ETSI TR 103 886 V1.1.1 (2025-03)

Satellite Earth Stations & Systems (SES);
DVB-S2x/RCS2 versus 3GPP New Radio protocol technical comparison for broadband satellite systems

Reference

DTR/SES-00456

Keywords

5G, broadband, DVB, interface, mobile, NR, protocol, radio, radio measurements, satellite, system

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI IPR online database.

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™**, **LTE™** and **5G™** logo are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

Foreword

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

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

In view of the recent extension of 3GPP defined New Radio (NR) to support Non-Terrestrial Networks (NTN) operating in the Ka- and Ku-band allocated satellite services, it is necessary to understand the merits and limitations of this access technology in comparison with the long-established satellite access technology defined by the DVB forum as 'DVB-S2x/RCS2'.

The present document includes a qualitative and quantitative comparison of both access technologies in the context of broadband satellite networks, based on GSO space segment operating in above 10 GHz frequencies. The quantitative analysis is leveraging link- and system level simulation methodologies typically adopted in 3GPP.

Clause 2 provides the references. Clause 3 provides the definitions of terms, explains symbols and expands abbreviations. Clause 4 provides qualitative technology analysis on functional, operational, performance, and other non-technical aspects. Clause 5 provides a comprehensive quantitative link level analysis, including the simulation configuration and results. Clause 6 provides a system level comparison with simulation configurations and results, leveraging the link level results. Clause 7 concludes the technical comparison.

1 Scope

The present document contains a technical comparison of DVB-S2x/RCS2 and 3GPP New Radio (NR) Non Terrestrial Networks (NTN) radio interface/access technology for broadband satellite communication systems operating above 10 GHz for fixed satellite services. Possible enhancements (e.g. Peak-to-Average Power Ratio (PAPR) mitigation) for NR taking into account backward compatibility aspects and 3GPP specification impacts are identified and assessed.

Applicability of the study to frequencies below 10 GHz is not considered.

NOTE 1: The comparison analysis considered both Single SFPB and MFPB (with BFN) payload architectures.

NOTE 2: The GEO scenario is considered.

NOTE 3: The same carrier bandwidth is considered for the comparison between DVB and NR.

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] ETSI EN 302 307-2: "Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications; Part 2: DVB-S2 Extensions (DVB-S2X)".

[i.2] ETSI EN 302 307-1: "Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications; Part 1: DVB-S2".

[i.3] ETSI EN 301 545-2: "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 2: Lower Layers for Satellite standard".

[i.4] ETSI TS 138 214: "5G; NR; Physical layer procedures for data (3GPP TS 38.214)".

[i.5] 3GPP TR 38.886 (V16.3.0) (03-2021): "V2X Services based on NR; User Equipment (UE) radio transmission and reception (Release 16)".

[i.6] 3GPP TR 38.821: "Solutions for NR to support non-terrestrial networks (NTN)".

[i.7] 3GPP TR 38.811: "Study on New Radio (NR) to support non-terrestrial networks".

[i.8] Recommendation ITU-R P.1853-2: "Time Series synthesis of tropospheric impairments", Geneva, August 2019.

[i.9] 3GPP TR 36.889: "Study on Licensed-Assisted Access to Unlicensed Spectrum".

[i.10] ETSI TR 101 545-4: "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 4: Guidelines for Implementation and Use of EN 301 545-2".

[i.11] ETSI TR 103 297: "Satellite Earth Stations and Systems (SES); SC-FDMA based radio waveform technology for Ku/Ka band satellite service".

[i.12] IEEE 802.1ad™: "IEEE Standard for Local and Metropolitan Area Networks -- Virtual Bridged Local Area Networks -- Amendment 4: Provider Bridges".

[i.13] IEEE 802.1ah™: "IEEE Standard for Local and metropolitan area networks -- Virtual Bridged Local Area Networks -- Amendment 7: Provider Backbone Bridges".

[i.14] IETF RFC 3135: "Performance Enhancing Proxies Intended to Mitigate Link-Related Degradations".

[i.15] ETSI TS 122 261: "5G; Service requirements for the 5G system (3GPP TS 22.261)".

[i.16] ETSI TS 123 501: "5G; System architecture for the 5G System (5GS) (3GPP TS 23.501)".

[i.17] ETSI TS 101 545-1: "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 1: Overview and System Level specification".

[i.18] Void.

[i.19] ETSI TS 138 104: "5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104)".

[i.20] ETSI TS 138 101-5: "5G; NR; User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements (3GPP TS 38.101-5)".

[i.21] 3GPP R1-2005311: "Considerations on PAPR requirements for NR NTN downlink transmission", Thales.

[i.22] ETSI TS 138 101-2 (V18.0.0): "5G; NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone (3GPP TS 38.101-2 version 18.8.0 Release 18)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

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

ARQ	Automatic ReQuest
BAP	Backhaul Adaptation Protocol
BHTP	Beam Hopping Time Plan
BTP	Burst Time Plan
CMT	Correction Message Table
CSI	Channel State Information
DL	Down Link
DVB	Digital Video Broadcasting
FDD	Frequency Division Duplexing
GEO	Geostationary
GSE	Generic Stream Encapsulation
HARQ	Hybrid Automatic ReQuest

IBO Input Back-Off
LLC Logical Link Control
MAC Medium Access Control
NCR Network Clock Reference
NR New Radio
OBO Output Back-Off
PDCP Packet Data Convergence Protocol
PEP Performance-Enhancing Proxy
PRB Physical Resource Block
PTRS Phase Tracking Reference Signal
RLC Radio Link Control
RLE Return Link Encapsulation
SCS Sub Carrier Spacing
SDAP Service Data Adaptation Protocol
TIM Terminal Information Message
Tput Throughput
UL Up Link

4 DVB and NR Radio protocols for SatCom

4.1 General characteristics of the radio protocols

Table 1 provides in synthetic table comparing the radio protocol stacks of both radio protocols: DVB-S2x/DVB-RCS2 and 3GPP NR with NTN enhancements.

Table 1: Protocol stacks of the candidate Radio protocols for the service link

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
Sources	DVB forum. Published via ETSI TC BROADCAST. Down-link (DL): ETSI EN 302 307-1 [i.1] & 2 [i.2]. Uplink (UL): ETSI EN 301 545-2 [i.3].	www.3gpp.org Pre-standard: 3GPP TR 38.811 [i.7] & 3GPP TR 38.821 [i.6]. Standard: 3GPP TS 38.XXX series with Change Request defined by 3GPP work items "NR_NTN_solutions", "NR_NTN_enh" and "NR_NTN_ph3".
Physical layer (Waveform)	Down-link (DL): M-ary APSK TDM (S2x). Uplink (UL): M-ary PSK, 16QAM or CPM MF-TDMA (RCS2).	Down-link (DL): M-ary QAM CP-OFDM. Uplink (UL): M-ary QAM CP-OFDM or DFT-s-OFDM.
Access layer	User plane: MAC (Medium Access Control), LLC (Logical Link Control). Downlink: GSE (Generic Stream Encapsulation). Uplink: RLE (Return Link Encapsulation).	User plane: MAC, Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP), Service Data Adaptation Protocol (SDAP). Control plane: RRC, PDCP, RLC, MAC and PHY sub-layers (terminated in UE and gNB); NAS protocol (terminated in the UE and the AMF).
Network layer	IPv4/IPv6. For backhaul: IEEE 802.1ad [i.12] / 802.1ah [i.13].	IPv4/IPv6. For backhaul: Backhaul Adaptation Protocol (BAP).
Transport layer	TCP, UDP, Performance Enhancing Proxy (PEP - IETF RFC 3135 [i.14]) is possible to mitigate latency with GEO satellites.	TCP, UDP, Performance Enhancing Proxy (PEP - IETF RFC 3135 [i.14]) is possible to mitigate latency with GEO satellites only.

Overall both protocols feature a similar stack structure. However, NR has been designed to optimize mobile broadband and low latency communications, while DVB has been designed for fixed broadband communications re-using the DVB-S2x video broadcast channel.

This leads to some differences between the radio protocols with respect to a number of key technical operational, functional, performance as well as non-technical requirements as identified in the next paragraphs.

Although NR can operate in FR1 (frequency range) 410 MHz to 7 125 MHz, FR2 (24 250 MHz to 52 600 MHz) and soon in frequency bands beyond 52,6 GHz which are being studied in 3GPP Release 17, the comparison below will be mainly focused on Ku and Ka band Satcoms since DVB applies to bands allocated to satellite services above 3,4 GHz.

4.2 Functional aspects

Table 2 hereunder compares both radio protocols with respect to different functional criteria.

Table 2: Functional characteristics of DVB-S2x/DVB-RCS2 and of 3GPP NR with NTN enhancements

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
QoS management	Multi-CoS specific to SatCom.	Multi-CoS: 3GPP defined 5QI classes (see ETSI TS 122 261 [i.15] and ETSI TS 123 501 [i.16]).
Terminal states from radio access point of view once registered	(Not) Connected mode.	Idle, Inactive, Connected mode.
Terminal mobility	Connected mode (hand-over).	Idle and inactive mode (cell (re)selection) connected mode (hand-over).
Hand-over	Make before break (with dual reception chain) and break before make supported.	Make before break supported (with single reception chain).
Data transmission principles	DL: DVB-S2X: Continuous transmission of medium to large data blocks (FECFrame of typically 64 800 bits). UL: DVB-RCS2: Discontinuous transmission of small to medium data blocks (Burst length: [304 bits; 4 792 bits]).	DL & UL: Discontinuous or continuous transmission of small to medium data blocks (Code-block size range dependent [24 bits; 8 424 bits], see ETSI TS 138 214 [i.4]).
Contention channel	For initial access. For short data transmission (CRDSA Access with replicate suppression).	1) During initial access: Contention based: UEs randomly select preamble, More than 1 UE may select same preamble (collision). 2) For hand-over: Non-contention based: gNB dedicates preamble to UE, No collision possible. 3) For short burst transmission: grant free access may be considered as part of a future release.
System architecture context	The access network is designed to connect to the IP network.	The 5G NR protocol is part of a 3GPP defined system architecture including 5GC, NG-RAN and UE, API interfaces to 3rd party service providers, interface to network management system.
Inter system mobility (with 4G/5G system)	No.	Natively supported.
Support of 5G Core network	Via an Inter Working Function. DVB forum plans to define this feature.	Natively supported.
Multi connectivity satellite / 5G cellular access	No.	At core network level (Traffic Steering Switching Splitting). At radio access level (to be defined in future 3GPP releases).
Multi connectivity NGSO satellite / GEO satellite access	Possibly at service level through proprietary scheme.	At core network level (Traffic Steering Switching Splitting). At radio access level (to be defined in future 3GPP releases).
Terminal Location service	Not supported.	embedded GNSS receiver in the UE + other network based methods.
Use of GNSS for operation	Not necessary.	Yes.
Trusted location of terminal (i.e. network verified/provided)	Not supported.	RAN-based NTN NR positioning solutions via 3GPP defined LCS framework for LEO.
Reliability (see note)	Yes with automatic request at access layer.	Yes with automatic request at both physical (Hybrid Automatic Repeat Request = HARQ) and access layer RLC/PDCP (Automatic Repeat Request = ARQ).

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
Energy saving	No scheme defined in the standard. Proprietary scheme can be implemented.	Idle and inactive mode defined in the standard with all the radio protocol signalling. Management aspects of RAN and CN elements are also defined in the standard including all the related metrics (at Network side and UE side).
Synchronization	DL: Continuous synchronization except in beam hoping mode. UL: Burst synchronization.	DL/UL: Burst synchronization in DL and Timing Advance (TA) mechanism for UL synchronization.
Network slicing	Not supported in the standard. However, a satellite radio link (hub - terminal) can be statically configured to support VPNs that can be considered as slices. Dynamic control of radio resources to support the different slices can be achieved through proprietary implementation and appropriate interface exposure.	E2E network slicing across RAN is natively supported. Support of dynamic control of radio resources to support the different slices.
Cellular backhaul service	Support with static and quasi dynamic control of the backhaul connection irrespective of the traffic variation of the connection. Backhauling service may be implemented by IEEE 802.1ad [i.12] / 802.1ah [i.13] technics. Requires specific mapping of 3GPP QoS to DVB QoS.	Support with dynamic control of the backhaul connection in terms of Radio Resource Management adapted to the traffic variation of the connection. Support the 5G security architecture and the 3GPP defined QoS framework.
Spectrum sharing (Adjacent channel coexistence) of SatCom with terrestrial system (Mobile, microwave links)	Un coordinated only approach between independent satcom and the terrestrial systems.	Through uncoordinated or coordinated approach between satcom and the terrestrial systems. The coordinated approach can leverage existing techniques used for the spectrum coexistence between Macro and Femto cells.
Security framework	Security aspects are described in ETSI TS 101 545-1 [i.17] and ETSI TR 101 545-4 [i.10] Guidelines (DVB-RCS2). In practice the security framework of DVB system is proprietary and specific for each SatCom vendor. It can be adapted to meet specific European requirements.	3GPP has specified a 5G security architecture supporting user authentication, secured communications. Leveraging this 5G security framework, further additional security features can be developed to meet specific European requirements.
NOTE: Reliability is defined in ETSI TS 122 261 [i.15] as "in the context of network layer packet transmissions, percentage value of the amount of sent network layer packets successfully delivered to a given system entity within the time constraint required by the targeted service, divided by the total number of sent network layer packets". The relation of communication service availability and reliability is explained in Annex C (informative) of the same document.		

Compared to DVB-S2x/RCS2, the NR protocol is best suited to support:

- mobility procedures and energy saving features at both idle and connected modes;
- slicing including at RAN level;
- QoS management in 5G system including RAN and core network;
- mobility/multi connectivity across satellite/cellular access technology though integration of satellite networks in 5G system at different levels including RAN;
- backhaul service thanks to dynamic control of radio resources and the integrity of the 5G E2E security framework.

Beam hopping, both NR and DVB can in theory support Traffic-Driven Beam Hopping capability on the downlink with Beam Hopping Time Plan (BHTP):

- for DVB-S2x: See ETSI EN 302 307-1 [i.18];
- for NR, the flexibility of radio resource block allocation in both time and frequency domain and bandwidth part adaptations can be used to implement an equivalent beam hopping scheme.

4.3 Operational aspects

Table 3 hereunder compares both radio protocols with respect to operational criteria.

Table 3: Operational characteristics of DVB-S2x/DVB-RCS2 and of 3GPP NR with NTN enhancements

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
Spectrum supported	In theory all bands allocated to satellite services above 3,4 GHz.	FR1: (frequency range) 410 - 7 125 MHz. FR2: 24 250 - 52 600 MHz + frequency bands beyond 52,6 GHz are being studied in 3GPP Release 17.
Space segment supported	GEO and NGSO.	GEO and NGSO.
Min channel bandwidth requirements (DL/UL) for traffic	DL: 1 MHz carrier. UL: 64 kHz carrier in practice.	DL: 5 MHz in FR1, 50 MHz for FR2. UL: 5 MHz in FR1, 50 MHz for FR2. For UL transmissions, minimum size is one physical resource block (PRB, bandwidth 12* Subcarrier Spacing = 12* [15, 30, 60, 120 kHz]).
Min log-on burst signal bandwidth requirements (UL)	Same as carrier bandwidth.	1,08 MHz with 1,25 kHz SCS (FR1, Long PRACH formats). 8,64 MHz with 60 kHz SCS (FR2, Short PRACH formats). 17,28 MHz with 120 kHz SCS (FR2, Short PRACH formats).
Max channel bandwidth capability	DL: 500 MHz in practice (state of the art). UL: 167 MHz as per standard. Higher channel bandwidth is possible on DL only through channel bonding scheme.	DL & UL: 100 MHz in FR1, 400 MHz in FR2. Multiple channels (set of sub- carriers can be aggregated to achieve up to 6,4 GHz of transmission bandwidth through carrier aggregation scheme.
Duplex mode supported	FDD. TDD made possible with DVB-S2X Beam Hopping and RCS2 (though not defined as such in the technical specifications).	FDD and TDD.
Radio resource allocation flexibility	DL: Frame structure dependent on symbol rate hence creating variable size of data blocks. One frame can be allocated to several UEs. UL: Single frame is allocated to one UE. Allocation can be volume or rate based.	DL & UL: Allocation per UE is one PRB at a time or on a continuous periodical basis.
Min radio resource granularity assigned by the scheduler to a UE	On DL: typically a normal FECFrame of [64 800 bits], but also possible a short FECFrame [16 200 bits]. On UL: very short bursts of 266 symbols (QPSK 5/6 to 16QAM 5/6).	On both DL & UL: Min radio resource corresponds to one PRB (Physical Resource Block) mapped over 12 sub-carriers. The slot duration is 14 OFDM symbols and depends on Sub Carrier Spacing (SCS) configuration (1 ms with 15 kHz sub-carrier spacing; 0,250 ms with 60 kHz SCS, 0,125 ms with 120 kHz sub-carrier spacing). 1 frame is always 1 ms duration and the number of slot per frame depends on SCS. The useful OFDM symbol size is inversely proportional with the SCS.

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
Radio resource allocation efficiency	DL: Combination of Multi UE allocation and ACM scheme applied to one BB frame create the risk of resource waste since some BB frames are not usable by all UEs. UL: High risk of mismatch between allocated resource and traffic load creating waste of resource usage.	DL/UL: The granularity can be extremely small (On the order of 1 symbol) that risk of mismatch between allocated resource and traffic load creating waste of resource usage is low.
Radio resource management flexibility	Beam hoping **and** fractional frequency re-use supported.	Beam hoping **and** fractional frequency re-use supported.
Robustness to payload's phase noise	DL: phase noise can be tracked using pilot symbols in case of continuous transmission. For burst transmission (beam hoping), super framing structure help to handle phase noise and synchro issues. UL: phase noise can be tracked using pilot symbols.	Configurable Phase Tracking Reference Signal (PTRS) is a low density pilot sequence sent at regular time interval, it used to enable tracking of phase noise in both UL/DL.
Robustness to the payload's Group Delay	Sensitive for carriers with hundreds of Mega Symbol per seconds partially mitigated by wide-band equalizers.	Not sensitive.

Both radio protocols are able to support LEO and GEO systems operating in Ku and Ka bands and are able to support the same operational constraints.

Frequency Division Duplexing (FDD) mode is required by Regulations (space-earth & earth-space paired bands allocated).

4.4 General performance aspects

Table 4 hereunder compares both radio protocols with respect to different performance criteria.

Table 4: Performance characteristics of DVB-S2x/DVB-RCS2 and of 3GPP NR with NTN enhancements

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
PAPR on UL (at terminal level)	Reference performance which is based on the 20 % roll-off as per standard.	3GPP defines SC-FDMA (DFT-s-OFDM) mode for UL. Standard assumes 2,5 % of guard band (ETSI TS 138 104 [i.19] and ETSI TS 138 101 [i.20]). In terms of OBO, ETSI has demonstrated that NR Uplink performs comparably to DVB-RCS2 (see ETSI TR 103 297 [i.11] "SC-FDMA based radio waveform technology for Ku/Ka band satellite service".
PAPR on DL (at satellite level)	Mono carrier per amplifier: ~0 dB in QPSK (for broadcast payload) => not relevant for broadband. Multi carrier (> 3) per amplifier/active antenna: See note 1.	See note 1.
Overhead due to access layer in user plane (number of UE dependent)	DL: between 2 and 4 % (first order) mainly due to allocation tables + to a lower extent GSE encapsulation. UL: 2,1 % to 3,93 % mainly due to RLE encapsulation.	DL & UL: up to 4 % (due to MAC, RLC, PDCP + control plane signalling).

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
Overhead due to physical layer (modulation and coding dependent)	DL: 5 % to 10 % (main due to Roll off and to a lower extent Physical Layer framing including CRC). UL: up to 20 % (main due to Roll off and to a lower extent guard times and CRC).	Depending on Frequency Range: DL: Up to 18 % (mainly due to SSB, DL reference signals and DCI signalling). Note that the DL overhead can be optimized to 8,25 % to 12 % (through configuration of the reference signals and related MIMO layers). UL: Up to 10 % (Mainly due to PRACH, Sounding reference signal and demodulation reference signal).
Min spectral efficiency/Max modcod	DL: 0,1 bit/symbol @ BPSK-S 1/5 SF5 (VL-SNR mode for traffic). UL: 0,25 bit/symbol @ BPSK 1/3 (for traffic). UL: 0,02 bit/symbol @ π/2 BPSK with code rate 1/3 and SF 16.	DL: From 0,0586 bit/symbol @ QPSK 30/1 024 (for traffic). UL: From 0,0586 bit/symbol @ π/2-BPSK 30/1 024 or QPSK 30/1 024 (for traffic).
Highest spectral efficiency (and related modcod) but link budget dependent	DL: Up to 5,9 bits/symbol @ 256APSK 135/180 (also called 3/4). UL: Up to 3 bits/symbol @ 16 QAM 5/6.	DL: Up to 7,4063 bits/symbol @ 256QAM 948/1 024. UL: Up to 5,5547 bits/symbol @ 64QAM 948/1 024.
User plane latency (note 2)	DL: 7ms (at least 100 MHz bandwidth). UL:1ms (at least 5 MHz bandwidth).	DL & UL: < 4 ms (at least 5 MHz bandwidth) for eMBB service category Latencies depend on the selected QoS classes (see ETSI TS 123 501 [i.16]).
Control plane latency (note 2)	Not applicable.	10 ms.
Throughput versus SNR	Comparable performances can be expected thanks to similar coding techniques (LDPC based for the traffic) for a given error rate.	
Min required SNR performance	ModCod type and frame type (2 options) dependent. Target PER is 10E-5 for typically SatCom operation.	ModCod, Transport block size, HARQ, pilot density configuration, 5QI (target BLER) dependent.
Min Signal to Noise Ratio for synchronization on DL	DVB-S2X supports down to -9,90 dB (VL-SNR: Very Low SNR). (Makes use of specific π/2-BPSK MODCOD).	SNR = -9,20 dB (on PSS/SSS burst).
Min Signal to Noise Ratio for traffic on DL	DVB-S2X supports down to -9,90 dB @ BPSK-S 1/5 (VL-SNR: Very Low SNR) for FER 1E-5 (AWGN condition). See table 20c in clause "Error performance" of ETSI EN 302 307-1 [i.2]. SNR = -2,85 dB @QPSK 2/9 for FER 1E-5 (AWGN condition).	SNR = -12,2 dB @ QPSK 30/1 024 and for BLER = 1E-02 or 1 %. Lower BLER can be achieved thanks to HARQ.
Min Signal to Noise Ratio for log on burst on UL (initial access)	SNR = -0,27dB Es/N0 @FER 1E-3 (AWGN condition). SNR = -14 dB @BPSK 1/3 SF=16 for PER = 1E-05 and under AWGN Ideal synchronization. Possible lower SNR with spreading down to factor of 16.	PRACH: -8,5 dB @false detection 1E-3.
Min Signal to Noise Ratio for traffic on UL	SNR = -3,51 dB @BPSK 1/3, for PER = 1E-05 and under AWGN Ideal synchronization. SNR = -0,80 dB @QPSK 1/3, for PER = 1E-03 and AWGN channel. SNR = -2,35 dB @QPSK 1/3, for PER = 1E-07 and under AWGN channel. Possible lower SNR with spreading down to factor of 16. SNR = -11 dB @BPSK 1/3 SF = 8 for PER = 1E-05 and under AWGN Ideal synchronization. SNR = -14 dB @BPSK 1/3 SF = 16 for PER = 1E-05 and under AWGN Ideal synchronization .	SNR = -12,2 dB @ QPSK 30/1 024 and for BLER = 1E-02 or 1 %. Using an even more robust modcod, a lower SNR can be achieved: -13 dB @ π/2-BPSK 30/1 024 (with precoding enabled) and for BLER = 1E-04 or 0,01 % (for both control and data). Lower BLER can be achieved thanks to HARQ, at the expense of the throughput.

	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
NOTE 1: In 3GPP R1-2005311 [i.21]. NOTE 2: User plane latency refers to the time it takes to successfully deliver an application layer packet/message from the radio protocol layer 2/3 SDU ingress point to the radio protocol layer 2/3 SDU egress point via the radio interface in both uplink and downlink directions, where neither device nor Base Station reception is restricted by DRX. Scheduling delay is excluded. Control plane latency refers to the time to move from a battery efficient state (e.g. IDLE) to start of continuous data transfer (e.g. ACTIVE).		

Compared to DVB-S2x/RCS2, the NR protocol performs slightly worse on the DL and slightly better on the UL in terms of overhead at both access and physical layer. Further assessment is need taking into account detailed use case (e.g. user traffic profile, number of UE served, mean spectral efficiency per beam, …).

In terms of link level degradation arising with PAPR, almost no performance degradation is expected on the UL if SC-FDMA is considered (see ETSI TR 103 297 [i.11]). As per DL, the performance degradation at low to moderate spectral efficiency is expected to be similar for satellite with multi carrier per amplifier/active antenna payload configuration.

4.5 Other aspects

Table 5 compares both radio protocols with respect to additional non-technical criteria.

Table 5: Respective non-technical characteristics of DVB-S2x/DVB-RCS2 and of 3GPP NR with NTN enhancements

Comparison criteria	DVB-S2x/RCS2	3GPP NR radio protocol with NTN enhancements
Multi-vendor interoperability	On a case by case basis. No interoperability tests are defined.	3GPP defined interoperability tests allowing multi vendors interoperability across the radio protocol as well as across several interface of the satellite enabled 5G system.
Support of national regulated services (e.g. lawful intercept, emergency calls, public warning, charging)	Implemented through proprietary scheme.	Yes (key requirements taken into account in the protocol design).
Forward compatibility towards B5G/6G	Can be defined (specific for each SatCom system) once the first specs on 6G will be available.	Natively supported.
Carbon footprint impact	No specific energy saving enabling features are defined in DVB specifications. Some proprietary schemes are typically implemented.	Leveraging a continuous effort of more than 20 years on enabling energy saving technology and features (at both UE and network infrastructure level) based on Life cycle assessment methodology/studies.

5 Link level performance comparison

5.1 Reference scenario description

The reference scenario is based on a single GSO satellite system offering broadband services through a multi-beam service coverage. The satellite payload is transparent in the sense that it does not have signal regeneration capabilities. The payload architecture on the service link is based on an active antenna.