SATELLITE AND SPACE COMMUNICATIONS **SSC**
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IEEE COMMUNICATIONS SOCIETY

SSC Newsletter **Vol. 29, No. 1, May 2019**

CONTENTS

The Satellite and Space Communications (SSC) Committee is a volunteer group actively involved in advancing satellite and space communication technologies within the IEEE. This committee is approved by the IEEE Communications Society and is governed by the constitution and bylaws of the IEEE as well as the other twenty-three Technical Committees in the Society. The committee belongs to the Technical Committee Clusters of Communication/Signal Processing (C/SP).

SATELLITE & SPACE

- JOIN US -

All conference attendees are welcome to join us in the SSC Committee meeting.

Location: ICC'19, Shanghai, China
Room: Guilin, Level 3
Pudong Shangri-La
Date: Wednesday, May 22, 2019
Time: 12:30-14:00

Future SSC Meetings
December 2019, Waikoloa, USA
June 2020, Dublin, Ireland

ICC 2019 SSC Committee Activities:

Symposium on Selected Areas in Communications:

Tuesday, May 21, 9:00 - 10:30, Room: 5E
SAC8-SSC-1: Satellite Communications
Chair: Andreas Knopp (Bundeswehr University Munich, Germany)

Tuesday, May 21,14:00 - 15:30, Room: 5E
SAC8-SSC-2: Satellite Networking
Chair: Tomaso De Cola (German Aerospace Center (DLR), Germany)

Tuesday, May 21, 16:30 - 17:30, Room: 5E
SAC8-SSC-3: Next-Generation Satellite Networks
Chair: Min Lin (Nanjing University of Posts and Telecommunications, P.R. China)

Thursday, May 23, 9:00 - 10:30, Room: 3J
SAC8-SSC-4: Security in Satellite Systems
Chair: Angeles Vazquez-Castro (Universidad Autónoma de Barcelona, Spain)

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MESSAGE FROM THE CHAIR

Dr. Tomaso de Cola

In the continuation of the good trend of activities and visibility achieved by the TC, the plan drafted this ongoing year includes the preparation of a new proposal for the IEEE JSAC as well as other editorial initiatives. In addition to this, the TC has certainly the possibility to further strengthen its visibility within ComSoc by proposing distinguished lecturers, which was a bit unsuccessful in the past years. Another key point for the business of the TC is the upcoming recertification, whose dedicated documentation is to be provided by the end of May. In this regard, proper update and refinement of the main sections of the website will be carried out as well as highlighting the main achievements performed since the last recertification (happened in 2016). In this regard, an important aspect related to the concept of TC member, whose attention has been brought to by TAEC in order to further mobilize TC members towards a more active involvement in overall ComSoc activities. In general, it is encouraged that TC members subscribe to IEEE ComSoc, although not strictly necessary. It is however important to note that most of the activities (e.g., editorial ones) require the membership and last but not the least chair, vice, and secretary, as well the eligible voting members are mandated to be IEEE ComSoc members. In addition to that, there are also more stringent requirements to be eligible voting members so as to appear as real "active members", hence fully aware of the TC activity as well as the profile and the values of the candidates to be elected.

More details about the specific outcome of the TC are summarized in the following and then also reported in the course of the ICC'19 SSC meeting as usual.

Participation to TC Meetings. The SSC TC last meetings shown a good trend in the number of attendees, confirming the number already recorded in the previous meetings held in 2017. In particular, about 30-40 attendees participated to the SSC meeting, hence testifying the increasing interest in the TC activities and also confirming the stability of our TC. Nevertheless, we have to continue to publicize our meeting and to invite members, past and new, to attend.

Operative Policies and Procedures (OP&P). Upon discussion during the last meeting, the charter is expected to be update so as to include also topics related to UAV and more in general new space, which are going to become more and more important in the context of SatCom in a broad sense.

Membership Management. The approach started a few years ago to continuously attract more people is achieving quite good results, also in relation to the large audience of each SSC meeting. Moreover, the editorial initiatives around SatCom have increased the worldwide visibility of SSC hence possibly increasing the attention towards the TC and eventually getting new members.

Extended Cooperation. It consists of strict cooperation with Industries, research institutes, standardization institutes (e.g., CCSDS, ETSI, DVB), and space agencies of several countries (e.g., NASA, JAXA, ESA, DLR). The success of this task is further strengthened by the presence of industry and academia in many of the editorial initiatives promoted by the TC, counting on satellite operators and vendors. Moreover, most of the last perspective articles present in the newsletter are coming from industry-driven projects, hence showing the

great interest from industry and space agencies about the work being done in the TC.

SSC Website and Mailing List. Maintenance and periodic update of mailinglist and website are performed by the committee secretary, in order to guarantee up-to-date material and possibly attract new members interested in SatCom-related topics.

Current Journals/Magazines. After the publication of the IEEE Network special issue on the integration of satellite and 5G networks, the process to have a special issue on IEE JSAC has started, with focus on 5G and non-terrestrial networks, i.e. encompassing not just satellite systems but also more general purpose air vehicles such as HAPs and aeronautical systems. The proposal (lead by Dr. de Cola) has counted on a very competitive team (composed of research and industry from Europe, US, and Asia) was consolidated in the last weeks and eventually submitted to the attention of the IEEE JSAC EiC in early May, with the start of the review process in the coming weeks. It is expected that the result of the review will be communicated in the next few months.

Conference Activities (ICC/GC and others). In ICC/GC is consolidated the SSC Track. In the recent years the SSC track has been quite successful. The SSC track of past GC editions and the current IC'19 showed a very good number of submissions, being approximately 70 and 60 respectively. Concerning other conferences, the SSC TC has endorsed SPECTS, WiSee, and which are being held in the second and fourth quarter of 2019.

Standardization Activities. Since the meeting in Atlanta (IEEE GC'13), we have appointed the Standard Liaison, Dr. Henry Suthon, Principal Senior Engineer at Boeing (h.suthon@ieee.org), who has recently confirmed his commitment in this role. Additionally, a dedicated board (formerly conceived as WG) is being under formation so as to put even more effort and visibility on the standardization activities performed around satellite and space communications. In this respect, it is worth noting that the contribution of this group to the standardization context is also confirmed the perspective article present at the end of this newsletter, where the effort paid by the satellite community in 3GPP to promote the inclusion of non-terrestrial networks (including SatCom) is highlighted. Moreover, liaison with IEEE standardization groups are being formed in the exercise of providing inputs to the IEEE 5G initiative where the dedicated SatCom WG has already compiled a report about the technology roadmap until 2030.

Dr. Tomaso de Cola, Chair
Satellite and Space Communications TC

SCANNING THE WORLD

Song Guo

Recently, the Satellite Industry Association (SIA) published the 2019 report on the state of the satellite industry. According to the report, more than 300 satellites were launched in 2018, and the annual revenue of the satellite industry reached 277.4 billion dollars. The first half of 2019 has witnessed a lot of exciting news on satellite technologies and space probing activities. Some representative news is summarized below.

On February 19, NASA published a daily Mars weather report based on the data provided by the InSight lander. The weather report includes wind, temperature, and pressure information, which is collected by components of InSight lander called Auxiliary Payload Sensor Suite (APSS) and transmitted to the Earth via the Deep Space Network (DSN). DSN is an international network of antennas that provides communication links between planetary exploration spacecraft and their mission teams on Earth. Since InSight lander successfully touched down on the surface of Mars last November, it has been transmitted a large amount of Mars data and images to the Earth. On April 23, NASA announced that InSight lander has recorded for the first time ever a likely "marsquake", based on the faint seismic signal detected by the lander's Seismic Experiment for Interior Structure (SEIS) instrument. On May 1, InSight lander captured a series of sunrise and sunset images.

On April 24, the Unite States Air Force's Advanced Extremely High Frequency (AEHF) program successfully delivered the fifth satellite (AEHF-5) to Florida and prepared for Launch. When the AEHF system is completed, it will consist of six GEO (Geosynchronous Orbit) satellites. The AEHF satellites operate at 44 GHz and 20 GHz. They incorporate frequency-hopping radio technology as well as phased array antennas in order to support protections against potential sources of jamming. The objective of this program is providing global coverage, high data rate, confidential and anti-jamming communications for the military missions.

On May 7, Telesat and the University of Surrey, in cooperation with Newtec, confirmed that LEO (low-Earth orbiting) satellites can provide an effective solution for 5G backhaul. Several tests, including 8K streaming, Internet browsing, and video chat sessions, have been performed on University of Surrey's 5G Testbed network within its 5G Innovation Centre and Telesat's Phase 1 LEO satellite. Out of the technologies tested, they demonstrated that the proposed solution has higher modulation, efficiency and throughput performance. The experimental results also show that the round-trip delay is 18-40 milliseconds, reaching the lowest value of the satellite connection.

On May 11, Chang'e 4 lunar probe completed work for the fifth lunar day on the far side of the moon. The lander has traveled an accumulated 190.66 meters on the moon. Since direct communication with Earth is impossible on the far side of the Moon due to the occlusion, Queqiao relay satellite is employed for transmitting data and controlling the lander. Up to now, the Chang'e 4 lunar probe has transmitted the latest scientific detection data to the leading team, with a total data volume of 6.6 GB and a total of 494 data files.

On May 15, SpaceX launched 60 Starlink Internet satellites. This is the first group of satellites that SpaceX plans to deploy in the next few years, and these satellites will provide global Internet services in space. According to the plan, the Starlink will establish a very large satellite constellation, consisting of nearly 12,000 LEO satellites. The objective of Starlink

is to provide high-rated Internet connectivity to underserved areas of the planet, as well as reduce the cost of Internet access.

Prof. Song Guo, Vice Chair
Satellite and Space Communications TC

FORTHCOMING GLOBECOM AND ICC CONFERENCES

COSPONSORING / RELATED CONFERENCES AND WORKSHOPS

GLOBECOM 2019
December 9-13, 2019, Waikoloa, HI, USA
http://globecom2019.ieee-globecom.org/
IEEE GLOBECOM is one of two flagship conferences of the IEEE Communications Society (ComSoc), together with IEEE ICC. Each year the conference attracts about 3000 submitted scientific papers and dozens of proposals for industry events. A technical program committee of more than 1,500 experts provides more than 10,000 reviews, and from this a small fraction of the submitted papers are accepted for publication and presentation at the conference. The conference attracts roughly 2000 leading scientists, researchers and industry practitioners from all around the world. IEEE GLOBECOM is therefore one of the most significant scientific events of the networking and communications community, a must-attend event for scientists, researchers and networking practitioners from industry and academia. IEEE GLOBECOM is a five-day event. Two days are dedicated to tutorials and workshops, while the remaining three days are dedicated to the IF&E program and the technical symposia. The program of the technical symposia includes oral or poster presentations of about 1000 scientific papers, grouped into 13 thematic symposia, and more than 15 parallel sessions. Themed " Revolutionizing Communications," GLOBECOM 2019 will offer five full days of original paper presentations, tutorials, workshops, keynotes, demonstrations, industry sessions and social events designed to further career opportunities and the in-depth understanding of the latest communications advancements worldwide.

ICC 2020
June 7-11, 2020, Dublin, Ireland
http://icc2020.ieee-icc.org/
The International Conference on Communications (ICC) is one of the two flagship conferences of the IEEE Communications Society, together with IEEE GLOBECOM. Each year the ICC conference attracts about 2-3000 submitted scientific papers, a technical program committee involving about 1500 experts provides more than 10000 reviews, the conference being finally attended by 1500 - 2000 professionals from all around the world. IEEE ICC is therefore one of the most significant scientific events of the networking and communications community, a must-attend forum for both industrials and academics working in this area. IEEE ICC 2020 - Featuring the latest developments in telecommunications from a technical perspective. Subjects include Communications Theory, Wireless Communications, Wireless Networking, Optical Networking, Next Generation Networks for Universal Services, Multimedia Communication and Home Networking, Signal Processing for Communications, Communications QoS, Reliability and Performance Modeling.

CONFERENCES CALENDAR

CONFERENCE	DATE & LOCATION	INFORMATION
SPECTS 2019 International Symposium on Performance Evaluation of Computer and Telecommunication Systems	July 22-24, 2019 Berlin, Germany	http://atc.udg.edu/SPECTS2019/
ITC 2019 31st International Teletraffic Congress	September 27-29, 2019 Budapest, Hungary	http://itc31.org/
ICTS 2019 International Conference on Computer, Information and Telecommunication Systems	August 28-31, 2019 Beijing, China	http://atc.udg.edu/CITS2019/
ICL-GNSS 2019 International Conference on Localization and GNSS	June 4-6, 2019 Nuremberg, Germany	http://www.icl-gnss.org/2019/
PIMRC 2019 IEEE International Symposium on Personal, Indoor and Mobile Radio Communications	September 8-11, 2019 Istanbul, Turkey	http://pimrc2019.ieee-pimrc.org/
Ka-Band/ICSSC 2019 The 25th Ka and Broadband Communications Conference and the 37th International Communications Satellite Systems Conference (ICSSC)	October 29 - November 1, 2019 Okinawa, Japan	http://www.kaconf.org/
VTC-Fall 2019 2019 IEEE 90th Vehicular Technology Conference (VTC-Fall)	September 22–25, 2019, Honolulu, Hawaii, USA	http://www.ieeevtc.org/vtc2019spring/

To all SSC members: If your postal address, telephone or fax numbers have changed, please update them with the committee secretary. You can review our current records on our web page at http://committees.comsoc.org/ssc/.

PERSPECTIVE ARTICLE *May 2019*

Non-Terrestrial Networks and 5G Standardization: Overview of the Last Two Years

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***Abstract* —The main purpose of this article is to report about the last two years achievements in the 3GPP standardization groups on the integration of satellite and terrestrial networks deploying the same technology, 5G New Radio (5G-NR). Since the advent of 3G cellular systems (later on 4G) and their global success, the satellite community started and supported many R&D initiatives for the adaptations and the inclusion of satellite communications, nonetheless without big success in a full commercial deployment. Why should it be different this time from the past?**

INTRODUCTION

Almost two years ago, in March 2017 at the 3GPP RAN plenary meeting in Dubrovnik (RAN #75), for the very first time ever a Study Item (SI) about the integration among satellite and terrestrial networks was approved. This extraordinary achievements was the result of coordination and promotion among more than 40 Companies (not only from the satellite arena) listed in Figure 1. The SI title was "*Study on NR to support Non-Terrestrial Networks (NTN)*" [1] and the objectives were the following:

- study the feasibility of adapting the 3GPP channel model for non-terrestrial networks. If needed, identify and study new channel models;
- provide detailed description of deployment scenarios for non-terrestrial networks and the related system parameters such as architecture, altitude, orbit, etc;
- for the described deployment scenarios, identify potential key impact areas on the NR.

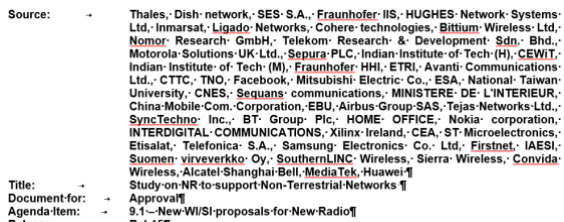

Figure 1: List of Companies supporting the first ever approved document in 3GPP about the integration with satellite networks.

Along with this study in the Radio Access Network (RAN) group, a companion activity was approved in the Service and System Aspects (SA) plenary meeting, still in Dubrovnik. The title was "Feasibility Study on using Satellite Access in 5G" [2] and was aiming at identifying use cases for the provision of services when considering the integration of 5G satellite-based access components in the whole 5G system. In particular, the scope was the identification of new potential requirements for 5G systems addressing:

- the associated identification of existing/planned services and the corresponding modified or new requirements;
- the associated identification of new services and the corresponding requirements;
- the requirements on set-up / configuration / maintenance of the features of UE's, when using satellite components related features, as well for other components from the 5G system;
- regulatory requirements when moving to (or from) satellite from (or to) terrestrial networks.

The approval of these two SIs has been very important to start the investigation and analysis of all potential issues related to the integration of the satellite component in 5G cellular networks. Looking backward, the satellite community have tried several times this process of integration and complementary use of their space assets in terrestrial systems, nevertheless this wedding never happened since the advent of 3G (later on 4G) technologies.

The question is spontaneous: why should it be different this time? First of all, due to the fact the specification stage (i.e., the kick-off of a Work Item on NTN) has not been scheduled yet, it is still too premature to talk about a successful ending, thus the challenge is still on-going. However, it is evident with respect to last decade that the needs of these two ecosystems are converging and synergies might be very beneficial for both. In particular, a big discriminator from the cellular world point of view (e.g., network and chipset manufacturers, cellular operators) is the fact that 5G objectives are not anymore primarily focused only on enhancements of mobile broadband connectivity (i.e., eMBB services). In fact, it is well known the presence in the 5G standardization groups of new verticals (automotive, internet of things, industrial automations, agriculture, asset monitoring, finance, etc.) asking for new set of requirements, which are enabling and supporting the need for satellite links. On the other hand,

the whole satellite community could leverage on the economy of scale to reduce and optimize their costs and to become worldwide competitive.

The rest of the paper will cover the achievements of the NTN activities in the Release 15 [3]-[4], the status within the Release 16 implementation roadmap [5], and finally some conclusions will be drawn.

RELEASE 15 ACHIEVEMENTS

A. Satellite and 5G Use Cases

The work performed in [3] was exactly focused on the identification of new use cases for 5G networks and the definition of requirements, where the presence of satellite links would be beneficial or even essential in order to provide such type of services and applications.

The SI has finally identified 12 cases:

- Roaming between terrestrial and satellite networks
- Broadcast and multicast with a satellite overlay
- Internet of things with a satellite network
- Temporary use of a satellite component
- Optimal routing or steering over a satellite
- Satellite trans-border service continuity
- Global satellite overlay
- Indirect connection through a 5G satellite access network
- 5G fixed backhaul between NR and the 5G core
- 5G moving platform backhaul
- 5G to premises
- Satellite connection of remote service centre to off-shore wind farm

The reader is invited to look at [3] for specific information. The main outcome of this NTN activity has been the inclusion of satellite 5G use cases and requirements in the Release 16 Stage-1 document [6].

B. Satellite Deployment Scenarios

Hereafter, some possible reference architectures for such satellite exploitation in terrestrial networks have been depicted. It shall be noted that the following architectures are applicable to all possible constellation (e.g., GEO or LEO) and all available radio frequency (e.g., S- or Ka- band).

The first and easiest configuration for connecting user terminals to the NG-RAN is shown in Figure 2, where a transparent satellite payload is assumed. The satellite payload implements only frequency conversion and power amplification functions in both up- and down- link directions. In practice, the NR-Uu interface is not terminated along the way between the user equipment and the on-ground gNB. As far as the user terminal is concerned, both handhelds or dedicated satellite equipment are envisaged.

The architecture in Figure 3 differs from the previous by the choice to embark directly the gNB on-board of the satellite. This requires more computational power in the satellite payload, but for instance it halves the propagation delay between the UE and the gNB with respect to the transparent solution. For clarity, in Figure 3 it is highlighted that the Satellite Radio Interface (SRI) between the gNB and the satellite gateway on-ground (i.e., the feeder link) is a transport link to carry over the NG interface capabilities directly to the 5G core network.

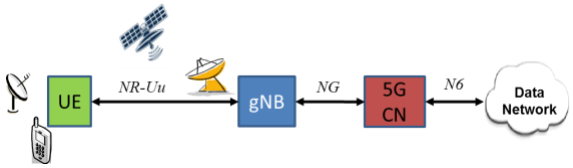

Figure 2: NTN integration based on satellite transparent payload.

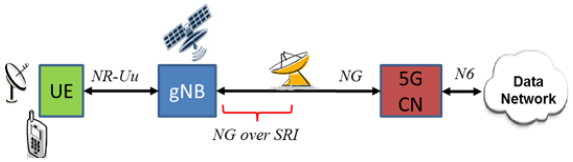

Figure 3: NTN integration based on satellite regenerative payload

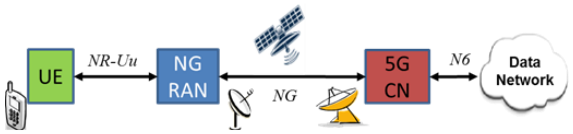

Figure 4: Satellite backhauling configuration.

For the sake of completeness, a third NTN based architecture is reported in Figure 4. In this configuration, a satellite backhaul is used between the core and terrestrial access network providing transport capabilities for the NG interface (e.g., N1/N2/N3 reference points). The satellite coverage plays no role, as the satellite system transparently carries the communication payload of all needed 3GPP reference points. Furthermore, the radio link can be either based on 3GPP RAT dependent or 3GPP RAT independent technology. This scenario is not a priority in RAN (i.e., the radio access network is not involved), however it is considered in the SA-2 working group [7].

C. *Channel Model*

The 3GPP channel model is defined in [8] for terrestrial links only. During the SI in Release 15, it has been necessary to define the specific propagation aspects for NTN (including HAPS). The main differences and peculiarities may be summarized in the following:

- the elevation angle between the satellite/HAPS and the UE can be much higher, resulting in different scattering statistics;
- the long distance between the satellite and the UE leads to almost no angular spread from the satellite;
- atmospheric effects (e.g., scintillations) may attenuate the transmitted signal.

The reader is invited to look at the section 6 of [4] for further details on NTN channel model guidelines. For completeness, the NTN modelling objectives have been summarized in Table 1.

Table 1: Objectives of NTN channel modelling

Target	Satellite	HAPS
Outdoor / Indoor	Only outdoor	Both
Frequency range	From 0.5GHz up to 100GHz	
Mobility	Up to 1000 km/h	Up to 500 km/h
Environment	Rural, suburban, urban, and dense urban	

The adopted methodology is to consider a new satellite link model between the satellite/HAPS and the terrestrial model, as depicted in Figure 5. The satellite link consists of the dynamic delay and Doppler shift (for LEO satellites only) and the dynamic attenuation due to rain, clouds and scintillations. The terrestrial part is very similar to the approach in [8], with specific parameter values obtained by ray-tracing simulations, including both large scale parameters (such as LOS probability, shadow fading and clutter loss) and fast fading parameters (such as angular spreads, K-factors, number of clusters, number of rays per cluster, …). It shall be noted that most of these parameters are elevation dependent.

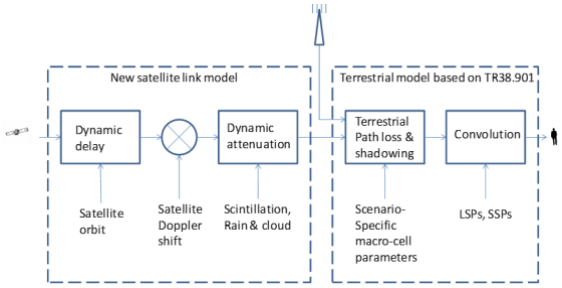

Figure 5: Conceptual drawing of combined satellite and terrestrial channel generation.

CURRENT ROADMAP IN RELEASE 16

The study phase in Release 16 is devoted to the analysis of the key aspects and potential issues involving the integration of NTN in 3GPP cellular systems. The outcomes will be reported in [5]. As depicted in Figure 6, this time the NTN SI has allocated resources in three RAN working groups: physical layer (RAN 1), link layer and protocols (RAN 2), and interfaces and network architectures (RAN 3).

A non-exhaustive list of potential areas of impact for all three working groups has been summarized in Table 2. The performance evaluation and the discussion of possible solutions will be concluded in December 2019.

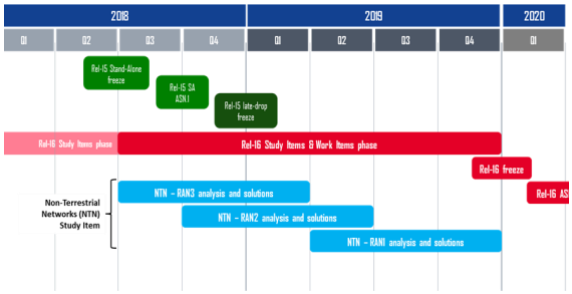

Figure 6: NTN Study item roadmap in Release 16.

Table 2: List of potential areas of impact for 5G-NR via satellite

RAN WGs	Potential Issues in 5G-NR
RAN-1	Mitigating Doppler and delay: • physical layer control procedures • uplink timing advance (TA) / RACH procedure • delay tolerant HARQ Performance assessment of 5G-NR in the selected deployment scenarios
RAN-2	Mitigating Doppler and delay: • timers of MAC/RLC control loops • random access response, TA parameters, scheduling request, etc. • 2-steps RACH Coping with moving cells: • Paging/hand-over procedures
RAN-3	Coping with moving cells: • RAN architecture • handling of network identities • paging and mobility management

CONCLUSIONS

This paper addressed the main achievements of NTN study items in the last two years of joint effort within the 3GPP standardization groups. The integration process is not ended yet, but it is closer than never before. The next challenge is the approval of a dedicated work item in Release 17, with the scope of writing the specifications for 5G-NR communications via satellite.

DISCLAIMER

Opinions, interpretations, recommendations and conclusions presented in this paper are those of the author, and those are not necessarily endorsed by the European Space Agency.

REFERENCES

[1] 3GPP RP-170717, "Study on NR to support Non-Terrestrial Networks", March 2017.
[2] 3GPP SP-170788, "Feasibility Study on using Satellite Access in 5G", March 2017.
[3] 3GPP TR 22.822, "Study on using Satellite Access in 5G", v.16.0.0, June 2018.
[4] 3GPP TR 38.811, "Study on New Radio (NR) to support non terrestrial networks", v.15.0.0, June 2018.
[5] 3GPP TR 38.821, "Solutions for NR to support Non-Terrestrial Networks (NTN)", v.0.5.0, April 2019.
[6] 3GPP TS 22.261, "Service requirements for the 5G system – Stage 1", v.16.4.0, June 2018.
[7] 3GPP TR 23.737, "Study on architecture aspects for using satellite access in 5G", v.0.6.0, March 2019.
[8] 3GPP TR 38.901, "Study on channel model for frequencies from 0.5 to 100 GHz", v.14.7.0, Sep. 2017.