



**Satellite Earth Stations and Systems (SES);
Seamless integration of satellite and/or HAPS
(High Altitude Platform Station) systems into 5G
and related architecture options**

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Modal verbs terminology

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1 Scope

The present document identifies how to integrate satellite and/or HAPS communication systems in 5G system for relevant use cases. The report identifies the necessary standardization activity in relation to the integration of satellite or HAPS in the 5G system.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long-term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ARIB 2020 and Beyond Ad Hoc Group White Paper, October 2014.

NOTE: Available at https://www.arib.or.jp/english/image/committee/adwics/02-00_2020bah/20bah-wp-100.pdf.

[i.2] NGMN 5G White Paper v1.0.

[i.3] ESOA 5G White Paper, "Satellite Communications Services: An integral part of the 5G Ecosystem," European and middle east Satellite Operator Association, 2017 (www.esoa.net).

NOTE: Available at <https://www.esoa.net/cms-data/positions/ESOA5G%20Ecosystem.pdf>

[i.4] European Commission H2020 5G PPP project "SaT5G" (Satellite and Terrestrial Network for 5G), 2017.

NOTE: Available at: <http://sat5g-project.eu/>.

[i.5] European Commission, "5G for Europe: An Action Plan," 14 September 2016.

NOTE: Available at http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=17131.

[i.6] 3GPP TR 38.811: "Study on New Radio (NR) to support non-terrestrial networks".

[i.7] ETSI TS 123 501: "5G; System architecture for the 5G System (5GS) (3GPP TS 23.501 Release 15)".

[i.8] ETSI TS 123 401: "LTE; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (3GPP TS 23.401 Release 15)".

[i.9] 3GPP TR 36.806: "Evolved Universal Terrestrial Radio Access (E-UTRA); Relay architectures for E-UTRA (LTE-Advanced) (Release 9)".

[i.10] ETSI TS 123 502: "5G; Procedures for the 5G System (5GS) (3GPP TS 23.502 Release 15)".

[i.11] IETF RFC 4555: "IKEv2 Mobility and Multi-homing Protocol (MOBIKE)".

- [i.12] Equivalent capacity and its application to bandwidth allocation in high-speed networks; R. Guerin, H. Ahmadi, M. Naghshineh ; IEEE Journal on Selected Areas in Communications (Volume: 9, Issue: 7, Sep 1991).
- [i.13] "Communicating Systems & Networks: Traffic & Performance". Georges Fiche, Gérard Hébuterne; London; Sterling, VA : Kogan Page Science, 2004.
- [i.14] ETSI TS 138 470: "5G; NG-RAN; F1 general aspects and principles (3GPP TS 38.470 Release 15)".
- [i.15] ETSI TS 136 300: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300)".
- [i.16] ETSI TS 138 300: "5G; NR; Overall description; Stage-2 (3GPP TS 38.300 Release 15)".
- [i.17] ETSI TS 138 473: "5G; NG-RAN; F1 Application Protocol (F1AP) (3GPP TS 38.473 Release 15)".
- [i.18] 3GPP TS 38.475: "Technical Specification Group Radio Access Network; NG Radio Access Network (NG-RAN); F1 interface user plane protocol (Release 15)".
- [i.19] ETSI TS 132 240: "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Charging management; Charging architecture and principles (3GPP TS 32.240)".
- [i.20] ETSI TS 133 501: "5G; Security architecture and procedures for 5G System (3GPP TS 33.501 Release 15)".
- [i.21] 3GPP TR 38.874: "Technical Specification Group Radio Access Network; Study on Integrated Access and Backhaul (Release 15)".
- [i.22] 3GPP TR 22.822: "Technical Specification Group Services and System Aspects; Study on using Satellite Access in 5G; Stage 1 (Release 16)".
- [i.23] ETSI TS 138 401: "5G; NG-RAN; Architecture description (3GPP TS 38.401 Release 15)".
- [i.24] ETSI TS 128 530: "5G; Management and orchestration; Concepts, use cases and requirements (3GPP TS 28.530 Release 15)".
- [i.25] ETSI TS 102 354: "Satellite Earth Stations and Systems (SES); Transparent Satellite Star - B (TSS-B); IP over Satellite (IPoS) Air Interface Specification [TIA-1008-B (April 2012)]".
- [i.26] RESOLUTION 155 (WRC-15) "Regulatory provisions related to earth stations on board unmanned aircraft which operate with geostationary-satellite networks in the fixed-satellite service in certain frequency bands not subject to a Plan of Appendices 30, 30A and 30B for the control and non-payload communications of unmanned aircraft systems in non-segregated airspace".

NOTE: Available at <https://www.itu.int/en/ITU-R/space/snl/Documents/RES-155.pdf>

- [i.27] IEEE 802.1adTM-2005: "IEEE Standard for Local and Metropolitan Area Networks -- Virtual Bridged Local Area Networks -- Amendment 4: Provider Bridges".

NOTE: Available at https://standards.ieee.org/standard/802_1ad-2005.html.

- [i.28] IEEE 802.1ahTM-2008: "IEEE Standard for Local and metropolitan area networks -- Virtual Bridged Local Area Networks Amendment 7: Provider Backbone Bridges".

NOTE: Available at https://standards.ieee.org/standard/802_1ah-2008.html.

- [i.29] IEEE 802.11TM-2016: "IEEE Standard for Information technology -- Telecommunications and information exchange between systems Local and metropolitan area networks -- Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

NOTE: Available at https://standards.ieee.org/standard/802_11-2016.html.

- [i.30] IEEE Std 1914.3TM (2018): "IEEE Standard for Radio over Ethernet Encapsulations and Mappings".

NOTE: Available at https://standards.ieee.org/standard/1914_3-2018.html.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

3GPP defined NTN access network: NTN which implements a 3GPP Access Networks

5G Access Network: 3GPP Access Network (NR-RAN) connecting to a 5G Core Network

5G higher protocol layers: set of 5G protocols layers that include:

- In the control plane: NAS-MM, NAS-SM, NG-AP, RRC, SCTP over IP, IP
- In the user plane: PDU layer (e.g. IP), GTP-U, 5GUPE, UDP, IP

NOTE 1: NAS-MM, NAS-SM, PDU layer are defined at the UE- 5G CN interface (in the control plane).

NOTE 2: 5GUPE is defined at internal interface within the 5G CN (in the user plane).

NOTE 3: NG-AP, SCTP are defined at the NG-C interface between the RAN and the 5G CN (in the control plane).

NOTE 4: RRC is defined at the UE-gNB interface (both in the control and user planes). RRC is a cross-layer in the UE, interfacing both with PDCP, MAC and Physical local sub-layers.

NOTE 5: GTP-U is defined at the NG-U interface between the RAN and the 5G CN (in the user plane).

5G Service Enablers: enabling features for the 5G service types including eMBB (Enhanced Mobile Broadband), mMTC (Massive Machine Type Communications), and URLLC (Ultra-Reliable and Low Latency Communications)

5G Use Case: particular case of how the 5G system is used

NOTE: See "Use case" definition.

access point: network entity providing an access to UEs or local RAN to the 5G CN, this access being either a 3GPP access or a non-3GPP access

NOTE: This definition conforms to the following ETSI terminology "device providing an interface between a Wide Area Network (WAN) and a local network".

aircraft: airborne vehicle including High Altitude Platforms (HAPS)

NOTE 1: As part of wireless network, aircraft embarks relay nodes or base stations for connection with UE's. Aircraft may also be interconnected together by means of Inter-HAPS Links.

NOTE 2: This may also refer to Unmanned Aircraft Systems (UAS) but preferably use HAPS in the present document.

bent-pipe vehicle: satellite or HAPS based on a transparent architecture

NOTE: Another wording is non-regenerative architecture.

feeder link: link between the vehicle (satellite or HAPS) and the Feeder Link terminal, at NTN Gateway side

gNB: 5G Base station i.e. 5G Access Controller, serving the UE, local to the UE

HAPS access: access network using an HAPS embarking a transmission equipment relay node or base station and providing connectivity with user equipment

"Higher" NR Data Link Layers: link layers protocols such as SDAP, PDCP, RLC

L1 or Layer 1: physical layer

L2 or Layer 2: data Link layer

L3 or Layer 3: network layer

line termination gNB: gNB that serves a Relay UE or a network termination UE

mobile network operator: actor that operates the mobile cellular system (including UEs, RAN, CN)

NOTE: A company may or endorse both "NTN operator" and MNO roles or not.

multiplexer node: network entity that multiplexes single flows into aggregate flows and forwards them to the next network entity in the transmission chain

NOTE: Endorses also the role of de-multiplexer node, which de-multiplexes aggregate flows into single flows and forwards them to next network entities or terminals, in the transmission chain, according to their destination.

N3IWF: non-3GPP Interworking Function

NOTE: Non-3GPP access networks can be connected to the 5G Core Network via the Non-3GPP Interworking Function (N3IWF). The N3IWF interfaces the 5G Core Network CP and UP functions via N2 and N3 interfaces, respectively. In case of untrusted non-3GPP access, an IPSec tunnelling is setup between the UE with non 3GPP access and the 5G Core Network (see ETSI TS 123 501 [i.7]).

N3IWFg: extension of N3IWF

NOTE: Extension to enable establishment of IPsec tunnel(s) between the 5G CN and the local security gateway connected to the local gNB, over an untrusted Non-3GPP Access Network. At 5G CN side, N3IWFg relays signalling and data.

Nadir: point of the celestial sphere that is directly opposite the zenith and vertically downward from the observer

network termination UE: network termination for which UE management applies

non-3GPP layer: protocol layer not defined by 3GPP

NOTE: For example, layer of radio protocols not defined by 3GPP, such as specified by ETSI (DVB-S2X, DVB-RCS2). For the mixed 3GPP access, 5G higher protocol layers (see the definition) and "Higher" NR Data Link layers (see the definition) may be implemented onto this Non-3GPP layer, providing adaptations of these 5G and NR layers.

non-3GPP access network: access network which is not fully defined by 3GPP but may support an interface with the CN

NOTE: The "mixed 3GPP NTN access network" enters in this category but implements some 3GPP defined NR radio interface protocols.

Non-Access Stratum (NAS): signalling between the UE and the Core Network

non-GEO: non geostationary satellite systems such as LEO or MEO

NR: New Radio interface for 5G system

NR data link layers: set of 5G protocol layers defined as: SDAP, PDCP, RLC, MAC

NR-radio access: 5G Access Network based on NR interface

Non-Terrestrial Network (NTN): network, or segments of network, using an airborne or space-borne vehicle to embark transmission equipment, a relay node or base station

NOTE: See 3GPP TR 38.811 [i.6].

NTN Access: access that is provided by a NTN access network based on a satellite or a HAPS system

NTN enabled line termination gNB: function able to serve NTN enabled network termination UE, via an NTN infrastructure

NOTE: It is either centralized (located at core network side) or distributed over the NTN infrastructure. It may be either located in the ground segment or embedded in an OBP payload.

NTN enabled LT gNB: short name for NTN enabled line termination gNB

NTN enabled network termination UE: network termination UE that terminates a NTN Service Link

NOTE: It may be integrated in a NTN Relay UE or be a standalone equipment. The NTN enabled network termination UE interfaces a dedicated gNB, namely the NTN enabled line termination gNB and a Core Network, via satellite or HAPS link(s).

NTN enabled NT UE: NTN enabled network termination UE

NTN enabled relay UE: relay UE able to be served by a NTN access

NOTE: This NTN enabled relay UE implements local gNB function and NTN enabled network termination UE functions.

NTN Gateway: gateway located in the ground segment, linked to the Core Network and Feeder Link terminal(s)

NTN gNB-CU: short name for NTN enabled gNB Central Unit

NTN gNB-DU: short name for NTN enabled gNB Distributed Unit

NTN NT UE: NTN enabled network termination UE

NTN NT UE radio bearer: NR radio bearer associated with a NTN enabled network termination UE

NTN NT UE radio transport container: non-3GPP radio transport container associated with a NTN enabled network termination UE

NTN operator: actor that operates the NTN. A company may endorse both "NTN operator" and MNO roles or not

NTN radio transport container: generic term which stands for a radio transport container associated with NTN network termination

NTN relay UE: NTN enabled relay UE

NTN terminal radio transport container: non-3GPP radio transport container associated with a NTN enabled terminal

NTN UE: NTN enabled network termination UE

Radio Access Network (RAN): access network based on 5G radio interface, local to the UEs

relay UE: equipment that implements local gNB function and network termination UE functions

satellites: space borne vehicles including Low Earth Orbiting (LEO) satellites, Medium Earth Orbiting (MEO) satellites as well as Geostationary Earth Orbiting (GEO) satellites

NOTE: As part of a wireless network, satellites embark relay nodes or base stations for connection with UE's. Satellites can be interconnected together by means of Inter-Satellite Links.

satellite access: access network using a space borne vehicle embarking a transmission equipment relay node or base station and providing connectivity with user equipment

NOTE: By extension, a satellite access may also rely on a multiplicity of satellites which relay nodes or base stations may or may not be interconnected with inter-satellite links.

satellite use cases: particular case of how the SatCom system is used in the 5G system to provide or to support the provisioning of a set of 5G services

scenario: instantiation of a Use Case for the accomplishment of a specific duty and driving the network topology and the architecture design

service link: link between the NTN terminal (NTN NT UE or VSAT) and the vehicle (satellite or HAPS)

trusted network: network or sub-network which are considered secured by the mobile network operator

NOTE: It depends on the commercial agreement between the MNO and the 3rd party operator (such as the Transport Network operator).

UE management: set of procedures and protocols over NR, N1 and NG interfaces to manage a UE

NOTE: Procedures (see ETSI TS 123 502 [i.10]).

EXAMPLE: Initial Access, Connection Management, PDU session management, Mobility Management, Radio resource Management.

UE mobility management: mobility management addresses the registration of an UE at a RAN, its location (how to keep track of an UE) and the handover (how to maintain service continuity following a mobility event)

NOTE: The mobility management and the afferent procedures are described in [i.7], [i.10] and [i.16] for the 5G and [i.8], [i.15] for LTE-A, updated for R15. In a 5G system, these mobility procedures are supported across several interfaces, such as NR, N1 and NG according to architectures specifications [i.16]. In the indirect scenarios, when embedded in a moving platform, the NTN NT UE may be considered as a mobile UE. In the Direct scenario, the NTN NT UE is mobile UE, as any handset.

untrusted network: network or sub-network which are considered unsecured by the Mobile Network Operator.

NOTE: It depends on the commercial agreement between the MNO and the 3rd party operator.

use case: particular example (a case) of how a system is used, literally a "case of system use", in order to achieve a specific goal

NOTE: The way a system is used corresponds to the interaction between a stakeholder and the system.

vehicle: satellite or HAPS

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP 3rd Generation Partnership Project

NOTE: See <https://www.3gpp.org/>.

4G	4 th Generation
5G	5 th Generation
5G CN	5G Core Network (in the present document).
5G-EIR	5G Equipment Identity Register

5GMF The fifth generation mobile communications promotion forum

NOTE: See <https://5gmf.jp/en/>.

5G PPP 5G Infrastructure Public Private Partnership

NOTE: See <https://5g-ppp.eu/>

5GUPE 5G User Plane Encapsulation

NOTE: The wording is defined in 3GPP but not the acronym.

5QI 5G QoS Identifier

AF Application Function

AMF Access and Mobility management Function

AN Access Network

AP Access Point

ARIB Association of Radio Industries and Businesses

NOTE: See <https://arib.or.jp/english/>.

AUSF AUthentication Server Function

CA Carrier Aggregation

CN Core Network

CoS Class of Service

CP Control Plane

CPRI Common Public Radio Interface

CU Central Unit

DeNB Donor eNodeB

DL Downlink

DN Data Network

DRB Data Radio Bearer

DSCP Differentiated Service Code Point

DU Distributed Unit

EMEA European, Middle East and Africa

eMBB enhanced Mobile Broadband

eNB eNodeB

ESOA European and middle east Satellite Operator Association

NOTE: See <https://www.esoa.net/>

F1AP F1 Application Protocol

F1-C F1 Control plane interface

F1-U F1 User plane interface

FFS For Further Study

FOTA Firmware Over-the-Air

GBR Guaranteed Bit Rate

GEO Geostationary Earth Orbit

gNB Next-Generation Node B

NOTE: Alias 5G base station.

gNB-CU gNB Central Unit

gNB-DU gNB Distributed Unit

GPRS General Packet Radio Service

GTP GPRS Tunnelling Protocol

GTP-U GPRS Tunnelling Protocol, for the User Plane

GW GateWay

H2020 Horizon 2020

HAPS High Altitude Platform Station

HPLMN Home Public Land Mobile Network

IAB Integrated Access and Backhaul