RADIO SPECTRUM MANAGEMENT

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Discussion document: Technical Arrangements of the 3.5 GHz Band

June 2019

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
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Interested parties are invited to comment on the content of this document, in particular the questions posed, and on any related issues. Comments should be submitted in writing, no later than **5pm** on **Monday 29 July 2019** to:

By email: *(preferred option)*

Radio.Spectrum@mbie.govt.nz

Subject line: "Technical Arrangements of the 3.5 GHz Band"

Or

By post:

Technical Arrangements of 3.5 GHz Band
Radio Spectrum Management Policy and Planning
Ministry of Business, Innovation and Employment
PO Box 2847
WELLINGTON 6140

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

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1. Introduction

Radio Spectrum Management (RSM) is consulting on the technical principles for future spectrum users in the spectrum range of 3410 – 3800 MHz (the '3.5 GHz band'). The current management rights in the 3.5 GHz band will expire by 31st October 2022. We are in the process of re-allocating this band.

This document sets out the proposed rules and the technical requirements for operating in the 3.5 GHz band. These proposed rules and associated technical arrangements will only come into effect when the new management rights are created. At the outset, this document proposes that all future users of the 3.5 GHz band synchronise their transmission to a set structure. Operators could opt not to synchronise as long as they do not cause harmful interference to adjacent spectrum users. It also proposes that an unwanted emission mask be observed throughout the band.

The 3.5 GHz band is envisioned for use by Time Division Duplex (TDD) systems. This frequency range is considered a pioneer band for the deployment of 5G systems internationally. The global trend is to use this band for TDD systems. In harmony with international trends, we have also decided to use the 3.5 GHz band for similar systems.

TDD systems have the inherent problem of causing interference between adjacent operators if transmission and reception are not synchronised. In TDD systems, a base station and a mobile handset take turns, in time, to transmit or receive their signal. If two adjacent operators do not perfectly align the timing of their transmission, there could be occasions when the transmission of one operator coincides with the reception of other operators. Such events will cause harmful interference.

To manage this interference problem, RSM convened a Technical Working Group (3.5 GHz TWG) comprising industry stakeholders who had an interest in deployment of the 3.5 GHz band. These stakeholders included mobile network operators, fixed network providers, equipment manufacturers and the Wireless Internet Service Providers Association (WISPA). The 3.5 GHz TWG met three times between April 2018 and March 2019 and considered a range of possible solutions.

The technical arrangements in this document are the result of recommendations and agreements attained through the 3.5 GHz TWG. The group agreed that synchronisation is the best method for interference prevention. It was proposed that the whole 3.5 GHz band should be synchronised to a 5G-specific frame structure and timing requirement. The group also considered an enforcement mechanism for the implementation of this synchronisation solution.

We are interested in your opinion about the content of this document; in particular on the questions posed, and also on any related issues. Your comments will help us to finalise the technical arrangement of the 3.5 GHz band. These arrangements will be used as the principles for allocations of spectrum in the 3.5 GHz band.

This technical arrangement is independent of any variation to the 3.5 GHz band plan or the intended spectrum allocation mechanism. We propose that the whole band operates under the same technical principles.

2. Rules of co-existence and process for change

The technical proposal to avoid interference for TDD networks in the 3.5 GHz band is to require operators to synchronise to the specified parameters (see Section 3).

Unsynchronised transmissions will only be permitted in the 3.5 GHz band if they are technically compatible and do not cause harmful interference to operators that are already synchronised. In other words, the following would apply in the 3.5 GHz band:

- In private management rights, the licensee must manage interference from its unsynchronised transmissions within the relevant management right by using either guard bands, filters, reduced transmit power or other means.
- In Crown management rights, the licensee’s unwanted emissions must not cause harmful interference to synchronised users. If such harmful interference is proven and the licensee is unable to remedy the harmful interference within 10 working days, the Crown will retain the right to cancel the unsynchronised licence immediately.

Operators in a private management right unable to licence a transmitter because it would cause interference to or suffer harmful interference from an existing licensed unsynchronised transmission in a Crown management right, must give at least 18 months’ notice to the unsynchronised licensee of their intention to install and operate a synchronised transmitter. The unsynchronised licensee may either elect to synchronise to the band parameters or to cease transmission when the transmitter in the private management right becomes operational. The Crown will retain the right to cancel the unsynchronised licence at the end of the 18 month notice period, to enable the synchronised licence to be established.

If harmful interference occurs between unsynchronised and synchronised transmissions in private management rights, the unsynchronised operator has the primary responsibility to address the harmful interference and, if required, to amend the relevant licence to reflect the changes.

The band synchronisation parameters may be changed at any time by agreement of all operators in the band or by making a submission to an independent arbitration process under the Arbitration Act.

Synchronisation parameters, technical compatibility and harmful interference rules will be imposed through agreements which will set out the synchronisation parameters and rules to manage harmful interference. In addition, the agreements will require all operators in the 3.5 GHz band to collaborate and cooperate to manage interference issues to maximise the use of the band. All operators in the band must be a party to the agreement. The agreement will be in force for the duration of the management rights.

Question 1:	*Do you agree with the proposed rules of co-existence and the process of change?*
Question 2:	*Do you have any additional comments about the process?*

3. Proposed arrangement for synchronisation

Operators in the 3.5 GHz band should align the timing of their downlink / uplink transmission in accordance to following descriptions.

3.1. Frame structure

The proposed frame is defined with the following characteristics: downlink/ uplink slots arrangements in a TDD frame:

Duration of a frame	10 ms
Reference Subcarrier Spacing	30 kHz (20 slots in one frame)
Periodicity of the DL-UL pattern	2.5ms
Number of consecutive full DL slots at the beginning of each pattern	3
Number of consecutive DL symbols in the beginning of the slot following the last full DL slot	10
Number of consecutive full UL slots at the end of each pattern	1
Number of consecutive UL symbols in the end of the slot preceding the first full UL slot	2

Using the above parameters, one TDD frame is constructed as below:

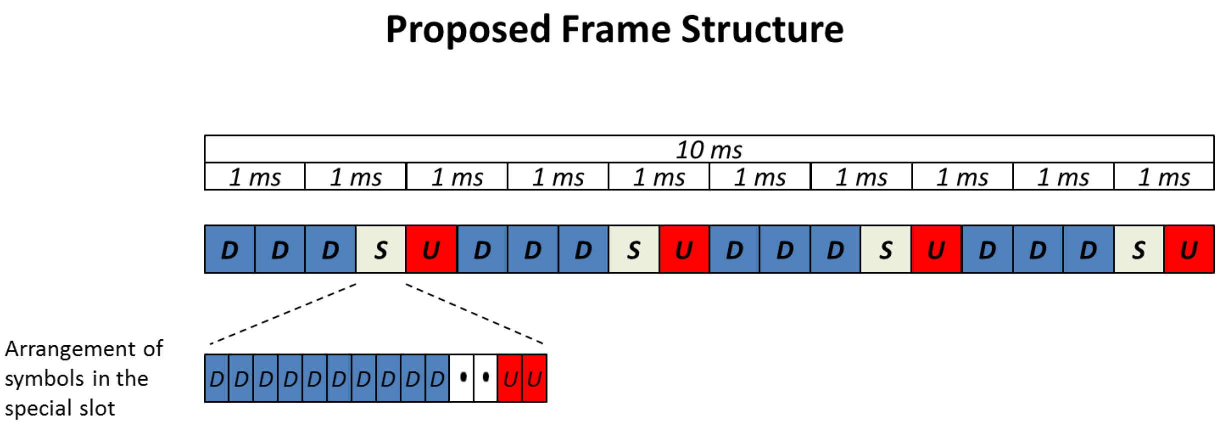

Figure 1: Proposed Frame Structure

Although we use terminologies specific to 5G systems for defining the frame structure, we do not restrict the use of the band exclusively to 5G technologies. Any other compatible technology which is able to align its transmission to this frame structure is also permitted to operate in the 3.5 GHz band.

3.2. Determining the start of the TDD frame

The process of determining the start of the frame for the first time will follow the first-in-time rule: The company that is the first to deploy in the 3.5 GHz band can start its transmissions at any time they see appropriate. Other entrants to the band should align their frame with existing users. The process of changing the start of the frame should follow the change process described in section 2.

We understand that some operators may require that the start of their frame to be aligned within different frequency bands to perform carrier aggregation. We propose this method of definition because this is the first time synchronisation is being implemented in New Zealand. We expect that different operators will have different frame starts. Therefore some operators would have to align their frames to this 3.5 GHz band in any case. However, for future synchronisation agreements in other frequency bands we may have to use the frame start that is set in this 3.5 GHz band.

3.3. Synchronisation source and timing alignment

We do not mandate any specific method to use for a timing source. The operators are responsible for making sure that their frame does not deviate in time from other operators. The onus is on the operators to maintain this timing with any method or technology they deem appropriate.

Question 3:	*Do you agree with the proposed frame structure?*
Question 4:	*Do you agree with the proposed arrangement for the special slot?*
Question 5:	*Do you agree with the process for defining the start of the TDD frame for the first time?*
Question 6:	*Do you agree with the proposed solution for a synchronisation source and timing alignment?*

4. Proposed unwanted emission mask

The unwanted emissions mask for the equipment operating in the 3.5 GHz band will be calculated using the 3GPP standard, namely 3GPP 38.104 V15.5.0 (2019-03). Although we use a 5G-specific standard to calculate the mask, we do not mandate any 5G-specific equipment. Any equipment which is able to comply with this mask is permitted.

Using the terminologies in this standard, we make the following assumptions to calculate unwanted emission limits:

- Operating band class: n78 (3300 – 3800 MHz)
- Base Station (BS) type: 1-H , Wide area BS category B
- The unit of power: dBW/MHz EIRP

4.1. Calculation method

The power of the unwanted emissions consists of out-of-band emissions and spurious emissions. The out-of-band emissions requirement for the BS transmitter is specified both in terms of the Adjacent Channel Leakage power Ratio (ACLR) and Operating Band Unwanted Emissions (OBUE). We will use the OBUE values.

3GPP 38.104 specifies the boundary between OBUE and Spurious emissions in table 6.6.1-1. Applying this table to the n78 band means that these boundaries should be at 3260 MHz and 3840 MHz. However, for the lower boundary we will deviate from the standard and set the boundary at 3370 MHz. This is to ensure other usages in the lower-adjacent band within 3300-3410 MHz, such as amateur radios and short range devices, could continue operation within this adjacent frequency range with minimal impact (see Section 5). We understand that a similar lower frequency boundary is also adopted in Europe and South Korea. Therefore, we do not expect that this decision will affect the economies of scale for the availability of devices.

The following figure illustrates the components of unwanted emissions:

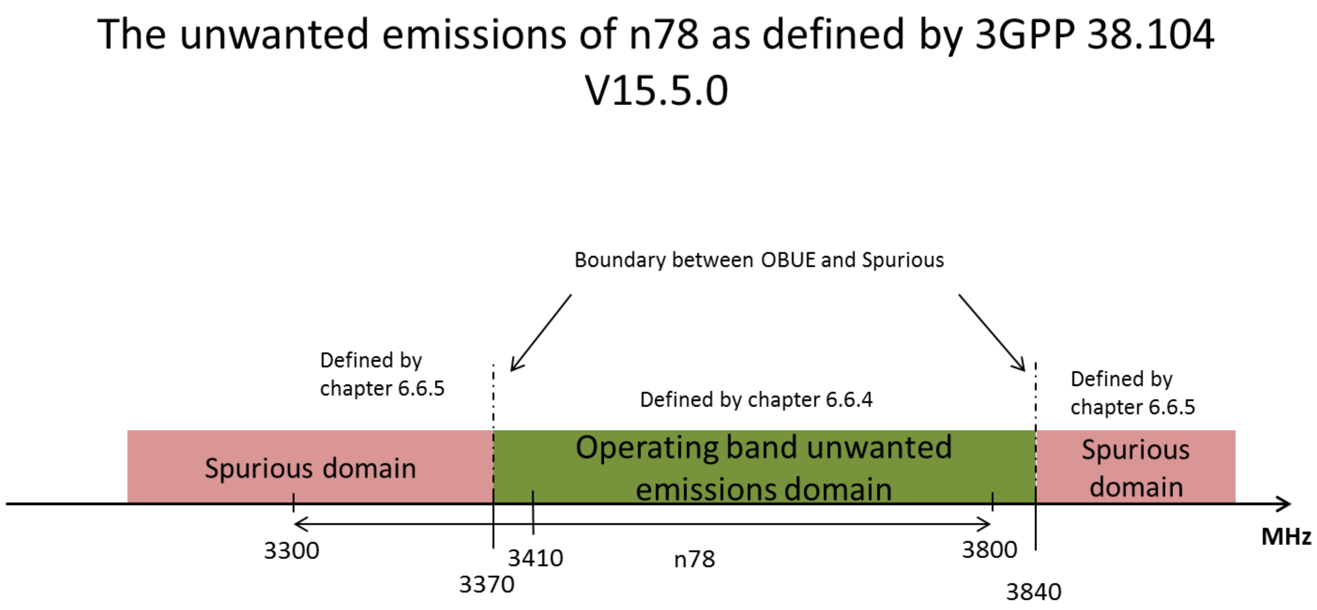

Figure 2: Unwanted emissions of 78

The 3GPP defines the unwanted emissions according to the formula below:

Unwanted emissions (dBW) = Basic limits (dBW) + X

Where:

The Basic limits are the emissions relating to the power of a single transmitter conducting to a single antenna. We will use table's 6.6.4.2.2.1-2 and 6.6.5.2.1-2 in 3GPP 38.104 for the basic limits of OBUE and spurious emissions respectively.

X is the scaling factor relating to Active Antenna Systems. For BS type 1-H:

$X = 10\log_{10} (N_{TXU,\ countedpercell})$

where:

$N_{TXU,\ countedpercell} = N_{TXU,\ counted} / N_{cells}$ and

$N_{TXU,\ counted} = min\ (N_{TXU,\ active},\ 8 \times N_{cells})$

We understand that the maximum possible value for $N_{TXU,\ countedpercell}$ is 8 according to the above formulae. Therefore, the maximum value for X is equal to 9 dB. The unwanted emissions will be defined as:

Unwanted emissions (dBW) = Basic limits (dBW) + 9 dB

As shown in Figure 3 from 3GPP, the standard does not define the equivalent/effective isotropic radiated power (EIRP). For the BS type 1-H, it defines the conducted power of unwanted emissions measured at the interface between the transceiver unit array and the composite antenna.

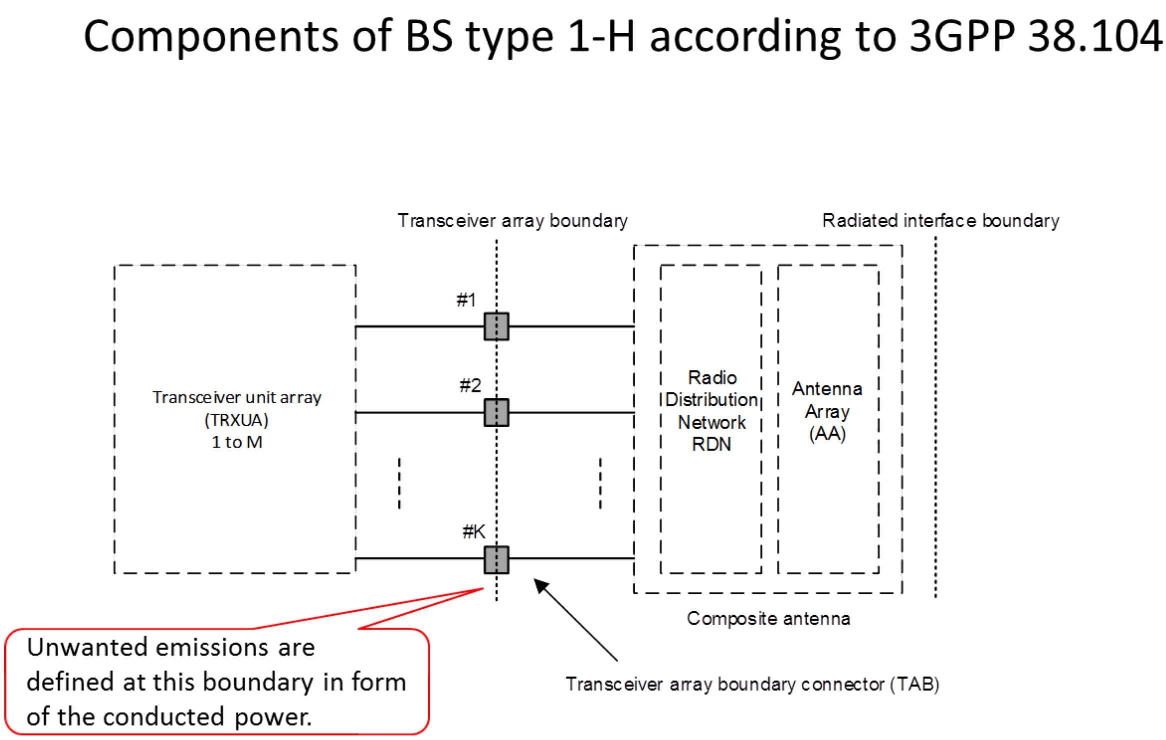

Figure 3: Components of BS type 1-H

To calculate the EIRP, the antenna gain must be added to the conducted power. Therefore, we use the formula below to calculate EIRP:

$EIRP_{dBW/MHz}$ = Unwanted emissions (dBW) + Composite antenna gain (dBi)

This methodology of calculating the EIRP is consistent with the method RSM used to calculate the Adjacent Frequency Emissions Limit (AFEL) for the management rights in the 700 MHz band.

The 3GPP does not define a maximum limit for the antenna. For this reason we have asked industry for the maximum intended antenna gain for this band. The commercial in-confidence submission we received from an international manufacturer has proposed to use the value of 28.03 dBi (Element gain dBi + 10*log (total elements)) for this purpose. Therefore, the EIRP value will be calculated from the formula below:

$EIRP_{dBW/MHz}$ = Unwanted emissions (dBW) + 28.03 dBi

Therefore, the final formula for calculating the EIRP would be:

$EIRP_{dBW/MHz}$ = *Basic limits (dBW/MHz) + 9 dB* + 28.03 dBi

Example of an unwanted emission mask:

Using the method above, we provide an example of a sample management right in the 3600 – 3610 MHz frequency range. Figure 4 and Figure 5 outline the emission masks for the upper and lower boundaries of this sample management right.

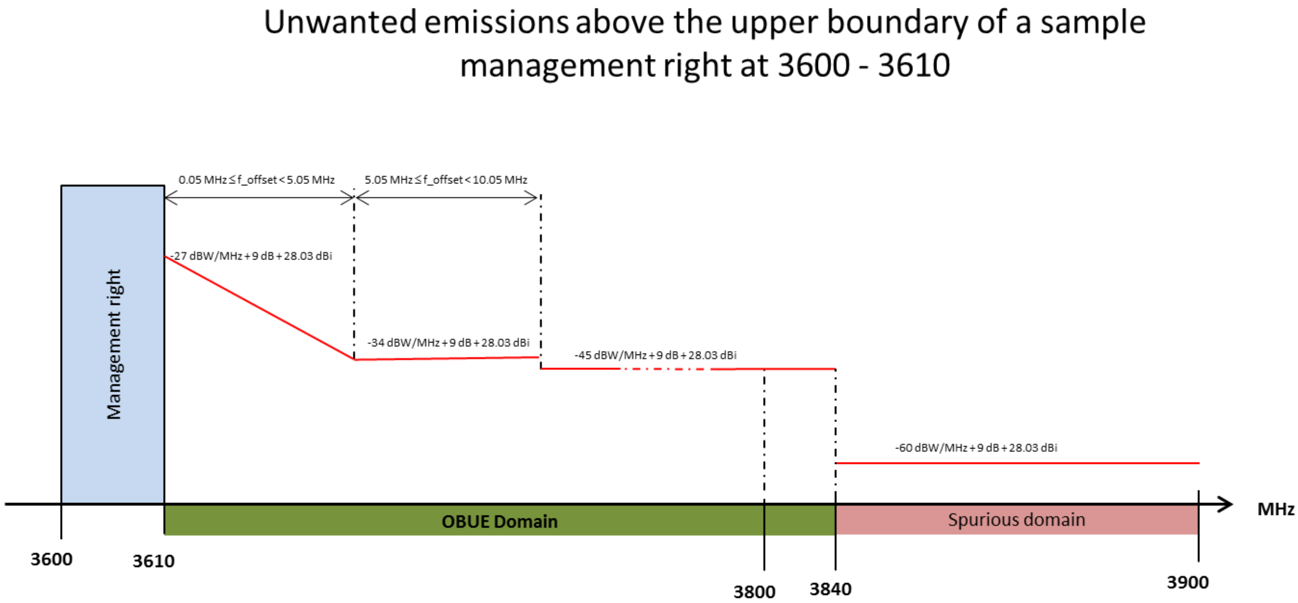

Figure 4: Unwanted emissions above the upper boundary of a sample management right

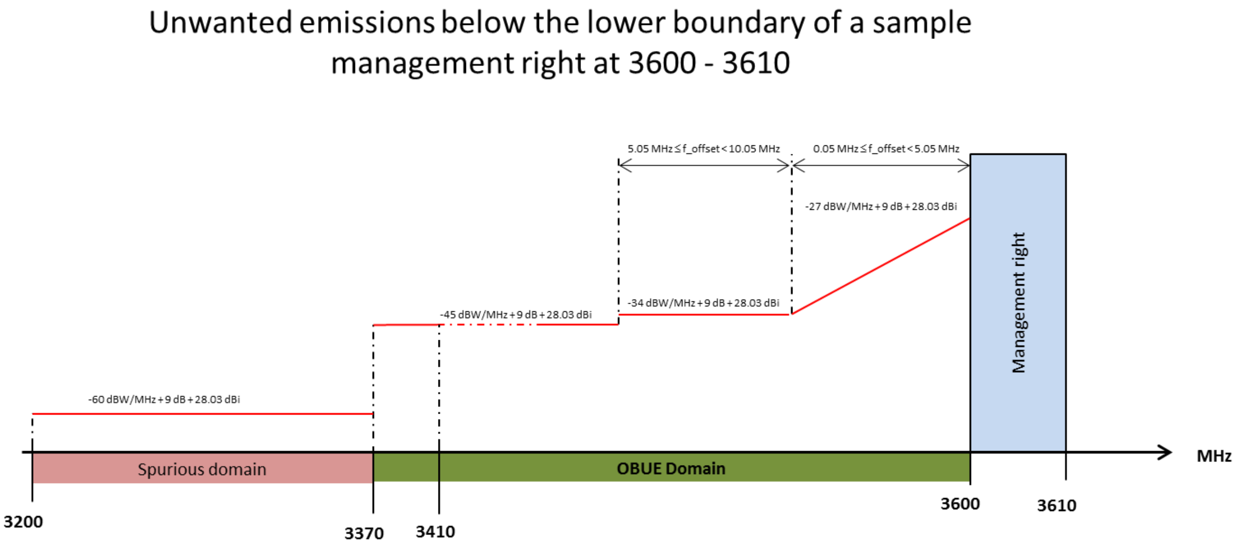

Figure 5: Unwanted emissions below the lower boundary of a sample management right

4.2. The choice between EIRP and TRP

Traditionally the power of unwanted emissions has been regulated by the maximum allowable EIRP level in adjacent bands. However, industry has proposed using the Total Radiated Power (TRP) measurement method for 5G systems.

TRP is the far field measurement of a transmitter that is measured and summed up over all possible angles without the effect of antenna gain. In comparison, EIRP is the far field measurement of a transmitted power in the direction of the maximum antenna gain. The relation between TRP and EIRP can be expressed in below equation:

$$\mathrm{TRP} = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} EIRP(\theta, \phi)\sin\theta \, d\theta d\phi$$

where theta and phi are standard variables in spherical coordinates.

There are two arguments recommending TRP for 5G systems. Firstly, TRP is more suitable for the 5G systems that will use active antenna system (AAS). These antennas, instead of having a single wide beam, could have multiple antenna elements in generating narrower beams which can be steered toward a specific location. Consequently, instead of distributing maximum power over a single wide beam, the power is divided into multiple narrow beams which also change direction in time. Therefore, the maximum emitted power would not be concentrated toward a fixed location or constant.

Secondly, the majority of 5G equipment to be deployed in the band will have an integrated radio unit similar to the BS type 1-O in the 3GPP 38.104 section 4.3.3. As can be seen from Figure 6 there is no accessible measuring port to measure the output power. Therefore, the power should be measured in the radiated interface boundary. For this reason, the 3GPP 38.104 defines the unwanted emission of this BS type is specified as TRP in section 9.7.

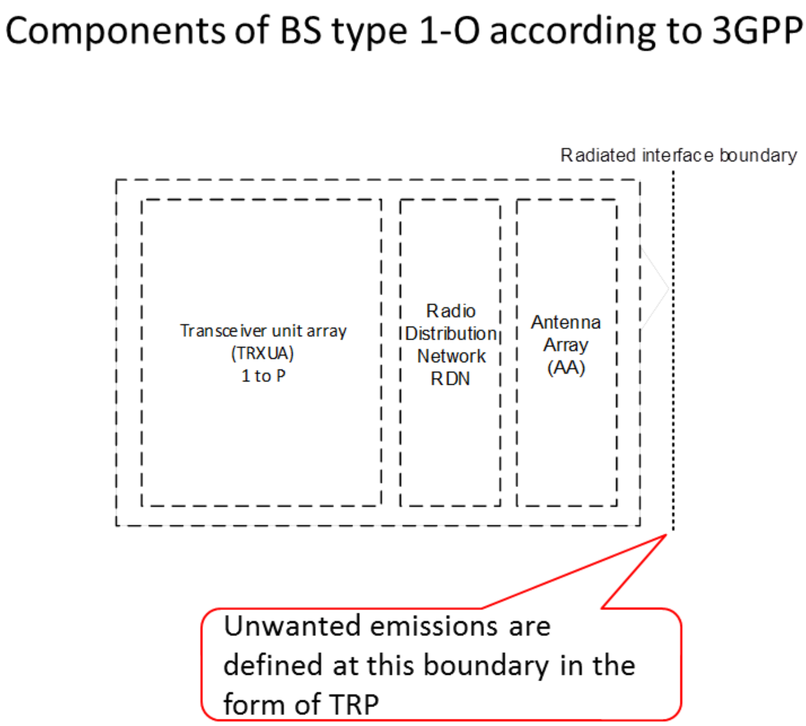

Figure 6: Components of BS type 1-O

While we understand the reasons for recommending the TRP, there are two reasons for proposing EIRP. Firstly, measuring the compliance of specific TRP would require placing the transmitter inside a measurement chamber. There is currently no practical way to inspect the compliance of installed transmitters. In contrast, inspecting EIRP compliance is possible with a signal strength measurement in the field.

Secondly, we are concerned about the worst-case interference into adjacent bands. The changes in direction of the beams mean that the amount of interference could vary over time. It does not mean that there is no possibility of interference. Therefore, it is important to regulate the maximum possible emitted power in any direction.

We understand that the 3GPP specifies the same emission mask for TRP for BS type 1-O and conducted powers of 1-H. Therefore we do not expect that enforcing EIRP restricts the deployment of BS type 1-O. 3GPP specifies the unwanted emission for BS type 1-O as basic limit + X, where X = 9 dB. These basic limits are the same basic limits defined for BS type 1-H. The value of X is also equal to the value we assumed in section 4.1.

Question 7:	*Do you agree with the calculation methodology for the unwanted emission mask, particularly the choice of the nominal antenna gain?*
Question 8:	*Do you agree with the choice of EIRP over the TRP?*
Question 9:	*Do you have any other comments regarding the out-of-band emission mask?*

5. Compatibility with the adjacent frequency bands[1]

The 3.5 GHz band is adjacent to Amateur Radio and Short Range Devices (SRD) through General User Radio Licences (GURLs), in the frequencies below 3410 MHz, and to the C-band satellite downlink (space-to-Earth direction) in the frequencies above 3800 MHz.

To ensure compatibility with users in the adjacent bands, we may need to consider some additional actions to manage interference risks.

5.1. Lower adjacent below 3410 MHz

Amateur radio operators are currently permitted to use the frequency range 3300-3410 MHz under the General User Radio Licence for Amateur Radio Operators (Amateur GURL). The maximum power of 30 dBW is allowed as prescribed in this GURL. The use of this frequency range by amateur radio operators is also subject to a special condition that amateur operators must accept interference from, and must not cause interference to, other services.

The possible amateur uses range from simple voice communication to beacon transmission for amateur research and experimentation – known as 'moon bounce' (the practice of broadcasting signals to the moon and testing its return echo).

We believe that the limited use of the frequency range 3300-3410 MHz in New Zealand makes it unlikely that amateur operators will cause interference to 5G (or compatible technology) in the 3.5 GHz band. Given that amateur radio operators must tolerate interference in the frequency range 3300-3410 MHz from other services, we are of the view that amateur radio operators should also tolerate interference in the adjacent frequency range above 3410 MHz. We have not analysed interference from 5G (or compatible technology) to amateur radio.

We will continue to monitor the use of the frequency range 3300-3410 MHz for amateur purposes. Should evidence emerge of a higher risk of interference, we could review the conditions in the Amateur GURL applicable to the frequency range in 3370-3410 MHz.

Radiolocation services also use the frequency range of 2900- 3400 MHz under the General User Radio Licence for Short Range Devices (SRD GURL). The maximum power is -10 dBW EIRP. Our initial understanding is that this is a legacy entry. We expect SRDs conforming to this entry would be ultra-wide band applications that would also comply with Ultra-Wide Band Devices GURL at very low power.

Given the low power application of this provision, we do not expect the SRDs to cause any harmful interference to 5G (or compatible technology) in the 3.5 GHz band. Additionally, the 10 MHz separation between the frequency boundary of 3400 MHz and the start of 3.5 GHz band at 3410 MHz would provide additional margin to ensure technical compatibility.

5.2. Upper adjacent above 3800 MHz

The C-band satellite downlink (space-to-Earth direction) is located in the frequency range 3800-4200 MHz. Our estimates indicate that satellite earth stations receiving downlink signals in this range may require additional protection from the 3.5 GHz band due to unwanted emissions from 5G (or compatible technology) when deployed in close proximity.

In light of this, we will only consider granting new receive-protection licences for satellite downlink in the frequency range 3800-3840 MHz on a case-by-case basis. Incumbent receive-protection licences that include 3800-3840 MHz, or parts thereof, will be protected through an

[1] The content of this section was not part of the 3.5 GHz TWG agenda.

encumbrance arrangement under a condition associated to the respective management right in the upper end of the 3.5 GHz band.

This arrangement would not affect satellite downlink in frequencies above 3840 MHz.

Question 10:	*Do you agree with the technical compatibility analysis between the amateur operation in 3300-3410 MHz and 5G (or compatible technology) in the 3.5 GHz band?*
Question 11:	*Do you agree with the technical compatibility analysis between SRD operation in 2900-3400 MHz and 5G (or compatible technology) in the 3.5 GHz band?*
Question 12:	*Do you agree with the arrangement for satellite services in the frequency range 3800-3840 MHz?*

6. Summary

This paper outlines the overall principles for the technical arrangements for operators in the 3.5 GHz band. It proposes that the operators of the band synchronise their transmission to a 5G-specific frame structure. It also proposes using the 3GPP specification for calculating out-of-band emissions. Operators can choose not to follow these technical principals as long as no harmful interference is caused to their adjacent operators.

We propose that these technical principles apply to the band regardless of the band plan allocation mechanism. At the moment the details of the band plan are not finalised. We understand that these principles could be applied to different types of deployment scenarios. Therefore, we do not believe that the finalised band plan significantly changes the overall technical principles.

Question 13:	*Do you agree that operators should be permitted to choose to not follow these technical principles as long as no harmful interference is caused to their adjacent operators?*
Question 14:	*Do you agree that the same technical principles should be imposed throughout the 3.5 GHz band?*