Q&A From Webinar:
5G Non-Terrestrial Networks – Technology Update
July 22, 2020 12:00PM EDT

Q) You mention beamforming support in the satellite base stations. Does R&S have to test capability in a chamber as over the air with the entire satellite or only components?

A) There is a wide portfolio of R&S in OTA, from components up to large chambers – further information is on our website www.rohde-schwarz.com. As analogy from the automotive: full vehicle testing is a method to measure coexistence and radio links of the vehicle as one entire DUT.

Q) As spectrum for NTN you mentioned the 2GHz and 20GHz range. Are there any other spectrum ranges discussed?

A) Spectrum is a pivotal aspect and there is a need for international standardization, especially with large coverage areas as provided by satellites. At the moment we see those two candidate bands as the first proposal – but as always, subject to be changed / extended.

Q) NTN is part of Rel. 17, will there be a delay due to the current COVID-19 issues?

A) R&S is member of 3GPP and we follow the timeline agreed by 3GPP. Current situation is Dec 2021 deadline for Rel. 17 but nobody knows how the future will look like. Despite the standardization, the research activity is ongoing with full speed and the motivation to go for NTN is very high. Thus R&S is working on test solutions to cover the 3GPP standards but also allow usability in additional settings.

Q) You mentioned latency as a critical challenge. What are the impacts on implementation?

A) It is not just the latency as an absolute latency but what harms is the floating latency depending on the coverage area and the UE position. Impacts are a flexible buffer management and related to this a flexible timing of the TX, i.e. known as timing advance. 5G offers the flexibility in the MAC layer

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Q) How can you implement circular polarization as by today 5G supports dual-polarized antennas?

A) NTN uses other bands and 5G provides already a high flexibility. Even today dual polarized antennas are used but they are not mandatory feature or are not signaled to the receiver. One motivation to use dual polarization in 5G is e.g. spatial multiplexing MIMO to obtain a kind of orthogonality in the radio channel. I see no big obstacles in the application of circular

polarization, but for sure as most of todays topics are current situation and proposals of the research – we will have to see what ideas will find their way into the standardization.

Q) Can you discuss the Cyclic Prefix versus numbers of users for a given bandwidth in 5G for NTN?

A) The CP is used to mitigate multipath propagation effects in OFDM and the RF resources are scheduled in 5G in time & frequency. Thus, it is difficult to set an absolute limit in number of users. In general, the CP provides an overhead and for sure effects the overall spectral efficiency but we do not see and relationship between the capacity of the cell and the CP duration.

Q) Yes, partially. I should have stated the question a little differently in terms of latency with respect to the size of the CP and the effect on the number of users in a given bandwidth.

A) Sure, the CP is typically designed to be aligned with the expected cell size in a terrestrial cell or better said, it is aligned to the typical expected delays spread and is attached to the OFDM symbol. Thus the CP is a relative time linked to the OFDM symbol time. The OFDM symbol is the reciprocal value of the subcarrier spacing and this is of course an important value for overall latency aspects. But please note that latency is measured as end to end and it is affected by many parameters, the air interface parameters is only one component, others are the distance between client and server (mobile edge computing), the radio capacity, the buffer management and retransmission timing (HARQ) etc. But we do not see a direct impact of CP to the cell capacity.

Q) What is the current occupied bandwidth that 5g will use at the various frequency bands?

A) For NTN I would refer to TS38.811 the study item and here the numbers are: 2*20MHz for S-band, 2*800MHz for Ka-band and 2*80MHz for other bands not yet defined. But this is only study item so far. In 5G FR2 the maximum bandwidth is 400MHz for one channel and it will be interesting to see if 3GPP will change the bandwidth from 400 to 800MHz for NTN use cases?

Q) As I understand, the Loon project (HAPS) is still under development, it didn't demostrated to provide communications in Puerto Rico after the hurricane Maria in 2017, and was being tested in Africa in 2019 https://www.reuters.com/article/us-alphabet-loon-focus/google-internet-balloon-spinoff-loon-still-looking-for-its-wings-idUSKCN1TW1GN. Do you have any update information about the status of their performance having being proved?

A) Unfortunately I cannot give any more information as you refer to this website. Personally, I am not directly involved with the Loon project, I can check if I find somebody from our local team who is in touch with them. R&S has business relationship with Loon but unfortunately we agree to an NDA and I cannot disclose that much information. If you like get in touch with me directly and I can help to get you in touch with our contacts at Loon and hope that they may help you with further information. Sorry about this, hope for your understanding.

Q) If the satellite component is only used in a cellular backhaul situation what aspects of the standard need modification?

A) Not much in that case, it would affect the backhaul interfaces. They are already today defined to use a not defined PHY layer, so the NG-interface can e.g. be radio based or fiber optic based or Ethernet. Thus I would not see much impact if the NG interface uses a NTN connection. For sure there would be some impacts like latency, bandwidth and data rate, capacity, etc. that should be tackled by meticulous planning.

Q) How big is the frequency shift due to Doppler that we can expect from LEO?

A) I suggest to take a closer look into TS38.811 which contains multiple examples. One is e.g. a LEO satellite with 2GHz carrier frequency and a Doppler from +40kHz to – 40kHz. If needed I can share that document with you offline.

Q) Great presentation. Thank you! It seems like there is good momentum for research on the topic of 5G / NR on non-terrestrial networks. Can you talk about the uptake from industry? Are there any companies working towards commercial solutions today? Anyone produced prototypes yet?

A) Thanks for the feedback, this is an interesting question. I know several studies and discussions and for sure several press related information that companies are working on NTN. But I have not yet seen any public presented prototypes, unfortunately. At R&S we enable technologies with our expertise in T&M and our equipment is used in many development environments. Unfortunately, with many of our customers we have NDAs signed so I can only disclose what is publically available information.

Q) NTN for standalone NBIOT network. What do you think about the challenges for non-latency sensitive applications?

A) This is of course one use case, to provide data for machine type communications. Several challenges are from our perspective: Coverage (as machines are typically located on fixed sites and you need the connection exactly at this position), permanent or sporadic coverage support (i.e. when a satellite is only visible a certain time of a day). And other aspects that are not directly related to NTN but also in general to NB-IoT like e.g. energy consumption, radio performance, security aspects, remote installation and less maintenance possibility, interference aspects due to mass deployments etc.

Q) Why can't we use the flights in the sky as base stations? At any given time there are multiple aircrafts in the sky?

A) Very good question. From a technical perspective I may answer that "hopefully" I did not say that this is not possible. ☺ We speak about an airborne base station and why not using a commercial civil airplane as gNB carrier? Challenges are what I see is the human aspects: coordination between network operator and the airline (when and where is my base station?), agreement on the connection to the core network (i.e. who owns the base station in the

airplane, is this a lease contract between MNO and airline?). But technically it is not forbidden and why not, you file for a patent on that ☺ Interesting idea but realization has to tackle multiple parties as input.

Q) Would it be better to focus on having the 5G satellites transmit and receive focused on fixed sites and then the fixed sites focus on the transmission and receive of all terrestrial 5G signals that then get transmitted to the 5G NTN emissions?

A) This is one specific use case I have shown in one of my slides. We have the flexibility of either using the access link as NTN link or we can only use the feeding link via satellite. So your proposal is discussed within the technology groups. Unfortunately, I cannot comment on a real deployment so far.

Q) Are there any tools or models for the optimization (for example for the drone-based example)? Thank you for this excellent session!

A) As NTN is in study item, there is research ongoing on aspects like e.g. channel models etc. From R&S perspective, we provide test equipment like signal generators with fading option and one idea could be to simulate various fading profiles. R&S company INRADIOS is active on satellite emulation and channel modelling and providing some planning tools. We can provide further information offline.

Q) What role do you think the Multi-Access Edge server playing in NTN?

A) MEC is a trend already supported in 5G in the background of network slicing and providing several data flows with different QoS requirements in and end-to-end scenario. So MEC are used in today's terrestrial based core networks and I do not see any obstacles why not using them in airborne-based situations. 5G interface structure offers this flexibility to have core network functions located at several physical positions.

Q) When will the first NTNs go live?

A) Sorry, I can only disclose what is publically available and announced by companies. From 3GPP perspective, NTN is part of Rel. 17 – scheduled for Q4, 2021. But research is ongoing already and as I have shown in my slides there are already some satellite networks in operation. So for me it is more a technical evolution than a start of a new network at one "jour fixe". Sorry this is what I can say so far.

Q) Most 5G uses TDD or full-D, but NTNs are FDD?

A) I can only refer to the frequency proposal document RP-193234 which does also contain a TDD proposal for the S-band. There are many discussion whether TDD or FDD is more suitable and some bands are already configured by the regulator authority as either TDD or FDD.

Q) Are there any special security considerations for NTNs?

A) I am not aware of any "specific" security but for sure it is a buzzword and more application driven there is a different ranking of security at all. E.g. a military communication is higher level security related as e.g. the bird tracking application I have shown. At the moment I see NTN using the same security features of 5G technology wise (see more details in our 5G book where there will soon be a new chapter on 5G security) and most likely the device vendors will work on specific security aspects depending on their customer requirements. But from the specification perspective, I cannot see a specific change in security when comparing NTN and 5G terrestrial.

Q) Does R&S implement LEO channel emulation?

A) With our signal generator we have implemented several fading profiles and provide a GUI for user specific fading profiles and one of our daughter companies works on planning tools for satellite communication budget planning and optimizations. But we should discuss offline what are your requirements on channel emulation.

Q) As 5G evolves will 5G replace broadband Wi-Fi?

A) R&S perspective is technology agnostic. We provide T&M equipment for all kind of radio technologies and enable those technologies. Our perspective is neutral, this is a reason for each of those radio technologies in this plethora and we never take position in ranking between those radio technologies. Personally I am convinced that there will be Wi-Fi in future and 5G, so both technologies will complement each other.

Q) Has any SATCOM systems planned to adapt the 3GPP NTN standard?

A) Yes, there is no official product released, but if you see the companies working and contributing to NTN in 3GPP you can clearly see that industry is working on 3GPP NTN standardization.

Q) How to correlate the 3 different regions with the 3 different colors on the global map?

A) The 3 color codes on the global map represent the 3 international regions defined by the ITU... was that the question? They correlate to the table for regions 1 (Europe) 2 (Americas) and 3 (Asia)

Q) Hello many thanks for this performance are there synchronization tight requirements for 5G with satellites and what are the redundancy for 5G satellites architectures thank you.

A) As NTN is still in study item mode it is hard to answer with detailed numbers. TS38811 talks about a 5ppm time variation as maximum failure for primary synchronization. This is the link using SSBs and network to UE synchronization. Here the main challenge is a high Doppler shift. I do not see any specific time synchronization between neighbor cells like e.g. in terrestrial TDD networks but for additional services like location estimation a certain network synchronization

can be beneficial. About redundancy, there will not be any 3GPP specific requirements, it would be more to the detailed application and implementation. The technology supports multiple feeding links and also a possible radio coverage overlapping for redundancy reasons, but if and how those mechanisms will be deployed, we will have to see in reality.

Q) How do you mitigate the ionospheric scintillation, TEC variation, extreme solar and geomagnetic effects in case of MEO and GEO?

A) Thanks, this is a very academic question and I have to refer to the various working groups in the standardization work. I am personally not aware of any specific countermeasures regarding ionospheric scintillation or electron constellations nor solar electromagnetic affects. There are some ideas to consider some minor parts of this in a kind of fading profiles and channel models. One requirement for 5G NTN has to be that it is a kind of ubiquitous communication model, thus it should be implemented with a feasible cost and complexity and should work in many conditions in a general procedure. Thus I do not expect any sophisticated measures to compensate such effects, they would work in a single direct link ground – satellite but not in a general worldwide standardized process. From R&S perspective we provide signal generators with fading capabilities and 5G support a flexible radio interface with mechanisms like adaptive modulation and coding which would definitively help in your mentioned atmospheric condition.

Q) What are the 5G satellite GEO or also MEO and LEO?

A) The current standard description does not restrict, so all three satellite types are allowed as well as airborne base stations (called HAPS) given as e.g. planes, helicopters, drones, balloons, etc.

Q) Consideration is being given to satellite use to the ground station, connecting base stations as a backhaul solution, as well as satellite direct to UE. Is any thought being given to satellite direct to cell site base station, cutting out the need for fibre or microwave connections to a dedicated SGS?

A) Yes, there can be either way, NTN for the so-called access link: Satellite to UE or NTN can only cover the backhaul connection, the so-called feeding link. There are no restrictions to that, for sure we will have to see whether such kind of architecture will be deployed in reality but from today technology perspective, both are possible.

Q) How does those delays work with a TTI of 1 ms in 5G TDD?

A) For sure we have to consider physical limits. First the TTI is the transmit time interval, so only the time needed for the transmission of one transport block. What is affecting latency is the overall round trip time, e.g. when using a TDD mode, you need a guard interval. I suggest to take a look in to TR 38.811 where such discussions are explained, e.g. for a 600km orbit suggestion is to have ~270ms guard time which would make the system not very spectral efficient. So we have to balance between the efficiency and the physical limits, for sure there will be restrictions, like e.g. a 1ms latency is hard to achieve with NTN, I do agree – but not all services do require such a latency.

Q) You talked about continuous coverage. What about IoT? do you think make sense to take into account discontinues coverage (disruptive coverage) for IoT for Delay Tolerant and Non real-time applications ?

A) Yes, I mentioned that continuous coverage is a kind of challenge. Please do not understand me wrong that I understand continuous coverage as a necessity. There are for sure services that tolerate discontinuous coverage (one example I know by today is e.g. tracking of the water level in remote area waterholes for agriculture). Challenge is to balance right between deployment complexity and service requirements.

Q) Thanks a lot for the very illustrative and comprehensive talk. Is there any specific satellite band specified in 3GPP?

A) There is no band so far agreed, but RP-193234 suggests two major frequency bands, the S band at ~2 GHz and the Ka-band at ~20 GHz.

Q) What would be valid/invalid in your presentation for a UAS to UAS communication scenario

A) Thanks for this interesting question. In general I see two possible scenarios to cover UAS to UAS communication with 5G. With NTN it is a device to network communication, simplified only difference is that the network is "airborne". Advantage would be the wider coverage range, challenges e.g. the longer latency. Not discussed today in the webinar, but from the automotive world we work on a technology NR V2X, using a so called sidelink, a direct radio link between two entities. First applications are vehicle to vehicles, but R&S is involved in projects like drones for UAM, urban air mobility and studies are being executed to apply a direct radio link based on LTE / 5G V2X technology for drone to drone communication. Challenges here would be the coverage aspects, e.g. what is the max distance of such a sidelink and a high relative Doppler shift.

Q) How do you perform the interference analysis with beamforming antenna (since it is dynamic) for this type of network?

A) Similar to the terrestrial network, R&S is market leader in mobile network. Further info: https://blog.mobile-network-testing.com/
For sure you can only measure signals that are visible, but for interference this is the case. If an interferer directs its beam in opposite direction, I may not see it but then it is no interferer any more. But yes, it is challenging as signals are dynamic, so e.g. a longer time evaluation of performance parameters is maybe needed.

Q) How much impacts on the 5G core network due to NTN LEO/GEO/MEO?

A) Hope to understand the question right. First, there is no change of the existing core network, functions, existing hardware and protocol layers stay unchanged. With NTN you get a complement. E.g. the core network functions have to be implemented in airborne components.

And the resulting affects like e.g. longer time delay, different antennas (wireless point to point terrestrial vs. Earth to space), but it is not a revolution more an evolution.

Q) What are the labs what are currently prototyping NTN technologies?

A) Sorry, I am engineer and not a marketing or sales person, I do not have a direct list of companies working on NTN so my answer may not be complete. You can see in the working groups which companies are cooperating here and for sure public press information. Hope this answers partially your question, sorry for not giving you a full list.

Q) Great presentation! Like mentioned already this is Deja Vu and just because something makes it in to a standard doesn't ensure success. What is the appetite this time around among MNOs, chipset and RAN vendors to actually adopt satellite as another access scheme? Especially in the light that MNOs does not (typically) own any satellite spectrum rights...

A) Sorry, I am electrical engineer not business person, so I may not comment on the business success of NTN. From R&S we see such requirements and we enable and support with our expertise in T&M but we are not an operator of neither satellite networks nor terrestrial networks. Motivation is definitively the ubiquitous coverage and the demand for internet connectivity worldwide. But what are the relevant and successful business models, sorry, I can not answer this question.

Q) For MEO / LEO, how the Link budget (UL & DL) is balanced. Any comments?

A) I can only remind to physician Harald Friis with his free space path loss equation. There are only three parameters where we can work on: TX power, RX sensitivity and antenna gain. Thus NTN talks about a higher UL transmit power of up to 33dBm for UEs (e.g. the VSAT type of UE) and beamforming methods in both directions. And methods like adaptive modulation and coding or polarization diversity etc. are additional measures.

Q) Given that Elon Musk's Starlink is being deployed (~600 satellites launched so far) aren't deployments ahead of standards?

A) I am very sorry but I do not see me in the position to answer this question. I do not know what is the status of Starlink and the technology details – I know some aspects of NTN within 3GPP and I presented the timeline here. What is the better business model and which technology will survive we will have to see in future. R&S is always technology agnostic, we support with our expertise in T&M and hope your equipment will be used in future T&M requirements, independent on what technology is used.

Q) Is going to be the IRIDIUM project from the past feasible from economical and technological point of view now with 5G-6G? I think Amazon and Tesla has a plan to offer Internet Services by using satellite Constellations.

A) Sorry, I cannot comment on the Iridium and what are there deployments and evolution plans. Yes, Iridium is already deployed, it will technology wise evolve but in which direction, you should ask them. There is of course a big hype on using satellites from various industry players and we will have to see which technology is used in future. R&S is technology agnostic, our challenge is to fulfil the T&M requirements of the future.

Q) Which ongoing constellation projects do have the S or Ka Band downlinks for base station, is there any?

A) Not sure if I understand the question right. The standard itself does not claim for any specific constellation scenario, there can be LEO, MEO and GEO satellites as well as HAPS. Coverage can be continuous and discontinuous, this is for sure the balance between deployment complexity and service requirements.

Q) Is there any concept that the base stations cope with the attenuation problems due to weather high frequencies?

A) As discussed in the webinar, the high pathloss is one challenge, for sure. The technology aspects to countermeasure are e.g. a higher TX power up to 33dBm and beamforming to increase the antenna gain. And radio link parameters like adaptive modulation and coding.

Q) Great Webinar by the way. Has Rohde and Schwarz conducted cost comparisons between terrestrial and non-terrestrial networks. Might this be a rather prohibitively expensive undertaking?

A) Thanks Brian. The cost comparison question is not part of our mandate. We support the operators with Test and Measurement, Education and Technical Support, only.