

ETSI TS 138 321 V18.9.0 (2026-04)



TECHNICAL SPECIFICATION

5G;  
NR;  
Medium Access Control (MAC) protocol specification  
(3GPP TS 38.321 version 18.9.0 Release 18)

get full document from [standards.iteh.ai](https://standards.iteh.ai)



---

**Reference**

RTS/TSGR-0238321 vi90

---

**Keywords**

5G

**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

---

**Important notice**

The present document can be downloaded from the  
[ETSI Search & Browse Standards](#) application.

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format on [ETSI deliver](#) repository.

Users should be aware that the present document may be revised or have its status changed, this information is available in the [Milestones listing](#).

If you find errors in the present document, please send your comments to the relevant service listed under [Committee Support Staff](#).

If you find a security vulnerability in the present document, please report it through our [Coordinated Vulnerability Disclosure \(CVD\)](#) program.

---

**Notice of disclaimer & limitation of liability**

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.

No recommendation as to products and services or vendors is made or should be implied.

No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.

In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

---

**Copyright Notification**

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2026.  
All rights reserved.

---

# 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.

---

# Legal Notice

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found at [3GPP to ETSI numbering cross-referencing](#).

---

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**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.

# Contents

Intellectual Property Rights .....	2
Legal Notice .....	2
Modal verbs terminology.....	2
Foreword.....	9
1 Scope .....	10
2 References .....	10
3 Definitions, symbols and abbreviations .....	11
3.1 Definitions .....	11
3.2 Abbreviations .....	13
4 General .....	15
4.1 Introduction .....	15
4.2 MAC architecture.....	15
4.2.1 General.....	15
4.2.2 MAC Entities .....	15
4.3 Services .....	17
4.3.1 Services provided to upper layers .....	17
4.3.2 Services expected from physical layer.....	17
4.4 Functions .....	17
4.5 Channel structure.....	18
4.5.1 General.....	18
4.5.2 Transport Channels.....	18
4.5.3 Logical Channels .....	18
4.5.4 Mapping of Transport Channels to Logical Channels .....	19
4.5.4.1 General .....	19
4.5.4.2 Uplink mapping.....	19
4.5.4.3 Downlink mapping.....	19
4.5.4.4 Sidelink mapping .....	19
5 MAC procedures .....	20
5.1 Random Access procedure .....	20
5.1.1 Random Access procedure initialization.....	20
5.1.1a Initialization of variables specific to Random Access type .....	25
5.1.1b Selection of the set of Random Access resources for the Random Access procedure.....	28
5.1.1c Availability of the set of Random Access resources.....	34
5.1.1d Selection of the set of Random Access resources based on feature prioritization .....	34
5.1.1e Selection of Msg1 repetition for SI request .....	35
5.1.2 Random Access Resource selection.....	35
5.1.2a Random Access Resource selection for 2-step RA type .....	39
5.1.3 Random Access Preamble transmission .....	40
5.1.3a MSGA transmission.....	42
5.1.4 Random Access Response reception.....	43
5.1.4a MSGB reception and contention resolution for 2-step RA type .....	47
5.1.5 Contention Resolution .....	50
5.1.6 Completion of the Random Access procedure.....	53
5.2 Maintenance of Uplink Time Alignment.....	53
5.2a Maintenance of UL Synchronization.....	57
5.3 DL-SCH data transfer.....	58
5.3.1 DL Assignment reception .....	58
5.3.2 HARQ operation.....	60
5.3.2.1 HARQ Entity.....	60
5.3.2.2 HARQ process .....	61
5.3.3 Disassembly and demultiplexing .....	62
5.4 UL-SCH data transfer.....	63
5.4.1 UL Grant reception .....	63

5.4.2	HARQ operation .....	68
5.4.2.1	HARQ Entity .....	68
5.4.2.2	HARQ process .....	72
5.4.3	Multiplexing and assembly .....	74
5.4.3.1	Logical Channel Prioritization .....	74
5.4.3.1.1	General .....	74
5.4.3.1.2	Selection of logical channels .....	75
5.4.3.1.3	Allocation of resources .....	75
5.4.3.2	Multiplexing of MAC Control Elements and MAC SDUs .....	77
5.4.4	Scheduling Request .....	77
5.4.5	Buffer Status Reporting .....	83
5.4.6	Power Headroom Reporting .....	86
5.4.7	Pre-emptive Buffer Status Reporting .....	93
5.4.8	Timing Advance Reporting .....	94
5.4.9	Delay status reporting .....	94
5.5	PCH reception .....	95
5.6	BCH reception .....	96
5.7	Discontinuous Reception (DRX) .....	96
5.7a	Discontinuous Reception (DRX) for MBS Broadcast .....	104
5.7b	Discontinuous Reception (DRX) for MBS Multicast .....	105
5.8	Transmission and reception without dynamic scheduling .....	109
5.8.1	Downlink .....	109
5.8.1a	Downlink for Multicast .....	109
5.8.2	Uplink .....	110
5.8.3	Sidelink .....	115
5.9	Activation/Deactivation of SCells .....	116
5.10	Activation/Deactivation of PDCP duplication .....	118
5.11	MAC reconfiguration .....	119
5.12	MAC Reset .....	120
5.12a	Void .....	122
5.13	Handling of unknown, unforeseen and erroneous protocol data .....	122
5.14	Handling of measurement gaps .....	122
5.15	Bandwidth Part (BWP) operation .....	122
5.15.1	Downlink and Uplink .....	122
5.15.2	Sidelink .....	127
5.16	SUL operation .....	128
5.17	Beam Failure Detection and Recovery procedure .....	128
5.18	Handling of MAC CEs .....	132
5.18.1	General .....	132
5.18.2	Activation/Deactivation of Semi-persistent CSI-RS/CSI-IM resource set .....	133
5.18.3	Aperiodic CSI Trigger State Subselection .....	134
5.18.4	Activation/Deactivation of UE-specific PDSCH TCI state .....	134
5.18.5	Indication of TCI state for UE-specific PDCCH .....	134
5.18.6	Activation/Deactivation of Semi-persistent CSI reporting on PUCCH .....	135
5.18.7	Activation/Deactivation of Semi-persistent SRS and Indication of spatial relation of SP/AP SRS .....	135
5.18.8	Activation/Deactivation of spatial relation of PUCCH resource .....	135
5.18.9	Activation/Deactivation of semi-persistent ZP CSI-RS resource set .....	136
5.18.10	Recommended Bit Rate .....	136
5.18.11	Void .....	137
5.18.12	Void .....	137
5.18.13	Void .....	137
5.18.14	Update of Pathloss Reference RS of SRS .....	137
5.18.15	Update of Pathloss Reference RS of PUSCH .....	137
5.18.16	Indication of spatial relation of SRS resource for a Serving Cell set .....	137
5.18.17	Activation/Deactivation of Semi-Persistent Positioning SRS .....	138
5.18.18	Timing offset adjustments for IAB .....	138
5.18.19	Guard symbols for IAB .....	138
5.18.20	Positioning Measurement Gap Activation/Deactivation Command .....	139
5.18.21	PPW Activation/Deactivation Command .....	139
5.18.22	Update of PUCCH Power Control Set for multiple TRP PUCCH repetition .....	140
5.18.23	Unified TCI States Activation/Deactivation MAC CE .....	140
5.18.24	Update of Differential Koffset .....	140

5.18.25	BFD-RS Indication MAC CE .....	140
5.18.26	Restricted and recommended beam indication for IAB .....	140
5.18.27	DL TX power adjustment for IAB .....	141
5.18.28	UL PSD range adjustment for IAB .....	142
5.18.29	Timing case indication for IAB .....	142
5.18.30	Case-6 Timing Request .....	142
5.18.31	Backhaul Link Beam Indication for NCR .....	142
5.18.32	Access Link Beam Indication for NCR .....	143
5.18.33	Enhanced Unified TCI States Activation/Deactivation MAC CE .....	143
5.18.34	Activation/deactivation of PSI-based SDU discard .....	143
5.18.35	LTM Cell Switch Command .....	143
5.18.36	Candidate Cell TCI States Activation/Deactivation .....	144
5.18.37	Activation/Deactivation of Aggregated Semi-Persistent Positioning SRS .....	144
5.19	Data inactivity monitoring .....	145
5.20	Void .....	145
5.21	LBT operation .....	145
5.21.1	General .....	145
5.21.2	LBT failure detection and recovery procedure .....	145
5.22	SL-SCH Data transfer and SL-PRS transmission .....	147
5.22.1	SL-SCH Data and SL-PRS transmission .....	147
5.22.1.1	SL Grant reception and SCI transmission .....	147
5.22.1.2	TX resource (re-)selection check .....	169
5.22.1.2a	Re-evaluation and Pre-emption .....	170
5.22.1.2b	Re-selection for using a received resource conflict indication .....	172
5.22.1.2c	Resource re-selection from SL LBT Failure indication .....	173
5.22.1.3	Sidelink HARQ operation and SL-PRS transmission .....	173
5.22.1.3.1	Sidelink HARQ Entity .....	173
5.22.1.3.1a	Sidelink process not associated with Dedicated SL-PRS resource pool .....	176
5.22.1.3.2	PSFCH reception .....	178
5.22.1.3.3	HARQ-based Sidelink RLF detection .....	179
5.22.1.3.4	Processing of sidelink grant on Dedicated SL-PRS resource pool .....	180
5.22.1.3.5	Sidelink process associated with Dedicated SL-PRS resource pool .....	181
5.22.1.4	Multiplexing and assembly .....	181
5.22.1.4.0	General .....	181
5.22.1.4.1	Logical channel prioritization .....	181
5.22.1.4.2	Multiplexing of MAC Control Elements and MAC SDUs .....	186
5.22.1.5	Scheduling Request .....	186
5.22.1.6	Buffer Status Reporting .....	187
5.22.1.7	CSI Reporting .....	190
5.22.1.8	Void .....	190
5.22.1.9	IUC-Request transmission .....	190
5.22.1.10	IUC-Information Reporting .....	191
5.22.1.10.1	General .....	191
5.22.1.10.2	Reception of IUC-Information Reporting .....	192
5.22.1.11	TX carrier (re-)selection .....	192
5.22.1.12	SL-PRS Resource Request .....	194
5.22.2	SL-SCH Data and SL-PRS reception .....	194
5.22.2.1	SCI reception .....	194
5.22.2.2	Sidelink HARQ operation and SL-PRS reception on Shared SL-PRS resource pool .....	195
5.22.2.2.1	Sidelink HARQ Entity .....	195
5.22.2.2.2	Sidelink process .....	196
5.22.2.3	Disassembly and demultiplexing .....	197
5.22.2.4	SL-PRS reception on Dedicated SL-PRS resource pool .....	198
5.23	SL-BCH data transfer .....	198
5.23.1	SL-BCH data transmission .....	198
5.23.2	SL-BCH data reception .....	198
5.24	Handling of PRS Processing Window .....	198
5.25	Positioning Measurement Gap Activation/Deactivation Request .....	199
5.26	Positioning SRS transmission in RRC_INACTIVE .....	199
5.26.1	General .....	199
5.26.2	TA validation for SRS transmission in RRC_INACTIVE .....	199
5.27	Small Data Transmission .....	200

5.27.1	General.....	200
5.27.2	TA Validation for CG-SDT .....	202
5.28	Sidelink Discontinuous Reception (DRX) .....	203
5.28.1	General.....	203
5.28.2	Behaviour of UE receiving SL-SCH Data .....	203
5.28.3	Behaviour of UE transmitting SL-SCH Data.....	207
5.29	Activation/Deactivation of SCG.....	208
5.30	Handling of FR2 UL gap.....	209
5.31	Sidelink LBT operation .....	209
5.31.1	General.....	209
5.31.2	Sidelink LBT failure detection and recovery procedure .....	209
5.32	Void.....	210
5.33	First PUSCH transmission of RACH-less handover .....	210
5.34	Cell-Level Energy Saving .....	211
5.34.1	General.....	211
5.34.2	Cell Discontinuous Transmission .....	211
5.34.3	Cell Discontinuous Reception.....	213
6	Protocol Data Units, formats and parameters.....	214
6.1	Protocol Data Units .....	214
6.1.1	General.....	214
6.1.2	MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response).....	214
6.1.3	MAC Control Elements (CEs).....	217
6.1.3.1	Buffer Status Report MAC CEs .....	217
6.1.3.2	C-RNTI MAC CE .....	226
6.1.3.3	UE Contention Resolution Identity MAC CE.....	226
6.1.3.4	Timing Advance Command MAC CE .....	226
6.1.3.4a	Absolute Timing Advance Command MAC CE.....	227
6.1.3.5	DRX Command MAC CE .....	227
6.1.3.6	Long DRX Command MAC CE .....	227
6.1.3.7	Configured Grant Confirmation MAC CE.....	227
6.1.3.8	Single Entry PHR MAC CE.....	227
6.1.3.9	Multiple Entry PHR MAC CE .....	229
6.1.3.10	SCell Activation/Deactivation MAC CEs .....	232
6.1.3.11	Duplication Activation/Deactivation MAC CE.....	233
6.1.3.12	SP CSI-RS/CSI-IM Resource Set Activation/Deactivation MAC CE .....	233
6.1.3.13	Aperiodic CSI Trigger State Subselection MAC CE .....	234
6.1.3.14	TCI States Activation/Deactivation for UE-specific PDSCH MAC CE .....	235
6.1.3.15	TCI State Indication for UE-specific PDCCH MAC CE .....	236
6.1.3.16	SP CSI reporting on PUCCH Activation/Deactivation MAC CE .....	236
6.1.3.17	SP SRS Activation/Deactivation MAC CE.....	237
6.1.3.18	PUCCH spatial relation Activation/Deactivation MAC CE.....	238
6.1.3.19	SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE.....	239
6.1.3.20	Recommended bit rate MAC CE .....	239
6.1.3.21	Timing Delta MAC CE .....	240
6.1.3.22	Guard Symbols MAC CEs .....	241
6.1.3.23	BFR MAC CEs .....	242
6.1.3.24	Enhanced TCI States Activation/Deactivation for UE-specific PDSCH MAC CE .....	243
6.1.3.25	Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE .....	244
6.1.3.26	Enhanced SP/AP SRS Spatial Relation Indication MAC CE.....	245
6.1.3.27	SRS Pathloss Reference RS Update MAC CE.....	246
6.1.3.28	PUSCH Pathloss Reference RS Update MAC CE.....	247
6.1.3.29	Serving Cell Set based SRS Spatial Relation Indication MAC CE.....	247
6.1.3.30	LBT failure MAC CEs .....	249
6.1.3.31	Multiple Entry Configured Grant Confirmation MAC CE .....	250
6.1.3.32	Duplication RLC Activation/Deactivation MAC CE.....	250
6.1.3.33	Sidelink Buffer Status Report MAC CEs.....	250
6.1.3.34	Sidelink Configured Grant Confirmation MAC CE.....	251
6.1.3.35	Sidelink CSI Reporting MAC CE .....	252
6.1.3.36	SP Positioning SRS Activation/Deactivation MAC CE.....	252
6.1.3.37	Guard Symbols MAC CEs for Case-6 and Case-7 timing modes .....	255
6.1.3.38	Case-7 Timing advance offset MAC CE.....	256

6.1.3.39	Case-6 Timing Request MAC CE .....	256
6.1.3.40	Positioning Measurement Gap Activation/Deactivation Request MAC CE .....	256
6.1.3.41	Positioning Measurement Gap Activation/Deactivation Command MAC CE .....	257
6.1.3.42	PPW Activation/Deactivation Command MAC CE .....	257
6.1.3.43	Enhanced BFR MAC CEs .....	258
6.1.3.44	Enhanced TCI States Indication for UE-specific PDCCH MAC CE .....	261
6.1.3.45	PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE .....	262
6.1.3.46	PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE .....	263
6.1.3.47	Unified TCI States Activation/Deactivation MAC CE .....	264
6.1.3.48	Enhanced Single Entry PHR MAC CE .....	265
6.1.3.49	Enhanced Multiple Entry PHR MAC CE .....	266
6.1.3.50	Enhanced Single Entry PHR for multiple TRP MAC CE .....	271
6.1.3.51	Enhanced Multiple Entry PHR for multiple TRP MAC CE .....	271
6.1.3.52	Sidelink DRX Command MAC CE .....	274
6.1.3.53	Sidelink Inter-UE Coordination Information MAC CE .....	274
6.1.3.54	Sidelink Inter-UE Coordination Request MAC CE .....	277
6.1.3.55	Enhanced SCell Activation/Deactivation MAC CEs .....	279
6.1.3.56	Timing Advance Report MAC CE .....	280
6.1.3.57	Differential Koffset MAC CE .....	280
6.1.3.58	BFD-RS Indication MAC CE .....	280
6.1.3.59	SP/AP SRS TCI State Indication MAC CE .....	281
6.1.3.60	Serving Cell Set based SRS TCI State Indication MAC CE .....	282
6.1.3.61	Child IAB-DU Restricted Beam Indication MAC CE .....	283
6.1.3.62	IAB-MT Recommended Beam Indication MAC CE .....	287
6.1.3.63	DL TX Power Adjustment and Desired DL TX Power Adjustment MAC CEs .....	290
6.1.3.64	Desired IAB-MT PSD range MAC CE .....	291
6.1.3.65	Timing Case Indication MAC CE .....	293
6.1.3.66	NCR Downlink Backhaul Link Beam Indication MAC CE .....	294
6.1.3.67	NCR Uplink Backhaul Link Beam Indication MAC CE .....	294
6.1.3.68	NCR Access Link Beam Indication MAC CE .....	295
6.1.3.69	SL LBT failure MAC CE .....	295
6.1.3.70	Enhanced Unified TCI States Activation/Deactivation MAC CE for Joint TCI States .....	295
6.1.3.71	Enhanced Unified TCI States Activation/Deactivation MAC CE for Separate TCI States .....	296
6.1.3.72	Delay Status Report MAC CE .....	297
6.1.3.73	PSI-Based SDU Discard Activation/Deactivation MAC CE .....	298
6.1.3.74	SL-PRS Resource Request MAC CE .....	299
6.1.3.75	LTM Cell Switch Command MAC CE .....	299
6.1.3.76	Candidate Cell TCI States Activation/Deactivation MAC CE .....	301
6.1.3.77	Cross-RRH TCI State Indication for UE-specific PDCCH MAC CE .....	302
6.1.3.78	Single Entry PHR with assumed PUSCH MAC CE .....	303
6.1.3.79	Multiple Entry PHR with assumed PUSCH MAC CE .....	304
6.1.3.80	Enhanced SP CSI reporting on PUCCH Activation/Deactivation MAC CE .....	307
6.1.3.81	Enhanced Single Entry PHR for multiple TRP STx2P MAC CE .....	308
6.1.3.82	Enhanced Multiple Entry PHR for multiple TRP STx2P MAC CE .....	309
6.1.3.83	Aggregated SP Positioning SRS Activation/Deactivation MAC CE .....	312
6.1.4	MAC PDU (transparent MAC) .....	314
6.1.5	MAC PDU (Random Access Response) .....	314
6.1.5a	MAC PDU (MSGB) .....	315
6.1.6	MAC PDU (SL-SCH) .....	316
6.2	Formats and parameters .....	317
6.2.1	MAC subheader for DL-SCH and UL-SCH .....	317
6.2.2	MAC subheader for Random Access Response .....	322
6.2.2a	MAC subheader for MSGB .....	322
6.2.3	MAC payload for Random Access Response .....	323
6.2.3a	MAC payload for MSGB .....	324
6.2.4	MAC subheader for SL-SCH .....	326
7	Variables and constants .....	327
7.1	RNTI values .....	327
7.2	Backoff Parameter values .....	330
7.3	DELTA_PREAMBLE values .....	330
7.4	PRACH Mask Index values .....	331

**Annex A (informative): Change history** .....332  
History .....341

# Sample Document

get full document from [standards.iteh.ai](https://standards.iteh.ai)

---

# Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

# Sample Document

get full document from [standards.iteh.ai](https://standards.iteh.ai)

---

# 1 Scope

The present document specifies the NR MAC protocol.

---

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 38.300: "NR; Overall description; Stage 2".
- [3] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".
- [4] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) protocol specification".
- [5] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".
- [6] 3GPP TS 38.213: "NR; Physical Layer Procedures for control".
- [7] 3GPP TS 38.214: "NR; Physical Layer Procedures for data".
- [8] 3GPP TS 38.211: "NR; Physical channels and modulation".
- [9] 3GPP TS 38.212: "NR; Multiplexing and channel coding".
- [10] Void.
- [11] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".
- [12] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".
- [13] 3GPP TS 26.114: "Technical Specification Group Services and System Aspects; IP Multimedia Subsystem (IMS); Multimedia Telephony; Media handling and interaction".
- [14] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".
- [15] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".
- [16] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios".
- [17] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer Procedures".
- [18] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access".
- [19] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".
- [20] 3GPP TS 23.285: "Architecture enhancements for V2X services".

- [21] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".
- [22] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC); Protocol specification".
- [23] 3GPP TS 37.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)".
- [24] 3GPP TS 38.215: "NR; Physical layer measurements".
- [25] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities".
- [26] 3GPP TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".
- [27] 3GPP TS 38.473: "NG-RAN; F1 Application Protocol (F1AP)".
- [28] 3GPP TS 24.587: " Technical Specification Group Core Network and Terminals; Vehicle-to-Everything (V2X) services in 5G System (5GS)".
- [29] 3GPP TS 24.554: "Technical Specification Group Core Network and Terminals; Proximity-services (ProSe) in 5G System (5GS) protocol".
- [30] 3GPP TS 23.586: "Technical Specification Group Services and System Aspects; Architectural Enhancements to support Ranging based services and Sidelink Positioning".
- [31] 3GPP TS 23.256: "Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2".

---

## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**A2X communication:** A communication to support A2X services leveraging PC5 reference points, as defined in TS 23.256 [31]. A2X services are realized by various types of A2X applications, e.g., BRID or DAA.

**Air to Ground network:** An NG-RAN consisting of ground-based gNBs, which provide cell towers that send signals up to an aircraft's antenna(s) of onboard ATG terminal, with typical vertical altitude of around 10,000 m and take-off/landing altitudes down to 3000 m.

**BWP for SRS for positioning Tx frequency hopping:** For SRS for positioning Tx frequency hopping, separate BWP configuration outside BWP configuration for data transmission.

**Dedicated SL-PRS resource pool:** A sidelink resource pool which can be used for the transmission of SL-PRS and cannot be used for the transmission of PSSCH.

**Dormant BWP:** The dormant BWP is one of downlink BWPs configured by the network via dedicated RRC signaling. In the dormant BWP, the UE stop monitoring PDCCH on/for the SCell, but continues performing CSI measurements, Automatic Gain Control (AGC) and beam management, if configured.

**DRX group:** A group of Serving Cells that is configured by RRC and that have the same DRX Active Time.

**eRedCap UE:** A UE with enhanced reduced capabilities as specified in clause 4.2.22.1 of TS 38.306 [25].

**HARQ information:** HARQ information for DL-SCH, for UL-SCH, or for SL-SCH transmissions consists of New Data Indicator (NDI), Transport Block Size (TBS), Redundancy Version (RV), and HARQ process ID.

**IAB-donor:** gNB that provides network access to UEs via a network of backhaul and access links.

**IAB-node:** RAN node that supports NR access links to UEs and NR backhaul links to parent nodes and child nodes.

**Listen Before Talk:** A procedure according to which transmissions are not performed if the channel is identified as being occupied, see TS 37.213 [18].

**LTM candidate cell:** A candidate cell configured for LTM as defined in TS 38.331 [5].

**Msg3:** Message transmitted on UL-SCH containing a C-RNTI MAC CE or CCCH SDU, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a Random Access procedure.

**Multi-path:** Mode of operation of a UE in RRC\_CONNECTED configured with one direct path on which the UE connects to gNB using NR Uu, and one indirect path on which the UE connects to the same gNB via another UE using PC5 unicast link or non-3GPP connection (N3C).

**Multi-PUSCH configured grant:** A configured grant configuration configured with *nrOfSlotsInCG-Period* (see TS 38.331 [5]). It includes multiple consecutive configured uplink grants within a single periodicity.

**N3C indirect path:** In Multi-path, the indirect path using Non-3GPP Connection between remote UE and relay UE.

**NCR-Fwd:** NCR-node function, which performs amplifying-and-forwarding of UL/DL RF signals between gNB and UE. The behavior of the NCR-Fwd is controlled according to the side control information received by the NCR-MT from a gNB.

**NCR-MT:** NCR-node entity which communicates with a gNB via a control link to receive side control information. The control link is based on NR Uu interface.

**NCR-node:** RAN node comprising NCR-MT and NCR-Fwd.

**Non-terrestrial network:** An NG-RAN consisting of gNBs, which provide non-terrestrial NR access to UEs by means of an NTN payload embarked on an airborne or space-borne NTN vehicle and an NTN Gateway.

**NR backhaul link:** NR link used for backhauling between an IAB-node and an IAB-donor, and between IAB-nodes in case of a multi-hop backhauling.

**NR sidelink communication:** AS functionality enabling at least V2X Communication as defined in TS 23.287 [19] and ProSe communication (including ProSe non-Relay, UE-to-Network Relay and UE-to-UE Relay communication (including ProSe UE-to-UE Relay communication with integrated discovery)) as defined in TS 23.304 [26], between two or more nearby UEs, using NR technology but not traversing any network node.

**NR sidelink discovery:** AS functionality enabling ProSe non-Relay discovery, ProSe UE-to-Network Relay discovery and ProSe UE-to-UE Relay discovery for Proximity based Services as defined in TS 23.304 [26], between two or more nearby UEs, using NR technology but not traversing any network node.

**NR sidelink transmission:** Any NR Sidelink-based transmission, including transmission for NR sidelink discovery, transmission for NR sidelink communication, transmission for Ranging/Sidelink Positioning, and transmission for A2X communication.

**PDCCH occasion:** A time duration (i.e. one or a consecutive number of symbols) during which the MAC entity is configured to monitor the PDCCH.

**Positioning SRS Bandwidth Aggregation:** Transmission of positioning SRS on multiple carriers in RRC\_CONNECTED and RRC\_INACTIVE where the positioning SRS resources are linked in RRC configuration as defined in TS 38.331 [5].

**PRS Processing Window:** A time window during which UE may perform PRS measurement inside the active DL BWP with the same numerology as the active DL BWP without measurement gap.

**Ranging/Sidelink Positioning:** AS functionality enabling ranging-based services and sidelink positioning as specified in TS 23.586 [30].

**RB set:** A RB set refers to a contiguous set of resource blocks (RBs) on which a channel access procedure is performed in shared spectrum as defined in TS 37.213 [18].

**RedCap UE:** A UE with reduced capabilities as specified in clause 4.2.21.1 in TS 38.306 [25].

**Serving Cell:** A PCell, a PSCell, or an SCell in TS 38.331 [5].

**Shared SL-PRS resource pool:** A sidelink resource pool which can be used for the transmission of both SL-PRS and PSSCH.

**Sidelink transmission information:** Sidelink transmission information included in an SCI for an SL-SCH transmission or SL-PRS transmission with or without SL-SCH transmission on Shared SL-PRS resource pool as specified in clause 8.3 and 8.4 of TS 38.212 [9] consists of Sidelink HARQ information including NDI, RV, Sidelink process ID, HARQ feedback enabled/disabled indicator, Sidelink identification information including cast type indicator, Source Layer-1 ID and Destination Layer-1 ID, and Sidelink other information including CSI request, SL-PRS request, SL-PRS resource ID, a priority, a communication range requirement and Zone ID and COT sharing information.

**SL-PRS delay budget:** Delay budget before which the SL-PRS is expected to be transmitted by the Tx UE.

**SL-PRS transmission information on Dedicated SL-PRS resource pool:** SL-PRS transmission information on Dedicated SL-PRS resource pool is included in an SCI for an SL-PRS transmission on Dedicated SL-PRS resource pool, as specified in TS 38.212 [9], consisting of

- SL-PRS identification information, including cast type indicator, source ID and destination ID;
- SL-PRS transmission other information, including SL-PRS priority, SL-PRS request, SL-PRS resource ID and resource reservation period.

**SRS positioning validity area:** An area consisting of a list of cells within which the corresponding positioning SRS configuration is considered as valid.

**Special Cell:** For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG depending on if the MAC entity is associated to the MCG or the SCG, respectively. Otherwise the term Special Cell refers to the PCell. A Special Cell supports PUCCH transmission and contention-based Random Access, and is always activated.

**Timing Advance Group:** A group of Serving Cells that is configured by RRC and that, for the cells with a UL configured, using the same timing reference cell and the same Timing Advance value. A Timing Advance Group containing the SpCell of a MAC entity is referred to as Primary Timing Advance Group (PTAG), whereas the term Secondary Timing Advance Group (STAG) refers to other TAGs.

**UE-gNB RTT:** For non-terrestrial networks, the sum of the UE's Timing Advance value (see TS 38.211 [8] clause 4.3.1) and *k<sub>mac</sub>*.

**V2X sidelink communication:** AS functionality enabling V2X Communication as defined in TS 23.285 [20], between nearby UEs, using E-UTRA technology but not traversing any network node.

NOTE 1: A timer is running once it is started, until it is stopped or until it expires; otherwise it is not running. A timer can be started if it is not running or restarted if it is running. A Timer is always started or restarted from its initial value. The duration of a timer is not updated until it is stopped or expires (e.g. due to BWP switching). When the MAC entity applies zero value for a timer, the timer shall be started and immediately expire unless explicitly stated otherwise.

NOTE 2: In this version of the specification, the SRS in the procedural description includes Positioning SRS except for the Positioning SRS for transmission in RRC\_INACTIVE as in clause 5.26. Positioning SRS except for the Positioning SRS for transmission in RRC\_INACTIVE is treated the same as SRS by the UE unless explicitly stated otherwise.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

A2X	Aircraft-to-Everything
AP	Aperiodic
BFR	Beam Failure Recovery
BRID	Broadcast Remote Identification
BSR	Buffer Status Report
BWP	Bandwidth Part
CE	Control Element

CG	Cell Group
CG-SDT	Configured Grant-based SDT
CI-RNTI	Cancellation Indication RNTI
CSI	Channel State Information
CSI-IM	CSI Interference Measurement
CSI-RS	CSI Reference Signal
CS-RNTI	Configured Scheduling RNTI
DAA	Detect And Avoid
DAPS	Dual Active Protocol Stack
DCP	DCI with CRC scrambled by PS-RNTI
DL-PRS	DownLink-Positioning Reference Signal
DSR	Delay Status Report
DTX	Discontinuous Transmission
G-CS-RNTI	Group Configured Scheduling RNTI
G-RNTI	Group RNTI
IAB	Integrated Access and Backhaul
INT-RNTI	Interruption RNTI
LBT	Listen Before Talk
LCG	Logical Channel Group
LCP	Logical Channel Prioritization
LTM	L1/L2 Triggered Mobility
MBS	Multicast/Broadcast Services
MCCH	MBS Control Channel
MCCH-RNTI	MBS Control Channel RNTI
MCG	Master Cell Group
MO-SDT	Mobile Originated SDT
MPE	Maximum Permissible Exposure
MTCH	MBS Traffic Channel
MT-SDT	Mobile Terminated SDT
N3C	Non-3GPP Connection
NCD-SSB	Non Cell Defining SSB
NCR	Network-Controlled Repeater
NSAG	Network Slice AS Group
NUL	Normal Uplink
NZP CSI-RS	Non-Zero Power CSI-RS
PDB	Packet Delay Budget
PEI-RNTI	Paging Early Indication RNTI
PHR	Power Headroom Report
PQI	PC5 QoS Identifier
PS-RNTI	Power Saving RNTI
PSI	PDU Set Importance
PTAG	Primary Timing Advance Group
PTM	Point to Multipoint
PTP	Point to Point
QCL	Quasi-colocation
PPW	PRS Processing Window
PRS	Positioning Reference Signal
RA-SDT	Random Access-based SDT
RRH	Remote Radio Head
RS	Reference Signal
SCG	Secondary Cell Group
SDT	Small Data Transmission
SFI-RNTI	Slot Format Indication RNTI
SI	System Information
SL-PRS-CS-RNTI	SL-PRS-Configured Scheduling-RNTI
SL-PRS-RNTI	SL-PRS-RNTI
SL-CS-RNTI	Sidelink-Configured Scheduling-RNTI
SL-PRS	Sidelink-PRS
SL-RNTI	Sidelink-RNTI
SpCell	Special Cell
SP	Semi-Persistent
SP-CSI-RNTI	Semi-Persistent CSI RNTI