Nokia response to Discussion document

“Preparing for 5G in New Zealand”, March 2018

Nokia welcomes the opportunity to share its views with respect to this very important discussion document on 5G spectrum.

Nokia agrees with the generic guidance and recommendations from GSA on 5G spectrum:

- *" Nationwide exclusive licenses should be awarded in the low-band below the frequency 1 GHz to allow for 5G services building on the current infrastructure design providing extended range and outdoor to indoor coverage*
- *Nationwide exclusive licenses should be awarded in the mid-band around 3.5 GHz to allow for 5G services building on the current infrastructure design for urban and suburban coverage providing spectrum blocks of the order of 100 MHz per Mobile Network Operator (MNO).*
- *Nationwide exclusive licenses should be awarded in the high band around 26 GHz to allow for 5G services building on the current infrastructure design, where possible, for urban and suburban outdoor and indoors. This would also allow for crucial high capacity deployments.*
    - *Where the lower part of the band (24.25 – 26.5 GHz) is heavily used, licenses should be issued to MNOs at least in the upper 1 GHz (26.5 – 27.5 GHz) as early as 2018.*
    - *Regulators should consider approaches that allow leasing. In addition, use-it-or-lease-it could be considered by regulators. These regulatory tools coupled with network slicing and other similar solutions can enable efficient spectrum utilization for both MNOs and industry verticals.*
- *National governments and regulators should license 26 GHz as early as in 2018 to provide sufficient time for trials, for commercial arrangements to be put in place and getting the technology working in a real-world environment*
    - *Countries in Europe should do their utmost to make the whole 26 GHz band available for 5G use before ITU WRC-19*
    - *In countries where the band has little use, the whole band (24.25-27.5 GHz) should be made available.*
    - *In countries where the lower part of the band 24.25 – 27.5 GHz is heavily used, the upper part 26.5 – 27.5 GHz as a minimum should be licensed in a first phase in 2018, as GSA understands that this part of the band 26 GHz is relatively underused and therefore easier to make available for 5G.*
        - *This also benefits from other anticipated commercial 5G deployments in this spectrum in the US, Japan and Korea as part of the 28 GHz range and therefore benefits from global economies of scale - this upper part is critical in the launch of the new 5G technology.*
        - *3GPP has specified bands n257 (26.5-29.5 GHz) and n258 (24.25-27.5 GHz) in Release 15. Band n257 equipment will in the market in 2019.*
    - *The remaining lower part of the spectrum, 24.25 – 26.5 GHz, which is more heavily used by other radio services, such as fixed links and Wireless Local Loop (WLL) in many countries, should be released in a second phase and regulators should give clear guidance as soon as possible to when this spectrum would become available. In particular, regulators should commence planning for national or regional*

clearance measures/refarming in early 2018 providing the essential regulatory conditions for 5G use.

- *If 2-phase approach is used, the recommended bandwidth to enable initial 5G services should be at least 400-500 MHz per network, or even more, in order to facilitate the true 5G wow-experience with extensively faster bit-rates than in 4G. Also, when possible, every MNO could be given locally in agreed locations the full 1GHz so that every MNO is able to do a pre-commercial show-case with super-fast 5G bitrates. The option for sharing of spectrum between MNOs or infrastructure could be another option to consider. The final division of the 26 GHz spectrum should allow 800-1000 MHz of contiguous spectrum per MNO. "*

In the response below, Nokia's answers are given under each question from the New Zealand discussion document.

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

5G is far more than just a new radio interface with faster throughput. Understanding what 5G can do begins with an analysis of the potential ways that 5G can deliver new services. To explore the possible business cases, Nokia has conducted in-depth modelling to give Communications Service Providers (CSPs) and verticals players realistic insights into the technical and commercial factors that affect a business case's profitability and investment return. Focusing on specific business cases will enable CSPs and vertical players to invest wisely at a controlled pace, certain that they are building a reliable technology base and developing the right business processes for success in the 5G future. As well as exploring the CSP business cases, many of which will be entirely new, the Nokia research has also investigated the value of new services for end users, different industries and the entire ecosystem.

One of the earliest business cases that could be deployed will be fixed wireless access to bring ultrabroadband to buildings hard to reach with fiber.

In other business cases aimed at consumers, 5G can deliver exciting infotainment services to passengers on public transport and enable spectators at large sporting and entertainment events to experience the action in new ways.

In the enterprise segment, 5G has the potential to reduce road transport costs and relieve traffic congestion through truck platooning, and replace inflexible fixed communications infrastructure while meeting the stringent performance requirements of the automated factory and also providing new flexibility for more dynamic manufacturing systems.

Meanwhile, 5G can bring new capabilities that will help to alleviate the pressure on hard-pressed healthcare systems.

These are just a few of the early business cases that Nokia is exploring for 5G. Nokia recognizes that 5G is not just about the technology, nor is it only about simply providing exciting new services. CSP success will depend on making investments in phases that will each bring a positive financial return and will create completely new business opportunities. With in-depth insight into network and 5G technology, backed by financial and technology expertise, Nokia is helping CSPs and vertical players to connect the possibilities of 5G to reality.

The underlying technologies of 5G communications are being developed rapidly. Although standardization of 5G is yet to be finalized, there is general agreement across the communications industry about the key enabling technologies, the architecture and deployment scenarios of 5G networks. This has enabled infrastructure manufacturers and CSPs to run increasingly advanced trials to show that the different technological components of 5G will perform as expected to be able to deliver exciting new services. Recent examples include Nokia

and AT&T successfully testing the capability of fixed wireless access using the 39 GHz band to deliver an Internet streaming service. Similarly, Nokia joined forces with Sprint to demonstrate the benefits of massive multiple input multiple output (MIMO), a key element of 5G, to boost cell capacity many-fold.

There is little doubt that the extremely high performance of 5G has the potential help transform the ways businesses operate and how people live and work. It is also clear that early adopter CSPs that begin to plan today for the 5G future and make decisions about how they will deploy and use the technology will gain an important lead in what are likely to be intensely competitive and rapidly moving markets. Planning begins with the business cases that a CSP targets as part of its business strategy. However, at this early stage, no commercial 5G deployments are yet in action. Many CSPs lack the business information they need to recognize the trends, identify the opportunities and understand what 5G can do for their brand. It must be very clear how additional revenues can be secured with 5G, what investments will be required and at what point a business case will break even. Investments in 5G will be needed and CSPs cannot afford to gamble. To help address the shortfall in the business justification of 5G, Nokia is conducting in-depth research into a variety of areas in which 5G is most likely to bring the first benefits for CSPs and their customers. These fall broadly into three categories:

- 5G immersive and interactive experience: How 5G will create life-changing experiences for consumers in their homes and on public and private transportation systems.
- 5G live experience: How 5G will provide new experiences for people attending large events and meet very high demand at traffic hot spots.
- 5G industry experience: How 5G can become the communications standard of the fourth industrial revolution.

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

As stated in the introduction, Nokia supports the competitive awarding of nationwide exclusive licenses to allow for 5G services to be built on the current infrastructure design providing extended range and outdoor to indoor coverage.

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

Nokia is of view that exclusive licensed spectrum will continue to play a major role in assuring the investments in the networks and the quality of the services provided, but the evolution of use of technologies in various spectrum bands will be reflected in the consequent evolution of the licensing regime.

Network configurations are evolving constantly to better meet users' needs in terms of indoor and outdoor coverage and to improve quality of service: new radio base stations are installed on a regular basis to increase the networks' capacity and their size deems to better match the ultra-

dense architectures. As such a high number of smaller cells is estimated to make part of the new 5G networks and regulatory and administrative frameworks should evolve to take into consideration rules that adapt to the processing of volumes of requests by the administrations. Nonetheless, apart from the need to streamline the administrative processes, as the French regulatory authority ARCEP identified in its 5G report1, two major aspects should be equally considered: the simplification of the declaratory regime based on the equipment's power and the taxation of the small cells. Altogether, lighter administrative processes and low taxes of volumes of small cells can improve the operators' business cases and incentivize the fast deployment of ultra-dense 5G infrastructures for the benefit of citizens that will have access to state-of-art networks and applications using them.

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

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

Yes, as widely acknowledged, the band 3400-3800 MHz is the primary frequency band below 6 GHz for 5G. It provides an optimal trade-off between favorable radio propagation conditions and sufficient bandwidth availability for the cost-efficient deployment. The 5G New Radio (NR) ecosystem supporting the 3400-3800MHz band is expected to be ready in 2018 with broader commercialization commencing from 2019.

The availability of sufficient bandwidth in 3400-3800 MHz is extremely important in this context. The ITU agreed vision and expected features of 5G can only be truly realized through the availability of channel bandwidths of around 100 MHz or more. The availability of sufficient bandwidth is especially critical when considering that 5G networks will not only support Enhanced Mobile Broadband (eMBB) but that they will also support a wide range of vertical industry use cases.

With its global perspective, Nokia emphasizes that the band 3400-3800 MHz is the European 5G Pioneer band and in China, there are plans to launch 5G services in the range 3300-3600 MHz. Furthermore, 3GPP has specified a new TDD band at 3300-3800 MHz to serve the early 5G NR markets.

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

As responded to in Q5, we fully support the band 3400-3800MHz for 5G, including 3587 to 3690 MHz. Consideration should also be given to allocating 3690 to 3800 MHz for 5G in New Zealand.

[1] https://www.arcep.fr/uploads/tx_gspublication/Report-5G-issues-challenges-march2017.pdf (pages 30/31)

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

Yes, the 26 GHz band is a priority band for 5G above 24 GHz and Nokia supports making this band available for 5G together with the 3400-3800 MHz band. The 26 GHz band offers a tremendous opportunity for the deployment of 5G services in the 2019/early 2020 timeframe. The 5G NR mmWave ecosystem supporting 26 GHz will be ready in 2018 with commercialization commencing from 2019. However, there are issues that remain to be resolved regarding protection of EESS(passive) below this 26 GHz band while not introducing unnecessarily stringent unwanted emission requirements for 5G. Unduly restrictive emission requirements for 5G could have severe adverse impacts for 5G users with reduced 5G performance and throughput.

This band will be specifically suited to enable multi-gigabit data rates to be delivered within 5G hot spots, with dense spatial re-use and flexible configuration of spectrum, enabling both access and backhaul services to be provided when and where needed. Large-scale investments by MNOs in 26 GHz is essential for its success and regulators should ensure that MNOs are designated, through the appropriate selection procedures, as the primary users of the 26 GHz band.

With its global perspective, Nokia emphasizes the availability of 26 GHz for 5G in New Zealand would benefit from the global eco-system of equipment. In Europe, 5G spectrum consultations are ongoing (or planned) in a number of countries including UK, Italy, Spain, Portugal, France, Germany and Finland; and 26 GHz band is expected to be made available for 5G in the near future.

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

Nokia supplies equipment for 5G trials already in various countries and expects to start trials also with MNOs in New Zealand

In general, 5G trials in 26 GHz bands are proliferating around the world and a number of announcements have been made by chipset, terminal and infrastructure manufacturers on product availability in the 2018 - 2019 timeframe.

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

Nokia sees the band 31.8-33.4 GHz as a low priority 5G band. The bands 40.5-42.5 GHz and 42.5-43.5 GHz are high priority 5G bands for Nokia.

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

Not in short-term, maybe well beyond WRC-19.

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

Yes, Nokia sees the 28 GHz band (27.5-29.5 GHz) as a very important band for 5G, especially concerning early deployments of 5G. Several countries, e.g. USA, Canada, Japan, Korea, Mexico, Singapore, and the USA are looking towards opening this 28 GHz "5G Frontier band" for 5G.

The important achievements in 3GPP with the recent approval of Release 15 non-Standalone New Radio specifications will facilitate 5G device implementations in the 28 GHz frequency band globally. It will also encourage harmonization of the technical and regulatory specifications for the 28 GHz frequency band to facilitate economies of scale and globally harmonized implementations.

The 5G mobile industry is developing chipsets, devices, and infrastructure equipment based on the approved Release 15 specifications from 3GPP to enable the first deployments of commercial 5G systems in the 28 GHz frequency band. In addition, the numerous 5G trials already ongoing in several countries are based on these industry equipment developments.

Some countries have already made the 28 GHz frequency band available for 5G in 2016, and other administrations are taking similar steps throughout this year and 2019. This 5G Frontier band initiative has a clear objective to realize the global 5G vision, which will accelerate 5G deployments around the world. For additional information see www.5g-28frontier.org.

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

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

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

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

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

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

In Nokia's opinion, spectrum should be made available in a fair and reasonable way and high up-front costs should be avoided.

It is expected that MNOs will be the ones to kick off the 5G ecosystem. With decades of experience in deploying national mobile communication infrastructures, MNOs are well placed to invest in 5G and establish a firm foundation for a 5G ecosystem.

Related to how to address new markets and industries (eg. vertical markets, with their diversified usage scenarios), see the answer to Q34 including a use-it-or-lease-it approach for 5G verticals.

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

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

In Nokia's opinion, 5G should be allowed in all IMT bands that can be refarmed.

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

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

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

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

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

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

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

5G above 3 GHz is expected to be TDD. FDD is expected to continue in line with the existing frequency arrangements below 3 GHz, and especially below 1 GHz.

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

Please see the quote from the GSA at the beginning of this document which gives recommendations on the suggested MNO spectrum blocks in each band.

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

Currently, there are issues that remain to be resolved regarding protection of EESS(passive), especially below 24 GHz, while not introducing unnecessarily stringent unwanted emission requirements for 5G, which could have severe adverse impacts for 5G users with reduced 5G performance and throughput.

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

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

As per today, the 3GPP specifications do not separate adjacent channel interference from the operating band interference, hence the answer to Q31 below applies also to Q30.

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

5G specifications allow dynamic allocation of UL and DL resources for TDD cells, but in practice the UL-DL resource configuration coordination between 5G cells on the same band will be required to avoid both severe BTS to BTS interference as well as UE to UE interference for which the interference would be worst at the cell edges.

The reason for this requirement comes mostly from 3GPP Adjacent Channel Leakage Ratio (ACLR) and Adjacent Channel Selectivity (ACS) specifications. (3GPP rel15 TS38.101-1 chapters 7.5 and 6.5, TS38.101-2 chapters 6.5 and 7.5, TS38.104 chapters 6.6 and 7.4, 3/2018)

Those specifications at their current state, as per 3/2018 version, allow 45 dB adjacent ACLR for BTS, 31 dB for UEs on 3.5 GHz and 17 dB for UEs on 26 GHz band. ACS requirements for BTS are still not very clear in the specifications and are bandwidth specific. For UEs operating on 3.5 GHz, ACS is 33 dB and for UEs on 26 GHz band it is 23 dB. Absolute ACLR limits from the above specifications can provide some but not substantial improvement to the unwanted emissions.

Due to the above, not only do all cells need to have matching UL-DL configuration, but all cells are also required to be phase synchronized. This is needed for adequate control of timing between

the cells on the same channel and between the MNOs on the same frequency band to avoid DL symbols from overlapping with UL symbols between different cells.

Additional care is required when two or more different TDD based systems (e.g. WiMAX, TD-LTE and 5G) or when two or more different UL-DL configurations within the same system are used in the same band. In these situations, generally separation distances (buffer zones) are required to avoid BTS to BTS interference and UE to UE interference at the cell edges unless the DL and UL symbols between the systems can be matched. In practice accommodating non-3GPP networks with 3GPP based systems in the same band is very challenging.

These requirements may change in future, but Release 15 UEs will remain a challenge from UE to UE interference point of view unless 3GPP specifications change radically before they are frozen. It is also worth mentioning that additional filters with guard bands can be built for the BTS specifically for use in New Zealand, but this will not remove the UE to UE or UE to BTS interference scenarios as well as UE selectivity in the BTS to UE interference scenario.

In practice the above reasons will be limiting the selection of UL-DL configurations for the whole band, not only between adjacent channels and operators will most likely be required to agree the configurations in use.

It is also worth mentioning that FDD and TDD operation on the same band cannot be mixed as FDD can be considered as combination of 100% UL TDD and 100% DL TDD channels.

3GPP Release 15 is still not frozen and Release 16 specifications are expected to bring further developments in this area.

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

Please see the response to Q34

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

Please see the response to Q34

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

Related to Q32, Q33 and Q34, Nokia would like first and foremost say that MNOs with several decades of experience in deploying national mobile communication infrastructures are well placed to invest in 5G and establish a firm foundation for an ecosystem of next generation radio communications in New Zealand. The importance of the MNOs' investments in kick-starting the deployment of 5G mobile networks cannot be overstated.

One of the biggest motivations for MNOs to consider investment in 5G lies in the fact that 5G is not only about delivering faster mobile broadband connectivity but it has a lot to do with the

possibility to address new vertical markets and industries with their diversified usage scenarios including extreme low latency, very high reliability and a massive number of connections.

Key industry players (MNOs, vendors, and verticals) are increasingly coming together to establish a common understanding on service-guaranteed network slicing in terms of the vision, end-to end solution, key enabling technologies, and the impacts for vertical industries.

The network slicing concept developed by 3GPP is the key enabler in this respect. Network slicing allows verticals to avoid the capital and operating costs of dedicated physical infrastructures and devices, by creating a "network factory" whereby a MNO can assign – via software – different slices of its core and radio access network resources to a range of verticals and applications. Network slicing is a major innovation in 5G that allows the verticals to benefit from the huge economies of scale in equipment, with guaranteed quality of service for use cases with extreme requirements such as ultra-reliable and/or low-latency communications.

As widely acknowledged, the band 3400-3800 MHz is the primary frequency band below 6 GHz for 5G that provides an appropriate trade-off between favorable radio propagation conditions and sufficient bandwidth availability for the cost-efficient deployment of macro-cellular networks and the wide area provision of a 5G quality of service. The 5G NR ecosystem supporting the 3400-3800MHz band will be ready in 2018 with commercialization commencing from 2019. The availability of sufficient bandwidth in 3400-3800 MHz is extremely important in this context. The vision and expected features of 5G for mobile networks can only be truly realized through the availability of channel bandwidths of around 100 MHz or more. The availability of sufficient bandwidth is especially critical when considering that mobile networks will not only support eMBB but that they will also support a range of vertical industry use cases.

Increasing collaboration between MNOs, vendors, and vertical industries promise the emergence of innovative business models, including:

- The provision of wholesale 5G capacity from MNOs' mobile networks to new players (in the form of MVNOs) with special focus on delivering end-to-end services and solutions (beyond purely connectivity) to the verticals.
- The provision of indoor coverage infrastructure by so-called neutral hosts in market-led collaboration with one or more mobile network operators, using the MNOs' licensed spectrum, and galvanizing the market for enterprise solutions.
- The leasing of spectrum from the MNOs, in circumstances where the verticals might require direct access to licensed bands, for example, in order to deploy their own private (dedicated) 5G networks.

The regulators will have opportunities to regulate wholesale capacity provision and/or spectrum leasing (for example through use-it-or-lease-it licence obligations) to create win-win scenarios among various market players, ensuring the verticals' expectations are met while maintaining incentives for the 5G MNOs investments.

Nokia considers that the above models, which assume that mobile operators would hold, individually or in a partnership, national licences for the respective parts of the 3400-3800 MHz band, would result in a more optimal use of spectrum than by applying a regional approach (possibly leading to spectrum fragmentation) to licensing different parts of the band expected to be made available for 5G.

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

Please see the response to Q37

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

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

Related to the timing of the 3.5 GHz band, Nokia supports all efforts to make the band available for 5G as soon as possible, prior to year 2022. Nokia also supports and encourages the defragmentation of the 3400-3800 MHz band, with a view to its future availability for nationwide 5G networks as contiguous blocks of at least 100 MHz.

In general, the timely availability of new spectrum, in sufficient amounts of contiguous blocks, in the 3400-3800 MHz and 26 GHz bands is the key for New Zealand to benefit from the full potential of 5G. This would enable both MNOs and vertical industry players to be in a position to select the most appropriate spectrum strategy combining both 3400-3800 MHz and 26 GHz.

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

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

Related to the timing of 26 GHz band, Nokia supports all efforts to make the band available for 5G as soon as possible. In general, the timely availability of new spectrum, in sufficient amounts of contiguous blocks, in the 3400-3800 MHz and 26 GHz bands is the key to benefit from the full potential of 5G. This would enable both MNOs and vertical industry players to be in a position to select the most appropriate spectrum strategy combining both 3400-3800 MHz and 26 GHz.

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

Not in short-term, maybe well beyond WRC-19.

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

The 600 MHz band is rising in importance in countries in the Americas and in some countries in Asia-Pacific for IoT use in remote areas and for indoor penetration in urban areas. In the United States, following the Voluntary Incentive Auction of the 600 MHz band, T-Mobile and Nokia are planning to collaborate to enable the 5G network capabilities where 600MHz spectrum is the preferred coverage layer[2].

As an alternative, in situations where the lower UHF band (470 – 694 MHz) is still used for TV broadcasting, the Supplemental Downlink (SDL) can help to add substantial downlink capacity to mobile networks for flexible distribution of audio visual content, while ensuring co-existence with digital terrestrial television where required. LTE SDL has the potential to allow broadcasters to offer interactive broadcast services over tablets and smartphones without causing interference to existing digital terrestrial television services. The technology allows media publishers and network operators to optimize the usage of available UHF frequencies. Besides LTE support, the technology is also expected to be supported in the early stages of 5G. In Europe, the European Commission has proposed to introduce more flexibility over the use of the lower UHF spectrum and Nokia has demonstrated the first trial of LTE SDL in 2016[3].

The L-band can be potentially used as SDL. This approach has a lot of traction as it is already specified in 3GPP; a possible extension is being considered in Europe.

The Supplementary Downlink option allows operators to optimize investments by avoiding the costs of additional base station and backhaul infrastructure; once mobile broadband demand exceeds network capacity, networks can be easily expanded by deploying a 1.4 GHz Supplementary Downlink on existing base station sites.

Supplementary Downlink and carrier aggregation have been enabled in standards from HSPA+ Release 9 and LTE Release 10. Nokia has for some time offered Supplementary Downlink radios for the two most common bands: the North American B29, and the 3GPP B32.

The 1.4 GHz Supplementary Downlink L-band, when paired with low frequency spectrum such as the 700 MHz (B28) in APAC, offers similar propagation characteristics as sub-1 GHz spectrum, because the uplink, which is the limiting factor for coverage, is only carried on the low frequency, while the 1400 MHz frequency is only used for the downlink. The Supplementary Downlink radios offer additional downlink link capacity and receivers, resulting in 4RX diversity for the primary band to deliver better service quality, in particular better indoor coverage.

[2] https://www.nokia.com/en_int/news/releases/2017/05/02/nokia-to-play-key-role-in-t-mobiles-5g-nationwide-network-plans

[3] https://yle.fi/aihe/artikkeli/2016/09/02/yle-qualcomm-and-nokia-announce-worlds-first-demonstration-lte-supplemental