We also see an increase in demands for applications such as ITS, CCTV, Safe City initiatives that would make strong use of the 3 GHz band in Metro Areas currently under embargo.

The benefits of fixed wireless solutions are being effectively realised by many operators and the community. Services are being rapidly deployed with increasing adoption. Users increasingly recognise the benefits of fixed wireless as a better alternative to current wire-line services and demand is growing. We are seeing massive positive adoption. We also suggest that a much greater awareness and understanding of Fixed Wireless is required across the board, in Government, Telcos and Industry Bodies, in order to generate a much more meaningful debate and discussion.

#### 4.11.2. WHICH REGIONS OF AUSTRALIA WILL BE IN DEMAND FOR FIXED BROADBAND/MBB SERVICES IN THE 3.6 GHZ BAND?

ALL regions, including councils and metro areas.

#### 4.11.3. IS DEMAND THE SAME OR SIMILAR ACROSS REGIONS, OR ARE SOME REGIONS/AREAS MORE LIKELY TO BE IN DEMAND FOR MBB PROVIDERS?

Currently we see most demand coming from regional and rural WiSPs as well as very effective use for mining communications and ITS. There is a key need for ITS/IIoT applications in metro and edge metro areas. There are also many fringe metro areas that current WiSPs would like to address but cannot under the current Embargo.

#### 4.11.4. DO INCUMBENT 3.6 GHZ BAND LICENSEES REQUIRE ONGOING ACCESS TO THE BAND, OR ARE THERE PLANS TO CEASE OPERATION AT SOME FUTURE POINT?

Yes, all current users that Cambium Networks are aware of including; WiSPs, TMR in QLD and various mining companies are making effective and vital use of the band. They are investing and expanding services and have no plans in the future to cease operations or services. There continues to be demand, and the technology is evolving to provide significantly increased spectral efficiency.

### 4.11.5. DO OTHER OPTIONS EXIST FOR THE DELIVERY OF FIXED, FIXED-SATELLITE AND AMATEUR INCUMBENT SERVICE, HOW PRACTICAL ARE THEY? WHAT ARE THE COSTS INVOLVED? WILL THERE BE A DIMINUTION OF THE SERVICE DELIVERED IF MBB SERVICES ARE INTRODUCED IN THE BAND?

The current use of the 3.6 GHz band for BWA, ITS and IIoT applications is effective today. The use of the 3 GHz band for mobile broadband requiring indoor coverage is very limited, and all effective services today make use of outdoor CPE. Loss of this spectrum would be catastrophic with significant economic ramifications. The current embargo put in place on the 9th Nov is already having significant negative impact.

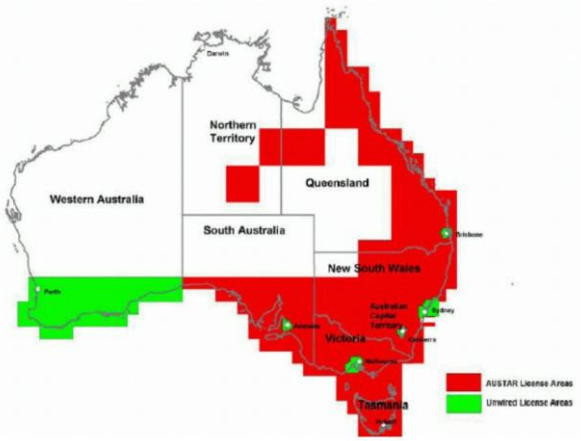
### 4.11.6. SHOULD FURTHER CONSIDERATION BE GIVEN TO THE MIGRATION OF INCUMBENT 3.6 GHZ BAND FSS EARTH STATIONS TO LOW DENSITY POPULATION AREAS?

Perhaps, especially if this will free up the use of more spectrum for use in regional, edge metro and metro areas. If, however, allocation of more spectrum for FWA in the 3.3 GHz to 3.4 GHz bands and also taking into account antenna directivity of FSS stations in the current 3.6 GHz, this may well not be required.

## 5. APPENDIX A NBN 4G FIXED WIRELESS.

Ref : http://3gwiz.com.au/ozmobilenet/?page_id=24

2.3 and 3.4GHz Spectrum Split Optus (Unwired) NBNCo (Austar)




The fixed wireless part of the NBN is using TDD LTE. The network is expected to service some 4% of NBN connections (around 500,000 premises) when it is completed in 2015. It will use around 2,300 base stations each costing between $300,000 and $400,000. The base stations are using the 2.3 and 3.4 GHz spectrum which NBN acquired from Austar for $M120 in February 2011. This spectrum 98 MHz in 2.3 GHz band and 65 MHz in 3.4 GHz band came to Austar as part of a swap with Unwired (then Vivid Wireless now owned by Optus). Basically Unwired had the spectrum in metro areas and Austar had the non metro.

The fixed wireless equipment used by NBN for this service is to be provided, built, operated and maintained by Ericsson. The up to $1.1Bn contract for this work was let in June 2011 and includes options covering 10 years. The contract also covers business support systems including service activation, management and assurance as well as network performance and capacity management. The agreement requires Ericsson to design, build, operate and maintain NBN Co's network end-to-end, including business support systems.

NBN are offering wholesale speeds on the radio network up to 25Mbps downlink and 5 Mbps up. Their design approach should offer good speed stability – obviously not as fast or consistent as fibre (either FTTP or FTTN) but superior to true mobile wireless broadband. NBN can engineer the TDD LTE base station capacity to the known demand of the customers served by the site. The radio path can also be more controlled as the customer antenna is externally mounted and can give predictable signal strength and signal to noise performance. NBN has a lot of spectrum to work with. It is higher frequency than common mobile broadband networks so exhibits a greater radio path loss. The greater path loss can

however be compensated for by the higher gain of the customer antenna and the predictable path due to the fixed external to the building mounting.

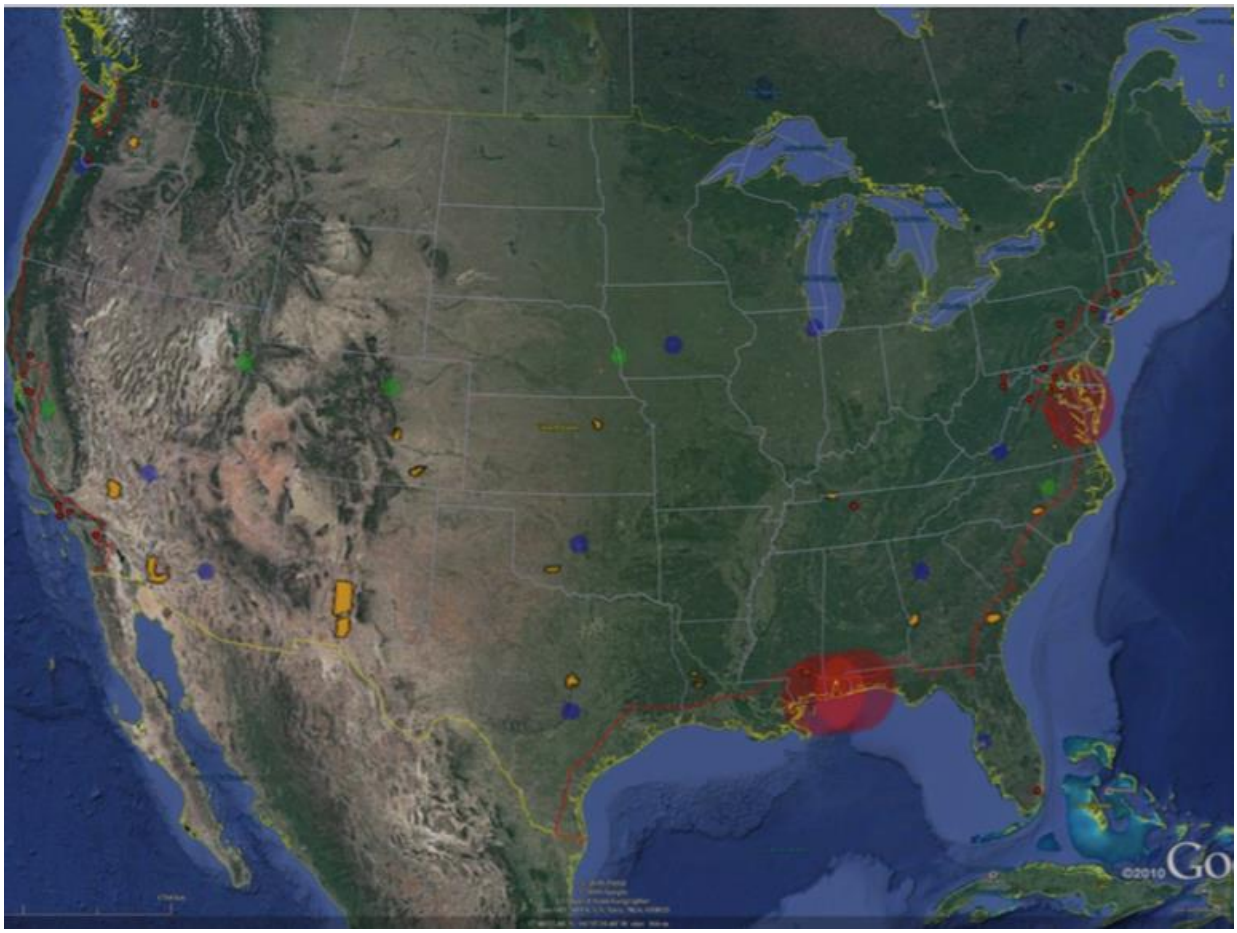
NBN has another strength in that it has access to fibre links and so it can engineer the base station backhaul capacity (the capacity of the transmission link from the base station to one of the 252 points of interconnection) to match customer demand on the base station.

## 6. APPENDIX B

**GOOGLE URGENTLY WANTS TO TEST SUPERFAST WIRELESS BROADBAND IN 24 US CITIES**

Google has sought urgent approval from the FCC to begin testing wireless broadband equipment in 24 cities across the US.

By Liam Tung | August 11, 2016 -- 10:52 GMT (03:52 PDT) | Topic: Networking



Blue dots indicate where Google wants to test 3.5 GHz wireless tech.

Image: Google

Google is urgently preparing a new round of secretive tests of wireless broadband delivery in the US, where it's angling to sidestep incumbent telecom operators.

In a new filing with the Federal Communications Commission (FCC), Google has sought a special license to test wireless broadband technologies in the 3.5 GHz band across 24 US locations for two years.

Google said the experiments would support the development of technologies for the Citizens Broadband Radio Service(CBRS), which operates in that band and will be used as a test bed for spectrum sharing.

Execs from Google Access, the unit responsible for Google Fiber, have been exploring fixed wireless broadband for low-density areas where costs prohibit laying fiber.

Google has requested the authorization be "granted expeditiously" for tests between 3.4 GHz and 3.8 GHz, the space that has been made available for small-cell spectrum sharing by CBRS devices.

It notes that existing licenses for ongoing tests in this band at several locations are set to expire in December. The 24 locations in the new application are spread across cities in California, Colorado, Kansas, Nebraska, North Carolina, Utah, and Virginia.

Google plans to test base stations as well as end-user devices with approved staff and contractors.

Google also intends to use the test to improve its Spectrum Access System (SAS) database, which may eventually be used to manage spectrum sharing in the 3.5 GHz band. Google had previously developed the SAS database for TV white-space spectrum sharing.

News of the application followed a report from the SAN JOSE MERCURY NEWS that Google's Fiber rollout has been delayed in some cities, including San Jose where a plan to lay fiber was abruptly brought to halt last month.

With its recent acquisition of the small ISP Webpass, Google does have another option now to roll-out high-speed broadband without necessarily digging up streetscapes to lay fiber cable.

> The Webpass technology is suited to high-density areas with an abundance of apartment blocks, whereas small cell networks in the 3.5 GHz range could also be used to provide fixed wireless broadband in rural areas.

## 7. APPENDIX C – MASSIVE MU-MIMO

cnMedusa technology in the new PMP 450m gives network operators that power of control. The PMP 450m is a first-of-its-kind fixed wireless broadband access platform that provides Massive Multi-User MIMO (Multiple-Input, Multiple-Output) technology in a commercially available, cost-effective solution. Massive MU-MIMO technology delivers ground breaking spectral efficiency in a highly integrated package, while being managed from a single pane of glass in the Cloud with cnMaestro. With the PMP 450m, network operators can offer dramatically higher throughput for the media-rich content that customers demand.

And it can be done with one simple Access Point change to the PMP 450m. This new AP is like no other, and offers:

- Increased capacity – The PMP 450m can provide more than 400 Mbps actual usable throughput per sector.
- Industry leading spectral efficiency – PMP 450m delivers >400 Mbps actual throughput in a 20 MHz channel (20+ bps/Hz, and over 40 bps/Hz when deployed in frequency re-use configurations).
- Investment protection – PMP 450m is fully compatible with PMP 450 Subscriber Modules (SM) in an existing network.

Sounds too good to be true? Check out the PMP 450m GO Massive page on our website, or view the recording of our launch event. Of course, you can always join the discussion on the Cambium Community.

A 3 GHz Massive MU-MIMO version of PMP 450m is expected to ship in Q4 2017.

## 8. APPENDIX D – PLANNED 5G BANDS BY FCC

FCC proposes rules for 4 different spectrum bands above 24 GHz for 5G networks

by Phil Goldstein |

Oct 22, 2015 12:33pm

WASHINGTON -- The FCC proposed new flexible rules for four different bands of high-band spectrum above 24 GHz designed to lay the foundation for 5G networks in the U.S. market. FCC Chairman Tom Wheeler said at the agency's monthly meeting that with the adoption of the proposed rules, the FCC is "taking a serious leap that creates a competitive opportunity for this nation to be a leader in the forthcoming 5G world."

The specific bands that will be studied for 5G services include the 27.5 to 28.35 GHz, also known as the 28 GHz band; the 37 to 38.6 GHz band, also known as the 37 GHz band; from 38.6 to 40 GHz, known as the 39 GHz band; and the 64-71 GHz band.

Commissioner Jessica Rosenworcel noted that these are the bands the FCC will propose to be considered part of 5G standards next month at the World Radio Conference 2015 in Geneva.

The FCC will propose in its Notice of Proposed Rulemaking a variety of rules for the bands, including geographic area licensing, unlicensed use and a licensing mechanism that can accommodate private enterprise uses and traditional mobile broadband deployments. The rules aim to promote coexistence among those alternatives, especially because several bands are shared with satellite services and with federal government and fixed users.

The 28 and 39 GHz bands are being contemplated for small cell deployments, with the proposal saying that the spectrum will be licensed as county-sized geographic services areas which auction winners could aggregate into larger service areas. Existing licensees could continue to do fixed, mobile or a combination of those services in those bands.

For the 37 GHz band, the FCC contemplates a hybrid licensing scheme that would grant operating right by rule to building and property owners while also establishing geographic license areas for outdoor services on a county-sized license area. Enterprise and industrial users could use the spectrum for indoor operations.

And finally, for the 64-71 GHz band, the FCC is proposing unlicensed use and more spectrum for services like WiGig while also protecting incumbent federal users. The FCC is seeking comment on how to ensure compatibility and facilitate coexistence.

"It was once thought that frequencies above 28 GHz could not support mobile services because their wavelengths were too short and the signal propagation losses were too high," Commissioner Mignon Clyburn said. "But industry engineers have now turned these weaknesses into strengths by finding ways to use short wavelengths to build dynamic beam-forming antennas to support high capacity networks that are small enough to fit into handsets. Many expect that these engineering advances will lead to 5G networks that will offer much higher data speeds and substantially lower latency than what commercial mobile services offer today."

Rosenworcel acknowledged the weak propagation characteristics of higher-band spectrum but said that dense networks of small cells could help overcome that and also called for new FCC rules to speed up the deployment of small cells. She noted that the WRC conference presents an opportunity to harmonize different 5G bands and thus create economies of scale that will lower the cost of 5G network gear and devices.

Both Commissioners Ajit Pai and Michael O'Rielly said they wished the FCC had included more bands in the item, as they had proposed. Pai said he suggested "including 12,500 MHz of spectrum in the 24 GHz band, 32 GHz band, 42 GHz band and the 70 and 80 GHz bands. Unfortunately, the votes were not there, and the Notice does not propose moving forward on them. The Commission's decision to sit on literally thousands of megahertz of spectrum that could very well be used for licensed and unlicensed innovation is a lost opportunity. The Notice offers no persuasive reason for leaving these bands on the cutting room floor." Pai also said "we don't know which millimeter wave bands will prove to be viable homes for 5G or other wireless uses."

However, Wheeler said that the proposed rule will include 3,850 MHz of spectrum, or six times the amount of all the commercial spectrum the FCC has ever authorized for wireless use. While not all spectrum is created equal due to the laws of physics, Wheeler said, it still represents a "huge increase."

To give the U.S. a lead in LTE deployments, Wheeler said, "spectrum was made available quickly and in sufficient amounts, and secondly, great flexibility was given to those to use the spectrum in expansive ways, unlike the kinds of government dictates that existed in other countries. We need to follow that kind of game plan in the 5G world."