Rohde & Schwarz
Regional Headquarters Singapore Pte Ltd

Response to

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INFO-COMMUNICATIONS MEDIA DEVELOPMENT AUTHORITY

Second consultation on 5G Mobile services and networks

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ROHDE&SCHWARZ

FOR THE ATTENTION OF:

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1 About Rohde & Schwarz

For more than 80 years, Rohde & Schwarz has stood for quality, precision and innovation in all fields of wireless communications. The electronics group is strategically based on five pillars: test and measurement, broadcast and media, cybersecurity, secure communications, radio-monitoring and radiolocation. The company addresses customers in the mobile radio, wireless, broadcasting, electronics and automotive industries, in aerospace and defense as well as government, security and critical infrastructures. Rohde & Schwarz is among the world market leaders in its established business fields. It is the world's leading manufacturer of wireless communications and EMC test and measurement equipment, as well as of broadcasting and T&M equipment for digital terrestrial television. The Executive Board is made up of Christian Leicher (President and CEO) and Peter Riedel (President and COO).

As an independent, family-owned company, Rohde & Schwarz generates its growth from its own resources. Since the company does not have to think in quarters, it can plan for the long term. In fiscal year 2017/2018 (July to June), Rohde & Schwarz generated EUR 2.04 billion in revenue. The company owes this tremendous success to its 11,500 highly qualified employees in over 70 countries.

Company with a global presence

To be always close to the customer, Rohde & Schwarz has an extensive service and sales network in over 70 countries. Exports account for approximately 90 percent of revenues. The company is headquartered in Munich (Germany) and also has strong regional hubs in Asia and the USA.

Rohde & Schwarz is a high-tech company that thrives on innovation. To maintain its high quality standards, Rohde & Schwarz keeps nearly its entire value-added chain within the company. Central R&D is located at its Munich headquarters. The company also maintains development centers outside Germany. The centers in the United States, Korea, China, Denmark, France and Great Britain implement applications that are tailored to the requirements of local customers. Engineers at the Singapore site develop products for the world market. Asia and North America are especially important growth markets for the group. The focus is therefore on rapidly establishing and expanding the company's locations in Singapore and the USA.

2 Introduction

2.1 Test & Measuring equipment for wireless communications

One out of every two mobile phones or smartphones worldwide is developed and produced using T&M equipment from Rohde & Schwarz. LTE FDD and TD-LTE networks are now operating in Europe, the USA and Asia. The group's test and measurement equipment for LTE and LTE Advanced makes a decisive contribution to the establishment of 4G technologies. Rohde & Schwarz also participates in leading 5G research initiatives around the world and is already working on 5G test solutions. The group covers almost all mobile radio and wireless technologies, from UMTS/HSPA(+), CDMA2000® to Bluetooth®, near field communications (NFC), GPS/Galileo and WLAN/Wi-Fi.

Regardless of the technology, Rohde & Schwarz offers a complete product portfolio for the development and production of chipsets, mobile terminal equipment and base stations. Mobile network operators also use these products to plan, install, optimize and maintain their networks. The company delivers tools for tasks ranging from mobile network quality measurements, network optimization and service quality monitoring to flexible solutions for IP network analysis. Together with its ipoque GmbH and SwissQual AG subsidiaries, Rohde & Schwarz is the only company that offers single-source T&M solutions for the entire lifecycle of a wireless communications network.

2.2 Experience in 5G NR laboratory and roll-out field trials worldwide

Rohde & Schwarz have participated in many 5G NR trials with industry partners worldwide. In APAC, Rohde & Schwarz is active with major telecommunication infrastructure vendors, network operators and equipment providers for both 5G NR laboratory trials and outdoor field coverage tests involving both FR1 and FR2 frequency range. Countries includes Australia, China, Japan, South Korea, Hong Kong, Taiwan, Malaysia, Thailand, Philippines and Singapore.

South Korea is one of the few countries to already rolled-out commercial 5G NR networks since April 2019. Prior to South Korea commercial network implementation, Rohde & Schwarz measurement tools and solutions were providing very useful insights to network operators and network infrastructure vendors helping to address and rectify initial network rollout problem. Rohde & Schwarz comprehensive 5G NR solutions allows the testing of both devices, infrastructure components and 5G NR spectrum.

In Singapore, Rohde & Schwarz is working closely with various operators and infrastructure vendors. Rohde & Schwarz tools and engineers are often at 5G trial sites testing the effects of our trial deployment. We are also working closely with our industry partners on data processing and analysis.

3 5G NR Network Quality of Experience

3.1 Background and Current Status

From the emergence of GSM to the global adoption of LTE, operators' focus has been on ensuring the quality of services delivered to subscribers. Various network quality measurement methodologies and test solutions were developed which allows the verification of network quality with reports and key performance indicators to diagnose network performance issues and to optimize performance. Historically, testing mobile networks has been built up from spectrum and physical layer parameters such as RSRP and SINR, to OSS and trace data and, latterly, smartphone-based solutions that measure the quality of services such as voice and video.

With the emergence of 5G, alongside a leap in network performance and capabilities is the increasing likelihood that an end user may be a machine, not a human. That means the test approaches should be expanded to encompass machine-type communication; a revised concept for quality of experience and new techniques for testing performance must be developed.

3.2 The challenges of 5G use cases, network performance, and services

It is important to note that 4G services will continue to evolve in coming years and to recognize that the implementation of 5G will be very different from all previous generations of cellular technology, particularly in the Radio Access Network (RAN). 5G use cases of eMBB, mMTC and URLLC will potentially means new dimensions in terms of real-time, higher bandwidth, scalability, etc. 5G network will therefore require a revised network quality measurement methodology and key performance indicating parameters.

Network quality measurement methodology is needed to measure new parameters more accurately at higher frequencies, for wider bandwidths and to meet the challenge of how to quantify quality of experience (QoE), particularly where the end user may not be using a smartphone or tablet. We therefore need to re-think our approach to what constitutes QoE and how to measure it. Smartphone-based test cases to measure the quality of eMBB will remain but for mMTC and URLLC, the end user will likely be a machine and the service will bring a new set of demanding measurement parameters.

For machine-type communications, the traditional concept of QoE will no longer appropriate because the end user is not a human and will not experience the service in an emotive way. A new interpretation and understanding of what constitutes quality of experience and how to map the consequences of changes in QoE for each application shall be developed.

3.3 Measuring 5G network slice performance

5G network support for possible use cases and applications such as autonomous vehicles (land, sea or air), industry 4.0 and remote robotic surgery are now more critical in nature and potentially life threatening in the event of any service degradation or complete disruption of service.

5G operators must therefore monitor networks with greater accuracy and in finer detail to pre-empt Quality of Service (QoS) requirements. The challenge for a 5G network operator moves from ensuring subscriber's basic satisfaction, compliance to authority framework, B2B service agreement to also possible legal liability for any failure to guarantee critical services which leads to an accident, injury or loss of life.

With each application potentially supported by a dedicated network slice and with its unique QoS definition, metrics and measuring thresholds. A network operator current approach to measure 4G network using on a single common measurement methodology will have to be redefine to suit 5G network using multiple, simultaneous performance and quality measurements as per use cases the 5G network is supporting.

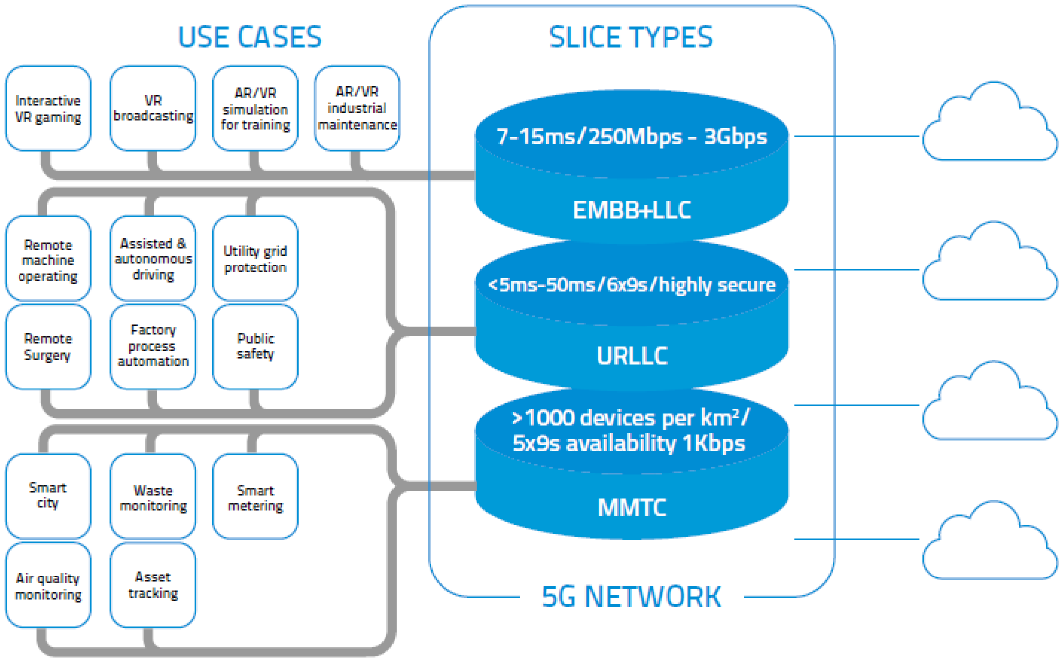

Figure 1: A much more diversified range of use cases, serviced by logical network slices, expanding performance measurement requirements for operators

Rohde & Schwarz are actively engaging and supporting International standards organizations such ITU and ETSI for their evolvements of 5G network test cases and methodologies. However, formalizing test cases and methodologies for 5G network has proven to be a complex and challenging task. In addition to hundreds of core KPIs a network operator has to fulfill, further KPIs of granular details for each use case and application are also needed.

To evaluate and benchmark 5G networks, KPIs are needed to truly reflect a network performance and a fair and transparent performance scoring method is to be defined.
ETSI has taken the lead to discuss and define best practices for network benchmarking and a scoring method that will enable 5G networks to be characterised in a single, unified metric. The method will provide 5G network operators a visibility on their network status and key factors influencing network quality.
The factors and weightings that influence the scoring method will be adapted for each 5G use case and application, but the fundamental methodology is robust and will provide the industry with an independent reference against which 5G QoS/QoE can be measured.

4 5G NR device performance

Successful 5G NR network rollout and outperformed experience not only relies on good network design and optimization, but also the performance of 5G devices. Optimal performance of 5G devices will greatly influence QoE for a 5G user. The following evaluations form a basis for evaluating a 5G device performance.

4.1 RF parametric tests

To achieve the full potential and capability for any 5G use case, other than the 5G network itself, it's also important to consider the performance of 5G devices as well for the quality of 5G devices will greatly influence the QoS and QoE performance within a 5G NR cell.

It is therefore important to test and verify a 5G device comply to a certain minimum threshold in terms of RF performance for both Rx and Tx parameters.

Key RF parameters may include;

a. Power measurement (Maximum and Minimum power)

b. Modulation measurement (EVM, Mod error, Phase error)

c. Spectrum measurement (ACLR, Occupied BW)

d. Receiver measurement (BLER, throughput)

4.2 Radio resource management tests

Mobility is another important aspect in any cellular networks. Mobility from 5G to legacy technologies, when the device is in idle mode and when the UE in connected mode are some scenarios which are challenging especially when the 5G network is deployed in mmwave frequencies. For mmwave deployment, 5G device has to perform beam mobility – a new implementation, totally different from all legacy cellular networks which are currently deploying omni direction transmission.

Failure of a 5G device to meet the desired performance during beam mobility could result in subpar user experience with frequent call drops or connection issues. A Radio resource management - RRM tests in presence of lab simulated fading and AWGN signals ensure a 5G device performance and functionality under difficult or extreme RF conditions.

4.3 Protocol tests

The signaling behavior and signaling message exchanged between the 5G network and 5G devices shall be verified for various scenarios. The verification of various signaling scenarios to record the behavior of the 5G device for varying parameter set on the 5G network will of particular interest. Given the numerous possibilities and scenarios, arising of the enormous flexibility offered by the 5G NR technology. One can expect various test scenarios to arise from the field after 5G roll out and implementation. 5G device test labs must be able to simulate and test a large variation of scenarios in a controlled, repeatable environment. Rohde & Schwarz 5G equipment and solutions allow test labs total control over parameters that can be change in a 5G network.

4.4 End to End Application test

From a device perspective, for a Non Standalone mode - NSA connection, which is most likely for 5G initial deployment, network operators might choose 5G devices to support both the LTE and 5G NR connection in parallel, this also known as dual connectivity mode.

In this mode, the control plane is handled by the LTE master node while the 5G NR is used as a secondary node to achieve higher throughput. Dual connectivity concepts also allows for “Split bearers” between LTE and 5G NR technologies – which shall give way to numerous combinations for testing as listed below;

a. Throughput and latency measurement
b. When 5G NR is preferred in the uplink
c. When LTE is preferred in the uplink
d. In 5G NR, TDD duplex is common deployment scenarios and 5G offers different number DL, UL and Flexible configuration. There are up to 62 different UL-DL configurations and it is important to verify that 5G device can support and operate well in all possible configurations.

4.5 IP Security

5G use case of mMTC expects millions or even billions of IoT devices to be connected to the internet. This essentially which means all devices are to be thoroughly tested for security vulnerabilities. A single or small amount of devices can sometimes be the weak points and their vulnerabilities may become a threat to the entire network or the business case the networks are serving. The application classification, checking for security protocols, the key lengths used in encryption, the geo location the device is trying to reach out to once a connection is established are parameters to be verified.

4.6 OTA measurement – the only way to test 5G NR FR2 (mmwave)

The wide frequency range, the greater number of antenna elements and the lack of conventional external RF connectors make 5G antenna characterization challenging. To assess the complete performance of 5G over-the-air - OTA, e.g. beam characteristics, coexistence testing and near-field and farfield measurements, fast and accurate pattern measurements are essential. With mmwave frequencies being used for 5G NR – the test concept differ drastically.

4.7 Power consumption measurement

Power consumption measurement to ensure that the battery powered devices are still able to offer the enormous flexibility which comes with 5G and yet not forgetting about the power consumption aspects. The power consumption has to be maintained to the same extent as with LTE which requires measuring power consumption and optimizing the network parameters for optimal user experience.

5 Rohde & Schwarz's Responses

Question 6: IMDA would like to seek views, comments and suggestions on:

i) The proposed network rollout and performance obligations to be imposed on the spectrum right holders

1.1. Rohde & Schwarz would like to highlight the difference in network performance between 5G network deployment at 3.5GHz and the existing LTE networks deployment. At 3.5GHz, the free space path loss is higher than the existing LTE networks in Singapore which are currently deployed at frequencies lower than 2.7GHz. This essentially translates to a smaller coverage area if these 5G gNBs are deployed at the same locations as the current eNBs. In other words, it could be necessary to deploy more 5G gNBs in order to cover the same defined area as compared to existing LTE networks.

1.2. For 5G deployment at mmWave frequencies, the free space path loss of the RF signal will be significantly much higher than frequencies at 3.5GHz. This could greatly impact the coverage for outdoor environment. It could be more efficient to deploy networks at mmWave frequencies indoors or controlled environments such as in shopping malls or concert venues where there could potentially be a high demand on network throughput concentrated within a small area. It is necessary that coverage field tests are to be conducted especially at mmWave frequencies in order to ensure there is sufficient coverage for the whole area of interest since these frequencies have a much smaller coverage radius.

1.3. Rohde & Schwarz would also like to highlight the difference in network performance between NSA mode and SA mode. In NSA mode, there is no 5G Core network and all essential signaling parameters is done through the LTE Core network. This potentially increases the network latency which in turns compromise the Ultra Low Latency performance. SA mode on the other hand, will require a complete re-haul of the backend core network but could theoretically achieve the Ultra Low Latency networks expected of a 5G NR network.

1.4. A 5G NR networks is based on the principles of having;

a) Enhanced Mobile Broadband with high data throughput (eMBB)

b) Ultra Low Latency Reliable Connection (URLLC)

c) Massive Machine to Machine Communication (mMTC)

In order to truly and completely test the performance of a 5G NR networks, all 3 characteristics of the networks should be taken into consideration. However, since mMTC is as of today still a relatively new concept, there is currently very limited measurement methodology to truly test and verify mMTC performance. While Rohde & Schwarz is actively engaging and supporting new proposal on mMTC performance measurements, a matured and well accepted methodology or standardization may not be available soon.

1.5. One of the many ways to measure the performance of eMBB use case is to verify the maximum data throughput the 5G NR network is capable of providing. Such a test currently typically involve a 5G device performing a huge file size content download via FTP or through video streaming. However, with higher data bandwidth and throughput expected of 5G NR networks, new applications can be expected which may lead to evolvement of new measurement methodologies and approach. New KPIs should also be considered for a comprehensive performance scoring metric.

1.6. The last of 5G NR use case, URLLC will also require new measurement methodologies depending on the supported application. Ping test is currently the most widely accepted measurement approach to measure a 4G network latency. However ping test may longer be a good approach for 5G NR without taking into consideration of the application actual latency demand. New measurement approach for URLLC performance are fast developing with Rohde & Schwarz are actively supporting such developments. Rohde & Schwarz expects new measurement approach to be available in the near future.

1.7. In summary, Rohde & Schwarz view that performance obligations should first consist of a set of basic scoring metric for QoS and coverage. This scoring metric must take into consideration of the operating spectrum band or at minimum consider 3.5GHz and mmWave frequencies seperately. Measurement for QoE will clearly require a different approach since 5G will not only address human users but also machines, robots, vehicles, etc. Current methods to measure QoE for 4G networks are no longer sufficient or applicable. QoE measurement for 5G networks will revolve around the 3 use cases of eMBB, URLLC and mMTC but the actual application demand and consequences in the event of service degradation or outage must be also taken into considerations. Legal liability of spectrum owners or network operators is also a complex topic in the event of service degradation or outage.

Question 6: IMDA would like to seek views, comments and suggestions on:

ii) The methodology and measurement criteria for the coverage obligation

Rohde & Schwarz would like to propose the following measurement criteria and methodology for basic coverage obligations:

2.1. Signal Synchronization Block (SSB) – due to the flexible architecture of 5G networks, the whole assigned channel bandwidth may not be constantly transmitting. SSB is the only signal that is constantly transmitted regardless if there is any data in the downlink. SSB measurements is therefore of high importance for any 5G network measurement. SSB signal can be easily measured using a Rohde & Schwarz RF network scanner.

2.2. Beam forming - Compared to LTE, beam forming is one key enhancements for 5G network. Each Physical Cell ID (PCI) now transmits multiple beams with different beam indexes to cover different areas of the same sector. It is therefore critical to ensure that different beams are providing sufficient RF signal coverage for each sector without any drop in signal quality among the different beams. For measurement, a 5G device can be used to test the handover between different serving cell beams to ensure a smooth transition between different PCIs and beams.

However, as a 5G device is only capable of measuring the serving cell beam parameters, it is also of equal importance that a network scanner is used alongside to measure the coverage of all beams from each of the individual PCIs. This is because RF network scanners are capable of detecting all the separate PCIs' beam indexes off the air simultaneously for a detailed coverage mapping of each and every beam as well was PCI.

2.3. Reference Signal Received Power (RSRP) – RSRP is a measure of the average power of the resource elements that carry cell-specific reference signals. This have mainly been used in LTE to identify and map the coverage of each individual EARFCN channel and its respective PCI. In 5G network, RSRP can be use as the main coverage criteria to verify if there is sufficient and reasonable 5G RF signal coverage for 5G devices. As explained in 2.2, there is a need to measure the coverage of each beam apart from the coverage of each PCI. This can be done by differentiating the SSB RSRP of each beam across the various PCIs using Rohde & Schwarz RF network scanner. It's also important to note methodology and measurement criteria of RSRP should be considered differently for 3.5GHz and mmWave frequency.

2.4. Reference Signal Received Quality (RSRQ) – RSRQ is a measure of signal quality as received. Together with RSRP, these 2 parameters provide a good indication of how a 5G device determine its cell re-selection. Using a RF network scanner, one can measure RSRQ of each SSB and PCI to identity spots that could have potential cell re-selection problems between different cells or different beams.

2.5. Signal to Interference plus Noise Ratio (SINR) – SINR is a measure of the quality of a channel and whether there is interference affecting the channel quality. With a higher SINR, devices will be able to download data with a higher Modulation Coding Scheme (MCS). A high SINR value for a channel indicates high data throughput compared to another channel having lower SINR value. Since more data bits can modulated in a single transmission using higher MCS.

SINR should be measured for each SSB beam in a 5G network as an important parameter for data throughput. A low SINR value generally indicate presence of nearby interference. Using a Rohde & Schwarz RF network scanner, accurate depiction of interference signals affecting 5G transmissions can be easily achieved. Further analysis can then allow authorities or network operators to locate source of interference to rectify areas with throughput problems

2.6. LTE vs 5G NR – Measurement parameters described above mainly address 5G network coverage and QoS performance. For a 5G NSA deployment model, it's also of equal importance the LTE channel with specific 5G signaling parameters are also measured for both coverage and QoS performance. Simultaneous measurement of both LTE and 5G network can be easily achieved using Rohde & Schwarz RF network scanner for a better understanding on how these channels correlate with one another and whether supplementary 5G base stations are required especially for the mmWave frequencies. Further measurement for proper handovers between LTE and 5G network when a data session is initiated can be done using a 5G device.

2.7. VoNR for SA mode – This measurement would be necessary as the voice can only be carried over 5G network. Measurement criteria shall include call setup time, call drop rate, call setup successful rate. Rohde & Schwarz will also suggest to evaluate voice quality of a VoNR call.`

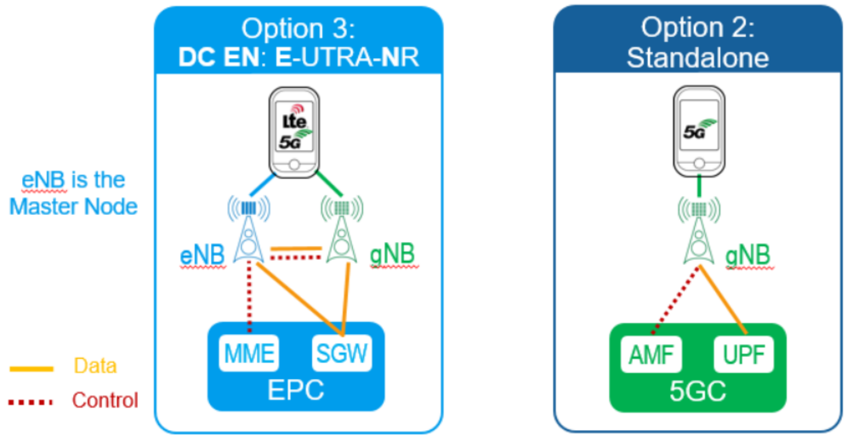

Figure 2: Examples of 5G NR deployment options

6 Conclusion

Rohde & Schwarz welcomes the opportunity to convey our views to IMDA on second consultation on 5G mobile services and networks. Views and recommendations discussed in this submission are experience mostly from the many 5G trials supported.

To conclude, measurement methodologies, KPIs and scoring metric for 5G network performance should take into consideration of frequency bands, SA or NSA mode and more importantly application demands on 5G use case of eMBB, URLLC and mMTC. New measurement methodologies and tools are in development can be expected in near future.

Measurements on 5G network can be currently classified into coverage, QoS and QoE. Their performance can be measured with 2 main equipment types; RF network scanners and 5G devices. Rohde & Schwarz view is availability of device for specific 5G use case is the current challenge and bottle-neck.

As part of various standard bodies and one of the market leaders in cellular and wireless testing. Rohde & Schwarz is actively involved in 5G developments worldwide and will be glad to update IMDA regularly on new developments, test cases and measurement methodologies.

Should you have any questions or comments on our submission, please do not hesitate to contact Joseph Lim at joseph.lim@rohde-schwarz.com or
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