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DYNASAT

Dynamic spectrum sharing and bandwidth-efficient techniques for high-throughput MIMO Satellite systems

D6.2: Standardization & Regulatory Action Plan

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Abstract

This document sets the standardisation and regulatory contexts in which the DYNASAT project takes place and identified the activities to be carried out in both standardisation (3GPP) and regulatory context for the DYNASAT features to be taken into account.

Keywords:

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DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc

EXECUTIVE SUMMARY

This document provides the plans for the activities related to standardization in 3GPP and the related actions in the regulatory domain. These actions focus in promoting 5G satellite access in both domains.

The standardization activities will leverage the on-going work in Release 17 on satellite integration carried out within 3GPP (especially TSG-RAN) under the Non-Terrestrial Network (NTN) items. Then, the work items which will be leveraged to introduce the DYNASAT features as part of the Release 18 to enhance the bandwidth efficiency and spectrum sharing capabilities of 5G satellite access providing direct connectivity to handset and Internet of Things (IoT) devices are identified.

The regulatory activities will aim at preparing material, through interactions with relevant organisations (e.g., national radio agencies) and monitoring of relevant ITU-R activities, in order to support the future establishment of the technical and regulatory conditions enabling enhanced spectrum sharing capabilities of 5G satellite access. The activities will also contribute to establish the ITU-R requirements for IMT-2020 satellite radio interfaces, to ease the further international recognition of NTN.

A first version of the report will be produced by the end of review period 1 (RP1), and a second updated version will be produced at RP2.

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ABBREVIATIONS

3GPP	Third Generation Partnership Project
BS	Base Station
BSS	Broadcast-Satellite Service
CA	Carrier Aggregation
CSI	Channel State Information
eMBB	enhanced Mobile BroadBand
eMBMS	enhanced Multimedia Broadcast/Multicast Service
DC	Dual Connectivity
DCI	Downlink Control Information
DRX	Discontinuous Reception
DSA	Dynamic Spectrum Access
DSS	Dynamic Spectrum Sharing
ESOA	EMEA Satellite Operators Association
GEO	Geostationary Earth Orbit
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
FDD	Frequency Division Duplexing
FDM	Frequency Division Multiplexing
FSS	Fixed-Satellite Service
HAPS	High Altitude Platform System
HARQ	Hybrid Automatic Repeat reQuest
HEO	Highly Elliptical Orbit
HIBS	HAPS as IMT Base Station
IMT	International Mobile Telecommunications
IoT	Internet of Things
ITU	International Telecommunications Union
IWF	Inter-Working Function
LEO	Low Earth Orbit
LTE	Long Term Evolution
MANO	Management and Orchestration
MIMO	Multiple Input Multiple Output
mMTC	massive Machine Type Communications
MEO	Medium Earth Orbit
MS	Mobile Service
MSS	Mobile Satellite Service

NB-IoT	NarrowBand-IoT
NFV	Network Function Virtualisation
NG-RAN	Next Generation – Radio Access Network
NGAT	Next Generation Access Technology
NGSO	Non Geostationary Synchronous Orbit
NR	New Radio
NTN	Non Terrestrial Networks
QoS	Quality of Service
RAN	Radio Access Network
RDSS	RadioDetermination-Satellite Service
RR	Radio Regulations
SA	System and Architecture
SDN	Software Defined Networks
SLA	Service Level Agreement
SRS	Sounding Reference Signal
SSIG	Support to Standardization Interest Group
TDD	Time Division Duplexing
TDM	Time Division Multiplexing
TRP	Transmission Point
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
uRLLC	ultra Reliable and Low Latency Communications
UTRAN	UMTS Terrestrial Radio Access Network
V2X	Vehicular-to-Everything
VSAT	Very Small Aperture Terminal
WID	Work Item Description
WRC	World Radiocommunication Conference

1 INTRODUCTION

This document recalls the standardisation and regulatory contexts in which the DYNASAT project takes place. It identifies the existing New Radio (NR) features which will be enhanced thanks to the DYNASAT research and the activities to be carried out in both the standardisation (3GPP) and regulatory contexts for the DYNASAT features to be taken into account.

2 RECALL OF DYNASAT TASK 6.2 DESCRIPTION

The objectives of this Task are to:

- Promote the need for standardising the features supporting bandwidth efficiency transmission techniques, as well as spectrum sharing techniques, for satellite access network as part of the 3GPP Release 18. We shall use the Support to Standardization Interest Group (SSIG) to collect the initial support and then promote to the rest of the 3GPP eco-system. Note that most SSIG members have already supported the preliminary Non-Terrestrial Networks (NTN) roadmap in 3GPP presented to TSG-RAN plenary in December 2019, which includes some of the features considered by DYNASAT (e.g., coordinated MIMO).
- Identify the 3GPP technical specifications (RAN1, RAN2, RAN3, RAN4) that need to be adapted to support the proposed techniques.
- Prepare/promote technical contributions to define the features supporting bandwidth efficiency transmission techniques, as well as spectrum sharing techniques, for satellite access network as part of the 3GPP Release 18 Work Item (typically follow-up of the Release 17 NR-NTN Work Item), as well as RAN4 specific Work Items possibly reviewing some of the performance requirements for User Equipments (UE) and Base Staitons (BS).
- Coordinate with relevant stakeholders having interest in NTN standardisation in 3GPP.

Furthermore, the task will prepare/promote the contributions to ITU-R/CEPT that propose needed adaptations of the regulatory framework for satellite and mobile services sharing selected frequency bands (see T2.3 outcomes).

3 STANDARDIZATION ACTION PLAN

3.1 Rationale for Satellite network solutions for 5G

The 5G ecosystem, system architecture, and radio access technology that are currently being defined provide a broad range of design flexibilities and capabilities (e.g., deployment scenarios) that are of great potential benefit to Satellite Communication (SatCom) solutions.

Integration of SatCom solutions into the 5G system can take place at different levels, as depicted in [1]; notably:

- The integration of satellite at data network level. Non 3GPP defined Satellite access network can be used as transport network for backhaul purposes. It is configured by the 5G network management system to support the required Service Level Agreements (SLA).
- The integration of satellite at core network level. Non 3GPP defined Satellite access network can be used to provide 5G services to satellite specific terminals. This requires to implement some Inter Working Function (IWF) in the satellite access network to provide the 3GPP defined NG interface (N1, N2 & N3 interface points);
- The integration of a satellite at radio access network level. A 3GPP defined satellite access network can serve directly 5G devices and provide seamless service continuity beyond areas covered by 5G cellular network infrastructures.

On one hand, the integration of a satellite at data and core network levels allows legacy SatCom solutions to contribute to the provision of selected 5G services. This carries forward a fragmented SatCom market with no interoperability between SatCom system vendors and a loose integration with cellular systems.

On the other hand, the integration of a satellite at radio access level refers to the definition of a global satellite radio interface standard leveraging 3GPP defined 5G standard for all SatCom systems. This approach is characterised by a full integration of satellite in the 5G eco system creating new opportunities for:

- satellite stakeholders
  - To create global market and a unique technology framework for the satellite network solutions whatever orbit, frequency band, terminal types (smart phones, Very Small Aperture Terminal, etc.), services with open architectures that create market opportunity for Small and Medium Enterprises.
  - To access a wider ecosystem to develop equipment for future satellite network infrastructure and terminals and access development tools and human skills resulting in the reduction of costs associated to procurement, operation, and maintenance of satellite networks.
  - To support multi-vendor interoperability and, in particular, create a global market for satellite terminals with sufficient volume to encourage investment on low cost and self-installation user devices.
  - To address the requirements of typical user groups of SatCom solutions (e.g., transport, logistics, public safety, agriculture, security of utilities) calling for standard for a reduction of their overall procurement/operation/maintenance expenses.
- cellular stakeholders
  - To offer seamless global coverage and increased reliability through native Support of Mobility and Multi connectivity across cellular and satellite access.

- To enrich cellular products and technologies with satellite features.
- To ease spectrum sharing through cooperation between both cellular and satellite component.

The main targeted 5G satellite network scenarios for 3GPP standardisation activities are:

- 3GPP defined Satellite access network providing direct connectivity between satellite(s) and user equipment
  - Geostationary Earth Orbit (GEO) and Non Geostationary Synchronous Orbit (NGSO) systems operating in sub 6 GHz band and addressing IoT devices with narrowband service.
  - NGSO systems operating in sub 6 GHz band and addressing handset devices with wideband services.
  - GEO and NGSO systems operating in Ku or Ka band and addressing VSAT type devices (fixed and vehicle mounted) with broadband services.
- Satellite transport networks (based on 3GPP or non 3GPP defined access networks) providing connectivity to base stations or local access points (backhaul).

One should distinguish different non-terrestrial vehicles and their capabilities, as reported in Table 1.

Table 1 – Non-Terrestrial Network capabilities

	HAPS	LEO	MEO	GEO
Altitude [km]	8 to 50	300 to 2000	8000 to 25000	35786
Coverage	Area of several hundred kilometers diameter	Up to Worldwide	Up to Worldwide	Regional between +/-70) latitude and up to 100° longitude span
5G services support with 3GPP class 3 devices (FR1), (Note 1)	eMBB, mMTC, uRLLC	eMBB, mMTC	mMTC, [eMBB]	mMTC, [eMBB]
5G services support with Directional antenna devices (FR1 or FR2), (Note 2)	eMBB, mMTC, uRLLC	eMBB, mMTC	eMBB, mMTC	eMBB, mMTC
Latency (Note 3)	Latency comparable to NG-RAN based Cellular network	Latency comparable to LTE based Cellular network	Latency comparable to UTRAN based Cellular network	Latency comparable to GSM/GPRS based cellular network
Added value for 5G system	Service coverage extension through direct access, network resiliency + Backhaul			
Note 1: Targeted services with possible service rate limitation (e.g. edge coverage performances) **Note 2: Directional antenna devices may refer to building or vehicle mounted devices with directional antenna such as parabolic or phased array antenna but also handset with high gain antenna (e.g. protuberating)** **Note 3: The QoS over a high latency access may be degraded for delay sensitive applications. This can be mitigated by combining the high latency access with a relatively low latency access technologies (e.g. cellular, HAPS or LEO based access) and the use of appropriate traffic steering techniques across these access technologies.**				

For the 3GPP standardisation work, non-terrestrial network specific characteristics compared to cellular networks' shall be taken into account. These are summarised in Table 2.

Table 2 – Non-Terrestrial Network specific characteristics compared to cellular networks for the New Radio protocol to be NTN friendly

Effects		HAPS	LEO	MEO	GEO	HEO
Motion of the space/aerial vehicles	Moving cell pattern	Yes if beams are moving on earth	Yes if beams are moving on Earth (hence high speed)		No	Yes if beams are moving on Earth (hence high speed)
		No if beams are fixed on Earth				No if beams are fixed on earth
	Delay variation	No	High (Note 1)	Medium (Note 1)	No	Low (Note 1)
	Doppler	Low	High (Note 1)	Medium (Note 1)	Negligible	Low (Note 1)
Altitude [km]	Latency	Negligible	Low	Medium	High	High
Cell size	Differential delay	Small	Typically relatively medium	Typically relatively medium	Possibly relatively high	Possibly relatively high
Propagation channel	Frequency selectiveness impairments	Note 2			No	No
	Delay spread impairments	Note 2			No	No
Duplex scheme	Regulatory constraints	FDD and Possibly TDD	FDD and Possibly TDD	Only FDD	Only FDD	Only FDD
Note 1: Doppler and Delay variation can be pre compensated at beam centre. In such case residual Doppler and Delay variation is commensurate to the ones in cellular and can be accommodated by the UE						
Note 2: Some delay spread and frequency selective effect can be experienced in case of omni-directional antenna device especially at low elevation angle						

3.2 Satellite standardisation activities in 3GPP

During the definition of Release 15 and Release 16, 3GPP studied the feasibility and the standard enhancements needed to enable NR communication over satellite systems.

The Study Item phase has identified issues and consequently defined the recommendations on necessary features and adaptations enabling the operation of the NR protocol in NTN. The enhancing features to address the identified issues due to long propagation delays, large Doppler effects, and moving cells in NTN are captured in TR 38.821 (Release 16), [2].

At the RAN#86 meeting in Sitges, Spain, in December 2019, the corresponding Release 17 Work Item RP-193234 was approved, [3] revised in [4], with the aim to specify the enhancements identified for NR NTN and core part completion by June 2021 (RAN#92), and the RAN4 performance part by December 2021 (RAN#94). The focus is on transparent (non-regenerative) payload satellite systems for both Low Earth Orbit (LEO) and GEO scenarios.

Considering the effects that e-meetings in 2020 had on the work's progress and the pressure that cancellation of all face-to-face meetings has created, a new timeline for 3GPP Release 17 was approved at TSG#90-e Plenaries, in December 2020. This new timeline is depicted in Figure 1, in which all satellite related activities during Releases 15, 16, and 17 are reported, and summarized as follows:

- Release 17 Stage 2 Functional Freeze, June 2021 (TSGs#92-e)
- Release 17 Stage 3 Protocol Freeze, March 2022 (TSGs#95)
- Release 17 Protocol coding Freeze (ASN.1, OpenAPI), June 2022 (TSGs#96)

It is worth noting that only the timeline for the work to be performed has changed: the content of Release 17 remains as approved during the December 2019 TSG#86 meetings.

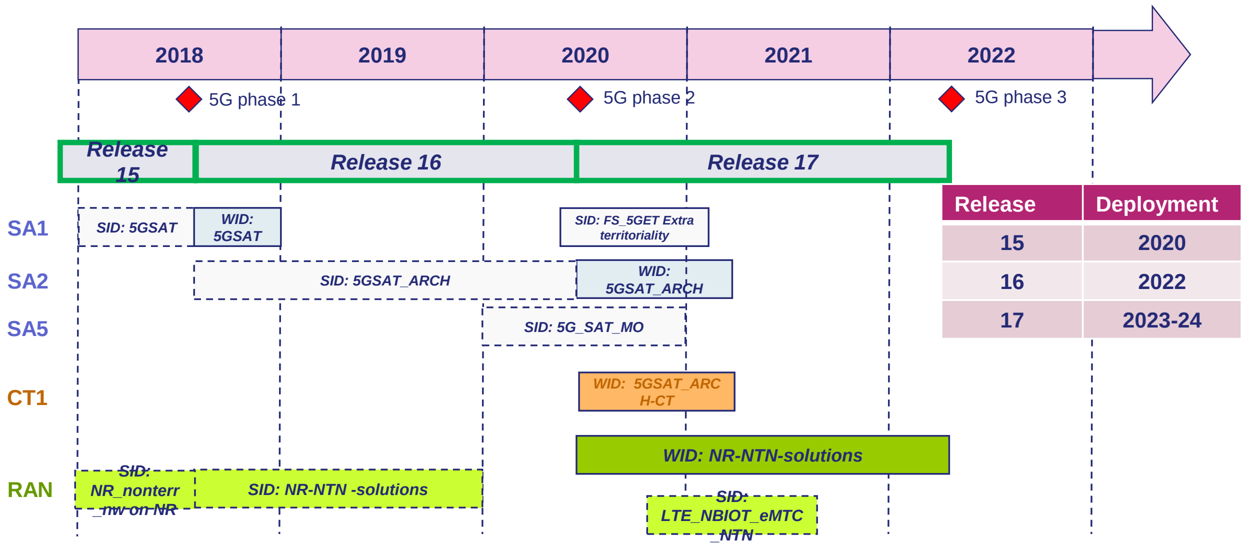

Figure 1 – Satellite related activities in 3GPP roadmap

Table 3 lists all of the satellite related activities during Releases 15, 16 and 17.

Table 3 – List of satellite related study and work items in 3GPP

Release	Item reference	Lead WG	Title	3GPP doc	Completion	Rapporteurs
15	SI "FS_NR_nonterr_nw on NR"	RAN	Study on New Radio (NR) to support Non Terrestrial Networks (Release 15)	TR 38.811	June 2018	N. Chuberre - Thales
	SI "FS_5GSAT"	SA1	Study on using Satellite Access in 5G; Stage 1 (Release 16)	TR 22.822	June 2018	C. Michel – Thales
16	SI "FS_NR_NTN_solutions"	RAN3	Solutions for NR to support non-terrestrial networks (NTN) (Release 16)	TR 38.821	Dec 2019	N. Chuberre - Thales
	WI "5GSAT"	SA1	Service requirements for the 5G system; Stage 1 (Release 16)	CR to TS 22.261	Dec 2018	C. Michel – Thales

	SI “FS_5GSAT_ARCH”	SA2	Study on architecture aspects for using satellite access in 5G (Release 16)	TR 23.737	June 2020	C. Michel - Thales
	SI “FS_5G_SAT_MO”	SA5	Study on management and orchestration aspects of integrated satellite components in a 5G network	TR 28.808	March 2021	C. Michel – Thales
17	WI “NR_NTN_solution”	RAN2	Solutions for NR to support non-terrestrial networks (NTN)	CR to TS 38.XXX	March 2022	N. Chuberre - Thales
	WI “5GSAT_ARCH”	SA2	Integration of satellite systems in the 5G architecture	CR to TS 23.XXX	March 2021	J.Y. Fine - Thales
	WI “5GSAT_ARCH-CT”	CT1	Study on PLMN selection for satellite access	TR 24.821	March 2021	A. Catovic – Qualcomm
	SI “FS_LTE_NBIOT_eMTC_NTN”	RAN1	Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN)	TR 36.763	June 2021	G. Charbit – MediaTek, Sanaa El Moumouhi – Eutelsat
18	FS_5GET “Extra territoriality”	SA1	Guidelines for extra-territorial 5G Systems (5GS)	TR 22.961	March 2021	C. Michel - Thales

As part of the Release 17 RAN2 led Work item “NR_NTN_solutions”, a set of features are being defined for the provision of enhanced Mobile BroadBand (eMBB) services via LEO and GEO satellite assuming Frequency Division Duplexing (FDD) mode, Earth-fixed Tracking area, UEs with Global Navigation Satellite System (GNSS) capabilities, handheld devices in FR1 band (e.g., Power class 3), VSAT devices with external antenna (including fixed and moving platform mounted devices) at least in FR2 band.

- Main physical layer enhancements:
    - Timing relationship enhancements.
    - Enhancements on UL time and frequency synchronization.
    - Hybrid Automatic Repeat request (HARQ): enabling/disabling of HARQ feedback.
- Main access layer enhancements:
    - User plane: Random Access procedure, UL scheduling, Discontinous Reception (DRX) when HARQ disabled or turned off, extension of timer/value range for status reporting and sequence numbers.
    - Control plane: assistance for cell selection/reselection, assistance to trigger hand-over and measurement, NTN-TN service continuity, applicability of LCS to NTN.
- Main Radio access network architecture enhancements
    - Feeder link switch over, network identities handling, registration update and paging handling, cell relation handling.

As part of the Release 17 RAN1 led Study Item “FS_LTE_NBIOT_eMTC_NTN”, band sub 6 GHz, PC3 or PC5 devices, LEO and GEO, transparent payload, UE with GNSS capability and with the capability to estimate and pre-compensate timing and frequency offset with sufficient accuracy for UL transmission are being assumed. The following objectives for the study are:

- Evaluate and confirm solutions to address necessary specifications for NarrowBand IoT (NB-IoT) and massive Machine Type Communications (mMTC) to support NTN.
- Study and recommend necessary changes to support NB-IoT and mMTC over satellite addressing in particular Random Access procedure/signals, mechanisms for time/frequency adjustment including Timing Advance and UL frequency compensation indication, timing offset related to scheduling and HARQ-ACK feedback, HARQ operation, timers (e.g., SR, DRX, etc.), idle mode and connected mode mobility, RLF-based for NB-IoT, handover-based for mMTC, System information enhancements, Tracking area enhancements.

3.3 Main features to be developed by DYNASAT to be standardised

3.3.1 Bandwidth efficient techniques

The DYNASAT Project will leverage on the on-going standardization work within 3GPP Release 17 to define the necessary features that will make 5G devices and NG-RAN support satellite operations. By exploiting the research results, the DYNASAT Consortium will contribute to the next 3GPP releases (execute Release 18 and prepare Release 19) by promoting respective Work Items at plenary level and then defining the necessary features in the 5G standard at working group level.

The project will research the applicability of bandwidth efficient transmission techniques developed for 5G NR systems in the context of LEO based satellite access network infrastructure to maximise spectrum usage and provide higher performance. Among the techniques that will be investigated are (but are not limited to): full frequency reuse based on multi-satellite cooperative multiuser Multiple Input Multiple Output (MIMO), multibeam precoding, precoding with user clustering, beam hopping, and advanced interference management.

Particularly, the project will leverage on the on-going enhancements on MIMO for NR that were included already in Release 16 and further enhanced in Release 17. The Work Item Description (WID) of the Enhancements on MIMO for NR in Release 16 can be found in RP-182863, [5], and the WID of Further enhancements on MIMO for NR in Release 17 is captured in RP-193133, [6]: overall, the Release 15 MIMO features offer ample foundation for further potential enhancements which are unlocked in Release 16 and Release 17. Release 16 introduces enhanced beam handling and channel-state information (CSI) feedback, as well as support for transmission to a single UE from multiple transmission points (multi-TRP). These enhancements increase the throughput, reduce the overhead, and/or provide additional robustness. Release 17 aims to specify the further enhancements identified for NR MIMO: enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1, enhancement on the support for multi-TRP deployment, enhancement on Sounding Reference Signals (SRS) and on CSI measurement and reporting.

One potential feature included in both Work Items is the enhancement on multi-TRP/panel transmission and reception including improved reliability and robustness with both ideal and non-ideal backhaul. Downlink multi-TRP transmission is already introduced in 3GPP Release 16: both single Downlink Control Information (DCI) based and multi DCI based multi-TRP transmission are supported: in the NTN context, it would be challenging to use single DCI based multi-TRP transmission as the transmission from the two TRPs should be tightly time-aligned.

But, for further study: whether multi DCI based multi-TRP can be used in NTN and what are needed enhancements if any.

Additionally, it is for further studies whether asynchronous NR-NR Dual Connectivity (DC) and Carrier Aggregation (CA) would be beneficial for NTN and whether some enhancements are needed. There was a Work item to introduce asynchronous NR-NR DC in Rel-16 specifications. Such enhancement reduces latency for setup and activation of DC, thereby leading to improved system capacity and the ability to achieve higher data rates. The work item description on enhancements to DC and CA can be found in RP-191600, [7]. Such enhancements avoid need to synchronize gNBs and allow non-co-located deployments.

Leveraging on a comprehensive investigation of State-of-the-Art point to multipoint (PTM) technologies including enhanced Multimedia Broadcast/Multicast Service (eMBMS) 3GPP LTE Rel-14 as well as eMBMS support in Release 17 of 5G NR, the DYNSAT project will develop broadcast and multicast capabilities for 5G satellite air interface.

NR broadcast/multicast feature support is not specified in NR Release 15 and Release 16. However, there are important use cases for which broadcast/multicast could provide substantial improvements, especially in regards to system efficiency and user experience. Therefore, a study item on the Architectural enhancements for 5G multicast-broadcast services has been approved in SP-190625, [8]. The main objective is about enabling general MBS services over 5GS and the uses cases identified that could benefit from this feature include, but not limited to; public safety and mission critical, Vehicular-to-Everything (V2X) applications, transparent IPv4/IPv6 multicast delivery, IPTV, software delivery over wireless, group communications and IoT applications. The basic RAN functions for broadcast/multicast for UEs in RRC_CONNECTED state as well as IDLE/INACTIVE state are being specified in Release 17 under agenda item: 9.10.8. The related WID can be found in RP-201038, [9].

3.3.2 Spectrum sharing techniques

Among the techniques that will be investigated is the Dynamic Spectrum Access (DSA), especially by taking the advantage of the same radio interface of terrestrial and satellite communications, developing solutions for NGSO systems and understanding new environments of use, adapting and inventing solutions of protection with respect to new interference issues, while maintaining the key design characteristics of a given system;

Current NR specifications supports flexible spectrum use through mechanisms including NR supports of spectrum sharing with LTE. Dynamic Spectrum Sharing (DSS) provides a very useful migration path from LTE to NR by allowing LTE and NR to share the same carrier. DSS was included already in Rel-15 and further enhanced in Release 16 and Release 17.

Similar feature needs be investigated to support spectrum sharing between NR TN and NTN. The operating carrier of NR TN and NR NTN can be overlapped or adjacent. From network perspective, NR TN users and NR NTN users can share and co-exist on the overlapped carrier in Frequency Division Multiplexing (FDM) or Time Division Multiplexing (TDM) manner, with dynamic scheduling or semi-static configurations.

3.4 Promotion of DYNASAT features for standardisation

The Release 18 package of Study and Work Items is expected to be approved at the TSG-RAN plenary of March 2022, while the discussions will start at the plenary meeting in June 2021.

Hence, the DYNASAT consortium plans to submit for RAN#92 (June 2021) meeting the following set of contributions:

- A TDOC justifying the added value of the proposed DYNASAT techniques.
- A preliminary Work Item (WI) proposal including justification/objective (impacted RAN1, 2, 3, 4 WG).

- A TDOC proposing an overall NTN roadmap (update of the roadmap presented in 3GPP RAN#86/Sitges, see RP-192501**, [10]**) in which the Release 18 features are highlighted.

With the support of the University of Bologna, Magister Solutions, and Fairspectrum Oy, Thales will promote its WI proposal to 3GPP members via different channels among which:

- SSIG (Support to Standardization Interest Group): gathering SatCom stakeholders.
- EMEA Satellite Operators Association (ESOA) pre stand group: European and Middle East Satellite Operator Group.

Note that Thales has managed to collect more than 70 co-sources to the first work item on satellite approved as part of the Release 17 and will leverage its network.

3.5 Standardisation activity

The Release 18 content and timeline is yet-to-be-defined. The prioritization process on Release 18 features, should be complete by March 2022, with the Release 18 Package Approval scheduled for TSGs#94 planned for December 2021.
It is possible that the duration of the release could be short that is 15 months with a Stage 3 Protocol Freeze in June 2023 (TSGs#100).

The DYNASAT consortium plans to lead (as rapporteur) and contribute to the Work Item enhancing the support of NTN.

4 REGULATORY ACTION PLAN

4.1 State of play

4.1.1 Spectrum aspects

The mobile broadband applications are known in ITU under the generic acronym IMT. The various generations of mobile systems have their ITU corresponding designation:

- 2G: IMT.
- 3G: IMT-2000.
- 4G: IMT-Advanced.
- 5G: IMT-2020.

In the ITU Radio Regulations (RR), the table of frequency allocations defines the services (in the ITU sense) that can use any specific portion of spectrum. For mobile cellular systems, the relevant application is the Mobile Service (MS), while mobile satellite services rely on Mobile-Satellite Service (MSS) allocations.

Certain MS allocations are identified for use by IMT in the table of frequency allocation (RR Article 5, [11]), which provides the necessary recognition and harmonisation for individual national regulators to make the spectrum available for the service.

Since 1992, the ITU has developed the concepts of terrestrial and satellite components of IMT, relying respectively on MS and MSS allocations. In effect, most of the MSS allocations above 1 GHz are also identified for the satellite component of IMT. Except the noticeable exception of the 2 GHz MSS band, bands identified for the terrestrial and the satellite component of IMT do not overlap. Therefore, under the current regulations, systems as envisaged in DYNASAT (i.e., implementing optimized spectrum sharing between cellular and satellite) could only be allocated in the 2 GHz MSS band, while other bands are suited to host stand-alone cellular or satellite systems. The objective of increased capacity could be reached by relying on terrestrial IMT bands for the DYNASAT satellite access.

The implementation of the DYNASAT concept of efficiently shared spectrum for combined terrestrial and satellite access for 3GPP-standardized UEs will likely require adaptations of the regulatory framework applying in terrestrial MS bands.

In the ITU context, the satellite and terrestrial spectrum matters are sensitive, hence any proposal should be consolidated, discussed and endorsed by relevant involved parties before being brought forward in regulatory groups.

4.1.2 Radio interface aspects

The ITU-recognized radio interface specifications for IMT are described in ITU Recommendations. For the terrestrial component of IMT, the interface specifications are mainly developed in 3GPP, and agreed by ITU through an ad-hoc process as per ITU-R Resolution 65 on *Principles for the process of future development of IMT for 2020 and beyond*, [12].

The graph reported in Figure 2 illustrates such process.

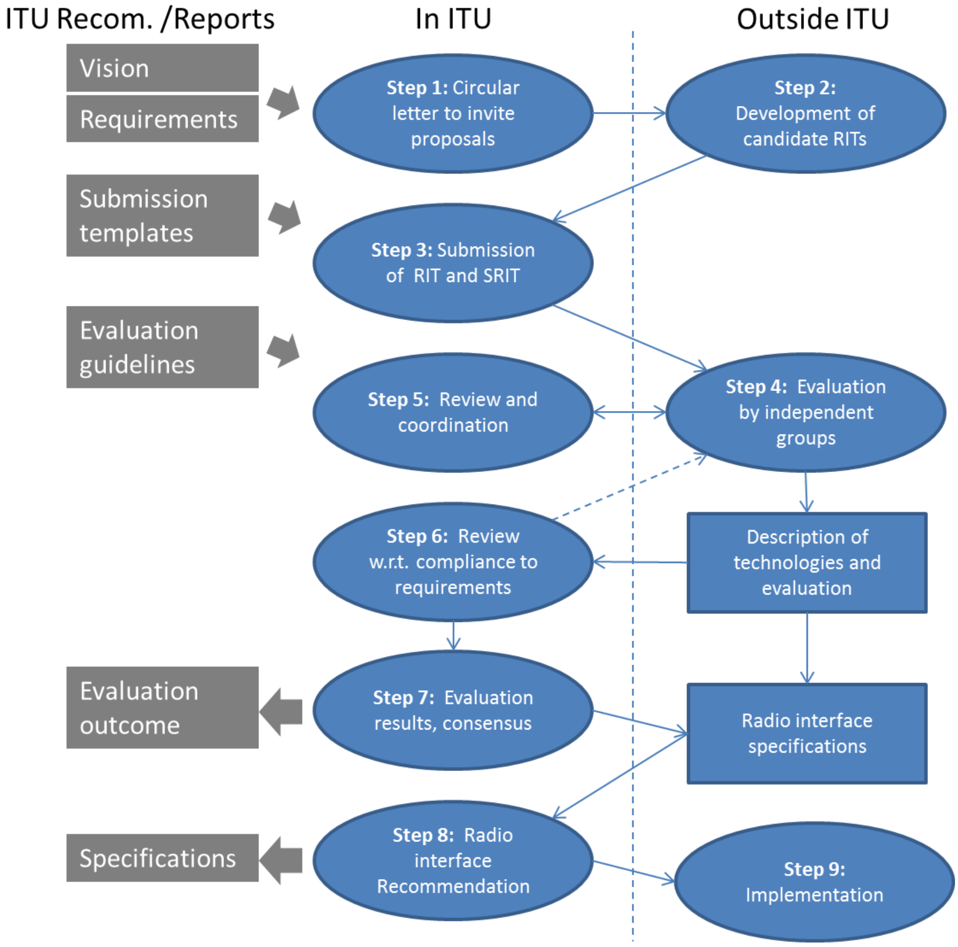

Figure 2 - IMT interfaces elaboration process

As of early 2021, the schedule for the IMT-2020 interfaces approval is as shown in Figure 3.

It can be observed that the whole process, now almost completed for 3GPP Release 16 specifications, lasted almost 5 years. For subsequent 3GPP releases (e.g., Release 17 that include NTN), only a revision of the ITU-R Recommendation containing the specifications may be required.

Table 4 - ITU deliverables for IMT interfaces provides the references of relevant deliverables for the various generations of IMT systems for both the satellite and terrestrial component.

At this stage, and unlike for 3G and 4G, there is no consolidated plan to develop satellite-specific radio interface specifications for 5G / IMT-2020.

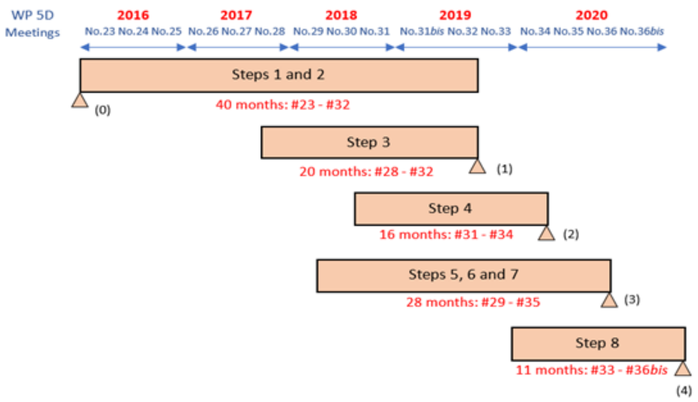

Figure 3 - IMT-2020 approval timeline

Table 4 - ITU deliverables for IMT interfaces

	IMT-2000		IMT-Advanced		IMT-2020	
	Terrestrial	Satellite	Terrestrial	Satellite	Terrestrial	Satellite
Vision	Rec M.687&M.816 **1992**	Rec M.818 **1994**	Rec. M.1645 **2003**		Rec M.2083 **2015**	?
Requirements	Rec M.1034 **1997**		Rep M.2134 **2008**	Rep M.2176 **2010**	Rep M.2410 **2017**	
Submission templates	8/LCCE/47 **1998**		Rep M.2133 **2008**		Rep M.2411 **2017**	
Evaluation guidelines	Rec M.1225 **1997**		Rep M.2135 **2009**		Rep M.2412 **2017**	
Outcome			Rep M.2198 **2010**	Rep M.2279 **2013**	Rep M.2483 **July 2020**	
Specifications	Rec M.1457 **2000** **Last version 2017**	Rec M.1850 **2000** **Last version 2014**	Rec M.2012 **2012** **Last version 2018**	Rec. M.2047 **2013**	Rec. M.2150 **Feb 2021**	

4.1.3 Other relevant ITU activities and background

The ITU-R has developed the ITU-R Report M.2460 on *Key elements for integration of satellite systems into Next Generation Access Technologies*, [13]. This report was approved in 2019. With integration of satellite systems into NGAT, it is meant in the scope of this report that the satellite element of the end-to-end network can be seamlessly managed, (e.g., ensuring end-to-end Quality of Service (QoS), Network Slicing, Software Defined Networks (SDN), Network Functions Virtualisation (NFV), Management and Orchestration (MANO), etc.). It is therefore not about “integrating” at the RAN level. As DYNASAT targets a RAN level integration, this Report is not directly relevant, in its current form, but provides valuable information on specific use cases for satellite in 5G.

World RadiocommunicationConference 23 (WRC-23) Agenda Item 1.4 aims at considering the use of High-Altitude Platform Stations (HIBS) in the mobile service in certain frequency bands below 2.7 GHz. Specifically, the bands 694-960 MHz, 1710-1885 MHz and 2500-2690 MHz are in the scope of this agenda item. Note that IMT terrestrial identifications around 2 GHz are not in this agenda item, as they are already identified for High Altitude Platform use in the Radio Regulations. This agenda item is of interest because the type of integration sought for HIBS (Base station on a HAPS) is similar to the DYNASAT concept (Base station on a satellite) and, in addition, in 3GPP, the NTN concept encompasses both HAPS and Satellite. There could be commonalities in the technical issues to be solved, the regulatory solutions envisaged and the interactions between 3GPP and ITU.

Resolution 212 modified by WRC-19 addresses the implementation of IMT around 2 GHz. WRC-19 amended this Resolution in its Annex 1 to provide guidance on the implementation of technical and operational measures to facilitate coexistence between terrestrial and satellite components of IMT in the MSS S-band (i.e., 1980-2010 MHz and 2170-2200 MHz). Resolution 212 also invites to further studies on possible technical and operational measures to improve such coexistence situation when these frequency bands are shared in different countries by independent satellite and terrestrial components of IMT. Such studies may be of relevance for some DYNASAT sharing scenarios, noting that DYNASAT is not targeting independent operations, but rather tight integration with cellular networks. It is unclear yet if any such studies will be undertaken.

4.2 Relevant regulatory forums

The relevant ITU fora are:

- Working Party 5D (WP5D), responsible for the overall radio system aspects of IMT systems, comprising the IMT-2000, IMT-Advanced and IMT for 2020 and beyond.
- Working Party 4C (WP4C), responsible for the efficient orbit/spectrum utilization for the MSS and the radiodetermination-satellite service (RDSS).
- Working Party 4B (WP4B), responsible for systems, air interfaces, performance and availability objectives for FSS, BSS, and MSS, including IP-based applications and satellite news gathering
- WRC: responsible for reviewing the Radio Regulations, including frequency allocation to radio services. The next WRC is planned for 2023. Planning was made prior to covid pandemic.
- Radiocommunication Assembly (RA), responsible for the structure, programme, and approval of radiocommunication studies. It approves the ITU-R Resolutions, including Resolution ITU-R 65, setting the process for IMT-2020 radio interface approval. RA meeting are held in conjunction with WRCs, i.e. every 3-4 years. The next RA meeting is planned in 2023. Planning was made prior to covid pandemic.

At the European level: ECC PT1 is responsible for IMT matters.

4.3 Targeted objectives

The Objective 9 of the DYNASAT project proposal is as follows:

Contribute to the preparation of WRC-2023 in order to promote the evolution of the regulatory framework needed to support efficient spectrum sharing between Satellite and Mobile Services in the targeted bands allocated to satellite and/or mobile services.

More specifically, Task 6.2, in addition to standardisation activities, is labelled:

Furthermore, the task will prepare/promote the contributions to ITU-R/CEPT context that propose needed adaptations of the regulatory framework for satellite and mobile services sharing selected frequency bands (see T2.3 outcomes).

Enabling satellite use of cellular bands is a considerable regulatory challenge. Decisions are taken in ITU based on consensus; hence, it is of critical importance that the main stakeholders in the decision-making have formed a favourable opinion with respect to the above objectives. Making untimely, or not sufficiently supported, proposals could prove counter-productive.

Therefore, the optimal impact creation for DYNASAT in the regulatory domain will be to prepare analyses and background material for later use, when appropriate. Interactions with third parties outside the project (e.g., selected national Radio agencies) will be sought to consolidate findings.

The general objective can be adjusted and broken-down into two main areas:

- Satellite use of cellular bands: study the potential technical conditions and associated regulatory measures that would enable sharing between satellite and terrestrial mobile networks in the targeted bands.
- IMT interfaces: facilitate the long-term acceptance of satellite access as part of the ITU approved IMT-2020 interfaces, resulting from 3GPP 5GNR updated specifications which include NTN.

Regarding the satellite use of cellular bands, the studies carried-out in Task 2.3 will determine the options and limitations. Hence, it is required to first consolidate Task 2.3 results before elaborating specific proposals. However, the first year of the project will be used, in relation to Task 2.3, to exchange with external entities to raise awareness and build more robust analyses. In addition, during the first year of the project, DYNASAT will monitor relevant developments in ITU related Resolution 212 and Agenda Item 1.4 (HIBS).

Regarding IMT interfaces, the final approval of Release 17 (which will include NTN features) is not expected to occur before Q2 2022. In the meantime, DYNASAT will foster awareness in ITU of the work undertaken in 3GPP on NTN Release 17 by favouring liaison activity between 3GPP and ITU. In addition, DYNASAT will contribute to the preparation of ITU deliverables setting the requirements and evaluation process for IMT-2020 satellite interfaces.

4.4 Actions to be undertaken towards the objectives

The actions reported in Table 5 are of the first year of the project (up to PR1 review at T0+12) to meet the objectives described in the previous section. They will be revised on a yearly basis.

Table 5 - Actions for year 1.

#	Description	Target group/entities	Target start date
1	Monitor developments related to Resolution 212 and HIBS (WRC-23 Agenda Item 1.4)	WP5D, WP4C, ECC/PT1	Q1-2021

2	Follow-up of 3GPP LS to ITU-R WP 5D/4C/4B providing status on NTN in Release 17	3GPP, WP5D/4C/4B as appropriate	Q1-2021
3	Contribute to the development of IMT-2020 satellite radio interfaces requirements in ITU-R	WP4D mainly, WP5D as necessary	Q2-2021
4	Raise awareness, and build technical/regulatory exchanges with external entities on cellular/satellite spectrum sharing.	Selected Radio agencies	Q1 2021

5 CONCLUSION

To satisfy the overall telecommunication market needs, the 5th Generation network (5G) requires a blend of network technologies and, therefore, a seamless and harmonized combination of access technologies including satellite. 3GPP is paving the way for the development of such network of networks where satellite is being seamlessly integrated as part of the Release 17. DYNASAT project will contribute to enhance the standard to offer higher performance and allow access to new spectrum for future 5G satellite access.

In parallel, the project will evaluate how to influence the regulatory framework so that the satellite radio interface as defined by 3GPP leveraging the 5G New Radio can be taken into account in the IMT-2020 framework.

REFERENCES

[1]. N. Chuberre, S. Anjuere, C. Michel, "Benefits and constraints associated to 5G satellite networks," *10th Advanced Satellite Multimedia Systems Conference (ASMS) and 16th Signal Processing for Space Communications Workshop (SPSC)*, October 2020.

[2]. 3GPP TR 38.821, "Solutions for NR to support Non-Terrestrial Networks (NTN) (Release 16)," January 2020

[3]. 3GPP RP-193234, Work Item on "Solutions for NR to support non-terrestrial networks (NTN)", Thales, submitted at 3GPP RAN#86, December 2019

[4]. 3GPP RP-202908, Work Item on "Solutions for NR to support non-terrestrial networks (NTN)", Thales, submitted at 3GPP RAN#90-e, December 2020 (revision of approved WI at 3GPP RAN#86 in Sitges/Spain, December 2019)

[5]. 3GPP RP-182863, Work Item on "Revised WID: Enhancements on MIMO for NR," Samsung, submitted at 3GPP RAN#82, December 2018

[6]. 3GPP RP-193133, Work Item on "New WID: Further enhancements on MIMO for NR," Samsung, submitted at 3GPP RAN#86, December 2019

[7]. 3GPP RP-191600, revised Work Item on "Multi-RAT Dual-Connectivity and Carrier Aggregation enhancements," Ericsson-Nokia-Nokia Shangai Bell, submitted to 3GPP RAN#84, June 2019

[8]. 3GPP SP-190625, revised Study Item on "Architectural enhancements for 5G multicast-broadcast services," SA WG2, submitted to 3GPP SA#85, September 2019

[9]. 3GPP RP-201038, revised Work Item on "NR Multicast and Broadcast Services," Huawei-HiSilicon, submitted to 3GPP RAN#88-e, July 2020

[10]. 3GPP RP-192501, "Rel-17 NTN Work Item proposed approach," submitted to 3GPP RAN#86, December 2019

[11]. ITU-R Radio Regulations, Edition of 2020, available at: https://www.itu.int/pub/R-REG-RR

[12]. ITU-R Resolution 65, "Principles for the process of future development of IMT for 2020 and beyond," 2015

[13]. ITU-R Report M.2460-0, "Key elements for integration of satellite systems into Next Generation Access Technologies," July 2019

