RADIO SPECTRUM MANAGEMENT

NOT GOVERNMENT POLICY

24 – 30 GHz use in New Zealand

Discussion document

April 2021

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

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Glossary

Abbreviation/Term	Meaning
3GPP	Third Generation Partnership Project
4G	Fourth generation cellular technology
5G	Fifth generation cellular technology
AAS	Active Antenna Systems
ACMA	Australian Communications and Media Authority
AFEL	Adjacent Frequency Emission Limit
BS	Base Station
EESS	Earth Exploration Satellite Service
EHF	Extremely high frequencies (30 GHz to 300 GHz)
EIRP	Effective Isotropic Radiated Power
eMBB	Enhanced Mobile Broadband
ESIM	Earth station in motion. A satellite terminal based on moving vehicles such as aircraft, ships and land based vehicles where terrestrial services are not available
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FDD	Frequency Division Duplex: separate frequencies are used for the uplink and downlink communications
FSS	Fixed Satellite Service
FR	Frequency range
FWA	Fixed wireless access
GSO	Geostationary satellite orbit
GURL	General User Radio Licence
IMT	International Mobile Telecommunications (generic term for cellular connectivity)
ITU	International Telecommunications Union
LMDS	Local Multipoint Distribution Service
LTE	Long term evolution or 4G technology
mmWave	Millimetre wave. Commonly used to describe frequency bands above 24 GHz.
MS	Mobile Station
NGSO	Non-geostationary satellite orbits
NR	New Radio, the radio terminology for 5G
OBUE	Out of band unwanted emissions

Abbreviation/Term	Meaning
RR	ITU Radio Regulations
RRF	RSM Register of Radio Frequencies
SHF	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	The Crown in right of New Zealand acting by and 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
TRP	Total Radiated Power
UE	User Equipment
UEL	Unwanted Emissions Level
VSAT	Very small aperture terminal. This technology consists of small terminals connected to a central hub via satellite and can support internet, voice, video and data services

Invitation for submissions

This document sets out the spectrum plan for future use of radio frequencies between 24 and 30 GHz in New Zealand.

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 **27th of May 2021** to:

By email: *(preferred option)*

Radio.Spectrum@mbie.govt.nz

Subject line: "24 - 30 GHz use in New Zealand"

Or

By post:

24 - 30 GHz use in New Zealand
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, in the first instance, email Radio.Spectrum@mbie.govt.nz

Publication and public release of submissions

Except for material that may be defamatory or out of scope, the Ministry of Business, Innovation and Employment (the Ministry) will post all written submissions on the Radio Spectrum Management website at www.rsm.govt.nz. The Ministry will consider you to have consented to posting by making a submission, unless you clearly specify otherwise in your submission.

Submissions are also subject to the Official Information Act 1982. If you have any objection to the release of any information in your submission, please set this out clearly with your submission. In particular, identify which part(s) you consider should be withheld, and explain the reasons(s) for withholding the information. The Ministry will take such objections into account when responding to requests under the Official Information Act 1982.

Privacy Act 2020

The Privacy Act 2020 establishes certain principles with respect to the collection, use and disclosure by various agencies, including the Ministry, of information relating to individuals and access by individuals to information relating to them, held by such agencies. Any personal information you supply to the Ministry in the course of making a submission will be used by the Ministry in conjunction with consideration of matters covered by this document only. Please clearly indicate in your submission if you do not wish your name to be included in any summary the Ministry may prepare for public release on submissions received.

Executive Summary

Radio Spectrum Management (RSM) is considering the best use of radio spectrum in 24 - 30 GHz. This paper proposes new uses of radio spectrum between 24.25 GHz and 30 GHz. This frequency range encompasses the “26 GHz” and “28 GHz” bands.

The 26 GHz band covers the 3.25 GHz of spectrum between 24.25 GHz and 27.5 GHz. It was identified for International Mobile Telecommunications (IMT) at World Radiocommunications Conference (WRC) 2019 and the ITU Radio Regulations were updated (see Edition of 2020).

The 28 GHz band (27.5 - 29.5 GHz) is commonly used by satellite, mobile and fixed services worldwide. It is also planned for use by 5G services by a number of countries. Although deploying IMT in 28 GHz band was not a study item in WRC-19, the band has been specified by the third Generation Partnership (3GPP)[1] as a portion of n257 (26.5 - 29.5 GHz) since its first 5G standards release (Release 15).

This frequency range is part of the Ka band (26.5 - 40 GHz) which is the key satellite spectrum used currently for earth stations, gateways and Earth Stations in Motion (ESIM). The significant bandwidth available in the Ka band makes its attractive for satellite broadband applications.

RSM has analysed the technologies and applications in use, or proposed for use, in the 24 - 30 GHz frequency band. Given the emerging equipment eco-system and global harmonisation trends, we propose the 26 GHz band primarily for IMT use. This use includes enhanced mobile broadband (eMBB), fixed wireless access (FWA) and industry verticals. For 28 GHz, we propose sharing between IMT, fixed satellite services (FSS) and earth stations in motion (ESIM).

We have considered the technical requirements for the radio services using these bands. The technical requirements include unwanted emission limits, network synchronisation options and sharing methods.

This consultation seeks to gather views from stakeholders on our proposals. We are interested in understanding the use cases and gaining feedback on licensing options and technical parameters that will determine how the band is planned.

The consultation does not include radiofrequency field exposure standards or spectrum policy matters such as the Crown-Māori partnership, how rights will be allocated or competition issues.

[1] The 3rd Generation Partnership Project (3GPP) is an umbrella term for a number of standards organizations which develop protocols for mobile telecommunications.

1 Introduction

1.1 Background

This document sets out our initial thinking on the high-level use cases and technical parameters for use of the 24 - 30 GHz frequency range. The aim is to gather further information about sector and stakeholder perspectives on potential uses.

The consultation covers band planning, licensing options and technical considerations. The results of this consultation will feed into our work to finalise band planning, licensing rules and technical requirements. This will provide important technical inputs to future policy decisions that will cover allocation details.

International bodies generally divide the 24 - 30 GHz frequency range into the 26 GHz band (24.25 - 27.5 GHz) and the 28 GHz band (27.5 - 30 GHz). The band has a range of uses and is allocated in the ITU Radio Regulations to fixed, satellites and mobile service (including identification for IMT in 24.25 - 27.5 GHz).

In the 2017 – 2021 Five Year Spectrum Outlook (5YSO), RSM signalled an intention to develop a spectrum agenda to "provide a vision on the expected timelines and resources required for the development of 5G spectrum allocations in New Zealand". In 2018, we released a consultation document Preparing for 5G in New Zealand. We acknowledged that to deliver the highly-reliable, ultra-low latency, multi-gigabit connectivity opportunities that 5G promises, spectrum for 5G services needs to include low, mid, and high band spectrum. Among the options for high band spectrum, 26 GHz and 28 GHz bands are the primary areas interest. This primarily technical engagement finally confirmed support for allocating the 600 MHz, 3.5 GHz and 26 GHz bands as priority bands for 5G in New Zealand.

1.2 The WRC-19 and ITU frequency allocation

The International Telecommunications Union (ITU) holds a World Radiocommunication Conference (WRC) every 3 - 4 years. Over the past 20 years, WRCs have approved a number of bands for IMT network deployment. Along with the standardisation work that 3GPP has undertaken, an eco-system of equipment and bands for cellular deployment has developed. Our 2018 consultation (noted above) covered these bands (including 600 MHz, 1.5 GHz, 3.5 GHz, 24 - 29 GHz and 38 - 43 GHz).

In November 2019, the final acts of WRC-19 were signed by over 150 countries. Two key outcomes influence the direction for 24 - 30 GHz allocation in New Zealand. First, additional bands for IMT were identified to facilitate development of 5G mobile networks (24.25 - 27.5 GHz, 37 - 43.5 GHz and 66 - 71 GHz globally; 45.5 - 47 GHz and 47.2 - 48.2 GHz to some countries through footnote). These higher frequency bands are sometimes referred to as millimetre wave (mmWave) bands. Second, the WRC-19 allows Earth Stations in Motion (ESIM) to operate between 27.5 and 29.5 GHz.

1.3 Current spectrum use of 24.25 - 30 GHz

1.3.1 Current allocations

Table 1, which is extracted from PIB 21[2], summarises the current New Zealand allocations and usage for 23.6 - 30 GHz. This table extends the frequency range to 23.6 GHz to show the allocations to the Earth Exploration-Satellite (passive), Space Research (Passive) and Radio Astronomy Services which are relevant to some of the planning considerations for spectrum between 24.25 and 27.5 GHz.

Table 1 Frequency allocation and usage between 23.6 - 30 GHz

Frequency Range	ITU Region 3 Allocation	New Zealand Allocation	Summary of Usage
23.6-24 GHz	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) 5.340	RADIO ASTRONOMY SPACE RESEARCH (passive)	22-26.625 GHz Short Range Vehicular Radar (until 1 January 2022)
24-24.05 GHz	AMATEUR AMATEUR-SATELLITE 5.150	AMATEUR AMATEUR-SATELLITE	22-26.625 GHz Short Range Vehicular Radar (until 1 January 2022) 24-24.25 GHz Amateur usage 24-24.25 GHz Industrial, scientific and medical band 24-24.25 GHz Short Range Devices
24.05-24.25 GHz	RADIOLOCATION Amateur Earth exploration-satellite (active) 5.150	RADIOLOCATION Amateur	
24.25-24.45 GHz	RADIONAVIGATION FIXED MOBILE 5.338A 5.532AB	RADIONAVIGATION FIXED MOBILE	
24.45-24.65 GHz	FIXED INTER-SATELLITE MOBILE 5.338A 5.532AB RADIONAVIGATION 5.533	FIXED MOBILE RADIONAVIGATION	24.549-25.392 GHz Private Management Rights – planned for Local Multipoint Distribution Services (LMDS) and fixed services 22-26.625 GHz Short Range Vehicular Radar (until 1 January 2022)
24.65-24.75 GHz	FIXED FIXED-SATELLITE (Earth-to-space) 5.532B INTER-SATELLITE MOBILE 5.338A 5.532AB	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	
24.75-25.25 GHz	FIXED FIXED-SATELLITE (Earth-to-space) 5.535 MOBILE 5.338A 5.532AB	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	

[2] PIB 21 – The New Zealand table of frequency allocation

25.25-25.5 GHz	FIXED 5.534A INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB Standard frequency and time signal-satellite (Earth-to-space)	FIXED MOBILE	
25.5-27 GHz	EARTH EXPLORATION-SATELLITE (space-to-Earth) 5.536B FIXED 5.534A INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB SPACE RESEARCH (space-to-Earth) 5.536C Standard frequency and time signal-satellite (Earth-to-space) 5.536A	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED MOBILE	25.557-26.4 GHz Private Management Rights – planned for Local Multipoint Distribution Services (LMDS) and fixed services 22-26.625 GHz Short Range Vehicular Radar (until 1 January 2022)
27-27.5 GHz	FIXED 5.534A FIXED-SATELLITE (Earth-to-space) INTER-SATELLITE 5.536 5.537 MOBILE 5.338A 5.532AB	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	27-27.5 GHz Fixed satellite “Ka” band – uplink
27.5-28.5 GHz	FIXED FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.539 MOBILE 5.538 5.540	27.5–29.5 GHz FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	27.5-29.5 GHz Fixed satellite “Ka” band – uplink
28.5-29.1 GHz	FIXED FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.523A 5.539 MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540		
29.1-29.5 GHz	FIXED FIXED-SATELLITE (Earth-to-space) 5.516B 5.517A 5.523C 5.523E 5.535A 5.539 5.541A MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540		

29.5-29.9 GHz	FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space) 5.540 5.542	FIXED-SATELLITE (Earth-to-space) Mobile-satellite (Earth-to-space)	29.5-30 GHz Fixed Satellite "Ka" band – uplink (including earth station in-motion) 29.5-30 GHz Mobile satellite "Ka" band – uplink
29.9-30 GHz	FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541 5.543 5.525 5.526 5.527 5.538 5.540 5.542	FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space)	

1.3.2 Assignments and usage

A further breakdown of 24.25 - 30 GHz assignments and usages is shown in Figure 1 and described in more detail below.

- 24.549 - 26.4 GHz is mostly assigned in private MRs. These expire on 31 October 2022. The right holders have been advised that they will not be offered renewals.
- 26.4 - 30 GHz is under the radio licence regime.
  - 27 - 30 GHz is used by licensed Fixed Satellite Service (FSS) and ESIM Maritime
  - 29.5 - 30 GHz has several short-term licensed FSS licences and a General User Radio Licence (GURL)[3] for very small aperture terminal (VSAT) use.

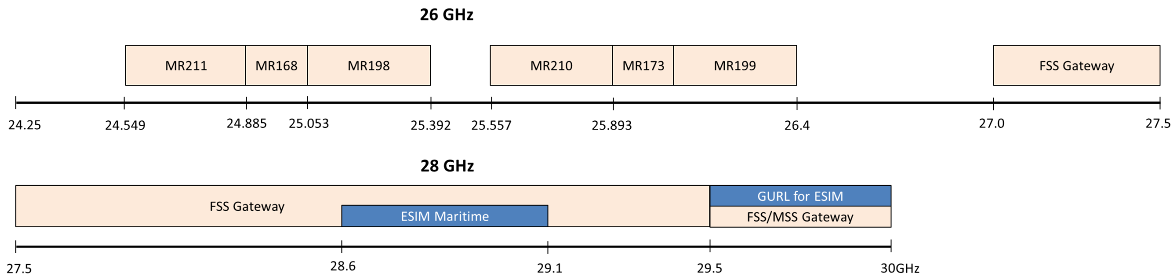

Figure 1 Current spectrum use between 24.25 and 30 GHz

The frequency range 24.549 - 28.35 GHz was allocated for a technology called local multipoint distribution system (LMDS) in 2002. However, LMDS was never deployed and use today is limited to a small number of fixed links. Given the limited use of this band, a ministerial decision was made in May 2018 that no renewal offer would be made to the right holders of those existing MRs. Therefore these MRs lapse on expiry on 31 October 2022.

[3] General User Licences (GUL) are frequencies have been licensed for anyone to use, they allow people to use particular types of radio transmitters, under certain technical conditions without applying a licence of their own. In other jurisdictions, these are also called licence-exempt, unlicensed or class licences.

There is a GURL for Short Range Devices (SRD) between 24.05 and 26.5 GHz[4]. This is for radiodetermination transmitters operated within shielded enclosures. The maximum EIRP is -54 dBW. We therefore expect it to be able to continue and to co-exist with future services using the band.

A GURL for vehicular radar (22 - 26.625 GHz) will expire in January 2022 in line with the European sun-setting of this use of this band. Therefore, this GURL will not be renewed after 2022.

The frequencies between 27 and 30 GHz, which is part of satellite Ka band, are also globally allocated to FSS for communications in the earth to space direction. In recent years, there is increasing interest from international satellite operators to use these bands for the feeder link of their broadband services. They have also approached RSM to request access to the spectrum for their satellite earth station gateway use in New Zealand.

The frequencies between 27 and 29.5 GHz are also used by 5G technology in a few countries. There are already equipment ecosystems built to work in that frequency range. Considering an efficient use of spectrum while not have negative impact on the future planning, RSM has decided to grant fixed term licences for FSS earth stations in a few rural locations.

IPSTAR currently holds three satellite gateway licences at Albany[5] between 27.0 and 27.5 GHz. These are fixed term licences that expire in January 2022. Those three licences are used for earth station transmitters communicating with the THAICOM-IPSTAR 1 satellite located at 119.5° easting GSO orbit.

27.5 - 29.5 GHz is currently used for satellite gateway uplinks. This includes licensed fixed satellite earth stations and ESIM. IPSTAR, Inmarsat, SpaceX, Venture Southland Trust Board and SES Singapore all have licences at a number of locations (Albany, Warkworth, Wellsford, Awarua and New Zealand's maritime area).

FSS earth station uplinks and ESIMs also operate in 29.5 - 30 GHz. As a result of WRC-15 outcomes and the subsequent updates to the ITU Radio Regulations (RR) in 2016, RSM permitted ESIM use in the Earth to Space direction from 29.5 - 30 GHz. There are three GULs for earth to space transmissions:

- GURL for Satellite Service Licence number: 258016– Special Condition 5[6];
- GURL for Aeronautical Purposes Licence number: 254932 – Special Condition 12[7]; and
- GURL for Maritime Purposes Licence number: 254943 – Special Condition 27[8].

The current ITU Radio Regulations restrict ESIM use in the 19.7 - 20.2 GHz and 29.5 - 30 GHz bands to geostationary orbit (GSO) satellites. However, in New Zealand, ESIMs use both GSO and NGSO (non-geostationary orbit) satellites. The current provision for ESIM uplink

[4] Condition 27: Use is limited to radiodetermination transmitters operated within shielded enclosures and installations must be inside the shielded enclosure. The maximum power -54 dBW e.i.r.p. applies at 3 metres as measured outside the shielded enclosure over a maximum of 50 MHz bandwidth. The emission leakage outside the shielded enclosure must not exceed the maximum permitted power spectral density -71.3 dBW/MHz (-41.3 dBm/MHz) e.i.r.p. at any time.

[5] Grid reference: 174.6952922, -36.7484803

[6] Transmissions are permitted from land earth stations operating in accordance with the class of station known as ESIM to communicate with satellite network for the purpose of FSS or MSS.

[7] Use is limited to aircraft earth station operating in accordance with the class of station known ESIM as defined in the ITU Radio Regulations.

[8] Use is limited to earth stations on-board vessels operating in accordance with the class of station ESIM as defined in the ITU Radio Regulations.

frequencies in 29.5 - 30 GHz does not impose any altitude restriction since the frequency range 29.5 - 30 GHz is exclusively for satellite use.

1.4 Next steps

The chapters that follow contain our analysis and proposals for future use of the 24 - 30 GHz frequency range. They also contain specific questions on which we seek submissions.

Once feedback received, RSM will:

- Publish the submissions
- Analyse the submissions and feed into our planning work
- Finalise its advice and brief the Minister for Digital Economy and Communications.

Although the Radiocommunications Act 1989 empowers the Chief Executive of MBIE to create Management Rights for use by the Crown or allocation to a third party, any policy decisions that seek to create Management Rights are, by convention, elevated to Cabinet for their approval. Typically, the Minister may be further delegated to finalise the details or any allocation to a third party for example the design and reserve price of an auction.

2 The technologies and applications in 24 - 30 GHz

We have considered various radio technologies and use cases in this planning. Among these use cases, we consider that 5G mobile broadband, FWA and satellite broadband are likely to be the most beneficial to New Zealand.

2.1 IMT-2020 (“5G”)

As outlined in the ITU-R vision for IMT-2020 in Figure 2, 5G is envisioned to dramatically increase access, bandwidth, and reduce latency. Not only will the Enhanced Mobile Broadband (eMBB) provide connectivity at gigabits per second, 5G also has the potential to enable new applications, industries, and business models that require high data-rate, low latency communications, and massive connectivity for new applications such as eHealth, autonomous vehicles, smart cities, smart homes, and the IoT.

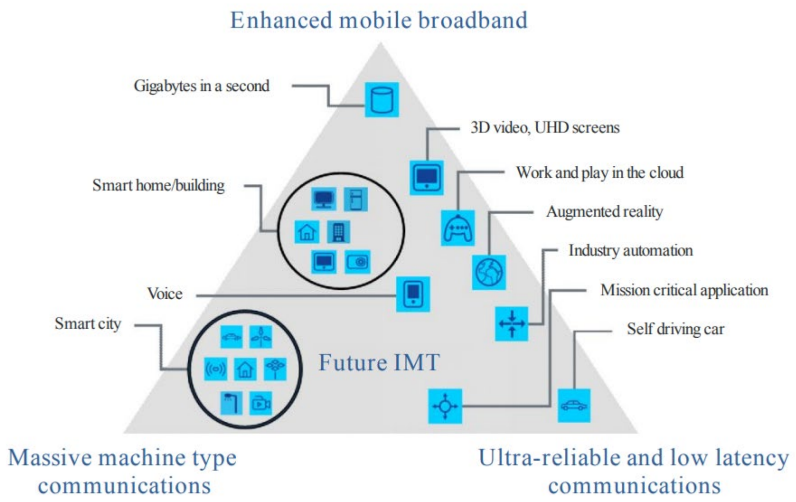

Figure 2 5G use cases[9]

One of the key enablers for 5G is the availability of suitable radio spectrum. The diverse set of applications 5G is being designed to deliver will require access to different spectrum bands with different characteristics.

Compared with low and mid-range frequencies to enable the coverage and connectivity, spectrum at high-range frequencies offers very large bandwidths, provides high capacity and supports services requiring very low latency.

Enhanced Mobile Broadband

eMBB is a natural evolution to existing 4G LTE/LTE-Advanced cellular networks, that will provide increased data rates and will therefore lead to a better user experience than current mobile broadband services. Within the eMBB use case, high-band based 5G connections will be able to deliver higher capacity enhanced connectivity.

[9] ITU-R Recommendation M.2083 “IMT 2020 vision statement as developed by WP5D”

eMBB will likely be a focus for Mobile Network Operators (MNO), with initial deployments in urban areas and indoor venues, such as convention centres, concert halls, and stadiums. An overview of the 4G/5G sub-6 GHz and mmWave 5G deployment scenario is seen in Figure 3.

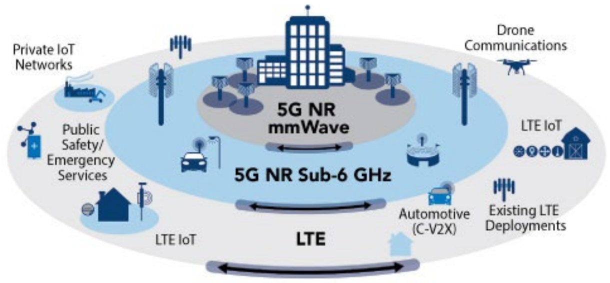

Figure 3 5G eMBB deployment scenario[10]

Fixed Wireless Access (FWA)

FWA is used as a substitute to fixed copper or fibre connections for "last mile" connectivity. In terms of functionality, the role of FWA is comparable to that of Fibre-to-the-node / premise, as both offer connectivity solutions for the edge of the network.

With active antenna systems (AAS) and wider bandwidth, FWA can achieve a similar performance to broadband on fibre. Although New Zealand is building fibre to the premises connections to 87% of the population, FWA can also provide an alternative solution in places where fixed infrastructure is not present or only copper connections are in place. Even in places with fibre available, FWA can provide additional flexibility for broadband connections.

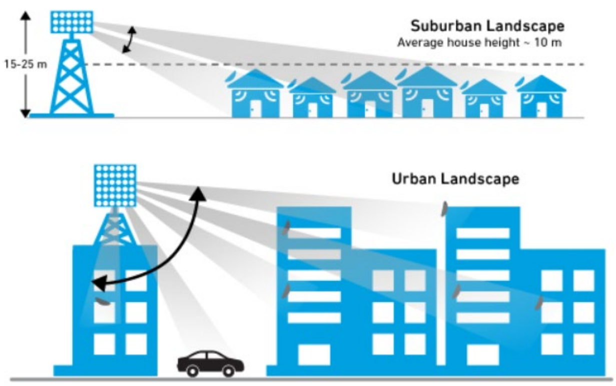

Figure 4 5G FWA deployment scenario[11]

Industry verticals and private networks

5G will create an ecosystem for technical revolution and business innovation involving vertical markets including automotive, energy, city management, mission critical communication, healthcare, manufacturing, public transportation.

At this time, the requirements of vertical networks are rapidly evolving – most notably from voice to include high speed data for automation. Many industrial processes are already highly automated by using wired systems. However, these wired systems present limitation for processes being in fixed locations and may not be easily re-configured.

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[10] Quote from Microwave Journal May 2018, "5G Update: Standards Emerge, Accelerating 5G Deployment"

[11] Quote from Qorvo, "5 Things to Consider When Designing Fixed Wireless Access (FWA) Systems"

With Edge Computing[12] technology coming with 5G, service and computing function are able to be allocated closer to the users to provide a network with low latency, ultra-reliable and highly secured. This will make the network more attractive to vertical industry.

The deployment of private networks provides an opportunity to replace wired connections whist still maintaining required capacity, latency and reliability for the control of many processes.

There are other applications would require networks that can support low transmission power applications such as connecting smart meters and sensors for utilities and smart cities. For example, these sensors can provide process and status monitoring for better planning resource and scheduling in smart cities.

Q1. What are the most likely use cases in New Zealand for mmWave based 5G services?

2.2 Fixed Satellite

Satellite communication technology is accelerating the availability of high-speed broadband services. The satellite broadband system architecture generally relies on three primary components: a satellite, either a GSO or a NGSO constellation; a number of ground stations known as gateways that relay Internet data to and from the satellite via radio waves; and user terminals, often a VSAT (very-small-aperture terminal) antenna with a transceiver.

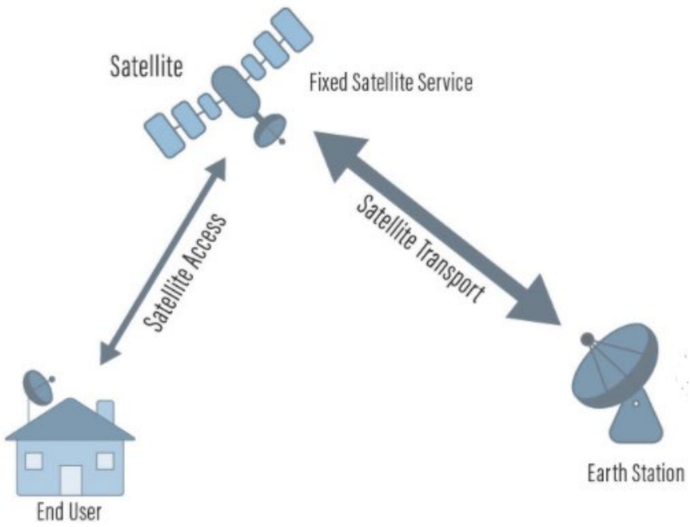

Figure 5 Satellite broadband architecture

Traditional satellite broadband uses C-band (4 - 6 GHz) and Ku-band (11 - 14 GHz) for delivering data services. As a result of the C and Ku-band's frequencies and capacity having mostly been taken by GSO satellite use, the Ka band has become a popular choice for new satellite broadband operators. Ka band satellites typically use spectrum in the 27.5 - 30 GHz range for earth to space transmissions.

Most new Ka band satellites have implemented spot-beam technology to reuse spectrum across the desired coverage area. In addition, because of greater spectrum availability in the

[12] Edge computing provides execution resources (compute and storage) for applications with networking close to the end users. The main benefits edge solution provide include low latency, high bandwidth, device processing and data offload as well as trusted computing and storage.

Ka band and greater frequency reuse with multiple beams, Ka band satellites typically use multi-channels wideband transponders.

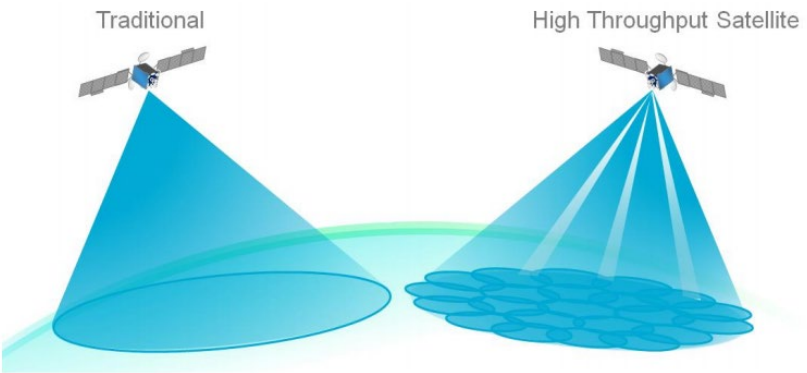

Figure 6 Difference between Traditional Satellite Beam and HTS Spot Beams[13]

NGSO constellation broadband

NGSO constellations consist of tens to thousands of satellites that orbit the earth at lower altitudes than GSO satellites. They have lower latency than GSOs as the distance that signals travel between the gateway, satellite and user terminal is much shorter. NGSO networks use constellations of satellites to increase the coverage area and overall capacity.

Satellite broadband over NGSO constellations can provide low latency connectivity in remote areas where terrestrial networks may not be economic to deploy. The feature is very attractive for rural broadband in terms of deployment speed and cost.

The earth stations serving NGSO networks use tracking antenna. This means that the earth station antenna radiation pattern closely resembles an omni-directional antenna above a certain elevation angle (typically 5 - 10 degrees above the horizon) over time. As each individual satellite must be connected to an earth station to provide data backhaul, NGSO constellations also need to deploy a large number of gateway earth stations.

3GPP non-terrestrial networks (NTN)

3GPP has undertaken a study of NTN for 5G and published this in TR 38.811[14]. 3GPP's roadmap indicates that in Release 17, NTNs will be incorporated into the 5G NR standards.

The integration of NTNs for 5G will permit the roll out of 5G service in areas that are not covered by terrestrial 5G networks. It also increases 5G service reliability by providing service continuity for M2M/IoT devices or for passengers on board moving platforms (e.g. aircraft, ships, trains).

[13] Quote from "ITU Satellite Symposium November 2018", Geneva, Switzerland.
[14] Technical Specification Group Radio Access Network; Study on New Radio (NR) to support non-terrestrial networks.

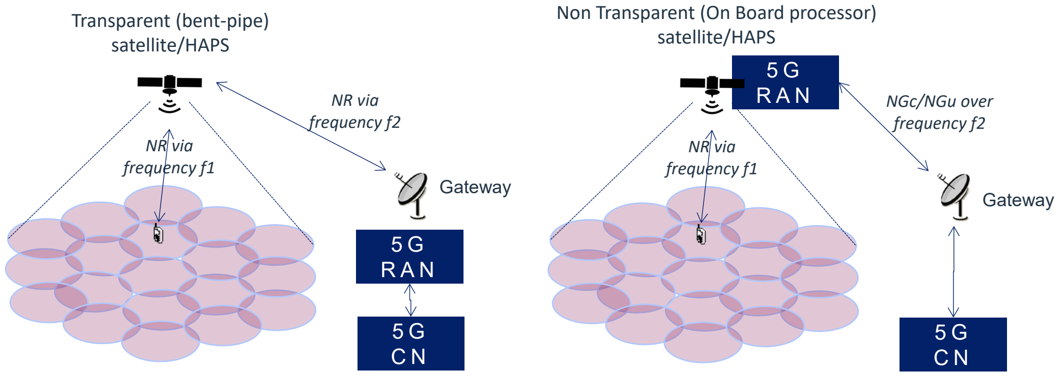

Figure 7 Proposed NTN Beam patterns and network architectures

The NTN satellite acts as a relay between the satellite gateway and user equipment. 3GPP has defined two different network architectures, being that the gNodeB is on-board the satellite, or the gNodeB remains on the ground at the satellite gateway.

It is envisaged that NTN will operate in the appropriate frequency bands as per ITU Radio Regulations and band plans. Typically, it will use up to 800 MHz bandwidth in Ka band.

Q2. What are the likely use cases for Ka band satellite services in New Zealand in the short and long term?

2.3 Earth Stations in Motion

ESIMs provide continuous broadband connectivity when ships and aircraft are out of reach of terrestrial networks. In addition, ESIMs can provide broadband connectivity for terrestrial vehicles in areas where terrestrial networks have limited or no coverage. They can also assist when terrestrial communication infrastructure is down due to natural disasters.

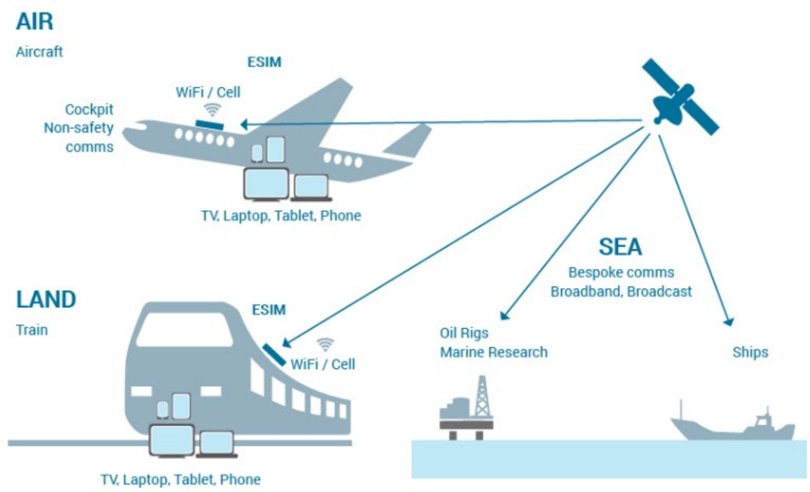

Figure 8 ESIM use cases[15]

In the past, ESIMs use the frequencies of 19.7 - 20.2 GHz (space-to-Earth) and 29.5 - 30 GHz (Earth-to-space) for their communications. With the increasing demand of data throughput,

[15] Quote from Global Satellite Coalition website

ESIMs has expanded the frequency range to 17.7 - 20.2 GHz (space-to-Earth) and 27.5 - 30 GHz (Earth-to-space). This spectrum demand is also addressed in WRC-19 Resolution 169[16].

ESIMs communicate with both GSO satellites and NGSO satellite constellations. Agenda 1.16 for WRC-23 outlines the parameters for the sharing and compatibility studies to be undertaken between ESIMs operating with non-GSO constellation and other existing primary services allocated in the frequency bands.

Q3. What are the spectrum requirements for ESIM use in New Zealand?

2.4 Fixed Services

The 26 and 28 GHz bands are also allocated in the ITU Radio Regulations for fixed service use. In New Zealand we currently have a small number of point-to-point fixed links using the 26 GHz band. These existing licenses are used for cellular backhaul and are held by a private MR holder. With the increasing fibre coverage in the past years, some of the microwave backhaul services have been gradually replaced by fibre. Although fibre could replace most of the microwave backhaul, there are still some rural cell towers that need fixed services for backhaul.

Given the current limited and diminishing usage of the 26 GHz fixed service, we are considering if fixed service channel arrangements in other nearby bands would be sufficient to accommodate the current cellular backhaul use in the 26 GHz. This includes consideration of existing fixed service channels in the 23 GHz and 38 GHz bands.

The lower frequency of the 23 GHz band ensures that similar or longer path lengths are achievable. The 38 GHz band will be able to provide significant capacity as well, though the path length is likely to be slightly shorter when compared to the 26 GHz bands.

The existing 26 GHz fixed service licences have bandwidths of 28 or 56 MHz. The 23 and 38 GHz fixed service bands have similar channelling arrangements, as shown in Table 2.

Table 2 Summary of 23 GHz and 38 GHz fixed service channel arrangement

Band (GHz)	Frequency Range (GHz)	Supported Channel size (MHz)	Number of available channel pairs for each channel size
23	21.2 - 23.6	7, 14, 28, 56, 112	64, 32, 38, 19, 10
38	37 - 39.5	3.5, 7, 14, 28, 56	16, 8, 80, 40, 20

Migrating licences from private MR to fixed service radio bands means licences need to comply Radio Standards. Currently, RSM mandates EN 302 217-2-2[17] for the fixed service radio standard.

Q4. Do you think the existing fixed service licenses in 26 GHz can be migrated to the 23 GHz and/or 38 GHz fixed service bands?

Q5. If not, do you think the existing fixed services should be allowed in the 26 GHz?

[16] Resolution 169 (WRC-19) Use of the frequency bands 17.7 - 19.7 GHz and 27.5 - 29.5 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service.
[17] EN 302 217-2-2 Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-2: Digital systems operating in frequency bands where frequency co-ordination is applied; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive

3 Spectrum allocations

The band re-planning covers the frequency range from 24.25 - 30 GHz. This includes what is known as the 26 GHz (24.25 - 27.5 GHz) and 28 GHz (27.5 - 29.5 GHz) bands respectively.

3.1 24.25 - 27.5 GHz

The 26 GHz band was identified for IMT in the ITU Radio Regulations at WRC-2019. It has been adopted by a number of administrations for the implementation of 5G services. The band is also known as n258 defined by 3GPP from Release 15 of its technical specifications.

3.1.1 Global perspective

Work towards the standardisation and harmonisation of the 26 GHz band for 5G is well advanced. 26 GHz use has been harmonised within CEPT[18] and within the EU[19]. The decision of CEPT to harmonise technical conditions for mobile/fixed communications networks (MFCN) reflects the objective to harmonise the band for 5G in Europe. Italy and Finland have already auctioned spectrum within the 26 GHz band for IMT use[20] [21].

In Germany, BNetzA announced its plans for assigning frequencies for local and broadband use at 24.25 - 27.5 GHz in December 2020. The plan calls for first-come, first-served administrative assignments of the spectrum[22]. The entire band is intended for broadband use in Germany, and it can be used for wireless network access, Industry verticals and the IoT.

The UK regulator Ofcom has made 24.25 - 26.5 GHz available for indoor use on a per-location, first-come, first-served basis[23].

In 2019, the FCC auctioned 24.25 - 24.45 GHz and 24.75 - 25.25 GHz spectrum for 5G services, with 29 mobile operators winning 2904 licenses across the country[24].

Within ITU Region 3, a number of countries are considering or have made decisions on the use of the 26 GHz band.

In 2017, China's Ministry of Industry and Information Technology consulted on the re-planning and use of the 26 GHz band for 5G use.

Australia has identified the frequency range 25.1 - 27.5 GHz for IMT in 34 specified cities and regional centres[25]. Allocation of the 26 GHz band is expected to be undertaken in April 2021. Three types of licensing authorisation are used in the ACMA's licensing regime of 26 GHz allocation. Spectrum licences will authorise the use of a particular frequency band within a particular geographic area, apparatus licences will authorise the use under a particular radiocommunications service type within a dedicated frequency channel, and a class licence will authorise licensing-exempt use under certain conditions.

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[18] ECC Decision (18)06 "Harmonised technical conditions for Mobile/Fixed Communications Networks (MFCN) in the band 24.25-27.5 GHz".
[19] Commission Implementing Decision (EU) 2020/590 of 24 April 2020 amending Decision (EU) 2019/784
[20] 26GHz Spectrum Auction in Finland, https://www.traficom.fi/en/news/5g-spectrum-auction-has-ended
[21] Italian 5G spectrum auction, https://5gobservatory.eu/italian-5g-spectrum-auction-2/
[22] Policy Tracker, Feb 2021, "Europe's three approaches to mmWave licensing"
[23] Ofcom Statement, March 2019, Enabling wireless innovation through local licensing
[24] FCC, Auction 102 Closing Public Notice
[25] ACMA, "Draft spectrum reallocation recommendation for the 26 GHz band"

3.1.2 New Zealand's Proposal

5G requires a wide set of spectrum bands to achieve all the characteristics of eMBB, low latency and massive connectivity. Sub 1 GHz spectrum provides a broad coverage area with good building penetration. Mid-band spectrum (1 - 6 GHz) provides faster throughput and lower latency but less coverage. High-band spectrum (> 6 GHz) enables speed up in the tens of Gbps with even lower latency but within a limited coverage area.

In 2020, RSM allocated some 3.5 GHz spectrum for 5G, as the first stage in 5G spectrum allocation in New Zealand. To get the full potential of 5G, We are now proposing to allocate the 24.25 - 27.5 GHz band primarily for IMT use. This is consistent with industry feedback from our 2018 consultation and harmonises with international allocations.

Parts of the band is also allocated to space services in Region 3, though the use in New Zealand is very limited. To accommodate such use, we propose to consider such applications on a case-by-case basis.

Q6. Do you agree New Zealand should allocate 24.25 - 27.5 GHz primarily for IMT use?

Q7. How should RSM accommodate other use in this band such as space services?

3.2 27.5 - 29.5 GHz

The 28 GHz band (27.5 - 29.5 GHz) has shared use by mobile, satellite and fixed services globally.

3.2.1 Global perspective

ITU

The band is allocated to fixed, fixed satellite (Earth-to-space) and mobile on a primary basis in all three regions. Article 5 of the Radio Regulations includes a number of footnotes for the 28 GHz band. Footnote 5.516B is of particular interest and identifies several frequency ranges in the different Regions for the provision of high-density applications in the fixed-satellite service (HDFSS). The frequency range for HDFSS in Region 3 is 28.45 - 29.1 GHz.

To address the increasing demand for spectrum for ESIMs globally, while protecting other services deployed in the same band, Resolution 169 decided on the regulatory and technical conditions under which the frequency bands 17.7 - 19.7 GHz (space-to-Earth) and 27.5 - 29.5 GHz (Earth-to-space) can be used by the three types of ESIM communicating with GSO in the FSS.

3GPP

Although only the 26 GHz band has been identified for use IMT by the ITU, a number of countries have deployed 5G networks in the 28 GHz band.

Since Release 15, 3GPP developed three new radio (NR) bands within 24.25 - 29.5 GHz. These are called bands n257, n258 and n261. Band n261 from 27.7 - 28.35 GHz is a sub-band of n257.

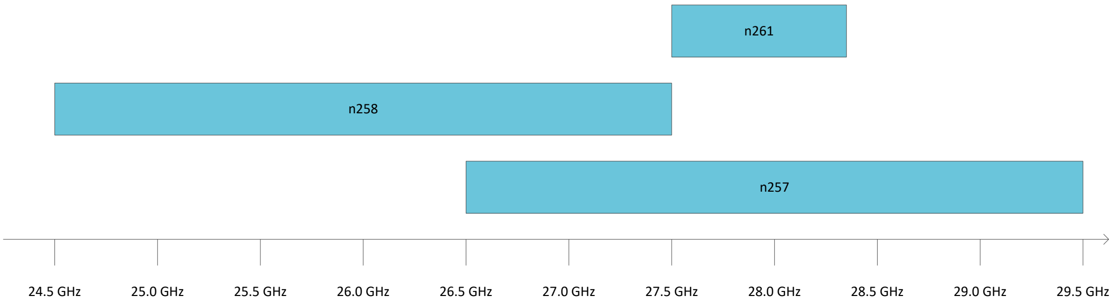

Figure 9 3GPP FR2 plan from 24 - 30 GHz

Europe

The 28 GHz band is currently designated for fixed services (both point-to-point and point-to-multipoint) and satellite services in Europe. Europe has not designated the 28 GHz band for 5G. ECC Decision (18)06[18] on harmonised technical conditions for mobile/fixed communications networks in the 26 GHz band reflects the objective of CEPT to harmonise the 24.25 - 27.5 GHz band for 5G.

CEPT supports a regulatory framework for the operation of ESIM in the bands 17.7 - 19.7 GHz and 27.5 - 29.5 GHz, while ensuring the protection of, and not imposing undue constraints on services allocated in those frequency bands. In ECC Decision (13)01, ECC decided that CEPT administrations should designate the frequency bands 27.5 - 27.8285 GHz, 28.4445 - 28.8365 GHz, and 29.4525 - 29.5 GHz to the operation of ESIMs[26].

In ECC Decision (13)01, CEPT also designed appropriate sharing techniques, including EIRP, antenna elevation, power flux density (PFD) values and references ETSI harmonised standard EN 303 978[27] for ESIM to protect the fixed and mobile services allocated in the bands.

USA

The Federal Communications Commission (FCC) has designated the frequency range 27.5 - 28.35 GHz on a primary basis for upper microwave flexible use service (UMFUS). UMFUS bands are presently held and/or in use by national MNOs deploying 5G mobile and by other organisations seeking to deploy mobile networks or provide FWA services.

In November 2018, the FCC undertook an auction for spectrum from 27.5 - 28.35 GHz for both fixed and mobile operation. Spectrum was allocated to a number of MNOs for 5G services[28]. FSS earth stations are allowed to be deployed on a secondary basis. There are also specified interference zones defined. In the interference zones, the FSS earth stations are not required to protect UMFUS operations.

The FCC has split the frequency range from 28.35 - 29.5 GHz into sections for fixed and satellite services on a primary basis. 28.35 - 28.6 GHz has been allocated to geostationary FSS earth stations only. 28.6 - 29.1 GHz has been allocated with priority for non-geostationary FSS applications over geostationary FSS applications and coordinated earth stations. The frequency range 29.1 - 29.5 GHz has been allocated to feeder links of mobile satellite services (MSS), which share with fixed between 29.1 - 29.25 GHz and FSS in 29.25 - 29.5 GHz.

[26] ECC Decision (13)01, "The harmonised use, free circulation and exemption from individual licensing of Earth Stations On Mobile Platforms (ESOMPs) within the frequency bands 17.3-20.2 GHz and 27.5-30.0 GHz."

[27] ETSI EN 303 978 - "Satellite Earth Stations and Systems (SES); Harmonised European Standard for Earth Stations On Mobile Platforms (ESOMP) transmitting towards satellites in geostationary orbit in the 27.5 GHz to 30.0 GHz frequency bands".

[28] FCC Auction 101: Spectrum Frontiers – 28 GHz

UK

Ofcom has implemented regulations that allow some flexibility for the implementation of terrestrial services deployed in parts of the 28 GHz band. Those include two sets of 224 MHz national spectrum rights and three sets of 112 MHz. The allocations are mainly for FWA use, and Ofcom mandates specified Block Edge Mask (BEM) unwanted emissions requirements[29].

Ofcom has implemented arrangements for the fixed satellite earth stations in the frequency ranges 27.5 - 27.8285 GHz, 28.4445 - 28.8365 GHz and 29.4525 - 29.5 GHz.

Ofcom has harmonised its 5G plans with the rest of Europe, which is consistent with the CEPT position, in using the 26 GHz band.

Australia

In 2018, ACMA consulted industry on the spectrum planning for 28 GHz, with decisions published in 2019[30]. The decision allocates the 28 GHz band to FWA and FSS (including ESIM). From 27.5 to 28.1 GHz, FWA/FSS gateway has primary use within large population centres. Outside large population centres, FWA becomes the secondary user. From 28.1 to 30 GHz, FSS has primary use and FWA has secondary.

Figure 10 ACMA allocation for 28 GHz band

Other Region 3 countries

In June 2018, South Korea's Ministry of Science and ICT undertook its auction of mmWave spectrum. 26.5 - 28.9 GHz was assigned to SK Telecom, KT and LG Uplus[31].

In Japan, the Ministry of Internal Affairs and Communications (MIC) published its final report on the 2020 Japan Radio Policy in July 2016. This included the use of the 28 GHz band for 5G commercial services. In April 2019, the MIC assigned 27 - 28.2 GHz and 29.1 - 29.5 GHz to Rakuten, NTT Docomo, KDDI and Softbank[32].

3.2.2 New Zealand Proposal

The emerging satellite broadband market sees an increased demand for spectrum access for satellite use, including ESIM and NGSO satellite constellations providing broadband services. To support such demand, we propose to allocate the whole 28 GHz band for satellite use.

Given there is sufficient spectrum for MNOs in the 26 GHz band, allocating spectrum in the 28 GHz band for national mobile broadband would bring only marginal gains. However, depending on the results of the 26 GHz spectrum allocation and global developments, there may be requirements for spectrum in 28 GHz to be allocated to FWA, private IMT networks and/or indoor eMBB.

[29] Ofcom, SPECTRUM CO-EXISTENCE DOCUMENT-Spectrum Access 28 GHz.
[30] ACMA, "Future use of the 28 GHz band—Planning decisions and preliminary views"
[31] TeleGeography, MSIT announces results of 5G spectrum auction.
[32] Ministry of Internal Affairs and Communications ICT Policy https://www.soumu.go.jp/menu_news/s-news/01kiban14_02000378.html

As there are no fixed services operating in this band in New Zealand, and there are sufficient fixed service channels in 23 GHz and 38 GHz, we are not considering fixed services in the 28 GHz band.

Q8. How do you see our proposal of the 28 GHz band allocation?

Considering the current ecosystem and equipment deployment characteristics, we have identified two allocation options for 27.5 - 29.5 GHz:

Allocation option 1

In option 1, 27.5 - 28.35 GHz would be allocated on a shared basis between IMT private networks, FWA, FSS and Aeronautical and Maritime ESIMs. Given ESIM earth stations are mainly deployed outdoor, it would provide an opportunity for spectrum sharing with IMT services deployed indoor. Therefore, we would allocate a shared use of 28.35 - 29.5 GHz between FSS, ESIM all use and IMT indoor network in this option.

This allocation option would maintain the existing licences for FSS gateway and ESIM maritime services. In addition, the ESIM maritime licence would be operated under GURL regime.

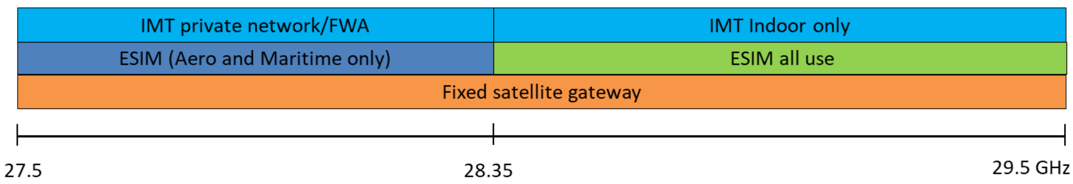

Figure 11 28 GHz allocation option 1

ITU-R Task group 5/1 has undertaken the sharing studies between IMT and FSS transmitting earth stations in the 26 GHz band. These studies suggest a geographic separation varying from less than 100m up to about 10 km. Although these studies did not cover 28 GHz, we expect these results would be indicative. Given the fixed nature of FSS gateways operating only in selected frequencies, we consider that sharing would be possible with appropriate coordination procedures in place.

One way to coordinate those two services is by defining a few satellite coordination zones. This coordination method has been used in RSM's recent replanning of the 1700 - 2300 MHz band[33]. The details are analysed in Section 4.5.6.

Registration and coordination of ESIM terminals are neither realistic nor economic. It is therefore better to authorise ESIM use under a GURL with specific conditions. However, as we cannot track ESIM use or individually licence terminals, ESIM sharing with an IMT network would be difficult. We are therefore considering two GURLs for ESIM use in this option.

27.5 - 28.35 GHz would only be permitted for aeronautic and maritime ESIM GURL use, which would enable sharing with outdoor IMT networks. 28.35 - 29.5 GHz would be permitted for all ESIM GURL use. This implies IMT stations would be limited indoor to avoid interference from ESIMs.

Allocation option 2

The second option would remove the indoor condition for IMT and the discrimination for ESIM use. In this option, IMT and ESIM would not share the spectrum. Instead, a portion of the 28 GHz band would be allocated to each service respectively.

[33] There are three protection zones (Warkworth, Awarua, and Mahia Peninsula) defined in 1700-2300 MHz Band Planning decision.

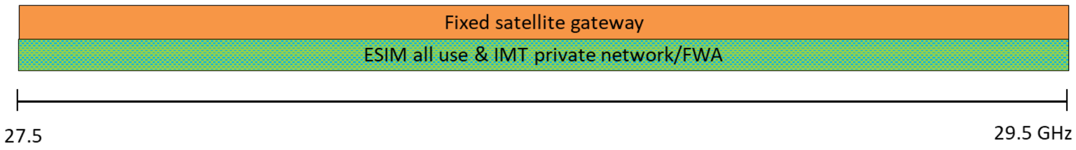

Figure 12 28 GHz allocation option 2

ESIM operations will be permitted under a GURL, which means that ESIM earth stations shall not cause interference to the co-channel licensed FSS and other licensed services from adjacent channels.

The second option also maintains the existing FSS radio licences. Thus, a similar coordination method between IMT and FSS as in option 1 would be needed.

Q9. Which option do you prefer for allocating 28 GHz band? Or is there any other option for managing the shared use of IMT, ESIMs and FSS in the 28 GHz band?

Q10. If you prefer option 1, do you agree with the proposed sharing mechanism (defining satellite coordination zones) between IMT use and FSS ground stations?

Q11. If you prefer option 2, how much spectrum do you think RSM should allocate to ESIM, IMT private network/FWA? And what's the preferred spectrum placement?

Q12. Are there any other issues of sharing use between satellite earth stations and ESIMs that you would like to bring to our attention?

3.3 29.5 - 30 GHz

At the present time, 29.5 - 30 GHz is licenced for use by a number of services:

- FSS earth stations are authorised under the radio licence regime on an individual basis;
- Very small aperture terminal (VSAT) use is authorised under the GURL for Satellite services on a shared basis; and
- ESIM use is authorised under a number of GURLs depending on the type of earth station being used (e.g. maritime applications).

We are proposing no changes to any of these licencing arrangements nor use in this part of the band for any new use cases. However, we may need to review licence conditions that support NGSO operation after study item 1.16[34] of WRC-23, to assess if there are any impacts on the rules in this part of the band.

Q13. Do you agree that the current satellite allocation and licensing regime for 29.5 - 30 GHz should remain?

3.4 Licensing Options

When considering the combined effect of propagation characteristics of mmWave frequencies, antenna beamforming techniques and their resulting deployment scenarios, it follows there are a number of licensing options RSM could use when allocating spectrum in these bands.

[34] WRC-23 agenda item 1.16 - to study and develop technical, operational and regulatory measures, as appropriate, to facilitate the use of the frequency bands 17.7-18.6 GHz and 18.8-19.3 GHz and 19.7-20.2 GHz (space-to-Earth) and 27.5-29.1 GHz and 29.5-30 GHz (Earth-to-space) by non-GSO FSS earth stations in motion, while ensuring due protection of existing services in those frequency bands, in accordance with Resolution 173 (WRC-19);

Option 1 National management rights

This option is consistent with spectrum rights we have previously allocated for cellular use. Interested parties (e.g. MNOs) purchase the MRs[35] and issue licences for the use of that block of spectrum to themselves or third parties as they see fit.

Option 2 Regional rights

Regional rights are authorised for limited market subscriber networks including, but not limited to, Wireless Internet Service Providers (WISPs).

Regional rights have both frequency and geographic boundaries. Each right would contain a certain portion of the band, within a defined geographic region e.g. a territorial local authority.

Another licensing option for the allocation of regional right is through an arrangement such as our Managed Spectrum Park (MSP). This is currently used for 2575 - 2620 MHz spectrum. It has a defined set of rules for geographic exclusivity within a national MR. With the MSP regime, RSM can design standard channel plans to allocate the spectrum more efficiently.

Option 3 Radio Licences

Radio licences are allocated on a first come, first served basis. We expect they will be largely used by satellite operators and IMT “industry verticals”.

The ITU-R’s vision for 5G defined a set of industry use cases for 5G private networks. Such industry verticals typically rely on a private network that can be configured to specific needs such as latency or data security. Configurations tend to be more flexible, depending on the type of work undertaken in each venue.

To facilitate the above use cases, RSM could license some spectrum under the radio licence regime. For efficient spectrum use by industry verticals, we propose to create a channel plan in the radio licence band. The bandwidth in the channel will be based on 3GPP standard NR FR2 bandwidth.

Option 4 General User Licence

The General User Licence regime could also be used in licensing the services in the 24 - 30 GHz band, this includes GURL-SRD for 5G unlicensed service and GURL for satellite service.

General user licences (GUL) are shared on a co-equal basis. However, if a general user licence frequency is also shared with licensed service, then the GUL users can’t cause interference or claim protection from individually licensed users.

5G on GUL services can either play a complementary role in mobile network deployment or open a new network deployment model. This is reflected in 3GPP Release 16 which adds support for 5G NR in “open” spectrum, referred to as 5G NR-U.

There are two ways of using GUL spectrum in 5G, licensed assisted access (LAA) NR-U or stand-alone NR-U. In the LAA, operators’ licensed spectrum functions as the anchor carrier and GUL spectrum is aggregated with that carrier. This mode enables operators to boost network performance. LAA can be deployed either by using carrier aggregation in a small-cell supporting both licensed and GUL spectrum or by dual-connectivity between a macro-cell using licensed spectrum and a local small-cell using GUL spectrum.

The second mode, stand-alone NR-U doesn’t require an anchor of operators’ licensed spectrum. Operators can deploy a 5G network without requiring their own spectrum asset. By

[35] New Zealand has a system of Management Rights, which are similar to land purchase under the Torrens System. These rights are fixed term for a defined block of spectrum. They can be mortgaged, caveated, leased and sold in a similar way that land parcels can be traded.

using “listen before talk”, GUL spectrum can be used on a shared basis[36]. A network built on standalone NR-U reduces the entry barrier for new service providers such as traditional broadcast or internet service providers.

General use licence for satellite service would also be suitable for ESIM in 28 GHz band, this licensing method is already used in 29.5 - 30 GHz.

Q14. What’s your preferred licensing option in 26/28 GHz spectrum?

Q15. Do you see any need for general user licence spectrum for IMT? If so, what use case might there be?

Q16. If there is a need for general use spectrum for IMT and ESIM, how much spectrum should we set aside for it? Should RSM mandate technical conditions on the general use licence?

Q17. Do you agree RSM should adopt 3GPP NR FR2 based channel bandwidth to design a channel plan in the radio licence regime for IMT services?

[36] MulteFire technology runs standalone 3GPP network on unlicensed spectrum. It uses Listen-Before-Talk for fair co-existence with other access technology operating in the same spectrum.

4 Technical Considerations

4.1 5G technical standards

The first publication of the 5G NR standards package was in 3GPP Release 15 (2017). Since then 3GPP has released two further 5G standard packages in Releases 16 and 17. These form the basis of the 3GPP 5G NR technology. 5G NR offers a wide range of new applications and use cases in both industry and public services.

The radio access network base station performance is described in 3GPP TS 38.104[37] and the user equipment performance is described in 3GPP TS 38.101[38]. As a regulator, RSM is most interested in the radio performance characteristics (e.g. transmit power and unwanted emissions). One of our key roles is to enable efficient spectrum use and manage interference between systems. 3GPP defines two categories of 5G NR frequencies, FR1 (410 - 7125 MHz) and FR2 (24.25 - 52.6 GHz). The base stations operating in FR2 belongs to BS type 2-O, in which the transceivers and antenna array are integrated, and there isn't a way to directly measure the conducted power from a transmitter. Therefore, for BS type 2-O, radio technical regulatory requirements are only defined as a Total Radiated Power (TRP), and 3GPP refers to the radiated interface as the Radiated Interface Boundary.

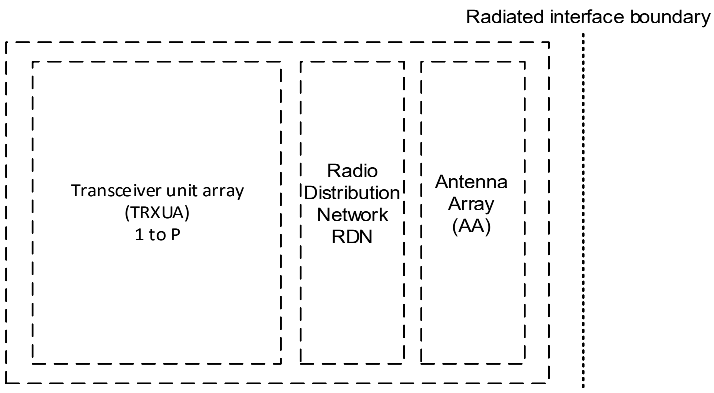

Figure 13 Radiated reference points for BS type 2-O

Q18. Do you agree RSM should refer 3GPP standards to set the regulatory requirements for spectrum allocated to IMT?

4.2 Regulatory regime for equipment

Private MR holders manage their own equipment performance standards and can choose what standards to apply to equipment operating in their MRs as long as the Unwanted Emissions Limit (UEL) on any spectrum licence is below the Adjacent Frequency Emissions Level (AFEL).

[37] 3GPP TS 38.104 V16.4.0 (2020-06) Technical Specification Group Radio Access Network NR Base Station (BS) radio transmission and reception (Release 16)
[38] 3GPP TS 38.101-2 V16.4.0 (2020-06) Technical Specification Group Radio Access Network NR User Equipment (UE) radio transmission and reception Part 2: Range 2 Standalone (Release 16)

For Crown MR, the UEL on spectrum licences within the MR must be within the limits of the AFEL. RSM can also specify particular standards in the spectrum licence conditions to enable efficient spectrum usage and minimise the risk of interference.

For equipment operating in the radio licence regime, RSM normally requires that equipment comply with a relevant standard in the Radio Standard Notice.

With the fast pace of technology evolution, the next generation of telecommunication technology and standards are likely to be less than 10 years away. Typically MRs are created for a duration of 20 years and we need to consider how best to enable potential changes in technology.

Q19. Should we introduce a break point for MR technical conditions mid-way through the duration of the MR? Or is it sufficient to set AFELs based on current technology and standards only?

Q20. Do you agree RSM should mandate equivalent ETSI harmonised standards for radio licences in Radio Standards Notices and review these standards regularly?

4.3 Use TRP to set the unwanted emission limits

AFEL is defined in effective isotropic radiated power (EIRP). These have previously been derived through the combination of the conducted power of emissions, the effective isotropic antenna gain (assuming a passive antenna) and any losses between radio head and antenna. Any spectrum licence within a management right must be within the AFEL.

With 5G AAS being introduced, the metric used for limits is in TRP and therefore it is no longer possible to derive an EIRP for an AFEL as we have done for previous generations of technology. 5G AAS radio benefits from a smaller size of transmitter and antenna elements and is able to use massive transmitter arrays and antenna elements (e.g. 8 x 8 or 16 x 16 elements) to get advanced beamforming through software control. This also makes the antenna gain more dynamic compared with 4G where the variation is usually within a few dBs.

Globally, the TRP metric has been used in spectrum regulation to specify limits. Europe has used the TRP metric in its regulatory framework for 5G AAS regulatory limits.

In 2018, CEPT reviewed the harmonised technical conditions applicable to the 3.4 - 3.8 GHz frequency band[39]. This was the first frequency band considered for 5G AAS. The report analysed the TRP metric compared with the EIRP metric (see section 4.4.2). CEPT sets its Block Emission Masks (BEMs) in TRP for AAS. The TRP value does not change with antenna pattern as shown in Figure 14. This gives MNOs the least restrictive conditions for their deployment.

[39] CEPT Report 67, Report A from CEPT to the European Commission in response to the Mandate "to develop harmonised technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union" Review of the harmonised technical conditions applicable to the 3.4-3.8 GHz ('3.6 GHz') frequency band.

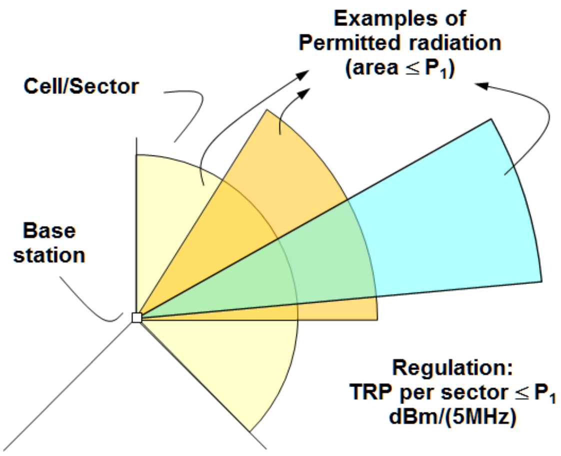

Figure 14 An illustration of the use of TRP for specification of emission limits (extract from Figure 4 in CEPT Report 67)[40]

For mmWave, the TRP metric is used in both the ECC Decision (18)06[18] and the Commission Implementing Decision (EU) 2020/590 of 24 April 2020 amending Decision (EU) 2019/784. The technical conditions for these decisions are based on CEPT Report 68[41], which is similar to the conditions in CEPT Report 67.

ACMA has done a similar technical consultation on the licensing technical framework for 26 and 28 GHz[42]. In their 'Radiocommunications Spectrum Marketing Plan (26 GHz Band) 2020', ACMA defined emission limits outside the band in the TRP metric.

In 3GPP, the BS 2-O output power and unwanted emissions are also defined as the TRP. 3GPP studies[43] have shown that the impact in terms of throughput degradation of the unwanted emissions on the adjacent mobile systems depends on the total amount of interference radiated into the network. Such total amount of interference is well represented by TRP. Setting the requirements in terms of TRP would limit the level of throughput degradation in the victim network to the desired level because the total emissions power and not the spatial pattern impacts the victim network.

The first option for RSM is to align with international methods by using TRP to define the unwanted emissions. However, it requires a change on the Radiocommunications Regulations 2001. Currently, the AFEL and UEL in Schedule 7 of the Radiocommunication Regulations are expressed in the format of EIRP.

The other option to set the AFEL and UEL is applying the highest possible antenna gain on transmitter power to get an EIRP value. However, there are two issues with this option. Firstly, the maximum antenna gain could be quite hard to predict in the long term given the evolution of radio technology. Secondly, the UEL/AFEL based on the highest estimated antenna gain may allow a poor performance transmitter with lower antenna gain to operate, which is not the objective for efficient interference management.

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40 Although CEPT Report 68 covers 24.25-27.5 GHz 5G characteristics, the principle of using TRP for specification of emission limits is described in CEPT Report 67.

41 CEPT Report 68, Report B from CEPT to the European Commission in response to the Mandate "to develop harmonised technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union" Harmonised technical conditions for the 24.25-27.5 GHz ('26 GHz') frequency band.

42 Australian Government, Federal Register of Legislation Radiocommunications Spectrum Marketing Plan (26 GHz Band) 2020

43 3GPP R4-168430: "On NRb BS ACLR requirement".

While UEL/AFEL in EIRP format has its disadvantages, adopting TRP unwanted emissions can have challenges on the measurement, particularly when the beam is dynamic. Usually, TRP is measured in the anechoic chamber in the laboratory environment and field measurement methods are under development.

Q21. Which option do you prefer to set the unwanted emissions?

Q22. If we use a TRP option for setting AFEL and UEL, do you have any recommended solutions on TRP measurement in field?

4.4 3GPP Unwanted Emissions Limits

3GPP defines unwanted emissions in both operating band unwanted emissions (OBUE) and spurious emissions. The OBUE are the unwanted emissions in each supported downlink operating band as well as the frequency ranges Δf_{OBUE} above and Δf_{OBUE} below each band. For BS 2-O, the Δf_{OBUE} is 1500 MHz.

For BS operation, 3GPP defines unwanted emissions limits in either category A or category B which are applicable in different regions. For FR2 BS, category B has an additional emission level requirement between Δf_B and Δf_{max}. Table 3 describe the OBUE limits for category A and category B operations.

Table 3 OBUE limits applicable in the frequency range 24.25 - 33.4 GHz[37]

Frequency offset of measurement filter -3 dB point, Δf	Frequency offset of measurement filter centre frequency, f_offset	Limit	*Measurement bandwidth*	*Note*
0 MHz $\leq \Delta f <$ 0.1*$BW_{contiguous}$	0.5 MHz $\leq$ f_offset < 0.1* $BW_{contiguous}$ +0.5 MHz	Min(-5 dBm, Max($P_{rated,t,TRP}$ – 35 dB, -12 dBm))	1 MHz	Cat A and B
0.1*$BW_{contiguous} \leq \Delta f$ < Δf_B	0.1* $BW_{contiguous}$ +0.5 MHz $\leq$ f_offset < Δf_B +0.5 MHz	Min(-13 dBm, Max($P_{rated,t,TRP}$ – 43 dB, -20 dBm))	1 MHz	Cat A and B
$\Delta f_B \leq \Delta f < \Delta f_{max}$	Δf_B +5 MHz $\leq$ f_offset < f_offset_{max}	Min(-5 dBm, Max($P_{rated,t,TRP}$ – 33 dB, -10 dBm))	10 MHz	Cat B only
NOTE 1: For non-contiguous spectrum operation within any *operating band* the limit within sub-block gaps is calculated as a cumulative sum of contributions from adjacent sub-blocks on each side of the sub-block gap. NOTE 2: Δf_B = 2*$BW_{contiguous}$ when $BW_{contiguous} \leq$ 500 MHz, otherwise Δf_B = $BW_{contiguous}$ + 500 MHz.				

- Δf is the separation between the *contiguous transmission bandwidth* edge frequency and the nominal -3dB point of the measuring filter closest to the *contiguous transmission bandwidth* edge.
- f_offset is the separation between the *contiguous transmission bandwidth* edge frequency and the centre of the measuring filter.
- f_offset_{max} is the offset to the frequency Δf_{OBUE} outside the downlink *operating band*, where Δf_{OBUE} is defined in table 9.7.1-1.
- Δf_{max} is equal to f_offset_{max} minus half of the bandwidth of the measuring filter.

Unwanted emissions outside of this frequency range are defined as spurious emissions. In category A, spurious emissions is -13 dBm/100 KHz from 30 MHz - 1GHz and -13 dBm/MHz from 1 GHz to the second harmonic of the upper frequency edge of the operating band.

Spurious emissions limits in category B are applicable in Europe (and some other regions) and are tighter than category A which are used in the Americas.

Table 4 BS radiated Tx spurious emission limits in FR2 (Category B) [37]

Frequency range (Note 4)	Limit
30 MHz ↔ 1 GHz	-36 dBm
1 GHz ↔ 18 GHz	-30 dBm
18 GHz ↔ $F_{step,1}$	-20 dBm
$F_{step,1}$ ↔ $F_{step,2}$	-15 dBm
$F_{step,2}$ ↔ $F_{step,3}$	-10 dBm
$F_{step,4}$ ↔ $F_{step,5}$	-10 dBm
$F_{step,5}$ ↔ $F_{step,6}$	-15 dBm
$F_{step,6}$ ↔ 2nd harmonic of the upper frequency edge of the DL *operating band*	-20 dBm

Table 5 Step frequencies for defining the BS radiated Tx spurious emission limits in FR2 (Category B) [37]

Operating band	$F_{step,1}$ (GHz)	$F_{step,2}$ (GHz)	$F_{step,3}$ (GHz) (Note 2)	$F_{step,4}$ (GHz) (Note 2)	$F_{step,5}$ (GHz)	$F_{step,6}$ (GHz)
n258	18	21	22.75	29	30.75	40.5
NOTE 1: $F_{step,X}$ are based on ERC Recommendation 74-01 [19], Annex 2.						
NOTE 2: $F_{step,3}$ and $F_{step,4}$ are aligned with the values for Δf_{OBUE} in Table 9.7.1-1.						

RSM considers that unwanted emission limits (that form UELs and AFELs) should be set based on category B as this will assist with long-term spectrum efficiency and minimise the risks of interference. In particular, this will assist with the protection of 50.2 - 50.4 GHz and 52.6 - 54.25 GHz EESS (Passive) from the second harmonic of IMT-2020 (see section 4.5.1 and ITU Radio Regulations, Resolution 242, Recognising f). Category B is also more closely aligned with the generic unwanted emission requirements with Table 2 of the Radiocommunications Regulations (Radio Standards) Notice. We believe that equipment is built for a global market and most, if not all will already be able to meet category B limits.

Q23. Do you agree that RSM should set unwanted emissions limits (in UELs and AFELs) base on 3GPP category B requirements? If no, please explain the reasons and provide your suggestions?

4.5 Sharing and compatibility considerations

In the preparations for WRC-19, the ITU-R (Task Group 5-1) undertook sharing and compatibility studies between IMT networks operating in the 26 GHz band (24.25 - 27.5 GHz) and existing services on the same and adjacent frequency ranges. A summary of these studies can be found in the Report of the CPM to WRC-19[44] The detailed analysis can be found in the Report on the sixth meeting of Task Group 5/1 (5-1/478[45]). These technical studies formed the basis of the decisions made at WRC-19 and subsequent regulatory provisions in the ITU Radio Regulations.

4.5.1 Sharing and compatibility with Earth Exploration Satellite (Passive) Service in 23.6 - 24 GHz

The 23.6 - 24 GHz band is allocated to the Earth Exploration Satellite (Passive) Service (EESS) which is adjacent to IMT in 24.25 - 27.5 GHz. ITU-R studies showed that an unwanted emission limits would be needed to mitigate the risk of interference to passive services. Studies suggested a range of unwanted emission limits, which was largely dependent on the input assumptions used. EESS (Passive) is used for very sensitive passive sensing applications used to

[44] Report of the CPM to WRC-19.

[45] Report on the sixth meeting of Task Group 5/1 (Geneva, Switzerland, 20-29 August 2018).

collect a range of environmental information (e.g. observations of weather and climate) and are susceptible to artificial noise.

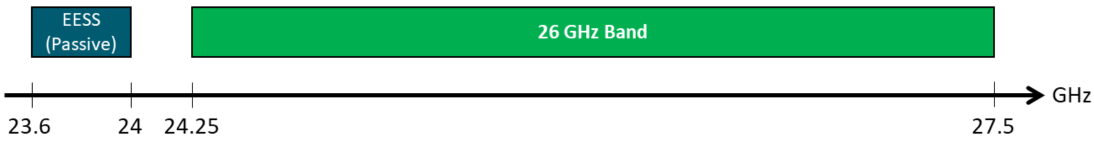

Figure 15 EESS band adjacent to 3GPP n258

WRC-19 decided on an appropriate unwanted emission limit to protect EESS (Passive). The ITU Radio Regulations were updated accordingly with resolves 1, table 1 in Resolution 750 prescribing unwanted emissions limits on IMT system in 24.25 - 27.5 GHz. The unwanted emission limits are applied in the following two stages:

1. Equipment brought into use before 1 September 2027 must meet the unwanted emissions limit of -33 dBW/200 MHz for BS and -29 dBW/200 MHz for MS. This limit will not apply to equipment which have been brought into use prior to this date.
2. Equipment brought into use after 1 September 2027 must meet the unwanted emissions limit of -39 dBW/200 MHz for BS and -35 dBW/200 MHz for MS.

The two-stage approach is based on an assumption that mass-market deployments will not occur during the initial step and therefore the aggregate unwanted emissions from network deployment will remain below the EESS protection requirement. In addition, it assumed that with the evolution of the radio technology, it will be easier for equipment providers to meet the more stringent unwanted emission limits.

Europe has implemented[18] the outcomes of WRC-19 and the unwanted emission limits in Resolution 750. However, it decided to bring the transition date forward, from 1 September 2027 to 1 January 2024. Europe (CEPT) concluded that a transition date in September 2027 poses a risk to EESS (passive) bands since mass market deployments in Europe might happen significantly earlier than 2027.

Consideration was also given to the second harmonic of 24.25 - 27.5 GHz IMT base stations falling within the 50.2 - 50.4 GHz and 52.6 - 54.25 GHz EESS (Passive) bands the ITU-R Radio Regulations. Resolution 242, Recognising d) states that Category B spurious limits from Recommendation ITU-R SM.329 is sufficient to protect EESS (passive) in these frequency bands.

3GPP Release 16 reflects the decisions for both BS and MS operations in the 24.25 - 27.5 GHz band and application of the additional unwanted emission limits for protection of EESS.

RSM considers that the unwanted emission limits as defined in Resolution 750 should be reflected as technical input when setting the UEL or AFEL. We intend to keep the transition date to the new unwanted emission limits as 1 September 2027 as set out in Resolution 750 and do not consider that this date be brought forward. This means only stations brought into use after 1 September 2027 will need to meet the more stringent unwanted emission limits. Stations in use before 1 September 2027 can continue to operate.

Q24. Do you agree that we should we implement (e.g. through UELs and AFELs) the ITU Radio Regulations, Resolution 750 limits, including the 1 September 2027 transition date and grandfathering clause for the protection of the EESS (Passive) Band? If not, please explain what limits and transition dates you consider to be more appropriate.

Q25. Do you have any insights on equipment availability at, or close to, the edge of 24.25 GHz that can meet both pre-1 September 2027 and post-1 September 2027 unwanted

emission limits? Is there any additional technical solution such as frequency separation or filtering required for some equipment types?

4.5.2 Sharing and compatibility with the Radio Astronomy Service in 23.6 - 24 GHz

The 23.6 - 24 GHz band is allocated in the ITU Radio regulations to Radio Astronomy Services (RAS). ITU-R studies showed that separation distances / co-ordination zones around RAS stations should be 9 - 52 km for the deployment of IMT BS and 5 - 27 km for IMT MS. The range of separation distances / co-ordination zones is largely dependent on the input assumptions, particularly of unwanted emissions (e.g. if Category A or B unwanted emission limits for Recommendation ITU-R SM.239 were assumed). Noting that RAS shares the 23.6 - 24 GHz band with EESS (passive) service, the mandatory unwanted emission limits on IMT networks to protect them may also be of benefit in reducing the separation distances / co-ordination zones required. When considering real scenarios such as terrain, the separation distances / coordination zones may be further reduced.

RSM notes that there are no licences for RAS in the 23.6 - 24 GHz band in the Register of Radio Frequencies (RRF). RSM is not aware of any current, planned or future operations of RAS in this band in New Zealand. Therefore, RSM does not plan to establish a framework for coordination zones. However, if in the future a licence is granted for RAS receive protection in the 23.6 - 24 GHz we expect it will be in rural areas and approved radio engineers will need to consider when engineering new licences in the adjacent band.

Q26. Do you agree with RSM's position to not establish a framework for coordination zones for RAS?

4.5.3 Sharing and compatibility with Earth Exploration Satellite and the Space Research Services (space to Earth) in 25.25 - 27 GHz

The 25.25 - 27 GHz band is allocated in the ITU Radio Regulations to EESS and the Space Research Services (SRS) (space to Earth) receiving earth stations which overlap with 24.25 - 27.5 GHz IMT. ITU-R studies showed a proper separation distances / co-ordination zones around 0.2 - 7 km for EESS Earth stations and 0.8 - 2.0 km (urban and suburban) / 24 - 92 km (site specific) for SRS Earth stations. The range of separation distances / co-ordination zones is largely dependent on the input assumptions. When considering real scenarios such as terrain, the separation distances / coordination zones may be further reduced.

RSM notes that there are no receive only licences EESS or SRS earth stations for in 25.25 - 27 GHz band in the RRF. RSM is not aware of any current, planned or future operations of EESS or SRS in this band in New Zealand. However, if in the future a licence is granted for receive protection in the 25.25 - 27 GHz we expect these will be in rural areas and approved radio engineers will need to consider this.

Q27. Do you see a need for RSM to allow EESS and SRS earth stations to operate in the band?

4.5.4 Synchronisation options for IMT network

The physical characteristics of radio transmissions mean that 5G on high band experience higher path loss due to their shorter wavelength than low and mid band. In addition, mmWave signals are easily blocked by objects, such as human bodies, walls, or foliage. When determining how to have 5G TDD networks co-existing in adjacent frequency bands, it is worth designing synchronisation options that take into consideration mmWave physical characteristics.

Synchronisation operation options

There are a number of options for high band 5G synchronisation. ECC Report 307[46] outlines synchronised, semi-synchronised, and unsynchronised systems for high band TDD network co-existence.

Option 1: Synchronised networks

RSM has previously mandated synchronised operation in the 3.5 GHz early access 5G allocation. The synchronisation requires the operation of different 5G networks in a TDD configuration, where no simultaneous uplink and downlink transmissions occur, i.e. at any given time period, either all networks transmit downlink signals or all networks transmit uplink signals. This requires the alignment of all downlink and uplink transmissions for all the networks involved, as well as synchronising the start of the frame across all networks.

When designing synchronised networks for TDD operation, the following parameters need to be centrally defined:

1. A common phase clock reference and its accuracy; and
2. A common frame structure as defined by 3GPP TS 38.211, which includes:
    a. Selection of a timing reference (beginning of the frame)
    b. Selection of a frame format
    c. Selection of subcarrier Spacing (SCS)
    d. Selection of normal or extended prefix
    e. Selection of a special slot configuration.

In the 3.5GHz early access allocation, RSM chose to use the following parameters:

1. UTC time was used as the reference phase clock with an accuracy of ±1.5µs ; and
2. A common frame structure of:
    a. The frame structure was defined to be DDDSU, with 30 kHz SCS
    b. a normal cyclic prefix (corresponding to 3GPP numerology 1)
    c. A radio frame with a 10ms duration contains 10 sub-frames and 20 slots, with each 0.5ms slot containing 14 symbols
    d. The Special slot “S” format used in the SCS 30 kHz 5G NR DDDSU frame configuration is configured with a ratio of 10 Downlinks, a 2 Symbol Guard Period and 2 Uplinks (10:2:2).

This frame structure has also been recommended by the GSMA[47] when deploying synchronised 3.5 GHz 5G national networks.

For 5G FR2, only 60 and 120 kHz subcarrier spacing can be used due to increased Doppler frequencies and RF oscillator phase noise limitation. This corresponds to a slot length of 250µs and 120µs respectively.

[46] ECC Report 307, “Toolbox for the most appropriate synchronisation regulatory framework including coexistence of MFCN in 24.25 - 27.5 GHz in unsynchronised and semi-synchronised mode”.
[47] GSMA, “5G TDD Synchronisation Guidelines and Recommendations for the Coexistence of TDD Networks in the 3.5 GHz Range”

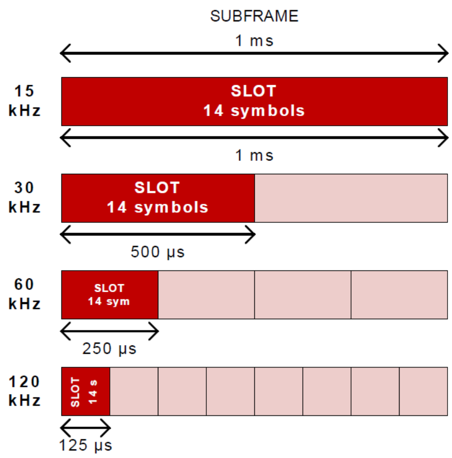

Figure 16 Numerology and sub-frame structure for different SCS

<u>Option 2: Unsynchronised networks</u>

Unsynchronised operation refers to the case where there is no synchronisation between operators in terms of network timing and transmissions.

The benefit of unsynchronised operation is that it does not require the adoption of a compatible frame structure among network operators. Operators can select the frame structure independently of other operators and can therefore adopt the frame structure that is most appropriate to service their customers' requirements. This allows flexibility in the operators' network configuration.

However, in a multi-operator unsynchronised network scenario, the flexibility in an operators' frame structure selection leads to a number of interference scenarios that needs to be assessed and potentially managed.

For unsynchronised network operation, there is usually a requirement of large geographic separation or very tight out of band emissions limits to mitigate the potential interference between networks. This situation is therefore not beneficial for operators wanting to deploy nationwide networks for example.

For example, in Europe, the ECC has defined a baseline BEM (Block Emission Mask) for networks that are synchronised and a restricted BEM for unsynchronised network operation. The restricted BEM has a much more stringent unwanted emissions requirement to protect unsynchronised networks.

Another option to consider is the geographic separation of adjacent networks. ECC Report 307 describes how a simulated 5G network operating between 24.25 - 27.5 GHz copes when interference is presented. The results show how two geographically adjacent 5G networks work together, depending on the location scenarios (urban, suburban and open space) and with either the co-channel or adjacent channel use case.

A number of different unsynchronised deployment scenarios were simulated in the ECC report 307. The report presents the derived restrictions on the separation distances of base stations in co-channel and adjacent channel cases, based on 5% degradation in the mean uplink throughput of the victim networks, for the non-synchronised operation. The worst case scenario is interference between outdoor networks with 0 degree offset between aggressor and victim antenna.

The simulation on distance analysis results of co-channel and adjacent channels can be found in Table 6.

Table 6 Separation distances between two geographically adjacent networks for unsynchronised operation

Scenario	Separation distance Adjacent channel	Separation distance co-channel
Outdoor hotspot, 6 m antenna height (with high clutter loss)	150 metres	600 metres
Outdoor hotspot, 6 m antenna height (with low clutter loss)	900 metres	1.6 km
Outdoor hotspot, 15m antenna height	1.5 km	3 km

When the separation distances that were simulated are less than those values for unsynchronised networks, the ECC report recommends a restricted baseline limit of -13 dBm/50 MHz, which is 17 dB stricter than the 3GPP specifications. This restricted baseline limit will possibility require additional filtering and guard bands to allow unsynchronised networks to operate beside each other.

Option 3: Semi-synchronised networks

A semi-synchronised operation is where part of the frame is consistent with a synchronised operation as described in option 1, while the remaining portion of the frame is consistent with an unsynchronised operation as described in option 2. In particular, semi-synchronised operation requires the adoption of a default frame structure (for which uplink/downlink directions are defined across the whole frame) and at the same time part of the frame is flexible, where each operator is allowed to reverse the default transmission direction (flexible part).

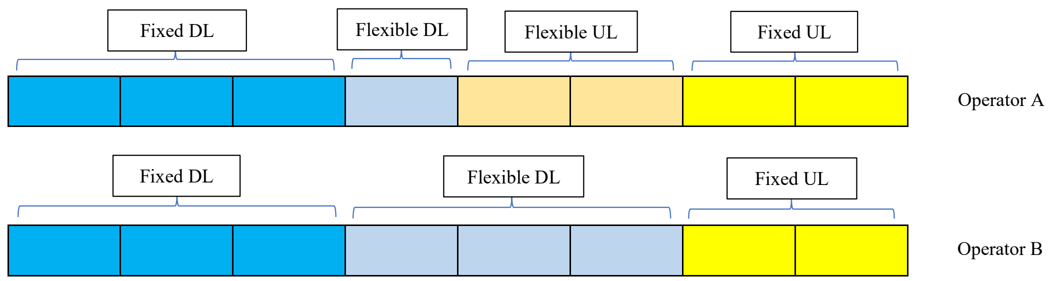

Figure 17 Example of semi-synchronised operation

Semi-synchronised operation aims to strike a balance between being more flexible (when compared to synchronised operation) and some acceptable data-loss. In one implementation of semi-synchronised operation, the control plane can be protected by ensuring that the control signals never belong to the flexible part of the frame. This differs from unsynchronised operation, where both the control and data channels can be interfered with, leading to potentially larger loss of network throughput.

Semi-synchronised operation can also be applied to the case of co-existence between different technologies operating in adjacent frequency blocks. One example of a semi-synchronised network is 3.4 GHz spectrum in the UK where 4G and 5G networks operate in the same band[48]. The UK regulator set the band to LTE-TDD frame configuration #2, along with special sub-frame configuration #6 (or equivalent frame structures whose transmit and receive periods are aligned with this configuration) as the "preferred frame structure". An operator must comply

[48] Ofcom, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands, Section 11.32-11.36

with the preferred frame structure in order to be allowed to use the "permissive transmission mask". An operator unwilling to adopt the "preferred frame structure" must comply with the "restrictive transmission mask" and the "compatible frame structure", i.e. the operator must undertake semi-synchronised operation within the band.

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
Any	D	S	U							

Figure 18 Semi-synchronised frame structure in UK award for the 3400-3600 MHz

A comparison between the three types of network is listed in Table 7. The analysis compared network value, change flexibility, performance degradation and cost of interference mitigation between synchronized, semi-synchronised and unsynchronised network.

Table 7 Comparison between synchronized, semi-synchronized and unsynchronized network

	Synchronised	**Semi-synchronised**	**Unsynchronised**
Network value	May not suitable for some use cases	Can configure for different use cases	Can easily configure for different use cases
Change flexibility	Low, changing frame structure requires RSM to coordinate	Some limitation. Control signal must be allocated into certain subframe.	Least limitation, though the later licence holder may be forced to synchronise to avoid causing interference
Interference /performance degradation	Low interference risk	Medium risk, may suffer some throughput loss if network co-located	High risk, may suffer high throughput loss if networks co-located
Cost of interference mitigation	Low and little cost on filter	Medium, require additional filtering or involved operators to resolve the interference	High, require good filtering or involved operators to resolve the interference

Based on the analysis above, there are a few reasons for us not to mandate a synchronised network:

- The 5G mobile networks on high band are not likely to be deployed nationwide and will only be in a few high-density urban areas.
- The use case for co-located networks will be very similar, which means operators are likely to use the same frame structure at the same location for their deployment.
- 5G high band networks will be used by other applications such as private networks or IoT. The features of these other networks are likely to be quite different, and it will require different frame structures to optimise the coverage and traffic throughput.
- The network demand may change based on different scenarios, an easy configuration mechanism will assist with those changes.

However, there will be some situations where networks will undertake co-location of BS equipment. In this case, the network operators will need to agree on certain synchronisation parameters or use a guard band and filters to mitigate potential interference to each other's network.

Q28. Do you agree a semi-synchronised or unsynchronised network should be used in 5G high band deployment?

Q29. If the network is unsynchronised, what is the best way to manage the interference between unsynchronised operators?

Q30. If your preference is a semi-synchronised network, what is your suggestion on setting the synchronized parameter?

4.5.5 Sharing and compatibility with the fixed satellite and inter-satellite service space station receivers in 24.25 - 27.5 GHz

The 24.45 - 27.5 GHz band is allocated in the ITU Radio Regulations to the fixed-satellite service (Earth to space) and inter-satellite service receiving space stations which overlap with 24.25 - 27.5 GHz IMT. ITU-R studies showed that a significant margin of 14 - 20 dB for FSS and 12 - 25 dB for ISS was achieved when compared with the protection criteria for worst case aggregate interference scenarios. Studies were based on an agreed set of assumptions. The variation results are largely due to the application of the assumptions and analysis methods used. One of these assumptions was that IMT base stations would normally be pointed downward, below the horizon to serve user equipment on the ground.

The assumption of the study was implemented in the ITU Radio Regulations, Resolution 242, resolves 2.1:

"that administrations shall apply the following conditions for the frequency band 24.25-27.5GHz:

> *2.1 take practical measures to ensure the transmitting antennas of outdoor base stations are normally pointing below the horizon, when deploying IMT base stations within the frequency band 24.25-27.5GHz; the mechanical pointing needs to be at or below the horizon; "*

One ITU-R study considered that there could be occasions where a beam may point upwards to serve user equipment (e.g. an IMT base station serving user equipment in the window of a multi-story office building) which showed large positive margins. Given the large margin in the study and the urban environment with clutter, beams from IMT base stations pointing upward momentarily are very unlikely to cause interference to space stations, particularly with the low population densities in New Zealand.

To mitigate the interference risk and provide some flexibility, RSM proposes to implement resolves 2.1 in the management right and licence conditions to manage ongoing sharing and compatibly between IMT system and FSS / ISS space stations.

Resolution 242 also resolves GSO satellite avoidance in 2.2:

> *"2.2 as far as practicable, sites for IMT base stations within the frequency band 24.45 - 27.5GHz employing values of e.i.r.p. per beam exceeding 30dB(W/200MHz) should be selected so that the direction of maximum radiation of any antenna will be separated from the geostationary-satellite orbit, within line-of-sight of the IMT base station, by ±7.5 degrees;"*

RSM notes that 2.2 relates to site selection and is a matter for licensees and Approved Radio Engineers to consider.

Q31. Do you agree that think RSM should implement ITU Radio Regulations, Resolution 242, resolves 2.1 in the management rights and licences conditions? If not please explain why or propose an alternative?

4.5.6 Sharing and compatibility between FSS transmitting earth stations and IMT/FWA

24.25 - 27.5 GHz

The 24.65 - 25.25 GHz band and the 27 - 27.5 GHz band are also allocated in the ITU Radio Regulations to the FSS (Earth to space). Transmitting earth stations have the potential to cause interference to receiving IMT stations in the 24.25 - 27.5 GHz band. ITU-R studies showed that separation distances / co-ordination zones radius around FSS Earth Stations are from less than 100 m up to 10 km depending on different parameters and input assumptions. When considering FSS earth stations on a case by case basis, real world factors (e.g. that terrain may reduce the size of the coordination zones).

ITU Radio Regulations Resolution 242 encourages administrations to ensure that provisions for the implementation of IMT allow for the continued use of EESS, SRS and FSS earth stations and their future development;

The ITU-R is also developing a Recommendation to assist administrations to mitigate interference from FSS earth stations into IMT stations. In addition, CEPT has already published guidelines for the coexistence use[49].

RSM notes that there are no licences for FSS earth stations in the 24.65 - 25.25 GHz band in the RRF. RSM is not aware of any current, planned or future operations in this band in New Zealand. It is observed that the 24.65 - 25.25 GHz band was generally intended for feeder links for the broadcasting-satellite service operating in 21.4 - 22 GHz (following review at WRC-12) although it can be used for other FSS feeder links. RSM is also not aware of any intended deployment of the 21.4 - 22 GHz for broadcasting-satellite service in New Zealand. In addition, we have not had any requests for FSS earth station licences to operate in this band. Therefore, RSM does not currently see a case to make the 24.65 - 25.25 GHz available for FSS Earth Stations in New Zealand.

RSM note that there are three licences for FSS to IPSTAR at Albany SES in the 27.0 - 27.5 GHz band in the RRF. These licences are set to expire on 31 January 2022. RSM is not aware of any planned or future operations of FSS earth stations in in this band in New Zealand.

Q32. Do you see a need for RSM to allow continued FSS gateway access to 27.0 - 27.5 GHz on a case by case basis? If so, how should we coordinate FSS Earth stations and IMT?

27.5 - 29.5 GHz

The 27.5 - 29.5 GHz band is also allocated in the ITU Radio Regulations to the FSS (Earth to space) where transmitting earth stations have the potential to cause interference to IMT FWA receiver in the same frequency range. There will be a separation distances / co-ordination zones around each FSS Earth stations, which is similar to the case in 24.25 - 27.5 GHz.

[49] ECC Recommendation (20)01, "Guidelines to support the introduction of 5G while ensuring, in a proportionate way, the use of existing and planned FSS transmitting earth stations in the frequency band 24.65-25.25 GHz and the possibility for future deployment of these earth stations".

In allocation options in the section 3.2.2, we proposed a shared spectrum use between FWA, private networks and FSS in the 28 GHz band. Given the different use cases, FSS earth stations may be more prevalent in less populated areas while IMT FWA may be more prevalent more densely populated urban and suburban areas.

To manage the spectrum sharing and minimise the interference impact, RSM proposes the following options to consider in developing a framework for use of the spectrum:

- Require that all FSS earth stations and FWA Base Stations be licenced for specific locations.
- Require the FWA service areas recorded in the licence.
- Establish certain geographic areas where FSS has priority over FWA. RSM will define certain geographic areas in sparsely populated rural areas where FSS earth stations may be licenced and have a primary status. Within these geographic areas the following will apply:
    - Each FSS earth station will have a coordination zone calculated on a case by case basis. IMT FWA operating within this co-ordination zone must tolerate the interference.
    - IMT FWA will have a secondary status meaning that if a new FSS earth station is established, existing IMT FWA in the co-ordination zone will have to tolerate the interference.
- RSM will define certain geographic areas in more densely populated urban and suburban areas where IMT FWA may be licenced and will have a primary status.
    - Approved Radio Engineers will calculate a co-ordination zone for each FWA licence. FSS Earth Station may operating within this co-ordination zone provided there is mutual, documented agreement with the licensee.
    - FSS earth stations will have a secondary status in those defined areas meaning that if a new FWA is established, existing FSS earth stations within the co-ordination zone should not cause interference to the FWA service.
- Set an EIRP limit towards the horizontal plane for FSS earth station transmitters.

Q33. Do you have any comments regarding the spectrum sharing approach proposed by RSM between FSS and IMT FWA in the 28 GHz band?

Q34. If RSM were to apply an EIRP limit on horizontal plane for FSS, what is the maximum EIRP value we should assume?

4.5.7 Sharing with the existing fixed service

The 24.25 - 27.5 GHz band is allocated in the ITU Radio Regulations to fixed service, and there is the potential for interference with IMT in the same frequency range. ITU-R deterministic studies showed that separation distances / co-ordination zones around fixed service between 2.6 km up to 70 km for co-channel cases. In the cases of services in adjacent bands, the range is from 0.9 to 12 km. However, statistical studies found a smaller separation distance might be required. The sharing case is very common in Europe, thus CEPT has produced guidance on co-existence between 5G and fixed link in ECC Report 303[50].

[50] ECC Report 303, Guidance to administrations for Coexistence between 5G and Fixed Links in the 26 GHz band ("Toolbox")

As per analysis in Chapter 2.4, there are alternative bands and solutions to 26 GHz cellular backhaul service. Given the large geographic separation requirement, we do not think it is economically beneficial for us to continue supporting the fixed service operating in 26 GHz band after 31 October 2022. However, there may be a case for a longer transition period in rural areas but these should not continue in the long term.

To help with the transition while not causing disproportionate impact on IMT deployment, there are two options that could be considered.

Option 1 Secondary use for the existing fixed service only after 31 October 2022

In this option, fixed services can not cause interference or claim protection from IMT. When a new IMT station is deployed, licence holders of the fixed service in the affected area must cease operation where their fixed link transmitter will cause interference to IMT stations.

Option 2 Private arrangement

In option 2, fixed service licence holders need to arrange or negotiate migration with new band managers. Licence holders can either change the frequency of their fixed links to their own bands or get approval for longer term licences from the new band manager to continue use.

Q35. Which option do you prefer for arranging the existing fixed service in the 26 GHz band?

4.6 ESIM shares with other services

ESIM, which will be permitted under a GURL, must not cause interference to a licensed service and cannot claim protection. Potential licence conditions need to incorporate Annex 1 to 3 of Resolution 169.

Annex 1 outlines the radiation pattern requirements for ESIM to protect NGSO FSS feeder links at 27.5 - 28.6 GHz and NGSO MSS feeder links in 29.1 - 29.5 GHz.

For aeronautical and maritime ESIM, a more nuanced approach could be considered. Factors such as limiting Aeronautical ESIM use to defined heights above ground level and Maritime ESIMs to defined distances from the shore could be implemented as well as other technical limits (e.g. power and pfd limits). Annex 3 of Resolution 169 sets the detailed technical and regulatory requirements for maritime and aeronautical ESIM use to protect terrestrial services in the 28 GHz band.

ITU-R Working Party 4A are currently studying the methodology for the examination of the characteristics of aeronautical ESIMs and conformity of power flux density limits in Part II, Annex 3, relating to Resolves 1.2.5. Studies are ongoing in a Working Party 4A Correspondence Group (CG), and the next meeting of Working Party 4A is 14-28 July where further progress should be made. We are keeping a watching brief on this work and consider that it is independent of domestic technical conditions to be applied to any GURL when permitting aeronautical ESIM use in the 27.5 - 29.5 GHz band, or parts thereof.

If the option 1 in section 3.2.2 is taken after the consultation, there will be a spectrum sharing between IMT and ESIM from 27.5 - 28.35 GHz. To allow an efficient share use, we propose following two licence conditions from Annex 3 of Resolution 169 for Aeronautical and Maritime ESIM:

- A different power flux density mask for aeronautical based ESIM in the shared frequency range below and above 3km.

- Maritime based ESIMs should operate further than 70 km from the low water tide mark, and the maximum maritime ESIM EIRP spectral density towards the horizon shall be limited to 24.44 dB(W/14 MHz).

Q36. Do you think RSM should mandate the regulatory requirements as laid out in Resolution 169 (WRC-19) for ESIM use if a shared use between 27.5 – 28.35 GHz?

5 Summary of questions asked