Final report for Trustpower

Review of 5G policy objectives in the context of discussion document on ‘Preparing for 5G in New Zealand’

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Contents

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1 Executive summary

In March 2018, the Radio Spectrum Management (RSM) function of the Ministry of Business, Innovation and Employment (MBIE) published a discussion document on 'Preparing for 5G in New Zealand'.[1] Trustpower has asked Analysys Mason to review the discussion document and provide views on the key points raised. This document sets out the findings from our review.

1.1 Overall context and key comments

The overall aims of the MBIE discussion document are encouraging – namely facilitating the early commercial roll-out of 5G technology to the benefit of citizens and businesses in New Zealand, by making suitable spectrum available. The frequency bands being considered for 5G use as set out in the discussion document are compatible with internationally harmonised spectrum for 5G, which is highly positive given the importance of economies of scale for mobile deployments.

The spectrum that will be released for 5G use in New Zealand will support the transformation of mobile networks. This transformation will be the key determinant of the development of new mobile services and infrastructure over the next five to ten years and beyond. Hence, the MBIE might consider that policies which guide, and regulations which govern, this market evolution to 5G should be developed with a longer-term view of mobile market competitiveness in mind, to maximise the potential for 5G to benefit all consumers and businesses in New Zealand.

Accordingly, it will be important to consider consistency between the issues addressed in 5G spectrum policy development and the issues being considered in the study of mobile telecommunications markets being undertaken by the Commerce Commission (ComCom),[2] such as in relation to structure and competitiveness of the mobile market.

Our overall comments on the MBIE discussion document are as follows:

- A broad view of potential 5G use cases is likely to be relevant when deciding on the best approach for authorising 5G use in the different spectrum bands that 5G might use
- Options to enable more operators to deliver 5G services might be relevant to consider, consistent with the market study being conducted by ComCom. Several different licensing options for 5G have been identified in some other leading markets worldwide (as described in Annex A to this report)

1 See https://www.rsm.govt.nz/projects-auctions/current-projects/preparing-for-5g-in-new-zealand-technical-consultation/5g-spectrum-road-map-discussion-document.pdf

2 See http://www.comcom.govt.nz/regulated-industries/telecommunications/monitoring-reports-and-studies/mobile-market-study/

- Core network changes will be an essential part of 4G-to-5G network transition, and 5G policies should reflect this transition, which will bring about greater flexibility and scalability to deliver different use cases, and alternative business models

- A coherent approach to the release of 5G spectrum across all the spectrum bands that 5G is able to use is highly desirable, taking account of the different likely purposes of use of each band (coverage/capacity), differences in the timing of availability of each band, and the varying available bandwidths in the different bands.

We discuss these points in more detail below.

1.2 Potential 5G use cases

Although 5G networks are not yet being commercially deployed (and hence commercial viability of possible 5G use cases is untested), we believe that a broad view is appropriate on the potential use of 5G technology, given that the current global industry view encompasses a variety of 5G services and applications across consumer and non-consumer markets. Whilst enhanced mobile broadband (eMBB) services for consumers might be the initial focus of 5G deployment for existing MNOs, there are a wide range of further possible use cases for individual vertical industries, and a range of deployment models for 5G technology.

At the global level, eMBB, massive machine-type communication (mMTC) and ultra-reliable low-latency communications (uRLLC) are all globally recognised use cases for 5G. Although MNOs might first prioritise eMBB to complement current mass-market consumer mobile broadband services, alternative and niche players are likely to find ways to innovate on service delivery in the 5G era by bringing new services to market (such as in the uRLLC and mMTC areas). 5G also has potential to supply fixed-wireless access links in local areas.

As such, in response to *Question 1* in the discussion document ("What are the likely use cases for 5G in New Zealand initially and in the longer term?"), our view is as follows:

> Based on the mobile industry's vision for 5G technology, we believe that 5G networks can be expected not only to deliver high-capacity mobile broadband services in high-demand areas to meet increasing consumer demand, but also to enable potential new uses and applications, such as industrial automation, transport applications, augmented- and virtual-reality video, and low-latency, highly reliable data links connecting multiple types of device and objects in the Internet of Things (IoT). Although traditional MNO business models may target eMBB services initially for 5G, it is possible there could be a role for additional players and alternative deployment solutions beyond those that MNOs will provide, given the broad scope of the use cases that 5G technology might support.

1.3 Regulatory options to enable more operators to deploy 5G networks and/or deliver 5G services

There are several options for authorising 5G spectrum use, depending on the frequency bands being considered, the characteristics of those bands and the services that might be supported. International experience indicates that a broad range of potential regulatory conditions have been applied to 4G mobile licensing – including wholesaling capacity and obliging open access – and these considerations will also be relevant for 5G.

Regulators in several other advanced markets have discussed a range of regulatory options for 5G spectrum authorisation, recognising the potential increase in flexibility and use cases and the new value chains that might emerge with 5G.[3] As MBIE develops its position on spectrum allocation options in the coming months it could consider a similarly broad range of solutions to introduce flexibility and enable players other than nationwide MNOs to have access to 5G spectrum.

In response to *Question 2* in the discussion document ("Do you consider competition should be encouraged at the infrastructure level or purely at the retail level? Why?), our view is as follows:

> We consider that competition should be encouraged at both the infrastructure and retail levels. The increased capacity, scalability and flexibility of 5G networks can be expected to drive innovation in retail services and has the potential to create new markets. The ability to build standalone networks with 5G to support different use cases and alternative business models, as well as virtualisation in radio access and core networks (see Section 1.4 below), raises the possibility of alternative players and/or new entrants deploying 5G networks and/or offering 5G services, in addition to the existing MNOs. Effective wholesale access could also be a key regulatory component in the licensing of spectrum for 5G networks. From an infrastructure perspective, the high costs involved in rolling out new radio and core infrastructure may mean that current trends towards greater use of radio access network (RAN) sharing and enablement of wider coverage through wholesale access will continue to be relevant in 5G.

1.4 Changes at the core network level, relevant to competition considerations

Virtualisation in core networks, along with new radio network architectures (e.g. centralised RANs) will enable end-to-end network slicing in 5G, bringing about increased flexibility and configurability and support for new business models.

Network slicing provides for end-to-end logical (virtual) networks with dedicated capacity and/or other service-specific characteristics. Slicing in 5G networks can potentially be used to deliver differentiated latency, performance, reliability, availability and other characteristics, tuned to the needs of each use case/service. The number of slices that are created is currently uncertain and will be driven by market needs. The proliferation in demand for these slices might have implications for

[3] See examples in Annex A.

spectrum authorisation, in that a greater number of players might wish to have access to their own 5G spectrum (e.g. to build their own radio access networks, using the 5G core of another operator).

Accordingly, virtualisation in 5G core networks is particularly relevant to the competition issues raised by *Question 2* in the discussion document ("Do you consider competition should be encouraged at the infrastructure level or purely at the retail level? Why?), as follows:

> Virtualisation in radio access networks, and in core networks, will in time result in the delivery of configurable end-to-end network slices, which can be provisioned to provide unique services to different types of user/customer, based on their needs. This could be relevant when considering competition at the retail level. To deploy 5G, operators can use a 4G network as an underlay ('non-standalone') initially, and in subsequent deployments they can operate 5G standalone networks. These 5G technological developments will bring new capabilities to mobile networks that can be expected to drive innovation and could also increase the demand for spectrum beyond that of traditional nationwide MNO spectrum demands.

1.5 Consistency with ComCom's mobile market study

We note that the scoping stages of ComCom's study raised several market issues, including competition (recognising infrastructure, virtual and retail competition), consumer outcomes, and barriers to entry faced by operators. ComCom's study aims to inform policy makers such as MBIE of the performance of the mobile markets, and, as such, encourage the government's preparations for 5G to take account of and support growth and innovation in mobile markets in their widest sense.

This suggests that the significant regulatory issues to be considered for 5G should be consistent with those being considered in ComCom's study into mobile markets in New Zealand.

Accordingly, in answer to *Question 3* ("What regulatory issues need to be considered from a 5G perspective in New Zealand?") and *Question 4* ("What aspects of these regulatory issues are most significant for 5G") in the discussion document, we suggest the following view:[4]

> The most significant regulatory issues that need to be considered from a 5G perspective in New Zealand are likely to be similar to those raised in the scoping document for ComCom's market study[5] – regulations that enable the creation of a more dynamic retail market and allow for a greater diversity of mobile virtual network operators and other players making use of 5G technology, improved wholesale market arrangements, the implications of convergence between fixed and mobile networks, and new forms of spectrum sharing. Given our answers to the previous questions in relation to use cases and 5G technology characteristics, we believe

[4] We note that *Question 3* and *Question 4* in the discussion document are primarily directed at three specific issues: (1) ensuring access to suitable sites for cell sites, (2) the resource management consenting issues associated with new and existing sites, and (3) managing any potential health effects from increased exposure to non-ionising radiation. However, we have taken the broad wording of the questions as an opportunity to summarise our view of the general regulatory issues which need to be considered for 5G.

[5] See http://www.comcom.govt.nz/regulated-industries/telecommunications/monitoring-reports-and-studies/mobile-market-study/

it is relevant to consider if there is potential for players other than existing MNOs to use 5G spectrum and provide 5G services. This potential for new 5G players to be enabled through innovative spectrum sharing has also been identified as being relevant for consideration in other advanced markets – such as the USA, and in Australia, where the government indicated in a 5G consultation paper published in 2017 that 5G technology creates opportunities for players other than MNOs, such as for increased spectrum sharing (see Annex A for more detail).

1.6 Coherence in timing of 5G spectrum awards across multiple bands

MBIE's approach is that 5G will require a variety of spectrum bands – lower frequencies for coverage combined with higher bands (where significantly more bandwidth, and less scarcity exists) for capacity and for new services. This is consistent with international 5G trends. The 3.5GHz band is emerging as the most promising band globally for initial 5G deployment, and several regulators are considering authorising 5G spectrum use in the millimetre-wave bands below 30GHz, either around 26GHz or 28GHz. Annex A contains examples from other Asia–Pacific markets, confirming this broad approach.

Whereas the propagation characteristics of lower frequencies being considered for 5G have similarities to mobile spectrum in use today, the new bands in the millimetre-wave portion of spectrum have different propagation characteristics. Regulators in other markets (such as Ofcom in the UK) have recognised that the limited range of operation in the millimetre-wave spectrum, combined with new technologies being developed for 5G, could facilitate greater geographical re-use of spectrum. These features could be exploited within alternative licensing approaches, such as use of shared spectrum and non-national licences, to allow more operators to deploy networks than has been possible to date.

We note that the market structure might vary across bands, due to differences in scarcity as well as other factors. For example, lower bands where demand is especially high (and bandwidth is limited) might support a small number of mainly national operators – potentially with additional retail competition – whereas the higher bands have capacity to support spectrum ownership by a larger number of operators, and new forms of deployment.

An overall framework should be considered, especially given that 5G spectrum release will occur over a period of several years, and so there is a need to have a spectrum release strategy which remains coherent over time.

MBIE has asked several questions relating to spectrum allocation, specific bands for 5G use and award conditions (such as acquisition limits (e.g. spectrum caps)). We have not answered all questions individually. However, we set out our view on the key points (i.e. allocation, use and award conditions) below. These views correspond to the following questions in the discussion document – *Question 17* (Which allocation methodology should be used for allocating spectrum bands identified for use with 5G? Why?), *Question 19* (Should deployment of 5G technology be

specified for some or all bands? If not, why not?) and *Question 23* (Should acquisition limits be imposed on 5G bands? If so what should these be and why?):

We note that the wide bandwidth, and the limited propagation range of 5G millimetre-wave spectrum, combined with new 5G network technology, could facilitate alternative methods for allocating some of the spectrum in this range, compared to exclusive-use nationwide licensing. For example, the greater geographical re-use possibilities for spectrum in millimetre-wave bands could unlock additional sharing opportunities, and/or make sub-national licensing approaches more viable (either regional licences, or licences to deploy 5G in localised areas). The wide bandwidth available in the millimetre-wave bands will reduce the scarcity of spectrum which, combined with new sharing possibilities, might mean that alternative authorisation approaches for 5G spectrum are possible. The UK regulator identified a range of approaches in its 26GHz call for input published in 2017, and a similar broad analysis of different options might be relevant in New Zealand – including auctions along with other forms of assignment, such as administrative, or 'first-come, first-served' licensing, and sub-national, as well as national, approaches to defining geographical rights of use.

The market structure might vary across the different bands being used for 5G, due to scarcity as well as other factors; for example, the lower bands (where bandwidth is limited) might support a limited number of mainly national operators – potentially with additional retail competition (if MBIE and ComCom consider that to be a key additional requirement) – whereas the higher bands (where bandwidth is more widely available) might support a larger number of operators owning their own spectrum, and new forms of deployment.

However, an overall framework should be considered, especially given that 5G spectrum release will occur over a period of several years, and so there is a need to have a spectrum release strategy which remains coherent over time. This overall framework should consider whether specific measures are needed within 5G licensing to ensure that the regulatory and market objectives identified for 5G are met in full.

Acquisition limits on spectrum holdings might be a relevant consideration in some if not all 5G bands, bearing in mind our answer to *Question 3* that 5G could unlock new business models and new opportunities for alternative players and new entrants.

2 Introduction

In March 2018, the Radio Spectrum Management (RSM) function of the Ministry of Business, Innovation and Employment (MBIE) published a discussion document on 'Preparing for 5G in New Zealand'.[6] Trustpower has asked Analysys Mason to review the discussion document and provide views on the key points raised. This document sets out the findings from our review.

Our views are based on international precedents on 5G policy in other markets, as well as taking account of issues raised in the scoping study consultation on mobile telecommunications markets in New Zealand that the Commerce Commission (ComCom) published in 2017.

As agreed with Trustpower, we have not answered each individual question in the MBIE discussion document, but have focused on the key questions, namely Questions 1, 2, 3, 4, 17, 19 and 23.

The remainder of this document is laid out as follows:

- Section 3 describes the mobile market context in New Zealand
- Section 4 discusses relevant 5G technology considerations
- Section 5 discusses relevant regulatory considerations for 5G licensing
- Annex A provides selected case studies illustrating 5G policy approaches in other markets.

6 See https://www.rsm.govt.nz/projects-auctions/current-projects/preparing-for-5g-in-new-zealand-technical-consultation/5g-spectrum-road-map-discussion-document.pdf

3 The mobile market context

In New Zealand, mobile networks are currently operated by three national mobile network operators (MNOs) – Spark, Vodafone and 2degrees. The frequencies they use span from 700MHz to 2.6GHz, in line with internationally allocated spectrum for 2G, 3G and 4G use.

The new technologies being developed for 5G will use a combination of existing, and new, mobile spectrum bands. Existing mobile spectrum is largely allocated in New Zealand to existing MNOs. However, the characteristics of the new frequency bands that 5G will use (especially millimetre-wave spectrum) might provide opportunities for more players to provide 5G services and to deploy 5G infrastructure.

Infrastructure competition itself is a continuum of options, from entirely separate networks, through partial sharing of passive assets (sites), through to innovative and advanced technical network sharing such as multi-operator radio access networks (RANs), spectrum pooling and (dynamic) network capacity slicing. We expect that these more innovative and advanced forms of sharing will become commonplace in 5G, supported by its flexible, scalable network deployment mode, and virtualisation in core and RANs.

Our view is therefore that new 5G network technologies and deployment styles can improve the quality, speed and cost of mobile services in New Zealand, and enable new types of operator to enter the market.

We would note that:

- A more dynamic retail market for 5G services could dilute the relatively highly concentrated market that exists currently in New Zealand. This might be facilitated through regulations that support introduction of a greater proportion of competitive retail supply from a diversity of mobile virtual network operators, more players making use of wholesale access arrangements for 5G and/or exposing the full benefits of advanced 5G technologies (e.g. virtualised end-to-end network slices) to allow non-national players to deploy infrastructure

- Improved wholesale market arrangements, particularly given significant capacity increase and the ability to 'slice' the network, can support a more dynamic, competitive and innovative retail market

- Convergence of fixed and mobile networks and services will become increasingly relevant in the 5G era as wide area and indoor services begin to seamlessly converge – more than is currently possible using mobile and Wi-Fi access today. This can be supported by 5G services at low frequencies for ubiquitous coverage and high frequencies for hotspots of high traffic density (e.g. buildings and campus areas).

There is growing recognition among regulators in other advanced markets that the approaches taken to 5G licensing should allow for a range of possible users being interested in acquiring 5G spectrum, beyond nationwide MNOs.

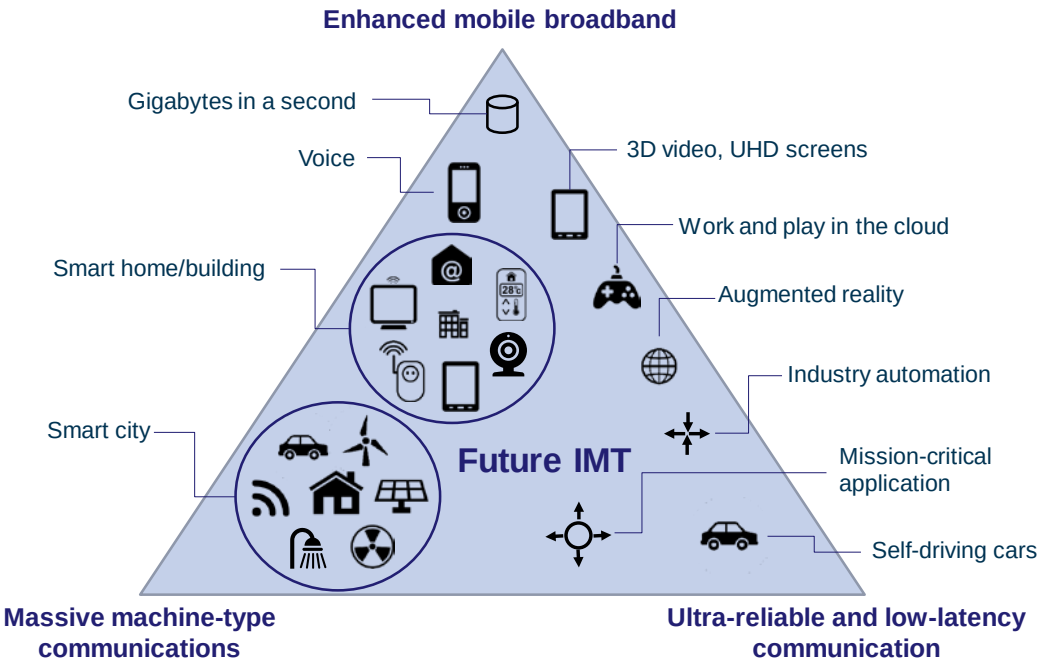
Annex A provides more detail on relevant proposals in other markets.

4 Relevant 5G considerations

4.1 Use cases

The use cases for 5G have been studied extensively by the wireless industry and are widely supported and consistently presented in published industry reports. The most widely quoted source is the discussion on 5G use cases in study groups of the radio sector of the International Telecommunication Union (ITU-R), which has resulted in agreement on the range of possible 5G applications illustrated in Figure 4.1 below.

Figure 4.1: Use cases and applications for 5G [Source: ITU-R, 2017[7]]



As shown in Figure 4.1, the applications within the ITU-R's vision for 5G can be grouped into three main categories:

- Enhanced mobile broadband (eMBB) – the evolution of 3G/4G mobile services to provide significantly higher throughput, capacity and performance (moving towards providing connections with fibre-like quality using wireless technology)
- Massive machine-type communication (mMTC) – this embraces the IoT to deliver services in a world where a vast number of devices, things and objects are connected by 5G networks

7 Recommendation ITU-R M.2083-2.

- Ultra-reliable low-latency communications (uRLLC) – the capabilities of 5G will enable extremely low latency for applications and services demanding this, achieving a latency of no more than a few milliseconds for the connections between devices and applications servers.

The potential use cases for 5G technology therefore include, but extend significantly beyond, eMBB services: mMTC and uRLLC applications include smart infrastructures in towns and cities (e.g. connected bus stops, connected buses, connected and autonomous vehicles, connected railways), remote control of machinery, factory automation, and many others.

Whilst eMBB services for consumers might be the initial focus of 5G deployment for existing MNOs, there are a wide range of further possible uses, and deployment models, for 5G technology. This would suggest that the government should take a broad view on the potential use of 5G technology in New Zealand.

Indeed, since 5G technology is being designed to serve the needs of multiple industries and consumers, the supply of 5G services is likely to become more diverse, with the possibility of niche players emerging to cover specific use cases, or specific locations, alongside traditional 'mass-market' nationwide players.

4.2 Frequency bands, timing and award of licences

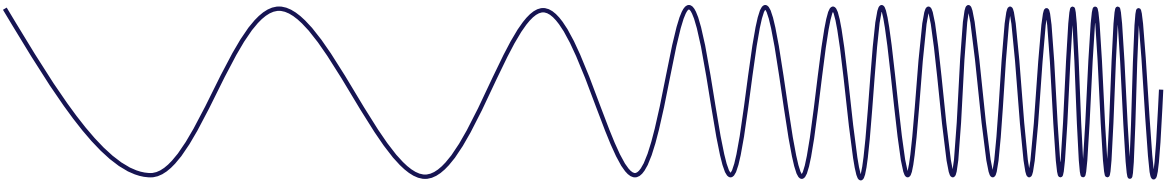
The use of internationally harmonised 5G spectrum in New Zealand, and internationally harmonised configurations for 5G spectrum (i.e. unpaired spectrum in the 3.5GHz band, along with wide unpaired channels in millimetre-wave bands such as 26GHz or 28GHz) is likely to promote economies of scale and choice for consumers (e.g. in terms of available devices).

For consistency with international timescales, 5G licensing should be in place in time for network launch around 2020.

There is a view that large amounts of spectrum might be needed to deliver some (though not all) 5G services, such that these provide a significant change in user experience compared to 4G networks. Access to significantly more spectrum may be required in localised 5G 'hotspots', e.g. 1GHz (or more) of millimetre-wave bandwidth per network has been suggested, to deliver truly differentiated 5G services.

However, as MBIE recognises, mid- and low-band spectrum (see Figure 4.2 below) will also be needed to support increased capacity for 5G services, over a wider area.

Figure 4.2: Spectrum being considered for 5G [Source: Analysys Mason, 2018]



Low band	Mid band	High band (mm-wave)
Sub-3GHz Existing IMT bands (800, 900MHz, 1800, 2100, 2300 and 2600MHz), as well as 600MHz and 700MHz	3–24GHz Spectrum in the 3.4–3.8GHz band is the most globally referenced for 5G	Above 24GHz. 11 candidate bands on ITU WRC-19 AI 1.13: 24.25–27.5GHz, 31.8–33.4GHz, 37.0–40.5GHz, 40.5–42.5GHz, 42.5–43.5GHz, 45.5–47.0GHz, 47.0–47.2GHz, 47.2–50.2GHz, 50.4–52.6GHz, 66–76GHz, 81–86GHz

Given the range of spectrum that will be needed for 5G, and the uncertainty in the requirement (and demand) for bandwidth to provide different 5G services, flexible approaches to the award of spectrum might be relevant to consider. These flexible approaches might include alternatives to conventional national exclusivity, such as regional licensing and spectrum sharing.

There are also several approaches that could be considered to ensure that the award of 5G licences takes account of new entrants and smaller players, such as setting aside specific spectrum blocks for non-MNO use, spectrum caps on larger operators, etc.

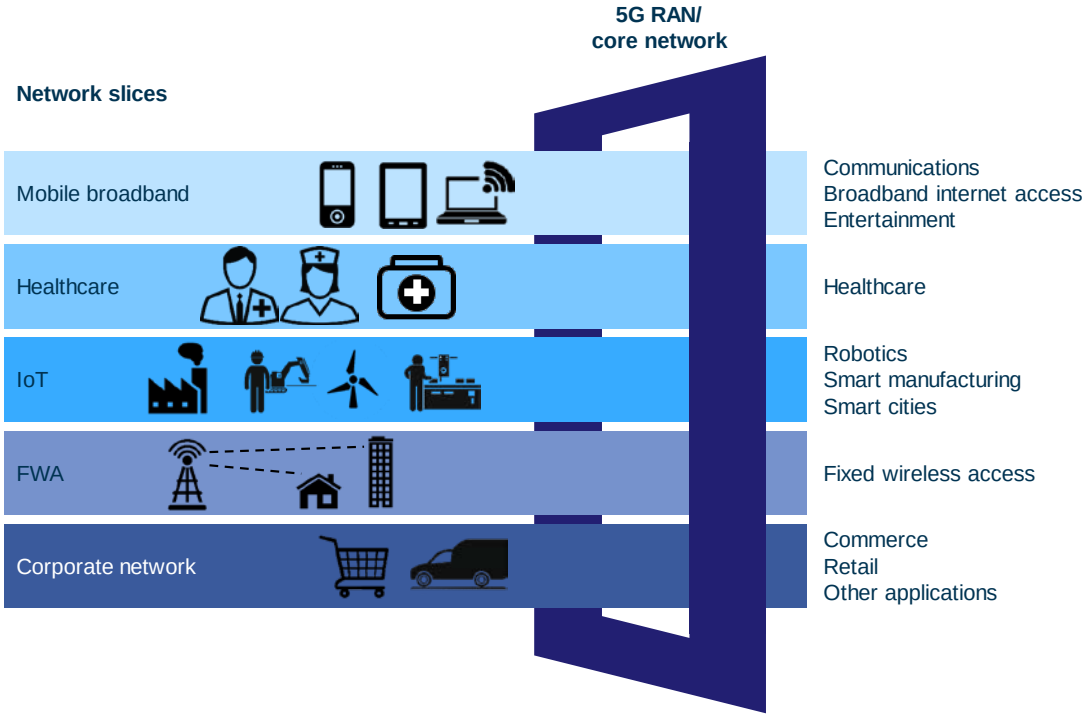
Furthermore, the potential for shared use and unlicensed use of 5G spectrum might be considered. Technologies are currently being developed for managing shared use in other markets. As discussed in Annex A, the Citizens Broadband Radio Service (CBRS) initiative in the USA is a significant example of an authorisation approach that incorporates both shared use and unlicensed use of spectrum within a shared bandwidth.

4.3 Core network changes

5G networks will embrace virtualisation and associated innovations within the core network.

End-to-end 'network slicing' is widely considered as an essential component of 5G networks, allowing them to provide a network performance that is tailored to the specific requirements and applications of different industries with bespoke needs in terms of coverage, quality of service, resilience, data rate and services. This additional configurability and scalability of 5G technology will be especially relevant for applications that require more robust performance and high reliability, such as autonomous driving, health, manufacturing, energy, media and entertainment. The concept of network slicing is illustrated in Figure 4.3 below.

Figure 4.3: Network slicing [Source: Analysys Mason, 2018]



New virtualisation features through slicing could stimulate innovation and could also increase the number of organisations wishing to access spectrum.

Furthermore, these features might drive new deployment models (e.g. neutral host models for small-cell deployment, vertical users owning their own spectrum and networks), with implications for competition.

Spectrum licensing for 5G might therefore need to consider new types of competition, allowing for connectivity to be delivered in new ways and to facilitate the emergence of effective and sustainable new players.

5 Regulatory considerations for 5G licensing

5.1 Spectrum flexibility and additional operators

The mobile market in New Zealand is currently characterised by three MNOs owning spectrum, with limited downstream retail diversity as a result of vertical integration. Continuing with, or designing a licensing regime which arrives at, an allocation of spectrum to just the three national MNOs is one option for MBIE in the release of 5G spectrum. This option should only be taken if it is determined that this in the best long-term interests of end users.

As an alternative, release of 5G spectrum could support a widening of the market in terms of the number of players that own spectrum. Given the large amount of spectrum available, especially at higher frequencies, it is possible that more players could own useful blocks of spectrum with which to develop innovative network deployments.

International examples in which regulators are (considering) adopting 5G licensing approaches that might increase the number of operators with 5G spectrum are provided in Annex A.

5.2 Spectrum sharing

Obligations may be placed on 5G spectrum owners to introduce downstream diversity and improvements, to the benefit of consumers. This might start with the network infrastructure (sites) which could be shared, or made available to other spectrum owners, but could extend to the incentive to support more retail competition, e.g. through obligations to wholesale a set amount of active-layer capacity to third parties.

Smaller players might also share spectrum, either through explicit, flexible rules or through unlicensed spectrum use. Spectrum leasing could also be applied to national licences, whereby national operators are able to lease bandwidth to local players in areas not covered by their networks.

A notable example of a spectrum-sharing authorisation approach is the CBRS initiative in the USA, which allows the deployment of private networks using unlicensed spectrum in the 3.5GHz band. Further details are provided in Annex A.

5.3 Open access

As an alternative to widening the market, it is also possible to focus the operations of the spectrum owner(s) specifically on the upstream infrastructure, and to introduce new downstream markets to support a wider retail activity. Allocating (more) spectrum to wholesale-only businesses, or to operators with an open-access obligation, seeks to reduce vertically integrated silos, and to introduce different incentives to maximise utilisation of the scare spectrum asset. Although not widely implemented to date, some countries have considered wholesale licensing of some or all of the 4G spectrum being awarded (e.g. Mexico and South Africa).

In the 5G market, similar considerations will be relevant. It is possible that wholesale models, or neutral-host providers, might offer a viable solution for the further roll-out of specific coverage and capacity enhancements – such as mobile small cells, avoiding the need for duplication of small-cell infrastructure between MNOs.

Annex A International examples

This annex contains six examples of pro-competition and innovative licensing approaches to mobile spectrum authorisation proposed by regulators in other markets.

These examples highlight:

- New styles of network deployment and new wholesale models (i.e. the CBRS initiative in the US, and possible licensing arrangements in the 26GHz band in the UK)
- The importance of broad licensing objectives for 5G – enabling a wide range of services, promoting competition and encouraging innovation in relevant markets (i.e. millimetre-wave licensing in the UK and the USA)
- The importance of ensuring flexibility and avoiding barriers when making (5G) spectrum available (e.g. spectrum management reforms in Australia)
- The relevant frequency bands being considered internationally for 5G, highlighting the global focus on spectrum around 3.5GHz and in millimetre-wave bands below 30GHz (26GHz, and 28GHz) – as illustrated by 5G spectrum licensing proposals in South Korea and China.

A.1 UK – 26GHz consultation

The UK communications regulator, Ofcom, published a call for input (CFI) on authorising 26GHz spectrum for 5G use during 2017. In this CFI, Ofcom states that 5G millimetre-wave spectrum could enable new opportunities for both incumbents and new entrants and that technology developments brought in by 5G in millimetre-wave bands have the potential to enable innovative services and alternative business models, beyond the traditional MNO model. Ofcom also notes that the limited range of operation in millimetre-wave frequencies (due to the short wavelengths in this type of spectrum) could facilitate greater geographical re-use, thereby allowing more operators to deploy networks. Ofcom explores a variety of types of demand and corresponding licensing models, including neutral hosts for small cells, private 5G network providers and fixed wireless access (FWA) players.

Ofcom's CFI sought information from stakeholders on making spectrum in the 26GHz band (24.25–27.5GHz) available for 5G.[8] Section 4 of the CFI explicitly considers potential demand for millimetre-wave spectrum in the UK. Ofcom expects that 5G millimetre-wave spectrum will provide supplementary MBB capacity in high demand areas. However, Ofcom also states that such spectrum "*could enable new services and applications for citizens and consumers, opening up new business models and new opportunities not only for existing operators, but also for new entrants*". Ofcom also notes that the organisations wishing to access 5G millimetre-wave spectrum could increase as

8 See https://www.ofcom.org.uk/__data/assets/pdf_file/0014/104702/5G-spectrum-access-at-26-GHz.pdf

a result of the new technologies being developed for 5G (i.e. network slices that are configurable to provide bespoke services to individual users). Technology developments combined with the physical properties of millimetre-wave spectrum may also mean that alternative forms of licensing could be viable, as a result of increased scope for geographical re-use.

Ofcom provides the following overview of potential new services and deployment solutions:

- **Increasing MBB capacity of existing mobile networks** in high demand locations (e.g. railway stations and sports stadiums) through the use of small cells
- **'Neutral hosts'**, i.e. small-cell wholesale access providers. Neutral hosts install and operate small cells, and then provide wholesale access to other operators/service providers. Ofcom notes that this model could result in more efficient use of spectrum. The possibility of non-neutral hosts (in which the wholesale access provider also provides a retail service) is also recognised; in both cases, Ofcom states that competition issues would need to be considered.
- **Industrial and enterprise applications** (e.g. automation in factories/warehouses, low-latency medical technologies, and many others). Existing MNOs may seek to serve the specialist requirements of such customers using 'network slicing', or with dedicated sites. Industrial customers might also be served by new entrants, e.g. by private 5G network providers (which build/operate networks at the enterprise premises).
- **Fixed wireless access (FWA)**. Ofcom notes that some operators are already planning to use millimetre-wave 5G spectrum for this purpose.
- **Wireless backhaul**, either using conventional point-to-point (PTP) microwave links, or point-to-multipoint (PTMP) and mesh type networks.
- **Road and rail**. Enhancement of in-vehicle MBB services, as well as 'vehicle to everything' (V2X) communication, connected and autonomous vehicles (CAV), smart highways, etc.

Ofcom also identified the following alternative licensing approaches in its 26GHz CFI:

- Shared, uncoordinated use (i.e. licence exempt, or unlicensed) – noting that the inherent propagation characteristics of millimetre-wave propagation and the potential development in 5G equipment specifications of protocols to share between 5G new radio (NR) cells might make 5G small cells more suitable for licence-exempt or unlicensed operation than current-generation mobile technology
- Shared, coordinated deployment – for example, based on 5G cells being coordinated with existing cells, and requests to use spectrum being considered on a 'first come, first served' basis by the regulator
- Tiered sharing models, by having a database of deployments and using spectrum sensing techniques
- Area-defined licences, allowing for regional deployment

- National licences, but potentially with some mechanism to avoid under-utilisation of spectrum (e.g. to assess if there are areas of un-met demand after a pre-defined period, and to authorise additional operators to use the spectrum in these un-met areas).

A.2 Australia – 5G consultation and broader approach to spectrum

The ACMA is currently implementing reforms to ensure that spectrum management is as flexible as possible to promote choice and innovation. Reforms are taking place to migrate towards a more flexible, unified licensing system across the spectrum that the ACMA manages. Additionally, the ACMA's consultation documentation on 5G deployment in the 3.5GHz band notes the potential benefit of allowing new entrants access to 5G spectrum.

A number of 5G spectrum (and broader) developments in Australia indicate the intention to allow for non-MNO users:

- The Australian government and the ACMA are currently[9] implementing a number of spectrum management reforms, after conducting a comprehensive 'Spectrum Review' in 2014/15. Among other things, the reforms aim to increase flexibility and accommodate innovative uses. One of the key guiding principles of the reforms was "*ensuring [spectrum] arrangements are as flexible as possible to promote choice and innovation*".[10]

- The Australian government published its '5G – Enabling the Future Economy' paper on 12 October 2017.[11] The paper includes explicit discussion of novel licensing approaches, such as spectrum sharing, which may allow the use of 5G spectrum by players other than existing MNOs:

  "*Spectrum sharing, that is spectrum accessed by numerous users on a shared basis, has also been identified as an option for 5G technology […] 5G opens up new opportunities for increased spectrum sharing, through mechanisms such as network slicing. 5G technology is also designed to support shared arrangements and allows for the sharing of the same spectrum ('unlicensed Wi-Fi' spectrum) with other technologies. Operators can augment their holdings in situations where existing exclusive holdings are insufficient to meet customer needs*".

- The ACMA has outlined plans[12] to auction spectrum in the 3575–3700MHz and 24.25–27.5GHz bands for 5G. In discussing the benefits of refarming the 3.6GHz band for 5G, the consultation

9 See https://www.communications.gov.au/what-we-do/spectrum/spectrum-reform

10 See https://www.communications.gov.au/publications/spectrum-review-report, section 1.3.

11 See https://www.communications.gov.au/documents/5g-enabling-future-economy

12 On 5 March 2018, the Minister for Communications approved the auction of 125MHz of spectrum in the 3.6GHz band (3575–3700MHz). The auction is scheduled for October 2018.

The ACMA's *Five Year Spectrum Outlook* (FYSO) 2017–2021, published in October 2017, classifies the 24.25–27.5GHz band as "second of the 5G bands' with 'broader interest to be determined". The FYSO suggests that an auction date of Q1 2019/20 is likely for the millimetre-wave spectrum; see https://www.acma.gov.au/theACMA/five-year-spectrum-outlook-2017-21

documentation[13] explicitly lists the "*potential to improve competition in the MBB market by providing incumbent and/or new operators with access to more spectrum in key market areas*". More broadly, the ACMA recognises the "*[high] rate of change and innovation in global spectrum use generally*", and therefore "*the uncertainties inherent in predicting future changes in highest value use of bands*".[14]

A.3 USA – CBRS initiative

The Citizens Broadband Radio Service (CBRS) initiative in the USA is making spectrum in the 3.55–3.70GHz range available for unlicensed use on a shared basis. The market has shown considerable interest in the deployment of private LTE (and, in the future, potentially 5G) networks using CBRS spectrum.

The communications regulator, the FCC, is in the process of releasing the CBRS band (3550–3700MHz) for shared wireless broadband use.[15] The band is governed by a three-tier authorisation framework that allows commercial users to share spectrum with existing federal and non-federal users:

- Tier 1 consists of incumbent users[16] (primarily the US military), which have top priority.
- Tier 2 organisations can be granted priority access licences (PALs) for a fee. A maximum of seven PALs (in the 3550–3650MHz range), each 10MHz in size, will be licensed in any given geographical area. Use of these bands can be pre-empted by Tier 1 users. The exact structure of the PALs (licence duration, geographical extent, etc.) has been the subject of significant debate, which was ongoing at the time of producing this paper.[17] PALs are expected[18] to be auctioned in late 2018 or 2019.
- Tier 3 users have general authorised access (GAA) – that is, they can make opportunistic use of any available block of the 3550–3700MHz band without a defined licence term. These users must accept

13 'Future use of the 3.6 GHz band' – Options paper, published June 2017; see https://www.acma.gov.au/theACMA/~/link.aspx?_id=17BFF36784FF4151B1217647D6957112&_z=z

14 *Ibid*. The statement is made in relation to apparatus licence arrangements in the 5.6GHz band.

15 See https://www.fcc.gov/rulemaking/12-354#block-menu-block-4 for an index of FCC CBRS documentation.

16 Tier 1 incumbent users mainly use these bands for naval radar applications in coastal areas, so this capacity remains largely unused in inland areas.

17 See, for example, http://www.wispa.org/Wispa-News/ArtMID/13028/ArticleID/199/CategoryID/55/CategoryName/Top-Story/FCC-VOTE-IS-A-STEP-BACKWARD-FOR-RURAL-BROADBAND-WISPA-SAYS. For a more recent example, see https://www.fiercewireless.com/wireless/t-mobile-smaller-license-areas-cbrs-would-result-inefficient-use-spectrum

As of mid-April 2018, the FCC's website stated that: 'Each PAL is defined as a non-renewable authorization to use a 10MHz channel in a single census tract for three-years. Up to seven total PALs may be assigned in any given census tract with up to four PALs going to any single applicant. Applicants may acquire up to two-consecutive PAL terms in any given license area during the first auction".

18 See, for example, https://www.cablelabs.com/meet-cablelabs-tech-policy-whisperer-rob-alderfer

interference from Tier 1 and 2 users. We understand that use of GAA spectrum can begin as soon as the necessary equipment has been certified,[19] which is expected in the second half of 2018.[20]

Access and operations will be managed by a dynamic spectrum access system (SAS), conceptually similar to the databases used to manage television white-space (TVWS) devices.

Among other things, the FCC intends that the novel CBRS spectrum-sharing approach will enable "*wide deployment of wireless broadband in industrial applications – advanced manufacturing, energy, healthcare, etc. – supporting innovation and growth throughout our economy*".[21]

There is considerable industry interest in the CBRS band; the CBRS Alliance (a group promoting the technology) includes all four major US MNOs, equipment vendors (Motorola, Samsung, Nokia, Ericsson) as well other key technology players such as Google, Intel and Qualcomm.

Interest has primarily focused around use of the CBRS spectrum for in-building LTE coverage or private LTE networks for enterprises. However, the spectrum (which lies in the main band being harmonised for 5G globally) may be used for 5G networks in the future.[22]

A.4 USA – millimetre-wave bands

The FCC has confirmed plans to release several millimetre-wave bands for 5G. Consultation documentation highlights the FCC's intention to license spectrum in such a way as to allow for a range of possible users (i.e. not just the major MNOs).

The FCC issued[23] an NOI (October 2014), NPRM (October 2015) and R&O/FNPRM (July 2016) under the title 'Use of Spectrum Bands Above 24GHz For Mobile Radio Services' (also referred to as the 'Spectrum Frontiers' initiative).

The R&O adopts new rules that aims to authorise ~11GHz of high-frequency spectrum for flexible, mobile and fixed use, including 3.85GHz of licensed spectrum (27.5–28.35, 37–38.6, 38.6–40GHz) and 7GHz of unlicensed spectrum (64–71GHz).[24]

19 Cloud-based spectrum access systems (SASs) will actively manage users of the three CBRS tiers. The SAS will tell the CBRS base stations (called CBRS devices, or CBRDs) which channels to use in order to avoid interference with other users in a given geographical area. The main instance of incumbent use will come from US military shipborne radar. A radar detection network known as an ESC (environmental sensing capacity) will detect the arrival of these ships on either the east or west coast of the USA. SAS and ESCs must be certified before the GAA tier of the CBRS can be used.

20 See, for example, Federated Wireless' response to the NPRM: https://ecfsapi.fcc.gov/file/122836319522/Federated%20Wireless%20Comments%20on%202017%20CBRS%20NPRM%20-%20FINAL%2012.28.17.pdf

21 See https://www.fcc.gov/news-events/blog/2015/04/21/breaking-down-barriers-innovation-35-ghz-band

22 See https://www.sdxcentral.com/articles/news/3-5-ghz-cbrs-band-breakthrough-5g/2017/03/

23 All documentation is available at https://www.fcc.gov/5G. NOI = Notice of Inquiry, NPRM = Notice of proposed rulemaking, R&O = Report and order, FNPRM = Further NPRM (see https://www.fcc.gov/general/rulemaking-fcc for full explanation).

24 The unlicensed 64–71GHz band is adjacent to the 57–64GHz band, which is already unlicensed, resulting in a continuous unlicensed band of 14GHz.

The FCC's licensing approach attempts to allow for a broad range of uses. For example:

- the NPRM considers the 28GHz and 39GHz bands "*suitable for deployment of high-capacity, high-throughput small cells as part of mobile broadband deployments*". At the same time, the FCC proposed rules that "*would provide licensees with the flexibility to conduct fixed and/or mobile operations*".

- In the 37GHz band, the NPRM proposed a hybrid licensing mechanism that would "*grant operating rights by rule to property owners, while establishing geographic area licenses based on counties for outdoor use*". This licensing mechanism was designed to "*facilitate the deployment of advanced enterprise and industrial applications not suited to unlicensed spectrum or public network services, while also providing additional spectrum for more traditional cellular deployments*".

A.5 South Korea

In early 2017, the Ministry of Science and ICT (MSIT) released[25,26] a national broadband/spectrum plan (K-ICT), indicating that it planned to allocate a minimum of 1300MHz for 5G by 2018, consisting of 300MHz in the 3.5GHz band (3.4–3.7GHz[27]) and 1GHz in the 28GHz band (27.5–28.5GHz, with a possible 2GHz extension).

On 19 April 2018, Yonhap News Agency[28] reported that MSIT had confirmed the structure and reserve prices for the auction,[29] which will be held in June 2018.

A.6 China

The Ministry of Industry and Information Technology (MIIT) in China has committed[30] to making available more than 100MHz of mid-band spectrum per operator, and 2GHz of high-band spectrum per operator for 5G.

25 See https://blog.naver.com/with_msip/220917986508. The plan aims to release a total of 40GHz of additional spectrum by 2026 across four service categories: IoT, public sector, private sector and broadcast/satellite.

26 MSIT released a notice in July 2017 indicating that the government may be reserving 76–81GHz and 3.1–3.735GHz for 5G; see http://www.msit.go.kr/web/msipContents/contentsView.do?cateId=mssw352&artId=1364893

27 See https://www.ituaj.jp/wp-content/uploads/2017/05/nb29-2_web.pdf

28 See http://english.yonhapnews.co.kr/news/2018/04/19/0200000000AEN20180419010500320.html

29 Bidders will compete for 28 blocks in the 3.5GHz band and 24 blocks in the 28GHz spectrum, with the period of use starting in December for 10 years and five years, respectively.

30 See https://5g-ppp.eu/wp-content/uploads/2016/11/03_9-Nov_Session-2_Chang-Ruoting-1.pdf, which also references the 4.4–4.5GHz range for 5G. See also 'Radio Spectrum Management in China', Bureau of Radio Regulation, MIIT, 11 September 2017.

In June 2017, the MIIT released[31] a consultation on using spectrum in the 3.3–3.6GHz and 4.8–5.0GHz ranges for 5G. Reports state[32] that China is likely to assign the 3.6–4.2GHz range to 5G in the future. In relation to high-band spectrum, the MIIT approved[33] two millimetre-wave bands (24.75–27.5GHz and 37–42.5GHz) for research and testing in July 2017 and has stated[34] that it will continue to consider more bands (both low and high frequency) for 5G development.

31 See https://www.fiercewireless.com/wireless/china-reserves-spectrum-for-5g-says-more-low-band-frequencies-coming-report. We understand that the MIIT also sought comment on non-exclusive use of the 24.75–27.5GHz and 37–42.5GHz bands in June 2017; see https://www.qualcomm.com/media/documents/spectrum-4g-and-5g

32 See http://www.atimes.com/article/china-reserves-spectrum-5g-services/

33 See http://www.miit.gov.cn/n1146295/n1652858/n1653100/n3767755/c5677054/content.html and http://www.miit.gov.cn/n1146290/n1146402/n1146440/c5730538/content.html

34 See http://www.miit.gov.cn/n1146290/n4388791/c5906943/content.html