Vodafone New Zealand

Technical arrangement of the 3.5 GHz band

Response to Radio Spectrum Management
proposal for 3.5 GHz technical arrangement

August 2018

1. Introduction

1. Vodafone welcomes RSM's effort in leading the discussion on technical arrangement for the 3.5 GHz band. It is critical that the technical requirements for the 3.5 GHz band are optimised for both current networks and future 5G networks to maximise the transformative benefits that 5G technology will bring to New Zealand customers.

2. There have been extensive discussions in the industry on the optimal band plan and technical requirements for this band. During this time, a number of overseas operators have launched commercial 5G networks, so more knowledge and real world experience has been gathered in the design, build and operation of these networks.

3. Vodafone has been working closely with Vodafone Group and other Vodafone companies, as well as our network vendor, Nokia, to carry out extensive testing and technical trials using 5G equipment and spectrum. We have gained invaluable first-hand knowledge of 5G technologies through this process.

4. We are currently upgrading our network to launch 5G service in Auckland, Wellington, Christchurch and Queenstown later this year.

5. In this brief submission, we outline our views on the proposed technical arrangements for the 3.5 GHz band, and answer the questions contained in the consultation document.

2. Rules of co-existence and process for change

6. While not stated in the consultation document, we understand that part of the 3.5 GHz band to be allocated may be reserved by the Crown, to be licensed for use on a regional basis.

7. Vodafone agrees that it is important for the government to support regional operators (WISPs) by providing radio spectrum for their operations. However as we have previously stated, we believe that providing access to the 3.5 GHz band beyond 2022 for regional WISPs who do not intend to deploy 5G technology would undermine efficient 5G deployment in this band. We strongly suggest that another band should be offered for non-5G regional usage.

8. A number of other frequency bands, including the 3.3-3.4 GHz, 3.8-4.2 GHz and 2.37-2.4 GHz bands, are more suitable for non-5G use. Allocating these bands for non-5G use would avoid potential interference between 5G operators and non-5G operators. It also provides more spectrum in the 3.5 GHz band for 5G use, which in turn will maximise the benefits that 5G technology provide.

9. In the consultation document, with an assumption that non-5G or unsynchronised technologies are allowed to operate in the 3.5 GHz band, RSM have proposed a process to avoid harmful interference. This includes a process for synchronised users to notify unsynchronised users

before a new synchronised transmitter is to be built. The process would require an 18 month notification period to the unsynchronised licensee. Vodafone believes that this process will be unworkable for the following reasons:

a. it is impossible to assess potential interference without knowing the exact location of users of the unsynchronised network;

b. even with all the required information and best available propagation models and tools, it may still be difficult to accurately assess the impact of possible interference before a transmitter is built;

c. the exact location of the new transmitter may be changed through the build process for a number of reasons, which will affect the interference assessment. If a new 18-month notification needs to be issued when the location changes, it will significantly delay the build process;

d. the process does not cover a scenario where interference was only discovered after the synchronised transmitter is built based on inaccurate interference assessment; and

e. the unsynchronised operator may have to stop operation and mothball their investment if they are unable to resolve the specific interference issue. This would adversely impact their business plan and reduce confidence to invest further in their networks.

10. Taking these issues into account, allowing unsynchronised technology to operate in the 3.5 GHz band alongside the synchronised 5G operators is not an optimal arrangement, which will cause significant issue to the whole industry in long term. The smaller regional operators may also be more affected due to their size and available resources.

11. It is essential that synchronisation parameters are initially set to allow optimal operation of all parties, and that a robust process is set up to allow for future changes of such parameters and network configurations to ensure evolution of the technology.

Question 1: Do you agree with the proposed rules of co-existence and the process of change?

12. As discussed, Vodafone recommends that a separate frequency band is allocated for regional operators who do not intend to operate 5G networks. This would leave the 3.5 GHz to be efficiently used for 5G technology and allows for future evolution.

13. A process to manage any change of synchronisation parameters in the future will need to be set up and binding on all users in this frequency band.

Question 2: Do you have any additional comments about the process?

14. As discussed above.

3. Proposed arrangement for synchronisation

15. Vodafone has previously proposed a set of synchronisation parameters which is the same as that set out in the consultation document. However, it has emerged as 5G technology has evolved, and based on overseas experience, that the original parameters may not be optimal for 5G networks in New Zealand.

16. Therefore we propose that a new set of parameters to be adopted. The new parameter is in line with suggestions from our network vendor Nokia, and based on best practice from a number of overseas operators.

17. The key limitation of the frame structure originally proposed is the restricted cell range, which make 5G in 3.5 GHz band unsuitable for rural deployment. To rectify this issue, Vodafone proposes that the frame structure "DDDSUDDSUU" be adopted as the initial technical requirement for the 3.5 GHz band. This structure supports long PRACH formats and consequently a larger cell range to allow for economical deployment of 5G NR in the 3.5 GHz band in rural environments. We set out a detailed explanationof our revised proposal below.

Limitation of cell range due to PRACH configuration

18. There are 13 physical random access channel (PRACH) formats supported as defined 3GPP specifications. Each format requires a specific transmission time duration and allows a different theoretical maximum cell range.

19. PRACH configurations are classified into one of the 2 categories:

- 4 are classified as long PRACH format, each requiring a minimum of 1ms contiguous UL transmission period; and
- 9 are classified as short PRACH format, mostly requiring less than 0.5ms of contiguous UL transmission period.

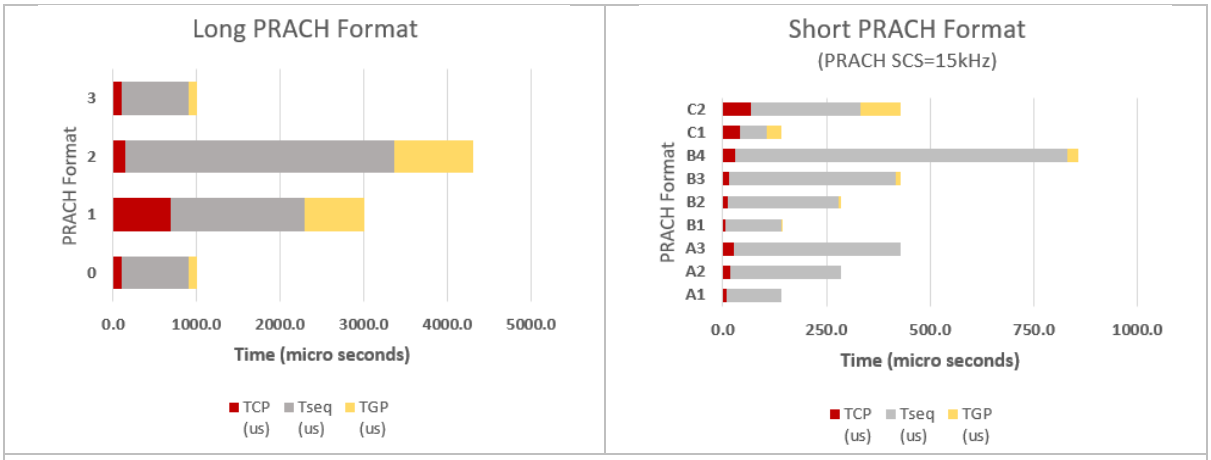

Figure 1. Random-Access Channel (RACH) format.

T_{CP} denotes the time duration of cyclic prefix; T_{seq} denotes the time duration of preamble sequence; and T_{GP} denotes the time duration of guard period.

20. Similar to LTE, 5G NR requires careful root-sequence (RS) planning so that overlapping cells will not have the same preamble configuration. There are a limited number of RS available, therefore RS re-use is inevitable, with a pre-requisite that cells with the same RS must have adequate signal isolation to avoid events of PRACH conflict.

21. Table 1 shows several examples of achievable cell range with different PRACH formats. Theoretical maximum range considers no RS re-use and supports up to several kilometres. In practice RS re-use must be considered because a typical cell will have multiple adjacent cells, which can significantly reduce the achievable cell range.

22. For example, short PRACH formats such as A2 and C2, may only support up to about 1.12 km with RS re-use factor of 13, which is still a challenging RS planning especially in urban scenarios. On the other hand, long PRACH format such as format 0, may support cell range close to theoretical limits with a comfortable RS re-use factor of 83, which means easy RS planning.

Format	UL Duration	Theoretical maximum cell range	Practical cell range
A2 (Short)	0.285 ms (SCS=15kHz)	2.65 km	1.12 km (RS reuse = 13)
C2 (Short)	0.428 ms (SCS=15kHz)	9.64 km	1.12 km (RS reuse = 13)
0 (Long)	1 ms (SCS=1.25kHz)	15.38km	15.38 km (RS reuse = 83)

Table 1. Examples of theoretical maximum and practically achievable cell range with different PRACH format and configurations with typical channel delay spread assumptions.

23. The frame structure “DDDSUDDDSU” proposed by RSM with 30 kHz sub-carrier spacing (SCS) is limited to a maximum of 0.5ms contiguous UL transmission period (Figure 2). Therefore, it is not possible to support any long PRACH format, restricting the practical achievable cell range to approximately 1 km only. This places a significant limitation on the possible deployment scenarios of NR in the 3.5 GHz band.

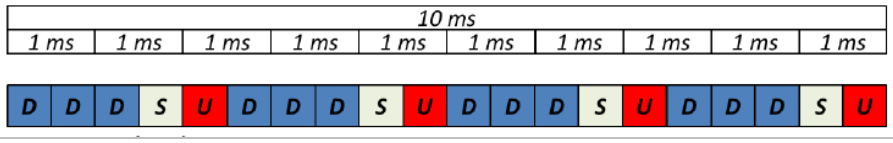

Figure 2. Proposed frame structure of Band n78 by MBIE

Deployment Scenario of NR in 3.5 GHz in NZ Environment

24. Rural communities are vital to the New Zealand economy. 4G LTE in the 1800MHz band has been a key capacity layer for the Rural Broadband Initiative Phase 1 (RBI-1), and has continued to play a significant role in the RBI phase 2 programme.

25. Network studies and trials have shown that NR in 3.5 GHz with massive MIMO and antenna beamforming technology are able to achieve coverage within 4 to 6 dB from LTE 1800MHz (referred to Figure 3). Therefore, it is expected that NR in 3.5 GHz will become an important layer for rural 5G deployment in New Zealand. A frame structure that supports long PRACH format is essential in order to make rural deployment scenario possible.

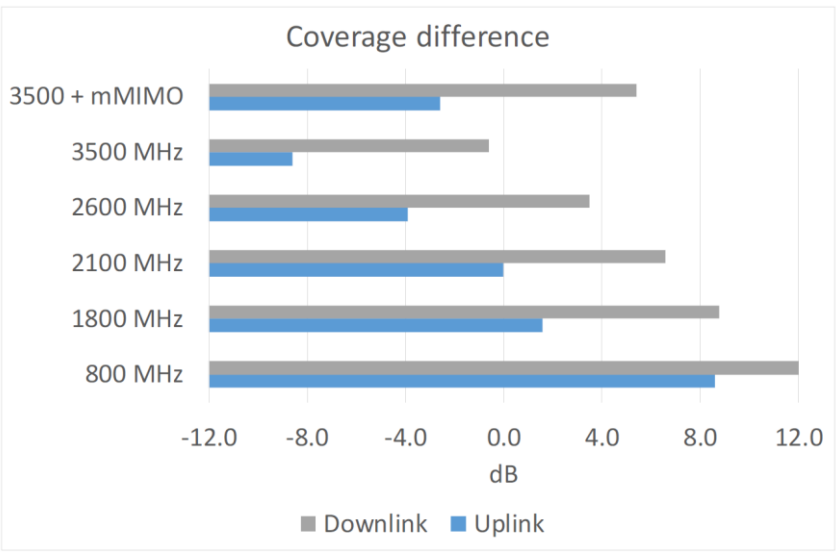

Figure 3. Coverage range comparison of various frequency bands (source: Nokia)

Recommended NR Frame Structure for 3.5 GHz band – DDDSUDDSUU

26. Vodafone recommends that the frame structure be changed to DDDSUDDSUU, while keeping the SCS the same as 30 kHz. This allows two consecutive UL transmission slots and supports contiguous UL transmission period of 1 ms, enabling long PRACH format to be implemented. This opens up the opportunity of NR n78 in rural deployment scenarios. It makes the network implementation much more flexible, and as a result, better spectrum utilisation can be achieved throughout New Zealand.

Question 3: Do you agree with the proposed frame structure?

27. As discussed above

Question 4: Do you agree with the proposed arrangement for the special slot?

28. As discussed above

Question 5: Do you agree with the process for defining the start of the TDD frame for the first time?

29. Vodafone agrees with the proposed 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?

30. Vodafone agrees with the proposed solution.

4. Proposed unwanted emission mask

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.

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?

31. Vodafone agrees with the analysis.

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?

32. Vodafone agrees with the analysis.

Question 12: Do you agree with the arrangement for satellite services in the frequency range 3800-3840 MHz?

6. Summary

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?

33. All operators must be required to follow these technical principles, even if no harmful interference is observed. Due to the nature of RF interference, while there may not be any harmful interference observed initially, a risk remains that interference is discovered later, or emerges as other operators expend their operations. In such situations, it will become very difficult to remove such interference and creates an unacceptable risk to other operators who have invested significantly in their network and leading edge technologies.

34. We propose that all users of the 3.5 GHz band are required to adhere to the agreed technical parameters, including synchronisation using suitable frame structures and network configuration.

Question 14: Do you agree that the same technical principles should be imposed throughout the 3.5 GHz band?

35. Vodafone agree that the same technical principles should be imposed throughout the whole 3.5 GHz band (3410-3800 MHz) to be allocated.