RADIO SPECTRUM MANAGEMENT

NOT GOVERNMENT POLICY

Preparing for 5G in New Zealand

Discussion document

March 2018

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

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Glossary

Abbreviation/Term	Meaning
2G	Second generation (first digital) cellular technology
3G	Third generation cellular technology
4G	Fourth generation cellular technology
5G	Fifth generation cellular technology
3GPP	Third Generation Partnership Project
AFEL	Adjacent Frequency Emission Limit
DTV	Digital Terrestrial Television
Extremely high frequencies	30 GHz to 300 GHz
FDD	Frequency Division Duplex: separate frequencies are used for the uplink and downlink communications
IMT	International Mobile Telecommunications (generic term for cellular connectivity)
ITU	International Telecommunications Union
LTE	Long term evolution or 4G technology
NESTF	National Environmental Standard for Telecommunications Facilities
Super high frequencies	3 GHz to 30 GHz
TDD	Time Division Duplex: the same frequencies are used for both uplink and downlink, with the network alternating between uplink and downlink on a time basis
The Act	Radiocommunications Act 1989
The Crown	Her Majesty the Queen, acting through the Chief Executive of the Ministry of Business, Innovation and Employment
The Ministry	The Ministry of Business, Innovation and Employment
The Regulations	Radiocommunications Regulations 2001
Ultra high frequencies	300 MHz to 3 GHz
Very high frequencies	30 MHz to 300 MHz

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Invitation for submissions

Interested parties are invited to comment on the content of this document, in particular the questions posed, and on any related issues. Comments should be submitted in writing, no later than **5pm** on **Monday 30 April 2018** to:

By email: *(preferred option)*

Radio.Spectrum@mbie.govt.nz

Subject line: "Preparing for 5G in NZ"

Or

By post:

Preparing for 5G in NZ
Radio Spectrum Management Policy and Planning
Ministry of Business, Innovation and Employment
PO Box 2847
WELLINGTON 6140

Any party wishing to discuss the proposals with Ministry officials should email, in the first instance, Radio.Spectrum@mbie.govt.nz

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Preparing for 5G in New Zealand

1 Introduction

There has been much discussion around 5G and its impact on data networks. It is expected that 5G will increase mobile connectivity and support new services and as yet unimagined innovations. It will be central to future economic growth, employment, education, transport and more. It is anticipated to facilitate transformative change for New Zealanders and New Zealand business.

5G is the next generation of the global broadband multimedia international mobile telecommunication systems, known as IMT. 5G is not yet fully standardised but its key specifications and technological building blocks are being developed and tested. Trials of 5G technology are planned overseas starting in 2018 and are likely to begin in New Zealand prior to 2020.

This document sets out our current thinking on preparations for the roll out of 5G services in New Zealand. The objective of this discussion document is to canvas industry's views on the key issues and actions by government required to support the roll out of 5G technology. In particular, we wish to better understand the preferred spectrum configuration and optimal timing for spectrum release for 5G services, including providing for early technical and pre-commercial testing of 5G services in New Zealand.

We welcome views from Māori industry representatives. In addition, the government will be considering the Crown's Treaty of Waitangi obligations as part of its decision making. We intend to engage with Māori about those issues in the coming months.

1.1 What is 5G?

5G is the most recent 'generation' of cellular mobile technology. Since the introduction of the first cellular mobile networks in the late 80's, new technology developments have been rolled out roughly every decade. Each new technology (or generation) has changed the way we communicate. The first generation (1G) services were analogue mobile voice services only. The next generation (2G) introduced digital technology, increased the capacity for voice services and added small data messaging (text) services. Third generation (3G) mobile technology carried voice and messaging services plus introduced mobile broadband (data) services. The latest generation (4G or Long Term Evolution (LTE)) is a dedicated data network with faster speeds and greater capacity than the 3G network. Voice services at the present time are carried on the 'legacy' 3G networks in New Zealand. However it is expected that voice services will migrate to the 4G network using Voice over LTE (VoLTE) in the near future as more cell phones (handsets) are compatible with this technology.

The specifications for 5G technology are not yet finalised and significant work internationally is being carried out to complete the specifications and technology standards. The draft specifications for 5G technology provide another step change in speed and data capacity compared to 4G services, with

- peak data rates of up to 20 Gbits per second (a twenty fold increase from 4G)
- maximum connection densities of 1 million connections per square kilometre (a tenfold increase from 4G)

- very high connection reliability (99.999% for mission critical 'ultra-reliable' communications),
- fast response times (latency) of 1 millisecond (a tenfold reduction from 4G), and
- a threefold increase in spectrum efficiency compared to 4G.

The first systems able to meet the 5G technology specifications are likely to be enhanced 4G networks. Standalone 5G networks are anticipated to become available from 2020 onwards. Early 5G networks are expected to use existing 4G networks to manage device access to the network and functionality (i.e. to act as the control layer).

The infrastructure requirements for 5G are likely to be different to 4G. Cell sites are likely to use panel antenna, increasing the overall size of the antenna used if the current frequencies designated for 4G were to be used for 5G. Use of the super high or extremely high frequencies will reduce the size of antenna for 5G significantly. However, this will also require a greater density of antenna, particularly in urban areas. Early indications are that, even with sub 6 GHz spectrum, the number of cell towers in urban areas required to deliver a 5G cellular mobile network will double. Use of the super high or extremely high frequencies will increase the required density of cell sites further.

To achieve ultra-low latency, networks will move away from a core 'hub' to a dispersed network model. Equipment is being developed with the expectation that the network architecture will be software-defined allowing multiple virtual networks to be created within a single physical network (known as network slicing). For uses requiring low latency, a dispersed network model will be used, whereas uses requiring a massive density of connections such as the internet of things, the core hub network model could apply. In addition, the network capability is expected to support different frequency bands to be used for the control (connecting to the network and other information exchanges) and user (downloading data) layers.

Whilst the data throughput of the wireless network will increase significantly, the core network changes are the most substantial changes between 4G and 5G technology.

1.2 What will 5G be used for?

Initially, 5G is likely to be used mainly as an enhancement of the existing wireless broadband services. However, other uses identified by the technology developers include self-driving cars, increased use of robotics and industry automation, and massive machine type communications (the internet of things).

How these uses will develop in New Zealand is unclear. Some, such as self-driving cars, are likely to require substantial additional infrastructure investment. We are interested in your views on the likely New Zealand uses of 5G and the nature of the roll out and infrastructure requirements these uses will have.

Q1. What are the likely uses for 5G in New Zealand initially and in the longer term?

1.3 International milestones for 5G

The ITU World Radiocommunications Conference at the end of 2019 (WRC-19) is a significant milestone for seeking harmonisation in candidate bands for 5G in the super high or extremely high frequencies. The previous World Radiocommunications Conference in 2015 (WRC-15) agreed the allocation of the expanded 3.5 GHz band, the 600 MHz and 1400 MHz bands for

IMT (5G). WRC-19 is expected to make decisions on the initial candidate bands above 24 GHz to be allocated for 5G.

By the end of 2019, the ITU will also finalise the ITU-R Recommendations on 5G specifications to complement the anticipated decisions at WRC-19. Other international standards for the 5G core network and radio frequency equipment are also expected to be completed by this time.

A number of countries including the UK, US and Australia have consulted with industry on the roll out of 5G and related spectrum requirements. The FCC in the US has already identified multiple frequency bands above 24 GHz to facilitate different 5G deployment scenarios. Equipment manufacturers, cellular mobile providers and governments have announced 5G trials during

- the Winter Olympics in Korea in February 2018 using the 28 GHz band
- the Australian Gold Coast Commonwealth Games in April 2018 using parts of the 3.5 GHz band and parts of 26 GHz band
- the FIFA World Cup in Russia in mid 2018 using the 28 GHz band
- the Tokyo Summer Olympics in mid 2020 using the 3.5 GHz and 28 GHz bands and possibly some spectrum in 4.5 GHz band
- the 2020 UEFA Championship in Europe in 2020 using the 3.5 GHz band.

Network operators are likely to want to begin 5G equipment trials in New Zealand from 2018 onwards.

2 Regulatory considerations for 5G in New Zealand

The allocation of spectrum is a core regulatory issue for the deployment of 5G in New Zealand. We are interested in industry's views on any potential regulatory barriers to 5G deployment.

2.1 Network competition

The New Zealand market is, and is likely to remain, small compared to the level of investment required to roll out a national network. The question of whether there is 'room' in the New Zealand market for multiple 5G networks, or whether a single national 5G network would be more cost effective, has been raised in the media. A single 5G network is also being considered in the United States based on network security concerns.

In other countries, mobile markets have been consolidating. In New Zealand, there has been some consolidation in network provision with the Rural Broadband Initiative programme supporting a single national network provider in rural and remote areas. However, competition occurs at the retail level between the three national providers and the smaller regional providers.

When competing in the urban and peri-urban areas, three national cellular mobile providers set a national price for their services. This enables rural customers to benefit from the competition between providers in the larger urban markets.

Existing mobile network providers are likely to incrementally deploy 5G technology, relying on their existing networks to provide national coverage. These early 5G networks will use the 4G network as the control layer. If a single national 5G network were to be built by a new provider, it may require investment in a network core plus the building of a 4G and a 5G

network. This will increase the cost of delivering a 5G network. Waiting until a standalone 5G network could be built may impose (potentially unacceptable) delays in the deployment of 5G.

New Zealand has sufficient spectrum available for 5G to support the rollout of at least three national networks. All cellular mobile network operators have indicated their desire to build their own 5G network and compete at the infrastructure level. Given this, there would have to be strong public policy reasons to prevent this occurring.

The single network approach used for the second tranche of the Rural Broadband Initiative (RBI2) was authorised under the Commerce Act 1986 by legislative change in the Telecommunications Act 2001. Any move to providing a single national 5G network would need to be similarly authorised.

The Commerce Commission has recently announced a review of the level of competition in the mobile market. A report on the scope of and timeframes for the review is due in March 2018.

Q2. Do you consider competition should be encouraged at the infrastructure level or purely at the retail level for 5G? Why?

2.2 Other regulatory issues

Other regulatory issues for development of 5G networks include

- ensuring access to suitable sites for cell sites,
- the resource management consenting issues associated with new and existing sites and
- managing any potential health effects from increased exposure to nonionizing radiation.

Access to sites is a commercial arrangement between the landowner / building owner and the operator. If a site is on legal road, network operators have the right to place infrastructure. The national environmental standard for telecommunications facilities (NESTF) sets the maximum scale and location of telecommunications facilities that can be installed without requiring resource consent from a local authority. We are seeking feedback on whether industry considers 5G antenna will comply with the NESTF.

The New Zealand standards for non-ionizing radiation[1] are consistent with international standards. For cell sites, the NESTF requires installations to comply with the New Zealand standard. Some territorial local authorities also require compliance with these standards when issuing resource consents for cell sites under the Resource Management Act 1991.

For handsets, the New Zealand non-ionizing radiation standards are non-mandatory. Given the global nature of market for cellular mobile handsets, handsets will have to meet international exposure standards to gain access to more regulated economies. New Zealand benefits from this international compliance regime. Given the scale of the market in New Zealand it is unlikely that equipment would be specially manufactured for the New Zealand market without significant additional cost to end users.

Q3. What regulatory issues need to be considered from a 5G perspective in New Zealand?

Q4. What aspects of these regulatory issues are most significant for 5G?

[1] NZS 2772.1:1999 "Radiofrequency fields – Maximum exposure levels – 3 kHz to 300 GHz"

3 Possible frequency bands for 5G

Internationally, there is on-going activity to identify suitable bands for 5G. For New Zealand, it is important that any bands used for 5G are also used by many other countries to increase equipment availability, and ease of global roaming.

The bands we are considering for 5G include the 3.5 GHz and 26 GHz bands. Both bands are currently allocated with rights and licences expiring within the next four years. In addition, we are considering the future of the 600 MHz and 1400 MHz bands as there appears to be growing consensus on these bands as future 5G bands. These are discussed further below.

3.1 3.5 GHz band

The 3.5 GHz band extends from 3.4 to 3.7 GHz. The band is expected to be the main band for initial 5G deployment around the world. Equipment manufacturers have announced trials of 5G services using this band beginning in February 2018. Given the international trends, we consider the 3.5 GHz band is the top priority band for allocation for 5G.

In New Zealand, the lower part of the 3.5 GHz band (3410 to 3487 MHz and 3510 to 3587 MHz) is used for wireless broadband and is in Crown and private management rights. These management rights expire in October 2022. There has been little or no deployment of services in private management rights in the band.

The band is currently configured for frequency division duplex (FDD) technology with separate frequencies used for the uplink and downlink communications. Two attempts have been made to reach agreement between incumbent owners to reconfigure the band to make it more useable for time division duplex (TDD) technology[2], however these were not successful.

The previous Minister for Communications decided that no renewal offers would be made to incumbent rights holders in the 3.5 GHz band to allow re-planning of the band for 5G when the existing rights expire in 2022.

The upper part of the 3.5 GHz band (3589 to 3700 MHz) is allocated to fixed satellite services (in the space-to-earth direction) and is largely unused. The only use is for a satellite gateway earth station in north Auckland. These licences will expire in October 2022. The satellite operator has been given five years notice to quit the band.

With the low level of use of the upper portion of the 3.5 GHz band in New Zealand, we consider this could also be reallocated for 5G. This, together with the lower part of the band, would allow a total of 280 MHz of spectrum from 3410 to 3690 MHz to be available for 5G networks (see Figure 1).

If the 3.5 GHz band is allocated to 5G, there are two issues to be addressed. Firstly, rightholders in the Crown management rights have a legitimate expectation for continued access to spectrum once the rights expire. However, these users are unlikely to deploy 5G technology. This is discussed further in section 6. Secondly, network operators have indicated a desire to begin 5G deployment from 2020 onwards. The Ministry has been considering how this can be facilitated. This is discussed further in section 7.

Q5. Do you agree that the 3.5 GHz band is the top priority for allocation for 5G?

[2] TDD: the same frequencies are used for both uplink and downlink, with the network alternating between uplink and downlink on a time basis.

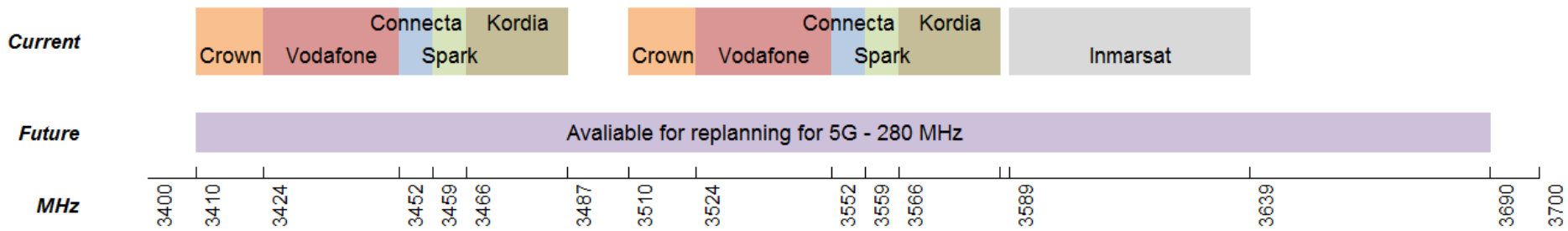

Figure 1: Current band plan for 3.5 GHz band

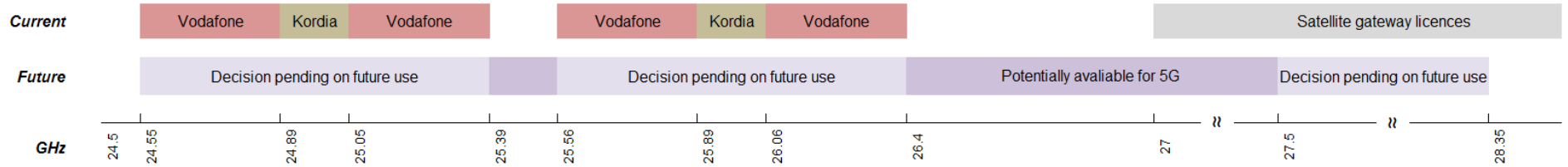

Figure 2: Current band plan for 26 GHz

Q6. Do you have any comments on reallocating 3587 to 3690 MHz for 5G?

3.2 26 GHz band

There are variations internationally in the exact frequency boundaries of the "26 GHz" band. In New Zealand, the 26 GHz band spans frequencies from 24.25 GHz to 28.35 GHz.

Management rights in the lower part of the 26 GHz band between 24.549 GHz and 26.4 GHz expire in 2022. Some rights are used for fixed links, whilst others are largely vacant. No

decision on the renewal or future of these bands has been made. However, policy precedent would lean towards non-renewal of the vacant and low use management rights.

Management rights in the upper part of the 26 GHz band between 26.4 GHz and 28.35 GHz expired in January 2018. No renewal offers were made to incumbent rights holders resulting in the spectrum being available for reallocation. Incumbent satellite providers hold radio licences for their operations expiring in January 2020. The decision for the future renewal of these radio licences will be considered in conjunction with the spectrum reallocation for 5G in New Zealand.

Vehicular radar is permitted in the frequency band 22-26.625 GHz through a general user licence (see Figure 2). Over the last decade, the automotive industry has moved to different frequency bands for vehicular radar technology. The use of the 26 GHz band for vehicular radar in New Zealand must cease on 1 January 2022. This is consistent with moves in Europe.

The under-utilisation of much of the 26 GHz band allows for replanning of some, or the entire, band. Re-planning options include

- creating new unencumbered management rights dedicated for 5G mobile,
- creating new management rights for 5G encumbered with licences for existing fixed links and /or satellite uplink transmission at earth station gateways,
- renewing existing rights in use and re-planning the remainder of the band
- consolidating existing rights in use to a single contiguous block and replanning the remainder of the band
- extending the current general user radio licence for vehicular radar, or
- a combination of the above.

We anticipate that further work on the band will be undertaken in 2020 once decisions at WRC-19 are known. Decisions on renewal of management rights expiring in 2022 will be made prior to this.

In the meanwhile, the frequencies currently in the radio licensing regime are available in some parts of the country for short term trials of 5G related technologies.

Q7. Do you agree that the 26 GHz band is a high priority for allocation to 5G in New Zealand?

Q8. Would this band be of interest to your organization for trials for 5G services in New Zealand?

3.3 Other extremely high frequency bands

There is a significant amount of work globally to address the need for 5G spectrum in frequency bands above 6 GHz. A number of candidate bands were considered at WRC-15 and

being studied for their suitability for 5G deployment. A decision on their suitability for 5G is expected at the WRC-19. The candidate bands are

- *24.25 to 27.5 GHz (26 GHz band)***
- *31.8 to 33.4 GHz ***
- *37 to 40.5 GHz*
- *40.5 to 42.5 GHz ***
- *42.5 to 43.5 GHz ***
- *45.5 to 47 GHz*
- *47 to 47.2 GHz*
- *47.2 to 50.2 GHz*
- *50.4- to 52.6 GHz*
- *66 to 76 GHz*
- *81 to 86 GHz*

At this stage, the New Zealand position in international discussions is to present a preference for the four bands marked ** above. These bands are either vacant or likely to become available in the near future in New Zealand.

The 26 GHz band discussed in section 3.2 covers the first candidate band above. We are aware that a number of countries including Korea and the United States are also considering the frequencies between 27.5 to 29.5 GHz for early 5G deployment. 27.5 to 29.5 GHz was not considered at WRC-15 for studies by the ITU and therefore is not expected to be considered at WRC-19. However, given the overlap with the 26 GHz band, we are monitoring the work being undertaken on the suitability of different portions of the frequencies between 24.25 to 29.5 GHz for 5G deployment.

The remaining preferred bands are either under-utilised or unallocated in New Zealand. We will be maintaining a watching brief on international agreements on the future of these bands and will respond when consensus and equipment availability becomes imminent. We will revisit allocation of these bands in New Zealand for 5G after WRC-19. As a consequence, we consider these bands to be a lower priority for allocation.

Q9. Do you agree that the 31.8 to 33.4 GHz, 40.5 to 42.5 GHz and 42.5 to 43.5 GHz bands are a low priority for allocation to 5G in New Zealand?

Q10. When do you think equipment is likely to become available in the bands identified in Q9?

Q11. Do you have any comment on the possible allocation of 27.5 to 29.5 GHz to IMT?

3.4 Possible ultra high frequency bands

3.4.1 1400 MHz band

The 1400 MHz (L) band was identified for IMT (including 5G) at the 2015 World Radiocommunications Conference. However, portions of this band are subject to compatibility studies to resolve the sharing between IMT and satellite in certain countries. The findings of these studies are due to be considered at WRC-19. International consensus on the final band plan is yet to emerge.

In New Zealand, the band is used for fixed links. The main user is Chorus, with other users including Airways Corporation, NZ Police and utility companies.

There are a number of different proposals for the band plan internationally based on FDD, TDD and supplemental downlink options. If there is a demand to use the band for IMT, we would need to adopt an appropriate band plan to suit the deployment scenarios in New Zealand. We would also need to develop a plan to free up the band and relocate incumbent users.

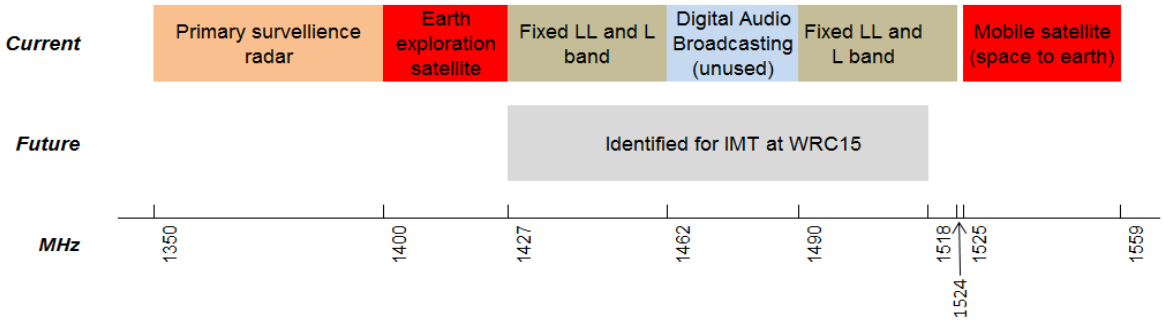

Figure 3: Current band plan for 1400 MHz

We see this as a low to medium priority for reallocation to IMT and are interested in feedback from industry on the future use of this band.

Q12. Is there demand for alternative uses other than IMT of the 1400 MHz band? If so, what uses?

Q13. When is the demand likely to require consideration of reallocation of the 1400 MHz band for IMT, if at all?

3.4.2 600 MHz band

The 600 MHz band and adjacent 500 MHz band are planned for use by digital terrestrial television (DTV) broadcasting in New Zealand. The 500 MHz band is fully utilised by DTV services. Te Mātāwai holds a management right used by the Māori Television Service in the lower part of the 600 MHz band from 606 to 622 MHz which expires in 2033. The remainder of the 600 MHz band is currently unused except by radio microphones. Radio microphones are permitted through a general user licence on a non-interference non-protection basis.

With changes to the broadcasting market and the move to more online channels, we are not convinced that there is future demand for more terrestrial DTV channels. As a consequence, the upper part of the 600 MHz band above Te Mātāwai's management right is likely remain unused for terrestrial DTV services.

Internationally, 610 to 698 MHz has been identified for IMT at the 2015 World Radiocommunication Conference. Deployment of cellular mobile networks in the 600 MHz band is commencing in the USA. If use of the band for IMT occurs more widely outside the USA, there will be sufficient market scale for manufacturers to develop equipment for the band for use internationally.

New Zealand could allocate the top part of the band above the management right held by Te Mātāwai for IMT. If this were to occur, then alternative spectrum would need to be found for radio microphones. Given that radio microphones have only recently moved to the 600 MHz band, any plan to relocate radio microphones to an alternative frequency band would need to consider fairness and compensation.

Whilst sub 1 GHz spectrum is sought after for IMT given its good propagation characteristics, we consider that identification of the 600 MHz band for IMT in New Zealand is a low priority for New Zealand until more countries begin using the band and equipment availability improves.

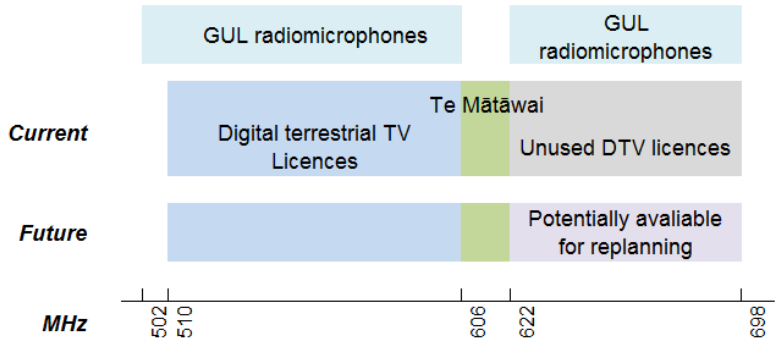

Figure 4: Current band plan for 600 MHz band

Q14. Is there a need for more sub 1 GHz spectrum for IMT/5G?

Q15. If so, how should we deal with radio microphones in the 600 MHz band?

Q16. When is the demand likely to require reallocation of the 600 MHz band to IMT, if at all?

4 Spectrum allocation

4.1 Allocation methodology

Spectrum may be allocated in a variety of ways, including through:

- first come, first served – allocation is based on the time order applications are received
- lottery – allocation is based on a random draw of applicants
- administrative allocation – allocation is based on criteria set by the administration
- auction – allocation is based on the highest bid.

Each method has strengths and weaknesses. Some may be more suited to the allocation of national management rights whilst others may be more suitable for regional licences. In all methods, the government can set the entry criteria and terms and conditions. The key differentiating aspects between methods are how the price is set and the level of discretion reserved by the government over which parties receive the spectrum.

Except in allocation by auction, the government is able to set the price for the spectrum. Given spectrum is difficult to value, there is a significant risk that the government sets the price too high (resulting in additional costs to consumers or reduced investment in network infrastructure) or too low (resulting in reduced returns to the government and potential windfall profits for spectrum holders if they on-sell quickly). A low price could also mean network operators have more funds to invest in the roll out of a network, however there is no certainty that this will occur.

In administrative allocations, the government retains full discretion over who receives spectrum rights. However, criticism of administrative allocations often centres on a perceived lack of transparency and the time taken to make the awards. First come, first served and lottery allocations have the benefit of being quick. A risk is that speculative bids may be successful and spectrum could either not be put to its highest value use, or on-sold for windfall profits.

Auctions have the advantages of being transparent and tend to allocate spectrum to the party that values the spectrum it most. Auctions are sometimes criticised for resulting in the high prices and favouring those with the greatest ability to pay. However, it's important to note that businesses are unlikely to pay more than the spectrum is worth, and auction revenue benefits taxpayers.

Administrative allocation and auction are the main methods used for allocating spectrum for cellular mobile networks around the world. In New Zealand, with the exception of some very early allocations and spectrum used by regional users, most new national management rights for spectrum has been allocated using auctions.

Auction design can be varied to suit the circumstances of the allocation. In New Zealand both simultaneous ascending and combinatorial clock auctions have been used for cellular mobile spectrum allocation. A simultaneous ascending auction is similar to the traditional 'outcry' auction, except multiple lots are auctioned at the same time. Bidders place bids on multiple lots at once, enabling bidders to create contiguous and/or paired holdings. Simultaneous ascending auctions allow bidders to modify their bidding strategy as the auction progresses. These have been used for the majority of spectrum auctions in New Zealand.

For the auction of management rights in the 700 MHz band, a combinatorial clock auction was used. In a combinatorial clock auction, the price of spectrum blocks rises incrementally until demand no longer exceeds supply. The 700 MHz auction allowed bidders to identify the number of lots they wished to purchase, and in a second phase, identify and bid for the position in the band their lots were to be placed. This allowed bidders to access contiguous blocks of spectrum enabling efficient use of spectrum.

Allocation of spectrum licences for regional wireless broadband have used auction or a blend of first come first served and lottery, depending on the band. This latter method is an unusual arrangement developed to encourage spectrum sharing. We do not consider a similar process would be relevant for national rights. However, it may be appropriate for regional allocations in 5G bands if a decision is made to provide for regional users in the re-planned bands.

We are keen to hear views on which allocation methodology is the most appropriate to allocate for national and / or regional spectrum rights for 5G.

Q17. Which allocation methodology should be used for allocating spectrum bands identified for use with 5G? Why?

Q18. Should different allocation mechanisms be used for rights for regional providers and national providers? Why?

4.2 Implementation requirements

A key objective of spectrum regulation is to ensure spectrum is put to its highest economic use. Whilst market-based methods of allocation contribute to this objective, there is a risk that spectrum is purchased for its foreclosure value (i.e. for its value in excluding competitors) rather than economic use. Implementation requirements are designed to ensure that spectrum is put to use.

Network operators are likely to invest in 5G networks in urban areas initially. The government could encourage a fast roll out through imposing a short timeframe for deployment in these areas. Given that some operators are still progressively rolling out their 4G network, a fast deployment of 5G may not be accommodated within their current investment plans. The government could take a similar approach to that used for the 700 MHz band and encourage

roll out in rural areas where it may be less commercially attractive to roll out 5G particularly using frequencies above 3 GHz. These options are not mutually exclusive.

Currently regional providers tend not to use LTE technology for wireless broadband even when operating in frequency bands internationally harmonised for LTE. As such, implementation requirements specifying a 5G roll out may not suit regional providers. How implementation requirements could be framed for regional providers would have to link to how spectrum is allocated to regional providers. This is discussed further in section 6.

The Ministry is keen to hear feedback on whether deployment of 5G technology should be required in some or all bands.

Q19. Should deployment of 5G technology be specified for some or all bands? If not, why not?

Q20. What implementation requirements should be specified and how should these be expressed? – time, extent, etc –

Q21. What should be the consequence of non-implementation – lose spectrum, additional payment, other

Q22. Should the implementation requirements be different for regional and national providers? What should these be and why?

4.3 Acquisition limits

A risk when allocating any band is that one or two companies could dominate spectrum holdings in the band, excluding others and stifling competition in downstream markets. In order to address this matter, acquisition of management rights and spectrum licences is subject to the prohibition on anti-competitive acquisitions in the Commerce Act 1986.

Due to concerns about how well the Commerce Act is able to deal with acquisitions in new markets, previous governments have elected to impose caps on how much spectrum any one party may purchase where competition is a particular concern. This occurred most recently in the allocation of 700 MHz management rights for 4G services where no company was permitted to hold more than 2 x 20 MHz (44%) of the band.

According to the recently released Third Generation Partnership Project (3GPP) 5G specification, the maximum carrier width in bands below 6 GHz is 100 MHz and 400 MHz for frequencies above 24 GHz. This would support the fastest peak data speeds possible for 5G.

We want to balance encouraging competition at the infrastructure level with maximising the benefit of 5G technology to New Zealand. With the large tranches of spectrum potentially available for 5G services, we consider that acquisition limits could be set

- at or near the maximum carrier bandwidth for sub 6 GHz frequencies (a single full carrier equates to 35% of the band) and
- at two or more maximum carrier bandwidths for frequencies above 24 GHz (a single carrier equates to between 13% and 24% of the band depending on the extent of management right renewal and reassignment of the 26 GHz band to 5G).

Under existing allocation rules for regional broadband providers, acquisition limits are expressed both in spectrum and geographic terms. Regional providers cannot own national rights in some bands and are limited to the number of territorial authorities they can hold licences in. Similar acquisition limits for regional providers could apply to 5G bands. However,

other more novel approaches to acquisition limits may be required is regional providers are accommodated through spectrum sharing arrangements.

Q23. Should acquisition limits be imposed on 5G bands? If so, what should these be and why?

Q24. Should acquisition limits be imposed for regional providers? If so, what should these be and why?

4.4 Duration of allocated rights

The maximum term of any management right (and hence spectrum licence) is set in the Radiocommunications Act at 20 years. However rights may be created for any lesser duration, for example 5, 10 or 15 years. A spectrum licence cannot have an expiry date beyond that of the relevant management right.

A shorter duration for management rights allows allocation adjustments to be made as the technology develops and new uses become more apparent. However, too short a duration for the rights may not provide sufficient certainty for network operators to invest in the roll-out of 5G networks.

5G technology is likely to be disruptive causing significant change in telecommunications and downstream markets. This leans towards having a duration of less than 20 years to enable the government to be able to respond to technology changes requiring, for example, replanning of a band. We are keen to hear views on the appropriate term for allocated rights.

Q25. What term should be used for management rights suitable for 5G? Why?

5 Management rights for 5G

5.1 Band planning

Cellular mobile technologies are available using either FDD or TDD modes. In New Zealand, with the exception of the 2.3 GHz band, all bands currently used for 3G and 4G are planned for FDD technology.

The draft standards for 5G and test equipment are favouring TDD technology and it is likely that 5G equipment will first be available using TDD technology. TDD allows asymmetry of the uplink and downlink data rates, i.e. number of uplink time slots and downlink time slots in a radio time frame may be different to reflect the relative proportions of upload and download data usage.

Our preference is to replan bands suitable for 5G as TDD bands to align with international trends and standards. At this stage, we consider that if a band is allocated for 5G, then no portion of the band will be planned for FDD equipment.

Q26. Should the 5G bands be replanned as TDD bands or some bands or parts of bands be retained as FDD? Why?

5.2 Bandwidth

The 3GPP recently released its technical specification for 5G. It identifies the range of transmission bandwidths available for 5G networks for frequencies below 6 GHz and above 24 GHz.

Table 1: Maximum transmission bandwidth configurations for 5G

	For frequencies			
Bandwidths	**Below 1 GHz**	**1 GHz to 3 GHz**	**3 GHz to 6 GHz**	**Above 24 GHz**
5 MHz	✓	✓		
10 MHz	✓	✓		
15 MHz	✓	✓		
20 MHz	✓	✓	✓	
25 MHz		✓		
40 MHz		✓	✓	
50 MHz		✓	✓	✓
60 MHz		✓	✓	
80 MHz		✓	✓	
100 MHz		✓	✓	✓
200 MHz				✓
400 MHz				✓

When management rights are created prior to an allocation process, the rights could be created for any of the bandwidth configurations in the standards. A larger bandwidth would reduce the complexity / duration of the allocation process. However, as a basis for allocation, using the larger bandwidths may be a barrier to entry for some potential participants and/or reduce the number of operators able to access the band. Using a narrower bandwidth would allow greatest flexibility in the final allocations held by participants.

At this stage, we suggest that the allocation lot size be 20 MHz for frequencies between 3 and 6 GHz and 100 MHz for frequencies above 24 GHz. We seek industry's views on what bandwidth should be used as the basis for allocation.

Q27. What bandwidth should be used as the basis for allocation? Why?

5.3 Out of band emissions

Management rights for the 5G bands will be created prior to any allocation process. Purchasers acquiring management rights are likely to purchase multiple contiguous rights. The frequency range covered by out of band emissions is related to the transmission bandwidth. As the transmission bandwidth increases so does the out of band emissions. Given this, there is a question of whether the out of band emission limits (Adjacent Frequencies Emission Limits or AFELs) on the management rights created prior to allocation should reflect those for the narrower bandwidth of the initial management right or that of the anticipated bandwidth post allocation.

If the narrower transmission bandwidth is used to set the out of band emission bandwidth on management rights, holders of multiple management rights would need to negotiate with their neighbouring management right holders to amend the out of band emissions to maximise the use of the spectrum they had acquired. Where holdings are unequal, this may

lead to inefficient outcomes. However, if the initial management rights are created with AFELs based on the widest transmission bandwidth possible, this may lead to inefficient outcomes if the final allocation results in holdings narrower than the maximum carrier width.

A second factor that needs to be considered in setting out of band emission limits is whether management rights created in bands identified for 5G are technology neutral. Out of band emissions from non 5G technologies may cause incompatibility and interference issues to adjacent 5G networks.

For the allocation of 700 MHz, the out of band emissions limits on the management rights were set at those for the maximum possible bandwidth for a single 4G carrier (i.e. 20 MHz). Similarly for 5G, our preference is to set the out of band emission limits on the management rights created for allocation as at the maximum possible transmission bandwidth. Compatibility issues between users would be a matter for negotiation between users.

Q28. What out of band emission limits should apply to management rights when first created for allocation? Why?

Q29. Should out of band emission limits be different if the band is technology neutral? If so, what out of band emission limits should be applied?

5.4 Interference between TDD networks

When TDD networks operate in adjacent spectrum blocks and in the same geographic area, interference may occur between the two systems. Out-of-band and spurious emissions from the transmitter may prevent one or more receivers in an adjacent spectrum block from operating properly.

Options to manage the potential for interference include:

1. Retain a fixed guard band between TDD networks
2. Require synchronization of adjacent TDD networks
3. Place a restriction on the maximum transmission power for the lower and/or upper portion of spectrum holding. The restriction could be lifted if two neighbouring TDD operators reach an agreement on how to manage interference between their networks.

Retaining a fixed guard band is the simplest method but is spectrally inefficient as the guard band will remain unused. Synchronizing networks is more spectrally efficient and likely to be effective in high density networks, but may be unsuitable in rural areas where base stations may be more widely spaced. Synchronization requires any asymmetry between upload and download times to be the same for all networks, calling for significant cooperation between network operators. Placing a restriction on transmission power for frequencies immediately adjacent to the boundary between holdings may result in the spectrum being unused, and potentially be less spectrally efficient than a fixed guard band depending on the final allocation outcomes.

We are interested in hearing views of the preferred method to manage interference between 5G TDD networks in adjacent frequency bands.

Q30. How should interference between adjacent frequency 5G TDD networks be managed? Should this be the same for all frequency bands?

Q31. How should interference between different technologies within the same band be managed, if bands are technology neutral?

6 Access to spectrum for regional providers

Regional wireless broadband providers operate in the 3.5 GHz band. When the Crown management rights in this band expire, these regional providers have a legitimate expectation they will be able to continue to operate a service. As noted previously, regional users are unlikely to use 5G technology to provide services.

There are number of options for how spectrum could be allocated to regional providers. These include

1. Renewing the existing Crown management rights in the 3.5 GHz band and allocating licences to regional users (status quo)
2. Consolidating the Crown management rights in the 3.5 GHz band into the lower part of the band and allocating licences to regional users
3. Requiring national rights holders to provide access to regional providers in national management rights where the national rights holder is not using the spectrum (sharing)
4. Requiring regional providers to relocate to alternative bands. Possible bands include
    - the vacant portion of the 600 MHz band
    - the unallocated portion of the 2.3 GHz band (2370-2395 MHz)
    - the 2100 MHz expansion band (1980 – 2010 MHz and 2170 – 2200 MHz).

Renewing the existing Crown management rights will reduce the number of full 5G carriers available in the 3.5 GHz band. Compatibility issues between the technology used by regional providers and 5G services is likely to reduce the amount of spectrum available for 5G further. Consolidating the Crown management rights into one part of the band will improve efficiency over the status quo. However, this may cause issues for regional providers using FDD equipment.

Requiring sharing of national management rights could be encouraged through the design of the allocation process. Options to achieve this include

- impose a spectrum cap of [60] MHz, with an additional [40] MHz available only if shared in areas outside the top [10] main urban centres
- identify particular lots in the band for sharing in areas outside the top [10] main urban centres. These lots would attract a lower reserve price that those with no sharing obligation
- require purchasers of national rights to publish their roll out plans within specified timeframes. Sharing would be required in areas not identified in the roll out plan. When the spectrum is subsequently required by national rights holders, they would need to compensate the regional providers for loss of spectrum.

In all examples above, the default would be that shared access would be on a no cost basis (except for licence fees).

Relocating regional providers to other bands may also be challenging. Some of these bands would need to be freed up to allow access which may be challenging within the timeframes required. In addition, there may not be suitable equipment available for regional providers to use.

The Ministry is interested in hearing views on how to allow for regional wireless broadband providers and which, if any, of these options is suitable / preferred.

Q32. Should regional uses be provided for in the 3.5 GHz band plan? Why?

Q33. If allowed in the 3.5 GHz band, how could this be managed or facilitated?

Q34. Which alternative bands may be suitable for regional allocation? Why?

7 Timing

As noted above, management rights in the lower portion of 3.5 GHz band (3410 to 3587 MHz) and lower portion of 26 GHz band (24.549 to 26.4 GHz) expire in 2022. Rights in the upper portion of 26 GHz band (26.4 to 28.35 GHz) expired earlier this year. We anticipate that allocation of long term rights commencing in 2022 will begin in 2018/19. With many countries looking to roll out 5G from 2020, waiting until 2022 for network operators to have access to spectrum and roll out their 5G networks may be detrimental to New Zealand businesses.

7.1 3.5 GHz band

Indications to date are that the 3.5 GHz band will be the priority internationally for early deployment of 5G networks. Early deployment is likely to begin in 2019 and 2020. Mobile network operators in New Zealand have indicated they are keen to begin commercial deployment in 2020, if appropriate spectrum is made available in a timely manner.

Management rights (expiring in 2022) in the lower portion of the 3.5 GHz band (3410 to 3487 MHz and 3510 to 3587 MHz) are in limited use. No rights exist in the upper portion of the band, vacant except for satellite earth station licences in Auckland (Albany), which also expire in 2022. The allocation design could attempt to enable early access to the band. There are a number of options to achieve this including:

1. Allocate long term commencing in 2022 across the whole band - no government intervention and commencement of all rights aligned in time. Access seekers could reach commercial arrangements with the current right holders
2. Allocate long terms rights commencing in 2020 in the upper portion of the 3.5 GHz band (i.e. 3590 to 3690 MHz) and 2022 in the lower portion of the 3.5 GHz band (i.e. 3410-3590 MHz). No intervention by government in establishing early access in the lower portion of the band. Owners of new rights commencing in 2022 in the lower portion of the band could reach commercial arrangements for early access with incumbent rights owners
3. Government purchases remaining rights in the band from incumbents and allocates all rights from the time agreement can be reached on the lower part of the band
4. Incumbents receive a portion of the final auction price (based on factors including remaining duration of the right and bandwidth) to release existing rights and enable access to the whole band from the date the auction is complete.

If all rights are allocated commencing 2022, the rollout of a 5G network is likely to be delayed. Rights owners in the lower portion of the band could begin deployment using their existing rights. However this may only occur if incumbents in the lower portion are successful in purchasing new rights commencing in 2022 covering the same (or sufficiently close) frequencies as they already hold.

In the second option, the successful bidder(s) for the upper portion of the 3.5 GHz band would have a significant advantage over other bidders as they would be able to roll out their 5G

network using the band two years earlier. This could result in high prices for the upper portion of the 3.5 GHz band with the possibility of flow on impacts to consumers. Commercial negotiations for early access to the lower portion of the 3.5 GHz band may not be successful particularly if one of the incumbent owners is the successful bidder for the upper portion of the band.

In options 3 and 4, it may be challenging for the government to reach agreement with incumbent rights holders to participate in the process. In option 3, some rights owners may hold out for a higher price, impeding the allocation of all spectrum within the band. In option 4, some rights owners may be concerned that the price for their spectrum is unknown at the point of agreement. However, option 4 removes the need for the government to set a price for the repurchase of the existing rights.

No option is ideal and we want to hear views on whether early access to the 3.5 GHz band is needed and if so, which is the best way forward to achieve this.

Q35. Is early access to the 3.5 GHz band required for roll out of 5G networks prior to the expiry of existing rights in 2022? If so, why?

Q36. How could early access to the 3.5 GHz band be achieved?

Q37. Should the government be involved in early access arrangements for the 3.5 GHz band?

7.2 26 GHz band

Similar to the 3.5 GHz band, management rights in the lower portion of the 26 GHz band, (24.549 to 25.392 GHz and 25.557 to 26.4 GHz) expire in 2022. One set are in substantial use for fixed links, with the remaining in no or limited use. In 2022, licences in the upper portion of the band and the general user licence for vehicular radar expires.

A decision on the future of management rights in the 26 GHz band is pending. Even if no renewal for some or all of the rights is offered, the rights will not be available for 5G before 2022.

Q38. Is early access to the 26 GHz band required for roll out of 5G networks prior to the expiry of existing rights in 2022? If so, why?

Q39. How could early access to the 26 GHz band be achieved?

7.3 Other bands

The bands above 30 GHz are likely to be used as additional capacity layers for 5G networks. We are not convinced that this additional capacity will be required in 2020 for initial deployment of 5G in New Zealand. As such, we do not consider there is any need to facilitate early access to these bands at this stage.

At present, we do not consider there is demand for the 600 MHz and 1400 MHz bands to be allocated to IMT. However, we intend to revisit the timing for allocation of these bands once allocation of the 3.5 GHz and 26 GHz bands is complete.

We are interested in industry's views on when there is realistically likely to be demand for these bands.

Q40. When is demand for the bands above 30 GHz likely to eventuate?

Q41. When is demand for the 600 and 1400 MHz band likely to eventuate, if at all?

8 Summary of questions asked