



**Digital cellular telecommunications system (Phase 2+) (GSM);  
Universal Mobile Telecommunications System (UMTS);  
LTE;  
5G;  
Release 17 Description;  
Summary of Rel-17 Work Items  
(3GPP TR 21.917 version 17.0.1 Release 17)**



---

**Reference**

---

DTR/TSGS-0021917vh01

---

---

**Keywords**

---

5G,GSM,LTE,UMTS

---

**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:

<http://www.etsi.org/standards-search>

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 at [www.etsi.org/deliver](http://www.etsi.org/deliver).

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

If you find a security vulnerability in the present document, please report it through our  
Coordinated Vulnerability Disclosure Program:

<https://www.etsi.org/standards/coordinated-vulnerability-disclosure>

---

**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 2023.  
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 Web server (<https://ipr.etsi.org/>).

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™** and **LTE™** 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 Report (TR) 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 under <http://webapp.etsi.org/key/queryform.asp>.

---

# 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.

# Contents

Intellectual Property Rights .....	2
Legal Notice .....	2
Modal verbs terminology.....	2
Foreword.....	7
Introduction .....	7
1 Scope .....	8
2 References .....	8
3 Definitions of terms, symbols and abbreviations .....	8
3.1 Terms.....	8
3.2 Symbols.....	8
3.3 Abbreviations .....	8
4 Rel-17 Executive Summary.....	9
5 Integration of satellite components in the 5G architecture.....	9
5.1 General traffic (non-IoT).....	9
5.1.1 SA and CT aspects .....	9
5.1.2 RAN aspects .....	12
5.2 NB-IoT/eMTC support for Non-Terrestrial Networks .....	16
6 Services to "verticals" .....	21
6.1 Introduction .....	21
6.2 Generic functionalities, to all verticals.....	21
6.2.1 Network and application enablement for verticals.....	21
6.2.1.1 Enhanced Service Enabler Architecture Layer for Verticals.....	21
6.2.1.2 Enhancements for Cyber-physical control Applications in Vertical domains (eCAV) .....	22
6.2.1.3 Enhancements of 3GPP Northbound Interfaces and APIs .....	23
6.2.2 Location and positioning .....	24
6.2.2.1 RAN aspects of NR positioning enhancements .....	24
6.2.2.2 Enhancement to the 5GC LoCation Services-Phase 2.....	26
6.2.3 Support of Non-Public and Private Networks.....	27
6.2.3.1 Enhanced support of Non-Public Networks .....	27
6.2.3.2 Enhancement of Private Network support for NG-RAN.....	28
6.3 Specific verticals support .....	30
6.3.1 Railways .....	30
6.3.1.1 Enhancements to Application Architecture for the Mobile Communication System for Railways Phase 2 .....	30
6.3.1.2 Enhanced NR support for high speed train scenario (NR_HST).....	31
6.3.1.2.1 NR_HST for FR1 .....	31
6.3.1.2.2 NR_HST for FR2 .....	31
6.3.1.3 NR Frequency bands for Railways.....	32
6.3.1.3.1 Introduction of 900MHz NR band for Europe for Rail Mobile Radio (RMR) .....	32
6.3.1.3.2 Introduction of 1900MHz NR TDD band for Europe for Rail Mobile Radio (RMR) .....	32
6.3.2 Mission Critical (MC) and priority service.....	33
6.3.2.1 Mission Critical Push-to-talk Phase 3 .....	33
6.3.2.2 Mission Critical Data Phase 3 .....	34
6.3.2.3 Mission Critical security Phase 2 .....	35
6.3.2.4 Mission Critical Services over 5GS .....	36
6.3.2.5 Enhanced Mission Critical Communication Interworking with Land Mobile Radio Systems (CT aspects).....	36
6.3.2.6 Mission Critical system migration and interconnection (CT aspects).....	37
6.3.2.7 MC services support on IOPS mode of operation .....	38
6.3.2.8 MCPTT in Railways .....	39
6.3.2.9 Multimedia Priority Service (MPS) Phase 2 .....	39
6.3.3 Drone/UAS/UAV/EAV .....	41

6.3.3.1	Introduction .....	41
6.3.3.2	General aspects .....	41
6.3.3.2.1	5G Enhancement for UAVs.....	41
6.3.3.2.2	Application layer support for UAS.....	42
6.3.3.3	Remote Identification of UAS.....	44
6.3.4	Media production, professional video and Multicast-Broadcast.....	45
6.3.4.1	Communication for Critical Medical Applications .....	45
6.3.4.2	Audio-Visual Service Production.....	46
6.3.4.3	Multicast-Broadcast Services (MBS).....	47
6.3.4.3.1	Multicast-broadcast services in 5G.....	47
6.3.4.3.2	NR multicast and broadcast services .....	49
6.3.4.3.3	5G multicast and broadcast services.....	51
6.3.4.3.4	Security Aspects of Enhancements for 5G MBS.....	52
6.3.4.4	Study on Multicast Architecture Enhancements for 5G Media Streaming .....	52
6.3.4.5	5G Multicast-Broadcast User Service Architecture and related 5GMS Extensions.....	52
6.3.4.6	Other media and broadcast aspects .....	53
6.3.5	Asset Tracking for 5G.....	53
6.4	Other "verticals" aspects.....	54
7	IoT, Industrial IoT, REDuced CAPacity UEs and URLLC .....	54
7.1	NR small data transmissions in INACTIVE state .....	54
7.2	Additional enhancements for NB-IoT and LTE-MTC .....	56
7.3	Enhanced Industrial IoT and URLLC support for NR .....	57
7.4	Support of Enhanced Industrial IoT (IIoT).....	58
7.5	Support of reduced capability NR devices .....	60
7.6	IoT and 5G access via Satellite/Non-Terrestrial (NTN) link.....	62
7.7	Charging enhancement for URLLC and CIoT .....	62
7.8	Messaging in 5G.....	63
8	Proximity/D2D/Sidelink related and V2X .....	65
8.1	Enhanced Relays for Energy efficiency and Extensive Coverage.....	65
8.2	Proximity-based Services in 5GS .....	65
8.3	Sidelink/Device-to-Device (D2D).....	67
8.3.1	NR Sidelink enhancement .....	67
8.3.2	NR Sidelink Relay .....	69
8.4	Vehicle-to-Everything (V2X).....	72
8.4.1	Support of advanced V2X services - Phase 2 .....	72
8.4.2	Enhanced application layer support for V2X services .....	73
9	System optimisations.....	74
9.1	Edge computing.....	74
9.1.1	Enhancement of support for Edge Computing in 5G Core network .....	74
9.1.2	Enabling Edge Applications .....	75
9.1.3	Edge Computing Management .....	77
9.2	Slicing .....	77
9.2.1	Network Slicing Phase 2 (CN and AN aspects).....	77
9.2.2	Network Slice charging based on 5G Data Connectivity.....	79
9.3	Access Traffic Steering, Switch and Splitting support in the 5G system architecture; Phase 2 .....	80
9.4	Self-Organizing (SON)/Autonomous Network .....	81
9.4.1	Enhancement of data collection for SON/MDT in NR and EN-DC .....	81
9.4.2	Autonomous network levels .....	84
9.4.3	Enhancements of Self-Organizing Networks (SON) .....	85
9.5	Minimization of service Interruption.....	86
9.6	Policy and Charging Control enhancement .....	87
9.7	Multi-(U)SIM .....	88
9.7.1	Support for Multi-USIM Devices (System and CN aspects) .....	88
9.7.2	Support for Multi-SIM Devices for LTE/NR .....	89
10	Energy efficiency, power saving .....	90
10.1	UE power saving enhancements for NR.....	90
10.2	Enhancements on EE for 5G networks.....	92
10.3	Other energy efficiency aspects.....	93
11	New Radio (NR) physical layer enhancements.....	93

11.1	Further enhancements on MIMO for NR .....	93
11.2	MIMO Over-the-Air requirements for NR UEs .....	96
11.3	Enhancements to Integrated Access and Backhaul for NR .....	97
11.4	NR coverage enhancements .....	100
11.5	RF requirements for NR Repeaters .....	102
11.6	Introduction of DL 1024QAM for NR FR1 .....	103
11.7	NR Carrier Aggregation .....	104
11.7.1	NR intra band Carrier Aggregation.....	104
11.7.2	NR inter band Carrier Aggregation.....	104
11.8	NR Dynamic Spectrum Sharing .....	105
11.9	Increasing UE power high limit for CA and DC .....	105
11.10	RF requirements enhancement for NR FR1 .....	107
11.11	RF requirements further enhancements for NR FR2 .....	107
11.12	NR measurement gap enhancements .....	108
11.13	UE RF requirements for Transparent Tx Diversity for NR .....	109
11.14	NR RRM further enhancement.....	110
11.15	Further enhancement on NR demodulation performance.....	111
11.16	Bandwidth combination set 4 (BCS4) for NR.....	112
11.17	Study on band combination handling in RAN4.....	113
11.18	Other NR related activities .....	113
11.19	NR new/modified bands .....	115
11.19.1	Introduction of 6GHz NR licensed bands .....	115
11.19.2	Extending current NR operation to 71 GHz.....	116
11.19.3	Other NR new/modified bands .....	122
12.	New Radio (NR) enhancements other than layer 1 .....	123
12.1	NR Uplink Data Compression (UDC).....	123
12.2	NR QoE management and optimizations for diverse services.....	123
13	NR and LTE enhancements.....	124
13.1	NR and LTE layer 1 enhancements.....	124
13.1.1	High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands ..	124
13.1.2	UE TRP and TRS requirements and test methodologies for FR1 (NR SA and EN-DC).....	125
13.1.3	Other Dual Connectivity and Multi-RAT enhancements.....	126
13.2	NR and LTE enhancements other than layer 1 .....	128
13.2.1	Enhanced eNB(s) architecture evolution for E-UTRAN and NG-RAN .....	128
13.2.2	Further Multi-RAT Dual-Connectivity enhancements .....	129
13.2.3	Further Multi-RAT Dual-Connectivity enhancements .....	131
14	LTE-only enhancements.....	131
14.1	LTE inter-band Carrier Aggregation.....	131
14.2	LTE new/modified bands .....	132
14.2.1	New bands and bandwidth allocation for 5G terrestrial broadcast - part 1 .....	132
14.3	Other LTE bands-related aspects.....	132
15	User plane improvements.....	133
15.1	Immersive Teleconferencing and Telepresence for Remote Terminals .....	133
15.2	8K Television over 5G .....	133
15.3	5G Video Codec Characteristics .....	134
15.4	Handsets Featuring Non-Traditional Earpieces.....	135
15.5	Extension for headset interface tests of UE.....	136
15.6	Media Streaming AF Event Exposure .....	136
15.7	Restoration of PDN Connections in PGW-C/SMF Set .....	139
15.8	Other media and user plane aspects.....	140
16	Standalone Security aspects .....	140
16.1	Introduction .....	140
16.2	Authentication and key management for applications based on 3GPP credential in 5G (AKMA) .....	140
16.3	AKMA TLS protocol profiles .....	140
16.4	User Plane Integrity Protection for LTE.....	141
16.5	Non-Seamless WLAN offload authentication in 5GS.....	142
16.6	Generic Bootstrapping Architecture (GBA) into 5GC .....	142
16.7	Security Assurance Specification for 5G.....	143
16.8	Adapting BEST for use in 5G networks .....	143

16.9	Other security aspects.....	144
17	Signalling optimisations.....	144
17.1	Enhancement for the 5G Control Plane Steering of Roaming for UE in Connected mode .....	144
17.2	Same PCF selection for AMF and SMF .....	145
17.3	Enhancement of Inter-PLMN Roaming .....	146
17.4	Enhancement on the GTP-U entity restart.....	146
17.5	Packet Flow Description management enhancement .....	147
17.6	PAP/CHAP protocols usage in 5GS .....	147
17.7	Start of Pause of Charging via User Plane .....	148
17.8	Enhancement of Handover Optimization .....	148
17.9	Restoration of Profiles related to UDR.....	149
17.10	IP address pool information from UDM.....	149
17.11	Dynamic management of group-based event monitoring.....	149
17.12	Dynamically Changing AM Policies in the 5GC .....	150
17.13	Other aspects .....	151
18	Standalone Management Features.....	152
18.1	Introduction .....	152
18.2	Enhanced Closed loop SLS Assurance.....	152
18.3	Enhancement of QoE Measurement Collection .....	153
18.4	Plug and connect support for management of Network Functions.....	154
18.5	Management of MDT enhancement in 5G .....	154
18.6	Management Aspects of 5G Network Sharing .....	155
18.7	Discovery of management services in 5G .....	155
18.8	Management of the enhanced tenant concept.....	156
18.9	Intent driven management service for mobile network .....	156
18.10	Improved support for NSA in the service-based management architecture .....	157
18.11	Additional Network Resource Model features .....	158
18.12	Charging for Local breakout roaming of data connectivity.....	159
18.13	File Management.....	160
18.14	Management data collection control and discovery .....	160
18.15	Other charging and management aspects .....	161
19	Features without summary .....	162
<b>Annex A:</b>	<b>Change history .....</b>	<b>163</b>
History .....		168

---

# Foreword

This Technical Report 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.

---

# Introduction

The present document provides a summary of each 3GPP Release 17 Feature, and more generally of all Work Items for which a summary has been estimated to be useful.

These summaries are based on the inputs issued by the Work Item Rapporteurs, sometimes modified by the Work Plan manager to ensure overall consistency of this document. The original inputs can be retrieved as temporary document (tdoc). The original tdoc number is provided just below the table of each clause.

The present document presents the "current status" of the Features introduced in Release 17, i.e. as they are by the time of publication of this document. Each Feature can be modified or enhanced, over several years, by the means of Change Requests (CRs).

The list of all the Change Requests related to a Work Item can be retrieved by selecting "TSG Status = Approved" in the Work Item page of the 3GPP Portal at:

[https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=](https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=[6-digit identifier of the Work Item, separated by a coma if several Work Items]) [6-digit identifier of the Work Item, separated by a coma if several Work Items]

For example, for "NR support for high speed train scenario": the table at the beginning of its section indicates that the corresponding Work Items have the numbers 840192 and 840292. So, all the CRs related to this Feature are retrieved by selecting "TSG Status = Approved" in <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840192,840292>



---

# 1 Scope

The present document provides a summary of each Release 17 Feature or, whenever needed, of each significant Work Item.

The information provided in the present document is limited to an overview of each Feature, explaining briefly its purpose and the main lines of the system's behaviour to execute the Feature.

The present document presents the "initial state" of the Features introduced in Release 17, i.e. as they are by the time of publication of the present document. Each Feature is subject to be later modified or enhanced, over several years, by the means of Change Requests (CRs). It is therefore recommended to retrieve all the CRs which relate to the given Feature, as explained in Annex C, to further outline a feature at a given time.

---

# 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] TR 21.905: "Vocabulary for 3GPP Specifications".

NOTE: Due to the specificity of the present document, consisting in a collection of independent summaries, the references are given at the end of each clause rather than in this clause.

---

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms 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].

## 3.2 Symbols

Void.

## 3.3 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]. Abbreviations specific to a given clause are provided in the clause they appear.

KPI	Key Performance Indicator
Rel	3GPP Release

## 4 Rel-17 Executive Summary

Release 17 is dedicated to consolidate and enhance the concepts and functionalities introduced in the previous Releases, while introducing a small number of brand new Features.

The improvements relate to all the key areas of the previous Releases: services to the industry (the "verticals"), including positioning, private network, etc.; improvements for several aspects of 5G supporting Internet of Things (IoT), both in the Core Network and in the Access Network, of proximity (direct) communications between mobiles, in particular in the context of autonomous driving (V2X), in several media aspects of the user plane related to the entertainment industry (codec, streaming, broadcasting) and also of the support of Mission Critical communications. Furthermore, a number of network functionalities have been improved, e.g. for slicing, traffic steering and Edge-computing.

The Radio interface and the Access Network have been significantly improved too (MIMO, Repeaters, 1024QAM modulation for downlink, etc.). While most of the improvements target 5G/NR radio access (or are access-agnostic), some improvements are dedicated to 4G/LTE access. Such improvements are clearly identified in the title and in the chapters where they appear.

**Note:** To avoid terminology such as "even further improvements of...", the successive enhancements are now referred to as "Phase n": "phase 2" refers to the first series of enhancements, "Phase 3" to the enhancements of the enhancements, etc. In this transition Release, the "Phase n" way of referring to successive enhancements has not always been used consistently nor enforced.

As for the new Features, the main new Feature of this Release is the support of satellite access, and a dedicated chapter covers this topic.

Note that the classifications, groupings and order of appearance of the Features in this document reflect a number of choices by the editor as there is no "3GPP endorsement" for classification/order. This Executive Summary has also been written by the editor and represents his view.

## 5 Integration of satellite components in the 5G architecture

### 5.1 General traffic (non-IoT)

#### 5.1.1 SA and CT aspects

UID	Name	Acronym	WG	WID	WI rapporteur name/company
<b>890034</b>	<b>Integration of satellite components in the 5G architecture</b>	<b>5GSAT_ARCH</b>		<b>SP-191335</b>	<b>Jean-Yves FINE and Cyril MICHEL, Thales</b>
800048	<b>Stage 1 of 5GSAT</b>	5GSAT	S1	SP-180326	Jean-Yves FINE and Cyril MICHEL, Thales
800026	Study on architecture aspects for using satellite access in 5G	FS_5GSAT_ARCH	S2	SP-181253	Jean-Yves FINE and Cyril MICHEL, Thales
860005	<b>(Stage 2 of) Integration of satellite components in the 5G architecture</b>	5GSAT_ARCH	S2	SP-191335	Jean-Yves FINE and Cyril MICHEL, Thales
<b>911030</b>	<b>CT aspects of 5GC architecture for satellite networks</b>	<b>5GSAT_ARCH-CT</b>	ct	<b>CP-210149</b>	<b>Catovic, Amer, Qualcomm</b>
890005	CT1 aspects of 5GC architecture for satellite networks	5GSAT_ARCH-CT	C1	CP-210149	Catovic, Amer, Qualcomm
920057	CT3 aspects of 5GC architecture for satellite networks	5GSAT_ARCH-CT	C3	CP-210149	Catovic, Amer, Qualcomm
911031	CT4 aspects of 5GC architecture for satellite networks	5GSAT_ARCH-CT	C4	CP-210149	Catovic, Amer, Qualcomm
930044	CT6 aspects of 5GC architecture for satellite networks	5GSAT_ARCH-CT	C6	CP-210149	Catovic, Amer, Qualcomm

Summary based on the input provided by M. Jean-Yves FINE, Thales in SP-220967, with the assistance of M. Amer Catovic, Qualcomm, for the "Terminal and Core Network aspects".

#### Introduction

The "Integration of satellite components in the 5G architecture" work item adds or enhances a number of features in 5GCore architecture in order to support Non-Terrestrial Networks (NTN), for several use cases:

- Coverage extension: Many commercial activities, such as agriculture, mining, forestry take place outside inhabited areas. Coverage extension with satellite networks is useful to enable e.g. voice communication, video monitoring, and remote control in uncovered or under-covered areas.
- Internet of Things: many Internet-of-Things applications relate to monitoring of assets (e.g. ships, trains, trucks), infrastructure (e.g. bridges, pipelines, railway track), or the environment (e.g. agriculture sensors). In many IoT applications, only small amounts of data are exchanged and communication is optimized for low power usage. Satellite communication should also be able to address these requirements.
- Disaster communication: Public safety authorities have a responsibility to provide assistance in case of natural disasters. This requires communication, also in cases where because of that disaster the cellular infrastructure is damaged. Satellite communication can be used as fall back for these cases. Ideally the user equipment (UE) and way of working when cellular networks are available should also be usable with satellite access.
- Global roaming: Applications like tracking and tracing of containers need to be available globally across satellite and terrestrial networks. When a container is in a harbour or transported on a truck, using a terrestrial cellular network is probably most efficient. However, when the container is on a ship in the middle of an ocean, only satellite communication is possible.
- Broadcasting: Satellite communication is particularly suitable to broadcast the same information over a very wide area. This can also be used in context of 5G mobile edge applications (e.g. mobile gaming), where application content needs to be available in many different edge locations.

To address such use cases, 3GPP has set Key Performance Indicator (KPI) targets for satellite in TS 22.261 [1].

At 5G Core Network architecture level, in SA2, a dedicated study on architecture aspects for using satellite access in 5G (FS\_5GSAT\_ARCH) was conducted to select the solutions able to cope with satellite specific key issues. The outcome of the study (TR 23.737 [2]) identifies the impacts of satellite integration in the 5GS and solutions to adjust the 5G system accordingly.

The 5GSAT\_ARCH work item, following the study, updated architecture specifications (TS 23.501 [4], TS 23.502 [5], TS 23.503 [6]) to implement the solutions identified.

In CT1, TR 24.821 [3] studied "Non-Terrestrial Impact of PLMN selection procedure" and, following 5GSAT\_ARCH\_CT, led to update TS 23.122 [7] and TS 24.501 [8].

Furthermore, RAN has defined "3GPP defined radio access networks supporting non-Terrestrial Networks" [10], described in the next clause.

### **Architectural/general aspects**

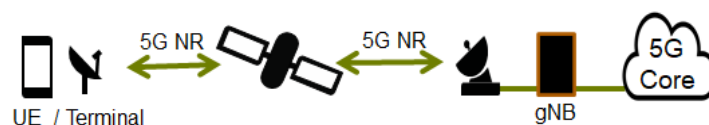
A PLMN core network can be connected to a satellite NG-RAN. A satellite NG-RAN can be shared between more than one core networks.

Satellite NG-RAN can be used as a new RAN 3GPP access but also as backhaul between the core and terrestrial access network, providing a transport for the N1/N2/N3 reference points.

Multi-connectivity and URLLC over satellite are not considered in Rel-17. Basic assumptions are that UEs are equipped with GNSS, and transparent mode: satellites (LEO/MEO/GEO) are relaying the Uu interface only at physical layer level.

### **Impacts on 5GC of Satellite NG-RAN used as new RAN 3GPP access**

In Rel-17, only direct access with transparent satellite is considered, as shown in following figure:



**Figure 1: Direct access with transparent satellite**

Impacts of satellites onto 5GS are linked to the size of the cells (larger than the terrestrial ones), the fact that the satellite cells can be fix on earth, when beam is steerable, but also moving on earth, when beam is not steerable. This characteristics impacts 5GS mobility management, i.e. the management of the handover of radio bearer between nodes and the management of the reachability of a UE for downlink services (paging), that need to be adapted to take into account both the satellite beam size and fix or moving cells configuration.

A basic assumption in Re-17 is that tracking areas (TAs) and cell identities (cell IDs) refer to specific geographical areas, so that 5G services can use these identifiers as representation of a UE location.

To avoid Tracking Area Codes (TAC) fluctuations, in the moving cells case, it has been decided that the Radio Access Network will broadcast in the cell the list of Tracking Area Codes, corresponding to tracking areas that have been define on the earth surface through network planning, for the zone currently enlighten by the radio cell.

New Radio Access Technology types are introduced in the 5GC to distinguish between different satellite configurations (LEO, MEO, GEO, other).

The distance earth – satellite also introduces higher delay values than for terrestrial cells and new 5QI is also introduced in TR 23.501 [4] to cope with this delay, depending on the satellite RAT type.

#### Impacts on 5GC of Satellite NG-RAN used as backhaul

Rel-17 only considers backhauling with constant delay. Here, the satellite operator is able to mask any delay changes in service/feeder links by exploiting the knowledge of the satellite position to calculate how much variable delay should be added to keep the overall delay constant. Connecting gNBs to 5GC via, e.g., a single GEO satellite or a single NGSO satellite without ISLs are examples of such backhauling as shown in following figure.



**Figure 2: satellite backhauling with constant delay**

Backhauling with constant delay minimizes the impact on the 3GPP network architecture. However, there are following new features introduced in TR 23.501 [4] related to the QoS aspects of satellite backhauling:

- o Reporting of satellite backhaul category to the 5G Core Network.
- o New 5G QoS Indicator (5QI) defined for satellite backhaul and satellite access.

#### Terminal and Core Network aspects

PLMN selection procedure is updated for satellite integration in 5GS. Then, in the continuity of the study done in TR 24.821 [3], the following aspects of UE impact at the NAS layer (including PLMN selection) have ben specified by CT1:

- New “NG-RAN satellite” RAT type in USIM
- Extension of the NAS supervision timers over satellite access for GEO and MEO RAT types (LEO uses legacy timers)
- Modification of the higher priority PLMN selection procedure to include shared MCC 9xx
- New minimum periodic search timer for higher priority PLMN search over satellite access when PLMN uses shared MCC
- New trigger for PLMN selection upon transition in/out international areas (based on UE implementation)
- New Forbidden List of PLMNs not allowed to operate at UE location and its handling
- New 5GMM cause value#78 and its handling (related to the list in the previous bullet)
- Support for multiple TACs for the same PLMN broadcast in the radio cell, including corresponding logic for determining the “Current TAI” and impact on ME-USIM procedures

There are corresponding network impacts.

#### **References**

List of related CRs: select "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890034,800048,800026,860005,911030,890005,920057,911031,930044>

- [1] TS 22.261: "Service Requirements for the 5G System".
- [2] TR 23.737: "Study on architecture aspects for using satellite access in 5G";
- [3] TR 24.821: "Study on PLMN selection for satellite access in 5G";
- [4] TR 23.501: "System architecture for the 5G System (5GS), Stage 2";
- [5] TR 23.502: "Procedures for the 5G System (5GS), Stage 2";
- [6] TR 23.503: "Policy and charging control for the 5G System (5GS), Stage 2";
- [7] TR 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode";
- [8] TR 24.501: "Non-Access-Stratum (NAS) protocols for the 5G System (5GS), Stage 3"
- [9] RP-221946 "Summary for NR support for Non-Terrestrial Network (NTN)"
- [10] RP-221169 "Solutions for NR to support non-terrestrial networks (NTN)" / UID 860046

## 5.1.2 RAN aspects

UID	Name	Acronym	WG	WID	WI rapporteur name/company
860046	<b>Solutions for NR to support non-terrestrial networks (NTN)</b>	<b>NR_NTN_solutions</b>		<b>RP-221169</b>	<b>Nicolas CHUBERRE, Thales</b>
860146	<b>Core part: Solutions for NR for NTN</b>	NR_NTN_solutions-Core	R2	RP-221169	Nicolas CHUBERRE, Thales
860246	<b>Perf. Part: Solutions for NR for NTN</b>	NR_NTN_solutions-Perf	R4	RP-221169	Nicolas CHUBERRE, Thales

Summary based on the input provided by Thales in RP-221946.

### Introduction

This Rel-17 RAN WI "Solutions for NR to support Non-Terrestrial Networks (NTN)" introduces support of non-terrestrial networks into the NR protocol and NG-RAN architecture. NTN refers to networks, or segments of networks, using a spaceborne vehicle or an airborne vehicle for transmission, defined as follows:

- Spaceborne vehicles: Geosynchronous (GSO) and Non-Geosynchronous (NGSO) orbiting satellites. NGSO includes Low Earth Orbit at altitude approximately between 300 km and 1500 km and Medium Earth Orbit at altitude approximately between 7000 km and 25000 km.
- Airborne vehicles: High Altitude Platforms (HAPs) encompassing Unmanned Aircraft Systems (UAS) including Lighter than Air UAS (LTA), Heavier than Air UAS (HTA), all operating in altitudes typically between 8 and 50 km, quasi-stationary.

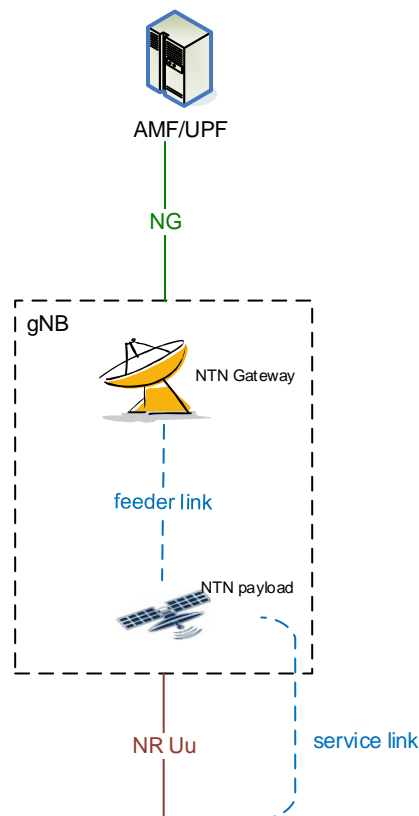
This clause present the RAN aspects while the System and core network aspects ("5GSAT\_ARCH") are covered in the next clause.

The addressed radio specifics of NTN compared to 5G terrestrial networks include

- Delay variation, Doppler variation as well as possible Earth moving radio cells, due to the motion of space/airborne vehicles
- Long latency due to the altitude of the space/airborne vehicles
- Differential delay and possible multi country cell coverage due to larger radio cell size
- Different propagation channel model (See 3GPP 38.811)
- Different radio unit performance due to specific payload performance

### Overall architecture and general aspects

As illustrated in Figure 1, non-terrestrial access is provided by means of an NTN payload, i.e. a network node on-board a satellite or HAPS, and an NTN Gateway interconnected by a feeder link, the UE accessing NTN network services through the NTN payload via a service link.



**Figure 1: Overall illustration of an NTN (from TS 38.300 [4])**

The NTN payload transparently forwards the radio protocol received from the UE (via the service link) to the NTN Gateway (via the feeder link) and vice-versa. A gNB may serve multiple NTN payloads while an NTN payload may be served by multiple gNBs.

Three types of service links are supported:

- Earth-fixed: provisioned by beam(s) continuously covering the same geographical areas all the time (e.g., the case of GSO satellites);
- Quasi-Earth-fixed: provisioned by beam(s) covering one geographic area for a limited period and a different geographic area during another period (e.g., the case of NGSO satellites generating steerable beams);
- Earth-moving: provisioned by beam(s) whose coverage area slides over the Earth surface (e.g., the case of NGSO satellites generating fixed or non-steerable beams).

With NGSO satellites, the NTN gNB can provide either quasi-Earth-fixed cell coverage or Earth-moving cell coverage, while gNB operating with GSO satellite can provide Earth fixed cell coverage.

#### Timing, Synchronization and HARQ enhancements (RAN1)

The network broadcast ephemeris information and common Timing Advance (common TA) parameters in each NTN cell. Since NTN capable UE are expected to be all GNSS-capable, they shall acquire a valid GNSS position as well as the satellite ephemeris and common TA before connecting to an NTN cell.

To achieve uplink synchronisation, before performing random access, the UE shall autonomously pre-compensate the Timing Advance, as well as the frequency Doppler shift by considering the common TA (information from the gNB), the UE position, the satellite position and satellite velocity through the satellite ephemeris. In connected mode, the UE shall continuously update the Timing Advance and frequency pre-compensation. If the UE does not have a valid GNSS position and/or valid satellite ephemeris, it does not communicate with the network until both are regained. The UEs may be configured to report Timing Advance at initial access or in connected mode. In connected mode triggered reporting of the Timing Advance is supported.

While the pre-compensation of the instantaneous Doppler shift experienced on the service link is to be performed by the UE for the uplink, the management of Doppler shift experienced over the feeder link is left to the network implementation.

To accommodate the propagation delay in NTN, several timing relationships are enhanced by a Common Timing Advance (Common TA) and two scheduling offsets  $\Delta_{\text{TA}}$  and  $\Delta_{\text{TA}}^{\text{NTN}}$ .  $\Delta_{\text{TA}}$  is a configured offset that corresponds to the Round Trip Time (RTT) between the Reference Point (RP) and the NTN payload.  $\Delta_{\text{TA}}^{\text{NTN}}$  is a configured scheduling offset that approximately corresponds to the sum of the service link RTT and the common TA.  $\Delta_{\text{TA}}^{\text{NTN}}$  is a configured offset that approximately corresponds to the RTT between the RP and the gNB.

To mitigate the impact of HARQ stalling in NTN the HARQ feedback can be disabled in the presence of ARQ re-transmissions at the RLC layer (e.g., in GSO satellite systems) and/or the number of HARQ processes for re-transmissions at the MAC layer can be increased to 32 (e.g., in NGSO satellite systems).

#### Mobility Management (RAN2)

To enable mobility in NTN, the network provides serving cell's and neighbouring cell's satellite ephemeris needed to access the target serving NTN cell in the handover command.

UE supports mobility between NTN and Terrestrial Network (i.e. from NTN to Terrestrial Network (hand-in) and from Terrestrial Network to NTN (hand-out)), but is not required to connect to both NTN and Terrestrial Network at the same time. It may also support mobility between radio access technologies based on different orbit (GSO, NGSO at different altitude).

Triggering conditions upon which UE may execute Conditional Hand-Over (CHO) to a candidate cell, have been introduced: event A4, time-based trigger condition, location-based trigger condition. The two last conditions are configured together with one of the measurement-based trigger conditions. Location is defined by the distance between UE and a reference location. Time is defined by the time between T1 and T2, where T1 is an absolute time value and T2 is a duration started at T1.

For the measurements the network can configure multiple SS/PBCH Block Measurement Timing Configuration (SMTCS) in parallel per carrier and for a given set of cells depending on UE capabilities using propagation delay difference and ephemeris information. It can also configure measurement gaps based on multiple SMTCS.

The adjustment of SMTCS is possible under network control based on UE assistance information if available for connected mode and under UE control based on UE location and satellite assistance information (e.g., ephemeris, common TA parameters) for idle/inactive modes.

In the quasi-earth fixed cell scenario, UE can perform time-based and location-based measurement in RRC\_IDLE/RRC\_INACTIVE. The timing and location information associated to a cell are provided via system information. They refer respectively to the time when the serving cell is going to stop serving a geographical area and to the reference location of serving cell.

A Tracking Area corresponds to a fixed geographical area. Any respective mapping is configured in the RAN. The network may broadcast multiple Tracking Area Codes (TAC) per PLMN in a NR NTN cell in order to reduce the signalling load at cell edge, in particular for Earth-moving cell coverage. A TAC change in the System Information is under network control and may not be exactly synchronised with real-time illumination of beams on ground.

Regarding the UE location aspects, upon network request, after AS security is established in connected mode, a UE should report its coarse UE location information (most significant bits of the GNSS coordinates, ensuring an accuracy in the order of 2 km) to the NG-RAN if available.

#### Switch-over (RAN3)

A service link switch refers to a change of serving satellite.

A feeder link switch over is the procedure where the feeder link is changed from a source NTN Gateway to a target NTN Gateway for a specific NTN payload. The feeder link switch over is a Transport Network Layer procedure. Both hard and soft feeder link switch over are applicable to NTN.

Service and feeder link switch overs apply mostly for the case of NGSO.

#### NG-RAN signalling (RAN3)

The Cell Identity, indicated by the gNB to the Core Network as part of the User Location Information corresponds to a Mapped Cell ID, irrespective of the orbit of the NTN payload or the types of service links supported. It is used for Paging Optimization in NG interface, Area of Interest and Public Warning Services.

The Cell Identity included within the target identification of the handover messages allows identifying the correct target radio cell as well as for RAN paging.

The mapping between Mapped Cell IDs and geographical areas is configured in the RAN and Core Network. The gNB is responsible for constructing the Mapped Cell ID based on the UE location info received from the UE, if available. The mapping may be pre-configured (e.g., up to operator's policy) or up to implementation.

The gNB reports the broadcasted TAC(s) of the selected Public Land Mobile Network (PLMN) to the Access and Mobility Management Function (AMF) as part of UE Location Information (ULI). In case the gNB knows the UE's location information, the gNB may determine the Tracking Area Indicator (TAI) the UE is currently located in and provide that TAI to the AMF as part of ULI.

#### AMF (Re-)Selection by gNB (RAN3)

For a RRC\_CONNECTED UE, when the gNB is configured to ensure that the UE connects to an AMF that serves the country in which the UE is located. If the gNB detects that the UE is in a different country to that served by the serving AMF, then it should perform an NG handover to change to an appropriate AMF, or initiate an UE Context Release Request procedure towards the serving AMF (in which case the AMF may decide to de-register the UE).

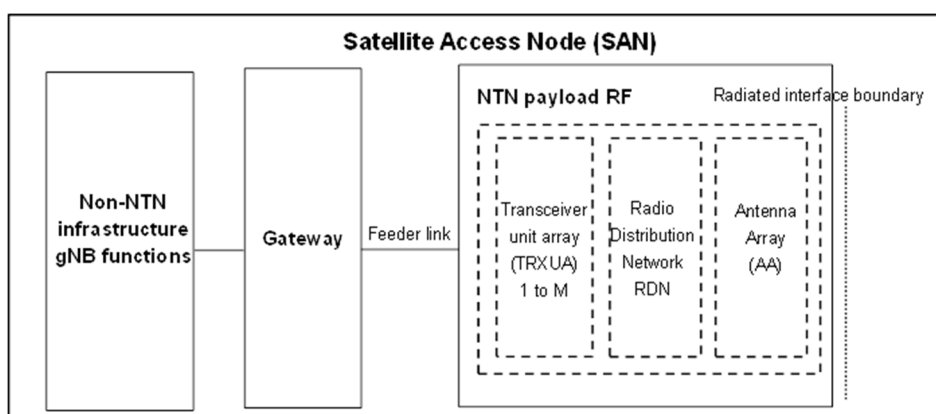
#### O&M Requirements (RAN3)

The NTN related parameters, as listed in clause 16.14.7 of TS 38.300, shall be provided by O&M to the gNB providing non-terrestrial access. Additional NTN related parameters in Annex B4 of TS 38.300 may be provided by O&M to the gNB for its operation.

#### RF performances and RRM requirements (RAN4)

Based on coexistence studies captured in TR 38.863, the minimum RF and performance requirements in FR1 for respectively NR User Equipment (UE) supporting satellite access operation and NR Satellite Access Node (SAN) are defined in TS 38.101-5 and TS 38.108.

Figure 2 illustrate the satellite access node which encompass on ground non-NTN infrastructure gNB functions, gateway and feeder link and the RF functions of the NTN payload.



**Figure 2: Satellite Access Node (SAN) (from TS 38.108 [16])**

The considered operating bands in frequency range FR1 are defined in Table 1:

**Table 1: Satellite operating bands [16]**

Satellite operating band	Uplink (UL) operating band SAN receive / UE transmit $F_{UL,low} - F_{UL,high}$	Downlink (DL) operating band SAN transmit / UE receive $F_{DL,low} - F_{DL,high}$	Duplex mode
n256	1980 MHz – 2010 MHz	2170 MHz – 2200 MHz	FDD
n255	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD



RF requirements of an NTN capable UE (as defined in TS 38.101-5) requires the same RF performance as UE operating with terrestrial network. This allows connectivity to both NTN or Terrestrial Network.

Note that RF requirements of the SAN as defined in TS 38.108 [16] are lower compared to the BS RF requirements of a terrestrial network as defined in TS 38.104 [19].

Specific requirements for radio resource management in NTN are defined in TS 38.133. They mostly relate to specific delay as well as timing and frequency errors in the different procedures.

In addition to SAN, RF requirements of HAPS were defined in TS 38.104 [19] as HAPS BS class which refers to Wide Area BS class without additional changes.

NR operating band n1 can be applied for HAPS operation, as defined in TS 38.104 [19].

NR UEs as defined by current TS 38.101-1 can support HAPS deployments with no additional changes needed in TS 38.101-1.

## References

- [1] TS 38.211 NR; Physical channels and modulation (RAN1)
- [2] TS 38.213 NR; Physical layer procedures for control (RAN1)
- [3] TS 38.214 NR; Physical layer procedures for data (RAN1)
- [4] TS 38.300 NR; Overall description; Stage-2 (RAN2)
- [5] TS 38.304 NR; User Equipment (UE) procedures in idle mode and in RRC Inactive state (RAN2)
- [6] TS 38.306 NR; User Equipment (UE) radio access capabilities (RAN2)
- [7] TS 38.321 NR; Medium Access Control (MAC) protocol specification (RAN2)
- [8] TS 38.322 NR; Radio Link Control (RLC) protocol specification (RAN2)
- [9] TS 38.323 NR; Packet Data Convergence Protocol (PDCP) specification (RAN2)
- [10] TS 38.331 NR; Radio Resource Control (RRC); Protocol specification (RAN2)
- [11] TS 38.401 NG-RAN; Architecture description (RAN3)
- [12] TS 38.410 NG-RAN; NG general aspects and principles (RAN3)
- [13] TS 38.413 NG-RAN; NG Application Protocol (NGAP) (RAN3)
- [14] TS 38.423 NG-RAN; NG-RAN; Xn Application Protocol (XnAP) (RAN3)
- [15] TS 38.101-5 NR; User Equipment (UE) radio transmission and reception, part 5: Satellite access Radio Frequency (RF) and performance requirements (RAN4)
- [16] TS 38.108 NR; Satellite Access Node radio transmission and reception (RAN4)
- [17] TS 38.133 NR; Requirements for support of radio resource management (RAN4)
- [18] TR 38.863 Non-terrestrial networks (NTN) related RF and co-existence aspects (RAN4)
- [19] TS 38.104 NR; Base Station (BS) radio transmission and reception (RAN4)

## 5.2 NB-IoT/eMTC support for Non-Terrestrial Networks

920069	<a href="#">NB-IoT/eMTC support for Non-Terrestrial Networks</a>	LTE_NBIOT_eMTC_NTN	R1	RP-211601	MediaTek
920169	<a href="#">Core part: NB-IoT/eMTC support for Non-Terrestrial Networks</a>	LTE_NBIOT_eMTC_NTN-Core	R1	RP-211601	MediaTek
930019	<a href="#">Architecture support for NB-IoT/eMTC Non-Terrestrial Networks in EPS</a>	IoT_SAT_ARCH_EPS	S2	SP-211124	SEBIRE, Guillaume, MediaTek Inc.
940001	<a href="#">CT1 aspects of NB-IoT/eMTC Non-Terrestrial Networks in EPS</a>	IoT_SAT_ARCH_EPS	C1	CP-213273	NIEMI, Marko, MediaTek Inc.
950045	<a href="#">CT4 aspects of NB-IoT/eMTC Non-Terrestrial Networks in EPS</a>	IoT_SAT_ARCH_EPS	C4	CP-213273	NIEMI, Marko, MediaTek Inc.
950046	<a href="#">CT6 aspects of NB-IoT/eMTC Non-Terrestrial Networks in EPS</a>	IoT_SAT_ARCH_EPS	C6	CP-213273	NIEMI, Marko, MediaTek Inc.
830025	<a href="#">Study on management and orchestration aspects with integrated satellite components in a 5G network</a>	FS_5GSAT_MO	S5	SP-190138	Floris Drijver, TNO
860033	<a href="#">Study on NB-IoT/eMTC support for NTN</a>	FS_LTE_NBIOT_eMTC_NTN	R1	RP-202689	MediaTek

Summary based on the input provided by MediaTek Inc. in SP-220455 (merge of RP-221547 and CP-221272).

The "NB-IoT/eMTC support for Non-Terrestrial Networks (NTN)" work item specifies enhanced features necessary for the support of Bandwidth reduced Low complexity (BL) UEs, UEs in enhanced coverage and NB-IoT UEs by Non-Terrestrial Networks (NTN).

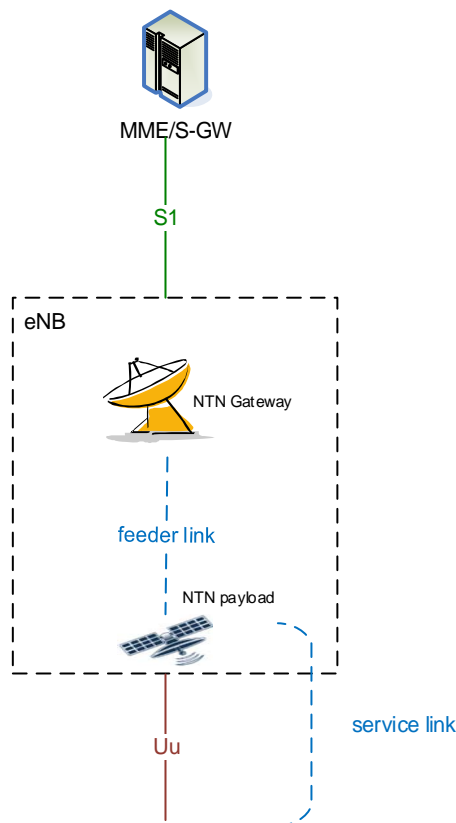
SA and CT aspects of NB-IoT/eMTC Non-Terrestrial Networks in EPS provide minimum essential functionality for the Rel-17 UE and the network to support satellite E-UTRAN access in WB-S1 mode or NB-S1 mode with CIoT EPS

optimization. The functionality is largely aligned with that of Rel-17 NR Non-Terrestrial Networks in 5GS, with the exception of discontinuous coverage that is addressed only within the present work item in Rel-17.

### **Overall architecture and general aspects:**

E-UTRAN supports radio access over non-terrestrial networks for BL UEs, UEs in enhanced coverage and NB-IoT UEs. Non-terrestrial networks encompasses platforms that provide radio access through satellites in Geosynchronous orbits (GSO) as well as Non-Geosynchronous Orbit (NGSO), which includes Low-Earth Orbit (LEO) and Medium Earth Orbit (MEO).

As illustrated in Figure 1, non-terrestrial access is provided by means of an NTN payload, i.e. a network node on-board a satellite, and an NTN Gateway interconnected by a feeder link, the UE accessing NTN network services through the NTN payload via a service link.



**Figure 1: Overall illustration of an NTN**

Three types of service links are supported:

- Earth-fixed: provisioned by beam(s) continuously covering the same geographical areas all the time (e.g., the case of GSO satellites);
- Quasi-Earth-fixed: provisioned by beam(s) covering one geographic area for a limited period of time and a different geographic area during another period of time (e.g., the case of NGSO satellites generating steerable beams);
- Earth-moving: provisioned by beam(s) whose coverage area slides over the Earth surface (e.g., the case of NGSO satellites generating fixed or non-steerable beams).

With NGSO satellites, the eNB can provide either quasi-Earth-fixed cell coverage or Earth-moving cell coverage, while eNB operating with GSO satellites can provide Earth fixed cell coverage or quasi-Earth-fixed cell coverage.

Support for BL UEs, UEs in enhanced coverage and NB-IoT UEs over NTN is only applicable to E-UTRA connected to EPC.

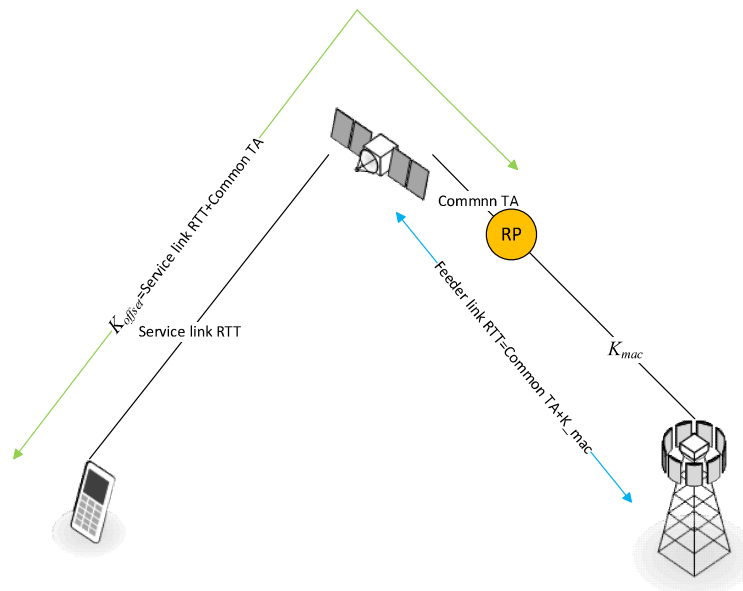
Only BL UEs, UEs in enhanced coverage and NB-IoT UEs with GNSS capability are supported.

### **Timing and Synchronization:**

The network broadcasts ephemeris information and common Timing Advance (common TA) parameters in each NTN cell. A UE shall acquire its GNSS position as well as the satellite ephemeris and common TA before connecting to an NTN cell. To achieve uplink synchronisation, before performing random access, the UE shall autonomously pre-compensate the Timing Advance, as well as the frequency doppler shift by considering the common TA, the UE position and the satellite position through the satellite ephemeris. In connected mode, the UE shall continuously update the Timing Advance and frequency pre-compensation, but the UE is not expected to perform GNSS acquisition. The UE does not perform any transmissions due to outdated satellite ephemeris, common TA or GNSS position based on timers. In connected mode, upon outdated satellite ephemeris and common Timing Advance, the UE re-acquires the broadcasted parameters and upon outdated GNSS position the UE moves to idle mode. The UEs may be configured to report Timing Advance at initial access or in connected mode. In connected mode triggered reporting of the Timing Advance is supported.

For downlink synchronization in case of NB-IoT, the two LSB of the ARFCN is signalled in MIB for bands for which a 200 kHz channel raster is not supported, and the legacy 100 kHz raster is used. Otherwise, for bands for which a 200 kHz channel raster is supported, there is no signalling of ARFCN information in MIB.

Downlink and uplink timings are frame aligned at the uplink time synchronization reference point (RP). To accommodate the long propagation delays in NTN, the timing relationships are enhanced by the support of two scheduling offsets:  $K_{offset}$  and  $K_{mac}$  as illustrated in Figure 2:



**Figure 2: Timing relationship parameters**

Uplink segmented transmission is supported for uplink transmission with repetitions. The UE shall apply UE pre-compensation per segment of UL transmission of PUSCH/PUCCH/PRACH for BL UEs and UEs in enhanced coverage and NPUSCH/NPRACH for NB-IoT from one segment to the next segment. The configuration of uplink transmission segment is indicated on SIB for initial access and can be re-configured by RRC signalling.

### **Discontinuous coverage and assistance information:**

As a satellite moves on a specified orbit, for example in case of a NGSO satellite, the satellite beam(s) coverage area may move and cover different portions of a geographical area due to the orbital movement of the satellite. As a consequence, a UE located in the concerned geographical area may experience a situation of discontinuous coverage, due to e.g., a sparse satellite constellation deployment.

The network may broadcast assistance information relating to the serving satellite and other satellites of the constellation to enable UEs to predict upcoming satellites fly-over periods and save power during periods of no coverage. The broadcast assistance information includes SGP4 ephemeris elements based on the TLE (Two-Line Elements) sets industry standard. Additional assistance information, such as coverage footprint parameters and cell radius, may also be optionally broadcast by the network.

Predicting out of coverage and in coverage periods is up to UE implementation. When out of coverage, the UE is not required to perform Access Stratum (AS) functions.

In the Core Network, discontinuous coverage is handled by means of Tracking Area- or RAT-specific configuration of the MME such that the MME is able, via existing functionality (namely periodic TAU timer, mobile reachable timer, implicit detach timer and high latency communication), to ensure that when the UE is unreachable, a) the UE does not trigger NAS transaction or detach from the network and b) mobile-terminated data destined to the UE can be stored in the network.

#### **Mobility Management:**

The network may broadcast more than one Tracking Area Code (TAC) per PLMN in a cell in order to reduce the signalling load at cell edge in NTN, in particular for Earth-moving cell coverage. The AS layer indicates all received TACs for the selected PLMN to the NAS layer. The network may update the UEs upon TAC removal. UEs may by UE implementation also check whether a TAC has been removed from the TACs broadcast by the network.

At the NAS layer, the UE need not trigger a Tracking Area Update due to mobility reason, if any of the broadcast TAC(s) in the cell where the UE is located is part of the UE's Tracking Area List.

For quasi-Earth-fixed cells, timing information on when the cell is going to stop serving the area may be broadcast by the network. This may be used by the UE to start measurements on neighbour cells before the broadcast stop time of the serving cell, while the exact start of the measurements is up to UE implementation.

Radio link failure and RRC connection re-establishment are supported in NTN. To enable mobility in NTN, the network provides target cell satellite parameters needed to access the NTN cell in the handover command. Conditional handover is supported for BL UEs and UEs in enhanced coverage.

Different RAT types are introduced that allow distinction by the Core Network between existing terrestrial accesses and new non-terrestrial accesses as well as, among non-terrestrial accesses, between the different types of satellite constellations (LEO, MEO, GEO, OTHERSAT) and radio access type (i.e. WB-EUTRAN, NB-IoT and LTE-M). This allows the Core Network nodes and the HSS to identify the access a UE is using such that they are able to adjust their behavior and that of the UE accordingly (e.g. setting of NAS timers, determination and enforcement of access restrictions, etc.).

#### **Feeder-link switch-over:**

The NTN Control function determines the point in time when a feeder link switch over between two eNBs is performed. For BL UEs and UEs in enhanced coverage, the transfer of the affected UE(s)' context between the two eNBs at feeder link switch over is performed by means of either S1 based or X2 based handover, and it depends on the eNBs' implementation and configuration information provided to the eNBs by the NTN Control function.

#### **Network-interfaces signalling aspects:**

The Cell Identity in NTN corresponds to a fixed geographical area identified by a Mapped Cell ID, irrespective of the orbit of the NTN payload or of the type of the service link. For a BL UE or a UE in enhanced coverage, the Cell Identity included within the target identification of the handover messages allows identifying the correct target cell. The mapping between Mapped Cell IDs and geographical areas is configured in the RAN and the Core Network (e.g. pre-configured depending on operator's policy, or based on implementation). For a BL UE or a UE in enhanced coverage or a NB-IoT UE that supports S1-U data transfer or User Plane CIoT EPS optimisation, the eNB is responsible for constructing the Mapped Cell ID based on the UE location information received from the UE, if available. The User Location Information may enable the MME to determine whether the UE is allowed to operate at its present location. Pre-configuration of special mapped cell identifiers may be used to indicate areas outside the serving PLMN's country.

The eNB reports the broadcasted TAC(s) of the selected PLMN to the MME. In case the eNB knows the UE's location information, the eNB may determine the TAI the UE is currently located in and provide that TAI to the MME.

#### **MME(Re-)Selection by eNB:**

For an RRC\_CONNECTED UE, when the eNB is configured to ensure that the BL UE or the UE in enhanced coverage is using an MME that serves the country in which the UE is located. If the eNB detects that a BL UE or a UE in enhanced coverage is in a different country from that served by the serving MME, it should perform an S1 handover to change to an appropriate MME or initiate a UE Context Release Request procedure towards the serving MME (in which case the MME may decide to detach the UE).

For an RRC\_CONNECTED NB-IoT UE, when the eNB is configured to ensure that the NB-IoT UE is using an MME that serves the country in which the UE is located. If the eNB detects that the UE is in a different country to that served by the serving MME, it should initiate a UE Context Release Request procedure towards the serving MME (in which case the MME may decide to detach the UE).

#### **Verification of UE location:**

The network may, according to regulatory requirements, need to enforce that the PLMN selected by the UE is allowed to operate in the geographical location where the UE is located. To this end, the MME may invoke the ULI (User Location Information) procedure during Mobility Management and Session Management procedures in order to determine the UE location. If the MME is able to determine with sufficient accuracy that it is not allowed to operate in the UE location it may reject and/or detach the UE.

#### **O&M Requirements:**

The NTN related parameters shall be provided by O&M to the eNB providing non-terrestrial access, as specified in TS 38.300 for NR NTN.

#### **Support for E-UTRAN:**

For S1 and X2 interfaces, codepoints in the RAT Restriction Information IE (in the Handover Restriction List) allow the selection of different constellation types, i.e., "LEO", "MEO", "GEO", "OTHERSAT" for satellite access.

For S1 interface, additional codepoints are added to the RAT Type IE associated with a TAC, i.e., "NB-IoT-LEO", "NB-IoT-MEO", "NB-IoT-GEO", "NB-IoT-OTHERSAT", "EUTRAN-LEO", "EUTRAN-MEO", "EUTRAN-GEO", "EUTRAN-OTHERSAT".

For S1 interface, the UE Context Reference at Source IE (eNB UE S1AP ID) is introduced in the Source eNB to Target eNB Transparent Container.

For S1 interface, a new cause value is added signalling that a UE is not within the serving area of its current PLMN.

For TAC reporting over S1, the LTE NTN TAI Information IE and the semantics description for the TAI IE are added in the User Location Information IE; the LTE NTN TAI Information IE and the semantics description for the TAI IE are added to the eNB CP RELOCATION INDICATION, HANDOVER NOTIFY, PATH SWITCH REQUEST, INITIAL UE MESSAGE, UPLINK NAS TRANSPORT, and LOCATION REPORT messages.

#### **Other NAS protocol Aspects:**

Enhancements to NAS signalling allow the UE to register to EPS core network using satellite E-UTRAN radio access technology. UICC-ME interface is extended to support network selection over satellite access and allowing to prioritize networks offering satellite access. EPS NAS re-transmission timers are extended to support longer propagation delays and response times due to extended distance between peer entities when satellite access is used. The UE supporting satellite E-UTRAN access supports also GNSS and potential uplink signalling delays to be considered in UE and network NAS implementations.

#### **References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920069,920169,930019,830025,860033>

- [1] TS 36.300 Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (RAN)
- [2] TS 38.300 NR; NR and NG-RAN Overall description; Stage-2 (RAN)
- [3] TS 36.306 E-UTRAN; User Equipment (UE) radio access capabilities (RAN)
- [4] TS 36.413 E-UTRAN; S1 Application Protocol (S1AP) (RAN)
- [5] TS 36.423 E-UTRAN; X2 Application Protocol (X2AP) (RAN)
- [6] TS 23.203 Policy and charging control architecture (SA2)
- [7] TS 23.271 Functional stage 2 description of Location Services (LCS) (SA2)
- [8] TS 23.401 General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (SA2)
- [9] TS 23.682 Architecture enhancements to facilitate communications with packet data networks and applications (SA2)
- [10] TS 23.122 Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle model (CT1)

- [11] TS 24.301 Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3 (CT1)
- [12] TS 23.008 Organization of subscriber data (CT4)
- [13] TS 27.007 AT command set for User Equipment (UE) (CT1)
- [15] TS 29.212 Policy and Charging Control (PCC); Reference points (CT3)
- [16] TS 29.272 Evolved Packet System (EPS); Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol (CT4)
- [17] TS 29.274 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3 (CT4)
- [18] TS 31.102 Characteristics of the Universal Subscriber Identity Module (USIM) application (CT6)
- [19] TS 31.111 Universal Subscriber Identity Module (USIM) Application Toolkit (USAT) (CT6)

## 6 Services to "verticals"

### 6.1 Introduction

A key segment of the Rel-17 improvements of the 5G System (5GS) refers to the services provided by 5GS to segments of the industry other than telecommunications, e.g. factory automation, agriculture, electricity distribution, etc. These segments are referred to as "verticals", as explained in TR 21.915 [1].

The boundary of "verticals" is unclear, in the sense that whether a Feature can be classified as offered to verticals or not can be arguable – besides, a Feature can be usable both for verticals and for the wide audience.

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920049,900024,920006,920050>

- [1] TR 21.915: "Release 15 Description; Summary of Rel-15 Work Items".

### 6.2 Generic functionalities, to all verticals

#### 6.2.1 Network and application enablement for verticals

##### 6.2.1.1 Enhanced Service Enabler Architecture Layer for Verticals

UID	Name	Acronym	WG	WID	WI rapporteur name/company
920049	<b>Enhanced Service Enabler Architecture Layer for Verticals</b>	<b>eSEAL</b>		<b>SP-200987</b>	<b>Basavaraj (Basu) Pattan, Samsung</b>
900024	<b>Stage 2 of eSEAL</b>	eSEAL	S6	SP-200987	Basavaraj (Basu) Pattan, Samsung
920006	<b>CT1 aspects of eSEAL</b>	eSEAL	C1	CP-212098	Sapan Shah (Samsung Electronics)
920050	<b>CT3 aspects of eSEAL</b>	eSEAL	C3	CP-212098	Sapan Shah (Samsung Electronics)

Summary based on the input provided by Samsung in SP-220623.

In Rel-16, Service Enabler Architecture Layer (SEAL) was specified, in TS [1] to [8]. SEAL offers a set of common services to the verticals industry applications and to V2X applications. These services include the management of Groups, Configurations, Keys, Identities, Locations and Network Resource. SEAL is further described in clause 9.4 of TR 21.916 [9].

In Rel-17, enhancements are made to several SEAL services, namely:

- 1) The SEAL architecture is enhanced to support Light Weight Protocol (LWP) for constrained devices.
- 2) The "Configuration Management" capability is enhanced to support generic container to carry Vertical Application Layer (VAL) service-specific information.
- 3) The "Group Management" capability is enhanced to support temporary groups in a VAL system, to remove the limitation where VAL service specific data cannot be sent to group members, to add location criteria in the group creation, to support management of 5G VN groups, to control notification rate, to control group communication messages, support for external group Id and group fetch procedure.
- 4) The "Location Management" capability is enhanced to support the tracking of UE and obtaining dynamic UE information at a location, to distinguish the VAL services, to obtain list of UEs based on location area, monitoring location deviation, to include supplementary location information to verticals, to add timestamp for location report and off-network location management.



5) The "Network resource management" is enhanced to add local MBMS support, to allow NRM server to use TSN and 5G native TSC for resource management, to subscribe to unicast QoS monitoring, to Subscribe to Unicast QoS Monitoring and real-time monitoring status information.

Beside these enhancements, an entirely new service, called Network Slice Capability Enablement (NSCE), is defined. It includes: the functional model; Procedure for VAL server-triggered and network-based network slice adaptation for VAL application; Procedure for VAL UE-triggered and network-based network slice adaptation for VAL application.

The SEAL enhancements are specified in TS 24.544 [3], TS 24.545 [4], TS 24.546 [5], TS 24.547 [6], TS 24.548 [7] and TS 29.549 [8], while the SEAL new service is specified in TS 24.549 [10].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920049,900024,920006,920050>

- [1] TS 23.434: "Service Enabler Architecture Layer for Verticals; Functional architecture and information flows".
- [2] TS 33.434: "Security aspects of Service Enabler Architecture Layer (SEAL) for verticals".
- [3] TS 24.544: "Group Management - SEAL; Protocol specification".
- [4] TS 24.545: "Location Management - SEAL; Protocol specification".
- [5] TS 24.546: "Configuration management - SEAL; Protocol specification".
- [6] TS 24.547: "Identity management - SEAL; Protocol specification".
- [7] TS 24.548: "Network Resource Management - SEAL; Protocol specification".
- [8] TS 29.549: "SEAL; Application Programming Interface (API) specification".
- [9] TR 21.916: "Release 16 Description; Summary of Rel-16 Work Items"
- [10] TS 24.549: "Network slice capability enablement- SEAL; Protocol specification; Stage 3".

### 6.2.1.2 Enhancements for Cyber-physical control Applications in Vertical domains (eCAV)

UID	Name	Acronym	WG	WID	WI rapporteur name/company
840050	<a href="#">Enhancements for cyber-physical control applications in vertical domains</a>	eCAV		SP-190310	Bahr, Michael, Siemens AG
830020	Study on eCAV	FS_eCAV	S1	SP-190092	Michael Bahr, Siemens AG
840041	Stage 1 of eCAV	eCAV	S1	SP-191043	Bahr, Michael, Siemens AG

Summary based on the input provided by Siemens in SP-220458.

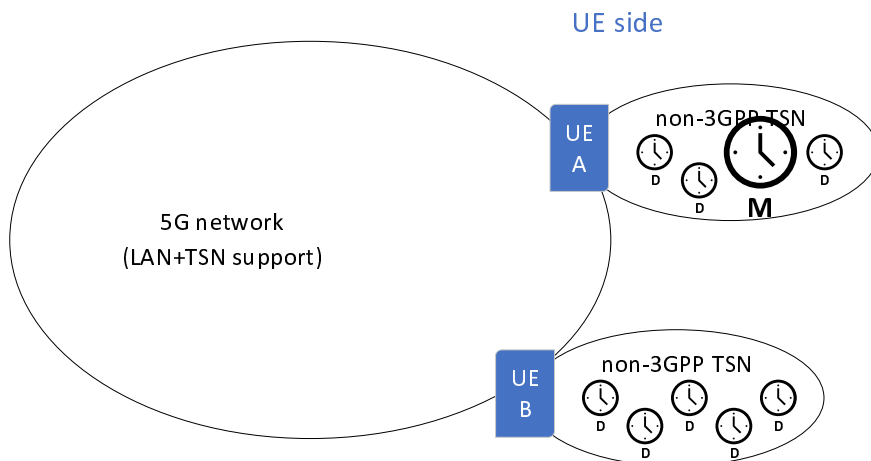
Cyber-physical control applications in vertical domains (CAV) was introduced in Rel-16 [2]. As a reminder, "cyber-physical control applications" refers to applications that control physical processes over a network, using algorithms. Communication for cyber-physical control applications supports operation in various vertical domains, for instance industrial automation, Smart Grid. CAV requires very high levels of communication service availability and some of them also require a very low end-to-end latency as well as real-time capabilities.

Rel-17's enhancements for CAV (eCAV) refines the service requirements for CAV and specifies new service requirements for specific aspects (Stage 1): additional service performance requirements (KPIs, influencing parameters) have been provided for enhanced and new use cases of cyber-physical control applications: control-to-control communication, wired-to-wireless link replacement (100 Mbit/s, 1 Gbit/s), cooperative carrying, mobile operation panels, and industrial wireless sensors.

eCAV addresses further and enhanced service requirements for industrial Ethernet integration, which includes time synchronization, clock synchronization performance requirements, different time domains, integration scenarios, and support for time-sensitive networking (TSN).

An essential requirement specifies: "The 5G system shall support clock synchronization (e.g. IEEE 802.1AS) through the 5G network if the sync master and the sync devices are served by different UEs". See Figure 1. The flow of clock

synchronization messages is in either direction, UL and DL, and can contain two wireless links on its path.



**Figure 1: 5G network on path of synchronization messages with two wireless links (both, UL and DL)**  
[1]

Service requirements on direct device communication (ProSe communication) for cyber-physical control applications are provided (general, network performance, clock synchronization, service continuity, aspects of indirect communication), many of them supporting the use case of cooperative carrying.

Furthermore, high-level requirements for enhancements in network operation and maintenance in 5G non-public networks for cyber-physical control applications in vertical domains and enhancements and clarifications for positioning have been provided.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840050,830020,840041>

- [1] TR 22.832, "Study on enhancements for cyber-physical control applications in vertical domains"
- [2] TS 22.104, "Service requirements for cyber-physical control applications in vertical domains"
- [3] TS 22.261, "Service requirements for the 5G system"

### 6.2.1.3 Enhancements of 3GPP Northbound Interfaces and APIs

UID	Name	Acronym	WG	WID	WI rapporteur name/company
920058	<b>Rel-17 Enhancements of 3GPP Northbound Interfaces and Application Layer APIs</b>	<b>NBI17</b>		<b>CP-220058</b>	<b>Abdessamad EL MOATAMID, Huawei</b>
920013	<b>CT1 aspects of NBI17</b>	NBI17	C1	CP-220058	Abdessamad EL MOATAMID, Huawei
920053	<b>CT3 aspects of NBI17</b>	NBI17	C3	CP-220058	Abdessamad EL MOATAMID, Huawei
920054	<b>CT4 aspects of NBI17</b>	NBI17	C4	CP-220058	Abdessamad EL MOATAMID, Huawei

Summary based on the input provided by Huawei in CP-220394.

The 3GPP Northbound Interfaces and APIs are specified as to enable external entities and third party Application Servers/Functions to access a set of exposed 3GPP network services and capabilities in a secure and controlled manner. The 3GPP application layer APIs are defined by 3GPP as to allow the support of various applications/services (e.g. V2X, UAS, EDGE, etc.) over 3GPP networks and to ensure the efficient use and deployment of these applications/services over 3GPP systems via an optimized application layer framework. 3GPP northbound interfaces/APIs as well as application layer APIs are used and supported by various external entities including third party Application Servers/Functions.

This work relates to the introduction of pure stage 3 (i.e. there are no related stage 1 nor stage 2 requirements) technical improvements and enhancements, i.e. improvement of the overall efficiency, reliability and flexibility, enhancement of the signalling efficiency, consolidation of the common protocol aspects, alignment with the 5GC service based principles and guidelines when relevant, corrections/changes missed in the previous 3GPP Releases, etc., especially that such enhancements may not be covered by the other more dedicated and functionality-driven work items.



## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920058,920013,920053,920054>

- [1] TS 24.558: "Enabling Edge Applications; Protocol specification".
- [2] TS 29.122: "T8 reference point for Northbound APIs".
- [3] TS 29.222: "Common API Framework for 3GPP Northbound APIs"
- [4] TS 29.257: "Application layer support for Uncrewed Aerial System (UAS); UAS Application Enabler (UAE) Server Services; Stage 3".
- [5] TS 29.486: "V2X Application Enabler (VAE) Services; Stage 3".
- [6] TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".
- [7] TS 29.549: "Service Enabler Architecture Layer for Verticals (SEAL); Application Programming Interface (API) specification; Stage 3".
- [8] TS 29.558: "Enabling Edge Applications; Application Programming Interface (API) specification; Stage 3".

## 6.2.2 Location and positioning

### 6.2.2.1 RAN aspects of NR positioning enhancements

UID	Name	Acronym	WG	WID	WI rapporteur name/company
900060	<b>RAN aspects of NR positioning enhancements</b>	<b>NR_pos_enh</b>		<b>RP-210903</b>	<b>Intel</b>
860034	<a href="#">Study on NR positioning enhancements</a>	FS_NR_pos_enh	R1	RP-202094	CATT
900160	<b>Core part: NR positioning enhancements</b>	NR_pos_enh-Core	R1	<b>RP-210903</b>	Intel
900260	<b>Perf. part: NR positioning enhancements</b>	NR_pos_enh-Perf	R4	<b>RP-210903</b>	Intel

Summary based on the input provided by Intel in RP-220919.

This Work Item specifies solutions for NR Positioning enhancements, including improvement of positioning accuracy and latency of Rel-16 NR positioning methods, improvements of network efficiency (On-Demand PRS transmission), improvement of device efficiency (positioning in RRC\_INACTIVE), providing high integrity and reliability requirements (GNSS integrity) and enhancements of A-GNSS positioning (BDS B2a/B3I and NavIC to NR).

All these aspects are detailed below.

#### **Improvement of positioning accuracy**

To improve positioning accuracy, several solutions were considered:

**Mitigation of gNB/UE Tx/Rx timing delay errors:** For mitigation of gNB/UE Tx/Rx timing delay errors, multiple enhancements are introduced in Rel-17:

- For DL-TDOA, a UE can be requested to provide the Rx TEG IDs together with RSTD measurements and a TRP can be requested to provide TRP Tx TEG association information of DL PRS resources to mitigate UE Rx timing errors and TRP Tx timing errors. A UE can also be requested to measure the same DL PRS resource of a TRP with different UE Rx TEGs and report the corresponding multiple RSTD measurements to mitigate UE Rx timing errors.
- For UL-TDOA, Rel-17 supports a TRP to provide the Rx TEG IDs together with RTOA measurements and a UE to provide UE Tx TEG association information of UL positioning SRS resources to mitigate TRP Rx timing errors and UE Tx timing errors. A TRP can also be requested to measure the same UL SRS resource of a UE with different TRP Rx TEGs and report the corresponding multiple RTOA measurements to mitigate TRP Rx timing errors.
- Multi-RTT, Rel-17 supports a UE/TRP to provide the RxTx TEG IDs, or combination of {Rx TEG ID, Tx TEG ID} together with UE/gNB Rx-Tx time difference measurements and a UE/gNB to provide its Tx TEG association information for mitigating UE/TRP Rx/Tx timing errors;

In addition, Rel-17 supports a UE to report more than one measurement instance of RSTD, DL RSRP, and/or UE Rx-Tx time difference measurements in a single measurement report, and support a TRP to report more than one measurement instance of RTOA, UL RSRP, and/or gNB Rx-Tx time difference measurements in a single measurement report. Each measurement instance is reported with its own timestamp;

**UL-AOA enhancements:** The new assistance information (expected UL-AOA value and uncertainty range) can be provided by the LMF to facilitate gNB measurements for NR UL-AOA, UL-TDOA and Multi-RTT positioning methods. Support of the first arrival path UL-AOA/ZOA measurement pair per SRS resource were introduced, including reporting of multiple per path AOA value pairs (including additional paths) to cope with possible ambiguity

of angle measurements in antenna arrays with larger spacing than a half wavelength, and reporting ZoA only to cope with angle measurements in linear antenna arrays.

The per path UL SRS receive reference signal power (UL SRS-RSRPP) measurement definition was introduced.

The antenna reference point (ARP) location can be associated with UL measurements for NR Positioning (UL AOA, UL-RTOA, UL SRS-RSRP, UL SRS-RSRPP and gNB Rx-Tx time difference measurements).

Finally, to facilitate hybrid RAT dependent positioning, gNB can report to LMF the following set of measurements {one SRS-RSRP, multiple UL-AOAs (AOA/ZoA pairs), one UL-RTOA or one-gNB Rx-Tx time difference}.

**DL-AOD enhancements:** The enhancements of assistance data (a subset of PRS resources for each PRS resource for the purpose of prioritization of DL-AOD reporting or the boresight direction information for each PRS resource) were defined to improve DL-AOD estimation. In addition, the assistance information on DL-AOD/DL-AOA expected value and uncertainty range can be provided by LMF to UE. In Rel-17, for more accurate DL-AOD measurements, the gNB can provide the beam/antenna information to LMF (and LMF can further share it to UE for UE-based positioning). The per path DL PRS reference signal received power (DL PRS RSRPP) for the first path measurements were defined for DL-AOD estimation, and the maximum number of DL PRS RSRPP for the first path measurements was 24. Finally, the maximum number of DL PRS RSRP measurements per TRP was increased up to 24 compared to 8 in Rel.16.

**Multi-path and NLOS mitigation:** In Rel-17, multi-path (additional path) report enhancements and LOS/NLOS indication were introduced for NR positioning solutions. The maximum number of additional paths that can be reported is increased (up to 8) with per path RSRP measurements and associated relative timing supported. Multiple UL-AOAs (up to 8) per additional path reporting is supported for the UL-TDOA and Multi-RTT positioning methods. The LOS/NLOS indicator was introduced that can be associated with specific measurements, DL/UL reference signals / resources for positioning.

#### **Improvement of positioning latency**

To improve the positioning latency, following solutions were considered:

**Preconfigured measurement gap:** To reduce latency of procedures for DL PRS processing with measurement gaps, the set of measurement gap patterns can be pre-configured to UE and activated/deactivated by gNB using new DL MAC CE signalling designed to control DL PRS measurement by UE. The UE can request activation and deactivation of the pre-configured MG using new UL MAC CE signalling introduced in Rel-17. The LMF can request activation of pre-configured MG using new NRPPa signalling introduced in Rel-17.

**Preconfigured PRS processing window:** To further reduce latency of DL PRS processing, UEs can perform DL PRS measurement outside measurement gaps and inside the active DL BWP with PRS having the same numerology as the active DL BWP. The gNB can use RRC signalling to pre-configure PRS processing window and DL MAC CE signalling for activation of PRS processing window, respectively. gNB can indicate the DL PRS processing priority relative to other DL signals/channels within the PRS processing window for PRS measurement outside MG.

**M-sample measurement ( $M = 1$ ):** In Rel-17, LMF can request UE and/or TRP to perform measurement over either a single RS transmission period ( $M=1$ ) or four RS transmission periods ( $M=4$ ). Configuring  $M=1$  for a UE reduces UE measurement period comparing to Rel.16 (In Rel-16, UE is expected to measure DL PRS over four periods ( $M = 4$ )). An AGC sample, in addition to the  $M=1$  sample may be required at the UE subject to measurement conditions.

**Lower Rx beam sweeping factor:** In Rel-17, a new UE capability on lower Rx beam sweeping factor ( $<8$ ) is introduced to reduce the PRS measurement latency for FR2 positioning frequency layers.

**Storing LPP capability in AMF:** The LMF may interact with the AMF to provide (updated) UE Positioning Capability to AMF and to receive stored UE Positioning Capability from AMF as described in TS 23.273. The LPP procedures to transfer UE LPP positioning capabilities may be skipped if the LMF already obtained the UE positioning capabilities from the AMF.

**Preconfigured assistance data:** Preconfigured assistance data is the DL-PRS assistance data (with associated validity criteria, i.e. area ID) that can be provided to the UE (before or during an ongoing LPP positioning session), to be then utilized for potential positioning measurements at a future time (e.g. for deferred MT-LR). Pre-configured DL-PRS assistance data may consist of multiple instances, where each instance is applicable to a different area within the network.

**Scheduled location time:** During positioning procedure, the LMF may obtain the scheduled location time from the AMF. Based on the obtained scheduled location time, the LMF may schedule location measurements by the UE and/or location measurement by the NG-RAN to occur at or near to the scheduled location time.

**On-Demand PRS transmission**

On-Demand PRS transmission procedure allows the LMF to control and decide whether PRS should be transmitted or not and whether the characteristics of an ongoing PRS transmission should be changed or not.

In case of UE-initiated On-Demand PRS, the LMF may configure the UE with pre-defined PRS configurations via LPP Provide Assistance Data message or via posSI. The UE sends an On-Demand PRS request to the LMF via LPP Request Assistance Data message. The On-Demand PRS request can be the request for a defined PRS configuration with PRS configuration ID or explicit parameter for PRS configuration and may be a request for PRS transmission or change to the PRS transmission characteristics for positioning measurements.

In case of LMF-initiated On-Demand PRS, the LMF and the UE may exchange LPP messages e.g., to obtain UE measurements or the DL-PRS positioning capabilities of the UE, etc).

The actual PRS changes are requested by the LMF irrespective of whether the procedure is UE- or LMF-initiated.

**Positioning in RRC\_INACTIVE state**

Positioning may be performed when a UE is in RRC\_INACTIVE. Any uplink LCS or LPP message can be transported in RRC\_INACTIVE. If the UE initiated data transmission using UL SDT, the network can send DL LCS, LPP and RRC message (e.g. to configure SRS for UL positioning, if it is supported) to the UE. UE may also receive PRS or transmit SRS in RRC\_INACTIVE. Support of all NR positioning measurements and support of NR positioning methods such as NR E-CID, DL-TDOA, DL-AOD, UL-AOA, UL-TDOA, Multi-RTT and RAT-independent positioning methods are extended for UEs in RRC\_INACTIVE state.

**GNSS Integrity**

Positioning integrity is a measure of the trust in the accuracy of the position-related data and the ability to provide associated alerts. UE based GNSS integrity is supported in Rel-17. It allows the UE to determine and report the integrity results of the calculated location, where only protection level (PL) reporting mode is supported; the UE can use the integrity requirements and assistance data obtained via NG-RAN, together with its own measurements, to determine the integrity results of the calculated location.

For integrity operation, the network will ensure that:

$$P(\text{Error} > \text{Bound for longer than TTA} \mid \text{NOT DNU}) \leq \text{Residual Risk} + \text{IRallocation} \quad (\text{Equation 8.1.1a-1})$$

for all values of IRallocation in the range  $\text{irMinimum} \leq \text{IRallocation} \leq \text{irMaximum}$

for all the errors in Table 8.1.2.1b-1 as specified in section 8.1.2.1b of TS38.305, which have corresponding integrity assistance data available and where the corresponding DNU flag(s) are set to false.

**Enhancements of A-GNSS positioning**

Enhancements of A-GNSS positioning specified: BDS B2a signal; BDS B3I signal; NavIC to NR.

**References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900060,860034,900160,900260>

- [1] RP-220803 "Status Report to TSG on NR Positioning Enhancements", Intel Corporation
- [2] TR 38. 857 "Study on NR positioning enhancements" v17.0.0

**6.2.2.2 Enhancement to the 5GC LoCation Services-Phase 2**

UID	Name	Acronym	WG	WID	WI rapporteur name/company
910052	<b>Enhancement to the 5GC LoCation Services-Phase 2</b>	<b>5G_eLCS_ph2</b>		<b>SP-200082</b>	<b>Ming Ai, CATT</b>
870001	Stage 2 of 5G_eLCS_ph2	5G_eLCS_ph2	S2	SP-200082	Ming Ai, CATT
910006	CT aspects of 5G_eLCS_ph2	5G_eLCS_ph2	ct	CP-211090	Chenxi Bao, CATT
910053	CT1 aspects of 5G_eLCS_ph2	5G_eLCS_ph2	C1	CP-211090	Chenxi Bao, CATT
910054	CT3 aspects of 5G_eLCS_ph2	5G_eLCS_ph2	C3	CP-211090	Chenxi Bao, CATT
910055	CT4 aspects of 5G_eLCS_ph2	5G_eLCS_ph2	C4	CP-211090	Chenxi Bao, CATT

## 6.2.3 Support of Non-Public and Private Networks

### 6.2.3.1 Enhanced support of Non-Public Networks

UID	Name	Acronym	WG	WID	WI rapporteur name/company
840024	<a href="#">Study on enhanced support of Non-Public Networks</a>	FS_eNPN	S2	SP-200094	Peter Hedman
<b>910065</b>	<b><a href="#">Enhanced support of Non-Public Networks</a></b>	<b>eNPN</b>		<b>SP-200980</b>	<b>Hedman, Peter, Ericsson</b>
900015	<b>Stage 2 for eNPN</b>	eNPN	S2	SP-200980	Hedman, Peter, Ericsson
<b>910016</b>	<b>CT aspects of eNPN</b>	<b>eNPN</b>	<b>ct</b>	<b>CP-212103</b>	<b>Sedlacek, Ivo, Ericsson</b>
910066	CT1 aspects of eNPN	eNPN	C1	CP-212103	Sedlacek, Ivo, Ericsson
910067	CT3 aspects of eNPN	eNPN	C3	CP-212103	Sedlacek, Ivo, Ericsson
910068	CT4 aspects of eNPN	eNPN	C4	CP-212103	Sedlacek, Ivo, Ericsson
920025	<b>Security Aspects of eNPN</b>	eNPN	S3	SP-210422	Jost, Christine, Ericsson
880008	<a href="#">Study on enhanced security support for Non-Public Networks</a>	FS_eNPN_SEC	S3	SP-200353	Normann, Henrik, Ericsson
870023	<a href="#">Management of non-public networks (NPN)</a>	OAM_NPN	S5	SP-200189	ZHANG, Kai, Huawei

Summary based on the input provided by Ericsson in SP-220584.

The support of non-public networks (NPN) was introduced in Rel-16 by the WI Vertical\_LAN with UID 830042. Deployments of NPN to provide coverage within a specific geographic area for non-public use is a key demand of emerging 5G applications and verticals.

This Rel-17 work item enables the four following enhancements:

**Support for accessing an SNPN using credentials from a Credential Holder (CH):** A UE can be configured with user or CH controlled prioritized list of information, SNPN identifiers or Group IDs for Network selection (GINs), enabling the UE to discover SNNPs supporting access using credentials from a CH. If the UE selects and accesses the SNPN, the CH is involved in the primary authentication and for authorizing the access to the SNPN. The CH can either include 5GC NFs e.g. AUSF and UDM (if the CH is an SNPN or a PLMN) or include a AAA server.

**Support for Onboarding of UEs:** Onboarding of UEs allows the UE to access an Onboarding Network (ONN) for the purpose of provisioning the UE with SNPN credentials and other information to enable the UE to select and access a desired SNPN. It also allows provisioning the UE with credentials for Network Slice-Specific Authentication and Authorization (NSSAA) or secondary authentication/authorization. Provisioning of the UE is done via User Plane connectivity.

To be able to provision SNPN credentials in a UE, as the 5GS requires security to be enabled the UE needs to use some already available credentials to access a 5GS, i.e. either:

1. The UE has Default UE credentials in which case the UE selects an SNPN as ONN and then the UE registers using Registration Type set to "SNPN Onboarding" that enables the 5GC to restrict the connectivity to Onboarding service e.g. using a dedicated S-NSSAI within the network.
2. The UE uses existing PLMN or SNPN credentials in which case the UE uses the existing credentials to get access connectivity to a PLMN or SNPN.

During the PDU Session establishment the UE can get one or more addresses to one or more Provisioning Server(s) that the UE access over the User Plane for getting provisioning with the SNPN credentials and additional information to get connectivity to the SNPN.

**Support of IMS voice and emergency services for SNPN:** Support for IMS voice and emergency services is enabled e.g. allowing the UE to select an SNPN in limited service to access IMS emergency services. Informative description how an SNPN can deploy an IMS or how one or more independent IMS providers can be used by an SNPN.

**NPN support for Video, Imaging and Audio for Professional Applications (VIAPA):** Informative description how a UE accessing an overlay network via an underlay network, see figure 1, can be kept in CM-CONNECTED state in the overlay network.

Informative description how session/service continuity between SNPN and PLMN can be achieved when the UE has a subscription for a PLMN and for an SNPN and accessing one network as overlay network using the other network as underlay network.

Informative description how to support QoS differentiation for User Plane IPsec Child SA in an underlay network.



#### Support SNPN along with subscription / credentials owned by an entity separate from the SNPN

For this feature, the term "Credentials Holder (CH)" is used for the external entity providing subscription or credential for SNNPs and the term "Group IDs for Network Selection (GINs)" is used for the service provider Group IDs.

In TS38.331, the following statement is added: "An SNPN may allow access to UEs being authorized using credentials or subscription owned by a separate credential holder (CH). The support of this feature is uniform across the SNPN as specified in TS 23.501 [3]."

For Uu interface, the indication of SNPN access with subscription of a Credentials Holder is broadcast in SIB1 per SNPN.

Optionally, Group IDs for Network selection (GINs) could be broadcast in SIBXY. Each GIN may be assigned to one or more SNNPs. There is a common list of GINs for both onboarding and SNPN access using external CHs.

For each SNPN there is a vector that describes which GINs are supported, the maximum number of GINs is 24 per cell.

For cell selection/reselection, since SA2 has the conclusion the indication of SNPN access with subscription of a Credentials Holder should be set uniformly, there is no impact on cell (re)selection to support SNPN with subscription or credentials by a separate entity.

No UE impact was identified on connected mode mobility for external CH.

#### Support UE onboarding and provisioning for NPN

For onboarding support, the section "Support of UE onboarding and remote provisioning" is added in TS 38.331.

The procedure of AMF selection in TS 38.410 is modified for supporting onboarding as follow: "Therefore, a NAS node selection function is located in the NG-RAN node to determine the AMF association of the UE, based on the UE's temporary identifier, which was assigned to the UE by the AMF. When the UE's temporary identifier has not been yet assigned or is no longer valid the NG-RAN node may instead take into account other information (e.g. slicing information, onboarding indication) to determine the AMF."

For Uu interface, the indication of UE onboarding and remote provisioning is broadcast in SIB1 per SNPN.

As for "on-boarding support" indicator, cell selection and suitability criteria of a SNPN cell are not affected. NAS will anyway allow access for onboarding only if the cell/SNPN supports onboarding.

Toggling the 1-bit onboarding indication in SIB1 allows to control congestion due to onboarding request.

No UE impact was identified on connected mode mobility for onboarding.

For NG interface, the new "Onboarding Support" IE is included within the same PLMN Support Item IE in the NG SETUP RESPONSE/AMF CONFIGURATION UPDATE message, the related statement for NG SETUP procedure, in 38.413, is added as follows:

"If the Onboarding Support IE is also included within the same PLMN Support Item IE, the NG-RAN node shall, if supported, consider that the AMF supports UE onboarding for the identified SNPN, as specified in TS 23.501 [9]."

#### Support of IMS voice and emergency services for SNPN

Emergency services are supported for SNPN in Rel-17, which is the new feature compared with Rel-16. UE in SNPN access mode could select the SNPN with `imsEmergencySupportForSNPN=true` for emergency services.

For Uu interface, the indication of support for emergency services is broadcast in SIB1 per SNPN.

#### Support of PWS for SNPN

PWS over SNPN is supported in Rel-17. In TS 38.300, the statement that ETWS and CMAS are not supported over SNPN is removed.

#### **References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890049,890149>



- [1] RP-200732, Status report of WI: Private Network Support for NG-RAN; rapporteur: China Telecom.

## 6.3 Specific verticals support

### 6.3.1 Railways

#### 6.3.1.1 Enhancements to Application Architecture for the Mobile Communication System for Railways Phase 2

UID	Name	Acronym	WG	WID	WI rapporteur name/company
840042	<a href="#">Complete Gap Analysis for Railways Mobile Communication System</a>	MONASTERYEND	S1	SP-190312	Gach, Guillaume, UIC
<b>890035</b>	<b><a href="#">Enhancements to Application Architecture for the Mobile Communication System for Railways Phase 2</a></b>	<b>eMONASTERY2</b>		<b>SP-191104</b>	<b>Oettl, Martin, Nokia</b>
840037	<b>Stage 2 of eMONASTERY2</b>	eMONASTERY2	S6	SP-191104	Oettl, Martin, Nokia
890063	<b>Stage 3 of eMONASTERY2</b>	eMONASTERY2	C1	CP-202256	Gkatzikis, Lazaros, Nokia(Nokia)
840043	<a href="#">Study on Future Railway Mobile Communication System3</a>	FS_FRMCS3	S1	SP-200578	Gach, Guillaume, UIC,

Summary based on the input provided by Nokia in SP-220485.

The railway community is considering a successor to GSM-R, with 2G-based GSM-R technology envisaged to be completely replaced around 2030.

Initial specification work has been done in Release 15 on developing support for railway requirements for MCPTT group calls (on-network) to support the multi-talker feature and to allow the use of functional aliases. Additional specification work has been done in Release 16 on supporting railway requirements for MCPTT group and private calls and on enabling the use of functional aliases in MCPTT private calls, MCVideo and MCDData service.

Additional Stage 1 requirements were identified in Release 17 (MONASTERYEND) and Stage 2 architectural solutions were developed in Release 17 (eMONASTERY2 / MONASTERY2\_ARCH) which were specified in Stage 3 (eMONASTERY2).

The Mission Critical Communication framework specified by 3GPP is used as bases for railway communication and is continuously extended with railway specific functionality.

For Release 17 the Mission Critical Communication were enhanced with new functionality required by the railway community to support call forwarding and call transfer for private MCPTT calls. The MCDData IP connectivity service was extended to support functional aliases and an MC service user can select an appropriate functional alias when be called by another MC service user. The relationship between MC service groups and the use of functional aliases is clarified, including those functions preventing de-affiliation when using a specific functional alias(es) or providing a list of functional aliases used by affiliated group members. For MCVideo services the use of functional aliases was added and is now available as for MCPTT. A functional alias as target address for MCPTT private emergency calls was specified and can be used as alternative to MCPTT IDs. An MC service user can now request an application layer priority, which allow arbitration of multiple service requests by MC service servers.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840042,890035,840037,890063,840043>

- [1] TS 22.280: "Mission Critical Services Common Requirements (MCCoRe); Stage 1"
- [2] TS 22.281: "Mission Critical (MC) video"
- [3] TS 22.282: "Mission Critical (MC) data"
- [4] TS 22.179: "Mission Critical Push to Talk (MCPTT); Stage 1"
- [5] TS 22.289: "Mobile communication system for railways"
- [6] TS 23.280: "Common functional architecture to support mission critical services; Stage 2"
- [7] TS 23.281: "Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2"
- [8] TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCDData); Stage 2"
- [9] TS 23.283: "Mission Critical Communication Interworking with Land Mobile Radio Systems"

- [10] TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2"
- [11] TS 24.379: "Mission Critical Push To Talk (MCPTT) call control; Protocol specification"
- [12] TS 24.282: "Mission Critical Data (MCDATA) signalling control; Protocol specification"
- [13] TS 24.481: "Mission Critical Services (MCS) group management; Protocol specification"
- [14] TS 24.483: "Mission Critical Services (MCS) Management Object (MO)"
- [15] TS 24.484: "Mission Critical Services (MCS) configuration management; Protocol specification"
- [16] TS 24.582: "Mission Critical Data (MCDATA) media plane control; Protocol specification"

### 6.3.1.2 Enhanced NR support for high speed train scenario (NR\_HST)

#### 6.3.1.2.1 NR\_HST for FR1

890058	<b>Enhanced NR support for high speed train scenario for frequency range 1 (FR1)</b>	NR_HST_FR1_enh		RP-210833	CMCC
890158	Core part: Enhanced NR support for high speed train scenario for FR1	NR_HST_FR1_enh-Core	R4	RP-210833	CMCC
890258	Perf. part: Enhanced NR support for high speed train scenario for FR1	NR_HST_FR1_enh-Perf	R4	RP-210833	CMCC

Summary based on the input provided by CMCC in RP-220631.

This WI specifies the UE RRM requirements for carrier aggregation (CA) and UE demodulation requirements for CA for FR1 high speed train scenario (HST). The supported velocity is up to 500km/h and the carrier frequency is up to 3.6GHz covering both TDD and FDD. This WI is the enhancement of Rel-16 WI NR-HST (WID: RP-191512), which targets for single carrier scenario.

In Rel-17 WI on enhanced NR support for high speed train scenario for frequency range 1 (FR1), the enhanced RRM requirements and demodulation requirements for CA were specified to support the speed of up to 500km/h and carrier frequency of up to 3.6GHz.

For RRM, to guarantee the mobility performance for FR1 HST with velocity up to 500km/h, both enhanced requirements for NR inter-frequency measurement and enhanced requirements for CA scenario are specified in TS 38.133. The enhanced requirements for NR inter-frequency measurement include NR cell re-selection requirements, time period for PSS/SSS detection, time period for time index detection and measurement period requirements. The enhanced requirements for CA include both measurement on activated SCells and measurement on deactivated SCells.

For UE demodulation requirements for CA, both HST-SFN (High Speed Train Single Frequency Network) joint transmission scheme and DPS (Dynamic Point Selection) transmission scheme are considered, and the requirements are specified in TS38.101-4. With speed of up to 500km/h and carrier frequency of up to 3.6GHz, the maximum doppler shift is 1667Hz and 870Hz for 30KHz SCS and 15KHz SCS respectively. For 15KHz SCS, specify PDSCH requirements on single carrier of BW of {5, 10, 15, 20, 25, 30, 35, 40, 45, 50} MHz. For 30KHz SCS, specify PDSCH requirements on single carrier of BW of {5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 90, 100} MHz.

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890058.890158.890258>

#### 6.3.1.2.2 NR\_HST for FR2

890060	<b>NR support for high speed train scenario in frequency range 2 (FR2)</b>	NR_HST_FR2		RP-210800	Samsung
890160	Core part: NR support for high speed train scenario in FR2	NR_HST_FR2-Core	R4	RP-210800	Samsung
890260	Perf. Part: NR support for high speed train scenario in FR2	NR_HST_FR2-Perf	R4	RP-210800	Samsung

Summary based on the input provided by Ericsson in RP-220191.

This WI is targeted to specify NR UE RF requirements, RRM requirements and BS/UE performance requirements for train roof-mounted high-power devices in HST scenario with speed up to 350km/h and applicable frequency is up to 30GHz. The considered FR2 HST scenario is different from existing 3GPP WIs (for either LTE or NR) with operating bands up to 3.5GHz, and the NR FR2 RRM and demodulation requirements for non-HST scenarios are also not applicable and need to be specified.



In this WI, the FR2 HST deployment scenarios are studied, based upon which FR2 HST channel models are provided accordingly. From radio resource management (RRM) and demodulation perspectives, FR2 HST scenario is focused and evaluated, with the feasibility of FR2 HST scenario being technically confirmed.

For UE RF requirement, FR2 power class 6 for band n257, n258 and n261 is newly introduced, which is corresponding to the UE type of high speed train roof-mounted UE. Relevant UE TX and RX RF requirements for power class 6 are specified, in which the TX and EIS spherical coverage requirements are defined over the newly introduced spherical coverage evaluation areas. For UE beam correspondence requirement, the applicability rule and requirement side conditions are specified.

The RRM requirements for FR2 HST scenarios are introduced and enhanced over existing FR2 RRM requirements. Specifically, the enhancements for FR2 HST are introduced on cell re-selection, RRC connection mobility control, gradual timing adjustment, SSB based radio link monitoring and beam failure detection, intra-frequency measurement and L1-RSRP/SINR measurement. The new requirements of one shot large UL timing adjustment and TCI state switch delay are specified for FR2 HST scenarios.

The BS/UE performance requirements are discussed for FR2 HST scenarios, which will be further completed in the performance phase of this WI.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890060,890160,890260>

- [1] R4-2206594, TR 38.854 v0.4.0, NR support for high-speed train scenario in frequency range 2 (FR2), Nokia, Nokia Shanghai Bell, and Samsung.
- [2] RP-220317, Status report for WI NR support for high-speed train scenario in frequency range 2 (FR2), Samsung.

## 6.3.1.3 NR Frequency bands for Railways

### 6.3.1.3.1 Introduction of 900MHz NR band for Europe for Rail Mobile Radio (RMR)

911016	<a href="#">Introduction of 900MHz NR band for Europe for Rail Mobile Radio (RMR)</a>	NR_RAIL_EU_900 MHz		RP-211495	UIC
911116	Core part: NR_RAIL_EU_900MHz	NR_RAIL_EU_900 MHz-Core	R4	RP-211495	UIC
911216	Perf. part: NR_RAIL_EU_900MHz	NR_RAIL_EU_900 MHz-Perf	R4	RP-211495	UIC

This work item adds the support of Railways communications for bands n100 in CEPT countries.

It deals with the use of the Rail Mobile Radio spectrum in the 900MHz frequency band, which was assigned by the ECC Decision (20)02 [2] for the use by the railways in Europe.

It addresses all the necessary precautions to make the paired spectrum of 874.6-800/919.4-925MHz usable for 5G NR.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=911016,911116,911216>

- [1] 3GPP TR 38.853: Introduction of 900MHz NR band for Europe for Rail Mobile Radio (RMR)
- [2] ECC Decision (20)02: "Harmonised use of the paired frequency bands 874.4-880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR)".

### 6.3.1.3.2 Introduction of 1900MHz NR TDD band for Europe for Rail Mobile Radio (RMR)

911017	<a href="#">Introduction of 1900MHz NR TDD band for Europe for Rail Mobile Radio (RMR)</a>	NR_RAIL_EU_1900MHz_TDD		RP-211542	UIC
911117	Core part: NR_RAIL_EU_1900MHz_TDD	NR_RAIL_EU_1900MHz_TDD-Core	R4	RP-211542	UIC
911217	Perf. part: NR_RAIL_EU_1900MHz_TDD	NR_RAIL_EU_1900MHz_TDD-Perf	R4	RP-211542	UIC

This work item deals with the use of the Rail Mobile Radio spectrum in the 1900MHz frequency band, which was assigned by the ECC Decision (20)02 [2] for the use by the railways in Europe, in CEPT countries.

It addresses all the necessary precautions to make the unpaired spectrum of 1900-1910MHz usable for 5G NR.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=911017,911117,911217>

- [1] 3GPP TR 38.852: Introduction of 1900MHz NR band for Europe for Rail Mobile Radio (RMR)
- [2] ECC Decision (20)02: "Harmonised use of the paired frequency bands 874.4-880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR) ".

## 6.3.2 Mission Critical (MC) and priority service

### 6.3.2.1 Mission Critical Push-to-talk Phase 3

870034	Enhanced Mission Critical Push-to-talk architecture phase 3	enh3MCPTT		SP-200108	Dom Lazara; Motorola Solutions
870016	Stage 2 aspects of enh3MCPTT	enh3MCPTT	S6	SP-200108	Dom Lazara; Motorola Solutions
900039	Stage 3 aspects of enh3MCPTT	enh3MCPTT-CT	C1	CP-202188	

Summary based on the input provided by Motorola Solutions in SP-220682 (earlier version provided by FirstNet in CP-220111).

For Release 17, the enhancements to MCPTT (and related services) were contained in two work items: Enhanced Mission Critical Push-to-talk architecture phase 3 -- enh3MCPTT for stage2 (SA6); and enh3MCPTT-CT for stage 3 (CT1). The corresponding items which have been completed in Release 17 are described in the following clause.

These enhancements impact the following areas of the MCPTT, MCVideo, and MCDATA architecture and protocols: call control and media handling, configuration, and security.

The following features have been enhanced.

**Preconfigured group usage:** Certain groups are designated for preconfigured group usage only, and as such, should not be allowed to be the target of a call or alert. Enhancements were made to identify preconfigured groups and protect against their use in call scenarios. The enhancements have been applied to the MCPTT, MCVideo, and MCDATA services. In addition, enhancements have been made to give parity to the preconfigured regrop feature across all three MC services

**Emergency alert area notification handling:** The emergency alert area notification feature allows for an MC user to be notified whenever said user moves into, or moves out, of a predefined area. The functionality is applicable to the MCPTT, MCVideo, and MCDATA services. Enhancements have been made to give parity of this feature across all three MC services.

**Entry / exit from group geographic area handling:** The group geographic area notification feature allows for an MC user to be notified whenever said user moves into, or moves out, of a predefined group geographic area requiring affiliation to, or de-affiliation from, a group. The functionality is applicable to the MCPTT, MCVideo, and MCDATA services. Enhancements have been made to give parity of this feature across all three MC services.

**PDN and APN configuration:** The UE initial config allows for configuration of certain APN parameters such as ServiceServerUri. These APN parameters need to be consistent with the Managed Object definitions. These are applicable for all MC services. Similarly, PDN parameters that provide for PDN connectivity information for each of the MC services need to be consistently specified within the MC UE initial configuration document. Enhancements have been made to align stage 3 with stage 2 specifications.

**Location altitude, accuracy and handling:** The handling of location information should provide for an accuracy (uncertainty) that can be given to the various location vectors. These vectors include not just horizontal and vertical location, to support latitude and longitude, but also vertical location to support altitude. Enhancements have been made to the MCPTT, MCVideo, and MCDATA services to provide for this enhanced location handling.

**Clearing the floor request queue:** Previously, an authorized MCPTT user has had the ability to clear a portion of the MCPTT floor request queue for a given call by specifying the list of users to be cleared from the queue. This functionality is further enhanced to allow the authorized MCPTT user to clear the entire floor request queue for all users in the queue for a given call. Enhancements have been made to allow for this new capability. Although this capability will remove all currently queued floor participants, it does not prevent the removed users from immediately retrying to access the floor for the same call.

**MCPTT unicast media start and stop:** The MCPTT service has been enhanced to give the capability to the MCPTT client to indicate to the server that a certain unicast media flow for a given group call can be stopped and then resumed at a later time. This capability can reduce radio resources for an MCPTT user who may be participating in other higher priority group calls.

The requirements, architecture, protocol, and security aspects related to these enhancements are described in the following specifications:

1. The MCPTT service requirements are specified in TS 22.179 and TS 22.280;
2. The MCVideo service requirements are specified in TS 22.281 and TS 22.280;
3. The MCDData service requirements are specified in TS 22.282 and TS 22.280;
4. The MCPTT service architecture (including information flows, procedures, and configuration) is specified in TS 23.379 and TS 23.280;
5. The MCVideo service architecture (including information flows, procedures, and configuration) is specified in TS 23.281 and TS 23.280;
6. The MCDData service architecture (including information flows, procedures, and configuration) is specified in TS 23.282 and TS 23.280;
7. The security aspects of the MCPTT service are specified in TS 33.180;
8. The protocol aspects of the MCPTT service for call control and media plane are specified in TS 24.379 and TS 24.380 respectively;
9. The protocol aspects of the MCVideo service for call control and media plane are specified in TS 24.281 and TS 24.581 respectively;
10. The protocol aspects of the MCDData service for call control and media plane are specified in TS 24.282 and TS 24.582 respectively;
11. The protocol aspects of MC services for group configuration, identity management, and general configuration are specified in TS 24.481, TS 24.482, TS 24.483, and TS 24.484 respectively;
12. The protocol aspects of the MCPTT service for codecs and media handling are specified in TS 26.179;
13. The protocol aspects of MC services for policy and charging control are specified in TS 29.213 and TS 29.214;
14. The protocol aspects of MC services for data management related to MC service user profile are specified in TS 29.283;

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870034,870016,900039>

- |      |  |
|------|--|
| [1]  | TS 22.179 Mission Critical Push To Talk (MCPTT); Stage 1;  |
| [2]  | TS 22.281 Mission Critical Video services; Stage 1;  |
| [3]  | TS 22.282 Mission Critical Data services; Stage 1;   |
| [4]  | TS 22.280 Mission Critical Services Common Requirements (MCCoRe); Stage 1;   |
| [5]  | TS 23.379 Functional architecture and information flows to support Mission Critical Push-To-Talk (MCPTT); Stage 2; |
| [6]  | TS 23.281 Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2;      |
| [7]  | TS 23.282 Functional architecture and information flows to support Mission Critical Data (MCDData); Stage 2;       |
| [8]  | TS 23.280 Common functional architecture to support mission critical services; Stage 2;                            |
| [9]  | TS 24.379 Mission Critical Push To Talk (MCPTT) call control; Protocol specification;                              |
| [10] | TS 24.380 Mission Critical Push To Talk (MCPTT) media plane control; Protocol specification;                       |
| [11] | TS 24.481 Mission Critical Services (MCS) group management; Protocol specification;                                |
| [12] | TS 24.482 Mission Critical Services (MCS) identity management; Protocol specification;                             |
| [13] | TS 24.483 Mission Critical Services (MCS) Management Object (MO);  |
| [14] | TS 24.484 Mission Critical Services (MCS) configuration management; Protocol specification;                        |
| [15] | TS 26.179 Mission Critical Push-To-Talk (MCPTT); Codecs and media handling;  |
| [16] | TS 29.213 Policy and Charging Control signalling flows and Quality of Service (QoS) parameter mapping;             |
| [17] | TS 29.214: Policy and Charging Control over Rx reference point;  |
| [18] | TS 29.283: Diameter data management applications;  |
| [19] | TS 33.180: Security of the mission critical service (Release 17).  |

### 6.3.2.2 Mission Critical Data Phase 3

890039	<a href="#">Mission Critical Data</a>	eMCDData3		SP-191106	Shih, Jerry, AT&T
860007	Stage 2 of MCDData3	eMCDData3	S6	SP-191106	Shih, Jerry, AT&T
890038	CT aspects of eMCDData3	eMCDData3	C1	CP-201177	

Summary based on the input provided by at&t in SP-220089.

For Release 17, the enhancements for the MCDData service were defined by the two work items above. The following functionalities have been introduced:

- new network-based MCDData notification server. The MCDData notification server provides the centralized notification function in the network that allows an application (e.g. resident in the UE) to create a communication channel to receive real-time notifications from the network in either Pull or Push mode.
- MCDData communication (SDS or file distribution) supports using functional alias as target end points, except FD using HTTP.
- new "search folder" and "retrieve folder content" operations to MCDData message store operations.
- Support application specific metadata container in MCDData communication for application specific handling.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890039,860007,890038>

- [1] TS 22.282 Mission Critical Data services; Stage 1;
- [2] TS 22.280 Mission Critical Services Common Requirements (MCCoRe); Stage 1;
- [3] TS 23.282 Functional architecture and information flows to support Mission Critical Data (MCDData) Stage 2 (together with 23.280, it specifies the architecture, including information flows, procedures, and configuration) ;
- [4] TS 23.280 Common functional architecture to support mission critical services; Stage 2;
- [5] TS 23.303 Proximity-based services (ProSe); Stage 2 (ProSe is an enabler for MC services);
- [6] TS 23.468 Group Communication System Enablers for LTE (GCSE\_LTE); Stage 2;
- [7] TS 24.282 Mission Critical Data (MCDData) signalling control (specifies the protocol aspects for call control);
- [8] TS 24.582 Mission Critical Data (MCDData) media plane control(specifies the protocol aspects for media plane);
- [9] TS 24.481 Mission Critical Services (MCS) group management; Protocol specification;
- [10] TS 24.482 Mission Critical Services (MCS) identity management; Protocol specification;
- [11] TS 24.483 Mission Critical Services (MCS) Management Object (MO);
- [12] TS 24.484 Mission Critical Services (MCS) configuration management; Protocol specification;
- [13] TS 29.213 Policy and Charging Control signalling flows and Quality of Service (QoS) parameter mapping;
- [14] TS 29.214: Policy and Charging Control over Rx reference point;
- [15] TS 29.283: Diameter data management application (specifies the protocol aspects for data management related to MC service user profile )
- [16] TS 33.180: Security of the mission critical service.

### 6.3.2.3 Mission Critical security Phase 2

890011	Mission critical security enhancements phase 2	MCXSec2	S3	SP-200879	Woodward, Tim, Motorola Solutions, Inc.
--------	--	---------	----	-----------	---

Summary based on the input provided by Motorola Solutions in SP-220019.

Mission critical (MC) services security enhancements phase 2 defines the confidentiality, integrity, user authentication, service authorization, and overall security architecture for Release 17 mission critical services (MCPTT, MCVideo, MCDData, MC Location, MC Interworking, MC Interconnection, and MC Railway).

Release 17 expands on the mission critical security architecture already defined in previous releases and includes some mission critical security clarifications and corrections.

In this release, mission critical user service authorization and security for the mission critical MCDData message store service. Similar to user service authorization for the other MC services, an appropriately scoped access token obtained from the Identity Management server permits only authorized users the authorization to access and use the MCDData message store service.

Security for Preconfigured Group Regroup and Preconfigured User Regroup calls defines the use of the preconfigured group to establish the security context.

Enhancements to the security architecture to support mission critical security services over a 5G system. This includes the mission critical security architecture, which describes the use and integration of 5G nodes and servers.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890011>

[1] TS 33.180: "Security of the Mission Critical (MC) service; (Release 17)"

### 6.3.2.4 Mission Critical Services over 5GS

920051	<b>Mission Critical Services over 5GS</b>	MCOVer5GS		SP-200833	Wendler, Ingo, UIC
890027	<b>Stage 2 of MCOVer5GS</b>	MCOVer5GS	S6	SP-200833	Wendler, Ingo, UIC
920007	<b>CT1 aspects of MCOVer5GS</b>	MCOVer5GS	C1	CP-211118	Gkatzikis, Lazaros, Nokia

Summary based on the input provided by UIC.

MCOVer5GS (Mission Critical service over 5GS) aims to enable 5GS for the use by Mission Critical Services supporting on-network as well as off network Mission Critical communication. In a first phase (Rel-17) unicast transmission service are now available for the on-network approach. In consecutive phases multicast/broadcast services and off network are in focus. In the area of off-network communication, the main aim is to align transmission services using 5GS capabilities. Another important aspect is to provide interoperability when Mission Critical Services are supported by both, the EPS and 5GS.

MCOVer5GC adapts the general Mission Critical Communication functional model so it is applicable when using 5GS. Rel-17 enables the use of unicast based transmission mode for Mission Critical services and the proper use of 5GS Quality of Service categories. Relevant procedures were adapted to be applicable under 5GS conditions.

With use of 5GS, Mission Critical services are now also be used taking the untrusted approach into account so that MC service servers can be operated geographically independently from the IMS/SIP core infrastructure.

MC services can be deployed using different infrastructures, public or non-public. With 5GS, MC services and their traffic can be operated in isolation from others using network slicing. Transport resources are thus virtualized and can be used for MC service, considering predefined bit rates. In this context a minimum amount of bandwidth can also be guaranteed for handling Mission Critical services, e.g. when using public networks.

## References

Related CRs: set "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920051,890027,920007>

[1] TS 23.289: "Mission Critical services over 5G System; Stage 2"

### 6.3.2.5 Enhanced Mission Critical Communication Interworking with Land Mobile Radio Systems (CT aspects)

890003	<b>CT aspects of Enhanced Mission Critical Communication Interworking with Land Mobile Radio Systems</b>	eMCCI_CT	C1	eMCCI_CT	Mike Dolan, FirstNet
--------	--	----------	----	----------	----------------------

Summary based on the input provided by FirstNet in CP-220110.

eMCCI\_CT refers to stage 3 aspects of the stage 2 work defined by eMCCI in Rel-16.

Note: This does not comply with the 3GPP methodology: all stages of a Feature shall be defined within a same Release and use the same Feature/acronym. An exception was granted, and this Feature is then "split" between Rel-16 (Stage 2 aspects) and Rel-17 (Stage 3 aspects).

It covers enhancements to interworking 3GPP mission critical systems with Land Mobile Radio (LMR, i.e. public safety communication networks) systems in Rel-17 to provide support for a conference event package, affiliation on behalf of a set of users, and private call floor control.

The Rel-17 IWF (interworking function) now supports the ability for the IWF to handle subscriptions to events that may occur in the LMR system, and for the IWF to be able to subscribe on behalf of LMR users to events in the 3GPP mission critical system (MCPTT and MCData).

Affiliation on behalf of a set of users is now handled from the IWF toward the 3GPP mission critical system to potentially reduce the signalling load due to repetitive messaging.

Private call floor control is now supported between an MCPTT system and an IWF.

## References



Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890003>

- [1] TS 29.379: "Mission Critical Push To Talk (MCPTT) call control interworking with Land Mobile Radio (LMR) systems"
- [2] TS 29.380: "Mission Critical Push To Talk (MCPTT) media plane control interworking with Land Mobile Radio (LMR) systems"
- [3] TS 29.582: "Mission Critical Data (MCDData) interworking with Land Mobile Radio (LMR) systems"

### 6.3.2.6 Mission Critical system migration and interconnection (CT aspects)

820040	<a href="#">Mission Critical system migration and interconnection</a>	MCSMI_CT	C1	CP-190143	Dom Lazara, Motorola Solutions
--------	---	----------	----	-----------	--------------------------------

Summary based on the input provided by Motorola Solutions in SP-220683.

MCSMI\_CT refers to stage 3 aspects of the stage 2 work defined by MCSMI in Rel-16.

Note: This does not comply with the 3GPP methodology: all stages of a Feature shall be defined within a same Release and use the same Feature/acronym. An exception was granted, and this Feature is then "split" between Rel-16 (Stage 2 aspects) and Rel-17 (Stage 3 aspects).

For Release 17, the enhancements to the MC service specifications (MCPTT, MCVideo, and MCDData) to support Mission Critical system interconnection were contained in the work items: MCSMI\_CT for stage 3 (CT1), and the earlier work items MCSMI (SA6) and eMCSMI (SA6) for stage 2. The latest revised WID for MCSMI\_CT in CP 220301 focused only on MC system interconnection. The stage 3 migration aspects for MC systems will be considered in a future release. The corresponding items which have been completed in Release 17 are described in the following clause.

Interconnection between mission critical systems is needed to provide inter-system communication for purposes such as operational support and mutual aid between mission critical systems in different security domains, operated by different mission critical organizations. All of the call types that are available within a single MC system may also be needed when communications between a primary and partner system involves interconnection.

These enhancements for interconnection that follow impact areas of the MCPTT, MCVideo, and MCDData service architecture and protocols. The following features have been added or enhanced to support MC system interconnection.

**Functional connectivity model and introduction of the MC gateway server:** To allow for interconnection of MC systems in different trust domains the MC gateway sever is introduced for each of the MC services to provide topology hiding and an interface between security domains. An MCPTT gateway server can act as a SIP and HTTP proxy for signalling with a partner MCPTT system in a different trust domain. Similarly, an MCVideo gateway server and an MCDData gateway server provides the same function for the MCVideo and MCDData services, respectively.

**MCPTT service changes to support MC system interconnection:** The following MCPTT procedures have been enhanced to support MCPTT interconnection: affiliation, emergency alert, pre-arranged group call, chat group call, common procedures, private call, remotely initiated group call, remote change of selected group, group regroup, user regroup, and the corresponding MCPTT gateway server procedures.

**MCVideo service changes to support MC system interconnection:** The following MCVideo procedures have been enhanced to support MCVideo interconnection: affiliation, ambient viewing, emergency alert, group call, private call, common procedures, remote change of selected group, group regroup, user regroup, and the corresponding MCVideo gateway server procedures.

**MCDData service changes to support MC system interconnection:** The following MCDData procedures have been enhanced to support MCDData interconnection: affiliation, disposition notifications, emergency alert, Short Data Service procedures, File Download procedures, common procedures, IP connectivity, group regroup, user regroup, and the corresponding MCDData gateway server procedures.

The requirements, architecture, protocol, and security aspects related to these enhancements are described in the following specifications:

1. The MCPTT service requirements are specified in TS 22.179 and TS 22.280;
2. The MCVideo service requirements are specified in TS 22.281 and TS 22.280;
3. The MCDData service requirements are specified in TS 22.282 and TS 22.280;
4. The MCPTT service architecture (including information flows, procedures, and configuration) is specified in TS 23.379 and TS 23.280;

5. The MCVideo service architecture (including information flows, procedures, and configuration) is specified in TS 23.281 and TS 23.280;
6. The MCDATA service architecture (including information flows, procedures, and configuration) is specified in TS 23.282 and TS 23.280;
7. The security aspects of the MCPTT service are specified in TS 33.180;
8. The protocol aspects of the MCPTT service for call control and media plane are specified in TS 24.379 and TS 24.380 respectively;
9. The protocol aspects of the MCVideo service for call control and media plane are specified in TS 24.281 and TS 24.581 respectively;
10. The protocol aspects of the MCDATA service for call control and media plane are specified in TS 24.282 and TS 24.582 respectively;
11. The protocol aspects of MC services for group configuration, identity management, and general configuration are specified in TS 24.481, TS 24.482, TS 24.483, and TS 24.484 respectively;
12. The protocol aspects of the MCPTT service for codecs and media handling are specified in TS 26.179;
13. The protocol aspects of MC services for policy and charging control are specified in TS 29.213 and TS 29.214;
14. The protocol aspects of MC services for data management related to MC service user profile are specified in TS 29.283;

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820040>

- [1] TS 22.179 Mission Critical Push To Talk (MCPTT); Stage 1;
- [2] TS 22.281 Mission Critical Video services; Stage 1;
- [3] TS 22.282 Mission Critical Data services; Stage 1;
- [4] TS 22.280 Mission Critical Services Common Requirements (MCCoRe); Stage 1;
- [5] TS 23.379 Functional architecture and information flows to support Mission Critical Push-To-Talk (MCPTT); Stage 2;
- [6] TS 23.281 Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2;
- [7] TS 23.282 Functional architecture and information flows to support Mission Critical Data (MCDATA); Stage 2;
- [8] TS 23.280 Common functional architecture to support mission critical services; Stage 2;
- [9] TS 24.379 Mission Critical Push To Talk (MCPTT) call control; Protocol specification;
- [10] TS 24.380 Mission Critical Push To Talk (MCPTT) media plane control; Protocol specification;
- [11] TS 24.481 Mission Critical Services (MCS) group management; Protocol specification;
- [12] TS 24.482 Mission Critical Services (MCS) identity management; Protocol specification;
- [13] TS 24.483 Mission Critical Services (MCS) Management Object (MO);
- [14] TS 24.484 Mission Critical Services (MCS) configuration management; Protocol specification;
- [15] TS 26.179 Mission Critical Push-To-Talk (MCPTT); Codecs and media handling;
- [16] TS 29.213 Policy and Charging Control signalling flows and Quality of Service (QoS) parameter mapping;
- [17] TS 29.214: Policy and Charging Control over Rx reference point;
- [18] TS 29.283: Diameter data management applications;
- [19] TS 33.180: Security of the mission critical service (Release 17).

### 6.2.3.7 MC services support on IOPS mode of operation

840038	MC services support on IOPS mode of operation	MCIOPS	S6	SP-190944	Camilo Solano, Ericsson
--------	---	--------	----	-----------	-------------------------

Summary based on the input provided by Ericsson in SP-220320.

For Release 17, Mission Critical (MC) services support in the Isolated Operation for Public Safety (IOPS) mode of operation defines the features required to support MC services based on the availability of an IOPS MC system, e.g., for the case of a backhaul failure. The stage 2 work has been developed based on the study results captured in TR 23.778, stage 1 service requirements defined in TS 22.346, stage 2 work related to the definition of the IOPS mode of operation in TS 23.401, and the support of MC services defined in TS 23.280, TS 23.379, and TS 23.282.

Those features that have been completed are described in the following clause.

NOTE: Stage 3 work was not completed at the time when this summary was introduced in the present document (March 2022).

The functional architecture, procedures and information flows to support MC services in the IOPS mode of operation have been specified in TS 23.180. The addressed architecture requirements were focused on the case of a backhaul

failure between the radio access network (RAN) and the macro Evolved Packet Core (EPC). For that, the IOPS MC system provides support for MC services in the IOPS mode of operation until the failure is recovered.

In this release, during the IOPS mode of operation the IOPS MC system supports the following MCPTT services: group call, emergency group call, private call and emergency private call. For the case of MCData services, only short data service is supported. MCVideo services are not supported in Release 17.

MC services in the IOPS mode of operation are specified based on the IP connectivity functionality. The IP connectivity functionality enables that MC services are provided by the MC service clients via the IOPS MC connectivity function.

The IP connectivity functionality defines that the IOPS MC connectivity function does not provide MC services to the MC service clients. Instead, it enables that MC service users are discovered by the IOPS MC connectivity function and get notified about the availability of other MC service users within the coverage of the IOPS Evolved Packet System (EPS). The IOPS MC connectivity function distributes then related IP traffic to discovered MC service UEs over IP unicast transmissions and/or multicast transmissions. An MC service UE supporting the IP connectivity functionality in the IOPS mode of operation enables transmitting the IP packets related to an MC service communication over the IOPS MC connectivity function.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820038>

- [1] TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".
- [2] TS 22.346: "Isolated Evolved Universal Terrestrial Radio Access Network (E-UTRAN) operation for public safety; Stage 1".
- [3] TS 23.280: "Common functional architecture to support mission critical services".
- [4] TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2".
- [5] TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCData); Stage 2".

### 6.3.2.8 MCPTT in Railways

See the section "Enhancements to Application Architecture for the Mobile Communication System for Railways Phase 2"

### 6.3.2.9 Multimedia Priority Service (MPS) Phase 2

UID	Name	Acronym	WG	WID	WI rapporteur name/company
<b>840046</b>	<b>Multimedia Priority Service (MPS) Phase 2</b>	<b>MPS2</b>		<b>SP-190305</b>	<b>Singh, Ray P; Perspecta Labs</b>
780005	Study on MPS2	FS_MPS2	S1	SP-190315	Singh, Ray P; Vencore Labs
850011	Study on MPS2, Stage 2	FS_MPS2_St2	S2	SP-190629	Don Lukacs; Perspecta Labs
840032	<b>Stage 1 of MPS2</b>	MPS2	S1	SP-190561	Singh, Ray P; Perspecta Labs
870002	<b>Stage 2 of MPS2</b>	MPS2	S2	SP-200519	Streijl, Robert; Perspecta Labs
<b>880031</b>	<b>Stage 3 of MPS2</b>	<b>MPS2</b>	<b>ct</b>	<b>CP-201207</b>	<b>Peter Monnes, Perspecta Labs</b>
880050	CT1 aspects of MPS2	MPS2	C1	CP-201207	Peter Monnes, Perspecta Labs
880058	CT3 aspects of MPS2	MPS2	C3	CP-201207	Peter Monnes, Perspecta Labs
880051	CT4 aspects of MPS2	MPS2	C4	CP-201207	Peter Monnes, Perspecta Labs

Summary based on the input provided by CATT in SP-220899.

Multimedia Priority Service (MPS) to support priority communications by authorized users, i.e., emergency service personnel, during times of emergency situations and network congestion was originally specified in Release 8. In Release 17, a stage 1 feasibility study on MPS Phase 2 identified new priority voice, video, and data communication capabilities. Based on the results of the MPS Phase 2 feasibility study as documented in TR 22.854 [1], the normative stage 1 requirements in TS 22.153 [2] were updated and associated stage 2 and stage 3 features were defined in Release 17.

#### Stage 1 summary

The following is a summary of the new stage 1 features included in TS 22.153 [2] Release 17:

##### 1. MPS for MMTEL voice/video

Explicit stage 1 requirements were added for MPS for MMTEL voice and MMTEL voice conference calls for an authorized Service User using a UE with a subscription for MPS; and new requirements for MPS for MMTEL voice and MMTEL voice conference calls for an authorized Service User using a UE that does not have an MPS subscription,



and MPS for all participants of an authorized MMTEL voice conference call. The corresponding extensions were also added for MPS for MMTEL video.

## 2. MPS for Data Transfer Service (DTS)

A new MPS for DTS feature was defined as a generic priority packet transport service that applies independently of the specific data application being used. In the case of EPS, MPS for DTS enables the prioritization of all traffic on the default bearer upon request. It may also apply to other bearers based on operator policy and regulatory rules. In the case of 5GS, MPS for DTS enables the prioritization of all traffic on the QoS Flow associated with the default QoS rule upon request. It may also apply to other QoS flows based on operator policy and regulatory rules. MPS for DTS is a specific example of Priority Data Bearer Service.

## 3. Attestation of Authorized MPS Priority

New stage 1 requirements were added for the attestation and verification of MPS authorization.

### Stage 2 summary

The following is a summary of the new stage 2 features included in Release 17:

#### 1. MPS for MMTEL voice/video

Enhancements were included in TS 23.228 [8] based on the new stage 1 requirements for MPS for MMTEL voice and video conference calls. A conferencing AS permits an authorized host with an MPS (IMS) priority subscription to request an upgrade of the host itself, specific participants, or all participants including the host in the conference, whether participants have an MPS subscription or not.

#### 2. MPS for DTS

A new MPS for DTS feature was specified in TS 23.401 [3], TS 23.203 [4], TS 23.501 [5], TS 23.502 [6], and TS 23.503 [7] to support priority packet transport service that applies independently of the specific data application being used. MPS for DTS enables the prioritization of all traffic on the EPC default bearer and the 5GC QoS Flow associated with the default QoS rule upon requests received via an AF. Based on additional configuration in the PCF, prioritization may also be applied to other bearers and QoS Flows.

#### 3. SBI Message Priority

TS 23.501 [5] and TS 23.502 [6] were enhanced to specify that 5GC service based messages carry a priority indication for the UE if the UE has a priority subscription. Specifications already supported the priority indication on service based messages via the AMF based on the receipt of an RRC connection request with a priority establishment cause. The enhancement informs all core network elements with service based interfaces to handle all activity from MPS subscribers with priority.

#### 4. MPS support in the UE Configuration Update procedure

TS 23.502 [6] was enhanced to support MPS subscription updates in the UE Configuration Update procedure so that a UE that receives an MPS subscription from the network does not have to wait for any re-registration events to obtain priority treatment.

### Stage 3 summary

The following is a summary of the new stage 3 features and improvements included in Release 17:

#### 1. MPS for MMTEL voice/video

TS 24.229 [9] was enhanced to specify that all IMS core elements (e.g., the P-CSCF, I-CSCF, S-CSCF, MGCF, BGCF, MRFC, MRB, IBCF, ISC gateway and AS) adjust priority treatment based upon the most recently received Resource Priority Header field. This allows voice/video calls to be upgraded to MPS while in progress.

#### 2. MPS for Data Transfer Service (DTS)

The new MPS for DTS feature was defined in support of stage 1 and stage 2 requirements for priority data, along with the associated PCC (Policy and Charging Control) related protocol and information element requirements, for both EPS and 5GS.

#### 3. Voice Call Continuity (VCC)

In TS 24.237 [10], the VCC procedure in the SCC AS was enhanced to prevent loss of priority for MPS voice calls across mobility events.

#### 4. SBI Message Priority

TS 29.500 [11] was enhanced to specify that 5GC service based messages carry a priority indication for the UE if either the UE has a priority subscription or has established an RRC connection with priority. The enhancement informs all core network elements on the service based interfaces that the activity is to be handled with priority.

#### 5. MPS support in the UE Configuration Update procedure

TS 24.501 [12] was enhanced to support MPS subscription updates in the UE Configuration Update procedure so that a UE that receives an MPS subscription from the network does not have to wait for any re-registration events to obtain priority treatment.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840046,780005,850011,840032,870002,880031,880050,880058,880051>

- [1] 3GPP TR 22.854: "Feasibility Study on Multimedia Priority Service (MPS) Phase 2".
- [2] 3GPP TS 22.153: "Multimedia priority service".
- [3] 3GPP TS 23.401, "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".
- [4] 3GPP TS 23.203, "Policy and charging control architecture".
- [5] 3GPP TS 23.501, "System architecture for the 5G System (5GS); Stage 2".
- [6] 3GPP TS 23.502, "System architecture for the 5G System (5GS); Stage 2".
- [7] 3GPP TS 23.503, "Policy and charging control framework for the 5G System (5GS); Stage 2".
- [8] 3GPP TS 23.228, "Policy and charging control framework for the 5G System (5GS); Stage 2".
- [9] 3GPP TS 24.229: "IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3".
- [10] 3GPP TS 24.237: "IP Multimedia Subsystem (IMS) Service Continuity; Stage 3".
- [11] 3GPP TS 29.500: "Technical Realization of Service Based Architecture; Stage 3".
- [12] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

## 6.3.3 Drone/UAS/UAV/EAV

### 6.3.3.1 Introduction

For several reasons, drone-related aspects have been using different names: during the course of Rel-17, "unmanned" was changed to "uncrewed". Also, some groups have been using "Vehicle" ("UAV") while other have been using "Systems" ("UAS").

This section refers to drone being supported as a vertical by the 5GS. It does not cover the case of drones being used *within* the system, e.g. to provide extended coverage (this is not covered in the Release).

### 6.3.3.2 General aspects

#### 6.3.3.2.1 5G Enhancement for UAVs

UID	Name	Acronym	WG	WID	WI rapporteur name/company
840083	<a href="#">5G Enhancement for Uncrewed Aerial Vehicle (UAVs)</a>	EAV		SP-190308	Qun Wei, China Unicom
810019	Study on EAV	FS_EAV	S1	SP-180909	Qun Wei, China Unicom
840039	<b>Stage 1 of EAV</b>	EAV	S1	SP-190308	Qun Wei, China Unicom
880007	<a href="#">Study on security aspects of Uncrewed Aerial Systems (UAS)</a>	FS_UAS_SEC	S3	SP-200352	Adrian Escott, Qualcomm
820011	<a href="#">Study on supporting Uncrewed Aerial Systems Connectivity, Identification, and Tracking</a>	FS_ID_UAS_SA2	S2	SP-200097	Qualcomm, Stefano Faccin

Summary based on the input provided by China Unicom in SP-220664.

This work item expands the scope of 3GPP system to support various enhanced UAV scenarios, especially for a wide range of applications and scenarios by using low altitude UAVs in various commercial and government sectors.

New service level requirements and KPIs for supporting various UAV applications by the 3GPP system have been identified and specified. Some new requirements are closely related to relevant work item 810049 in stage 1, such as C2 communication and related KPIs.

The main work of EAV item is based on the outcome of the study items resulting in TR 22.829 [1]. The General requirements needed for the 5G system to support UAV aspects are introduced in chapter 6.32 in TS 22.261[2], which points to the main normative work of TS 22.125 [3], where the following service requirements and KPIs are addressed:

Point1: Requirements for UAV usages; Network exposure for UAV services; Service restriction for UEs onboard of UAV; Requirements for UxNB; C2 communication

Point2: Performance requirements: KPIs for services provided to the UAV applications; KPIs for UAV command and control; Positioning performance requirements; Other requirements

Stage-2/3 works related to this WI were progressed by the work item "Application layer support for UAS" described in the next clause.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840083,810019,840039,880007,820011>

- [1] TR 22.829, Enhancement for Unmanned Aerial Vehicles; Stage 1
- [2] TS 22.261, Service requirements for the 5G system; Stage 1
- [3] TS 22.125, Unmanned Aerial System (UAS) support in 3GPP; Stage 1

### 6.3.3.2.2 Application layer support for UAS

820026	<a href="#">Study on application layer support for Uncrewed Aerial System (UAS)</a>	FS_UASAPP	S6	SP-200111	Niranth Amogh, Huawei
920045	<a href="#">Application layer support for Uncrewed Aerial System (UAS)</a>	UASAPP		SP-200988	Niranth Amogh, Huawei Telecommunications India
900025	Stage 2 of Application layer support for Uncrewed Aerial System (UAS)	UASAPP	S6	SP-200988	Niranth Amogh, Huawei Telecommunications India
920004	CT1 Aspects of Application Layer Support for Uncrewed Aerial Systems (UAS)	UASAPP	C1	CP-211111	Lin Shu, Huawei,
920046	CT3 Aspects of Application Layer Support for Uncrewed Aerial Systems (UAS)	UASAPP	C3	CP-211111	Lin Shu, Huawei

Summary based on the input provided by Huawei in SP-220651.

This Feature specifies enabler services related to application layer support for Uncrewed Aerial System (UAS). This feature enables efficient use and deployment of UAS on 3GPP networks. The architecture and protocols for UAS application layer consisting of UAS application enabler are specified considering stage 1 and stage 2 work within 3GPP related to UAS in TS 22.125 [1] and TS 23.256 [2].

The UAS application layer utilizes Service Enabler Architecture Layer (SEAL) functionalities. The enhancements to SEAL were specified using the eSEAL WI (see corresponding section).

An architecture for UAS application layer over 3GPP system is introduced as shown in figure x.



- [5] TS 29.257: "Application layer support for Uncrewed Aerial System (UAS); UAS Application Enabler (UAE) Server Services; Stage 3"
- [6] TR 23.755: "Study on application layer support for Unmanned Aerial Systems (UAS)"

### 6.3.3.3 Remote Identification of UAS

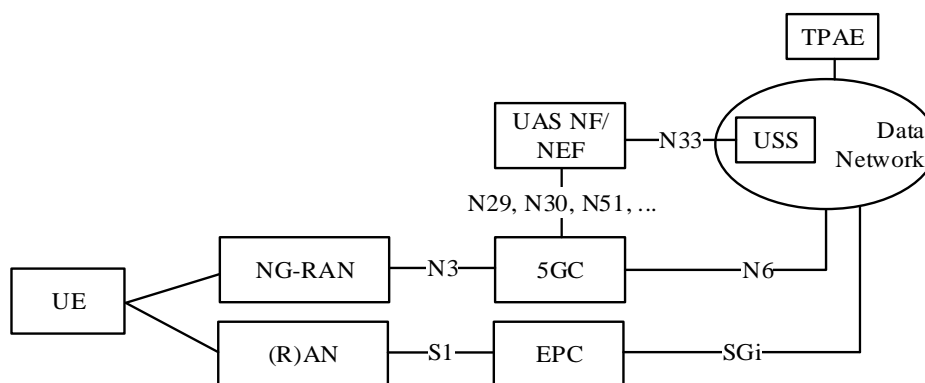
810049	<b>Remote Identification of Uncrewed Aerial Systems</b>	ID_UAS		SP-180771	Eddy HALL, Qualcomm
810013	<b>Stage 1 of Remote Identification of Uncrewed Aerial Systems</b>	ID_UAS	S1	SP-180771	Eddy HALL, Qualcomm
900014	<b>(Stage 2 of) Support of Uncrewed Aerial Systems Connectivity, Identification, and Tracking</b>	ID_UAS	S2	SP-200979	Faccin, Stefano, Qualcomm
910017	<b>CT aspects for ID_UAS</b>	ID_UAS	ct	CP-211112	Sunghoon Kim, Qualcomm
910069	CT1 aspects for ID_UAS	ID_UAS	C1	CP-211112	Sunghoon Kim, Qualcomm
910070	CT3 aspects for ID_UAS	ID_UAS	C3	CP-211112	Sunghoon Kim, Qualcomm
910071	CT4 aspects for ID_UAS	ID_UAS	C4	CP-211112	Sunghoon Kim, Qualcomm
920028	<b>Security aspects of Uncrewed Aerial Systems</b>	ID_UAS	S3	SP-210425	Escott, Adrian, Qualcomm

Summary based on the input provided by Qualcomm in SP-220619.

The work on Remote Identification of Uncrewed Aerial Systems (UAS) includes a set of 5GS enhancements aiming at supporting aviation industry needs for remote identification, tracking and authorization of Uncrewed Aerial Vehicles (UAVs) operating via the 3GPP system. Besides stage-1/2 requirements and principles, main stage-3 enhancements relate to Core Network and NAS.

High-level service requirements for remote UAS identification are described in [1].

Key functions of the 3GPP architecture for UAS are depicted in the following figure (where the UE is assumed to be part, or on board, of a UAV):



**Figure 1: High-level System architecture for UAS**

The main architectural and protocol functionalities, added to the stage-2&3 specifications, include the following ([2] - [10]):

#### UAV remote identification:

The CAA (Civil Aviation Administration)-Level UAV ID is introduced in the 3GPP system, which allows any entity receiving the identity (e.g. with means outside the scope of 3GPP) to address the correct USS for retrieval of UAV information. It can be assigned by the USS with assistance from 3GPP system, e.g., whereby the USS delegates the role of "resolver" of the CAA-Level UAV ID to the UAS NF (Network Function within the 3GPP CN).

It is assumed that, during initial UAV's owner registration of the UAV with the USS (out of 3GPP scope), the CAA-level UAV ID is provided to the UAV and the aviation-level information (e.g. UAV serial number, pilot information, UAS operator, etc.) is provided to the USS.

#### UAV USS authentication and authorization (UUAA):

After a successful 3GPP authentication of the UE (using existing procedures for 3GPP primary authentication, e.g., with MNO credentials stored in the USIM), a specific/new UUAA procedure is defined, to enable the 3GPP Core Network to verify that the UAV has successfully registered with the USS. The procedure pivots on the CAA-Level UAV ID that is

used by the UAV to identify itself with the USS and be authenticated by the USS. In 5GS, this procedure can take place during the 3GPP registration, or during the establishment of a PDU session for UAS services; In EPS, the UUAA procedure takes place during PDN connection establishment. As part of UUAA, a generic container (Service-level-AA container) and a generic SM procedure for authentication/authorization purpose (Service-level-AA procedure) are defined, to exchange the UUAA authentication information between the UE and the USS; in addition, an API based authentication/authorization procedure is also specified. The details of the security material used for the UUAA are outside the scope of 3GPP and considered application layer.

#### C2 (Command and Control) communication authorization:

For C2 communication over cellular connectivity, consisting of a UAV user plane connection with the UAVC, authorization by the USS is required to enable such traffic, including authorization for pairing of the UAV with a UAVC, as well as optional flight authorization for the UAV (performed by the USS). To support this, NAS PDU session establishment and modification procedures have been extended, to enable inclusion of the CAA-level UAV ID and other application layer authorization information in the Service-level-AA container.

#### UAV location reporting and tracking

UAV location reporting and tracking is specified by mostly re-using the existing location procedures. Different UAV tracking modes have been defined, e.g. where the USS can be notified of the location of a UAV, a UAV moving in/out of a given geographic area, or a list of UAVs in given geographic area.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810049,810013,900014,910017,910069,910070,910071,920028>

- |      |  |
|------|--|
| [1]  | TS 22.125: "Uncrewed Aerial System (UAS) support in 3GPP"  |
| [2]  | TS 23.256: "Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2"                  |
| [3]  | TS 23.501: "System architecture for the 5G System (5GS)"   |
| [4]  | TS 23.502: "Procedures for the 5G System (5GS)"  |
| [5]  | TS 24.501: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3"                        |
| [6]  | TS 24.008: "Mobile radio interface Layer 3 specification; Core network protocols; Stage 3"                     |
| [7]  | TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3"                                     |
| [8]  | TS 29.255: "5G System; Uncrewed Aerial System Service Supplier (USS) Services; Stage 3"                        |
| [9]  | TS 29.256: "5G System; Uncrewed Aerial Systems Network Function (UAS-NF); Aerial Management Services; Stage 3" |
| [10] | TS 33.256: "Security aspects of Uncrewed Aerial Systems (UAS)"   |

## 6.3.4 Media production, professional video and Multicast-Broadcast

### 6.3.4.1 Communication for Critical Medical Applications

840047	Communication Service Requirements for Critical Medical Applications	CMED		SP-190306	Lagrange, Mathieu, b<>com
810016	Study on CMED	FS_CMED	S1	SP-180783	Mathieu Lagrange, b<>com
840033	Stage 1 of CMED	CMED	S1	SP-190306	Lagrange, Mathieu, b<>com

Summary based on the input provided by b<>com in SP-220652.

This WI aims at defining 5G communication services requirements for critical medical applications, e.g. medical applications targeting the delivery of serious care to patients, such as:

- Image Assisted Surgery inside hybrid operating rooms equipped with high quality and augmented imaging systems
- Robotic Aided Surgery inside hybrid operating rooms or in remote medical facilities
- Tele-diagnosis and patient vital-signal monitoring in ambulances, hospitals, or remote healthcare facilities

The generated requirements cover network dependability, performances, medical data confidentiality and integrity, network auditability (to demonstrate to regulators that patient safety and privacy is maintained), and more generally specific 5G functionalities.

During the work, it has been detected that due to the very specific nature of the targeted vertical, several performance requirements look out of reach for current technology. For example, surgeons pay a lot of attention to video quality (very high resolution, frame rates, ...) and repeatedly ask for non-compressed video streams to avoid artifacts and to lower application latencies during non-invasive surgery. This led to very stringent data rate requirements (several dozen or higher Gbps in some identified use cases).



Interestingly, it has been noted that some of the requirements covered as part of CMED are similar to those generated by VIAPA (video, imaging, and audio for professional applications) and this has led to a joint specification for the two work items. For VIAPA, see section "Enhanced support of Non-Public Networks".

Beside SA1, no specific stage 2 nor stage 3 work could be carried out in 3GPP downstream groups as key performance requirements (bitrate, latency, ...) were felt too stringent for current technology generation.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840047,810016,840033>

- [1] TR 22.826: "Study on Communication Services for Critical Medical Applications"
- [2] TS 22.104: "Service requirements for cyber-physical control applications in vertical domains"
- [3] TS 22.261: "Service requirements for the 5G system"
- [4] TS 22.263: "Service requirements for video, imaging and audio for professional applications (VIAPA)"

### 6.3.4.2 Audio-Visual Service Production

UID	Name	Acronym	WG	WID	WI rapporteur name/company
840045	Audio-Visual Service Production	AVPROD		SP-190304	Wagdin, Ian, BBC
800014	Study on AVPROD	FS_AVPROD	S1	SP-181015	Roland Beutler, EBU
840031	Stage 1 of AVPROD	AVPROD	S1	SP-191041	Wagdin, Ian, BBC
910001	Study on Media Production over 5G NPN	FS_NPN4AVProd	S4	SP-210241	Lohmar, Thorsten, Ericsson

#### SA1 part: Audio-Visual Service Production (AVPROD)

Summary based on the input provided by BBC in xP-22xxxx.

AVPROD looks at applications for Programme Making and Special Events (PMSE) and use cases for media production.

It looks specifically at PMSE use cases and VIAPA (Video Imaging and Audio for Professional Applications) expands this to include areas such as medical and gaming.

The documents introduce requirements related to professional video, imaging and audio services. Unlike other consumer multimedia applications envisioned for 3GPP systems, the applications in which this document focuses have more demanding performance targets and includes user devices that are managed in different workflows when compared to typical UEs.

This can be divided into two main categories: contribution and production.

- Contribution links are heavily compressed and have lower latency requirements and are used for newsgathering and other programme items. They are currently serviced by satellite or bonded cellular and use the PLMNs
- Production links have higher bandwidth, due to less compression, and challenging latency requirements as well as strict Quality of Service metrics to ensure reliability.

The key parameters for these applications are:

**System latency.** In video production, overall system latency is referred to as imaging system latency and has an impact on the timing of synchronized cameras. For audio applications, overall system latency is referred to as mouth to ear latency and it is critical to maintain lip sync and avoid a performer to be put off by hearing their own echo. Finally, in medical applications the system latency impairs the achievable precision at a given gesture speed as it translates the time needed to traverse the whole imaging system into a geometrical error of the instruments position.

**Bandwidth.** Video and imaging applications have extremely high uplink bandwidth requirements and while compression may be used to mitigate this in certain user cases it often degrades the picture to the extent onward processing required by some applications is compromised. For Video Production certain standards have been determined which indicate the maximum allowable compression for a given type of production. In medical imaging, compression may introduce artefacts which can impact on diagnosis of critical illness and may also introduce additional delays which, in image assisted surgery, translate into misalignment between perceived instruments position on screen and their real position into patients' body.



**Quality of Service.** For Video Production certain standards have been determined which indicate the maximum allowable compression for a given type of production. In medical imaging, compression may introduce artefacts which can impact on diagnosis of critical illness and may also introduce additional delays which, in image assisted surgery, translate into misalignment between perceived instruments position on screen and their real position into patients' body.

**VIAPA** also highlights service aspects for Non-Public networks, clock synchronization, Network exposure, service continuity and multi-network connectivity.

Performance requirements are defined for all applications.

There are no specific Stage 2/3 works needed after the Stage 1 requirements, but work has continued in SA4 with the study item on NPNs for media production.

#### **SA4 part: Study on Media Production over 5G NPN**

Summary based on the input provided by Ericsson in SP-220650.

The media production industry uses its own set of codecs, protocols and procedures for IP-based media production. These protocols are (often) targeting dedicated networks installed at a production facility or at a temporary location, which allow transmission of either uncompressed or compressed video at high quality. For the orchestration and configuration of an IP-based media production setup, different solutions are defined.

There are cases for which the Media Producer may own their own 5G Network. There are other cases for which the media producer collaborates with a 5G Network operator to support media production events and services. Different collaboration scenarios require different means to establish 5G-based media production connectivity.

In deployments, 5G Systems including NPNs may have to be tailored to the needs of each industry vertical and the target use-case in question. The Media Production vertical may want to use the 5G System for different purposes, primarily for sending video and audio from remote locations to a central production studio, but also for return video, tally, talkback, remote device control (connectivity configuration, but also operational control of specialist UE). One aim of the study would be to identify how (in technical terms) media production can beneficially use 5G systems for media production.

TR 26.805 [4] documents the findings of the Study on Media Production over 5G NPNs. The document contains an elaborative description on different protocols and workflows used in media production at the time of writing. Several different standardization and industry fora are defining Ethernet- and IP-based protocols for media production purposes.

While the study has not identified an urgent technical area for standardisation at this point in time, a number of practical guidelines for implementers are identified and documented in the Technical Report. Those are intended to support media production device manufactures and media producers to leverage different 3GPP features for their purposes.

These guidelines may be further promoted and expanded, and more specific aspects are likely worthwhile to be defined. Communication with external organizations such as 5G-MAG is recommended in order to identify if they would follow up on those guidelines to support media production device manufactures and media producers to leverage different 3GPP features for their purposes.

#### **References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840045,800014,840031,910001>

- [1] TR 22.827: "Study on Audio Visual Service Production (AVPROD)"
- [2] TS 22.263: "System requirements for video, imaging and audio for professional applications (VIAPA)"
- [3] TS 26.805 : "Study on Media Production over 5G NPN systems"
- [4] TS 26.805: "Study on Media Production over 5G NPN Systems"

### **6.3.4.3 Multicast-Broadcast Services (MBS)**

#### **6.3.4.3.1 Multicast-broadcast services in 5G**

UID	Name	Acronym	WG	WID	WI rapporteur name/company
900038	<b>Multicast-broadcast services in 5G</b>	<b>5MBS</b>		<b>SP-201106</b>	<b>Meng Li, Huawei</b>
830030	Study on Architectural enhancements for 5G multicast-broadcast services	FS_5MBS	S2	SP-200690	Meng Li, Huawei

900009	Stage 2 for 5MBS	5MBS	S2	SP-201106	Meng Li, Huawei
920043	CT1 aspects of 5MBS	5MBS	C1	CP-212022	Gulbani, Giorgi, Huawei
920044	CT3 aspects of 5MBS	5MBS	C3	CP-212022	Gulbani, Giorgi, Huawei
910002	CT4 aspects of 5MBS	5MBS	C4	CP-212022	Gulbani, Giorgi, Huawei

Summary based on the input provided by Huawei, HiSilicon in SP-220587.

5G multicast and broadcast service specifies architectural enhancements to the 5G system using NR to support multicast and broadcast communication services; encompasses support for functions such as how to deliver multicast and broadcast communications including support within certain location areas, mobility, MBS session management and QoS; and covers interworking with E-UTRAN and EPC based eMBMS for Public Safety (e.g. MCX services).

The WI is linked to the RAN WI on NR Multicast and Broadcast Services [2].

As documented in TS 23.247 [3], the following features for 5G multicast and broadcast service are specified:

- **Architectural enhancement.** MBS Architecture defined in TS 23.247 [3] follows the 5G System architectural principles, enabling distribution of the MBS data from the 5GS ingress to NG-RAN node(s) and then to the UE.
- **QoS model** and parameters as defined in TS 23.501 [4] also apply to multicast/broadcast communication services with several differences documented in TS 23.247 [3]. **The policy and charging control framework** as defined in TS 23.503 [5] applies to Multicast and Broadcast services, i.e., for MBS Session binding, QoS Flow binding, PCC rules for MBS Session, and Policy information.
- **5GC Individual MBS traffic delivery** is for multicast only, and in which 5GC receives a single copy of multicast packets and delivers separate copies of those multicast packets to individual UEs via per-UE PDU sessions, hence for each such UE one PDU session is required to be associated with a Multicast MBS Session. **5GC Shared MBS traffic delivery** can be used for multicast and broadcast, and in which 5GC receives a single copy of MBS data packets and delivers a single copy of those MBS data packets to a RAN node. See following Figure 1 for details.

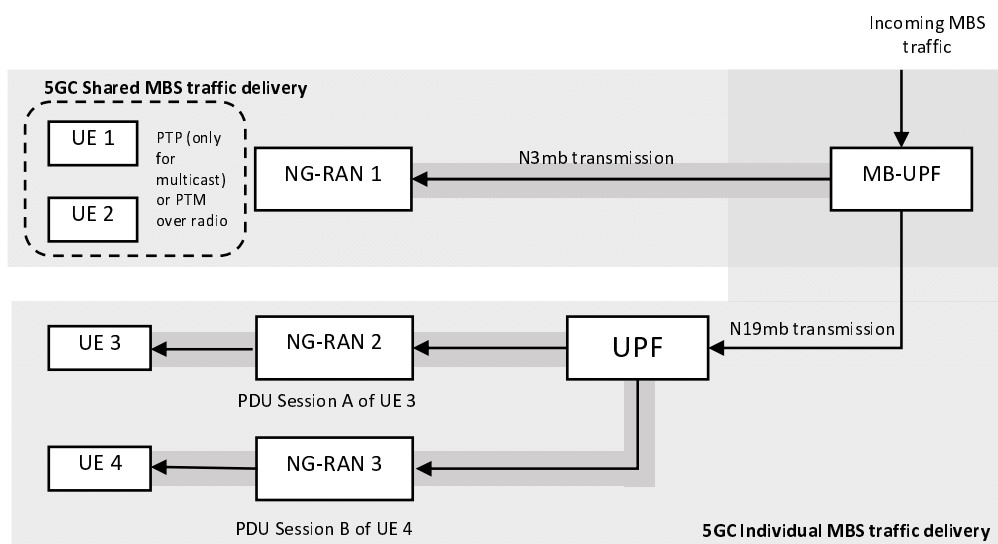


Figure 1: User plane data transmission example

- 5GC should **authorize the AF** for delivering MBS data to the 5GC and/or interacting with the 5GC. NEF perform authorization to the external AF for determination of whether the interaction with the 5GC is allowed or not.
- **Multicast communication service.** It aims at providing the same service and same specific content data to a dedicated set of UEs. The following characteristics for multicast are included in the WI.
  - For Multicast MBS session, 5GC **authorizes the UE** based on the MBS subscription data, based on MBS subscription data of the UE, and the MBS session information.
  - **Local multicast** service is the multicast MBS service limited in a certain MBS service area, and it is enforced by NG-RAN node and 5GC. A location dependent multicast service is an MBS service provided in several MBS service area(s), when UE moves to a new MBS service area, content data from the new MBS service area shall be delivered to the UE, and the network ceases to deliver the content data from the old MBS service areas to the UE.
  - **Mobility support of MBS service.** UE may move from one NG-RAN node to another NG-RAN node after UE has joined the MB Session. To minimize the data loss of the UE during the handover procedure, multicast MBS session data may be forwarded from source NG-RAN node to target NG-RAN node.
  - **Session activation and deactivation.** The MBS Session activation procedure is used for activating the resources for MBS data at NG-RAN node. The MBS Session deactivation procedure is used for deactivating the resources for

MBS data at NG-RAN node. Resources can be efficiently used by a proper control of session activation/deactivation.

- **Broadcast communication service.** It is to provide the same service and the same specific content data are provided simultaneously to all UEs in a geographical area. For Location dependent broadcast service, it is similar as the one for multicast.
- **Inter-system mobility with interworking at service layer.** In order to minimize the interruption of services, upon mobility for MBS service from NR/5GC to E-UTRAN/EPC and vice versa, the interworking is supported at service layer.
- **Security for multicast/broadcast service.** As defined in TS 33.501 [6], control-plane procedure and user-plane procedure are optionally supported in service layer for security protection of MBS traffic. The user plane security between UE and RAN shall be deactivated when 5GC shared MBS traffic delivery method for MBS data transmission is used to avoid redundant protection.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900038,830030,900009,920043,920044,910002>

- [1] SP-201106, New WID: Architectural enhancements for 5G multicast-broadcast services, Huawei, CBN;
- [2] RP-220428, WID revision: NR Multicast and Broadcast Services, Huawei, HiSilicon, CBN;
- [3] TS 23.247, "Architectural enhancements for 5G multicast-broadcast services".
- [4] TS 23.501, "System architecture for the 5G System (5GS)".
- [5] TS 23.503, "Policy and charging control framework for the 5G System (5GS)".
- [6] TS 33.501, "Security architecture and procedures for 5G system".

### 6.3.4.3.2 NR multicast and broadcast services

860048	<a href="#">NR multicast and broadcast services</a>	NR_MBS	R2	RP-220428	Huawei
860148	Core part: NR multicast and broadcast services	NR_MBS-Core	R2	RP-220428	Huawei

Summary based on the input provided by Huawei, HiSilicon in RP-220408.

This Rel-17 NR MBS WI specifies two delivery modes, i.e. MBS multicast and MBS broadcast, for services of PTM (Point-To-Multipoint) nature, such as for example public safety and mission critical services, V2X applications, IPTV, live video, software delivery over wireless and IoT applications.

Before introducing NR MBS, there was no broadcast/multicast transmission supported in NR for user data delivery. Services of PTM nature could only be delivered over NR based on unicast, which is inefficient, in particular from radio resources utilization point of view. Nevertheless, for the use cases mentioned above, broadcast/multicast transmission provides substantial benefits, especially in terms of system efficiency and user experience. The MBS multicast delivery mode is capable of addressing higher QoS services while the MBS broadcast delivery mode is focusing on lower QoS services.

The objectives of NR MBS WI are included in [2], and the WI is linked to the SA2 WI on Architectural enhancements for 5G multicast-broadcast services [3].

**MBS Multicast:** MBS multicast provides the MBS delivery mode for RRC\_CONNECTED mode UEs, with the following characteristics:

**Group scheduling:** A common frequency resource (CFR) is defined for multicast scheduling as an 'MBS frequency region' with a number of contiguous PRBs, which is configured within the dedicated unicast BWP. A group of UEs can be configured via RRC signalling with a G-RNTI for group scheduling, and the group of UEs can also be configured with downlink SPS and G-CS-RNTI for MBS multicast. The gNB schedules a transport block using G-RNTI (or G-CS-RNTI) to the group of UEs.

**HARQ feedback:** HARQ feedback is used to further improve the group scheduling efficiency, and the following two HARQ feedback reporting modes are supported:

- In the first HARQ feedback reporting mode, the UE transmits a PUCCH with HARQ-ACK information if the UE has correctly received the transport block or HARQ-NACK value if the UE has not correctly received the transport block.

- For the second HARQ feedback reporting mode, the UE transmits a PUCCH with HARQ-NACK information only if the UE has not correctly received the transport block.

HARQ reporting for multicast can also be disabled for a UE either semi-statically or dynamically.

Dynamic PTP (Point-To-Point)/PTM switch for MBS multicast

It is not always efficient for a gNB to schedule data based on G-RNTI (PTM), and sometimes PTP based scheduling (same as unicast) can bring more benefits thanks to the advanced unicast mechanisms. Based on the common PDCP entity, the gNB can decide whether to use PTM or PTP to deliver data of an MBS multicast session to the UE(s) at a certain time. The gNB makes its decision based on information such as MBS Session QoS requirements, the number of jointly scheduled UEs, UE feedback on link quality, and other criteria and ensures QoS requirements to be met for the service regardless of the chosen transmission method.

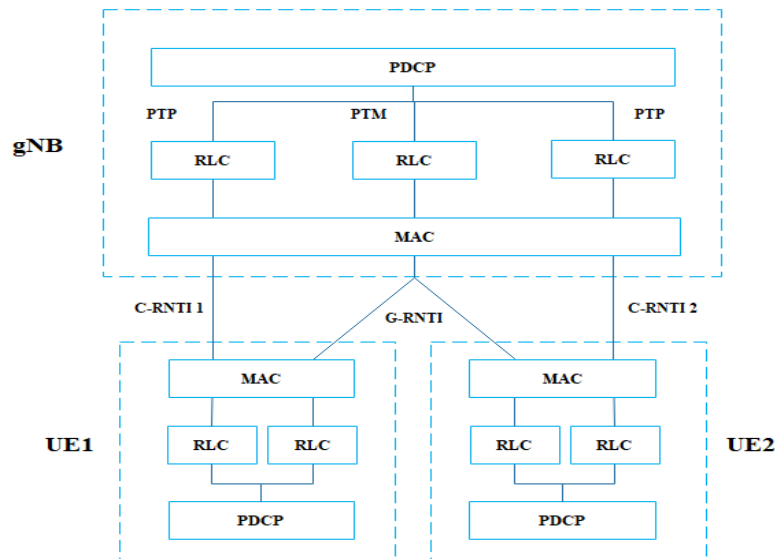


Figure 1: Dynamic PTP/PTM switch for MBS multicast

**Lossless handover for MBS multicast:** To support high QoS services, it is necessary to ensure lossless data delivery also during a handover. To enable lossless handover, synchronisation of PDCP SNs among source and target RAN nodes should be ensured, by either or a combination of the following methods:

- Derivation of the PDCP SNs from DL MBS QFI SNs provided on NG-U;
- Deployment of a Shared NG-U Termination at NG-RAN, shared among gNBs, which comprises a common entity for assignment of PDCP SNs.

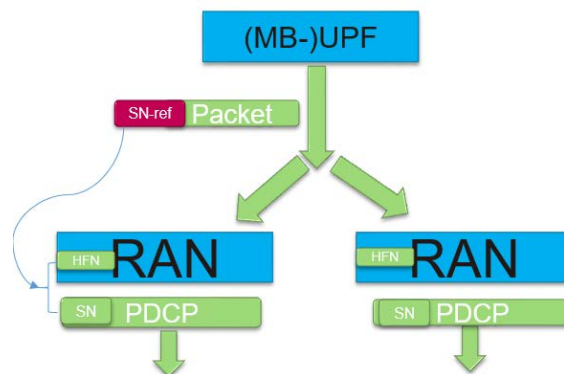


Figure 2: PDCP SN synchronization to enable lossless

**MBS Broadcast:** MBS broadcast provides the downlink only MBS delivery mode for UE in all RRC states, addressing lower QoS services, with the following characteristics:

**Group scheduling:** A common frequency resource (CFR) is defined for broadcast scheduling as an 'MBS frequency region' with a number of contiguous PRBs in which G-RNTI can be used to schedule the associated MBS broadcast service. The bandwidth of CFR can be equal to or larger than initial BWP, which is indicated by system information. HARQ feedback and HARQ re-transmission is not supported for MBS broadcast.

**MBS broadcast Configuration:** The UE can receive the MBS configuration for a broadcast service via a broadcast control channel, i.e. MCCH, which is the same for UEs in RRC\_IDLE, RRC\_INACTIVE and RRC\_CONNECTED states.

**Service continuity:** Lossless mobility cannot be ensured for MBS broadcast, but some mechanisms are specified to support service continuity of the broadcast service. NR MBS broadcast supports MBS frequency prioritization, which enables the UE in RRC\_IDLE/RRC\_INACTIVE to select the right frequency to camp on and receive its services of interest.

To ensure service continuity of MBS broadcast for UEs in RRC\_CONNECTED, the UE can send MBS Interest Indication to the gNB and the gNB can configure the UE in a way allowing it to receive the services the UE is interested in using MBS broadcast.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860048,860148>

- [1] RP-220407, Status report for WI NR Multicast and Broadcast Services, Huawei, HiSilicon;
- [2] TS 33.180: "Security of the Mission Critical (MC) service; (Release 17)"

### 6.3.4.3.3 5G multicast and broadcast services

940008	5G multicast and broadcast services	5MBP3	S4	SP-211335	Qualcomm
--------	-------------------------------------	-------	----	-----------	----------

Summary based on the input provided by Qualcomm in SP-220636.

The 5G MBS User Services had been developed by SA4 within the 5MBUSA Work Item, and the stage 2 architecture and procedures are documented in TS 26.502 [2]. In addition, architectural extensions to the delivery of 5GMS via eMBMS had been documented TS 26.501 [3] as part of the 5MBUSA work item. This work item now addresses relevant stage-3 specifications for 5MBS and 5GMS via eMBMS as follows:

1. Stage 3 format and protocol for User Service Announcement (between MBSF and MBS Client) are specified in a new specification TS 26.517 [4], addressing reference point M5.
2. Stage 3 protocols for the MBS distribution methods (between MBSTF and MBS Client) based on existing MBMS delivery methods are specified, addressing reference point M4, namely
  - Object distribution methods, based on download delivery methods defined in MBMS with reference to TS 26.346 [6].
  - Packet distribution methods, based on transparent delivery methods with reference to TS 26.346 [6].
3. Relevant extensions to TS 26.512 [5], TS 26.346 [6], TS 26.347 [7] and TS 26.348 [8] to support 5G Media Streaming via eMBMS.

Continuous exchange, in particular with RAN2, SA2, SA3, SA6, CT3 and CT4, was needed. Additional aspects are expected to be addressed in Rel-18 follow-up work items.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940008>

- [1] Tdoc SP-211335, Work Item on "5G Multicast-Broadcast Protocols"
- [2] TS 26.502, "5G Multicast-Broadcast User Service Architecture"
- [3] TS 26.501, "5G Media Streaming (5GMS); General description and architecture"
- [4] TS 26.517, "5G Multicast-Broadcast User Services; Protocols and Formats"
- [5] TS 26.512, "5G Media Streaming (5GMS); Protocols."
- [6] TS 26.346, "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs"
- [7] TS 26.347, "Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL"

- [8] TS 26.348, "Northbound Application Programming Interface (API) for Multimedia Broadcast/Multicast Service (MBMS) at the xMB reference point"

#### 6.3.4.3.4 Security Aspects of Enhancements for 5G MBS

920023	<b>Security Aspects of Enhancements for 5G Multicast-Broadcast Services</b>	5MBS	S3	SP-210420	Longhua Guo, Huawei Technologies
--------	---	------	----	-----------	----------------------------------

No summary provided for this work item.

#### 6.3.4.4 Study on Multicast Architecture Enhancements for 5G Media Streaming

870014	<a href="#">Study on Multicast Architecture Enhancements for 5G Media Streaming</a>	FS_5GMS_Multicast	S4	SP-200238	Peng Tan, Telus
--------	---	-------------------	----	-----------	-----------------

Summary based on the input provided by TELUS in SP-220646.

This Study is about potential architecture enhancement to enable 5G multicast-broadcast media streaming. It further provides recommendations for normative specification work on a generic 5G MBS User Service Architecture.

Note: Standalone Studies (i.e. without corresponding normative work) are usually not reported in this document. An exception has been made for this study.

The following key issues are studied in this work item:

- Support of Multicast ABR in 5G Media Streaming Architecture
- Nmb2 Design Considerations
- Collaboration and Deployment Scenarios
- Reuse of MBMS Service Layer
- Client Architecture Options
- Hybrid Services
- 5GMS via eMBMS

This study concludes that functional entities for a generic 5G MBS User Service Architecture are determined to be defined in normative specification TS 26.502 [2] to support 5G Multicast-Broadcast applications. It presents a complete service offering to an end-user, via a set of APIs that allows the MBS Client to activate or deactivate reception of the service.

The 5MBS User Service architecture is independent of 5G Media Streaming (5GMS) and may or may not be used by 5GMS. 5G Multicast ABR media streaming service could be a User Service where the MBS User Services allow streaming of DASH content as defined in TS 26.501 [3], and it also includes the use of an MBS session to deliver the DASH segments in multicast. When delivering content to a MBS Client, the MBSTF uses one or more MBS Delivery Methods.

#### References

- [1] TR 26.802: "Multicast Architecture Enhancement for 5G Media Streaming"  
 [2] TS 26.502: "5G multicast-broadcast services, User Service architecture"  
 [3] TS 26.501: "5G Media Streaming (5GMS), General description and architecture"

#### 6.3.4.5 5G Multicast-Broadcast User Service Architecture and related 5GMS Extensions

920010	<a href="#">5G Multicast-Broadcast User Service Architecture and related 5GMS Extensions</a>	5MBUSA	S4	SP-210376	TAN, PENG, TELUS
--------	--	--------	----	-----------	------------------

Summary based on the input provided by TELUS in SP-221269.

This Work Item has resulted in a new specification TS 26.502 [1] entitled "5G multicast-broadcast services, User Service architecture" and in CRs to TS 26.501 [2], to support 5G Media Streaming (5GMS) via eMBMS.

TS 26.502 defines the stage 2 5G multicast-broadcast User Services architecture as follows:

1. An MBS User Services network architecture that defines how MBS-related entities are involved in providing MBS User Services delivery and control.
2. An MBS User Services reference architecture model that describes roles of the principal network and UE functions involved.



3. New reference points in order to support MBS User Services, including MBS 4 MC, MBS 4 UC, MBS 5, MBS 6, MBS 7, and MBS 8 beyond the existing reference points defined in TS 23.247 [3].
4. Two distribution methods for multicast/broadcast transport of objects and packets respectively.
5. User Services domain model and dynamic model with relevant parameters for reception reporting, ingestion and announcement.
6. Procedures for 5G Multicast-Broadcast User Services, including baseline procedures, and procedures for user services provisioning, advertisement/discovery, data transfer and data repair.
7. Network function services exposed by MBSF and MBSTF.
8. Informative annexes that documents deployment and collaboration models, Nmb8 User Plane ingest examples, and data model examples.

TS 26.501 further specifies the architecture to allow 5GMS-based downlink media streaming to be deployed as an MBMS-Aware Application on top of eMBMS as defined in TS 23.246 [4], TS 26.346 [5], TS 26.347 [6] and TS 26.348 [7]. The procedures for the following uses cases when 5GMS uses eMBMS for delivery are defined:

1. 5GMS content delivered exclusively via eMBMS.
2. 5GMS consumption reporting for eMBMS.
3. 5GMS metrics reporting procedures for eMBMS.
4. Procedures for hybrid 5GMS content delivery via 5G systems and eMBMS.
5. Procedures for dynamic provisioning of 5GMS content delivery via eMBMS.

Collaboration models for 5GMS via eMBMS are documented in an informative annex in TS 26.501 [2].

Stage 3 is covered by TS 26.517 [9], TS 26.512 [8], TS 26.346 [5], TS 26.347 [6] and TS 26.348 [7].

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920010>

- |     |  |
|-----|--|
| [1] | 3GPP TS 26.502: "5G multicast-broadcast services, User Service architecture".  |
| [2] | 3GPP TS 26.501: "5G Media streaming (5GMS); General description and architecture".   |
| [3] | 3GPP TS 23.247: "Architectural enhancements for 5G multicast-broadcast services".  |
| [4] | 3GPP TS 23.246: "Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description".  |
| [5] | 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".   |
| [6] | 3GPP TS 26.347: "Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL".  |
| [7] | 3GPP TS 26.348: "Northbound Application Programming Interface (API) for Multimedia Broadcast/Multicast Service (MBMS) at the xMB reference point". |
| [8] | 3GPP TS 26.512: "5G Media Streaming (5GMS); Protocols".  |
| [9] | 3GPP TS 26.517: "5G Multicast-Broadcast User Services; Protocols and Formats".   |

### 6.3.4.6 Other media and broadcast aspects

For Frequency bands for broadcast, see the section "New bands and bandwidth allocation for 5G terrestrial broadcast - part 1"

Other specific broadcasting aspects appear in the sections on "V2V" and on "MC".

For Other Media production, professional video aspects, see section on User Plane.

810055	<a href="#">Study on location enhancements for mission critical services</a>	FS_enhMCLoc	S6	SP-190725	Dom Lazara, Motorola Solutions
850040	<a href="#">Broadcast / Multicast requirements supporting Mission Critical Services in 5G</a>	5MBS_eMC	S1	SP-190942	Toobe, Jens, BDBOS
880006	<a href="#">Study on Security Aspects of Enhancements for 5G Multicast-Broadcast Services</a>	FS_5MBS_SEC	S3	SP-200351	Longhua Guo, Huawei Technologies
850035	<a href="#">Study on Mission Critical services over 5G multicast-broadcast system</a>	FS_MC5MBS	S6	SP-190929	Val Oprescu, AT&T
800023	<a href="#">Study on Mission Critical services support over 5G System</a>	FS_MCOVer5GS	S6	SP-200837	Verweij, Kees, The Police of the Netherlands

### 6.3.5 Asset Tracking for 5G

<b>850046</b>	<b><a href="#">Asset Tracking for 5G</a></b>	<b>ATRAC</b>		<b>SP-190816</b>	<b>Thierry Berisot, NOVAMINT</b>
810017	<a href="#">Study on ATRAC</a>	FS_5G_ATRAC	S1	SP-180922	Thierry Berisot, NOVAMINT
850037	<b><a href="#">Stage 1 of ATRAC</a></b>	ATRAC	S1	SP-190931	Thierry Berisot, NOVAMINT

Summary based on an input from Novamint.



This Study is about asset tracking use cases and identifies service requirements as well as new KPIs to be supported by 5G communication services for asset tracking.

Several significant use cases for Asset Tracking are described in this study item such as container, wagon, pallet. Some of these use cases and related requirements were also used as an input for REFEC (see corresponding section).

The requirements coming out from ATRAC to support low power IoT/mMTC type of communications with satellite access has been addressed on Stages 2 and 3 in study and work items on NB-IoT/eMTC support for Non-Terrestrial Networks (see corresponding section).

## 6.4 Other "verticals" aspects

820025	<a href="#">Study on application layer support for Factories of the Future in 5G network</a>	FS_FFAPP	S6	SP-200836	Shao Weixiang, ZTE Corporation
840025	<a href="#">Study on enhancement of support for 5G LAN-type service</a>	FS_5GLAN_enh	S2	SP-190626	Runze Zhou, Huawei

# 7 IoT, Industrial IoT, REDuced CAPacity UEs and URLLC

## 7.1 NR small data transmissions in INACTIVE state

860051	<a href="#">NR small data transmissions in INACTIVE state</a>	NR_SmallData_IN ACTIVE		RP-212594	ZTE
860151	Core part: NR small data transmissions in INACTIVE state	NR_SmallData_INACTIVE-Core	R2	RP-212594	ZTE
860251	Perf. part: NR small data transmissions in INACTIVE state	NR_SmallData_INACTIVE-Perf	R4	RP-212594	ZTE

Summary based on the input provided by ZTE Corporation, Sanechips in RP-220154.

This work item enables the transmission of small signalling and/or data packets whilst the UE remains in RRC\_INACTIVE state. Prior to Rel-17, NR supports RRC\_INACTIVE state and UEs with infrequent (periodic and/or non-periodic) data transmission are generally maintained by the network in the RRC\_INACTIVE state. Until Rel-16, the RRC\_INACTIVE state doesn't support data transmission. Hence, the UE has to resume the connection (i.e. move to RRC\_CONNECTED state) for any DL (MT) and UL (MO) data. Connection setup and subsequently release to INACTIVE state happens for each data transmission however small and infrequent the data packets are. This results in unnecessary power consumption and signalling overhead.

Some examples of small and infrequent data traffic include Smartphone applications such as: traffic from Instant Messaging services; Heart-beat/keep-alive traffic from IM/email clients and other apps; Push notifications from various applications. Other examples are non-smartphone applications such as: traffic from wearables (periodic positioning information etc); sensors (Industrial Wireless Sensor Networks transmitting temperature, pressure readings periodically or in an event triggered manner etc); smart meters and smart meter networks sending periodic meter readings.

As noted in TS 22.891, the NR system shall be efficient and flexible for low throughput short data bursts, support efficient signalling mechanisms (e.g. signalling is less than payload) and reduce signalling overhead in general.

Signalling overhead from INACTIVE state UEs for small data packets is a general problem and will become a critical issue with more UEs in NR not only for network performance and efficiency but also for the UE battery performance. In general, any device that has intermittent small data packets in INACTIVE state will benefit from enabling small data transmission in INACTIVE.

The key enablers for small data transmission in NR, namely the INACTIVE state, 2-step, 4-step RACH and configured grant type-1 have already been specified as part of Rel-15 and Rel-16. So, this work builds on these building blocks to enable small data transmission in INACTIVE state for NR.

The Small Data Transmission (SDT) feature allows data and/or signalling transmission while the UE remains in RRC\_INACTIVE (i.e. without transitioning to RRC\_CONNECTED state). SDT is enabled on a radio bearer basis and is initiated by the UE only if:

- less than a configured amount of UL data awaits transmission across all radio bearers for which SDT is enabled, and;
- the DL RSRP is above a configured threshold, and;
- a valid SDT resource (either RACH or Configured grant) is available

SDT procedure is initiated with either a transmission over RACH (referred to as RA-SDT) or over Type 1 CG resources (referred to as CG-SDT). The SDT resources can be configured on initial BWP (for both RACH and CG). RACH and CG resources for SDT can be configured on either or both of NUL and SUL carriers. The initial PUSCH transmission during the SDT procedure includes at least the CCCH message. While the SDT procedure is ongoing, if data appears in a buffer of any radio bearer not enabled for SDT, the UE initiates a transmission of a non-SDT data arrival indication using UE assistance information message to the network and, if available, includes the resume cause. The network may configure UE to apply ROHC continuity for SDT either when the UE initiates SDT in the cell where the UE received RRCRelease and transitioned to RRC\_INACTIVE state or when the UE initiates SDT in a cell of its RNA.

### Details of RA-SDT

For RA-SDT, the network may configure 2-step and/or 4-step RA resources. The UE in RRC\_INACTIVE initiates RACH and requests RRC resume together with UL SDT data/signalling. If the UE accesses a gNB other than the last serving gNB, the UL SDT data/signalling is buffered at the receiving gNB, and then the receiving gNB triggers the XnAP Retrieve UE Context procedure. RA-SDT is supported with and without UE context relocation and these two mechanisms as depicted in Figure 1 and Figure 2 below.

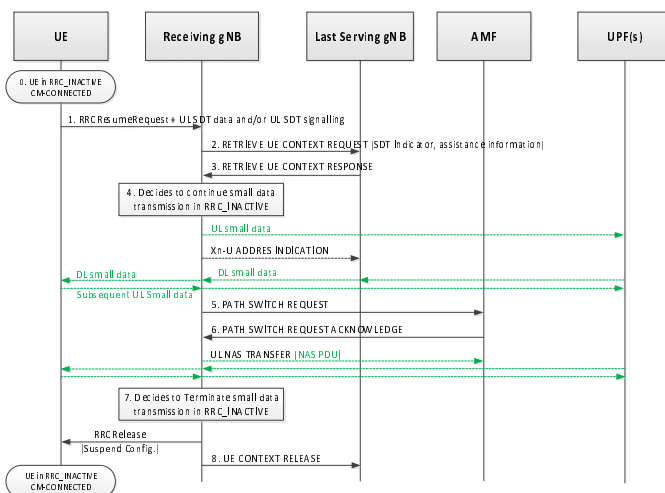


Figure 1: RA-SDT with UE context relocation

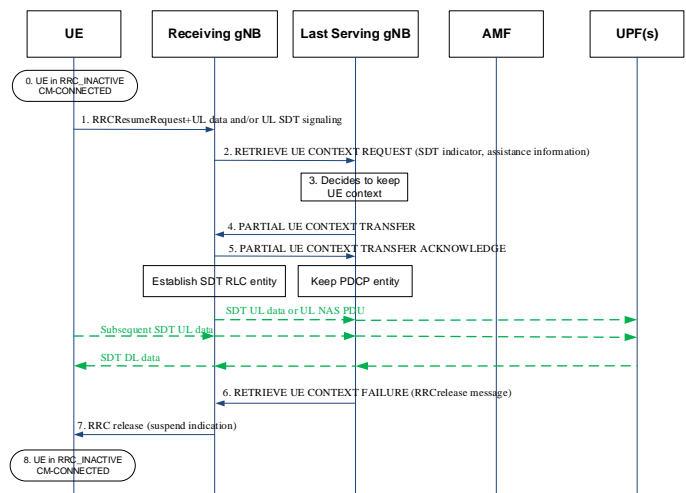


Figure 2: RA-SDT without UE context relocation

### Details of CG-SDT

The CG-SDT resources are valid only within the cell the UE receives the previous RRCRelease (i.e. only for the no cell change case). When using CG resources for initial SDT transmission, the UE can perform autonomous retransmission of the initial transmission if the UE does not receive confirmation from the network. The network can schedule subsequent UL transmissions using dynamic grants or they can take place on the following CG resource occasions. The DL transmissions are scheduled using dynamic assignments. The UE can initiate subsequent UL transmission only after reception of confirmation for the initial PUSCH transmission from the network. For subsequent UL transmission, the UE cannot initiate re-transmission over a CG-SDT resource. CG-SDT can only be initiated with valid UL timing alignment. The UL timing alignment is maintained by the UE based on a SDT-specific timing alignment timer configured by the network via dedicated signalling and, for initial CG-SDT transmission, also by DL RSRP of configured number of highest ranked SSBs which are above a configured RSRP threshold. Upon expiry of the SDT-specific timing alignment timer, the CG resources are released.

### References

List of related CRs:

select "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860051,860151,860251>

[1] RP-220153 Status Report TSG for WI: NR small data transmissions in INACTIVE state

## 7.2 Additional enhancements for NB-IoT and LTE-MTC

860044	<b>Additional enhancements for NB-IoT and LTE-MTC</b>	NB_IOTenh4_LTE_eMTC6		RP-211340	Huawei
860144	<b>Core part: Additional enhancements for NB-IoT and LTE-MTC</b>	NB_IOTenh4_LTE_eMTC6-Core	R1	RP-211340	Huawei
860244	<b>Perf. part: Additional enhancements for NB-IoT and LTE-MTC</b>	NB_IOTenh4_LTE_eMTC6-Perf	R4	RP-211340	Huawei

Summary based on the input provided by Huawei, HiSilicon in RP-220530.

This Rel-17 work item introduced additional enhancements for NB-IoT and LTE-MTC based on features standardized in Rel-13 and enhancements performed from Rel-14 through Rel-16. Rel-17 adds features such as 16QAM for NB-IoT in downlink and uplink, 14 HARQ processes in downlink for HD-FDD Cat. M1 UEs, NB-IoT neighbour cell measurement and triggering before RLF, NB-IoT carrier selection based on coverage level, and a maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs [1].

### 16-QAM for unicast in UL and DL for NB-IoT

From Rel-13 to Rel-16, an NB-IoT UE can use QPSK for unicast NPDSCH, and QPSK or BPSK for unicast NPUSCH.

This feature allows an NB-IoT UE to use 16-QAM for unicast NPDSCH with TBS up to 4968 bits for standalone and guard-band deployments and 3624 bits for in-band deployments; and allows an NB-IoT UE to use 16-QAM for unicast NPUSCH with TBS up to 2536 bits (which can be transmitted with up to half the time-domain resources with respect to QPSK). When 16-QAM for unicast NPDSCH is configured, an NB-IoT UE can report the channel quality report by reporting the recommended NPDCCH repetition and NPDSCH modulation and coding scheme.

### Additional PDSCH scheduling delay for 14-HARQ processes in DL for LTE-MTC

#subframe	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
MPDCCH	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9								M0	M1	M2	M3	M4	M5	M6	M7	M8	M9						
PDSCH	X	X	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9						X	X	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9				
PUCCH (ACK)															A0	A1	A2														A0	A1	A2

**Figure 1: PDSCH transmission with 10 HARQ processes for HD-FDD Cat. M1 UEs**

With 10 HARQ processes, a HD-FDD Cat. M1 UE cannot use all available downlink subframes to transmit PDSCH. As shown in Figure 1, the subframes #0, #1, #17, #18 cannot be scheduled to transmit PDSCH (as marked with an X).

This feature allows HD-FDD Cat. M1 UEs to use up to 14 HARQ processes in CE Mode A with an additional PDSCH scheduling delay to fully utilize the available BL/CE downlink and BL/CE uplink subframes, where the PDSCH scheduling delay can be indicated as 2 BL/CE DL subframes or a longer delay that consists of different subframe types. Two alternatives for the HARQ-ACK delay indication can be configured: either the HARQ-ACK delay consists of different subframe types, or the HARQ-ACK delay is indicated among sets of absolute subframes.

### Neighbour cell measurements and measurement triggering before RLF for NB-IoT

This feature introduces measurements in RRC\_CONNECTED for NB-IoT UEs to reduce the time taken for RRC connection reestablishment. The criteria to perform the measurements are signalled separately for intra- and inter-frequency measurements via broadcast signalling. Since dedicated measurements gaps are not supported, the UE may need to perform neighbour cell measurements during DL/UL idle periods that are provided by DRX or packet scheduling.

### Carrier selection based on coverage level for NB-IoT

This feature introduces coverage-based paging in NB-IoT to reduce the latency and the resource usage in the network.

When coverage-based paging is enabled, up to two groups of paging carriers can be configured for lower levels of coverage enhancements. The eNB configures the UE during RRC connection release to use one of these groups of paging carriers. If configured, the UE selects a paging carrier in its assigned group if its NRSRP is suitable according to the paging carrier configuration. Coverage based paging is only applicable in the last cell where the coverage information was received.

#### Maximum DL TBS of 1736 bits for eMTC

From Rel-13 to Rel-16, the max DL TBS size for LTE-MTC Cat. M1 UEs is 1000 bits.

This feature allows HD-FDD Cat. M1 UEs to use a DL TBS of up to 1736 bits in CE Mode A, and the soft channel bits for UE supporting this feature is 43008 bits.

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860044,860144,860244>

- [1] RP-220528 Status report for WI: Additional enhancements for NB-IoT and LTE-MTC;  
rapporteur: Huawei

## 7.3 Enhanced Industrial IoT and URLLC support for NR

860045	<b>Enhanced Industrial Internet of Things (IoT) and ultra-reliable and low latency communication (URLLC) support for NR</b>	NR_IIoT_URLLC_enh		RP-210854	Nokia
860145	<b>Core part: Enhanced IoT and URLLC support for NR</b>	NR_IIoT_URLLC_e nh-Core	R2	RP-210854	Nokia
860245	<b>Perf. Part: Enhanced IoT and URLLC support for NR</b>	NR_IIoT_URLLC_e nh-Perf	R4	RP-210854	Nokia

Summary based on the input provided by Nokia, Nokia Shanghai Bell in Nokia, Nokia Shanghai Bell.

In order to extend the NR applicability in various verticals with tight latency and reliability requirements, Release 16 IIoT work item has introduced transmission reliability enhancements for Time Sensitive Communications (TSC) and addressed efficiency of the system where UEs handle a mixture of URLLC and eMBB traffic. In TSG SA enhancements for the support TSC have been studied (see TR23.700-20) with normative work followed accordingly for Release 17. This Release 17 work item introduced the following enhancements in RAN:

**Physical Layer feedback enhancements for HARQ-ACK and CSI reporting:** For HARQ-ACK feedback enhancements, SPS HARQ-ACK deferral was introduced to prevent excessive SPS HARQ-ACK dropping for PUCCH on TDD cells. Besides, to reduce latency, PUCCH cell switching is supported between the PCell, PSCell, PUCCH-SCell and an additional PUCCH-sSCell for TDD cells. Furthermore, PUCCH repetition enhancements over multiple slots/subslots, HARQ-ACK codebook enhancements and triggered HARQ-ACK codebook retransmissions were introduced to improve the HARQ-ACK feedback reliability.

For CSI reporting, enhanced 4-bit sub-band CQI report with absolute values was introduced targeting URLLC services with high reliability requirements and tight latency constraints.

**Intra-UE multiplexing and prioritization of traffic with different priority:** To improve UL and DL efficiency and reduce PHY latency for high priority traffic, enhancements on intra-UE multiplexing and prioritization were introduced for overlapping dynamic grant and CG PUSCH of different PHY priorities, multiplexing HARQ-ACK on a PUCCH or PUSCH of a different PHY priority, and simultaneous PUCCH and PUSCH transmissions of different PHY priorities on different cells for inter-band carrier aggregation (CA).

**Uplink enhancements for URLLC in unlicensed controlled environments:** URLLC services can be supported in shared spectrum where LBT failures are assumed to be not frequent. For this scenario, semi-static channel occupancy initiated by the UE was introduced.

Besides, autonomous retransmissions for UL configured grant (CG) and enhanced intra-UE overlapping resource prioritization mechanisms may be enabled simultaneously to harmonize the NR-U and URLLC CG operation.

**Enhancements for support of time synchronization with propagation delay compensation:** To improve the absolute time synchronization accuracy of a UE being essential for Time-Sensitive Network (TSN)/TSC operation, two propagation delay compensation (PDC) enhancements are introduced to compensate for time synchronization errors

caused by the propagation delay between gNB and UE: PDC based on round-trip-time (RTT) measurements and PDC based on timing advance (TA), which can be performed at the UE or gNB side.

**RAN enhancements based on new QoS related parameter (survival time):** In addition to the TSC traffic characteristics introduced in Release 16 as TSC Assistance Information (TSCAI), the Core Network may provide survival time as part of the TSCAI to allow for efficient scheduling at the gNB while satisfying the performance requirements of periodic deterministic communication.

To support uplink periodic traffics of services with survival time requirement, configured grant resources can be used such that the mapping relation between the service and the configured grant is known to both gNB and UE. The gNB can use configured grant retransmission scheduling grant to trigger survival time state entry for a DRB which activates all the RLC entities configured for PDCP duplication of the corresponding DRB to prevent failure of subsequent messages.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860145>

- [1] RP-220151, Status report for WI Enhanced Industrial Internet of Things (IoT) and ultra-reliable and low latency communication (URLLC) support for NR; rapporteur: Nokia

## 7.4 Support of Enhanced Industrial IoT (IIoT)

UID	Name	Acronym	WG	WID	WI rapporteur name/company
850012	<a href="#">Study on enhanced support of Industrial IoT</a>	FS_IIoT	S2	SP-200298	Nokia, Devaki Chandramouli,
880010	<a href="#">Study on security for enhanced support of Industrial IoT</a>	FS_IIoT_SEC	S3	SP-200355	Nokia, Anja Jerichow
920024	<a href="#">Security for enhanced support of Industrial IoT</a>	IIoT_SEC	S3	SP-210421	Nokia, Anja Jerichow
<b>910059</b>	<b><a href="#">Support of Enhanced Industrial IIoT</a></b>	<b>IIoT</b>		<b>SP-200973</b>	<b>Devaki Chandramouli, Nokia</b>
900008	<b>Stage 2 for IIoT</b>	IIoT	S2	SP-200973	Devaki Chandramouli, Nokia
<b>910014</b>	<b>CT aspects of support of enhanced IIoT</b>	<b>IIoT</b>	<b>ct</b>	CP-212100	<b>Won, Sung Hwan, Nokia</b>
910060	CT1 aspects of support of enhanced IIoT	IIoT	C1	CP-212100	Won, Sung Hwan, Nokia
910061	CT3 aspects of support of enhanced IIoT	IIoT	C3	CP-212100	Won, Sung Hwan, Nokia
910062	CT4 aspects of support of enhanced IIoT	IIoT	C4	CP-212100	Won, Sung Hwan, Nokia

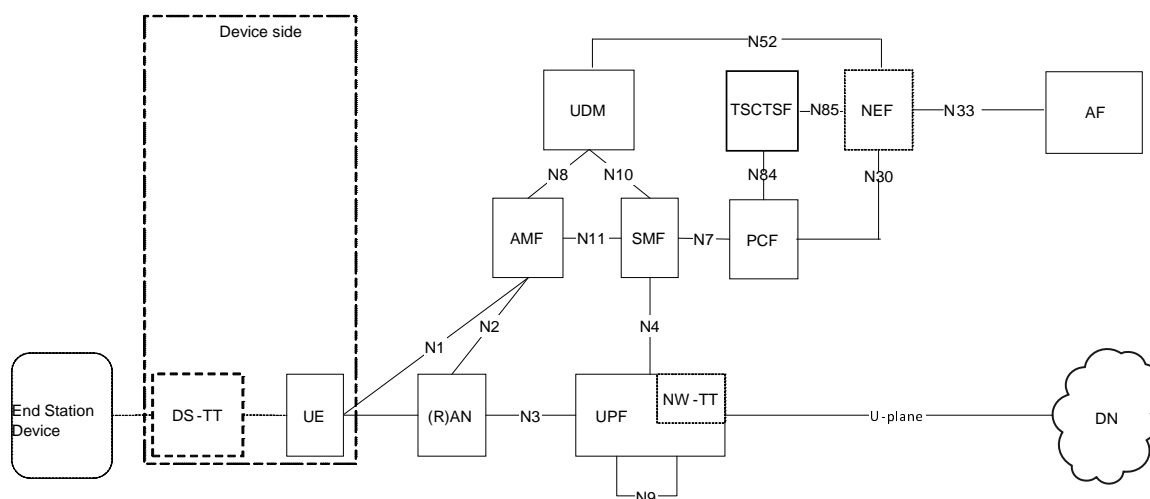
Summary based on the input provided by Nokia in SP-220425.

In Release 17, the 5G System expands the support for Time Synchronization and Time Sensitive communications for any application.

The 5G System architecture enables any Application Function (AF) - in the same or different trust domain - to provide its requirements for QoS, traffic characteristics for QoS scheduling optimization, time synchronization activation and deactivation.

If the AF is in a different trust domain from the 5G System, then it provides input via exposure framework, NEF API. If the AF is in the same trust domain as the 5G System, then it provides input directly via the Time Sensitive communication Time Synchronization function (TSCTSF).

The Functional Architecture is shown in the figure below:

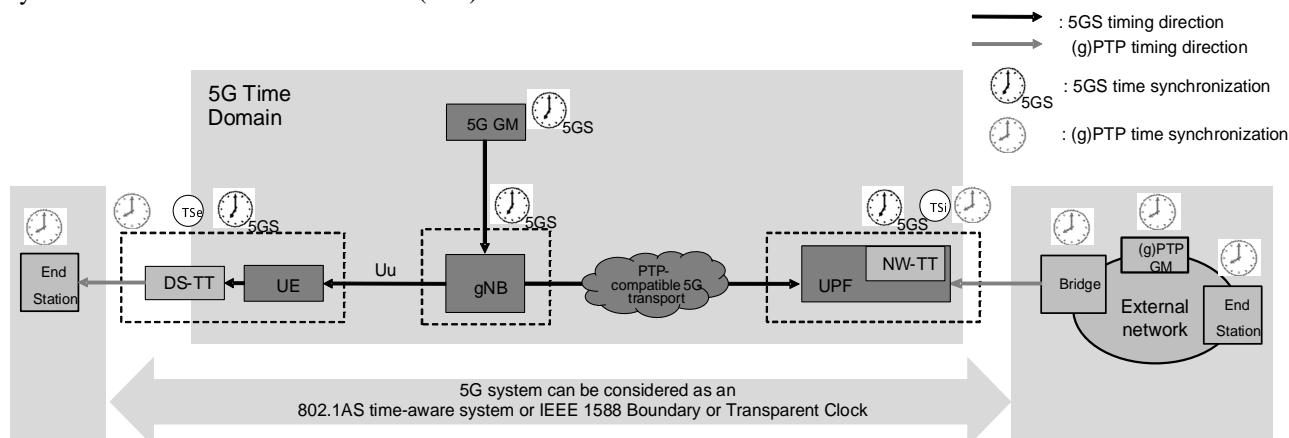


**Figure 1: Architecture to enable Time Sensitive Communication and Time Synchronization services**

The figure below depicts the two main synchronization methods supported: the 5GS synchronization and the (g)PTP domain synchronization.

- 5G Clock synchronization: Used for NG RAN synchronization and also distributed to the UE. 5G Clock synchronization over the radio interface towards the UE is specified in TS 38.331.
- (g)PTP synchronization: Provides time synchronization service to (g)PTP network. This process follows the standards IEEE Std 802.1AS or IEEE 1588 operation.

The two synchronization processes can be considered independent from each other and the gNB only needs to be synchronized to the 5G Grand Master (GM) clock.



**Figure 2: 5G system is modelled as PTP instance for supporting time synchronization**

In order to support (g)PtP time synchronization, the 5G System operates in any of the following modes:

1. as time-aware system (IEEE Std 802.1AS).
2. as Boundary Clock (IEEE Std 1588).
3. as peer-to-peer Transparent Clock (IEEE Std 1588).
4. as end-to-end Transparent Clock (IEEE Std 1588).

The 5GS shall be modelled as an IEEE Std 802.1AS or IEEE Std 1588 compliant entity based on the above configuration. The TTs located at the edge of the 5G system (i.e. device side DS-TT and network side NW-TT) are responsible for fulfilling functionalities related to IEEE Std 802.1AS or IEEE Std 1588.

The 5G System is provisioned by the profiles supported by 3GPP specifications that include: Default PTP Profile, IEEE Std 802.1AS PTP profile for transport of timing as defined in IEEE Std 802.1AS, SMPTE Profile for use of IEEE Std 1588 Precision Time Protocol in Professional Broadcast Applications.

Furthermore, (g)PtP time synchronization is supported for the scenarios when Grand Master clock is behind the UE (uplink time sync, UE – UE time sync) and behind the network (down link time sync).



The ability for the AF to influence activation of 5G reference time distribution to the UE(s) along with time synchronization error budget (based on the accuracy needed for the application) has also been introduced.

#### Time Sensitive Communication and QoS

TSC Assistance Information (TSCAI) describes traffic characteristics that may be provided for use by the gNB, to allow more efficiently scheduled radio resources for periodic traffic and applying to PDU session type Ethernet and IP.

TSCAI describes TSC traffic characteristics for use in the 5G System. The knowledge of TSC traffic pattern is useful for 5G-AN to allow it to more efficiently schedule periodic and deterministic traffic flows either via Configured Grants, Semi-Persistent Scheduling or with Dynamic Grants.

**Table 1: TSC Assistance Information (TSCAI)**

Assistance Information	Description
Flow Direction	The direction of the TSC flow (uplink or downlink).
Periodicity	It refers to the time period between start of two data bursts.
Burst Arrival Time (optional)	The latest possible time when the first packet of the data burst arrives at either the ingress of the RAN (downlink flow direction) or the egress interface of the UE (uplink flow direction).
Survival Time (optional)	Survival Time, as defined in TS 22.261 [2], is synonymous with the time period an application can survive without any data burst.

5GS determines TSC Assistance Container based on information provided by an AF/NEF and may provide it to PCF for IP type and Ethernet type PDU sessions.

The AF may provide the traffic pattern parameters such as Burst Arrival Time with reference to the ingress port, Periodicity, Flow Direction, Survival Time and Time domain to the NEF. The NEF forwards the received traffic pattern parameters to TSCTSF.

The AF trusted by the operator can be allowed to provide such traffic pattern parameters to TSCTSF directly. The TSCTSF is responsible for determining and forwarding these traffic pattern parameters in TSC Assistance Container to the SMF (via PCF).

Survival Time was also introduced as part of TSCAI in order for the AF to provide the time period an application can survive without any burst. It refers to the time that an application consuming a communication service may continue without an anticipated message. Maximum number of messages (message is equivalent to a burst) or in terms of time units. Single burst is expected within a single time period referred to as the periodicity.

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850012,880010,920024,910059,900008,910014,910060,910061,910062>

- [1] TS 23.501, System Architecture for 5G System; Stage 2 (clauses 4.4.8, 5.27, 5.28)
- [2] TS 23.502, Procedures for 5G System; Stage 2
- [3] TS 23.503, Policy and Charging Control Framework for the 5G System; Stage 2
- [4] For details of the IEEE work, go to: <https://1.ieee802.org/>

## 7.5 Support of reduced capability NR devices

900062	Support of reduced capability NR devices	NR_redcap		RP-211574	Ericsson
860035	Study on support of reduced capability NR devices	FS_NR_redcap	R1	RP-202704	Ericsson
900162	<b>Core part: NR_redcap</b>	NR_redcap-Core	R1	<b>RP-211574</b>	Ericsson
900262	<b>Perf. part: NR_redcap</b>	NR_redcap-Perf	R4	<b>RP-211574</b>	Ericsson
930018	<b>Architecture Enhancement for NR Reduced Capability Devices</b>	ARCH_NR_REDCAP	S2	SP-211100	Aihua Li, China Mobile
940005	CT1 aspects of NR_redcap	ARCH_NR_REDCAP	C1	CP-213081	Chen Xu, China Mobile
950047	CT3 aspects of NR_redcap	ARCH_NR_REDCAP	C3	CP-220304	Chen Xu, China Mobile
940100	CT4 aspects of NR_redcap	ARCH_NR_REDCAP	C4	CP-213081	Chen Xu, China Mobile
950044	CT6 aspects of NR_redcap	ARCH_NR_REDCAP	C6	CP-213081	Chen Xu, China Mobile
940027	Charging aspects of Architecture Enhancement for NR Reduced Capability Devices	ARCH_NR_REDCAP	S5	SP-211428	Dong Jia, China Mobile

Summary based on the input provided by Ericsson in RP-221163.



This Rel-17 work item introduces support for UE complexity reduction techniques and UE power saving techniques suitable for IoT use cases such as industrial wireless sensors, video surveillance, and wearables, with requirements on low UE complexity and/or low UE power consumption and with relatively relaxed data rate requirements. Following an initial study [1], this work item [2] specified support for a reduced capability (RedCap) UE type and two UE power saving techniques: Extended DRX in RRC idle/inactive state, and RRM measurement relaxation for neighbour cells.

The following key functionalities are introduced as part of this work item:

**Reduced capability (RedCap) UE type:** The new reduced capability (RedCap) UE type enables reduced UE complexity through various UE complexity reduction techniques. A RedCap UE supports a maximum UE Rx/Tx bandwidth of 20 MHz in FR1 and 100 MHz in FR2 (whereas a normal NR UE supports at least 100 MHz in FR1 and 200 MHz in FR2). A RedCap UE cannot support larger Rx/Tx UE bandwidths than 20 MHz in FR1 and 100 MHz in FR2, and it cannot support features related to carrier aggregation (CA), dual connectivity (DC), more than 2 UE Rx/Tx antenna branches, or more than 2 DL/UL MIMO layers.

A RedCap UE can furthermore have a reduced antenna configuration and a reduced number of DL MIMO layers:

- For FR1, a RedCap UE supports 1 or 2 UE Rx branches and 1 or 2 DL MIMO layers. The supported number of DL MIMO layers is the same as the implemented number of Rx branches, and as a result, 2-Rx RedCap UEs have twice as high DL peak rate as 1-Rx RedCap UEs. The UE indicates to gNB how many branches/layers it supports. The gNB can allow or disallow access from 1-Rx and 2-Rx RedCap UEs separately per cell.
- For FR2, a RedCap UE can either support a legacy UE power class such as PC3 or the new lower UE power class PC7 (with a reduced-complexity reference UE Rx/Tx antenna configuration with either 1 panel with 4 elements or 2 panels with 2 elements each, corresponding to half the number of array elements compared to a legacy PC3 UE). Furthermore, the UE indicates support for 1 or 2 DL MIMO layers (independent of the antenna configuration).

A RedCap UE in FDD mode can report per band whether it implements half-duplex FDD (HD-FDD) or full-duplex FDD (FD-FDD) support. In HD-FDD operation, the UE is not required to transmit and receive at the same time. The network indicates in SIB1 whether the cell supports HD-FDD RedCap UEs.

A RedCap UE can be implemented with or without support for DL 256QAM in FR1. Compared to 64QAM (which is mandatory for RedCap UEs), 256QAM support increases the peak data rate by ~33%. Support for UL 256QAM in FR1 and DL/UL 256QAM in FR2 is also optional for RedCap UEs, but this is true even for legacy NR UEs.

Some higher layer features are optional for RedCap UEs: RedCap UEs can optionally support 16 DRBs (as normal NR UEs) but only have mandatory support of 8 DRBs. RedCap UEs can optionally support 18-bit PDCP/RLC sequence numbers (as normal NR UEs) but only have mandatory support for 12-bit sequence numbers. RedCap UEs have optional (but not mandatory) support for automatic neighbour relation (ANR) functionality.

Due to the reduced UE bandwidth, there are some modifications of the bandwidth part (BWP) operation. Separate initial DL/UL BWPs can be configured for random access for RedCap UEs, which may be required if one or both of the ordinary initial DL/UL BWPs in the cell are configured with a bandwidth which is wider than the maximum RedCap UE bandwidth (i.e., wider than 20 MHz in FR1 or wider than 100 MHz in FR2). A separate initial DL BWP can, but does not need to, contain SSB/CORESET#0/SIB. A DL BWP used in connected mode needs to contain (cell-defining or non-cell-defining) SSB but not necessarily CORESET#0/SIB.

The UE provides an early indication already during random access that it is a RedCap UE. If RedCap-specific PRACH resources are configured in the cell, the early indication is provided implicitly already by Msg1. In any case, an indication will be provided in Msg3 (or MsgA in case of 2-step RACH) in the form of a RedCap-specific LCID value for CCCH.

To minimize UL resource fragmentation for other UEs, the network can choose to disable frequency hopping for the PUCCH transmission carrying HARQ-ACK feedback for Msg4 (similar to how PUCCH frequency hopping can be disabled in connected mode).

**Extended DRX in RRC idle/inactive state:** Extended DRX cycles are introduced for RRC idle state (up to 10485.76 seconds, i.e., roughly 3 hours) and RRC inactive state (up to 10.24 seconds) as an optional feature for both RedCap and non-RedCap UEs. For use cases with relatively relaxed requirements on DL reachability/latency, the network may configure an extended DRX cycle, which may reduce the UE power consumption substantially during periods with large enough packet inter-arrival time.

**RRM measurement relaxation for neighbour cells:** RRM measurement relaxation for neighbour cells is introduced as an optional feature for RedCap UEs that can be enabled by the network. In RRC idle/inactive states, to help reduce

UE power consumption, the UE is allowed to further relax neighbour-cell RRM measurements (compared to existing Rel-16 relaxation functionality) when an RSRP/RSRQ-based stationarity criterion is met for a period of time, or when both the stationarity criterion and a not-at-cell-edge criterion are met. In RRC connected state, the network may configure the RSRP/RSRQ-based stationarity criterion and in that case the UE shall report when the criterion is met or no longer met (and how to use the reporting information is up to the network implementation).

*Charging aspects (as per SP-220697 from China Mobile)*

SA2 have studied the architecture enhancement for NR RedCap and introduced the NR RedCap UEs differentiation requirement in clause 5.41 of TS 23.501[4]. Accordingly, CT3 and CT4 have specified a new RAT type NR RedCap. Based on the conclusion, SA5 mainly focus on the charging requirement of 'RedCap NR Devices' or 'devices using NR RedCap', which can be used by operators to charge differentially.

Stage 2 work on WI ARCH\_NR\_REDCAP for TS 32.255 [5], TS 32.256 [6] and TS 32.274 [7]: Add charging requirement for SMF, AMF and SMSF to support NR RedCap, providing for NR RedCap UE using NR the RAT Type NR\_REDCAP.

Stage 3 work on WI ARCH\_NR\_REDCAP for TS 32.298 [8]: Adding NR RedCap as a new RATType in CHF-CDR.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860035,900162,900262,930018,940005,950047,940100,950044,940027>

- |     |   |
|-----|---|
| [1] | TR 38.875 V17.0.0, "Study on support of reduced capability NR devices"  |
| [2] | RP-220966, "Revised WID on support of reduced capability NR devices"    |
| [3] | RP-221162, "Status report for support of reduced capability NR devices" |
| [4] | TS 23.501: "System architecture for the 5G System (5GS)"                |
| [5] | TS 32.255: "5G data connectivity domain charging"                       |
| [6] | TS 32.256: "5G connection and mobility domain charging"                 |
| [7] | TS 32.274: "Short Message Service (SMS) charging"                       |
| [8] | TS 32.298: "Charging Data Record (CDR) parameter description"           |

## 7.6 IoT and 5G access via Satellite/Non-Terrestrial (NTN) link

See the section "5G access via Satellite/Non-Terrestrial (NTN) link".

## 7.7 Charging enhancement for URLLC and CIoT

UID	Name	Acronym	WG	WID	WI rapporteur name/company
890020	<a href="#">Charging enhancement for URLLC</a>	5G URLLC	S5	SP-200769	Huawei, Chen Shan

Summary based on the input provided by Huawei in SP-220571

As per the TS 23.501 clause 5.33, the redundant transmission for high reliability communication to support Ultra Reliable Low Latency Communication (URLLC) is defined.

The WID 5G\_URLLC specifies the charging principle, charging requirements, service operations and charging information for URLLC service charging, including:

- For dual connectivity based end to end Redundant User Plane Paths, SMF shall collect and report the usage for each redundant PDU session.
- For redundant transmission at N3/N9 interface and transport layer, the SMF shall collect and report the usage not counting redundant packets.
- QoS Monitoring to assist URLLC Service are reported.

The corresponding Open API and ASN.1 for URLLC service charging are specified in the TS 32.291 and TS 32.298.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890020>

- |     |  |
|-----|--|
| [1] | TS 32.255: "Charging management; 5G Data connectivity domain charging; stage 2". |
| [2] | TS 32.291: "Charging management; 5G system; Charging service, stage 3".          |

[3] TS 32.298: "Charging management; Charging Data Record (CDR) parameter description".

UID	Name	Acronym	WG	WID	WI rapporteur name/company
940044	Charging enhancements for 5G CIoT	5G_CIoT_CH	S5	SP-211448	Zhu, Lei, Huawei

Summary based on the input provided by Huawei in SP-220573.

This WID provides some charging enhancements for the 5GS CIoT features specified e.g. in TS 23.501 and TS 23.502. This 5GS CIoT charging is specified in TS 32.255. The support 5GS and EPC interwork scenarios are considered, as well as the roaming scenario. The charging information and CDR content are described in TS 32.291 and TS 32.298.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940044>

## 7.8 Messaging in 5G

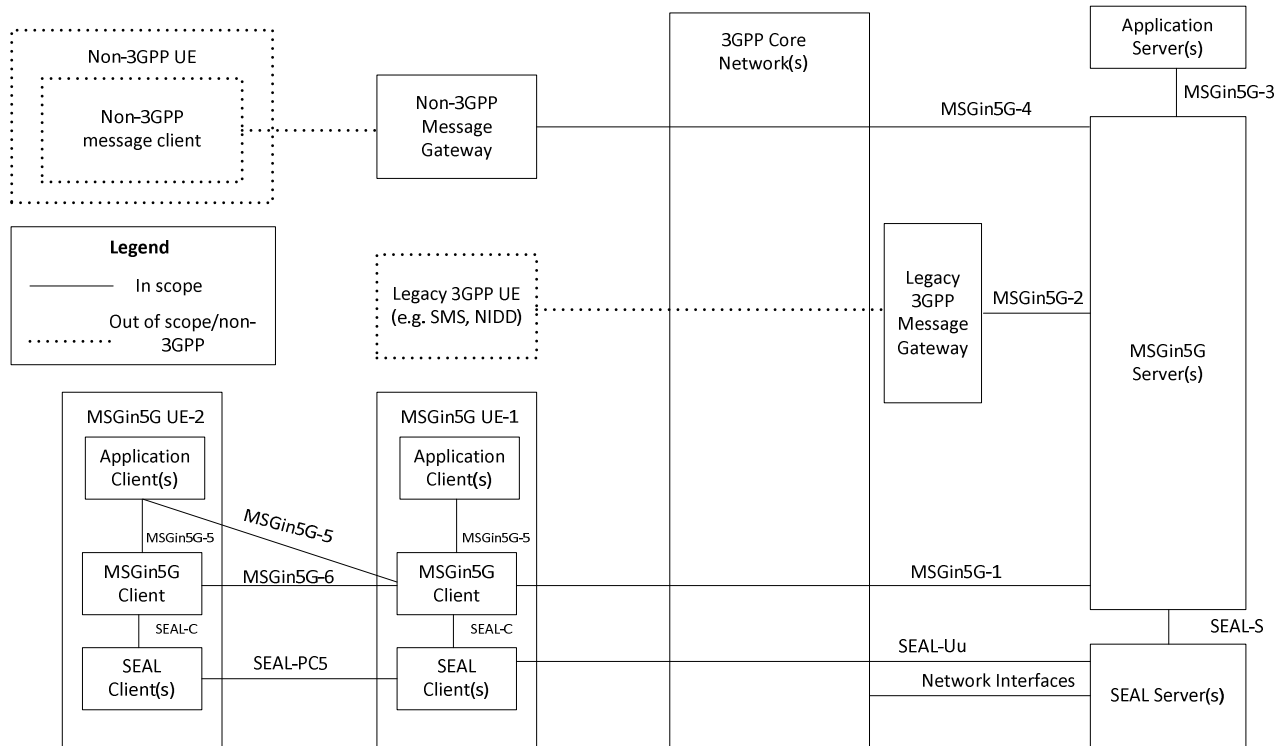
UID	Name	Acronym	WG	WID	WI rapporteur name/company
930030	Support of the 5GMSG Service	FS_5GMARCH	S6	SP-200835	Liu, Yue, China Mobile
840036	Study on support of the 5GMSG Service	FS_5GMARCH	S6	SP-200835	Liu, Yue, China Mobile
890010	Study on security aspects of the 5GMSG Service (St1 in Rel16)	FS_SEC_5GMSG	S3	SP-200878	Xiaoting Huang, China Mobile
930005	Security aspects of the 5GMSG Service	5GMSG	S3	SP-210835	Xiaoting Huang, China Mobile
930040	Application Architecture for MSGin5G Service	5GMARCH		SP-200832	Liu, Yue, China Mobile
890026	Application Architecture for MSGin5G Service	5GMARCH	S6	SP-200832	Liu, Yue, China Mobile
930004	CT aspects for enabling MSGin5G Service	5GMARCH	ct	CP-212106	Liu, Yue, China Mobile
930041	CT1 aspects for enabling MSGin5G Service	5GMARCH	C1	CP-212106	Liu, Yue, China Mobile
930042	CT3 aspects for enabling MSGin5G Service	5GMARCH	C3	CP-212106	Liu, Yue, China Mobile

Summary based on the input provided by China Mobile in SP-220285.

This Feature improves the messaging communication capability of the 5G System, especially for Massive Internet of Things (MIoT). It is based on the study in TR 23.700-24 [4].

Note: The different stages have been spread on different Releases, and on different Features, using different acronyms: Stage 1 is defined in Rel-16 by "MSGin5G" (TS 22.262 [2]), Stages 2 (TS 23.554 [1]) and Stage 3 are defined in Rel-17 by "5GMARCH" and Security aspects have been defined in Rel-17 by "5GMSG". This does not comply with the 3GPP methodology (all stages shall be defined within a same Release and using the same Feature/acronym). The name used to refer to this service in the specifications and in this summary is "MSGin5G".

The following figure, from TS 23.554 [1], provides the high level illustration of the MSGin5G service:



**Figure 1: Application Architecture of the MSGin5G Service**

The following functions are specified:

- a) Configuration of MSGin5G UE and Non-MSGin5G UE to get the MSGin5G Service configuration information (e.g. UE Service ID);
- b) Registration of MSGin5G UE and registration of Message Gateway on behalf of the Non-3GPP UEs;
- c) Message delivery procedures for the message communication models listed below (the message can be delivered between different PLMNs):
  - Point-to-point message which happens between a person and a thing or two things;
  - Application-to-point message/ Point-to-application message which happens between an application server and an IoT device;
  - Group message which originates at a UE and terminated at a group of UEs, all members in the group can send and receive the message;
  - Broadcast message which originates at an application sever in the network or an UE and terminated at all the UEs in a specific service area within a cell or multiple cells;
  - Message delivery based on messaging topic which the message is delivered to all subscribers (UE or Application Server) of this messaging topic.
- d) Message Aggregation can be used to optimize communications towards the same target by aggregating one or more messages into a single message;
- e) MSGin5G message can be segmented transmission if the content is larger than the maximum payload length of a message and reassembled by the suitable recipient;
- f) MSGin5G message can be stored by the MSGin5G Server if a UE is unavailable (disconnected or power off) for future delivery once the UE becomes available;
- g) 3GPP network functionalities of UE reachability status monitoring and device triggering can be leveraged by the MSGin5G Service via Core Network exposure.

h) The Service Enabler Architecture Layer for Verticals (SEAL) capabilities "Group management service" and "Configuration management service" can be used by the MSGin5G service. These services are specified in TS 23.434 [6] and TS 23.554 [1].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930030,840036,890010,930005,930040,890026,930004,930041,930042>

- [1] TS 23.554: "Application architecture for MSGin5G Service; Stage 2" (specifies functional architecture, procedures, information flows and APIs )
- [2] TS 22.262: "Message Service within the 5G System".
- [3] TS 33.501: "Security architecture and procedures for 5G System".
- [4] TS 24.538: "Enabling MSGin5G Service; Protocol specification" (specifies detailed procedures over CoAP protocol between MSGin5G Client and MSGin5G Server)
- [5] TS 29.538: "Enabling MSGin5G Service; Application Programming Interfaces (API specification);" (specifies the RESTful APIs provided by MSGin5G Server towards the Application Server and Message Gateway)
- [6] TS 23.434: "Service Enabler Architecture Layer for Verticals".

890001	Service-based support for SMS in 5GC	SMS_SBI		CP-212023	HAOUARI, Wafa, Orange
890028	CT1 aspects of SMS_SBI	SMS_SBI	C1	CP-212023	HAOUARI, Wafa, Orange
890029	CT4 aspects of SMS_SBI	SMS_SBI	C4	CP-212023	HAOUARI, Wafa, Orange

No summary was provided.

## 8 Proximity/D2D/Sidelink related and V2X

### 8.1 Enhanced Relays for Energy eEfficiency and Extensive Coverage

840048	Enhanced Relays for Energy eEfficiency and Extensive Coverage	REFEC		SP-190307	Norp, Toon, KPN
810018	Study on REFEC	FS_REFEC	S1	SP-180785	Jose Luis Almodovar Chico, KPN
840034	Stage 1 of REFEC	REFEC	S1	SP-190307	Norp, Toon, KPN

Summary based on an input provided by TNO.

REFEC introduces a number of requirements on 5G ProSe relaying.

Note that REFEC, despite its name, has very little to do with energy efficiency.

REFEC covers both " multipath relays" and "multihop relays". "Multipath relays" has been covered in SA2 within their Rel-18 ProSe study, while "multihop relays" was deprioritized.

The other topics covered in Stage 1 by REFEC and that have been taken into account into Stage 2 work to some extent are:

- Support of all kinds of data types
- Indicate QoS that can be provided
- Service continuity
- Permission authorization
- Relay selection
- Charging

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840048,810018,840034>

### 8.2 Proximity-based Services in 5GS

900030	Proximity based Services in 5GS	5G_ProSe		SP-200972	TBD
--------	---------------------------------	----------	--	-----------	-----

830033	Study on System enhancement for Proximity based Services in 5GS	FS_5G_ProSe	S2	SP-190443	Qiang Deng, CATT
900007	<b>Stage 2 for Proximity based Services in 5GS</b>	5G_ProSe	S2	SP-201096	Qiang Deng, CATT
<b>910018</b>	<b>CT aspects of proximity based services in 5GS</b>	<b>5G_ProSe</b>	<b>ct</b>	<b>CP-212105</b>	<b>Yong Jiang, CATT</b>
910072	CT1 aspects of 5G_ProSe	5G_ProSe	C1	CP-212105	Yong Jiang, CATT
910073	CT3 aspects of 5G_ProSe	5G_ProSe	C3	CP-212105	Yong Jiang, CATT
910074	CT4 aspects of 5G_ProSe	5G_ProSe	C4	CP-212105	Yong Jiang, CATT
920081	CT6 aspects of 5G_ProSe	5G_ProSe	C6	CP-212105	Yong Jiang, CATT
890018	Study on charging aspects of Proximity-based Services in 5GS	FS_5G_ProSe_CH	S5	SP-200767	Shu, Min, CATT
880005	Study on Security Aspects of Enhancement for Proximity Based Services in 5GS	FS_5G_ProSe_Sec	S3	SP-200350	Wei Zhou, CATT
930008	<b>Security Aspects of Proximity based Services in 5GS</b>	5G_ProSe	S3	SP-211120	Wei Zhou, CATT

Summary based on the input provided by CATT in SP-220695.

Based on the conclusions reached within clause 8 of TR 23.752 [1], the enhancements of 5G System to support Proximity base Services (5G ProSe) are specified in TS 23.304 [2].

The 5G ProSe features are specified in TS 23.304 [2] and consist of 5G ProSe Direct Discovery, 5G ProSe Direct Communication and 5G ProSe UE-to-Network Relay.

5G ProSe Direct Discovery identifies that 5G ProSe-enabled UEs are in proximity using NR. Both 5G ProSe Direct Discovery with 5G DDNMF and 5G ProSe Direct Discovery procedures over PC5 reference point are specified. For 5G ProSe Direct Discovery with 5G DDNMF, a new entity 5G DDNMF is introduced to handle network related actions required for dynamic 5G ProSe Direct Discovery. For 5G ProSe Direct Discovery procedures over PC5 reference point, both Group Member Discovery and UE-to-Network Relay Discovery are specified. For all the above 5G ProSe Direct Discovery, both Model A and Model B are supported.

5G ProSe Direct Communication enables establishment of communication paths between two or more 5G ProSe-enabled UEs that are in direct communication range using NR. 5G ProSe Direct Communication over NR based PC5 reference point supports Broadcast mode, Groupcast mode, and Unicast mode. The Broadcast and Groupcast mode Direct Communication is connection-less while Unicast mode Direct Communication requires a PC5 unicast link be established between two UEs. The Per-Flow QoS model is supported for 5G ProSe Direct Communication.

5G ProSe UE-to-Network Relay enables indirect communication between the 5G network and UEs (e.g. for UEs that are out of coverage of the network). Both 5G ProSe Layer-3 UE-to-Network Relay and 5G ProSe Layer-2 UE-to-Network Relay are specified. The 5G ProSe Layer-3 UE-to-Network Relay shall provide generic function that can relay any IP (e.g. acts as IP router), Ethernet or Unstructured traffic. The 5G ProSe Layer-2 UE-to-Network Relay provides forwarding functionality that can relay any type of traffic over the PC5 link, and 5G ProSe Layer-2 Remote UE has its own RRC connection and NAS connection to the network.

The Policy/Parameters for 5G ProSe may be provisioned by PCF to UE, and in order to support PC5 radio resource control in NG-RAN, the ProSe service Authorisation information and PC5 QoS parameters for 5G ProSe need to be made available in NG-RAN.

Based on the Stage 2 requirements to support 5G ProSe, the Stage 3 normative work is specified in TS 24.554 [3], TS 24.555 [4], TS 29.555 [5], TS 29.557 [6] and TS 29.559 [7], the Security normative work is specified in TS 33.503 [8], and ProSe Charging is embedded in normative charging work as specified in TS 32.240 [9].

*Charging aspects (as per SP-220696 from CATT)*

The charging aspects are specified in TS 23.304 [10]. The converged charging architecture, principle, requirements, uses cases and charging information for 5G ProSe charging in the TS 32.277 [11] includes: 5G ProSe Direct Discovery and Direct Communication, including UE-to-Network Relay; and PC5 QoS flow information for 5G ProSe Direct Communication, e.g. PC5 QoS Flow Id, QoS information, QoS Characteristics. The corresponding Open API and ASN.1 for 5G ProSe charging are specified in the TS 32.291[12] and TS 32.298 [13].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900030,830033,900007,910018,910072,910073,910074,920081,890018,880005,930008>

- [1] TR 23.752: "Study on system enhancement for Proximity based Services (ProSe) in the 5G System (5GS)".
- [2] TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".
- [3] TS 24.554: "Proximity based services (ProSe) in 5G system (5GS) protocol aspects; Stage 3".

- [4] TS 24.555: "Proximity based services (ProSe) in 5G system (5GS); User Equipment (UE) policies; Stage 3".
- [5] TS 29.555: "5G System; 5G Direct Discovery Name Management Services; Stage 3".
- [6] TS 29.557: "5G System; Application Function ProSe Service; Stage 3".
- [7] TS 29.559: "5G System; 5G ProSe Key Management Services; Stage 3".
- [8] TS 33.503: "Security Aspects of Proximity based Services (ProSe) in the 5G System (5GS)".
- [9] TS 32.240: "Telecommunication management; Charging management; Charging Architecture and Principles".
- [10] TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".
- [11] TS 32.277: "Charging management; Proximity-based Services (ProSe) charging".
- [12] TS 32.291: "Charging management 5G system; Charging service, stage 3".
- [13] TS 32.298: "Charging management; Charging Data Record (CDR) parameter description".

## 8.3 Sidelink/Device-to-Device (D2D)

### 8.3.1 NR Sidelink enhancement

860042	<a href="#">NR Sidelink enhancement</a>	NR_SL_enh		RP-202846	LG Electronics
860142	Core part: NR Sidelink enhancement	NR_SL_enh-Core	R1	RP-202846	LG Electronics
860242	Perf. part: NR Sidelink enhancement	NR_SL_enh-Perf	R4	RP-202846	LG Electronics

Summary based on the input provided by LG Electronics in RP-220521.

3GPP RAN technology for NR sidelink enhancement was specified through this WI to mainly define the means for power saving and enhanced reliability and reduced latency. This WI is the evolution of NR sidelink in Release 16.

The key functionalities of NR sidelink enhancement are detailed below.

#### Power Savings Resource Allocation

The SL UE in Mode 2 can support partial sensing-based resource allocation and random resource selection as power saving resource allocation methods. A SL mode 2 TX resource pool can be (pre)configured to enable full sensing only, partial sensing only, random selection only, or any combination(s) thereof. A UE decides which resource allocation scheme(s) can be used in the AS based on its capability (for a UE in RRC\_IDLE/RRC\_INACTIVE/OOC) and the allowed resource schemes in the resource pool configuration. Random resource selection is applicable to both periodic and aperiodic traffic.

A UE configured for partial sensing can perform periodic-based partial sensing and/or contiguous partial sensing for resource (re)selection. Periodic-based partial sensing can only be performed in a TX pool configured with partial sensing and periodic resource reservation. In periodic-based partial sensing, the UE monitors slots in periodic sensing occasion(s) for a given resource reservation periodicity. Contiguous partial sensing is performed by a UE configured for partial sensing when resource (re)selection is triggered by the UE in a TX pool configured with partial sensing. In contiguous partial sensing, the UE monitors slots in a contiguous sensing window which occur prior to the selected transmission resource.

#### Inter-UE Coordination (IUC)

The SL UE can support inter-UE coordination (IUC) in Mode 2, whereby a UE-A sends information about resources to UE-B, which UE-B then uses for resource (re)selection. The following schemes of inter-UE coordination are supported:

- IUC scheme 1, where the coordination information sent from a UE-A to a UE-B is the preferred and/or non-preferred resources for UE-B's transmission, and
- IUC scheme 2, where the coordination information sent from a UE-A to a UE-B is the presence of expected/potential resource conflict on the resources indicated by UE-B's SCI

In scheme 1, IUC can be triggered by an explicit request from UE-B, or by a condition at UE-A. UE-A determines the set of resources reserved by other UEs or slots where UE-A, when it is the intended receiver of UE-B, does not expect to perform SL reception from UE-B due to half-duplex operation. UE-A uses these resources as the set of non-preferred resources, or excludes these resources to determine a set of preferred resources and sends the preferred/non-preferred resources to UE-B. UE-B's resources for resource (re)selection can be based on both UE-B's sensing results (if available) and the coordination information received from UE-A, or it can be based only on coordination information received from UE-A. For scheme 1, MAC CE and second-stage SCI or MAC CE only can be used to send IUC. The explicit request and reporting for IUC in unicast manner is supported.



In scheme 2, UE-A determines the expected/potential resource conflict within the resources indicated by UE-B's SCI as either resources reserved by other UEs and identified by UE-A as fully/partially overlapping with the resources indicated by UE-B's SCI, or as slots where UE-A is the intended receiver of UE-B and does not expect to perform SL reception on those slots due to half-duplex operation. UE-B uses the conflicting resources to determine the resources to be reselected and exclude the conflicting resources from the reselected resources. For scheme 2, PSFCH is used to send IUC.

### SL DRX

Sidelink supports SL DRX for unicast, groupcast, and broadcast. Similar parameters as defined for Uu (on-duration, inactivity-timer, retransmission-timer, cycle) are defined for SL to determine the SL active time for SL DRX. During the SL active time, the UE performs SCI monitoring for data reception (i.e., PSCCH and 2nd stage SCI on PSSCH). The UE may skip monitoring of SCI for data reception during SL DRX inactive time. The SL active time of the RX UE includes the time in which any of its applicable SL on-duration timer(s), SL inactivity-timer(s) or SL retransmission timer(s) (for any of unicast, groupcast, or broadcast) are running. In addition, the slots associated with announced periodic transmissions by the TX UE and the time in which a UE is expecting CSI report following a CSI request (for unicast) are considered as SL active time of the RX UE. When data is available for transmission to one or more RX UE(s) configured with SL DRX, the TX UE selects resources taking into account the active time of the RX UE(s) determined by the timers maintained at the TX UE.

For unicast, SL DRX is configured per pair of source L2 ID and destination L2 ID. The UE maintains a set of SL DRX timers for each direction per pair of source L2 ID and destination L2 ID. The SL DRX configuration for a pair of source/destination L2 IDs for a direction may be negotiated between the UEs in the AS layer. For SL DRX configuration of each direction, where one UE is the TX UE and the other is the RX UE. RX UE may send assistance information, which includes its desired on duration timer, SL DRX start offset, and SL DRX cycle, to the TX UE and the mode 2 TX UE may use it to determine the SL DRX configuration for the RX UE. Regardless of whether assistance information is provided or not, the TX UE in RRC\_IDLE/RRC\_INACTIVE/OOC, or in RRC\_CONNECTED and using mode 2 resource allocation, determines the SL DRX Configuration for the RX UE. For a TX UE in RRC\_CONNECTED and using mode 1 resource allocation, the SL DRX configuration for the RX UE is determined by the serving gNB of the TX UE. TX UE sends the SL DRX configuration to be used by the RX UE to the RX UE. The RX UE may accept or reject the SL DRX configuration. A default SL DRX configuration for groupcast/broadcast can be used for DCR messages. When the TX UE is in RRC\_CONNECTED, the TX UE may report the received assistance information to its serving gNB and sends the SL DRX configuration to the RX UE upon receiving the SL DRX configuration in dedicated RRC signalling from the gNB. When the RX UE is in RRC\_CONNECTED, the RX UE can report the received SL DRX configuration to its serving gNB, e.g. for alignment of the Uu and SL DRX configurations. SL on-duration timer, SL inactivity-timer, SL HARQ RTT timer, and SL HARQ retransmission timer are supported in unicast. SL HARQ RTT timer and SL HARQ retransmission timer are maintained per SL process at the RX UE. In addition to (pre)configured values for each of these timers, SL HARQ RTT timer value can be derived from the retransmission resource timing when SCI indicates more than one transmission resource. SL DRX MAC CE is introduced for SL DRX operation in unicast only.

For groupcast/broadcast, SL DRX is configured commonly among multiple UEs based on QoS profile and Destination L2 ID. Multiple SL DRX configurations can be supported for each of groupcast/broadcast. SL on-duration timer, SL inactivity-timer, SL HARQ RTT and SL retransmission timers are supported for groupcast. Only SL on-duration timer is supported for broadcast. SL DRX cycle, SL on-duration, and SL inactivity timer (only for groupcast) are configured per QoS profile. The starting offset and slot offset of the SL DRX cycle is determined based on the destination L2 ID. The SL HARQ RTT timer (only for groupcast) and SL HARQ retransmission timer (only for groupcast) are not configured per QoS profile or per destination L2 ID. For groupcast, the RX UE maintains an SL inactivity timer for each destination L2 ID, and selects the largest SL inactivity timer value if multiple SL inactivity timer values associated with different QoS profiles are configured for that L2 ID. For groupcast and broadcast, the RX UE maintains a single SL DRX cycle (selected as the smallest SL DRX cycle of any QoS profile of that L2 ID) and single SL on-duration (selected as the largest SL on-duration of any QoS profile of that L2 ID) for each destination L2 ID when multiple QoS profiles are configured for that L2 ID. For groupcast, SL HARQ RTT timer and SL retransmission timer are maintained per SL process at the RX UE. SL HARQ RTT timer can be set to different values to support both HARQ enabled and HARQ disabled transmissions. A default SL DRX configuration, common between groupcast and broadcast, can be used for a QoS profile which is not mapped onto any non-default SL DRX configuration(s). For groupcast, the TX UE restarts its timer corresponding to the SL inactivity timer for the destination L2 ID (used for determining the allowable transmission time) upon reception of new data with the same destination L2 ID. TX profile is introduced to ensure compatibility for groupcast and broadcast transmissions between UEs supporting/not-supporting SL DRX functionality. A TX profile is provided by upper layers to AS layer and identifies one or more sidelink feature group(s). A TX UE only assumes SL DRX for the RX UEs when the associated TX profile corresponds to support of SL DRX. A RX UE determines that SL DRX is used if all destination L2 IDs of interest have an associated TX profile corresponding to the support of SL DRX.

Alignment of Uu DRX and SL DRX for a UE in RRC\_CONNECTED is supported for unicast, groupcast, and broadcast. Alignment of Uu DRX and SL DRX at the same UE is supported. In addition, for mode 1 scheduling, the alignment of Uu DRX of the TX UE and SL DRX of the RX UE is supported. For SL RX UEs in RRC\_CONNECTED, alignment is achieved by the gNB.

References

Related CRs: set "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860042,860142,860242>

[1] Last status report: RP-220520

8.3.2 NR Sidelink Relay

860038	<a href="#">Study on NR Sidelink relay</a>	FS_NR_SL_relay	R2	RP-202208	OPPO
911005	<a href="#">NR Sidelink Relay</a>	NR_SL_relay		RP-212819	OPPO
911105	Core part: NR Sidelink Relay	NR_SL_relay-Core	R2	RP-212819	OPPO
911205	Perf. part: NR Sidelink Relay	NR_SL_relay-Perf	R4	RP-212819	OPPO

Summary based on the input provided by OPPO, CMCC in RP-220211.

This WI specifies solutions to enable single-hop, sidelink-based, L2 and L3 based UE-to-Network (U2N) relay.

It specifies sidelink U2N relay supporting the following scenarios, i.e., for remote UE in and out of gNB coverage, in the same or different cell coverage as relay UE.

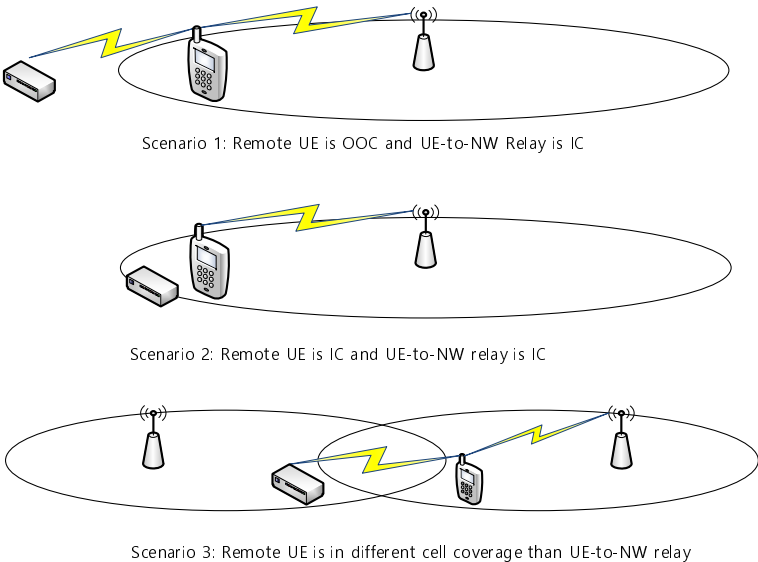
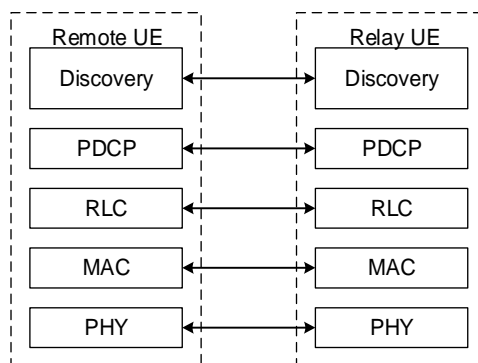


Figure 1: Scenarios for UE-to-Network Relay

Common aspect for both L2 and L3 U2N Relay

In order to enable remote UE and relay UE to identify each other and to establish sidelink connection, the scheme of sidelink discovery is introduced, including protocol stack design, interest report to network and etc. Further mechanism is adopted to enable network to configure the Uu RSRP threshold to (dis)allow remote / relay UE operation at specific cell location.



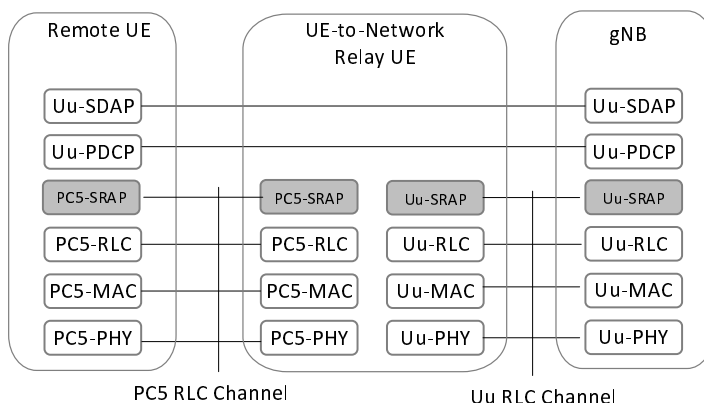
**Figure 2: Protocol Stack of Discovery Message for UE-to-Network Relay**

In order for remote UE to connection to the proper relay UE, relay (re)selection mechanism is introduced, in order for remote UE to base on the sidelink link quality to select proper relay UE. And relay UE can indicate the even of Uu link (e.g., Uu link disconnection or Uu link mobility) to remote UE, so that remote UE can decide whether to perform relay reselection.

In order to support PC5 radio resource control in NG-RAN, ProSe service authorisation information and PC5 QoS parameters for ProSe need to be made available in NG-RAN. Beside the authorization for 5G ProSe direct discovery and 5G ProSe direct communication, authorization IEs are introduced to indicate whether the UE is authorised to use a 5G ProSe Layer-3 and/or Layer-2 UE-to-Network Relay and 5G ProSe Layer-2 UE-to-Network Remote UE. 5G ProSe PC5 QoS parameters are also supported.

#### L2 U2N Relay specific aspect: User Plane

In order to support bearer mapping between sidelink connection between remote and relay UE, and Uu connection between relay UE and gNB, an adaptation layer is introduced, between RLC (which is per-hop deployed) and PDCP (which is end-to-end deployed). The header of adaptation layer would carry the identity for remote UE identification and bearer identification, in order for relay UE to perform packet forwarding between the two sides.



**Figure 3: User plane protocol stack for L2 UE-to-Network Relay**

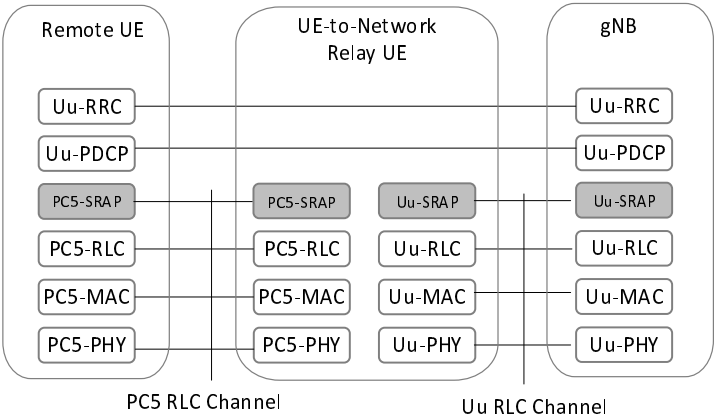


Figure 4: Control plane protocol stack for L2 UE-to-Network Relay

L2 U2N Relay specific aspect: Control Plane

In order for remote UE to acquire system information and paging message via relay UE, the SIB forwarding mechanism is designed, so that relay UE can base on the request and detailed parameter (for paging reception) from remote UE to forward the necessary SIB and paging information to remote UE, upon acquisition of SIB and paging message from network. Furthermore, in order to save relay UE power consumption, network can use dedicated signalling to delivery paging message to relay UE if it is in RRC\_CONNECTED state. Based on that, remote UE mobility in RRC\_IDLE and RRC\_INACTIVE state can be supported.

Furthermore, in order to support remote UE mobility in RRC\_CONNECTED state, the switching between direct and indirect path for intra-gNB scenario is introduced. Via the newly introduced measurement event, remote UE can report the identified candidate connection (direct or indirect) to network, and network can correspondingly switch the UE to the connection (indirect or direct).

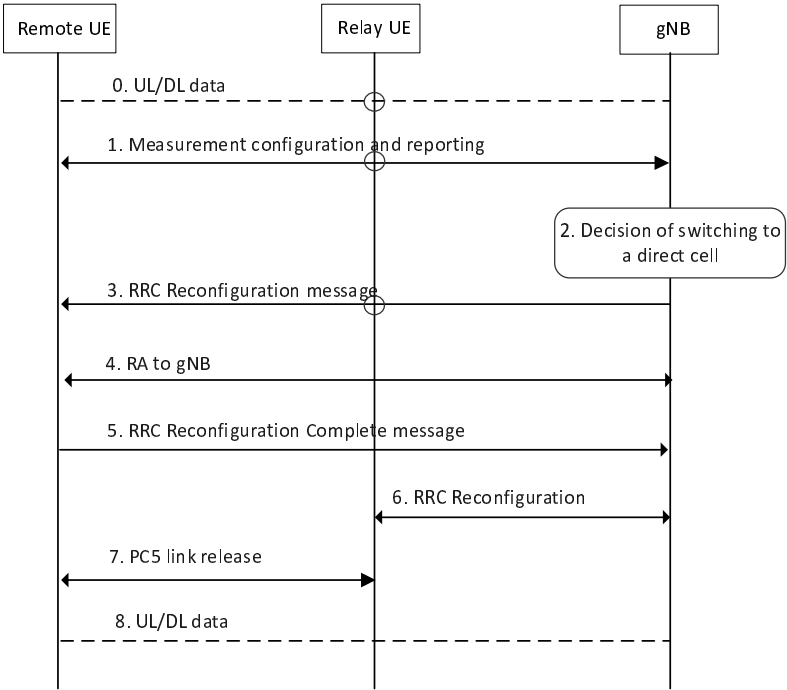


Figure 5: Procedure for U2N Remote UE switching to direct Uu cell

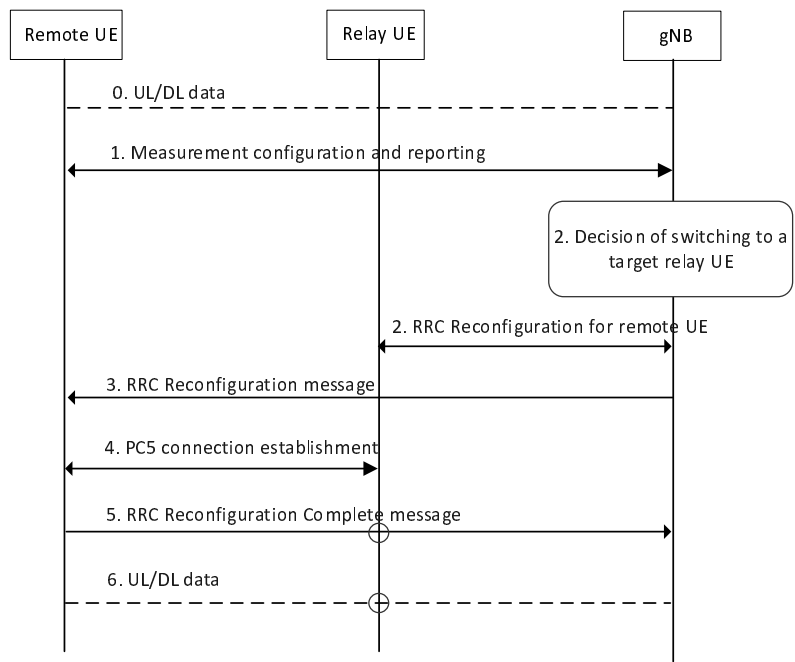


Figure 6: Procedure for U2N Remote UE switching to indirect path

References

Related CRs: set "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860038,911005,911105,911205>

- [1] RP-220210, Status report for WI on NR Sidelink Relay

8.4 Vehicle-to-Everything (V2X)

8.4.1 Support of advanced V2X services - Phase 2

910037	Support of advanced V2X services - Phase 2	eV2XARC_Ph2		SP-210090	LaeYoung Kim, LG Electronics
850013	Study on V2X services – Phase 2	FS_eV2XARC_Ph2	S2	SP-190631	LaeYoung Kim, LG Electronics
910021	Stage 2 of eV2XARC_Ph2	eV2XARC_Ph2	S2	SP-210090	LaeYoung Kim, LG Electronics
920005	CT1 aspects of eV2XARC_Ph2	eV2XARC_Ph2	C1	CP-220305	Herrero Veron, Christian (Huawei)
920048	CT6 aspects of eV2XARC_Ph2	eV2XARC_Ph2	C6	CP-220305	Herrero Veron, Christian (Huawei)

Summary based on the input provided by LG Electronics in SP-220357.

This work item specifies some improvements for the advanced Vehicle-to-Everything (V2X) services. More precisely, it deals with V2X communication over NR PC5 reference point (device-to-device) with power efficiency for pedestrian UEs, i.e. UEs for Vulnerable Road Users. It results from a preliminary study (TR 23.776 [1]).

The support of QoS-aware NR PC5 power efficiency for pedestrian UEs is specified in TS 23.287 [2] as below:

- Overall description about support of QoS-aware NR PC5 power efficiency for pedestrian UEs regarding NR PC5 Discontinuous Reception (DRX) operations.
- PC5 DRX configuration, e.g. the mapping of PC5 QoS profile(s) to PC5 DRX cycle(s), default PC5 DRX configuration, for broadcast and groupcast when the UE is "not served by E-UTRA" and "not served by NR" as provisioned parameters for V2X communications over PC5 reference point.
- NR Tx Profile for broadcast and groupcast as provisioned parameters for V2X communications over PC5 reference point.

For NR-based unicast, groupcast and broadcast mode communication over PC5 reference point, PC5 DRX operations are supported to enable pedestrian UE power saving.

The V2X layer determines the respective V2X service types, and derives the corresponding PC5 QoS parameters based on either the mapping of V2X service types to PC5 QoS parameters, or the V2X Application Requirements for the V2X service type provided by the application layer. The V2X layer passes the PC5 QoS parameters and destination Layer-2 ID to the AS layer. For broadcast and groupcast, the V2X layer also determines the NR Tx Profile for the respective

V2X service type based on the mapping of V2X service types to NR Tx Profiles and provides the NR Tx Profile to the AS layer.

When the PC5 DRX operation is needed, e.g. based on the NR Tx Profile in case of broadcast or groupcast, the AS layer determines the PC5 DRX parameter values for V2X communication over PC5 reference point, taking into account, e.g., PC5 QoS parameters and/or destination Layer-2 ID provided by the V2X layer.

For unicast, two UEs may negotiate the PC5 DRX configuration in the AS layer, and the PC5 DRX parameter values can be configured per pair of source and destination Layer-2 IDs and per direction in the AS layer.

For broadcast and groupcast when the UE is "not served by E-UTRA" and "not served by NR", the UE uses the provisioned PC5 DRX configuration for PC5 DRX operation.

Based on the Stage 2 requirements to support NR PC5 DRX operations, Stage 3 normative works are specified in TS 24.587 [3], TS 24.588 [4] and TS 31.102 [5].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910037,850013,910021,920005,920047,920048>

- [1] TR 23.776: "Study on architecture enhancements for 3GPP support of advanced Vehicle-to-Everything (V2X) services; Phase 2".
- [2] TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".
- [3] TS 24.587: "Vehicle-to-Everything (V2X) services in 5G System (5GS); Stage 3".
- [4] TS 24.588: "Vehicle-to-Everything (V2X) services in 5G System (5GS); User Equipment (UE) policies; Stage 3".
- [5] TS 31.102: "Characteristics of the Universal Subscriber Identity Module (USIM) application".

## 8.4.2 Enhanced application layer support for V2X services

UID	Name	Acronym	WG	WID	WI rapporteur name/company
840035	<a href="#">Study on enhancements to application layer support for V2X services</a>	FS_eV2XAPP	S6	SP-200110	Niranth Amogh, Huawei Telecommunications India
<b>910075</b>	<b>Enhanced application layer support for V2X services</b>	<b>eV2XAPP</b>		<b>SP-200831</b>	<b>Niranth Amogh, Huawei Telecommunications India</b>
890036	<b>Stage 2 of eV2XAPP</b>	eV2XAPP	S6	SP-200831	Niranth Amogh, Huawei Telecommunications India
<b>910019</b>	<b>CT aspects of eV2XAPP</b>	<b>eV2XAPP</b>	<b>ct</b>	<b>CP-211109</b>	<b>Herrero Veron, Christian (Huawei)</b>
910076	CT1 aspects of eV2XAPP	eV2XAPP	C1	CP-211109	Herrero Veron, Christian (Huawei)
910077	CT3 aspects of eV2XAPP	eV2XAPP	C3	CP-211109	Herrero Veron, Christian (Huawei)

Summary based on the input provided by Huawei in SP-220653.

This is an enhancement to the features specified for the application layer support for V2X applications in TS 23.286 [1]. The enhancement features support advanced V2X services (e.g. Tele-Operated Driving, HD Maps) considering the existing stage 1 and stage 2 work within 3GPP related to V2X enhancements in TS 22.185 [2], TS 22.186 [3], TS 23.285 [4] and TS 23.287 [5], as well as V2X application requirements defined outside 3GPP (e.g. 5GAA, ETSI ITS, SAE).

To support the enhancement features to support V2X applications, some enhancements to SEAL were specified using the eSEAL WI (see corresponding section).

The following capabilities are added in the V2X Application Enabler (VAE) layer:

- a) Assistance for V2V communication mode switching enables provisioning the V2X UE to apply V2V communication modes switching policies from the V2X application specific layer.
- b) V2X service discovery across multiple V2X service providers enables the V2X UEs to discover V2X services from partner V2X service providers serving in different geographic areas.
- c) Obtaining dynamic local service information by a V2X UE from a partner V2X service provider operating in the service area where the V2X UE is currently located.
- d) Dynamic group information update considering the consent of the user to support V2X platooning.
- e) Support for PC5 provisioning considering multi-operator scenario to enable V2V/V2I communications.
- f) Support for HD map dynamic information enables the V2X application server (HD map server) to obtain dynamic object information (e.g. V2X UEs in certain proximity range as decided by the V2X application server). Such information supports HD map based automated driving or remote driving scenarios.

- g) UE-to-UE Groupcast/Broadcast configuration and message delivery enables V2X application server to utilize the VAE layer entities (VAE server and VAE clients) to distribute UE-to-UE Groupcast/Broadcast policy configurations and also distribute the V2X messages as per the configured policies.
- h) VAE layer supported V2X communication using local MBMS is enabled.
- i) Session-oriented services supports the session management requirements of ToD applications where the ToD controller may reside in a UE or in the application server.
- j) Service adaptation and extended QoS monitoring and reporting provides a simplified service requirements adaptation service towards the V2X application server by abstracting the details of 3GPP system interactions.

The following capabilities are enhanced in the VAE layer:

- a) The VAE server's service API exposure is conformed to CAPIF framework.
- b) File distribution is enabled with Local MBMS.
- c) Network monitoring by the V2X UE is enhanced with 5GC analytics and RAT type.

The protocol aspects for the above capabilities are specified in TS 24.486 [6].

The openAPI specifications for the VAE server services (northbound APIs) exposed to V2X application specific servers over Vs reference point are specified in TS 29.486 [7].

To support the HD map dynamic information, the SEAL location management service is enhanced to enable tracking of a host vehicle and the nearby V2X UEs in the proximity range of the host vehicle and further obtaining dynamic information from the V2X UEs in proximity range of the host vehicle. For more details, please refer to eSEAL WI (see corresponding section).

The feasibility study for enhancements to application layer support for V2X services is specified in TR 23.764 [8].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840035.910075.890036.910019.910076.910077>

- [1] TS 23.286: "Application layer support for Vehicle-to-Everything (V2X) services; Functional architecture and information flows"
- [2] TS 22.185: "Service requirements for V2X services; Stage 1"
- [3] TS 22.186: "Enhancement of 3GPP support for V2X scenarios; Stage 1"
- [4] TS 23.285: "Architecture enhancements for V2X services"
- [5] TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services"
- [6] TS 24.486: "Vehicle-to-Everything (V2X) Application Enabler (VAE) layer; Protocol aspects; Stage 3"
- [7] TS 29.486: "V2X Application Enabler (VAE) Services; Stage 3"
- [8] TR 23.764: "Study on enhancements to application layer support for V2X services"

## 9 System optimisations

### 9.1 Edge computing

#### 9.1.1 Enhancement of support for Edge Computing in 5G Core network

910048	Enhancement of support for Edge Computing in 5G Core network	eEDGE_5GC		SP-201107	Hui Ni, Huawei Technologies
900016	Stage 2 of eEDGE_5GC	eEDGE_5GC	S2	SP-201107	Hui Ni, Huawei Technologies
910005	CT aspects of 5G eEDGE	eEDGE_5GC	ct	CP-212021	Qi Caixia, Huawei
910049	CT1 aspects of 5G eEDGE	eEDGE_5GC	C1	CP-212021	Qi Caixia, Huawei
910050	CT3 aspects of 5G eEDGE	eEDGE_5GC	C3	CP-212021	Qi Caixia, Huawei
910051	CT4 aspects of 5G eEDGE	eEDGE_5GC	C4	CP-212021	Qi Caixia, Huawei
920026	Security Aspects of Enhancements of Support for Edge Computing in 5GC	eEDGE_5GC	S3	SP-210423	Bo Zhang, Huawei Technologies
880002	Study on Security Aspects of Enhancement of Support for Edge Computing in 5GC	FS_eEDGE_Sec	S3	SP-200347	Bo Zhang, Huawei Technologies
930034	Charging aspects of Edge Computing	EDGE_CH	S5	SP-210861	Yao, Yizhi, Intel
880030	Study on charging aspects of Edge Computing	FS_EDGE_CH	S5	SP-200467	Yizhi Yao, Intel
930011	Charging aspects of Edge Computing	EDGE_CH	S5	SP-210861	Yao, Yizhi, Intel
870029	Study on enhancements of edge computing management	FS_eEDGE_Mgt	S5	SP-200195	Joey Chou, Intel



Summary based on the input provided by Huawei, Hisilicon in SP-220577.

This Feature enhances 5G core network to support Edge Computing as specified in TS 23.548[1]. The main functionalities include the discovery and re-discovery of Edge Application Server (EAS), edge relocation, network exposure to EAS, support of 3GPP application layer architecture for enabling Edge Computing, and AF guidance to determination of URSP rules.

The outputs of corresponding study phase are documented in TR 23.748[2].

**Discovery and re-discovery of Edge Application Server:** Before an UE accessing to edge service, a suitable EAS needs to be discovered by the UE considering different factors, e.g. UE location, UPF serving the UE and also the EAS deployment. When one of the above factors changes due to e.g. UE mobility, the EAS needs to be re-discovered to keep the path optimized.

EAS discovery and re-discovery mechanisms for different connectivity models are specified. An EASDF (Edge Application Server Discovery Function) is introduced to support these mechanisms.

**Edge relocation:** When EAS or PSA UPF relocates due to e.g. UE mobility, 5GS user plane path may be re-configured coordinating with AF to keep the path optimized and minimize the impact to the user experience. Both AF and network triggered edge relocation mechanisms are specified considering different application requirements on e.g. Packet loss and user plane latency.

**Network exposure to EAS:** Network exposure with low latency is specified to expose QoS monitoring results to EAS. With this UPF based network exposure, the exposure path is shorten to enable the quick reaction of application to the change of network condition.

**Support of 3GPP application layer architecture for enabling Edge Computing:** An Edge Configuration Server (ECS) is specified in TS 23.558[3] to support 3GPP application layer architecture for enabling Edge Computing. The ECS address provisioning to UE via 5GC is defined to support such a mechanism.

**AF guidance to PCF determination of URSP rules:** An AF related with Edge computing may need to guide PCF determination of proper URSP rules, so that the URSP configured on the UE can consider the requirements of application. The application guidance for URSP rules determination mechanisms defined in clause 4.15.6.10 of TS 23.502[4].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910048,900016,910005,910049,910050,910051,920026,880002,930034,880030,930011,870029>

- [1] TR 23.548: "5G System Enhancements for Edge Computing"
- [2] TR 23.748: "Study on enhancement of support for Edge Computing in 5G Core network (5GC)"
- [3] TS 23.502: "Procedures for the 5G System; Stage 2"
- [4] TR 23.558: "Architecture for enabling Edge Applications"

## 9.1.2 Enabling Edge Applications

UID	Name	Acronym	WG	WID	WI rapporteur name/company
<b>880042</b>	<b>Architecture for enabling Edge Applications</b>	<b>EDGEAPP</b>		<b>SP-200109</b>	<b>Gupta, Nishant, Samsung</b>
830008	Study on Application Architecture for enabling Edge Applications	FS_EDGEAPP	S6	SP-190065	Nishant Gupta, Samsung
860006	<b>Architecture for enabling Edge Applications</b>	<b>EDGEAPP</b>	S6	SP-200886	Gupta, Nishant, Samsung
<b>900006</b>	<b>CT aspects for Enabling Edge Applications</b>	<b>EDGEAPP</b>		<b>CP-211196</b>	<b>Narendranath Durga Tangudu</b>
900034	CT1 aspects for Enabling Edge Applications	EDGEAPP	C1	CP-211196	Narendranath Durga Tangudu
900035	CT3 aspects for Enabling Edge Applications	EDGEAPP	C3	CP-211196	Narendranath Durga Tangudu
830032	Study on enhancement of support for Edge Computing in 5GC	FS_enh_EC	S2	SP-200093	Hui Ni, Huawei

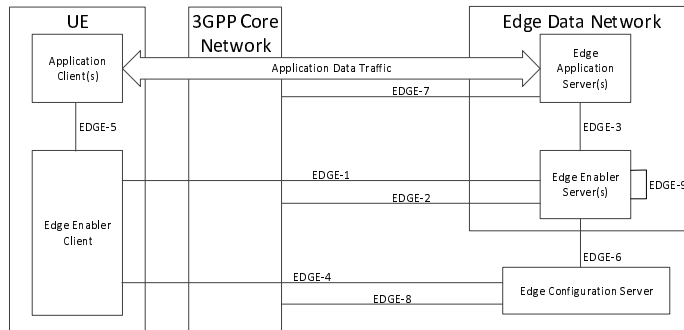
Summary based on the input provided by Samsung in SP-220622.

Edge computing is a well-known industry concept, and is supported within 3GPP networks with the introduction of Edge computing capabilities in 5G System Architecture (TS 23.501). While there have been efforts at the system level, the overall application layer architecture needs supporting environment (such as provisioning, discovery, registration, enabler layer capability exposure, network capability exposure, support for service continuity) to enable edge applications over 3GPP networks.

TS 23.558 [1] specifies the architecture, procedures and information flows to enable edge applications over 3GPP networks.

Architecture for enabling edge applications based on the architectures principles such as UE application portability, Edge Application portability, service differentiation and flexible deployment.

The Edge Data Network (EDN) is a local Data Network. Edge Application Server(s) and the Edge Enabler Server (EES) are contained within the EDN. EES is



(EES) is primarily responsible for enabling discovery of the EASs; Edge Enabler Client supports EAS discovery to the ACs in the UE; and, Edge Configuration Server, providing configurations to the EEC. The Edge Configuration Server provides configurations related to the EES, including details of the Edge Data Network hosting the EES. The UE contains Application Client(s) and the Edge Enabler Client (EEC). The Edge Application Server(s), the Edge Enabler Server and the Edge Configuration Server may interact with the 3GPP

Core Network.

With the support of the enabling layer, TS 23.558 [1] provides many rich features at the application layer for support of the Edge Application, such as:

- **Service Provisioning:** Enabling a UE with an Edge Enabler Client to find and connect to available Edge Data Networks.
- **Rich discovery:** On-demand configuration provisioning by the Edge Configuration Server and the query support of Edge Enabler Server allows discovery of the Edges and the Edge Application Servers by a UE equipped with the Edge Enabler Client.
- **Dynamic availability:** Due to the flexible nature, the availability of Edge and the EAS can change dynamically due to multiple reasons, such as change in deployments, mobility of the UE etc. UE can subscribe to such changes to fine tune the services provided accordingly.
- **Capability exposure:** EES capability is exposed as APIs to EAS (e.g. via CAPIF as specified in TS 23.222 [2]) as value added services to the EASs. The EASs and EESs can also utilize 3GPP network capability exposure as SCEF/NEF northbound APIs.
- **Support for service continuity:** With the UE being mobile, eventually, a different server on Edge or Cloud can become more suitable for serving the AC. To enable continuity of service in such scenarios, the architecture supports transfer of the UE's application context to the new server whenever needed; allowing the new server to restore the service without losing the application context.

Management aspects of application layer support of the Edge Applications is specified in TS 28.538 [3].

Security aspects of application layer support of the Edge Applications is specified in TS 33.558 [4].

Stage 3 normative work for application layer support of the Edge Applications are specified as open APIs in TS 24.558 [5] and 29.558 [6].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=880042,830008,860006,900006,900034,900035,830032>

- [1] TS 23.558: "Architecture for enabling Edge Applications".
- [2] TS 23.222: "Functional architecture and information flows to support Common API Framework for 3GPP Northbound APIs; Stage 2".
- [3] TS 28.538: "Management and orchestration; Edge Computing Management".
- [4] TS 33.558: "Security aspects of enhancement of support for enabling edge applications".
- [5] TS 24.558: "Enabling Edge Applications; Protocol specification".
- [6] TS 29.558: "Enabling Edge Applications; Application Programming Interface (API) specification; Stage 3".

### 9.1.3 Edge Computing Management

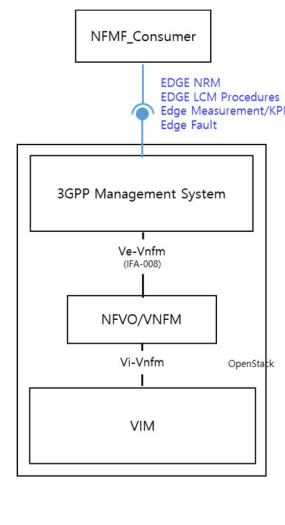
920019	<b>Edge Computing Management</b>	ECM	S5	<b>SP-210388</b>	Deepanshu Gautam, Samsung
--------	----------------------------------	-----	----	------------------	---------------------------

Summary based on the input provided by Samsung in SP-220020.

The ECM Work Item and the resulting specification in TS 28.538[4] provides management provisions and solutions for edge computing considering related requirements from SA6 EDGEAPP WI including lifecycle management, provisioning, performance assurance and fault supervision for EDGEAPP defined entities.

Edge computing is a well-known industry concept, with 3GPP 5G System Architecture supporting Edge computing deployments by enabling certain features as listed in sub clause 5.13 of TS 23.501[1]. SA6, as part of TS 23.558[2], have defined the functionality and concepts required for enabling Edge Applications in 3GPP networks. The functionalities defined to be deployed in 3GPP networks include Edge Application, Edge Enabler Server and Edge Data Network Configuration Server. The management provisions for these functionalities are addressed as part of this WI. The management solutions in preview of this WI includes.

- **Provisioning and LCM:** Provisioning includes configuration and lifecycle management. It deals with defining NRMs (Network Resource Model) for the edge entities to be managed and also defining usage of those NRMs by the management services to achieve provisioning and lifecycle management.
- **Performance Assurance:** It deals with defining edge specific performance measurements and KPIs. The collection mechanism for the same is also defined.
- **Fault Supervision:** It deals with defining edge specific alarm. The collection mechanism for the same is also defined.
- **Connection to 5GC:** Connecting edge nodes to 5GC is crucial part of edge computing management. The defined NRM fragments to enable the same.



### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920019>

- [1] TS 23.501: "System architecture for the 5G System (5GS)"
- [2] TS 23.558: "Architecture for enabling Edge Applications"
- [3] TR 28.814: "Study on enhancements of edge computing management"
- [4] TS 28.538: "Edge Computing Management"

## 9.2 Slicing

### 9.2.1 Network Slicing Phase 2 (CN and AN aspects)

UID	Name	Acronym	WG	WID	WI rapporteur name/company
<b>900032</b>	<b>Enhancement of Network Slicing Phase 2</b>	<b>eNS_Ph2</b>		<b>SP-200976</b>	<b>ZTE, Jinguo Zhu</b>
850010	Study on Enhancement of Network Slicing Phase 2	FS_eNS_Ph2	S2	SP-190931	So, Tricci, ZTE
900011	<b>Stage 2 for Enhancement of Network Slicing Phase 2</b>	eNS_Ph2	S2	SP-200976	ZTE, Jinguo Zhu
<b>920059</b>	<b>Stage 3 for Enhancement of Network Slicing Phase 2</b>	<b>eNS_Ph2</b>	<b>ct</b>	<b>CP-211091</b>	<b>Hannah Wang, ZTE</b>
910041	CT1 aspects of eNS_Ph2	eNS_Ph2	C1	CP-211091	Hannah Wang, ZTE
910042	CT3 aspects of eNS_Ph2	eNS_Ph2	C3	CP-211091	Hannah Wang, ZTE
910043	CT4 aspects of eNS_Ph2	eNS_Ph2	C4	CP-211091	Hannah Wang, ZTE
<b>911007</b>	<b>Enhancement of RAN slicing for NR</b>	<b>NR_slice</b>	<b>R2</b>	<b>RP-212534</b>	<b>CMCC</b>
911107	Core part: Enhancement of RAN slicing for NR	NR_slice-Core	R2	RP-212534	CMCC
860022	Study on network slice management enhancement	FS_NSMEN	S5	SP-200766	Brendan Hassett, Huawei Technologies Sweden AB,
900023	Study on Charging Aspects for Network Slicing Phase 2	FS_NETSLICE_CH_Ph2	S5	SP-201082	Matrixx, Gerald Görmer
910023	Study on enhanced security for network slicing Phase 2	FS_eNS2_SEC	S3	SP-210106	Zander Lei, Huawei

910026	<a href="#">Study on network slice management capability exposure</a>	FS_NSCE	S5	SP-210131	Xiaobo Yu, Alibaba Group
910095	<a href="#">Study on 5G NR UE full stack testing for Network Slicing</a>	FS_NR_Slice_Test	R5	RP-211977	CMCC

Summary based on the input provided by ZTE in SP-210890 for SA and CT aspects, and by CMCC, ZTE in RP-221376 for RAN aspects [note from the editor: one single summary was expected to cover ALL aspects].

### **SA and CT aspects:**

This work item specifies the system enhancements to support some parameters of GST (Generic Slice Template) as documented in NG.116. The following enhancements are specified in this work item.

- A new NSACF(Network Slicing Admission Control Function) is defined to monitor and control the number of registered UEs per network slice and the number of PDU Sessions per network slice for the network slices that are subject to Network Slice Admission Control (NSAC)
- A new QoS parameter "Slice-Maximum Bit Rate" (S-MBR) is defined to limit the aggregate data rate in UL and DL per UE across all GBR and Non-GBR QoS Flows for all PDU sessions associated with an S-NSSAI for the UE. The S-MBR is enforced in RAN and is available in PCF for optional input to apply current QoS functionality. In addition the PCF for the PDU Session may also be configured to monitor the data rate per Network Slice for a UE and to strengthen or relax the traffic restrictions for individual PDU Sessions or PCC rules accordingly
- The PCF is enhanced to monitor the data rate per Network Slice and based on operator policies, apply a policy decision to strengthen the traffic restrictions for individual PDU Sessions or PCC rules to ensure that the data rate for the network slice does not exceed the NW Slice maximum data rate parameter which is configured and stored in the UDR. The PCF may use NWDAF service to monitor the data rate per Network Slice.
- An optional Network Slice Simultaneous Registration Group (NSSRG) information for each S-NSSAI in UE subscription is defined to indicate which S-NSSAIs can be simultaneously provided to the UE in the Allowed NSSAI. The serving PLMN AMF may also provide the supporting UE with the NSSRG information related to the S-NSSAIs of the HPLMN which are in the mapping information of the Configured NSSAI. A UE which receives the NSSRG values in the network slicing configuration information shall only include in the Requested NSSAI S-NSSAIs that share a common NSSRG as per the received information.
- A mechanism is defined to allow the AMF to provide Target NSSAI and RFSP to RAN to steer the UE to another cell supporting network slices not available in a current cell and RA. The Target NSSAI includes at least one S-NSSAI from the Requested NSSAI not available in the current TA, but available in another TA in different frequency band possibly overlapping with the current TA, and optionally additional S-NSSAIs from the Requested NSSAI that are configured to be available within the same TAs as the S-NSSAIs not available in the current TA.

### **RAN aspects:**

Enhancement of RAN slicing for NR was specified through this WI to define the slice aware cell reselection and slice specific RACH configuration and prioritization, as well as to define solutions to support slice-based service continuity, and to support the enforcement of Slice MBR, the usage of Target NSSAI as introduced by SA2.

#### *Support slice aware cell reselection*

A new NSAG (Network Slice AS Group) mechanism is introduced for slice aware cell reselection and slice specific RACH configuration, in order to avoid exposing S-NSSAI over Uu interface for reason of security and overhead. In the system information, the NSAG information is broadcast instead of S-NSSAI.

In order to assist slice aware cell reselection, the NG-RAN node can provide NSAG specific cell reselection information of current cell and neighbour cell in system information and in RRCRelease message as specified in TS 38.331. The NSAG specific cell reselection information is provided per frequency per NSAG. If NSAG specific cell reselection information is provided in dedicated signalling, the UE shall ignore NSAG specific cell reselection information provided in system information.

In the UE, NAS provides the NSAG information and their priorities to be considered during cell reselection to the AS. When a UE supports slice aware cell reselection, and NSAG specific cell reselection information is provided to the UE, then the UE performs the slice aware cell reselection. The details of slice aware cell reselection are specified in TS 38.304. In general, the UE can derive reselection priorities for slice aware cell reselection, and then perform cell reselection evaluation using legacy evaluation criteria.

#### *Support slice specific RACH configuration*

In order to support slice specific RACH configuration, separated RACH partitioning (e.g., transmission occasions of time-frequency domain and preambles) and RACH prioritization parameters (i.e., scalingFactorBI and powerRampingStepHighPriority) can be configured per NSAG in system information as specified in TS 38.331. All slices of a NSAG use the slice specific RACH configuration of the same NSAG.

In a cell, there may be multiple slice-specific RACH configurations. One or more of the NSAGs can be linked to a slice-specific RACH configuration. If a NSAG is not linked to any slice specific RACH configuration, the common RACH configuration can be used.

#### *Support service continuity*

In order to support service continuity for specific slice(s), the NG-RAN node may use Multi-Carrier Resource Sharing or Resource Repartitioning to allocate resources to a slice in case of slice resources shortage.

In Multi-Carrier Resource Sharing the RAN node can setup the dual connectivity or carrier aggregation with different frequency and overlapping coverage where the same slice is available.

The Resource Repartitioning allows a slice to use resources from the shared pool or/and prioritized pool when its own dedicated or prioritized resources are not available and the use of unused resources in the prioritized pool is as specified in TS 28.541.

Slice RRM policies/restrictions associated with Resource Repartitioning are configured from O&M.

Measurements of RRM policy utilization according to resource types defined in TS 28.541 are reported from RAN nodes to O&M and may lead O&M to update the configuration of the Slice RRM policies/restrictions.

#### *Support the enforcement of Slice MBR and the usage of Target NSSAI*

The UE-Slice MBR is introduced to limit the aggregate bit rate that can be expected to be provided across all GBR and Non-GBR QoS Flows corresponding to PDU Sessions of the UE for the same slice (S-NSSAI) as specified in TS 23.501 and is ensured by the RAN.

In case of Dual Connectivity, the MN decides the DL UE Slice MBR and UL UE Slice MBR limits to be assigned to the SN, and indicates these to the SN. In addition, the PDCP entity at the SN applies the received DL UE Slice MBR limit to the set of all bearers for which the SN hosts PDCP for the concerned Slice, as defined in TS 23.501, and the MAC entity at the SN applies the received UL UE Slice MBR limit to the scheduled uplink radio traffic at the SN for the concerned Slice, as defined in TS 23.501.

In order to support the enforcement of Slice MBR, RAN interfaces including NG, Xn, F1 and E1 are enhanced to transmit UE-Slice-MBR.

Target NSSAI is determined by Core Network on a per UE basis, and used by NG-RAN to attempt to redirect the UE to a cell and TA in another frequency band and TA that supports the S-NSSAIs in the Target NSSAI, as defined in TS 23.501. In order to support the usage of Target NSSAI at NG-RAN, NG interface is enhanced to transmit Target NSSAI.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900032,850010,900011,920059,910041,910042,910043,911007,911107,860022,900023,910023,910026,910095>

- [1] Tdoc SP-200976, Work Item on "Enhancement of Network Slicing Phase 2"
- [2] Tdoc SP-210269, Updated Work Item on "Enhancement of Network Slicing Phase 2"
- [3] Tdoc SP-190931, Study Item on "Study on Enhancement of Network Slicing Phase 2"
- [4] TR 23.700-40, Technique Report on "Study on enhancement of network slicing"
- [5] TR 38.832 Study on enhancement of Radio Access Network (RAN) slicing (Release 17)
- [6] RP-221375 Status report on enhancement of RAN slicing for NR

## 9.2.2 Network Slice charging based on 5G Data Connectivity

9500xx	<b>Network Slice charging based on 5G Data Connectivity</b>	NETSLICE_DC_CH	S5	SP-220158	MATRIX Software, Gerald Görmer
--------	---	----------------	----	-----------	--------------------------------

Summary based on the input provided by MATRIX Software in SP-220075.



In 5G system when Network Slices allocated to third party providers are deployed by Mobile Network Operators, how these third-party providers can be charged for usage of assigned Network Slice(s), is not described. This work item introduces a description focusing on one particular type of Network Slice usage, leveraging from capabilities specified from Rel-15.

5G Data Connectivity charging specified in 5GS between SMF and CHF for individual UEs PDU sessions from Rel-15, is used with Converged Charging System (CCS) hosting the CHF extended to also cover the third-party provider (addressed under the tenant concept).

By receiving the S-NSSAI for each UE PDU session, the enhanced CCS is able to perform per tenant charging based on tenant's Network Slice total UEs data connectivity usage, the Network Slice being identified by the S-NSSAI.

The internal behaviour of the enhanced CCS is not specified in this release.

## References

One related CR: SP-220157: "Introduction of Annex on Network slice charging"

- [1] TS 32.255: "Charging management; 5G Data connectivity domain charging; stage 2".

## 9.3 Access Traffic Steering, Switch and Splitting support in the 5G system architecture; Phase 2

UID	Name	Acronym	WG	WID	WI rapporteur name/company
900033	<b>Access Traffic Steering, Switch and Splitting support in the 5G system architecture; Phase 2</b>	ATSSS_Ph2		<b>SP-200977</b>	Apostolis Salkintzis, Lenovo
840084	Study on ATSSS_Ph2	FS_ATSSS_Ph2	S2	SP-200095	So, Tricci, ZTE
900012	<b>Stage 2 of ATSSS_Ph2</b>	ATSSS_Ph2	S2	SP-200977	Apostolis Salkintzis, Lenovo
910013	<b>CT aspects of ATSSS_Ph2</b>	<b>ATSSS_Ph2</b>	<b>ct</b>	<b>CP-210136</b>	<b>ZHOU Xingyue (Joy), ZTE</b>
910056	CT1 aspects of ATSSS_Ph2	ATSSS_Ph2	C1	CP-210136	ZHOU Xingyue (Joy), ZTE
910057	CT3 aspects of ATSSS_Ph2	ATSSS_Ph2	C3	CP-210136	ZHOU Xingyue (Joy), ZTE
910058	CT4 aspects of ATSSS_Ph2	ATSSS_Ph2	C4	CP-210136	ZHOU Xingyue (Joy), ZTE

Summary based on the input provided by Lenovo in SP-220591.

The Access Traffic Steering, Switching and Splitting (ATSS) feature in 5G networks enables the establishment of a Multi Access (MA) PDU Session, which supports multipath data communication between the UE and UPF, by simultaneously exchanging data over a 3GPP access network (e.g., NG-RAN) and over a non-3GPP access network (e.g., WLAN).

The ATSSS work in Rel-17 (aka ATSSS\_ph2) specified enhancements for supporting the following features (see [3]):

- a) ATSSS steering mode enhancements (based on the conclusions in TR 23.700-93, clause 8.1); and
- b) Support of MA PDU Sessions with a 3GPP access over EPC and a non-3GPP access over 5GC (based on the conclusions in TR 23.700-93, clause 8.3).

More specifically, the following enhancements were specified for the ATSSS in Rel-17. They are grouped into two main categories: (1) Steering mode enhancements, and (2) supporting an MA PDU Session with a 3GPP access leg over EPC.

### Steering mode enhancements:

- **PMF measurements per QoS flow:** To decide how to steer the traffic of a data flow, access network performance measurements may need to be taken, to estimate the RTT and/or the Packet Loss Rate over each of the accesses of a MA PDU Session.

The access network performance measurements (which apply the Performance Measurement Function (PMF) protocol) were enhanced to support RTT measurements and Packet Loss Rate (PLR) measurements over a certain QoS flow (aka access performance measurements per QoS flow). This is an improvement over Rel-16 wherein the access performance measurements are always conducted over the default QoS flow and, therefore, provide a rough estimate of the RTT / PLR.

Whether the access performance measurements for a data flow are conducted over the default QoS flow (as in Rel-16), or over the same QoS flow used to carry the data flow, is determined by the network during the MA PDU Session establishment. More details can be found in [1], clause 5.32.5.

- **Load-Balancing without pre-defined split percentages:** This introduces enhancements to the Load-Balancing steering mode, which is a steering mode that splits the traffic of a data flow (in uplink and downlink direction

separately) across the 3GPP and the non-3GPP accesses. In Rel-16, the network always provides split percentages (referred to as pre-defined or fixed percentages), e.g., 20% on 3GPP access, 80% on non-3GPP access. In Rel-17, however, the network may provide an "autonomous load-balance indicator" in which case the UE and the UPF can freely and independently select their own percentages for each access type. The selected percentages may change over time, e.g., based on the RTT measurements. The UE and the UPF typically select the percentages in a way that maximizes the aggregated throughput. This means that using a load-balancing steering mode with the "autonomous load-balance indicator" can maximize the throughput of a given data flow in the uplink and in the downlink direction.

- **Load-Balancing with the UE-assistance indication:** When the network indicates that a data flow should be steered with the load-balancing steering mode, the network may also provide a "UE-assistance indication" which indicates that (a) the UE may decide how to distribute the UL traffic of the matching data flow based on the UE's internal state (e.g., based on UE's battery level), and that (b) the UE may inform the UPF how it decided to distribute the UL traffic of the matching data flow.

Typically, the UE-assistance indicator can be provided for data flows for which the network has no strong steering requirements. For example, when the network has no strong steering requirements for the default traffic of an MA PDU Session, the network can indicate (i) that this traffic must be steered with Load-Balancing steering mode using 50% - 50% split percentages, and (ii) that the UE is allowed to use other split percentages, such as 0% - 100%, if this is needed by the UE to optimize its operation (e.g., to minimize its battery consumption).

- **Threshold values:** A steering mode can be linked with a threshold condition, which specifies how the steering mode should be applied according to this condition. For example, if the threshold condition "RTT < 100ms" is applied with the Load-Balancing steering mode, it indicates that traffic can be transferred on 3GPP access or non-3GPP access only if the measured RTT of this access is less than 100ms.

One or more threshold values may be provided when the steering mode is either Priority-based or Load-Balancing with fixed split percentages. A threshold value may be either a value for RTT or a value for Packet Loss Rate (PLR). For more details, see [1], clause 5.32.8.

#### **Supporting an MA PDU Session with a 3GPP access leg over EPC:**

- A Multi Access (MA) PDU Session established over the 5G core (5GC) network typically has user-plane resources over a 3GPP access connected to 5GC and user-plane resources over a non-3GPP access connected to 5GC. In Rel-17, however, the user-plane resources over 3GPP access may be established in EPC (through a PDC Connection). In other words, instead of using a 3GPP access connected to 5GC, a 3GPP access (e.g., E-UTRAN) connected to EPC may be used by the MA PDU Session. This enables a scenario where a MA PDU Session can simultaneously send traffic over a 3GPP access connected to EPC and over a non-3GPP access connected to 5GC. More details can be found in [2], clause 4.22.2.3.

#### **References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900033,840084,900012,910013,910056,910057,910058>

- [1] TS 23.501, "System architecture for the 5G System (5GS); Stage 2 (Release 17)".
- [2] TS 23.502, "Procedures for the 5G System (5GS); Stage 2 (Release 17)".
- [3] ATSSS\_ph2 work item description:  
[https://www.3gpp.org/ftp/tsg\\_sa/TSG\\_SA/TSGs\\_90E\\_Electronic/Docs/SP-200977.zip](https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGs_90E_Electronic/Docs/SP-200977.zip)

## **9.4 Self-Organizing (SON)/Autonomous Network**

### **9.4.1 Enhancement of data collection for SON/MDT in NR and EN-DC**

860053	Enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR and EN-DC	NR_ENDC_SON_MDT_enh		RP-193255	CMCC
860153	Core part: Enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR and EN-DC	NR_ENDC_SON_MDT_enh-Core	R3	RP-193255	CMCC

Summary based on the input provided by CMCC in RP-220822.

This work item introduces enhancement of SON and MDT features support in NR standalone and MR-DC, including

CCO, inter-system inter-RAT energy saving, inter-system load balancing, 2-step RACH optimization, mobility enhancement optimization, PCI selection, energy efficiency (OAM requirements), Successful Handovers Reports, UE



history information in EN-DC, load balancing enhancement, MRO for SN change failure, RACH Optimisation enhancements, MDT enhancement and L2 measurements.

The key functionalities of this WI are described as below.

#### NR Coverage and Capacity Optimization (CCO)

NR Coverage and Capacity Optimization (CCO) function is to detect and mitigate coverage and cell edge interference issues. Each NG-RAN node may be configured with alternative coverage configurations by OAM. The alternative coverage configurations contain relevant radio parameters and may also include a range for how each parameter is allowed to be adjusted. An NG-RAN node may autonomously adjust within and switch between coverage configurations. When a change is executed, a NG-RAN node may notify its neighbour NG-RAN nodes using the NG-RAN NODE CONFIGURATION UPDATE message with the list of cells and SSBs with modified coverage included. The list contains the CGI of each modified cell with its coverage state indicator and optionally the SSB index of each modified SSB with its coverage state indicator.

#### Inter-system inter-RAT energy saving

The solution builds upon the possibility for the NG-RAN node owning a capacity booster cell to autonomously decide to switch-off such cell to dormant state. The decision is typically based on cell load information, consistently with configured information. The switch-off decision may also be taken by O&M. The NG-RAN node indicates the switch-off action to the eNB over NG interface and S1 interface. The NG-RAN node could also indicate the switch-on action to the eNB over NG interface and S1 interface.

The eNB providing basic coverage may request a NG-RAN node's cell re-activation based on its own cell load information or neighbour cell load information, the switch-on decision may also be taken by O&M. The eNB requests a NG-RAN node's cell re-activation and receives the NG-RAN node's cell re-activation reply from the NG-RAN node over the S1 interface and NG interface. Upon reception of the re-activation request, the NG-RAN node's cell should remain switched on at least until expiration of the minimum activation time. The minimum activation time may be configured by O&M or be left to the NG-RAN node's implementation.

#### Inter-system load balancing

The load reporting function for inter-system load balancing is executed by exchanging load information between NG-RAN and E-UTRAN. Both event-triggered and periodic inter-system load reporting are supported. Event-triggered inter-system load reports are sent when the reporting node detects crossing of cell load thresholds.

The following load related information should be supported:

- Cell Capacity Class value (UL/DL relative capacity indicator);
- Capacity value (per cell: UL/DL available capacity);
- RRC connections (number of RRC connections, and available RRC Connection Capacity);
- Number of active UEs.
- PRB usage (per cell: UL/DL)

NGAP procedures used for inter-system load balancing are Uplink RAN Configuration Transfer and Downlink RAN Configuration Transfer.

S1AP procedures used for inter-system load balancing are eNB Configuration Transfer and MME Configuration Transfer.

#### 2-step RACH optimization

2-step RACH optimization is supported by UE reported 2-step RACH related information made available at the NG RAN node and by PRACH parameters exchange between NG RAN nodes.

#### PCI selection

For aggregated architecture and centralized PCI assignment in gNB, the OAM assigns a single PCI for each NR cell in the gNB, and the gNB selects this value as the PCI of the NR cell.

For Aggregated architecture and distributed PCI assignment in gNB, the OAM assigns a list of PCIs for each NR cell in the gNB, and the gNB selects a PCI value from the list of PCIs. The gNB may restrict this list by removing some PCIs that are reported by UEs, reported over the Xn interface by neighboring gNBs, and/or acquired through other methods, e.g. detected over the air using a downlink receiver.

The PCI Optimization Function in split gNB case, the OAM configures a PCI for each NR cell to the gNB-DU. For centralized PCI assignment in split gNB architecture, the gNB-CU detects PCI conflict of NR cells and reports the NR cells suffering PCI conflict to OAM directly. The OAM is in charge of reassigning a new PCI for the NR cell subject to PCI conflict. For distributed PCI assignment in split gNB architecture, the OAM assigns a list of PCIs for each NR cell and sends the configured PCI list to the gNB-CU. If the gNB-CU detects PCI conflict, the gNB-CU may select a new PCI value from the preconfigured PCI list for the NR cell and send it to the gNB-DU by either F1 Setup procedure or gNB-CU configuration update procedure.

#### Energy efficiency (OAM requirements)

To calculate the energy efficiency of base stations, ETSI ES 203 228 ("Environmental Engineering (EE); Assessment of mobile network energy efficiency") defines the following high-level EE KPI:

$$EE_{MN,DV} = \frac{DV_{MN}}{EC_{MN}}$$

In which Mobile Network data Energy Efficiency (EEMN,DV) is the ratio between the performance indicator (i.e. Data Volume DVMN) and the energy consumption (ECMN).

#### Successful Handovers Reports

Successful Handovers Reports is reported by the UE to detect failure events happened during successful handovers.

The solution for the problem may consist of the following steps:

- 1) UE is configured with triggering conditions to compile the Successful Handover Report;
- 2) Only if the conditions are met, UE generates Successful Handover Report comprising a set of measurements collected during the successful handover phase, i.e. measurement at the handover trigger, measurement at the end of handover execution or measurement after handover execution.
- 3) The availability of a Successful Handover Report may be indicated by Completed message (RRCReconfigurationComplete, RRCReestablishmentComplete, RRCSetupComplete, RRCResumeComplete) transmitted from UE to NG-RAN node over RRC. The NG-RAN node may fetch information of a successful handover report via UE Information Request/Response mechanism.
- 4) NG-RAN node could forward the Successful Handover Report to the source NR-RAN node to indicate failures experienced during a successful handover event.

Upon reception of a Successful HO Report, the receiving node is able to analyse whether its mobility configuration needs adjustment.

#### UE history information in EN-DC

UE history information is introduced in EN-DC to avoid Ping Pong effect. The MN stores and correlates the UE History Information from MN and SN(s) as long as the UE stays in MR-DC, forwards UE History Information and optional UE History Information from the UE to its connected SNs. The resulting information is then used by SN in subsequent handover preparation. The SN is in charge of collecting SCG UE history information and providing the collected information to the MN based on MN request or MN subscription on the PSCell change.

The MN may retrieve the SCG UE history information via the SN Addition and SN Modification procedures. SN shall provide the SCG UE history information, if available, in the SN Addition, SN Modification, SN Release, and SN initiated SN Change procedures.

#### Load balancing enhancement

The load reporting function is executed by exchanging load information over the Xn/X2/F1/E1 interfaces. Besides the load metrics introduced in Rel-16, some more metrics are introduced for intra-system load balancing, including, PRB usage for slice(s): DL/UL GBR PRB usage, DL/UL non-GBR PRB usage, and DL/UL Total PRB allocation) and PRB utilisation for MIMO

To achieve load reporting function, Resource Status Reporting Initiation & Resource Status Reporting procedures are used.

#### MRO for SN change failure

For analysis of PSCell change failure, the UE makes the SCG Failure Information available to the MN.

MN performs initial analysis to identify the node that caused the failure. If the failure is caused by a SN, the MN forwards the SCG Failure Information to the SN. The SN performs the final root cause analysis. The details of the solution, including the description in this paragraph are FFS.

One of the functions of self-optimization for PSCell change is to detect PSCell change failures that occur due to Too late PSCell change or Too early PSCell change, or Triggering PSCell change to wrong PSCell. These problems are defined as follows:

- Too late PSCell change: an SCG failure occurs after the UE has stayed for a long period of time in the PSCell; a suitable different PSCell is found based on the measurements reported from the UE.
- Too early PSCell change: an SCG failure occurs shortly after a successful PSCell change from a source PSCell to a target PSCell or a PSCell change failure occurs during the PSCell change procedure; source PSCell is still the suitable PSCell based on the measurements reported from the UE.
- Triggering PSCell change to wrong PSCell: an SCG failure occurs shortly after a successful PSCell change from a source PSCell to a target PSCell or a PSCell change failure occurs during the PSCell change procedure; a suitable PSCell different with source PSCell or target PSCell is found based on the measurements reported from the UE.

#### MDT enhancement

- Support for NR MDT IDC mechanism
- Extension to LoggedMeasurementConfiguration with a flag to indicate if an early measurement/idle mode configuration has relevance for logged measurement purposes
- UE support to assist the network in preventing management based logged MDT overwriting signalling based logged MDT
- Extension to LoggedMeasurementConfiguration with Logged MDT type indication used for signalling MDT protection
- RACH failure report extension with 2-step RACH relevant information
- Support for multiple CEF reports
- Support of M5~M7 for EN-DC SN terminated MCG bearer/split bearers and MN terminated SCG/split bearers
- Immediate MDT configuration support for MN terminated SCG bearer and SN terminated MCG/split bearer by the terminated node, e.g., MN in case of MN terminated SCG bearer
- RLF report support for CHO and DAPS HO
- Support for logging of on-demand SI

#### L2 measurement

PRB usage for MIMO was first introduced to NR in Rel-16 to reflect the PRB usage at the case of MU-MIMO and multiple MIMO layers. Configuring the same constant value Alpha for all the cells sometimes is not suitable, especially for cells in bad radio condition. And it is also difficult to manually configure Alpha for each cell, considering the large number of NR base stations. In Rel-17, PRB Usage based on statistical MIMO layer and Enhanced PRB Usage for MIMO are specified. Comparing with R16 PRB usage measurement, the new PRB usage measurement can adjust Alpha autonomously, e.g., based on statistical data of MIMO layer. The objectives of the measurements are to measure usage of time and frequency resources. A use-case is OAM performance observability.

In addition, PDCP excess packet delay is also specified for delay sensitive services, e.g., URLLC. The objective of this measurement performed by UE is to measure Excess Packet Delay in Layer PDCP for QoS verification of MDT.

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860053,860153>

- [1] RP-22xxxx, Status report for WI on enhancement of SON\_MDT support for NR and MR-DC, CMCC

## 9.4.2 Autonomous network levels

850032	<a href="#">Study on autonomous network levels</a>	FS_ANL	S5	SP-190928	China Mobile
880027	<a href="#">Autonomous network levels</a>	ANL	S5	SP-200464	Cao, Xi, China Mobile

Summary based on the input provided by China Mobile in SP-220580.

This WI specifies the concepts for autonomous networks, autonomous network level (ANL), and use cases, requirements and solutions for the levels of autonomous functions in a 3GPP network. Examples of enablers for

autonomous network are: Self-Organization Network (SON), management data analytics (MDA), intent driven management (IDM), closed loop SLS assurance (COSLA).

Autonomous network is a telecommunication system (including management system and network) with autonomy capabilities which is able to be governed by itself, with minimal to no human intervention. ANL is used to describe the level of autonomy capabilities in the autonomous network. A framework approach for evaluating ANL is as follows:

Autonomous network level		Task categories				
		Execution	Awareness	Analysis	Decision	Intent handling
L0	Manual operating network	Human	Human	Human	Human	Human
L1	Assisted operating network	Human & Telecom system	Human & Telecom system	Human	Human	Human
L2	Preliminary autonomous network	Telecom system	Human & Telecom system	Human & Telecom system	Human	Human
L3	Intermediate autonomous network	Telecom system	Telecom system	Human & Telecom system	Human & Telecom system	Human
L4	Advanced autonomous network	Telecom system	Telecom system	Telecom system	Telecom system	Human & Telecom system
L5	Full autonomous network	Telecom system	Telecom system	Telecom system	Telecom system	Telecom system

NOTE 1: Human reviewed decision have the highest authority in each level if there is any confliction between human reviewed decision and telecom system generated decision.

NOTE 2: The order of above five task categories does not reflect the workflow sequence.

This WI specifies the Generic autonomous network level for network optimization, the RAN NE deployment and the fault management.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850032,880027>

- [1] TR 28.810: "Study on concept, requirements and solutions for levels of autonomous network"
- [2] TS 28.100: "Management and orchestration; Levels of autonomous network;"

## 9.4.3 Enhancements of Self-Organizing Networks (SON)

UID	Name	Acronym	WG	WID	WI rapporteur name/company
870028	<b>Enhancements of Self-Organizing Networks (SON) for 5G networks</b>	eSON_5G	S5	SP-200194	Joey Chou, Intel
<b>900031</b>	<b>Enablers for Network Automation for 5G - phase 2</b>	<b>eNA_Ph2</b>		<b>SP-200975</b>	<b>TBD</b>
840022	Study on Enablers for Network Automation for 5G - phase 2	FS_eNA_Ph2	S2	SP-200098	Xiaobo Wu, Huawei Technologies
890015	Study on security aspects of enablers for Network Automation (eNA) for 5GS Phase 2	FS_eNA_SEC	S3	SP-200722	Xiaoting Huang, China Mobile
900010	<b>Stage 2 of eNA_Ph2</b>	eNA_Ph2	S2	SP-200975	TBD
<b>910012</b>	<b>CT aspects of eNA_Ph2</b>	<b>eNA_Ph2</b>	<b>ct</b>	<b>CP-211191</b>	<b>Huang Zhenning (China Mobile)</b>
910088	CT3 aspects of eNA_Ph2	eNA_Ph2	C3	CP-211191	Huang Zhenning (China Mobile)
910089	CT4 aspects of eNA_Ph2	eNA_Ph2	C4	CP-211191	Huang Zhenning (China Mobile)
930007	<b>Security aspects of eNA_Ph2</b>	eNA_Ph2	S3	SP-210837	Chang Liu, China Mobile

Summary based on the input provided by vivo/China Mobile in SP-220629.

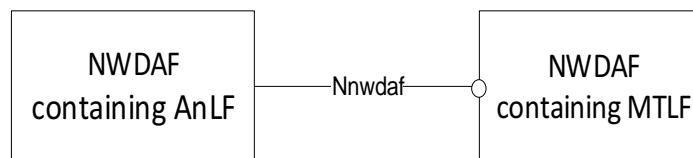
In addition to NWDAF related work initiated in Rel-15 and Rel-16, this WI (eNA\_Ph2) further specify framework enhancements and define extensions to existing Nnwdaf service for supporting network automation.

The Network Data Analytics Function (NWDAF) is to support network automation as listed in TS 23.288[4] and includes one or more of the following functionalities:

- Support data collection from NFs, AFs and OAM as shown;
- NWDAF service registration and metadata exposure to NFs and AFs;
- Support analytics information provisioning to NFs and AFs as shown;
- Support Machine Learning (ML) model training and provisioning to NWDAFs (containing Analytics logical function).

In addition to the framework specified in Rel-15 and Rel-16, further specify framework enhancements to support network data analytics service:

- Logical function decomposition of NWDAF (Model Training logical function, Analytics logical function) and the interactions between these logical functions as shown in Figure 1;
- Increasing efficiency of data collection;
- Trained data model sharing between multiple NWDAF instances, limited to single vendor environments;
- multiple NWDAF instances;
- UE data as an input for analytics generation (via AF);
- User consent for UE data collection/analysis;
- Triggering conditions for the Data Analytics;
- Enhancement for real-time communication.



**Figure 1 Trained ML Model Provisioning architecture**

In addition to Nnwdaf services defined in R15 and R16, define extensions to support the analytics that are required for Slice SLA enhancement, Dispersion Analytics, NWDAF-assisted UP optimization, NWDAF-assisted RFSP policy, UP optimization for edge computing, adding application attributes to User Data congestion Analytics.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870028,900031,840022,890015,900010,910012,910088,910089,930007>

- [1] TS 23.501: "System architecture for the 5G System (5GS)"
- [2] TS 23.502: "Procedures for the 5G System (5GS)"
- [3] TS 23.503: "Policy and charging control framework for the 5G System (5GS)"
- [4] TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services"
- [5] TR 23.700-91: "Study on enablers for network automation for the 5G System (5GS)"

## 9.5 Minimization of service Interruption

UID	Name	Acronym	WG	WID	WI rapporteur name/company
<b>850045</b>	<b>Support for Minimization of service Interruption</b>	<b>MINT</b>		<b>SP-190814</b>	<b>SungDuck Chun; LG Electronics</b>
830018	Study on MINT	FS_MINT	S1	SP-190090	SungDuck Chun; LG Electronics
850036	<b>Stage 1 of MINT</b>	MINT	S1	SP-190938	SungDuck Chun; LG Electronics
920062	<b>Stage 2 of MINT</b>	MINT	S2	SP-210582	Hyunsook Kim, LG Electronics
900004	Study on the CT aspects of Support for Minimization of service Interruption	FS_MINT-CT	C1	CP-203232	Sang Min Park, LG Electronics
<b>930003</b>	<b>Stage 3 of MINT</b>	<b>MINT</b>	<b>ct</b>	<b>CP-212166</b>	<b>Hyunsook Kim</b>
930049	CT1 aspects of MINT	MINT	C1	CP-212166	Hyunsook Kim
930045	CT4 aspects of MINT	MINT	C4	CP-212166	Hyunsook Kim
930048	CT6 aspects of MINT	MINT	C6	CP-212166	Hyunsook Kim

Summary based on the input provided by LG Electronics in SP-220484.

Based on the conclusions reached within clause 8 of TR 24.811 [1], the support of Disaster Roaming with Minimization of Service Interruption is specified.

MINT aims to enable a UE to obtain service from a PLMN offering Disaster Roaming service when a Disaster Condition applies to the UE's determined PLMN.

First, there are some assumptions as follows:

- Disaster Condition only applies to NG-RAN nodes, which means the rest of the network functions except one or more NG-RAN nodes of the PLMN with Disaster Condition can be assumed to be operational.
- The network nodes and NG-RAN are configured with Disaster Condition via OAM based on operator policy and the request by the government agencies.

Based on the requirements for Disaster Roaming service as specified in TS 22.011 [2] and clause 6.31 of TS 22.261 [3], the support of Disaster Roaming with Minimization of Service Interruption is specified in clause 5.40 of TS 23.501 [4] as the following overall descriptions;

- when the UE shall attempt Disaster Roaming.
- how/which information the UE is configured with
- how the UE determines the Disaster Condition
- how the UE registers for Disaster Roaming service
- how to handle when a Disaster Condition is no longer applicable
- how to prevent of signalling overload related to Disaster Condition and Disaster Roaming service

In addition, the relevant procedures such as registration, session establishment, etc., are updated in TS 23.502 [5].

The network selection and the access control for the Disaster Roaming are specified in clause 3.10 of TS 23.122 [6] and clause 4.24 of TS 24.501 [7]. Especially, the standardized Access Identity for MINT is specified in TS 22.261 [3], and it is applied in the access control for the UE for which Disaster Condition applies.

System information extensions for MINT are specified in TS 38.304 [8] and TS 38.331 [9] by RAN WG2.

The security aspects on the UE authentication during the authentication procedure are specified in clause 6.1.2 of TS 33.501 [10].

Based on the Stage 2 description to support Disaster Roaming service, Stage 3 normative works are specified in TS 24.501 [7], TS 29.503 [11] and TS 29.509 [12].

The information to be pre-configured or stored in USIM for Disaster Roaming service are specified in TS 31.102 [13] and TS 31.111 [14].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850045,830018,850036,920062,900004,930003,930049,930045,930048>

- |      |  |
|------|--|
| [1]  | TR 24.811: "Study on the support for minimization of service interruption".                  |
| [2]  | TS 22.011: "Service accessibility".  |
| [3]  | TS 22.261: "Service requirements for the 5G system; Stage 1"                                 |
| [4]  | TS 23.501: "System architecture for the 5G System (5GS); Stage 2"                            |
| [5]  | TS 23.502: "Procedures for the 5G System (5GS)"  |
| [6]  | TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode". |
| [7]  | TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3"                  |
| [8]  | TS 38.304: "NR; User Equipment (UE) procedures in idle mode and in RRC Inactive state"       |
| [9]  | TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification"                        |
| [10] | TS 33.501: "Security architecture and procedures for 5G System"                              |
| [11] | TS 29.503: "5G System; Unified Data Management Services; Stage 3"                            |
| [12] | TS 29.509: "5G System; Authentication Server Services; Stage 3"                              |
| [13] | TS 31.102: "Characteristics of the Universal Subscriber Identity Module (USIM) application"  |
| [14] | TS 31.111: "Universal Subscriber Identity Module (USIM) Application Toolkit (USAT)"          |

## 9.6 Policy and Charging Control enhancement

920012	<b>Enhancement of 5G PCC related services in Rel-17</b>	en5GPccSer17	C3	CP-211193	Xiaoyun Zhou, Huawei
--------	---	--------------	----	-----------	----------------------

Summary based on the input provided by Huawei in CP-211193.

This Work Item specifies the stage 3 procedures related to EPS functionality which are not completely covered in 5GS\_Ph1-CT and en5GPccSer.

The protocols and APIs for policy and charging control (PCC) have been specified in the previous 3GPP Releases. When the 5GS was deployed, it was found that some functionalities defined in Gx/Rx for EPS are still applicable in the



5GS and EPS interworking scenario. There are also some aspects of 5GS that are not supported by the Rx interface when the Rx interworks with the 5GS.

In order to optimize the operator's management, alignments have been made between the EPS and 5GS interfaces.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920012>

- [1] TS 29.512: "5G System; Session Management Policy Control Service".
- [2] TS 29.513: "5G System; Policy and Charging Control signalling flows and QoS parameter mapping; Stage 3".
- [3] TS 29.514: "5G System; Policy Authorization Service; Stage 3".
- [4] TS 29.214: "Policy and Charging Control over Rx reference point 5".

## 9.7 Multi-(U)SIM

### 9.7.1 Support for Multi-USIM Devices (System and CN aspects)

UID	Name	Acronym	WG	WID	WI rapporteur name/company
840049	<b>Support for Multi-USIM Devices</b>	<b>MUSIM</b>		<b>SP-190309</b>	<b>Liao, Ellen C, Intel</b>
830019	Study on MUSIM	FS_MUSIM	S1	SP-190091	Liao, Ellen C, Intel
840040	<b>Stage 1 of MUSIM</b>	MUSIM	S1	SP-190309	Liao, Ellen C, Intel
820012	Study on Stage 2 (System Enablers) for MUSIM	FS_MUSIM	S2	SP-200297	Sašo Stojanovski, Intel
900013	<b>System enablers for Multi-USIM devices</b>	MUSIM	S2	SP-210091	Sašo Stojanovski, Intel
910015	<b>CT aspects of MUSIM</b>	<b>MUSIM</b>	<b>ct</b>	<b>CP-212102</b>	<b>Thomas Luetzenkirchen, Intel</b>
910063	CT1 aspects of Enabling Multi-USIM Devices	MUSIM	C1	CP-212102	Thomas Luetzenkirchen, Intel
910064	CT4 aspects of Enabling Multi-USIM Devices	MUSIM	C4	CP-212102	Thomas Luetzenkirchen, Intel
900017	Study on the security of the system enablers for devices having multiple Universal Subscriber Identity Modules (USIM)	FS_MUSIM_SEC	S3	SP-201018	Abhijeet Kolekar, Intel Corporation

Summary based on the input provided by Intel in SP-220574.

The MUSIM work item specifies 5GS and EPS support for Multi-USIM UEs for delivery of Mobile Terminated (MT) services, enabling paging reception and performing coordinated leaving.

A Multi-USIM UE is a UE with multiple USIMs, capable of maintaining a separate registration state with a PLMN for each USIM at least over 3GPP access and supporting one or more of the MUSIM features described further below.

The stage-1, stage-2 and security studies are documented in TR 22.834 [1], TR 23.761 [2] and TR 33.873 [3], respectively. The service requirements are specified in TS 22.101 [4], TS 22.261 [5] and TS 22.278 [6]. The stage-2 aspects for 5GS are specified in TS 23.501 [7] and TS 23.502 [8]. The stage-2 aspects for EPS are specified in TS 23.401 [9] and TS 23.272 [10]. IMS-related aspects are specified in TS 23.228 [11]. NAS protocol aspects are specified in TS 24.501 [12] and TS 24.301 [13] for 5GS and EPS, respectively. A new MUSIM-specific rejection cause is specified in TS 29.518 [14] and TS 29.274 [15] for 5GS and EPS, respectively. MUSIM-specific AT commands are specified in TS 27.007 [16].

The RAN-related aspects of MUSIM are covered by a related RAN work item (RP-213679 [17]).

The following features were specified as part of the MUSIM work item:

- Connection Release, allowing the Multi-USIM UE to request the network to release the UE from RRC-CONNECTED state in 3GPP access for a USIM due to activity on another USIM in 3GPP access.
- Paging Cause Indication for Voice Service, allowing the network to indicate to the Multi-USIM UE when it is being paged for voice.
- Reject Paging Request, allowing the Multi-USIM UE to indicate to the network that the UE does not accept the paging and requests to return to CM-IDLE state after sending this response.
- Paging Restriction, allowing the Multi-USIM UE to request the network to not be paged for any MT service, or to be paged only for voice, or for traffic arriving on selected PDU Session / PDN Connection, or for a combination thereof.
- Paging Timing Collision Control, allowing the Multi-USIM UE to request an IMSI Offset (EPS) or a new 5G-GUTI (5GS) that is used for determination of paging occasions.

The Multi-USIM UE and the 5GC/EPC exchange their MUSIM capabilities as part of the Registration procedure (5GS), or the Attach and Tracking Area Update procedures (EPS).

The following 3GPP system entities are impacted by MUSIM:

- UE.



- MME / AMF.
- RAN / NG-RAN.
- SGW-C / SMF (new rejection cause).

The following procedures in TS 23.502 [8] and TS 23.401 [9] are impacted by MUSIM:

- Service Request (for Reject Paging, Connection Release, Paging Restrictions).
- Registration / Attach / Tracking Area Update (for MUSIM capability exchange, Paging Timing Collision Control).
- Registration / Tracking Area Update (for Connection Release, Paging Restrictions).
- N2 Paging / S1 Paging (for Paging Cause Indication for Voice Service).

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840049,830019,840040,820012,900013,910015,910063,910064,900017>

- [1] TR 22.834: "Study on support for devices with multiple Universal Subscriber Identity Modules (USIMs)".
- [2] TR 23.761: "Study on system enablers for devices having multiple Universal Subscriber Identity Modules (USIM)".
- [3] TR 33.873: "Study on the security of the system enablers for devices having Multiple Universal Subscriber Identity Modules (MUSIM)".
- [4] TS 22.101: "Service aspects; Service principles".
- [5] TS 22.261: "Service requirements for the 5G system".
- [6] TS 22.278: "Service requirements for the Evolved Packet System (EPS)".
- [7] TS 23.501: "System architecture for the 5G System (5GS)".
- [8] TS 23.502: "Procedures for the 5G System; Stage 2".
- [9] TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".
- [10] TS 23.272: "Circuit Switched (CS) fallback in Evolved Packet System (EPS); Stage 2".
- [11] TS 23.228: "IP Multimedia Subsystem (IMS); Stage 2".
- [12] TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".
- [13] TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".
- [14] TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".
- [15] TS 29.274: "3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3".
- [16] TS 27.007: "AT command set for User Equipment (UE)".
- [17] RP-213679: "Revised WID: Core part: Support for Multi-SIM devices for LTE/NR".

## 9.7.2 Support for Multi-SIM Devices for LTE/NR

860063	Support for Multi-SIM devices for LTE/NR	LTE_NR_MUSIM		RP-212610	Vivo
860163	Core part: Support for Multi-SIM devices for LTE/NR	LTE_NR_MUSIM-Core	R2	RP-212610	Vivo

Summary based on the input provided by vivo in RP -220604.

This work item specifies solutions to address the paging occasion collision issue for single-Rx/single-Tx Multi-USIM (MUSIM) UE, and to notify network A of its switch from network A for MUSIM purpose, and to support indicating to the MUSIM UE whether an incoming paging is for voice service.

The following schemes were introduced as part of the Work Item:

- Paging collision objective: To solve paging occasion collision problem, the MUSIM UE can trigger a new 5G-GUTI reallocation in 5GS or an IMSI offset assignment in EPS to modify the timing of the paging occasions. In 5GS, the UE obtains a new 5G-GUTI by performing a MRU without any specific indication. In EPS, the UE can provide a requested IMSI offset value in Attach Request or TAU Request, which triggers the MME to provide an accepted IMSI Offset value in the Attach Accept or TAU Accept message. The MME and UE use the alternative IMSI (calculated based on the IMSI and the accepted IMSI offset) for the determination of paging occasion.
- Network notification objective: AS-based network switching for leaving RRC\_CONNECTED and network switching without leaving RRC\_CONNECTED (i.e., requesting/configuring MUSIM gaps) were introduced. Both schemes can be configured by the network separately.

When determining it needs to leave RRC\_CONNECTED, the UE sends the UEAssistanceInformation message, which indicates the UE's preferred RRC state when leaving RRC\_CONNECTED for MUSIM purpose. gNB may

release the UE to RRC IDLE/INACTIVE when receiving this UAI. The UE is allowed to enter RRC\_IDLE if it does not receive response message from network within a certain configured time.

When determining it needs the MUSIM gaps, the UE sends the UEAssistanceInformation message, which indicates the UE's preference on the MUSIM gaps. The UE can request at most a single aperiodic MUSIM gap and two periodic MUSIM gaps. The MUSIM gap is per UE level.

- Paging cause objective: a paging cause field with only one codepoint voice was introduced in the NR/LTE Uu paging message, S1AP/NGAP paging message, and XNAP/F1AP paging message. The network provides this field for the upcoming paging triggered by IMS voice, only if the UE indicates the paging cause feature is supported to the network. In order to enable NG-RAN to deliver the paging cause in RAN paging for the UE in RRC-INACTIVE, the AMF provides an indication indicating the Paging Cause Indication for Voice Service feature is supported to the NG-RAN. The NG-RAN node knows the downlink data which triggers the RAN Paging message is related to voice service based on the Paging Policy Indicator, in the header of the received downlink data.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860063.860163>

[1] RP-220603, Status report for WI

# 10 Energy efficiency, power saving

## 10.1 UE power saving enhancements for NR

860047	UE power saving enhancements for NR	NR_UE_pow_sav_enh		RP-212630	MediaTek
860147	Core part: UE power saving enhancements for NR	NR_UE_pow_sav_enh-Core	R2	RP-212630	MediaTek
860247	Perf. part: UE power saving enhancements for NR	NR_UE_pow_sav_enh-Perf	R4	RP-212630	MediaTek

Summary based on the input provided by MediaTek Inc., ZTE in RP-221544.

User experience is key to 5G/NR success, not only in terms of experienced data rates and latency but also importantly UE power consumption. UE Power saving enhancements are therefore vital to the success of 5G/NR. In Rel-17, additional enhancements are required to address outstanding issues in Rel-16, including idle/inactive-mode power consumption in NR SA deployments and connected-mode power consumption with traffic of more frequent packet arrivals, etc. Accordingly, the following new functionalities are developed and supported for NR:

- Enhancements for idle/inactive-mode UE power saving: Paging enhancements to reduce UE reception power consumption in idle/inactive mode and Provision of potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs
- Enhancements for connected-mode UE power saving: Further PDCCH monitoring reduction, including enhanced search space set group (SSSG) switching and PDCCH skipping and Relaxation of UE measurements for RLM and/or BFD in connected mode

### Paging enhancements to reduce UE reception power consumption in idle/inactive mode

In order to reduce UE power consumption due to false paging alarms, the group of UEs monitoring the same PO can be further divided into multiple subgroups. With subgrouping, a UE shall monitor PDCCH in its PO for paging if the subgroup to which the UE belongs is paged as indicated via associated paging early indication (PEI). Since the false paging probability is reduced with subgrouping, UE reception power consumption in idle/inactive mode can be reduced accordingly. If the UE is unable to monitor the associated PEI occasion corresponding to its PO, it shall monitor the paging in its PO.

These subgroups have the following characteristics:

- Subgrouping is either CN controlled or UE ID based:
  - For CN controlled subgrouping, AMF is responsible for assigning subgroup ID to the UE. The total number of subgroups for CN controlled subgrouping which can be configured e.g. by OAM is up to 8. It is assumed CN-based paging subgrouping support in an RNA is homogeneous.

- o For UE ID based subgrouping, the gNB and UE can determine the subgroup ID based on the UE ID and the total number of subgroups for UE ID based subgrouping in the cell. The total number of subgroups for UE ID based subgrouping is decided by the gNB for each cell and can be different in different cells.
- Total number of subgroups allowed in a cell is up to 8 and represents the sum of CN controlled and UE ID based subgrouping configured by the network;
- A UE with CN controlled subgroup ID shall apply CN controlled subgroup ID if there is a corresponding indication allocated in the PEI for the CN controlled subgroup; otherwise, it derives UE ID based subgroup ID if the cell supports only UE ID based subgrouping.

PEI associated with subgroups has the following characteristics:

- If the PEI is supported by the UE, it shall at least support UE ID based subgrouping method;
- PEI monitoring can be optionally limited via system information to the last used cell;
- PEI monitoring is based on Type2A-PDCCH Common Search Space (CSS) set for a DCI format 2\_7 with CRC scrambled by a PEI-RNTI on the primary cell of the MCG. Each bit of paging indication field of DCI format 2\_7 indicates one UE subgroup of a paging occasion;
- A PEI occasion (PEI-O) is a set of PDCCH monitoring occasions (MOs) and can consist of multiple time slots (e.g. subframe or OFDM symbol) where PEI can be sent. The number of PO(s) associated with one PEI -O is a factor of total PO number associated with up to two paging frames (PFs).
- The time location of PEI-O for UE's PO is determined by a reference point and a symbol-level offset from the reference point to the start of the first PDCCH monitoring occasion of this PEI-O. The reference point is the start of a reference frame determined by a frame-level offset from the start of the first PF of the PF(s) associated with the PEI-O. The time location of PEI-O can be configured so that total UE reception power consumption in idle/inactive mode, including synchronization and RRM measurements, can be minimized.

#### **Provision of potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs**

In order to reduce UE power consumption due to synchronization for paging receptions, RS configuration of TRS occasion(s) for idle/inactive UE(s) can be provided via system information (SIB17). By exploiting TRS for synchronization, UE can reduce the number of wake-up for SSB before a paging reception and potentially achieve longer sleep. It is noticed that RS configuration in SIB17 does not affect the UE behaviour in CONNECTED mode and can be ignored by UE in CONNECTED mode.

The maximum number of TRS resource sets configured by higher layer is 64. If a TRS resource is configured, the L1 based availability indication is always enabled based on that configuration. A UE which acquired SIB17 with a TRS configuration but did not yet receive an associated L1-based availability indication considers the configured TRS as unavailable. The L1 availability indication is carried in a DCI format 2\_7, if configured, and a DCI format 1\_0 with CRC scrambled by P-RNTI. The TRS availability indication field in the DCI format(s) provides a bitmap for up to 6 groups of TRS resource sets where the configuration of each TRS resource set includes an association to a bit of the bitmap. The UE can be additionally provided a validity duration for TRS resource sets with indicated presence. UE considers the validity duration for all TRS resource set groups is ended when UE receives the changed TRS/CSI-RS configuration in the modification period following a SI change notification or until the validity time duration expires, whichever is earlier.

#### **Further PDCCH monitoring reduction, including enhanced SSSG switching and PDCCH skipping**

In order to reduce UE power consumption on PDCCH monitoring, enhanced PDCCH monitoring adaptation mechanisms within an active BWP and triggered by scheduling DCI formats are provided. The adaptation applies to Type3-PDCCH CSS sets or USS sets on the active DL BWP of the serving cell. The adaptation is triggered according to the PDCCH monitoring adaptation indication field, if present, in DCI format 0\_1/0\_2/1\_1/1\_2. With the fast adaptation mechanisms, UE can be indicated to perform reduced PDCCH monitoring at the end of or after a duration of data scheduling, thereby achieving UE power saving with minimum impact to data scheduling.

UE power saving can be achieved through Rel-17 SSSG switching mechanism when Rel-17 SSSG configuration is configured. UE can be indicated to switch to a target SSSG via the indication of a scheduling DCI. If search space switch timer is also configured, UE switches to the SSSG of the lowest group index after timer expiration if no detected DCI format with CRC scrambled by C-RNTI/CS-RNTI/MCS-C-RNTI for the configured timer duration. The switch delay is at least Pswitch symbols, and Pswitch depends on the numerology of the serving cell. For Rel-17, UE can be configured with up to 3 SSSGs.

UE power saving can also be achieved through PDCCH skipping mechanism when PDCCH skipping duration configuration is configured. UE can be indicated to skip PDCCH monitoring for a duration, starting from next slot after the indication, and shall resume PDCCH monitoring after the indicated duration. For Rel-17, UE can be configured with up to 3 skipping durations. In the following cases, UE ignores PDCCH skipping:

- on all serving cells of the corresponding Cell Group when SR is sent and is pending;
- on SpCell while contention resolution timer is running;
- on SpCell during monitoring of the RAR/MsgB window.

UE can be configured with both Rel-17 SSSG configuration and PDCCH skipping durations. In this case, UE performs either SSSG switching or PDCCH skipping based on the PDCCH monitoring adaptation indication field in a detected DCI format 0\_1/0\_2/1\_1/1\_2.

#### **Relaxation of UE measurements for RLM and/or BFD in connected mode**

UE power saving can be enabled by UE relaxing measurements for RLM/BFD. When configured, UE determines whether its serving cell radio link quality is better than a threshold and, if criterion is configured, whether it is in low mobility state. The configuration for good serving cell quality criterion and, if included, low mobility criterion is provided through dedicated signalling.

RLM and BFD relaxation may be enabled/disabled separately. Additionally, RLM relaxation may be enabled/disabled on per-CG basis while the BFD relaxation may be enabled/disabled on per serving cell basis.

The UE is only allowed to perform RLM and/or BFD relaxation when relaxed measurement criterion for good serving cell quality and, if configured, for low mobility is met. If configured to do so, the UE shall trigger reporting of its RLM and/or BFD relaxation status through UE assistance information if the UE changes its respective RLM and/or BFD relaxation status while meeting the UE minimum requirements specified.

#### **References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860047,860147,860247>

- |     |  |
|-----|--|
| [1] | RP-221543, "Revised WID_UE Power Saving Enhancements for NR", MediaTek Inc.            |
| [2] | RP-220747, "Status report for WI_UE Power Saving Enhancements for NR", MediaTek Inc.   |
| [3] | RP-212972, "Introduction of UE power savings enhancements in NR", RAN1                 |
| [4] | RP-220256, "Rel-17 maintenance of UE power savings enhancements in NR", RAN1           |
| [5] | RP-220483, "RAN2 CRs to UE power saving enhancements for NR", RAN2                     |
| [6] | RP-220960, "Introduction of UE power saving enhancements in 38.300", Huawei, HiSilicon |
| [7] | RP-220961, "Introduction of ePowSav in TS 38.331", CATT                                |
| [8] | RP-220235, "RAN3 CRs for UE power saving enhancements for NR", RAN3                    |
| [9] | RP-220366, "RAN4 CRs for Open REL-17 NR or NR+LTE WIs - Batch 23", RAN4                |

## 10.2 Enhancements on EE for 5G networks

870022	Enhancements on EE for 5G networks	EE5GPLUS	S5	SP-200188	Jean-Michel CORNILY, ORANGE
--------	------------------------------------	----------	----	-----------	--------------------------------

Summary based on the input provided by Ericsson in SP-210326.

This work item addresses Energy Efficiency (EE) of 5G networks from two angles: 1) define EE KPIs and 2) specify solutions to optimize EE via Energy Saving (ES) techniques.

Similar work items addressing 3G and 4G were launched and completed in the past.

- Overall concepts for EE in 5G networks have been described (see [1]);
- New EE KPIs have been defined at various granularity levels of 5G networks: Virtualized Network Function (VNF), 5G Core network function, 5G Core network, NG-RAN, network slice of various types (eMBB, URLLC, MIoT) (see [2]);
- Use cases, requirements and solutions for saving energy in NG-RAN have been described (see [1]);
- 5G NRM (Network Resource Model), representing the management perspective of 5G networks, has been augmented with attributes capturing customer's expectations in terms of energy efficiency of the network slice being ordered (see [3]), in relation with GSMA NG.116 attributes.

## References

- [1] TS 28.310: "Management and orchestration; Energy efficiency of 5G"
- [2] TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)"
- [3] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3"

## 10.3 Other energy efficiency aspects

See section on "Enhancement of data collection for SON/MDT in NR and EN-DC" and on "REFEC".

# 11 New Radio (NR) physical layer enhancements

## 11.1 Further enhancements on MIMO for NR

860040	<b>Further enhancements on MIMO for NR</b>	<b>NR_feMIMO</b>		<b>RP-212535</b>	<b>Samsung</b>
860140	<b>Core part: Further enhancements on MIMO for NR</b>	NR_feMIMO-Core	R1	RP-212535	Samsung
860240	<b>Perf. part: Further enhancements on MIMO for NR</b>	NR_feMIMO-Perf	R4	RP-212535	Samsung

Summary based on the input provided by Samsung in RP-220802.

This WI introduces enhanced specification support for several key aspects on multi-input multi-output (MIMO) operation where Rel-15 and 16 NR were found deficient in terms of signalling latency, overhead, as well as spectral efficiency and coverage.

First, although Rel-15/16 NR supports FR2 deployments via multi-beam operation, signalling latency and overhead especially for beam indication are high for common beam operation. This not only hampers deployments in high-speed scenarios, but also scenarios where the number of configured TCI states is large. In addition, it lacks the support for inter-cell operation, multi-panel UEs, and maximum permissible exposure (MPE) mitigation.

Second, although Rel-16 NR introduced mTRP support for PDSCH, it still lacks ample support for PDCCH, PUSCH, and PUCCH. In addition, enhancements for inter-cell mTRP and beam management aspects specific to mTRP are introduced along with features to facilitate high-speed train deployment on single frequency network (HST-SFN).

Third, SRS has been a useful tool to acquire UL or DL CSI since Rel-15. However, the triggering mechanism of aperiodic SRS limits its flexibility. Further, antenna switching SRS only supports up to 4 antennas, which limits the performance for use cases requiring larger than 4 receive antennas. In addition, along with the expansion of 5G deployment, the demand to further improve SRS capacity and coverage appears.

Fourth, although Rel-16 has enhanced the Rel-15 Type-II to allow improved performance-overhead trade-off, CSI enhancements designed for mTRP non-coherent JT and Type-II assuming FDD (angle-delay) reciprocity can be beneficial to support additional deployment scenarios.

### Enhancements for multi-beam operation

In Rel-15/16, UL beam indication utilizes a different framework from DL beam indication. As DL and UL beam indication share similar characteristics, a unified TCI-based framework for DL and UL beam indication is introduced in Rel-17 where UL TCI is used to represent UL spatial relation. Depending on whether DL and UL share the same TCI (e.g. in relation to the beam correspondence assumption supported by the UE), a UE can be configured with either joint DL/UL TCI (where DL and UL share the same TCI state hence a single TCI state update applies to both) or separate DL/UL TCI (which includes the signalling of DL-only, UL-only, and DL+UL TCI state update).

Central to the Rel-17 TCI framework is the use of common beam for UE-dedicated PDCCH and the associated PDSCH intended to streamline multi-beam operation. While Rel-15/16 supports the use of common beam for UE-dedicated PDCCH and the associated PDSCH, beam indication is performed via MAC-CE. The latency and overhead associated with MAC-CE potentially detract the application of NR for high-speed scenarios in the FR2 regime. In Rel-17, such latency and overhead are reduced with the introduction of DCI-based beam indication using the existing DCI formats 1\_1/1\_2 (with and without DL assignments) via the TCI field. To ensure that the NW and the UE are aligned in terms of TCI state, an ACK mechanism for the beam indication is supported either via the ACK associated with the PDSCH (when beam indication is accompanied with DL assignment) or an ACK mechanism analogous to that used for SPS

PDSCH release (when beam indication is not accompanied with DL assignment). When only one TCI state is activated via MAC-CE, the DCI-based beam indication is not used. In this case, beam indication is performed via MAC-CE.

The Rel-17 TCI framework also supports auxiliary features such as a common TCI state ID update using a common TCI state pool and/or reference CC for Carrier Aggregation, UL power control setting (including PL-RS) association with TCI state, as well as inter-cell beam management. Inter-cell beam management includes measurement and reporting of L1-RSRP as well as beam indication for TCI states associated with PCIs different from that of the serving cell. In addition, common beam operation can be configured to other signals such as non-UE dedicated reception associated with serving cell PCI, aperiodic CSI-RS, and aperiodic SRS.

To better support UEs equipped with multiple panels, UE reporting of the capability associated with the maximum number of SRS ports and its correspondence with CSI-RS or SSB resource indicators (CRI/SSB-RI) is introduced. This reporting is performed in conjunction with the supported beam reporting.

Due to adherence to the MPE (maximum permissible exposure) regulation, some UL coverage penalty is incurred as the UE ends up using a sub-optimal UL transmit beam. To alleviate this issue, some enhancement in the existing PHR report is introduced where beam-specific P-MPR along with the associated CRI/SSBRI is added into the MAC-CE-based PHR report.

#### Enhancements for multi-TRP operation

In Rel-17, PDCCH repetition is defined by explicit linkage between two search space sets. The two linked search space sets can be associated with corresponding CORESETs with different TCI states, hence, achieving beam-diversity for PDCCH transmission. In Rel-17, only intra-slot PDCCH repetition is supported, and also, PDCCH repetition is only supported for USS or Type3 CSS. In addition, the linkage is specified at the PDCCH candidate level by restricting configurations of two linked search space sets resulting in one-to-one mapping between monitoring occasions and between PDCCH candidates of the two linked search space sets. Two linked PDCCH candidates have the same aggregation level, same coded bits, and the same DCI payload. To avoid ambiguity at the UE, a reference PDCCH candidate is defined for various procedures such as timelines, PUCCH resource determination, PDSCH reception with mapping Type B or mapping Type A, determination of QCL assumption for PDSCH when TCI field is not present in DCI, etc. UE can report whether two blind decodes or three blind decodes are needed for two linked PDCCH candidates. In the case of three blind decodes, overbooking for PDCCH is enhanced accordingly. Furthermore, determination of two QCL-TypeD is specified for FR2 to support time-overlapping PDCCH repetitions. PDCCH repetition is supported also for cross-carrier scheduling through linking two search space sets in both scheduling cell and scheduled cell.

In Rel-17, to support multi-TRP PUCCH repetition, up to two sets of power control parameters in FR1 or up to two PUCCH-SpatialRelationInfo in FR2 can be activated per PUCCH resource or per PUCCH resource group via MAC-CE. In addition, multi-TRP PUCCH repetition can be configured by intra-slot PUCCH repetition as well as inter-slot PUCCH repetition for all PUCCH formats. Based on the number of activated PUCCH-SpatialRelationInfo or set of power control parameters for the scheduled PUCCH resource, dynamic switching between single-TRP PUCCH repetition and multi-TRP PUCCH repetition can be supported. Separate power control for multi-TRP PUCCH repetition is supported by two activated PUCCH-SpatialRelationInfo or two activated sets of power control parameters. Furthermore, up to two TPC field for PUCCH can be supported and each TPC field is applied for each closed loop index.

In Rel-17, multi-TRP PUSCH repetition is supported with up to two SRS resource sets with usage set to 'codebook' or 'nonCodebook'. If UE is provided by two SRS resource sets with usage set to 'codebook' or 'nonCodebook', the second SRI field, second TPMI field (if CB-based PUSCH is supported), and second PTRS-DMRS association field are indicated by DCI format 0\_1 or 0\_2 for PUSCH transmission occasion(s) toward the TRP which is related to the second SRS resource set with usage set to 'codebook' or 'nonCodebook' for dynamic grant based PUSCH scheduling. In addition, the new DCI field is defined as 'SRS resource set indicator' with 2 bits to support dynamic switching between single-TRP PUSCH repetition (corresponding to codepoint '00' and '01') and multi-TRP PUSCH repetition (corresponding to codepoint '10' and '11'). Separate power control for multi-TRP PUSCH repetition is supported by linking between two SRI fields and two sets of power control parameters via higher layer parameter. And also up to two TPC field for PUSCH can be supported and each TPC field is applied for each closed loop index. Furthermore, the aforementioned multi-TRP PUSCH repetition is also supported by configured grant type 1 and 2.

In Rel-16, multi-TRP PDSCH transmission is supported with two different mechanisms: single-DCI and multi-DCI. In Rel-17, multi-TRP PDSCH transmission is further extended to inter-cell operation. A UE can be configured with SSB associated with PCI which are different from serving cell PCI, known as additional PCI. At most 7 different additional PCI can be configured to the UE, and only one is activated for inter-cell multi-TRP operation. The additional PCI can



be associated with one or more TCI states, and gNB can schedule PDSCH dynamically from either TRP by indicating TCI in DCI.

In Rel-17, beam reporting and BFR are enhanced for mTRP scenario specifically. For beam reporting enhancement, framework of Rel-15 group based beam reporting is extended to facilitate simultaneous transmission of multiple TRPs. To achieve that, one CSI resource setting including two resource sets corresponding to two TRPs can be configured. In a CSI-report, UE can report  $N$  ( $N_{\max} = \{1, 2, 3, 4\}$ ) groups of simultaneously received beams, wherein each reported beam in one group corresponds to one TRP. Differential L1-RSRP reporting across all beam groups is supported, and 1-bit is added to indicate CMR set associated with the largest RSRP value in the first group. For BFR enhancements, both single-DCI and multi-DCI framework are supported. For multi-DCI, two explicit or implicit BFD-RS sets are introduced for two TRPs in one CC. BFRQ can be transmitted if any one of BFD-RS sets fails. BFRQ framework is enhanced based on Rel-16 SCell BFR. The maximum number of PUCCH-SR resources is extended to 2. After UE receives gNB's response, per-TRP beam reset can be performed. When both BFD-RS sets in SpCell fail, CBRA based RACH transmission can be triggered. For single-DCI, only explicit BFD-RS set configuration can be supported.

Rel-17 defines two key approaches for frequency offset compensation in HST-SFN scenario: UE-based and TRP-based compensation schemes. For UE-based compensation (scheme A), UE receives additional reference signals transmitted by the TRPs in a non-SFN manner to facilitate more accurate frequency offset compensation. The corresponding non-SFN TRS configurations are provided to the UE by using two TCI states (containing reference to the TRS of two TRPs) using DCI and MAC signalling. The TRP-based compensation (scheme B) relies on frequency offset pre-compensation at the network side, where each TRP estimates the downlink frequency by using uplink signal, e.g., SRS, and compensates the downlink frequency per TRP prior to transmission. For TRP based pre-compensation, UE also receives two TRS transmitted by the TRPs in a non-SFN manner using two TCI states. However, since network pre-compensates the PDCCH and PDSCH by the difference of the frequency offsets observed between two TRPs, frequency offset tracking at the UE is performed using only one TRS transmitted by the reference TRP.

#### SRS enhancements

In NR Rel-15/16, aperiodic SRS is triggered by DCI to provide dynamic indication of SRS transmission. However, only one triggering offset value can be configured in RRC per SRS resource set. This limits the valid combinations of the location to send the triggering DCI and the location to transmit SRS, esp. considering TDD slot format, where not all slots are available to transmit SRS. To address this issue, Rel-17 introduces SRS triggering offset enhancement based on available slot definition. Up to 4 offset values can be configured in RRC per SRS resource set, where each value is defined as the number of available slots counting from a reference slot. Reference slot is defined as the slot indicated by legacy triggering offset. In DCI format 0\_1/0\_2/1\_1/1\_2, one new field "SRS offset indicator" (SOI) is added to select one available slot offset value from the configured ones. In addition, Rel-15/16 DCI format 0\_1/0\_2 cannot be indicated to trigger SRS only, i.e., without CSI request and without data. This limitation is removed in Rel-17 by allowing gNB to trigger SRS based on DCI format 0\_1/0\_2 without CSI request and without data.

To ensure performance for use case with larger than 4 receive antennas, Rel-17 introduces antenna switching SRS to support 1T6R, 1T8R, 2T6R, 2T8R and 4T8R. In addition, to improve flexibility of antenna switching SRS, Rel-17 extends the P/SP configurations by supporting maximum 2 SP SRS resource sets and maximum 1 periodic SRS resource set for antenna switching, and the aperiodic configuration by supporting 1 or 4 aperiodic SRS resource sets for 1T4R and 2 aperiodic resource sets for 1T2R/2T4R.

In order to enhance the capacity and coverage for SRS, the following three schemes are specified in Rel-17.

- Increased repetition: Rel-17 supports 8, 10, 12 and 14 consecutive repetition symbols in one slot in one SRS resource.
- Partial frequency sounding: Rel-17 supports to transmit SRS only in  $\frac{1}{P_F} m_{\text{SRS}, B_{\text{SRS}}}$  contiguous RBs in one OFDM symbol, where  $m_{\text{SRS}, B_{\text{SRS}}}$  indicates the number of RBs configured by  $B_{\text{SRS}}$  and  $C_{\text{SRS}}$ . It can be applied on both frequency hopping case and non-frequency hopping case. The scaling factor  $P_F$  is configured by RRC per SRS resource, which can be 2 or 4. The start RB index of the  $\frac{1}{P_F} m_{\text{SRS}, B_{\text{SRS}}}$  RBs in the  $m_{\text{SRS}, B_{\text{SRS}}}$  RBs is  $N_{\text{offset}} = \frac{(k_F + k_{\text{hopping}}) \bmod P_F}{P_F} m_{\text{SRS}, B_{\text{SRS}}}$ , where  $k_F$  is configured by RRC with a value chosen from  $k_F = \{0, 1, \dots, P_F - 1\}$ .  $k_{\text{hopping}}$  is same for all SRS occasions within a legacy FH period but can hop across legacy FH periods. When the hopping of  $k_{\text{hopping}}$  is not enabled, it is fixed to be 0 for all SRS symbols. When the hopping of  $k_{\text{hopping}}$  is enabled, one hopping pattern is supported for each  $P_F$  value.
- Comb 8: Rel-17 supports comb-8 for SRS other than for positioning, where the maximum number of cyclic shifts is 6.

#### CSI for mTRP and FDD reciprocity



The Rel-17 eType-II port selection (PS) codebook assumes  $W_1 W_2 W_f^H$  codebook structure as Rel-16. The key enhancement comes from exploiting angle-delay reciprocity in DL and UL which is applicable for both TDD and FDD. By doing so, spatial domain and frequency domain compression operation inherent in the Rel-16 eType-II PS codebook can be shifted toward the gNB thereby reducing UE computational burden. While the amplitude and phase per channel/propagation path are generally not DL and UL reciprocal, the gNB can employ angle-delay information obtained from UL measurements to precode UE-specific CSI-RS. Therefore from CSI measurement perspective at the UE, a subset of CSI-RS ports based on beamformed CSI-RS resource are first selected by the UE and represented by  $W_1$ , frequency domain compression is represented by  $W_f$  giving rise to up to two selected DFT vectors, and lastly linear combination coefficients are quantized in amplitude and phase by  $W_2$  with configurable compression factors up to 1 by removing negligible coefficients.

Moreover, to improve CSI measurement accuracy over NCJT transmission in Rel-16, Rel-17 NCJT CSI enhancement supports a joint channel measurement at the UE by configuring a CMR pair within the same CSI-RS resource set corresponding to two TRPs respectively. Therefore a CSI-RS resource set is divided as two CMR groups so that each CMR pair consists of one CMR from Group 1 and one CMR from Group 2. From CSI reporting perspective, two modes are supported, whereas Mode 1 is to report X (X=0,1,2) single-TRP CSI and one NCJT CSI versus Mode 2 is to report one single-TRP or NCJT CSI. For the reporting quantity of NCJT CSI (up to rank 4), the main differentiation from legacy releases is that only single CQI/CRI is reported per CMR pair by jointly considering the best companion PMI/RI from two CMRs simultaneously to mitigate TRP interference. Also to use CSI-RS resources and configurations efficiently, sharing mechanism can be enabled by the gNB to reuse a CMR pair (configured for NCJT CSI measurement) for single-TRP CSI measurement if needed.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860040,860140,860240>

## 11.2 MIMO Over-the-Air requirements for NR UEs

880078	<b>Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) requirements for NR UEs</b>	NR_MIMO_OTA		RP-213101	CAICT
880178	Core part: NR_MIMO_OTA	NR_MIMO_OTA-Core	R4	RP-213101	CAICT
880278	Perf. Part: NR_MIMO_OTA	NR_MIMO_OTA-Perf	R4	RP-213101	CAICT

Summary based on the input provided by CAICT, OPPO, vivo in RP-221384.

Radiated multi-antenna reception performance is one of the most important characteristics to verify the MIMO receiver of the UE under conditions more closely resembling the end user's interaction with the device. This NR MIMO OTA core part WI specifies test parameters and channel models for MIMO OTA performance testing based on the outcome of the Rel-16 SI in TR 38.827. In addition, the channel model validation reference values and pass/fail limits to ensure the correct implementation of channel models have also been specified. The outcome of this WI is captured in a new technical specification TS 38.151.

The objective of this core part WI is to specify test parameters, channel models, and pass/fail limits for channel model validation for NR MIMO OTA requirement testing, including both FR1 and FR2. Based on the outcome in TR 38.827, the following aspects in this core part WI have been investigated and specified:

- Figure of Merits: Define the Figure of Merits for FR1 and FR2 MIMO OTA performance requirements for: FR1: Total Radiated Multi-antenna Sensitivity (TRMS) @ 70% throughput; FR2: MIMO Average Spherical Coverage (MASS) @ 50% CDF
- Measurement setup: Specify the test system for FR1 MIMO OTA requirements measurement: 16-probe Multi-Probe Anechoic Chamber (MPAC) ; Specify the test system for FR2 MIMO OTA requirements measurement: 3D Multi-Probe Anechoic Chamber (3D-MPAC)
- Test parameters: Down-select the test parameters for FR1 and FR2 MIMO OTA requirements
- Channel models: Define the FR1 and FR2 channel models for MIMO OTA requirement testing for FR1 UMi CDL-C and UMa CDL-C and FR2 UMi CDL-C; Refine the FR1 and FR2 Base Station beam configurations
- Channel model validation: Define the reference values and pass/fail limits for FR1 and FR2 channel model validation and Refine the measurement setups and procedures for FR1 and FR2 channel model validation

- Preliminary measurement uncertainty assessment: define the preliminary measurement uncertainty (MU) budget for FR1 and FR2 MIMO OTA test systems

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=880078,880178,880278>

- [1] TS 38.151, Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) performance requirements for NR UEs
- [2] RP-221382, Status Report: Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) requirements for NR UEs, RAN4

## 11.3 Enhancements to Integrated Access and Backhaul for NR

860050	Enhancements to Integrated Access and Backhaul (IAB) for NR	NR_IAB_enh		RP-213668	Qualcomm
860150	Core part: Enhancements to IAB for NR	NR_IAB_enh-Core	R2	RP-213668	Qualcomm
860250	Perf. part: Enhancements to IAB for NR	NR_IAB_enh-Perf	R4	RP-213668	Qualcomm
830021	Study on Security for NR_IAB	FS_NR_IAB_Sec	S3	SP-201016	Rajavelsamy Rajadurai, Samsung,

Summary based on the input provided by Qualcomm Incorporated, Samsung in RP-221178.

This WI builds on Rel-16 "IAB for NR", which introduced wireless backhauling of F1 over NR to enable flexible and dense deployment of 5G cells while reducing the need for wireline transport infrastructure.

The enhancements to IAB introduced in Rel-17 improve on various aspects over Rel-16 IAB such as robustness, degree of load-balancing, spectral efficiency, and backhaul performance.

The Rel-17 IAB enhancements support the following new functionality:

- Introduction of inter-donor migration of the IAB-MT to increase robustness and allow for more refined load-balancing and topology management.
- Reduction of service interruption during IAB-node migration and BH RLF recovery to improve network performance, allow the network deployment to undergo more frequent topology changes, and provide more stable backhaul performance.
- Enhancements to scheduling as well as flow and congestion control to improve end-to-end performance as well as spectral efficiency to the IAB network.
- Duplexing enhancements to increase spectral efficiency and reduce latency through the support of SDM/FDM-based resource management and through simultaneous transmissions and/or reception on IAB-nodes.

With Rel-17 enhancements, IAB remains transparent to the UE. At the same time, legacy UEs can benefit from the enhancement provided by Rel-17. The Rel-17 IAB enhancements are further applicable to FR1 and FR2.

### Inter-donor IAB-MT migration and connectivity

#### *Inter-donor IAB-MT migration and recovery*

To enhance robustness and load balancing, Rel-17 IAB introduces the inter-donor partial migration and RLF recovery. For inter-donor partial migration, the IAB-MT performs handover or conditional handover to migrate from the source IAB-donor to the target IAB-donor. For inter-donor RLF recovery, the IAB-MT performs the RRC Reestablishment procedure at the target IAB-donor. During these procedures, the IAB-MT obtains new IP addresses from the target IAB-donor that are anchored at the target IAB-donor-DU to enable IP connectivity via this target IAB-donor-DU. The F1 and non-F1 traffic of the migrating IAB-node and its descendent nodes is then routed via a new BAP path that uses the target IAB-donor-DU. The F1 connections, however, remain terminated at the source IAB-donor. This traffic migration is facilitated via coordination between source and target IAB-donors using the XnAP IAB Transport Migration Management/Modification procedures introduced in Rel-17 for this purpose. In these procedures, the source IAB-donor sends QoS information of the traffic to be migrated to the target IAB-donor, so that the target IAB-donor can establish the backhaul transport on RLC and BAP sublayers on the target path. The target IAB-donor informs the source IAB-donor about all layer-2 and IP information needed by the source IAB-donor to configure the necessary end-to-end transport. The XnAP IAB Transport Migration Management/Modification procedures are also used to allocate IP addresses for descendent nodes, and to ensure proper QoS and connectivity support via the target IAB-donor-DU over time, e.g., due to configuration or release of new F1-U GTP-tunnels.

Rel-17 introduces the concept of the IAB-topology, which contains all IAB-nodes and IAB-donor-DUs as well as all backhaul links that are controlled by the same IAB-donor via RRC and/or F1AP. After inter-donor partial or RLF recovery, all descendent node traffic has to pass through two IAB topologies controlled by separate IAB-donors. The migrating IAB-node is referred to as the boundary IAB-node since it is controlled by both IAB-donors and therefore resides in both topologies.

The concept of the IAB-topology is necessary to coordinate the L2 configurations across an IAB-network controlled by two IAB-donors. Each IAB-donor can independently use the full name space of BAP addresses, BAP path IDs and BH RLC CH IDs for the transport in its own IAB topology. Descendent-node traffic that travels across two IAB-topologies uses a separate BAP routing IDs for each of these two topologies. At the boundary node, the BAP routing ID used by a BAP PDU in one topology is rewritten to the BAP routing ID the BAP PDU uses in the other topology. The BAP routing ID mapping is coordinated between both IAB-donors during traffic migration.

Rel-17 enhancements also allow for the revocation of the traffic migration caused by inter-donor partial migration. For this purpose, the target IAB-donor conducts an Xn handover of the IAB-MT in reverse direction, i.e., back to the former source IAB-donor. The source IAB-donor can request the revocation of this traffic migration.

Source and target IAB-donors can further coordinate the use of radio resources used on parent and child links via the XnAP IAB Resource Coordination procedure introduced in Rel-17 for this purpose.

#### *Inter-donor topological redundancy*

For the enhancement of load balancing, Rel-17 IAB further introduces inter-donor topological redundancy. For this purpose, the IAB-MT executes the NR DC procedure to concurrently connect to two IAB-donors. The collocated IAB-DU can establish F1 with either of these two IAB-donors. Inter-donor topological redundancy also interconnects two IAB-topologies where the dual-connected IAB-node assumes the role of the boundary node. F1 and non-F1 traffic of the dual-connected IAB-node and its descendent nodes can be gradually migrated between the two paths via either the MN's or the SN's IAB-donor-DU. The XnAP IAB Transport Migration Management/Modification procedures are used for the coordination between MN and SN IAB-donors for this traffic migration. The boundary node applies BAP header rewriting for all traffic that passes through both IAB-topologies. The MN and SN further coordinate the use of radio resources used on the parent links and child links of the dual-connecting IAB-node.

#### *CP-UP separation*

For the enhancement of robustness, Rel-17 IAB introduces CP-UP separation for an IAB-node that is dual-connected with an IAB-donor and a gNB, which does not assume IAB-donor role. In this case, the IAB-node's F1-C can be exchanged via the backhaul with the IAB-donor or, alternatively, via the path containing the access link between IAB-node and gNB and the Xn connection between gNB and IAB-donor. For CP-UP separation, the gNB can either assume MN or SN role. In the former case, SRB2 is used on the NR access link for the passing of F1-C traffic, and split SRB in the latter case.

### **Reduction of service interruption**

#### *Intra-donor migration with parallel migration of descendent nodes*

For the reduction of service interruption during intra-donor IAB-node migration, Rel-17 introduces enhancements to enable concurrent traffic migration by the descendent nodes and the migrating IAB-node. For this purpose, the IAB-donor sends the RRC Reconfiguration messages to the descendent nodes prior to migration. It includes an indicator in the F1AP Transfer message for the descendant's parent node to withhold the RRC message from delivery until the migration has succeeded. When the migration succeeds, all RRC messages withheld are released in a top-down sequence through the tiers of the subtree. In this manner, all IAB-nodes affected can conduct the migration of F1-C in a concurrent rather than sequential manner.

#### *Support of inter-donor-DU local re-routing*

For the reduction of packet loss due to link unavailability, Rel-17 introduces inter-donor-DU local re-routing for UL traffic.

The NR dual-connected IAB-node can perform inter-donor-DU re-routing in case its parent backhaul links connect to separate IAB-donor-DUs, but do not share a single route to a common IAB-donor-DU. When one of the parent links is not available, the IAB-node can re-route the UL traffic via the other parent link to the alternative IAB-donor-DU. To ensure proper routing on the BAP sublayer, the IAB-node rewrites the BAP header of these re-routed UL PDUs with a BAP routing ID that contains the BAP address of this alternative IAB-donor-DU.

The alternative IAB-donor-DU can forward the traffic to the peer IAB-donor-DU, which was the packet's original destination, via a statically configured GTP-U tunnel. The alternative IAB-donor-DU selects a packet for tunneling by matching the packet's source IP address with a IAB-donor-configured IP address list. In case the alternative IAB-donor-DU and its peer belong to separate IAB-donor-CUs, the IP address list is forwarded between the IAB-donors.

#### *Enhancements to BH RLF indications*

For the reduction of packet loss due to BH RLF, Rel-17 introduces the BH RLF detection indication and the RLF recovery indication. In case an IAB-node attempts RRC Reestablishment due to BH RLF, it can send the RLF detection indication to each child node. If the child node has an alternative backhaul path available, it can apply UL rerouting for upstream packets. If it has no such alternative backhaul path, it can propagate the BH RLF detection indication to the next tier. When the IAB-node has recovered from the BH RLF, it can send the RLF recovery indication to each child node, which revokes all behaviour triggered by the BH RLF detection indication before. The BH RLF recovery indication is propagated in the same manner as the BH RLF detection indication.

#### **Performance enhancements in BH transport and scheduling**

##### *Enhancements to QoS*

For the improvement of UL QoS scheduling on the backhaul, Rel-17 introduces an extension of the LCG space. The extended LCG space supports 256 instead of just 8 LCGs. Extended LCGs can be signalled via new short and long BSR MAC CEs. The extended LCGs can also be used for pre-emptive BSR.

##### *Enhancements to congestion mitigation*

For the improvement of congestion mitigation, Rel-17 introduces DL local re-routing based on flow-control feedback on BAP sublayer as well as DL congestion reporting to the IAB-donor-CU-CP.

The IAB-node can apply DL local re-routing for a BAP destination when the congestion control feedback for this destination exceeds an IAB-donor-configured threshold.

The IAB-DU can report congestion with child BH RLC channel granularity to the IAB-donor-CU-CP. This allows the IAB-donor-CU-CP to apply congestion mitigation measures such as the configuration of routing changes, topology adaptation, or changes to the radio-resource configuration.

#### **Enhancements in multiplexing**

The following enhancements to physical layer procedures have been made in Rel-17 in the context of enhanced multiplexing:

FDM of IAB-MT and IAB-DU operation is enabled by extending the concept of Hard, Soft and Unavailable IAB-DU symbol resources to Hard, Soft, and Unavailable IAB-DU sets of RBs within a component carrier, provided through a Rel-17 IAB-DU frequency domain resource configuration in addition to the Rel-16 IAB-DU time domain resource configuration. The DCI 2\_5 mechanism is extended to support explicit release of Soft resources with RB set granularity. Similarly, the rules for implicit determination of availability of a Soft RB set are extended for FDM operation.

Interference mitigation is facilitated by the ability to exchange of semi-static Rel-16 IAB-DU time domain resource configuration information and the Rel-17 IAB-DU frequency domain resource configuration information among neighbouring IAB-nodes and IAB-donors.

SDM of IAB-MT and IAB-DU operation is facilitated by the introduction of two new timing alignment modes for IAB-MT transmit timing: Case 6 timing aligns the IAB-MT transmit timing with the IAB-DU transmit timing, facilitating SDM Tx at the IAB-node. Case 7 timing aligns the IAB-DU receive timing with the IAB-MT receive timing, facilitating SDM Rx at the IAB-node.

The provision for over-the-air synchronization, introduced in Rel-16 to enable an IAB-node to derive its IAB-DU Tx timing from the received DL signal by the collocated IAB-MT, is updated to account for the newly introduced Case 6 and Case 7 timing modes.

Simultaneous operation of the IAB-MT and the IAB-DU is further facilitated by the ability of an IAB-node to indicate to a parent node a list of preferred IAB-MT beams with the associated conditions under which such beam preference applies, and by the ability of a parent node to indicate to the IAB-node a list of restricted IAB-DU beams with the associated conditions under which such beam restriction applies. Additionally, concurrent IAB-MT and IAB-DU operation, is aided by the ability of the IAB-node to indicate to a parent node a desired DL power adjustment and/or a

desired IAB-MT Tx power spectral density range, where each indication includes the associated conditions for the desired adjustments.

Optimizations for dual-connectivity operation of an IAB-node are introduced by supporting coordination of IAB-MT's TDD configuration to avoid conflicts from the two parent nodes, by supporting the exchange of IAB-DU resource configurations between parent nodes, by applying Rel-16 CA TDD prioritization rules, and by supporting a per-child MT link Unavailable resource configuration.

### **RF and RRM requirements**

RAN4 decided to adopt following update to RF and RRM requirements for IAB enhancement:

RF perspective: the requirement applicability for simultaneous operation is agreed to be included in specification with clarification that the different declaration on transmission power in simultaneous transmission is allowed for ACLR and Modulation quality. Timing error between IAB-DU and IAB-MT of the same IAB-Node is also defined for transmission mode case 6.

RRM perspective: No impact is identified for RRM aspect to enable Rel-17 IAB enhancement except update with applicability clarification that existing transmit timing and timing adjust requirements of IAB-MTs apply when transmission mode is set to "case 1".

### **References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860050,860150,860250,830021>

- [1] RP-213668: New WID on Enhancements to Integrated Access and Backhaul; TSG RAN Meeting #94, electronic meeting, December 6-17, 2021.
- [2] RP-221176: Status Report for integrated access and backhaul; TSG RAN Meeting #96, Budapest, Hungary, June 3-6, 2022.

## **11.4 NR coverage enhancements**

<b>900061</b>	<b>NR coverage enhancements</b>	<b>NR_cov_enh</b>		<b>RP-211566</b>	<b>China Telecom</b>
860036	Study on on NR coverage enhancements	FS_NR_cov_enh	R1	RP-200861	China Telecom
900161	<b>Core part: NR_cov_enh</b>	NR_cov_enh-Core	R1	<b>RP-211566</b>	China Telecom
900261	<b>Perf. part: NR_cov_enh</b>	NR_cov_enh-Perf	R4	<b>RP-211566</b>	China Telecom

Summary based on the input provided by China Telecom in RP-220564.

Coverage is one of the key factors that an operator considers when commercializing cellular communication networks due to its direct impact on service quality as well as CAPEX and OPEX. The Rel-17 study item 860036 "Study on NR coverage enhancements" evaluated the baseline performance and identified the potential bottleneck channels for both FR1 and FR2 [1]. This work item [2] specifies enhancements for PUSCH, PUCCH and Msg3 PUSCH, including enhancements on PUSCH repetition Type A, TB processing over multiple slots PUSCH, DMRS bundling for PUSCH/PUCCH, dynamic PUCCH repetition factor indication and Type A PUSCH repetitions for Msg3.

The following key functionalities are introduced as part of the Work Item:

### **Enhancements on PUSCH repetition Type A**

For PUSCH repetition Type A, the maximum number of repetitions is increased up to 32. The increased maximum number of repetitions is applicable to PUSCH repetition Type A scheduled by DCI format 0\_1 and DCI format 0\_2 as well as PUSCH repetition Type A with Type 1 and Type 2 configured grant. In addition, PUSCH repetition Type A supports the repetitions counted based on available slots, and the maximum of repetitions for counting based on available slots is 32. When the counting based on available slots is enabled, a UE follows the 2-step procedure to perform PUSCH transmissions: in the first step, the UE determines available slots for K PUSCH repetitions; in the second step the UE determines whether to drop each of the K PUSCH repetition or not according to PUSCH dropping rules, where the PUSCH repetition is still counted in the K repetitions even if it is dropped.

### **TB processing over multiple slots PUSCH (TBoMS)**

A single Transport Block (TB) using a resource allocated over multiple slots is introduced for PUSCH except Msg3. A UE scheduled to perform a TBoMS transmission, via either dynamic or configured grant (Type 2), uses the resource allocated across multiple slots to calculate the transport block size (TBS) for the transmission. Advantages of this approach as compared to single-slot PUSCH operations are in the form of lower effective coding rate and/or energy per

resource element (EPRE) increase, both advantages leading to coverage enhancement. A TBoMS transmission can be performed w/ or w/o repetition, where a TBoMS transmission w/o repetition is referred to as single TBoMS transmission. The number of slots allocated for TBoMS is counted based on available slots. The UE transmits the TB across the slots determined as available for the TBoMS transmission, applying the same symbol and PRBs allocation in each slot, regardless of whether TBoMS is scheduled w/ or w/o repetition. Collision handling rules of Type A PUSCH repetition apply for TBoMS. TBS of a single TBoMS transmission is calculated using the resource in all the slots allocated for the single TBoMS transmission. The maximum supported TBS for TBoMS does not exceed legacy maximum supported TBS in Rel-15/16, for the same number of layers. TBoMS supports the transmission of only one layer and one code block. A single redundancy version (RV) is used for the transmission of a single TBoMS, irrespective of the number of slots allocated for a single TBoMS transmission, as per Figure 1. RV cycling is used across repetitions of a single TBoMS, as per Figure 2. Rate Matching (RM) for TBoMS is performed per slot.

0	1	2	3	Slot number
0	0	0	0	Used RV index per slot

**Figure 1. Example of single TBoMS transmission (w/o repetitions) where 4 slots are allocated for the single TBoMS.**

0	1	2	3	4	5	6	7	Slot number
0	0	2	2	3	3	1	1	Used RV index per slot

**Figure 2. Example of TBoMS transmission w/ repetitions, where 2 slots are allocated for the single TBoMS and 4 repetitions are configured.**

#### DMRS bundling for PUSCH/PUCCH

DMRS bundling to enable improved channel estimation is introduced for PUSCH repetition Type A scheduled by DCI format 0\_1 or 0\_2, for PUSCH repetition Type A with configured grant, for PUSCH repetition Type B, for TB processing over multiple slots PUSCH and for PUCCH repetitions of PUCCH formats 1, 3, and 4. A UE can report the maximum duration, in number of consecutive slots, during which the UE is able to maintain power consistency and phase continuity under certain tolerance level. With the duration of the nominal TDWs (Time Domain Windows), not longer than the maximum duration, configured by gNB, one or multiple nominal TDWs can be determined for PUSCH transmissions or PUCCH repetitions. A nominal TDW consists of one or multiple actual TDWs. Events, which cause power consistency and phase continuity not to be maintained across PUSCH transmissions or PUCCH repetitions within the nominal TDW, are defined. An actual TDW is terminated in case an event occurs. A new actual TDW is created in response to semi-static events not triggered by DCI or MAC-CE. Whether a new actual TDW is created in response to dynamic events triggered by DCI is subject to UE capability. Frequency hopping and UL beam switching for multi-TRP operation are regarded as semi-static events. The UE shall maintain power consistency and phase continuity within an actual TDW across PUSCH transmissions or PUCCH repetitions.

Inter-slot frequency hopping with DMRS bundling to enable improved channel estimation within the same frequency hop is introduced for PUSCH repetition Type A, PUSCH repetition Type B, TBoMS and PUCCH repetitions. With the frequency hopping interval, N consecutive slots, configured by gNB, the UE performs inter-slot frequency hopping every N consecutive slots for PUSCH transmissions or PUCCH repetitions.

#### Dynamic PUCCH repetition factor indication

Dynamic repetition factor indication is introduced for PUCCH. This feature allows network to adjust PUCCH repetition factor in a flexible fashion based on channel conditions and traffic load. The mechanism to support this feature is an enhanced RRC configuration to configure different repetition factor per PUCCH resource. With this configuration, network can use existing PRI (PUCCH resource indicator) in DCI to point to a PUCCH resource where the associated repetition factor will be applied to the PUCCH transmission. By pointing to a different PUCCH resource via PRI, a different PUCCH repetition factor could apply, which implements the dynamic PUCCH repetition factor indication.

#### Type A PUSCH repetitions for Msg3



Up to 16 repetitions is introduced for a Msg3 PUSCH transmission scheduled by RAR UL grant or DCI format 0\_0 with CRC scrambled by TC-RNTI. This is beneficial to enhance the coverage on both NUL and SUL. After carrier selection and BWP selection during the RACH initialization procedure, a UE requests repetition of Msg3 PUSCH scheduled by RAR UL grant via separate PRACH resource when the RSRP of DL path-loss reference fulfils a configured threshold. If requested by the UE, gNB decides whether or not to schedule repetition of the Msg3 PUSCH transmission. If scheduled, the number of repetitions N is indicated by the 2 MSBs of the MCS field in the RAR UL grant or in the DCI format 0\_0; and the MCS index used for the PUSCH transmission is indicated by the 2 LSBs of the MCS field in the RAR UL grant or by the 3 LSBs of the MCS field in the DCI format 0\_0. The Msg3 PUSCH transmission is performed over N slots, which is counted based on available slots. Only inter-slot frequency hopping is supported if N>1 is indicated for the PUSCH transmission.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900061,860036,900161,900261>

- [1] TR 38.830, v17.0.0, "Study on NR coverage enhancements", December, 2020.
- [2] RP-220563, "Status report for NR coverage enhancements", China Telecom, RAN#95e, March 17th – 23rd, 2022.

## 11.5 RF requirements for NR Repeaters

900070	<b>NR repeaters</b>	<b>NR repeaters</b>		<b>RP-212129</b>	<b>Qualcomm</b>
900170	<b>Core part: NR repeaters</b>	NR_repeater-Core	R4	RP-212129	Qualcomm
930250	<b>Perf. part: NR repeaters</b>	NR_repeater-Perf	R4	RP-212129	Qualcomm

Summary based on the input provided by Qualcomm in RP-220544.

This work item defines RF requirements for NR repeaters. These repeaters are network nodes designed to supplement/extend the coverage provided by base stations by simply amplifying and forwarding the signals from the input port without performing any other signal processing.

Repeater types: RF requirements for repeater types 1-C and 2-O are defined. Repeater type 1-C covers the conducted requirements for FR1 while type 2-O covers the radiated requirements for FR2. Other types of repeaters are not covered in this Release.

Repeater classes: Different repeater classes were introduced to cover different deployment scenarios and are differentiated for DL and UL as follows:

DL classes:

- Wide Area repeaters are characterised by requirements derived from Macro Cell scenarios with a repeater to UE minimum distance along the ground equal to 35 m.
- Medium Range repeaters are characterised by requirements derived from Micro Cell scenarios with a repeater to UE minimum distance along the ground equal to 5 m.
- Local Area repeaters are characterised by requirements derived from Pico Cell scenarios with a repeater to UE minimum distance along the ground equal to 2 m.

UL classes:

- Wide Area repeaters are characterised by requirements derived from Macro Cell and/or Micro Cell scenarios.
- Local Area repeaters are characterised by requirements derived from Pico Cell and/or Micro Cell scenarios.

Repeater Operating Bands: NR repeater is designed to operate in the operating bands in FR1 and FR2-1 which are defined in TS 38.104. New bands added to 38.104 which are in these frequency ranges will automatically be applicable to the repeaters also.

TDD Operation: NR repeaters specifications also cover operation in the TDD bands. In these bands, the repeaters are assumed to be synchronized to the base station in whose coverage they are deployed follow the UL/DL frame configuration that the base station is using.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900070,900170,930250>

- [1] TS 38.106: NR repeater radio transmission and reception
- [2] TS 38.114: Repeaters ElectroMagnetic Compatibility (EMC)
- [3] TS 38.115-1: Repeater conformance testing - Part 1: Conducted conformance testing
- [4] TS 38.115-2: Repeater conformance testing - Part 2: Radiated conformance testing
- [5] TS 33.180: "Security of the Mission Critical (MC) service; (Release 17)"

## 11.6 Introduction of DL 1024QAM for NR FR1

890056	<b>Introduction of DL 1024QAM for NR frequency range 1 (FR1)</b>	NR_DL1024QAM_FR1		RP-213654	Ericsson
890156	<b>Core part: Introduction of DL 1024QAM for NR FR1</b>	NR_DL1024QAM_FR1-Core	R4	RP-213654	Ericsson
890256	<b>Perf. part: Introduction of DL 1024QAM for NR FR1</b>	NR_DL1024QAM_FR1-Perf	R4	RP-213654	Ericsson

Summary based on the input provided by Ericsson in RP-220191.

This work item specifies downlink 1024QAM for NR PDSCH operation in FR1, which provides higher downlink peak rate compared with Release-15 NR, with the high downlink SINR and better channel condition (e.g., LOS or LOS-like channel), and with no mobility or very low mobility environment.

Beside specifying the downlink 1024QAM mapping function, the WI also defines the corresponding MCS/CQI tables and RRC signalling, as well as the corresponding BS/UE RF requirements to transmit/receive the signals with 1024QAM [2].

### Introduction of the modulation mapping function of 1024QAM

It was introduced the modulation mapping function of 1024QAM for PDSCH, where 10 tuples of bits,  $\{b_i, \dots, b_{i+9}\}$  are mapped to complex-valued modulation symbols  $d(i)$ , according to

$$d(i) = \frac{1}{\sqrt{682}}(1 - 2b_i) \left[ 16 - (1 - 2b_{i+2}) \left[ 8 - (1 - 2b_{i+4}) \left[ 4 - (1 - 2b_{i+6}) \left[ 2 - (1 - 2b_{i+8}) \right] \right] \right] \right] \\ + j \frac{1}{\sqrt{682}}(1 - 2b_{i+1}) \left[ 16 - (1 - 2b_{i+3}) \left[ 8 - (1 - 2b_{i+5}) \left[ 4 - (1 - 2b_{i+7}) \left[ 2 - (1 - 2b_{i+9}) \right] \right] \right] \right]$$

### Introduction of MCS table supporting 1024QAM

For supporting 1024QAM for PDSCH, a new five-bit MCS table with 1024QAM entries was introduced by removing 5 MCS entries and adding 5 new entries for 1024QAM from the existing MCS index table 2. The removed MCS indexes are 2, 4, 6, 8, and 10. The added MCS entries for 1024QAM are given as follows:

MCS index	Modulation	Target code rate $R_x$ [1024]	Spectrum efficiency
23	10	805.5	7.8662
24	10	853	8.3301
25	10	900.5	8.7939
26	10	948	9.2578
31	10	reserved	

New RRC signalling was also introduced to indicate use of 1024QAM MCS table.

### Introduction of CQI table supporting 1024QAM

For supporting 1024QAM for PDSCH, a new CQI table with 1024QAM entries was introduced by reusing LTE CQI table with 1024QAM entries as follows:

CQI index	Modulation	Code rate x 1024	Efficiency
0	Out of range		
1	QPSK	78	0.1523
2	QPSK	193	0.377
3	QPSK	449	0.877
4	16QAM	378	1.4766
5	16QAM	616	2.4063
6	64QAM	567	3.3223
7	64QAM	666	3.9023
8	64QAM	772	4.5234
9	64QAM	873	5.1152
10	256QAM	711	5.5547
11	256QAM	797	6.2266
12	256QAM	885	6.9141
13	256QAM	948	7.4063
14	1024QAM	853	8.3301
15	1024QAM	948	9.2578

New RRC signalling was also introduced to indicate use of 1024QAM CQI table.

### BS Tx EVM for DL 1024QAM

The Error Vector Magnitude (EVM) is a measure of the difference between the ideal symbols and the measured symbols after the equalization. The required gNB Tx EVM for 1024QAM is set to 2.5% for frequencies equal to or below 4.2GHz and 2.8% for frequencies above 4.2GHz in FR1.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890056,890156,890256>

- [1] RP-220190 "Status report for WI Introduction of DL 1024QAM for NR FR1; rapporteur: Ericsson, Nokia", Ericsson.

## 11.7 NR Carrier Aggregation

### 11.7.1 NR intra band Carrier Aggregation

UID	Name	Acronym	WG	WID	WI rapporteur name/company
881005	NR itrbCA for xCC DL/yCC UL including contiguous and non-contiguous spectrum ( $x \geq y$ )	NR_CA_R17_Intra		RP-211757	Ericsson
881105	Core part: NR_CA_R17_Intra	NR_CA_R17_Intra-Core	R4	RP-211757	Ericsson
881205	Perf. Part: NR_CA_R17_Intra	NR_CA_R17_Intra-Perf	R4	RP-211757	Ericsson

### 11.7.2 NR inter band Carrier Aggregation

UID	Name	Acronym	WG	WID	WI rapporteur name/company
900063	High power UE for NR TDD intra-band Carrier Aggregation in frequency range FR1	NR_intra_HPUE_R17		RP-212180	Huawei
900163	Core part: NR_intra_HPUE_R17	NR_intra_HPUE_R17-Core	R4	RP-212180	Huawei
900263	Perf. part: NR_intra_HPUE_R17	NR_intra_HPUE_R17-Perf	R4	RP-212180	Huawei
881006	NR iterbCA/Dual Connectivity for 2 bands DL with x bands UL ( $x \geq 1, 2$ )	NR_CADC_R17_2BDL_xBUL		RP-212511	ZTE
881106	Core part: NR_CADC_R17_2BDL_xBUL	NR_CADC_R17_2BDL_xBUL-Core	R4	RP-212511	ZTE
881206	Perf. part: NR_CADC_R17_2BDL_xBUL	NR_CADC_R17_2BDL_xBUL-Perf	R4	RP-212511	ZTE
881007	NR iterbCA for 3 bands DL with 1 band UL	NR_CA_R17_3BDL_1BUL		RP-212239	CATT
881107	Core part: NR_CA_R17_3BDL_1BUL	NR_CA_R17_3BDL_1BUL-Core	R4	RP-212239	CATT
881207	Perf. part: NR_CA_R17_3BDL_1BUL	NR_CA_R17_3BDL_1BUL-Perf	R4	RP-212239	CATT
881008	NR iterbCA/Dual Connectivity for 3 bands DL with 2 bands UL	NR_CADC_R17_3BDL_2BUL		RP-212512	ZTE
881108	Core part: NR_CADC_R17_3BDL_2BUL	NR_CADC_R17_3BDL_2BUL-Core	R4	RP-212512	ZTE
881208	Perf. part: NR_CADC_R17_3BDL_2BUL	NR_CADC_R17_3BDL_2BUL-Perf	R4	RP-212512	ZTE
881009	NR iterbCA for 4 bands DL with 1 band UL	NR_CA_R17_4BDL_1BUL		RP-211759	Ericsson
881109	Core part: NR_CA_R17_4BDL_1BUL	NR_CA_R17_4BDL_1BUL-Core	R4	RP-211759	Ericsson

881209	Perf. part: NR_CA_R17_4BDL_1BUL	NR_CA_R17_4BDL_1BUL-Perf	R4	RP-211759	Ericsson
881010	NR interCA/Dual connectivity for DL 4 bands and 2UL bands	NR_CADC_R17_4BDL_2BUL		RP-212110	Samsung
881110	Core part: NR_CADC_R17_4BDL_2BUL	NR_CADC_R17_4BDL_2BUL-Core	R4	RP-212110	Samsung
881210	Perf. part: NR_CADC_R17_4BDL_2BUL	NR_CADC_R17_4BDL_2BUL-Perf	R4	RP-212110	Samsung
881011	NR interCA for 5 bands DL with x bands UL (x=1, 2)	NR_CADC_R17_5BDL_xBUL		RP-212176	Huawei
881111	Core part: NR_CADC_R17_5BDL_xBUL	NR_CADC_R17_5BDL_xBUL-Core	R4	RP-212176	Huawei
881211	Perf. part: NR_CADC_R17_5BDL_xBUL	NR_CADC_R17_5BDL_xBUL-Perf	R4	RP-212176	Huawei
890054	Rel-17 High power UE for NR inter-band Carrier Aggregation with 2 bands downlink and x bands uplink (x=1,2)	NR_PC2_CA_R17_2BDL_2BUL		RP-211831	China Telecom
890154	Core part: NR_PC2_CA_R17_2BDL_2BUL	NR_PC2_CA_R17_2BDL_2BUL-Core	R4	RP-211831	China Telecom
890254	Perf. part: NR_PC2_CA_R17_2BDL_2BUL	NR_PC2_CA_R17_2BDL_2BUL-Perf	R4	RP-211831	China Telecom
920066	UE Conformance - Rel-17 High power UE for NR inter-band Carrier Aggregation with 2 bands downlink and x bands uplink (x=1,2)	NR_PC2_CA_R17_2BDL_2BUL-UEConTest	R5	RP-211140	China Telecom

## 11.8 NR Dynamic Spectrum Sharing

860043	NR Dynamic spectrum sharing (DSS)	NR_DSS		RP-211345	Ericsson
860143	Core part: NR DSS	NR_DSS-Core	R1	RP-211345	Ericsson

Summary based on the input provided by Ericsson in RP-220464.

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 Rel-16. As the number of NR devices in a network increases it is important that sufficient scheduling capacity for NR UEs on the shared carriers is ensured.

This is addressed by this WI, which introduces the support for cross-carrier scheduling from SCell to PCell/PSCell.

When cross-carrier scheduling from an SCell to sPCell is configured:

- PDCCH on that SCell can schedule sPCell's PDSCH and PUSCH,
- PDCCH on the sPCell can schedule sPCell's PDSCH and PUSCH but cannot schedule PDSCH and PUSCH on any other cell.

Only one SCell can be configured to be used for cross-carrier scheduling to sPCell.

The maximum number of monitoring candidates and non-overlapping CCEs for PDCCH monitoring (to schedule the sPCell) are split between the sPCell and the SCell used for scheduling the sPCell. The split is indicated via an RRC configured scaling factor.

Note: sPCell refers to 'Special Cell'. For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG, otherwise the term Special Cell refers to the PCell.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860043,860143>

- [1] RP-220463 – "Status report for WI: Core part: NR Dynamic spectrum sharing (DSS)", Ericsson, RAN#95e.

## 11.9 Increasing UE power high limit for CA and DC

930056	Increasing UE power high limit for CA and DC	Power_Limit_CA_DC	R4	RP-212622	Qualcomm
930156	Core part: Increasing UE power high limit for CA and DC	Power_Limit_CA_DC-Core	R4	RP-212622	Qualcomm

Summary based on the input provided by Qualcomm Incorporated, China Telecom in RP-221589.

This work item enables a UE to indicate a capability to transmit a maximum output power higher than what the power class for a UL CA or DC configuration would have previously allowed. In particular, for a UE supporting PC3 (23 dBm) in one band and PC2 (26 dBm) in another band, the carrier aggregation configuration may have been specified for PC2 (26 dBm). In such an example, the maximum composite power from both transmitters would be limited to 26 dBm. With this newly introduced Increased MOP capability, the UE is allowed to transmit at its maximum potential when

simultaneously transmitting at maximum power on each carrier, in other words, the maximum allowed power is increased to 27.8 dBm for this example.

Higher maximum UE transmit power is nearly universally accepted as a desirable feature for cellular radio systems to enable greater range, capacity, and cell edge user throughput. This can be seen by the introduction of PC2 (26 dBm) first in Rel-14 followed by PC1.5 (29 dBm) in Rel-16 along with the proliferation of operator requests for specification support of CA and DC combinations supporting these higher power classes. At the same time, UE front-end architectures are evolving to include multiple transmit chains capable of operating simultaneously in time. UL MIMO, UL CA, and transmit diversity are some of the recent developments where dual PA configurations are assumed in RAN4. It is therefore beneficial to introduce methods to unlock the maximum transmit capability of multiple PA's across different bands transmitting at the same time. This work item has enabled the possibility for a UE supporting PC3 within an NR TDD or FDD band and supporting PC2 within a second NR TDD band to signal a [HigherPowerLimitCADC] capability whereby the maximum output power indicated by the power class of the CA or DC configuration can be exceeded.

Using CA for illustration but without loss of generality to DC, this is achieved by replacing the PPowerClass,CA term in the expression for the upper and lower limits of the maximum configured output power. Specifically,

$$P_{\text{CMAX\_L}} = \text{MIN} \{ 10 \log_{10} \sum \text{MIN} [ p_{\text{EMAX,c}} / (\Delta t_{\text{C,c}}), p_{\text{PowerClass,c}} / (\text{MAX}(m_{\text{prc}} \cdot \Delta m_{\text{prc}}, a_{\text{mprc}}) \cdot \Delta t_{\text{C,c}} \cdot \Delta t_{\text{B,c}} \cdot \Delta t_{\text{RxSRS,c}}), p_{\text{PowerClass,c}} / p_{\text{mprc}}], P_{\text{EMAX,CA}}, P_{\text{PowerClass,CA}} - \Delta P_{\text{PowerClass,CA}} \}$$

$$P_{\text{CMAX\_H}} = \text{MIN} \{ 10 \log_{10} \sum p_{\text{EMAX,c}}, P_{\text{EMAX,CA}}, P_{\text{PowerClass,CA}} - \Delta P_{\text{PowerClass,CA}} \}$$

- PPowerClass,CA is the maximum UE power specified in Table 6.2A.1.3-1 without taking into account the tolerance specified in the Table 6.2A.1.3-1; If the UE indicates [HigherPowerLimitCADC] for an eligible CA configuration as specified in Table 6.2A.1.3-1 and  $\Delta P_{\text{PowerClass,CA}} = 0$ , PPowerClass,CA is replaced by  $10 \log_{10} \sum p_{\text{PowerClass,c}}$ .

From these equations, it can be seen that both the lower limit P<sub>CMAX\_L</sub> and the upper limit P<sub>CMAX\_H</sub> are increased by virtue of replacing the PPowerClass,CA term which appears in both lower and upper limits. Raising the upper limit has the effect of allowing the UE to increase its maximum aggregated configured output power. On the other hand, also raising the lower limit has the effect of ensuring that the UE will increase its maximum aggregated configured output power. The agreement in the CR to raise both lower and upper limits somewhat reduces the flexibility for the UE, but the UE has the freedom to not signal the optional capability, increasing both limits facilitates testability of the feature and imbues meaning to the signalled capability, provides assurance that the UE can indeed raise its power when signalled, and reduces the uncertainty to the base station by shrinking the difference between the upper and lower limits.

The scope of this work for Rel-17 as reflected in the agreed CR's is limited to specific PC2 + PC3 power configurations as indicated by the UE's reported power class, by [powerClassPerBand], or by the default power class specified in 38.101-1 for the band. The scope does not include greater than two PA's since three PA and higher configurations are not considered in RAN4 Rel-17 specifications. This limitation in scope for Rel-17 then omits CA configurations with both intra-band CA in one band and inter-band CA with another band, for example.

Moreover, during the course of the work item, the impact of increasing MOP on MSD, MPR and A-MPR, and SAR mechanisms was also studied by companies. It was found that specification changes were not needed for any of these within the context of this Rel-17 CR. Rather the existing specifications for MSD, MPR and A-MPR, and SAR can still apply. Hence, these requirements have not been adjusted.

## References

- [1] RP-221302, "New WID: Increasing UE power high limit for CA and DC," China Telecom, Qualcomm
- [2] RP-221588, "Status Report to TSG: Increasing UE power limit high for CA and DC," Qualcomm Incorporated
- [3] R4-2210767, "Increasing the maximum power limit for inter-band UL CA", Qualcomm Incorporated, Verizon, Vodafone, Deutsche Telekom, US Cellular, T-Mobile USA, AT&T, China Unicom, NTT DOCOMO, INC., China Telecom, Nokia, Nokia Shanghai Bell, CableLabs, Charter Communications, Inc., Dish Network, Skyworks Solutions, Inc., ZTE, Huawei, HiSilicon, SGS Wireless
- [4] R4-2210768, "Increasing the maximum power limit for inter-band UL DC," Qualcomm Incorporated, Verizon, Vodafone, Deutsche Telekom, US Cellular, T-Mobile USA, AT&T, China Unicom, NTT DOCOMO, INC., China Telecom, Nokia, Nokia Shanghai Bell, CableLabs, Charter Communications, Inc., Dish Network, Skyworks Solutions, Inc., ZTE, Huawei, HiSilicon, SGS Wireless
- [5] R4-2211189, "Rel-17 RAN4 UE feature list for NR," CMCC

## 11.10 RF requirements enhancement for NR FR1

890062	<b>RF requirements enhancement for NR frequency range 1 (FR1)</b>	NR_RF_FR1_enh		RP-220681	Huawei
890162	<b>Core part: RF requirements enhancement for NR FR1</b>	NR_RF_FR1_enh-Core	R4	RP-220681	Huawei
890262	<b>Perf. part: RF requirements enhancement for NR FR1</b>	NR_RF_FR1_enh-Perf	R4	RP-220681	Huawei

Summary based on the input provided by Huawei, HiSilicon in RP-220682.

This work item develops several enhancement aspects for UE RF FR1. New RF requirements, corresponding new feature groups and functionalities are introduced for the WI as follows:

- Specification restrictions for SUL bands supporting UL MIMO are removed in both RAN4 and RAN2 specs
- In Rel-16, switching period between case 1 and case 2 was introduced to enable enhancement on UL performance with 2Tx transmission on one UL carrier for inter-band UL CA, SA SUL and inter-band EN-DC. UE capability on uplinkTxSwitchingPeriod is introduced as 35µs, 140µs and 210µs (210µs only for inter-band UL CA and SA SUL). Meanwhile, UE DL interruption is allowed when configured with difficult band combinations. In Rel-17, the feature is extended to dynamic Tx switching between 2CC 2Tx-2Tx switching, 3CC 1Tx-2Tx switching and 3CC 2Tx-2Tx switching. In addition, capability to indicate whether UL-MIMO coherence is supported when dynamic Tx switching between 3CC (within 2 bands) 1Tx-2Tx switching and 2CC or 3CC (within 2 bands) 2Tx-2Tx switching are introduced.
- RF Requirements for PC3 and PC2 intra-band UL contiguous CA with UL MIMO are specified. During the study in Rel-17, it was agreed that no explicitly indication of specific UE architectures in the spec, i.e. 23+23, 23+26, 26+26. Also the conclusion is reached that MPR for 1T PC2 is applied for PC2 UL contiguous CA w/o UL MIMO or TxD indication while MPR for 2T 23+23 is applied for PC2 UL contiguous CA with UL MIMO and/or TxD indication.
- RF Requirements for PC3 and PC2 intra-band non-contiguous UL CA are specified, especially the MPR values are defined based on different UE architectures (indicated via supporting dualPA-Architecture or not).
- SCell dropping solution as a WI objective for preventing transmission power dropping on the cell with lower priority for both FR1 and FR2 CA is also discussed. As the solutions may have spec impact to other WGs, also there is no consensus whether it should be considered as a solution to address the potential in-field issue, the only possibility is to drop the discussion in Rel-17. Meanwhile, there was some discussion on PCMAX,CA and PHRCA reporting, similar to SCell dropping solution, no further discussion is considered in Rel-17.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890062,890162,890262>

- [1] RP-220680, SR on NR\_RF\_FR1\_enh, RAN#95e
- [2] R4-2107847, Reply LS on Rel-17 uplink Tx switching, China Telecom
- [3] R2-2203986, RRC configuration for UL Tx switching enhancement, Huawei, HiSilicon, China Telecom, Apple, CATT
- [4] R2-2203987, stage 2 CR for UL Tx switching enhancement, Huawei, HiSilicon, China Telecom
- [5] R2-2203998, Introduction of Rel-17 Tx switching enhancements, China Telecom, Huawei, HiSilicon, Apple, CATT

## 11.11 RF requirements further enhancements for NR FR2

890059	<b>Further enhancements of NR RF requirements for frequency range 2 (FR2)</b>	NR_RF_FR2_req_enh2		RP-220968	Nokia
890159	<b>Core part: NR_RF_FR2_req_enh2</b>	NR_RF_FR2_req_e nh2-Core	R4	RP-220968	Nokia
890259	<b>Perf. part: NR_RF_FR2_req_enh2</b>	NR_RF_FR2_req_e nh2-Perf	R4	RP-220968	Nokia

Summary based on the input provided by Nokia in RP-221206.

This work item introduces various new features into FR2:

- FR2 DL CA based on IBM for CA\_n258A-n260A, CA\_n257A-n259A and CA\_n258-n261 [3]
- FR2 UL CA based on IBM for CA\_n257A-n259A and CA\_n260-n261 [4][9][10]
- DLCA requirement framework extended to classes 1, 2 and 5.



- UL gaps for self-calibration and monitoring. [RAN4 RF/RRM, RAN2] Introduced UE specific and NW configured gap for general self-calibration and monitoring purposes including
  - o UE Tx power management [6][7]
  - o Detecting need to MPE measurements
- Introduce new FR2 CA BW classes and related Rx requirements to support of contiguous downlink aggregated channel BW up to 1600 MHz including classes with a mix of 100 and 200 MHz CCs [8]
- Specify DC location reporting scheme to cover intra-band UL CA with 2 CCs and more for FR1 and FR2, and intra-band DL CA for FR2.
  - o The DC location reporting scheme covers both DC locations within the used CCs as well as outside the used CCs.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890059,890159,890259>

- [1] RP-220968, last approved WID
- [2] TR 38.851 User Equipment (UE) Further enhancements of NR RF requirements for frequency range 2 (FR2)
- [3] R4-2210779 Addition of downlink CA\_n258-n261 configuration Nokia, Qualcomm Inc
- [4] R4-2210780 CR to 38.101-2 FR2+FR2 ULCA Feature Qualcomm, Nokia, Verizon, LGE
- [5] R4-2210777 CR to 38.101-2: FR2+FR2 IBM DLCA for PC1/2/5 Qualcomm, Nokia, Verizon, LGE
- [6] R4-2210576 Draft CR on RF related UL gap for FR2 (38.101-2) Apple
- [7] R4-2210781 Draft CR on UL gaps for BPS Apple, Ericsson, Nokia
- [8] R4-2210783 FR2 CA BW classes up to 2400 MHz aggregated BW with mixed channel bandwidths Ericsson, Verizon
- [9] R4-2208499 CR on RRM requirements for IBM inter-band FR2 UL CA Nokia, Nokia Shanghai Bell
- [10] R4-2210125 R4-2211080 Draft CR on RRM requirements for FR2 inter-band UL CA for IBM UEricsson

## 11.12 NR measurement gap enhancements

890061	NR measurement gap enhancements	NR_MG_enh		RP-213658	MediaTek
890161	Core part: NR and MR-DC measurement gap enhancements	NR_MG_enh-Core	R4	RP-213658	MediaTek
890261	Perf. part: NR and MR-DC measurement gap enhancements	NR_MG_enh-Perf	R4	RP-213658	MediaTek

Summary based on the input provided by MediaTek inc., Intel Corporation in RP-220752.

the 3 objectives of this WI are: 1) Pre-configured MG pattern(s), 2) Multiple concurrent and independent MG patterns and 3) Network controlled small gap. Corresponding network RRC signalling and measurement requirements are specified in TS38.331 and TS38.133, respectively.

### 1) Pre-configured MG pattern(s)

- Introduced 2 activation/de-activation mechanisms and corresponding UE capabilities to support these two mechanism: Network controlled mechanism, in which UE follows the 1-bit per-BWP indications in active servings cell and 1-bit indication in deactivated serving cells to decide the ON/OFF status of the pre-configured MG; UE autonomous mechanism, in which UE follows the defined rules in TS38.133 to decide the ON/OFF status of the pre-configured MG. If MG is not needed for all measurements, the pre-configured gap should be deactivated (OFF) ; Otherwise, activated (ON). Events that may trigger UE to re-check the ON/OFF status includes: [DCI/Timer based BWP switching, activation/de-activation of SCell(s), addition/removal of any measurement object(s), addition/release/change of a SCell under CA, BWP switching by RRC, initiation of LocationMeasurementIndication];

- Introduced additional delay for pre-configured MG activation/deactivation which is 5ms on top on the legacy procedure delay that may trigger pre-configured MG status change;

- Updated the corresponding UE requirements regarding gap interruption, measurement delay and L1 measurement impact.

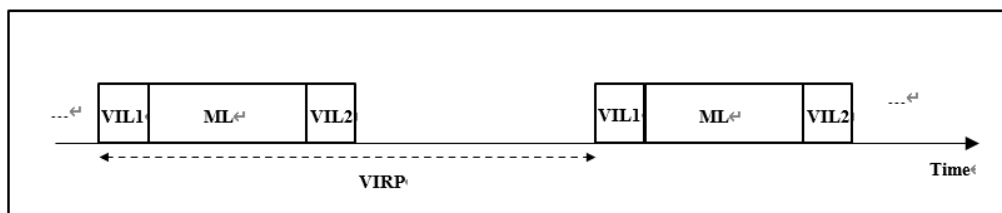
### 2) Multiple concurrent and independent MG patterns

- Introduced multiple gap configurations and corresponding UE capability

- Introduced a mandatory association between gap and dedicated use cases (e.g. PRS, SSB, CSI-RS, EUTRA) by indicating a gap ID in the measurement objective or MG configuration (for PRS only). So that UE's measurement behaviour is well-defined, because UE is only required to perform the measurement associated to the gap during that gap occasion.
- Introduced the maximum supported concurrent gap patterns for per-FR gap incapable/capable UEs. For per-FR gap incapable UE, up to 2 concurrent gap patterns can be configured. For per-FR gap capable UE, up to 3 concurrent gap patterns can be configured, which up to 2 gaps in one FR.
- Introduced a definition for the proximity condition of colliding gap occasions. Upon colliding, UE drops the gap with a lower priority level which is configured by network. Data scheduling is resumed on dropped gap occasion.
- Updated the corresponding UE requirements regarding gap interruption, measurement delay and L1 measurement impact.

### 3) Network controlled small gap (NCSG)

- Introduced a UE capability reporting based on RRCReconfigurationComplete and RRCResumeComplete messages (similar to NeedforGap). So that UE can report whether to support 'no-gap-no-interruption', 'ncsg' or 'gap' for each target band to be measured based on UE's current CA configuration.
- Introduced 24 NCSG patterns with visible interruption (VIL1 and VIL2, which are 1ms for FR1 and 0.75ms for FR2) before and after the measurement length (ML). UE is expected to continue DL reception or UL transmission with serving cells during ML. A new MG timing advance 0.75ms was introduced correspondingly.



**Figure 1: 24 NCSG patterns with visible interruption**

- Introduced the UE behaviours for the cases when UE reports different capabilities on 'no-gap-no-interruption', 'ncsg' or 'gap' but with a different a network configuration (NCSG or legacy MG) which may not perfectly match UE's reported capability.
- Introduced a new synchronization indication between the target NR band to be measured and a reference serving cell of UE to reduce the OFDM symbols restricted from data scheduling, when UE is incapable for simultaneous Tx/Rx or independent beamforming (FR2-specific).
- Introduced the corresponding UE requirements regarding gap interruption, scheduling restriction and measurement delay. Update the impact to L1 measurements.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890061,890161,890261>

- [1] RP-213350, "Status report for WI: NR and MR-DC measurement gap enhancements", Rapporteur (MediaTek Inc., Intel Corporation)

## 11.13 UE RF requirements for Transparent Tx Diversity for NR

920070	UE RF requirements for Transparent Tx Diversity (TxD) for NR	NR_RF_TxD	R4	RP-211940	Qualcomm
920170	Core part: UE RF requirements for Transparent Tx Diversity (TxD) for NR	NR_RF_TxD-Core	R4	RP-211940	Qualcomm
920270	Perf. part: UE RF requirements for Transparent Tx Diversity (TxD) for NR	NR_RF_TxD-Perf	R4	RP-211940	Qualcomm

Summary based on the input provided by Qualcomm in RP-220923.

UE requirements for transmission diversity with 2 antenna connectors were defined. Up to Rel-16 specification did not recognise a UE that needed power measured from two connectors to fulfil the power class.

The following aspects have been covered:

- Requirements for UE implementation with two antenna connectors active when it is configured for one logical antenna port for PC2 and PC1.5.
- Requirements for UE with tx diversity for SRS antenna switching were clarified
- Fallback DCI requirements with one logical port when UE supports ULFPTx, part of Rel-16 eMIMO WI. A UE indicating the feature ul-FullPwrMode-r16 or ul-FullPwrMode2-TPMIGroup-r16 for a band shall meet the 1Tx MOP requirement for at least one antenna connector
- Capability for UE to indicate if it implements tx diversity

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920070,920170,920270>

- [1] RP-220467, "Status report for WI: UE RF requirements for Transparent Tx Diversity (TxD) for NR; rapporteur: Qualcomm", RAN4, TSG RAN Meeting #95-e, Electronic Meeting, March 17 - 23, 2022
- [2] RP-220608, "TR 38.837 v1.0.0 UE RF requirements for Transparent Tx Diversity (TxD) for NR", vivo, RAN4, TSG RAN Meeting #95-e, Electronic Meeting, March 17 - 23, 2022

## 11.14 NR RRM further enhancement

890057	NR RRM further enhancement	NR_RRM_enh2		RP-202874	Apple
890157	Core part: Further RRM enhancement for NR and MR-DC	NR_RRM_enh2-Core	R4	RP-202874	Apple
890257	Perf. part: Further RRM enhancement for NR and MR-DC	NR_RRM_enh2-Perf	R4	RP-202874	Apple

Summary based on the input provided by Apple, CATT in RP-221827.

This WI defines the RRM requirements for the following UE features: SRS antenna port switching, HO with PSCell and PUCCH SCell activation/deactivation. The RRM requirements were missing for the above UE features in the TS38.133/TS36.133 before this WI, and the corresponding delay/interruption requirements have been specified in this WI to verify corresponding UE behaviour.

### SRS antenna port switching

RAN4 has specified interruption requirement for SRS antenna port switching as well as the impact to other existing RRM requirements:

- Interruption requirements were defined for two scenarios: when X=1 SRS symbol is configured in a slot for SRS antenna port switching, the configured number of SRS symbols is used as SRS transmission time; and otherwise, using X=6 SRS symbols in a slot as assumption of SRS transmission time
- RAN4 specified: Interruption requirement (symbol-level) for scenario 1 sync case; Interruption requirement (slot-level) for scenario 1 async case; and Interruption requirement (slot-level) for scenario 2

### Handover with PSCell

RAN4 has specified delay requirement of HO with PSCell for following scenarios:

- Handover with PSCell from NR SA to EN-DC
- Handover with PSCell from EN-DC to EN-DC
- Handover with PSCell from NR-DC to NR-DC (requirements in this release only applies to FR1+FR2 NR-DC)
- Handover with PSCell from NE-DC to NE-DC (requirements in this release only applies to NE-DC with FR1 PCell)

### PUCCH SCell activation/deactivation

RAN4 has specified delay requirements as well as interruption requirements for PUCCH SCell activation/deactivation:

- PUCCH SCell activation delay requirements
- PUCCH SCell activation delay requirements with multiple DL Scells
- PUCCH SCell deactivation delay requirements
- PUCCH SCell deactivation delay requirements with multiple DL Scells
- Interruption requirements on LTE and NR CCs due to PUCCH SCell activation/deactivation

- No PUCCH Scell requirements (including interruption requirements and delay requirements) for NR-DC.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890057,890157,890257>

- |     |  |
|-----|--|
| [1] | RP-213067, Revised WID of Rel-17 Further RRM enhancement for NR and MR-DC              |
| [2] | RP-220443, SR of Further RRM enhancement for NR and MR-DC                              |
| [3] | R4-2206870, PUCCH Scell activation delay requirements with multiple Scell              |
| [4] | R4-2206862, Interruption requirement to LTE serving cell, and impacts to other LTE RRM |
| [5] | R4-2206870 PUCCH Scell activation delay requirements with multiple Scell               |

## 11.15 Further enhancement on NR demodulation performance

890055	<a href="#">Further enhancement on NR demodulation performance</a>	NR_demod_enh2		RP-212636	China Telecom
890255	Perf. part: NR_demod_enh2	NR_demod_enh2-Perf	R4	RP-212636	China Telecom

Summary based on the input provided by China Telecom in RP-221286, covering RAN2 (Core part), RAN4 (Perf. part).

This work item introduced several Rel-17 enhancements for UE and BS demodulation requirements [1]. New UE/BS demodulation requirements, and the corresponding new features and/or network assistant signalling for UE side enhancement are introduced in the WI.

The different enhancements are:

1. PDSCH demodulation and CQI reporting requirements of MMSE-IRC receiver for suppressing inter-cell interference in FR1 with slot-based transmission and aligned SCS among cells scenario [2]. The interference covariance estimation for MMSE-IRC is based on the serving UE's PDSCH DMRS and serving cell's CSI-RS for PDSCH demodulation and CQI reporting respectively.
2. PDSCH demodulation requirements of MMSE-IRC receiver for suppressing intra-cell inter-user interference in FR1 with slot-based transmission and aligned SCS among cells scenario [3]. DMRS based interference covariance estimation for MMSE-IRC is assumed for PDSCH demodulation.

For the two points above, one UE feature without capability signalling is introduced for MMSE-IRC receiver in scenarios with both inter-cell and intra-cell inter-user interference. The requirements defined in objective #1 and #2 are release independent from Rel-15, optional for Rel-15 and Rel-16 UE, and mandatory for Rel-17 UE.

3. NR PDSCH demodulation requirements for neighbouring cell LTE CRS-IM in scenarios with overlapping spectrum for LTE and NR [4]. Two scenarios are covered, including: 1) scenario 1 with DSS scenario, where serving and neighbouring cells are both operating with DSS of NR and LTE, and the NR UE is suffering interference from the LTE CRS of neighbouring cells, and 2) scenario 2 with non-DSS scenario, where serving cell is operating in NR, neighbouring cells are operating in LTE, and the NR UE in the serving cell is suffering interference from the LTE CRS of neighbouring cells.

LLR weighting is used as the baseline reference receiver for CRS-IM. Synchronous network scenario is targeted. 15kHz NR SCS is covered in scenario 1, and 15 kHz and 30 kHz NR SCS is covered in scenario 2.

Based on RAN4 LSs in [5] and [6], the RAN2 CRs on UE capability signalling are endorsed in [7] [8], and the RAN2 CR on network assistant signalling is agreed in [9].

For points 2 and 3 above, the Phase I performance evaluation outcomes are captured in TR 38.833 [10].

4. PUSCH demodulation requirements for FR1 256QAM [11 - 13]. 1-layer PUSCH transmission with MCS 20 and under low mobility of TDLA30-10 channel is agreed and used for the requirement definition.

## References

- |     |  |
|-----|--|
| [1] | RP-213656 Revised WID: Further enhancement on NR demodulation performance China Telecom  |
| [2] | R4-2211331 Big CR for inter-cell MMSE-IRC Apple  |
| [3] | R4-2209828 BigCR for IRC for intra cell inter user MMSE receiver requirements Huawei   |
| [4] | R4-2210660 Draft Big CR for CRS-IM Ericsson  |
| [5] | R4-2207238 LS on UE capability and network assistant signalling for CRS interference mitigation in scenarios with overlapping spectrum for LTE and NR (contact: China Telecom) |

- [6] R4-2210435 LS on UE capability and network assistant signalling for CRS interference mitigation in the scenario with overlapping spectrum for LTE and NR with 30kHz SCS (contact: CMCC)
- [7] R2-2206523 CR to TS 38.306 on UE capability for Rel-17 CRS interference mitigation China Telecom, Huawei, HiSilicon
- [8] R2-2206524 CR to TS 38.331 on UE capability for Rel-17 CRS interference mitigation China Telecom, Huawei, HiSilicon
- [9] R2-2206525 CR to TS 38.331 on Network assistant signalling for Rel-17 CRS interference mitigation China Telecom, Huawei, HiSilicon
- [10] TR 38.833 Further enhancement on NR demodulation performance
- [11] R4-2207253 BigCR for TS38.104: Introduction of conformance testing requirements for FR1 PUSCH 256QAM Nokia
- [12] R4-2205824 BigCR for FR1 PUSCH 256QAM requirements in TS 38.141-1 Huawei
- [13] R4-2207251 Big CR for TS38.141-2 FR1 PUSCH 256QAM Ericsson

## 11.16 Bandwidth combination set 4 (BCS4) for NR

900167	<b>Introduction of bandwidth combination set 4 (BCS4) for NR</b>	NR_BCS4-Core	R4	RP-202832	Ericsson
--------	--	--------------	----	-----------	----------

Summary based on the input provided by Ericsson in RP-222107.

The purpose of BCS4 (Bandwidth Combination Set 4) for inter-band and intra-band NR-CA was for band combinations to indicate that all the possible defined bandwidths for each band in that band combination are supported.

It was in the scope of the WI to ensure that all required analysis including MSD, MPR/A-MPR, etc. be performed for BCS4 for every existing band combination configuration (up to 3 bands). Also, in the scope of the WI was to study and define the most suitable UE capabilities signalling methods to enable BCS4 support.

The technical work on introduction on BCS4 started from RAN#90-e Dec. 2020 [1].

In the study for possible new signalling, it was decided that BCS4 was to be introduced without signalling so that these band combinations can be introduced in a release independent manner. A new BCS5 were added to be used with signalling. It was decided that BCS4 and BCS5 need to be requested and introduced simultaneously.

For BCS5 supportedMinBandwidthDL-r17 signalling were introduced that indicates minimum DL channel bandwidth supported for a given SCS that UE supports within a single CC (and in case of intra-frequency DAPS handover for the source and target cells), which is defined in Table 5.3.5-1 in TS 38.101-1 for FR1 and Table 5.3.5-1 in TS 38.101-2 for FR2. This parameter is only applicable to the Bandwidth Combination Set 5. This field does not restrict the bandwidths configured for a single CC (i.e. non-CA case).

The MSD tables were rewritten to a more generic template to support accommodation of BCS4/BCS5 band combination requests more easily. For these requests, the MSD template reduces RAN4 workload, simplifies TS 38.101-1 maintenance, ensures that MSD tables due to harmonic interference and cross-band isolation interference are consistent with the template adopted for MSD due to dual-uplink intermodulation interference, and by doing so, it reduces the size and complexity of these MSD tables.

To introduce BCS4/BCS5 into the 3GPP core part specifications, RAN2 and RAN4 agreed the necessary changes in the corresponding CRs below.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900167>

and the following CRs:

- 38.306 Introduction of BCS4 and BCS5 RP-220838
- 38.331 Introduction of BCS4 and BCS5 RP-220838
- 38.101-1 CR for 38.101-1: Introduction of BCS4 and BCS5 RP-211896
- 38.101-1 CR 38.101-1 to improve how to include BCS4 and BCS5 RP-212827
- 38.101-1 Big CRs to TS 38.101-1 for NR\_BCS4 RP-220353
- 38.101-1 CR for 38.101-1 to introduce the missing requirements for BCS4 RP-221680
- 38.101-3 CR for 38.101-3: Introduction of BCS4 and BCS5 RP-211896
- 38.101-3 Improved wording for BCS4 and BCS5 RP-212827
- 38.101-3 CR for 38.101-3 to clarify that BCS4 and BCS5 can't be reported together RP-221680
- 38.307 CR to TS 38.307 on Release independence of BCS4 and BCS5 RP-220353



## 11.17 Study on band combination handling in RAN4

910096	<a href="#">Study on band combination handling in RAN4</a>	FS_NR_ENDC_co mbo_rules	R4	RP-211146	ZTE
--------	--	----------------------------	----	-----------	-----

Summary based on the input provided by ZTE Corporation in RP-220165.

Note: Although Studies are usually not reported in this document, it was estimated by the rapporteur that this study deserves a summary.

5G NR have much more complex band combination configurations than previous generations, due to the number of bands, multiple numerologies, larger channel bandwidth, size of channel bandwidth set, etc.

RAN4 specifications have been reorganized with the scope of this Work Item, as to provide a clearer view of all specified combinations. This CA/DC band combination related rule collections will help within and outside 3GPP.

This SI covers:

- Capture of the workflow on introduction of band combinations for block approval and introduce new template of band combination request sheets for basket WIs as to reduce the workload of the basket WI rapporteur.
- Indication of the rules for band combinations not valid or not for block approval.
- Collect agreements on the rules of specifying band combinations, and facilitate people's understanding of the complex notations of CA/DC combinations. This includes:
  - Rules of: CA/DC combination denotation; grouping EN-DC, NE-DC and NR-DC configurations.
  - Guidelines on: the band edge relaxation for MOP; introduction of PC2 combinations; introduction of band combinations with intra-band ULCA in UL configuration.
- Study optimization rules for Rel-17 band combinations and provide further possible optimization in Rel-18, such as:
  - Removal of the redundant SCS information for inter-band CA configuration tables in Rel-17.
  - Optimization of FR2 intra-band no-contiguous CA configuration table in Rel-17 with no sub-block column explicitly shown.
  - Optimization proposal of  $\Delta TIB,c$  and  $\Delta RIB,c$  tables for band combinations. A mix of rule-based and table-based approach is proposed in Rel-18.
  - Further optimization on the new template for NR inter-band CA and SUL configuration tables in Rel-18.

### References

- [1] R4-2203987, TR 38.862 V0.6.0, Study on band combination handling in RAN4.
- [2] RP-220164, Status report for SI Study on band combination handling in RAN4.
- [3] R4-2206440, Email discussion summary for [102-e][140] FS\_BC\_handling.

(No related CRs.)

## 11.18 Other NR related activities

UID	Name	Acronym	WG	WID	WI rapporteur name/company
911009	<a href="#">Rel-17 Power Class 2 UE for NR inter-band CA with or without SUL configurations with x (16&gt;=x&gt;2) bands DL and y (y=1, 2) bands UL</a>	NR_UE_PC2_R17_CADC_SUL_xBDL_yBUL		RP-212182	Huawei
911109	Core part: NR_UE_PC2_R17_CADC_SUL_xBDL_yBUL	NR_UE_PC2_R17_CADC_SUL_xBDL_yBUL-Core	R4	RP-212182	Huawei
911209	Perf. part: NR_UE_PC2_R17_CADC_SUL_xBDL_yBUL	NR_UE_PC2_R17_CADC_SUL_xBDL_yBUL-Perf	R4	RP-212182	Huawei
911012	<a href="#">High power UE (power class 1.5) for NR band n79</a>	NR_UE_PC1_5_n79		RP-210843	CMCC
911112	Core part: NR_UE_PC1_5_n79	NR_UE_PC1_5_n79-Core	R4	RP-210843	CMCC
911212	Perf. part: NR_UE_PC1_5_n79	NR_UE_PC1_5_n79-Perf	R4	RP-210843	CMCC
930052	UE Conformance - High power UE (power class 1.5) for NR band n79	NR_UE_PC1_5_n79-UEConTest	R5	RP-211979	CMCC
911013	<a href="#">High power UE (power class 2) for NR band n34</a>	NR_UE_PC2_n34		RP-210844	CMCC
911113	Core part: NR_UE_PC2_n34	NR_UE_PC2_n34-Core	R4	RP-210844	CMCC
911213	Perf. part: NR_UE_PC2_n34	NR_UE_PC2_n34-Perf	R4	RP-210844	CMCC
930053	UE Conformance - High power UE (power class 2) for NR band n34	NR_UE_PC2_n34-UEConTest	R5	RP-211980	CMCC
911014	<a href="#">High power UE (power class 2) for NR band n39</a>	NR_UE_PC2_n39		RP-210845	CMCC
911114	Core part: NR_UE_PC2_n39	NR_UE_PC2_n39-Core	R4	RP-210845	CMCC



911214	Perf. part: NR_UE_PC2_n39	NR_UE_PC2_n39-Perf	R4	RP-210845	CMCC
930054	UE Conformance - High power UE (power class 2) for NR band n39	NR_UE_PC2_n39-UEConTest	R5	RP-211981	CMCC
911015	Introduction of FR2 FWA (Fixed Wireless Access) UE with maximum TRP of 23dBm for band n259	NR_FR2_FWA_Bn259		RP-210875	SoftBank Corp., KDDI, NTT DOCOMO, Rakuten Mobile, Qualcomm
911115	Core part: NR_FR2_FWA_Bn259	NR_FR2_FWA_Bn259-Core	R4	RP-210875	SoftBank Corp., KDDI, NTT DOCOMO, Rakuten Mobile, Qualcomm
911215	Perf. part: NR_FR2_FWA_Bn259	NR_FR2_FWA_Bn259-Perf	R4	RP-210875	SoftBank Corp., KDDI, NTT DOCOMO, Rakuten Mobile, Qualcomm
910097	Study on optimizations of pi/2 BPSK uplink power in NR	FS_NR_Opt_pi2BPSK	R4	RP-210910	Huawei
870064	Introduction of FR2 FWA (Fixed Wireless Access) UE with maximum TRP (Total Radiated Power) of 23dBm for band n257 and n258	NR_FR2_FWA_Bn257_Bn258		RP-202565	Softbank
870164	Core part: NR_FR2_FWA_Bn257_Bn258	NR_FR2_FWA_Bn257_Bn258-Core	R4	RP-202565	Softbank
870264	Perf. Part: NR_FR2_FWA_Bn257_Bn258	NR_FR2_FWA_Bn257_Bn258-Perf	R4	RP-202565	Softbank
880092	Adding channel bandwidth support to existing NR bands	NR_bands_R17_BWs		RP-212531	Ericsson
880192	Core part: NR_bands_R17_BWs	NR_bands_R17_BWs-Core	R4	RP-212531	Ericsson
880093	Introduction of channel bandwidths 35MHz and 45MHz for NR FR1	NR_FR1_35MHz_45MHz_BW		RP-211386	Huawei
880193	Core part: NR_FR1_35MHz_45MHz_BW	NR_FR1_35MHz_45MHz_BW-Core	R4	RP-211386	Huawei
880293	Perf. Part: NR_FR1_35MHz_45MHz_BW	NR_FR1_35MHz_45MHz_BW-Perf	R4	RP-211386	Huawei
880097	SAR schemes for UE power class 2 (PC2) for NR inter-band Carrier Aggregation and supplemental uplink (SUL) configurations with 2 bands UL	NR_SAR_PC2_interB_SUL_2BUL		RP-212530	China Telecom
880197	Core part: NR_SAR_PC2_interB_SUL_2BUL	NR_SAR_PC2_interB_SUL_2BUL-Core	R4	RP-212530	China Telecom
880297	Perf. Part: NR_SAR_PC2_interB_SUL_2BUL	NR_SAR_PC2_interB_SUL_2BUL-Perf	R4	RP-212530	China Telecom
920065	UE Conformance - SAR schemes for UE power class 2 (PC2) for NR inter-band Carrier Aggregation and supplemental uplink (SUL) configurations with 2 bands UL	NR_SAR_PC2_interB_SUL_2BUL-UEConTest	R5	RP-211139	China Telecom
900064	Additional NR bands for UL-MIMO power class 3 (PC3) in Rel-17	NR_bands_UL_MIMO_PC3_R17		RP-212184	Huawei
900164	Core part: NR_bands_UL_MIMO_PC3_R17	NR_bands_UL_MIMO_PC3_R17-Core	R4	RP-212184	Huawei
900264	Perf. part: NR_bands_UL_MIMO_PC3_R17	NR_bands_UL_MIMO_PC3_R17-Perf	R4	RP-212184	Huawei
900167	Introduction of bandwidth combination set 4 (BCS4) for NR	NR_BCS4-Core	R4	RP-202832	Ericsson
900068	Downlink interruption for NR and EN-DC band combinations to conduct dynamic Tx Switching in Uplink	DL_intrpt_combos_TxSW_R17		RP-210478	China Telecom
900168	Core part: DL_intrpt_combos_TxSW_R17	DL_intrpt_combos_TxSW_R17-Core	R4	RP-202885RP-210478	China Telecom
900268	Perf. part: DL_intrpt_combos_TxSW_R17	DL_intrpt_combos_TxSW_R17-Perf	R4	RP-202885RP-210478	China Telecom
900069	High-power UE (power class 1.5) operation in NR bands n77 and n78	HPUE_PC1_5_n77_n78		RP-202912	Qualcomm
900169	Core part: HPUE_PC1_5_n77_n78	HPUE_PC1_5_n77_n78-Core	R4	RP-202912	Qualcomm
930055	UE Conformance - High-power UE (power class 1.5) operation in NR bands n77 and n78	HPUE_PC1_5_n77_n78-UEConTest	R5	RP-212581	Verizon
930057	Introduction of upper 700MHz A block E-UTRA band for the US	LTE_upper_700MHz_A	R4	RP-212618	Puloli
930157	Core part: Introduction of upper 700MHz A block E-UTRA band for the US	LTE_upper_700MHz_A-Core	R4	RP-212618	Puloli
930257	Perf. part: Introduction of upper 700MHz A block E-UTRA band for the US	LTE_upper_700MHz_A-Perf	R4	RP-212618	Puloli
930058	High power UE (power class 2) for one NR FDD band	NR_PC2_UE_FDD	R4	RP-212633	China Unicom
930158	Core part: High power UE (power class 2) for one NR FDD band	NR_PC2_UE_FDD-Core	R4	RP-212633	China Unicom
930258	Perf. part: High power UE (power class 2) for one NR FDD band	NR_PC2_UE_FDD-Perf	R4	RP-212633	China Unicom

## 11.19 NR new/modified bands

### 11.19.1 Introduction of 6GHz NR licensed bands

890050	<a href="#">Introduction of 6GHz NR licensed bands</a>	NR_6GHz	R4	RP-202844	Huawei
890150	Core part: Introduction of 6GHz NR licensed bands	NR_6GHz-Core	R4	RP-202844	Huawei
890250	Perf. part: Introduction of 6GHz NR licensed bands	NR_6GHz-Perf	R4	RP-202844	Huawei

Summary based on the input provided by Huawei in RP-221505.

The technical work on 6425-7125 MHz frequency range follows the RCC Recommendation 1/21 [2].

In order to make this frequency range available for IMT licensed usage, this work item has specified BS/UE RF requirements for licensed operation in the range of 6425- 7125 MHz, including:

- Band plan for licensed operation in the range of 6425- 7125 MHz
- System parameters such as channel bandwidths and channel arrangements
- UE transmitter and receiver characteristics
- BS transmitter and receiver characteristics

#### *Operating band*

NR operating band n104 is designed to operate in the range of 6425- 7125 MHz. The duplex mode is TDD.

NR operating band	Uplink (UL) operating band BS receive / UE transmit $F_{UL,low} - F_{UL,high}$	Downlink (DL) operating band BS transmit / UE receive $F_{DL,low} - F_{DL,high}$	Duplex mode
n104	6425 MHz – 7125 MHz	6425 MHz – 7125 MHz	TDD

#### *System parameters*

- BS/UE channel bandwidth (in MHz): 20, 30, 40, 50, 60, 70, 80, 90, 100
- Channel raster granularity: 15 kHz and 30 kHz
- Synchronization raster step size: 7

NR operating band	SS Block SCS	SS Block pattern	Range of GSCN (First – <Step size> – Last)
n104	30 kHz	Case C	9882 – <7> – 10358

#### *UE transmitter and receiver characteristics*

UE transmitter and receiver RF requirements for Band n104 are added to TS 38.101-1. The following band specific UE RF requirements are defined for Band n104. The detailed RF requirements can be found in the CR [3].

- UE Power Class 2 and Power Class 3
- Spurious emissions for UE co-existence
- UE reference sensitivity
- In-band blocking parameters
- Out-of-band blocking

#### *BS transmitter and receiver characteristics*

BS transmitter and receiver RF requirements for Band n104 are added to TS 38.104. The following band specific BS RF requirements are defined for Band n104. The detailed RF requirements can be found in the CR [4].

- Maximum offset of OBUE outside the downlink operating band
- Adjacent Channel Leakage power Ratio (ACLR)
- Operating band unwanted emission limits
- BS reference sensitivity

- Dynamic range
- Adjacent Channel Selectivity (ACS)
- OOB offset for NR operating band
- BS type 1-C Out-of-band blocking
- In-channel selectivity

## References

Impacted existing TS

RAN4 has agreed the following CRs:

- On 38.101-1 NR; UE Radio transmission and reception R4-2211224 [3]
- On 38.133 NR; Requirements for support of radio resource management R4-2210987 [10]
- On 38.104 NR; BS Radio transmission and reception R4-2210740 [4]
- On 36.104 E-UTRA; BS Radio transmission and reception R4-2209583 [8]
- On 37.104 E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception R4-2209537 [7]
- On 37.105 Active Antenna System (AAS) Base Station (BS) transmission and reception R4-2210739 [9]
- On 38.174 NR; Integrated access and backhaul radio transmission and reception R4-2208245 [6]
- [1] RP-220686, "Revised WID: Introduction of 6GHz NR licensed bands", Huawei, HiSilicon
- [2] RP-213605, "Liaison statement to TSG RAN on the inclusion of the 6425-7125 MHz frequency range in the 3GPP specification for 5G-NR/IMT-2020 systems," Regional Commonwealth in the Field of Communications.
- [3] R4-2211224, "Introduction of NR licensed band 6425 – 7125 MHz", Qualcomm Incorporated
- [4] R4-2210740, "CR to TS38.104 the introduction of 6425-7125MHz", ZTE Corporation
- [5] RP-221503, "Status report for WI: Introduction of 6GHz NR licensed bands", RAN4
- [6] R4-2208245, "Introducing 6GHz licensed operation into 38.174", CATT
- [7] R4-2209537, "CR to 37.104 on introduction of n104 co-existence requirements", Nokia, Nokia Shanghai Bell
- [8] R4-2209583, "CR to TS36.104 the introduction of coexistence requirements of licensed band 6425-7125MHz", ZTE Corporation
- [9] R4-2210739, "Introducing 6GHz licensed operation into 37.105", CATT

## 11.19.2 Extending current NR operation to 71 GHz

860041	<a href="#">Extending current NR operation to 71GHz</a>	NR_ext_to_71GHz	R1	RP-213540	Qualcomm
860141	Core part: Extending current NR operation to 71GHz	NR_ext_to_71GHz-Core	R1	RP-213540	Qualcomm
860241	Perf. part: Extending current NR operation to 71GHz	NR_ext_to_71GHz-Perf	R4	RP-213540	Qualcomm

Summary based on the input provided by Qualcomm in RP-222478.

This WID extends NR operation to 71GHz with the introduction of new unlicensed band n263. Relevant system parameters have been updated to consider the new sub-frequency range FR2-2, larger subcarrier spacings and channel bandwidths. This NR extension includes definition of n263 requirements for various form-factors (PC1, PC2, PC3), for both single carrier and CA operation.

### Introduction

NR Rel-15 defined two frequency ranges for operation: FR1 spanning from 410 MHz to 7.125 GHz and FR2 spanning from 24.25 GHz to 52.6 GHz.

RAN carried out a Rel-16 study on NR beyond 52.6 GHz (FS\_NR\_beyond\_52GHz) with corresponding TR in 38.807. From this study, it became apparent the global availability of bands in the 52.6 GHz to 71 GHz range, most notably in the form of the original 60 GHz band (57-66 GHz) and extended 60 GHz band (57-71 GHz). Moreover, WRC19 recently identified the 66-71 GHz frequency range for IMT operation in certain regions.

The proximity of this frequency range (57-71 GHz) to FR2 and the imminent commercial opportunities for high data rate communications makes it compelling for 3GPP to address NR operation in this frequency regime.

To minimize the specification burden and maximize the leverage of FR2 based implementations, 3GPP has decided to extend FR2 operation up to 71 GHz with the adoption of one or more new numerologies (i.e., larger subcarrier

spacings). Those new numerologies were identified in the study on waveform for NR>52.6 GHz in the first half of 2020. NR-U defined procedures for operation in unlicensed spectrum were also leveraged towards operation in the unlicensed 60 GHz band.

RAN1 completed a Rel-17 study on supporting NR from 52.6 GHz to 71 GHz. Subcarrier spacing (SCS) of 120 kHz with NCP was recommended to be supported. New subcarrier spacings 480 kHz, and 960 kHz along with 120 kHz were introduced for this frequency range. The spec impact for each subcarrier spacing choice was identified. Additional areas for further physical layer enhancements were also identified. For channel access, both LBT mode and no-LBT mode were recommended to be supported to cover a wide range of use cases and regulatory requirements. For LBT mode, the channel access mechanism defined in EN 302 567 was identified as the baseline and enhancements were chosen for further discussion.

The objectives of this work item are presented below.

*Physical layer aspects including [RAN1]*

In addition to 120 kHz SCS, specify new SCS, 480 kHz and 960 kHz, and define maximum bandwidth(s), for operation in this frequency range for data and control channels and reference signals, only NCP supported. Note: Except for timing line related aspects, a common design framework shall be adopted for 480 kHz to 960 kHz

Timeline related aspects adapted to 480 kHz and 960 kHz, e.g., BWP and beam switching timing, HARQ timing, UE processing, preparation and computation timelines for PDSCH, PUSCH/SRS and CSI, respectively.

Support of up to 64 SSB beams for licensed and unlicensed operation in this frequency range.

Supports 120 kHz SCS for SSB and 120 kHz SCS for initial access related signals/channels in an initial BWP. Study and specify, if needed, additional SCS (480 kHz, 960 kHz) for SSB for cases other than initial access. Note: coverage enhancement for SSB is not pursued.

In addition to 120 kHz, support 480 kHz SSB for initial access with support of CORESET#0/Type0-PDCCH configuration in the MIB with following constraints:

- Limited sync raster entry numbers. It is assumed that RAN4 supports a channelization design which results in the total number of synchronization raster entries considering both licensed and unlicensed operation in a 52.6 – 71 GHz band no larger than 665 (Note: the total number of synchronization raster entries in FR2 for band n259 + n257 is 599). If the assumption cannot be satisfied, it's up to RAN4 to decide its applicability to bands in 52.6 – 71 GHz.
- only 480 kHz CORESET#0/Type0-PDCCH SCS supported for 480 kHz SSB SCS.
- Prioritize support SSB-CORESET#0 multiplexing pattern 1. Other patterns discussed on a best effort basis.
- 960 kHz numerology for the SSB is not supported by the UE for initial access in Rel-17.
- Note: Strive to minimize specification impact by reusing tables for CORESET#0 and type0-PDCCH CSS set configuration defined for FR2 in Rel-15, as much as possible
- Note: 480 kHz is an optional SSB numerology for initial access for the UE. A UE supporting a band in 52.6-71 GHz must at least support 120 kHz SCS (for initial access and after initial access)
- Note: Dependency or lack thereof for a UE supporting 480 kHz and/or 960 kHz numerology for data and control to also support 480 kHz SSB numerology for initial access is to be tackled as part of UE capability discussion.

Support ANR and PCI confusion detection for 120, 480 and 960 kHz SCS based SSB, support CORESET#0/Type0-PDCCH configuration in MIB of 120, 480 and 960 kHz SSB

- FFS: additional method(s) to enable support to obtain neighbour cell SIB1 contents related to CGI reporting
- Only 1 CORESET#0/Type0-PDCCH SCS supported for each SSB SCS, i.e., (120, 120), (480, 480) and (960, 960).
- Prioritize support SSB-CORESET#0 multiplexing pattern 1. Other patterns discussed on a best effort basis.
- Note: Strive to minimize specification impact by reusing tables for CORESET#0 and type0-PDCCH CSS set configuration defined for FR2 in Rel-15, as much as possible
- Note: From UE perspective, ANR detection for 480/960 kHz SCS based SSB is not supported if the UE does not support 480/960 SCS for SSB.
- Note: for ANR, when reading the MIB, the cell containing the SSB is known to the UE, as defined in 38.133 specification.

Specify timing associated with beam-based operation to new SCS (i.e., 480 kHz and/or 960 kHz), study, and specify if needed, potential enhancement for shared spectrum operation: Rel-15/16 and any Rel-17 beam management enhancements can be considered for 52.6-71 GHz. Whether particular features should be excluded for 52.6-71 GHz can be further discussed. Note: As per usual procedure, duplication of work between work items in Rel-17 should be avoided

Support enhancement for PUCCH format 0/1/4 to increase the number of RBs under PSD limitation in shared spectrum operation.

Support enhancements for multi-PDSCH/PUSCH scheduling and HARQ support with a single DCI. Note: coverage enhancement for multi-PDSCH/PUSCH scheduling is not pursued

Support enhancement to PDCCH monitoring, including blind detection/CCE budget, and multi-slot span monitoring, potential limitation to UE PDCCH configuration and capability related to PDCCH monitoring.

Specify support for PRACH sequence lengths (i.e.,  $L=139$ ,  $L=571$  and  $L=1151$ ) and study, if needed, specify support for RO configuration for non-consecutive RACH occasions (RO) in time domain for operation in shared spectrum

Evaluate, and if needed, specify the PTRS enhancement for 120 kHz SCS, 480 kHz SCS and/or 960 kHz SCS, as well as DMRS enhancement for 480 kHz SCS and/or 960 kHz SCS.

#### *Physical layer procedure(s) including [RAN1]*

Channel access mechanism assuming beam-based operation in order to comply with the regulatory requirements applicable to unlicensed spectrum for frequencies between 52.6 GHz and 71 GHz.

- Specify both LBT and No-LBT related procedures, and for No-LBT case no additional sensing mechanism is specified.
- Study, and if needed specify, omni-directional LBT, directional LBT and receiver assistance in channel access
- Study, and if needed specify, energy detection threshold enhancement

#### *Radio interface protocol architecture and procedures [RAN2]:*

For operation in this frequency range: Introduce higher layer support of enhancements listed above that are agreed to be specified. Note: RAN2 is to prioritize protocol support of RAN1 design and not on optimizations on items not discussed in RAN1.

#### *Core specifications for UE, gNB and RRM requirements [RAN4]:*

Specify new band(s) for the frequency range from 52.6 GHz-71 GHz. The band(s) definition should include UL/DL operation and excludes ITS spectrum in this frequency range.

Specify gNB and UE RF core requirements for the band(s) in the above frequency range, including a limited set of example band combinations (see Note 1). For the case of FR2-2 DC or CA with an anchor in FR1 the following three example band combinations shall be considered:  $n_{79} + N_x$  ;  $n_{77} + N_x$  and  $n_{41} + N_x$  , where  $N_x$  is the 57-71 GHz band for unlicensed operation and the [66-71] GHz for licensed operation. RAN4 to further discuss the need for single or multiple bands relevant for FR2-2 licensed/unlicensed operation.

Specify RRM/RLM/BM core requirements. Notes: The WI can be completed provided requirements for at least one band combination involving a new NR-U band is specified as long as it is in line with country-specific regulatory directives. UEs supporting a band in the range of 52.6 GHz-71 GHz are not required to support 480 kHz SCS and 960 kHz SCS. The maximum FFT size required to operate the system in 52.6 GHz-71 GHz frequency is 4096, and the maximum of RBs per carrier is 275 RBs. The system is designed to support both single-carrier and multi-carrier operation. FR2 is extended to cover 24.25 GHz to 71 GHz with FR2-1 for 24.25-52.6 GHz and FR2-2 for 52.6-71 GHz.

*The related UE capabilities and their applicability to the frequency range 52.6 to 71 GHz will have to be analyzed on a case-by-case basis*

*The application of any of the UE feature introduced for 52.6-71 GHz to existing FR1/FR2 should be discussed case by case.*

TSG RAN specifications shall make it very clear (to readers) that frequency bands in the 52.6-71 GHz range are only Release-independent from Rel-17 onwards, to ensure that there is clear industry understanding about which FR2 features are applicable for operation in 52.6-71 GHz range. Notes: Whenever the FR2 is referred, both FR2-1 and FR2-

2 frequency sub-ranges shall be considered in this release, unless otherwise stated. The designations FR2-1 and FR2-2 should only be used when needed.

### **Description**

Similar to regular NR and NR-U operations below 52.6 GHz, NR/NR-U operation in the 52.6 GHz to 71 GHz can be in stand-alone or aggregated via CA or DC with an anchor carrier.

### **Physical Layer enhancements**

In addition to 120 kHz SCS already supported in FR2-1, new SCSs of 480 kHz and 960 kHz are introduced, that can support wider bandwidth up to 2 GHz. For operation in FR2-2, SCSs 480 kHz and 960 kHz are optionally supported by UE, while SCS 120 kHz is mandatory.

### **Initial access aspects**

SSB of SCS 120 kHz, 480 kHz and 960 kHz are supported in FR2-2, and SCS 120 kHz and 480 kHz SSBs can support initial access. Up to 64 SSB candidate positions are allowed for FR2-2 and Discovery Burst Transmission Window (DBTW) is supported with ssb-PositionQCL being 32 or 64.

CORESET#0/Type0-PDCCH SCS is always the same as SSB SCS. SSB-CORESET#0 multiplexing pattern 1 and pattern 3 are supported for FR2-2.

Time locations for SCS 120 kHz SSB in FR2-1 are reused for FR2-2. Time locations for SCS 480 kHz and SCS 960 kHz SSBs are newly defined.

For PRACH, length 139 sequence is supported for all SCS, length 571 sequence is supported for SCSs 120 kHz and 480 kHz, and length 1151 sequence is supported for SCS 120 kHz.

### **PDCCH monitoring enhancements**

For SCS 480 kHz and 960 kHz, since slots are short, and UE power consumption to monitor PDCCH in each slot will be high, multi-slot PDCCH monitoring capability is introduced where UE monitors PDCCH in Y slots out of every X slots.

### **Enhancements for PUCCH formats 0/1/4**

To support higher transmit power under PSD limitation for PUCCH formats 0/1/4, enhanced PUCCH formats 0/1/4 are supported such that the number of RBs can be RRC configured from 1 to 16. For PUCCH format 0/1, type-1 long sequence occupying all REs over the configured number of RBs is used. For PUCCH format 4, OCC 2 or 4 is supported, and the number of RBs is restricted to in the form of  $N_{RB}=2^{(\alpha_2)} \cdot 3^{(\alpha_3)} \cdot 5^{(\alpha_5)}$ .

### **Beam managements for new SCSs**

Beam switching related timing values for SCS 480 kHz and 960 kHz are defined.

### **PDSCH/PUSCH enhancements**

Multi-PDSCH scheduling with a single DCI and multi-PUSCH scheduling with a single DCI are supported, where the time domain allocations of the multiple PDSCH or multiple PUSCH can be discontinuous. Time domain HARQ-ACK bundling is supported for both Type 1 HARQ codebook and Type 2 HARQ codebook.

Processing timelines for 480 kHz and 960 kHz SCS are defined, such as HARQ timeline, UE processing timeline, etc. DMRS enhancements for 480 kHz and 960 kHz are introduced that allows the indication to the UE that FD OCC is disabled for rank 1 transmission. The maximum number of HARQ processes supported for FR2-2 are increased to 32 in both DL and UL.

### **Channel access mechanism**

In frequency range 2-2, Rel-17 NR supports licensed spectrum operation (Draft CRs for FR2-2 licensed band n264 were endorsed, but won't be agreed until the regulation is available in at least one country or region), shared spectrum operation with LBT and shared spectrum operation without LBT. gNB will indicate UE if LBT is used for channel access by higher layer signalling.

When LBT mode is enabled, a maximum channel occupancy time (COT) of 5ms is supported. COT sharing from gNB to UE and UE to gNB are supported, similar to Release 16 NR-U.



For channel access for LBT mode, 3 types of channel access are defined

Type 1 channel access can be performed by gNB or UE to initiate a channel occupancy. Type 1 channel access involves sensing the channel multiple times with a counter with maximum contention window size 3.

Type 2 channel access requires a single sensing slot channel sensing and can be used to share a COT.

Type 3 channel access does not require channel sensing and can be used to share a COT, or to initiate Discovery RS transmission when regulation allows.

The directional LBT is defined for gNB and UE with or without beam correspondence. The bandwidth on which LBT is performed by gNB/UE should at least include active DL/UL BWP bandwidth.

#### MAC Enhancements

Rel-16 NR-U has introduced several enhancements to MAC procedures to alleviate the impact of LBT mechanism which can cause delays or dropped transmissions. The following were also adopted for FR2-2: Consistent LBT failure detection and recovery; Configured Grant (CG) changes; Changes to RACH procedures (e.g., extended RAR window duration) and HARQ handling for uplink multi-TTI transmissions.

Consistent LBT failure detection and recovery is applicable to FR2-2 with no changes, assuming LBT is configured on the considered serving cell.

The changes to configured grant transmission in Rel-16 NR-U were mainly due to autonomous retransmission on CG resources, autonomous HARQ process ID. and RV selection. A new CG retransmission timer was introduced where the UE is allowed to retransmit a packet on a CG after this timer expires without any ACK from the gNB for the earlier transmission. The only change for FR2-2 is that this timer is now optional and configured by RRC. Thus, when the timer is configured, the UE follows Rel-16 NR-U procedures while it uses the licensed spectrum procedures otherwise.

For FR2-2, extended values were introduced for several DRX parameters due to the shorter symbol duration for SCS of 480 and 960 kHz.

#### Upper Layer Enhancements

The support of RSSI and Channel Occupancy (CO) measurements was also carried over to FR2-2. For FR2-2, the configuration can also include bandwidth serving cell and TCI information for the RSSI measurement.

The enhancements to Idle/Inactive mode mobility (due to the possible existence of multiple independent operators on the same carrier) and paging (multiple paging monitoring occasions per PO) for NR-U are also re-used in FR2-2.

We note that Channel Access Priority Class (CAPC) which is used for QoS in NR-U as well as LTE LAA are not applicable to FR2-2.

Since LBT is optional for FR2-2, a new parameter is broadcast in SIB1 to indicate the LBT mode. The same information for neighbor cells can be included in measurement object for RRM and SIB3/SIB4 for Idle/Inactive mobility (RAN2 is still discussing this).

Many RRC parameters with values dependent on symbol duration or bandwidth were enhanced to support the new SCS and bandwidths.

The legacy UE capabilities which had FR1/FR2 differentiation in Rel-15/16 required, in some cases, further differentiation between legacy FR2 and FR2-2. These capabilities also included some upper layer capabilities such as IMS voice, Rel-16 Power Saving, and Rel-16 DCCA. For the new UE capabilities which needed FR2-2 differentiation, per-band signaling was adopted with consistent signaling across the FR2 bands.

New signaling and procedures were also introduced in LTE specifications to support handover from E-UTRAN to NR FR2-2.

#### System parameters

##### Spectrum and operating band

FR2 has been divided into two sub-frequency ranges: FR2-1 which covers the original range of 24.25-52.6 GHz, and FR2-2 which extends NR operation from 52.6 to 71 GHz. Given the prevalence of unlicensed spectrum in this

frequency range, a new NR band for unlicensed operation was introduced in this work item, band n263. This band extends from 57 to 71GHz, ensuring the unlicensed spectrum of all regions is supported.

Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	$F_{UL\_low} - F_{UL\_high}$	$F_{DL\_low} - F_{DL\_high}$	
n263	57000 MHz – 71000 MHz	57000 MHz – 71000 MHz	TDD <sup>1</sup>
NOTE 1: This band is for unlicensed operation and subject to regional and/or country specific regulatory requirements			

### Channel arrangement

UE channel bandwidth for n263: Compared to FR2-1, FR2-2 supports larger channel bandwidths including 800, 1600 and 2000MHz. In this release, only 400MHz channel bandwidth support is mandatory for band n263. An optional capability enables the UE to indicate its supported channel bandwidths for 480 and 960kHz SCS [3].

Channel spacing for band n263:

$$\text{Nominal Channel spacing} = \text{ceil}((BW_{\text{Channel}(1)} + BW_{\text{Channel}(2)})/100.8 \text{ MHz}) * 50.4 \text{ MHz}$$

Channel raster: Band n263 is defined to support 138 entries of non-overlapping 100MHz CBW with 100.8MHz channel spacing, 34 entries of non-overlapping 400MHz CBW with 403.2MHz channel spacing, and 30 to 34 entries of overlapping 800, 1600, and 2000MHz CBW that are spaced part by 403.2MHz. Additionally, band n263 supports one 120kHz SCS-based synchronization raster entry for each 100MHz CBW, and one 480kHz SCS-based synchronization raster entry for 400MHz CBW. Initial access using 960kHz SCS is not supported.

### Core requirements

#### Extending requirement definition to 71GHz

Many core requirements, either their definition or approach used to define them in FR2-1, were reused in FR2-2. For example, given the highly integrated nature of designs in this frequency range, characteristics continue to be specified over-the-air in FR2-2.

As with FR2-1, minimum performance requirements for FR2-2 were defined per-band and per-UE power class. Tx and Rx requirements were defined for power class 1 (FWA UE), power class 2 (vehicular UE), and power class 3 (handheld UE) operation in band n263. These power classes use the same reference form-factor used in FR2-1, but the number of antenna elements used to derive the requirements was increased to help alleviate the impact of higher losses and more complex integration of this frequency range.

#### Carrier aggregation in FR2-2

In addition to single carrier requirements, FR2-2 requirements to support intra-band contiguous CA operation have also been defined. In this release, contiguous DL CA configurations within FR2-2 may only contain multiples of the same channel bandwidth. The supported CA band combinations include FR2-2 with an FR1 anchor; combinations for n48 + n263 were introduced in RAN4 #104e [4].

#### Beam correspondence

For band n263, support of beam correspondence without UL beam sweeping is defined for power class 3.

### **References**

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860041,860141,860241>

- [1] R4-2211189, "Rel-17 RAN4 UE feature list for NR," CMCC, RAN4 #103e, May 2022
- [2] R4-2215256, Big CR of TS38.101-3 to add new NR\_CADC 2BDL\_xBUL combinations containing FR1 + FR2-2, Intel Corporation

### 11.19.3 Other NR new/modified bands

UID	Name	Acronym	WG	WID	WI rapporteur name/company
<b>911016</b>	<b>Introduction of 900MHz NR band for Europe for Rail Mobile Radio (RMR)</b>	<b>NR_RAIL_EU_900 MHz</b>		<b>RP-211495</b>	<b>UIC</b>
911116	Core part: NR_RAIL_EU_900MHz	NR_RAIL_EU_900 MHz-Core	R4	RP-211495	UIC
911216	Perf. part: NR_RAIL_EU_900MHz	NR_RAIL_EU_900 MHz-Perf	R4	RP-211495	UIC
<b>911017</b>	<b>Introduction of 1900MHz NR TDD band for Europe for Rail Mobile Radio (RMR)</b>	<b>NR_RAIL_EU_190 0MHz_TDD</b>		<b>RP-211542</b>	<b>UIC</b>
911117	Core part: NR_RAIL_EU_1900MHz_TDD	NR_RAIL_EU_190 0MHz_TDD-Core	R4	RP-211542	UIC
911217	Perf. part: NR_RAIL_EU_1900MHz_TDD	NR_RAIL_EU_190 0MHz_TDD-Perf	R4	RP-211542	UIC
860037	Study on supporting NR from 52.6 GHz to 71 GHz	FS_NR_52_to_71G Hz	R1	RP-201838	Intel
870060	Study on IMT parameters for 6.425-7.025GHz, 7.025-7.125GHz and 10.0-10.5GHz	FS_NR_IMT_para m	R4	RP-202276	Ericsson
<b>870063</b>	<b>Introduction of NR band n13</b>	<b>NR_n13</b>	<b>R4</b>	<b>RP-200480</b>	<b>Huawei</b>
870163	Core part: Introduction of NR band n13	NR_n13-Core	R4	RP-200480	Huawei
870263	Perf. part: Introduction of NR band n13	NR_n13-Perf	R4	RP-200480	Huawei
<b>880082</b>	<b>Introduction of NR 47GHz band</b>	<b>NR_47GHz_band</b>	<b>R4</b>	<b>RP-212528</b>	<b>Ericsson</b>
880182	Core part: Introduction of NR 47GHz band	NR_47GHz_band-Core	R4	RP-212528	Ericsson
880282	Perf. part: Introduction of NR 47GHz band	NR_47GHz_band-Perf	R4	RP-212528	Ericsson
<b>880084</b>	<b>Introduction of NR band 24</b>	<b>NR_band_n24</b>	<b>R4</b>	<b>RP-211505</b>	<b>Ligado Networks</b>
880184	Core part: Introduction of NR band 24	NR_band_n24-Core	R4	RP-211505	Ligado Networks
880284	Perf. part: Introduction of NR band 24	NR_band_n24-Perf	R4	RP-211505	Ligado Networks
<b>920075</b>	<b>Introduction of operation in full unlicensed band 5925-7125MHz for NR</b>	<b>NR_6GHz_unlic_f ull</b>	<b>R4</b>	<b>RP-212302</b>	<b>Apple</b>
920175	Core part: Introduction of operation in full unlicensed band 5925-7125MHz for NR	NR_6GHz_unlic_ful l-Core	R4	RP-212302	Apple
920275	Perf. part: Introduction of operation in full unlicensed band 5925-7125MHz for NR	NR_6GHz_unlic_ful l-Perf	R4	RP-212302	Apple
<b>890051</b>	<b>Introduction of lower 6GHz NR unlicensed operation for Europe</b>	<b>NR_6GHz_unlic_E U</b>	<b>R4</b>	<b>RP-212625</b>	<b>Nokia</b>
890151	Core part: Introduction of lower 6GHz NR unlicensed operation for Europe	NR_6GHz_unlic_E U-Core	R4	RP-212625	Nokia
890251	Perf. part: Introduction of lower 6GHz NR unlicensed operation for Europe	NR_6GHz_unlic_E U-Perf	R4	RP-212625	Nokia
<b>900065</b>	<b>Introduction of NR band n67</b>	<b>NR_n67</b>	<b>R4</b>	<b>RP-202829</b>	<b>Ericsson</b>
900165	Core part: Introduction of NR band n67	NR_n67-Core	R4	RP-202829	Ericsson
900265	Perf. Part: Introduction of NR band n67	NR_n67-Perf	R4	RP-202829	Ericsson
<b>900066</b>	<b>Introduction of NR band n85</b>	<b>NR_n85</b>	<b>R4</b>	<b>RP-210707</b>	<b>Ericsson</b>
900166	Core part: Introduction of NR band n85	NR_n85-Core	R4	RP-210707	Ericsson
900266	Perf. part: Introduction of NR band n85	NR_n85-Perf	R4	RP-210707	Ericsson
<b>880083</b>	<b>Introduction of 1.6 GHz NR supplemental uplink (SUL) band with same uplink frequency range of Band 24</b>	<b>NR_SUL_UL_n24</b>		<b>RP-210341</b>	<b>Ligado Networks</b>
880183	Core part: NR_SUL_UL_n24	NR_SUL_UL_n24-Core	R4	RP-210341	Ligado Networks
880283	Perf. part: NR_SUL_UL_n24	NR_SUL_UL_n24-Perf	R4	RP-210341	Ligado Networks
<b>880085</b>	<b>Introduction of NR supplemental uplink (SUL) band 1880-1920MHz</b>	<b>NR_SUL_band_18 80_1920MHz</b>		<b>RP-201363</b>	<b>CMCC</b>
880185	Core part: NR_SUL_band_1880_1920MHz	NR_SUL_band_18 80_1920MHz-Core	R4	RP-201363	CMCC
880285	Perf. part: NR_SUL_band_1880_1920MHz	NR_SUL_band_18 80_1920MHz-Perf	R4	RP-201363	CMCC
<b>880086</b>	<b>Introduction of NR supplemental uplink (SUL) band 2300-2400MHz</b>	<b>NR_SUL_band_23 00_2400MHz</b>		<b>RP-201364</b>	<b>CMCC</b>
880186	Core part: NR_SUL_band_2300_2400MHz	NR_SUL_band_23 00_2400MHz-Core	R4	RP-201364	CMCC
880286	Perf. part: NR_SUL_band_2300_2400MHz	NR_SUL_band_23 00_2400MHz-Perf	R4	RP-201364	CMCC
900055	UE Conformance - New Rel-17 NR licensed bands and extension of existing NR bands	NR_lic_bands_BW_R17-UEConTest	R5	RP-202567	Huawei

## 12. New Radio (NR) enhancements other than layer 1

### 12.1 NR Uplink Data Compression (UDC)

911006	<a href="#">NR Uplink Data Compression (UDC)</a>	NR_UDC		RP-220140	CATT
911106	Core part: NR_UDC	NR_UDC-Core	R2	RP-220140	CATT

Summary based on the input provided by CATT in RP-220142.

This work item specifies NR Uplink Data Compression (UDC), i.e. uplink data can be compressed at the UE and can be decompressed at the NG-RAN node.

In this WI, DEFLATE based UDC solution is introduced which uses LTE UDC as baseline.

DEFLATE based UDC solution could achieve higher compression efficiency which would save more uplink resources and reduce the transmission latency. The NG-RAN node can configure the UE to use UDC or not. If UDC is configured for a DRB, ROHC or EHC is not used for that DRB. One byte UDC header is introduced to indicate whether the PDCP SDU is compressed by UDC or not, whether the compression buffer is reset or not, and 4 validation bits of checksum are used to indicate whether the compression and decompression buffers are synchronous. For each DRB, the maximum compression buffer is 8192 bytes. If there are errors or failures due to buffer mismatching, the NG-RAN node can send a PDCP control PDU for error notification to the UE, the UE may reset the compression buffer when such notification has been received.

Similar as for LTE UDC, to improve compression efficiency of the first packets, two types of pre-defined dictionary can be used for UDC. One is standard dictionary for SIP and SDP signalling as defined in RFC 3485, and another is operator defined dictionary. The NG-RAN node configures whether or which dictionary is used for a UDC DRB.

NR UDC can be applied to NR-DC, NE-DC and NGEN-DC scenarios. Also, NR UDC can be applied to split bearer type. For NR-DC, NE-DC and NGEN-DC scenarios, MN can send an indication to SN regarding the maximum number of UDC DRBs allowed to SN terminated bearer. Furthermore, NR UDC can also be applied to CU CP and UP splitting scenario, where corresponding configuration parameters can be carried via E1 interface.

NR UDC continuity is also supported, which is similar as the ROHC continuity mechanism.

UDC related capabilities are also defined for UEs. There are four capabilities defined: supporting basic UDC function, supporting standard dictionary, supporting operator defined dictionary, and supporting UDC continuity. If the UE supports operator defined dictionary, it shall report the version of the dictionary and the associated PLMN ID to assist the NG-RAN node to identify the dictionary stored by the UE. The NG-RAN node configures UDC according to the signalled UE capabilities.

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=911006,911106>

- [1] RP-220141 Status Report for WI: NR Uplink Data Compression (UDC) CATT

### 12.2 NR QoE management and optimizations for diverse services

911008	<a href="#">NR QoE management and optimizations for diverse services</a>	NR_QoE		RP-211406	China Unicom
911108	Core part: NR QoE management and optimizations for diverse services	NR_QoE-Core	R3	RP-211406	China Unicom
860061	<a href="#">Study on NR QoE (Quality of Experience) management and optimizations for diverse services</a>	FS_NR_QoE	R3	RP-193256	China Unicom

Summary based on the input provided by China Unicom in RP-220556.

This WI specifies the NR QoE functionality.

The QoE Measurement Collection function enables the collection of application layer measurements from the UE. The measurements are supported for Streaming services, MTSI services, and VR services. Both signalling based and management based QoE measurement collection are supported. In this Release, basic application layer measurement collection mechanism is supported, and RAN visible QoE measurement mechanism and metrics are supported.

In the WI, the feature of QoE Measurement Collection function is activated in the NG-RAN either by direct configuration from the OAM system (management-based activation), or by signalling from the OAM via the Core Network (signalling-based activation), using UE-associated signalling. One or more QoE measurement collection jobs can be activated at a UE per service type. The application layer measurement configuration and measurement reporting is supported in RRC\_CONNECTED state only. The QoE Measurement Collection deactivation permanently stops all or some of QoE measurement collection jobs towards a UE, resulting in the release of the corresponding QoE measurement configuration(s) in the UE. When a service is provided within a configured slice, the QoE Measurement Collection for this service type could also be configured together with the corresponding slice scope, so that the user experience of this service could also be evaluated on a per-slice basis.

The QoE Measurement Collection pause/resume procedure is used to pause/resume the reporting for all QoE reports or to pause/resume QoE reporting per QoE configuration in a UE for RAN overload situation. The gNB can send a downlink RRC message to temporarily stop the application layer measurement reports associated to one or multiple QoE configurations from UE to the network.

The QoE Measurement Collection continuity for intra-system intra-RAT mobility is supported in R17, with the area scope parameters configured by the OAM. The NG-RAN node is responsible for keeping track and identify whether the UE is inside or outside the area scope. A UE should continue an ongoing measurement even if it leaves the area scope, unless the NG-RAN node indicates to the UE to release the QoE configuration.

RAN visible QoE measurements are configured by the NG-RAN node, where a subset of QoE metrics is reported from the UE as an explicit IE to NG-RAN node. RAN visible QoE measurements (e.g., RAN visible QoE metrics, RAN visible QoE values) could be utilized by the NG-RAN node for network optimization. RAN visible QoE measurements are supported for the DASH streaming and VR service.

Radio-related measurements may be collected via immediate MDT for the supported services. The MCE/TCE performs the correlation of the immediate MDT results and the QoE measurement results collected at the same UE.

The following alignments are supported in this Release:

- Alignment between a signalling-based QoE measurement and a signalling-based MDT measurement.
- Alignment between a management-based QoE measurement and a management-based MDT measurement.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=911008,911108>

[1] RP-220554, Status report of SR for WI on NR QoE, China Unicom

## 13 NR and LTE enhancements

### 13.1 NR and LTE layer 1 enhancements

#### 13.1.1 High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands

920073	High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands	LTE_NR_HPUE_F WVM	R4	RP-212533	Nokia
920173	Core part: High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands	LTE_NR_HPUE_F WVM-Core	R4	RP-212533	Nokia
920273	Perf. part: High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands	LTE_NR_HPUE_F WVM-Perf	R4	RP-212533	Nokia

Summary based on the input provided by Nokia in RP-221201.

This work item introduced NR power class 1 requirements to be applicable to all NR bands instead of only n14 like it was during REL16.

The CR [3] has introduced core requirements for maximum output power, MPR and ACLR to be applicable to all bands.

Release independence aspects were confirmed [4]

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=911010,911110,911210>

- [1] RP-221200 Revised WID High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands
- [2] TR 37828 High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands
- [3] R4-2206455, CR to TS 38.101-1 on PC1 MPR table
- [4] R4-2210568, CR for TR 37.828 on release independence
- [5] RP-221199 SR of High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands

## 13.1.2 UE TRP and TRS requirements and test methodologies for FR1 (NR SA and EN-DC)

911010	Introduction of UE TRP (Total Radiated Power) and TRS (Total Radiated Sensitivity) requirements and test methodologies for FR1 (NR SA and EN-DC)	NR_FR1_TRP_TRS		RP-211158	Vivo
911110	Core part: NR_FR1_TRP_TRS	NR_FR1_TRP_TRS-Core	R4	RP-211158	Vivo
911210	Perf. part: NR_FR1_TRP_TRS	NR_FR1_TRP_TRS-Perf	R4	RP-211158	Vivo

Summary based on the input provided by vivo in RP-220606.

In Rel-15 and Rel-16, the UE FR1 transmit power and receiver sensitivity are tested by conducted methodology at the temporary antenna ports and it remains unknown what the actual performance of the UE would be in realistic network conditions with the UE antenna included. Radiated performance based on OTA testing is one of the most important characteristics to verify the entire UE performance under conditions more closely resembling the end user's interaction with the device.

In order to ensure the good overall system performance, the requirements for NR UE TRP and TRS is important for consistent devices performance in the real NR networks which operate in the OTA manner. Unified requirements in 3GPP will provide authoritative guidance and will greatly promote the development of 5G industries.

This WI defines the test methodology to verify the NR UE TRP TRS performance for NR standalone (SA) and NR non-standalone (NSA) operation mode. The outcome is captured in a new technical report TR 38.834. Then 3GPP can specify the follow-up OTA requirements for FR1 UE based on the available test method.

A full package of test method under SA and NSA mode aiming to specify 3GPP TRP TRS OTA requirements is defined:

- UE type: The test method covers device types including Smartphone (1st priority), Tablet, LEE and LME.
- Usage scenarios: Talk mode using head & hand phantom for narrow devices between 56 mm and 72 mm and for wide devices with a width >72 mm and <92 mm; Browsing mode using hand phantom for narrow and wide phones; Free Space for devices not used in talk or browsing mode
- Performance metrics: Definition of TRP and TRS for Anechoic-Chamber-based test methodology
- UE positioning guidelines: UE positioning guidelines for Free space, Hand phantom only (Browsing mode), and Head and Hand phantom (Talk Mode); Both Wide Grip Hand and PDA Grip Hand positioning guidance (Wide Grip Hand for UE with Width >72mm and ≤92mm ; PDA Grip Hand for UE with Width ≥56mm and ≤72mm)
- Test procedure for SA and EN-DC: Test setup for Single-antenna and multiple-antennas anechoic chambers; TRP TRS calibration procedure; Ripple test procedure for 30cm and 50cm, both theta-axis and phi-axis; SA TRP TRS performance measurement procedure; EN-DC TRP TRS performance measurement procedure (Only NR carrier measurement is needed); Minimum measurement distance of anechoic chambers
- UE configurations: TRP antenna configuration (TAS OFF with antenna locked at primary antenna); TRS antenna configuration (no specific setting); EN-DC configuration (For TRP UL configuration: the UL output power of LTE carrier should be set as a constant power of 10dBm, while measuring NR at maximum output power, i.e., with fixed p-MaxEUTRA-r15=10 dBm, and p-NR-FR1 not configured; For TRS UL configuration: The UL



power configuration for LTE and NR is 50%-50% power splitting, i.e. For PC3, p-MaxEUTRA-r15=20 dBm, and p-NR-FR1= 20dBm; For PC2, p-MaxEUTRA-r15=23 dBm, and p-NR-FR1= 23dBm.)

- Measurement uncertainty assessment (RAN5): Measurement error uncertainty contribution descriptions;  
Preliminary example of uncertainty budget (Expanded uncertainty for TRP hand only (browsing mode): 1.78 dB;  
Expanded uncertainty for TRP hand only (browsing mode): 2.20 dB)
- Test phantom definition: PDA Grip Hand; Wide Grip Hand; Head Phantom

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920073,920173,920273>

- [1] TR 38.834, Measurements of User Equipment (UE) Over-the-Air (OTA) performance for NR FR1; Total Radiated Power (TRP) and Total Radiated Sensitivity (TRS) test methodology
- [2] Status Report: Introduction of UE TRP (Total Radiated Power) and TRS (Total Radiated Sensitivity) requirements and test methodologies for FR1 (NR SA and EN-DC), vivo

## 13.1.3 Other Dual Connectivity and Multi-RAT enhancements

UID	Name	Acronym	WG	WID	WI rapporteur name/company
920072	<b>LTE/NR spectrum sharing in Band 34/n34 and Band 39/n39</b>	<b>DSS_LTE_B34_NR_Bn34_LTE_B39_NR_Bn39</b>	<b>R4</b>		<b>CMCC</b>
920172	Core part: LTE/NR spectrum sharing in Band 34/n34 and Band 39/n39	DSS_LTE_B34_NR_Bn34_LTE_B39_N R_Bn39-Core	R4	RP-211996	CMCC
920074	<b>Rel-17 Dual Connectivity (DC) of x bands (x=1,2) LTE inter-band CA (xDL1UL) and 4 bands NR inter-band CA (4DL1UL)</b>	<b>DC_R17_xBLTE_4BNR_yDL2UL</b>	<b>R4</b>	<b>RP-212606</b>	<b>Huawei</b>
920174	Core part: Rel-17 Dual Connectivity (DC) of x bands (x=1,2) LTE inter-band CA (xDL1UL) and 4 bands NR inter-band CA (4DL1UL)	DC_R17_xBLTE_4BNR_yDL2UL-Core	R4	RP-212606	Huawei
920274	Perf. part: Rel-17 Dual Connectivity (DC) of x bands (x=1,2) LTE inter-band CA (xDL1UL) and 4 bands NR inter-band CA (4DL1UL)	DC_R17_xBLTE_4BNR_yDL2UL-Perf	R4	RP-212606	Huawei
911019	<b>Addition of MSD (Maximum Sensitivity Degradation) for inter-band EN-DC combinations (1 band LTE+1 band NR FR1) due to added channel bandwidths</b>	<b>ENDC_R17_1BLTE_E_1BNR_MS</b>		<b>RP-212187</b>	<b>Huawei, HiSilicon</b>
911119	Core part: ENDC_R17_1BLTE_1BNR_MS	ENDC_R17_1BLTE_1BNR_MS-Core		RP-212187	Huawei, HiSilicon
911011	<b>Rel-17 Power Class 2 for EN-DC with x LTE bands + y NR band(s) in DL and with 1 LTE band +1 TDD NR band in UL (either x= 2, 3, y=1 or x=1, 2, y=2)</b>	<b>ENDC_PC2_R17_xLTE_yNR</b>		<b>RP-211760</b>	<b>Ericsson</b>
911111	Core part: ENDC_PC2_R17_xLTE_yNR	ENDC_PC2_R17_xLTE_yNR-Core	R4	RP-211760	Ericsson
911211	Perf. Part: ENDC_PC2_R17_xLTE_yNR	ENDC_PC2_R17_xLTE_yNR-Perf	R4	RP-211760	Ericsson
930051	UE Conformance - Power Class 2 for EN-DC with x LTE bands + y NR band(s) in DL and with 1 LTE band +1 TDD NR band in UL (either x= 2, 3, y=1 or x=1, 2, y=2)	ENDC_PC2_R17_xLTE_yNR-UEConTest	R5	RP-211870	Ericsson
911018	<b>Simultaneous Rx/Tx band combinations for NR CA/DC, NR SUL and LTE/NR DC</b>	<b>LTE_NR_Simult_RxTx</b>		<b>RP-211382</b>	<b>Huawei</b>
911118	Core part: LTE_NR_Simult_RxTx	LTE_NR_Simult_RxTx-Core	R4	RP-211382	Huawei
911218	Perf. part: LTE_NR_Simult_RxTx	LTE_NR_Simult_RxTx-Perf	R4	RP-211382	Huawei
890052	<b>Rel-17 Dual Connectivity (DC) of 5 bands LTE inter-band CA (5DL/1UL) and 1 NR band (1DL/1UL)</b>	<b>DC_R17_5BLTE_1BNR_6DL2UL</b>		<b>RP-211195</b>	<b>Samsung</b>
890152	Core part: DC_R17_5BLTE_1BNR_6DL2UL	DC_R17_5BLTE_1BNR_6DL2UL-Core	R4	RP-211195	Samsung
890252	Perf. part: DC_R17_5BLTE_1BNR_6DL2UL	DC_R17_5BLTE_1BNR_6DL2UL-Perf	R4	RP-211195	Samsung
890053	<b>Rel-17 Dual Connectivity (DC) of x bands (x=2, 3, 4) LTE inter-band CA (xDL/1UL) and 1 NR FR1 band (1DL/1UL) and 1 NR FR2 band (1DL/1UL)</b>	<b>DC_R17_xBLTE_2BNR_yDL3UL</b>		<b>RP-202542</b>	<b>Samsung</b>
890153	Core part: DC_R17_xBLTE_2BNR_yDL3UL	DC_R17_xBLTE_2BNR_yDL3UL-Core	R4	RP-202542	Samsung
890253	Perf. part: DC_R17_xBLTE_2BNR_yDL3UL	DC_R17_xBLTE_2BNR_yDL3UL-Perf	R4	RP-202542	Samsung
880080	<b>Band combinations for concurrent operation of NR/LTE Uu bands/band combinations and one NR/LTE V2X PC5 band</b>	<b>NR_LTE_V2X_PC5_combos</b>		<b>RP-210588</b>	<b>CATT</b>
880180	Core part: NR_LTE_V2X_PC5_combos	NR_LTE_V2X_PC5_combos-Core	R4	RP-210588	CATT

880280	Perf. part: NR_LTE_V2X_PC5_combos	NR_LTE_V2X_PC5_combos-Perf	R4	RP-210588	CATT
880094	High power UE (power class 2) for EN-DC with 1 LTE band + 1 NR TDD band	ENDC_UE_PC2_R17_NR_TDD		RP-211853	China Unicom
880194	Core part: ENDC_UE_PC2_R17_NR_TDD	ENDC_UE_PC2_R17_NR_TDD-Core	R4	RP-211853	China Unicom
880294	Perf. part: ENDC_UE_PC2_R17_NR_TDD	ENDC_UE_PC2_R17_NR_TDD-Perf	R4	RP-211853	China Unicom
911000	UE Conformance - ENDC_UE_PC2_R17_NR_TDD	ENDC_UE_PC2_R17_NR_TDD-UEConTest	R5	RP-211420	China Unicom
880095	LTE/NR spectrum sharing in Band 38/n38	DSS_LTE_B38_NR_Bn38		RP-201314	Vodafone
880195	Core part: DSS_LTE_B38_NR_Bn38	DSS_LTE_B38_NR_Bn38-Core	R4	RP-201314	Vodafone
880096	LTE/NR spectrum sharing in Band 40/n40	DSS_LTE_B40_NR_Bn40		RP-202084	Reliance Jio
880196	Core part: DSS_LTE_B40_NR_Bn40	DSS_LTE_B40_NR_Bn40-Core	R4	RP-202084	Reliance Jio
880296	Perf. part: DSS_LTE_B40_NR_Bn40	DSS_LTE_B40_NR_Bn40-Perf	R4	RP-202084	Reliance Jio
880098	Dual Connectivity (DC) of 1 LTE band (1DL/1UL) and 1 NR band (1DL/1UL)	DC_R17_1BLTE_1BNR_2DL2UL		RP-212096	CHTTL
880198	Core part: DC_R17_1BLTE_1BNR_2DL2UL	DC_R17_1BLTE_1BNR_2DL2UL-Core	R4	RP-212096	CHTTL
880298	Perf. part: DC_R17_1BLTE_1BNR_2DL2UL	DC_R17_1BLTE_1BNR_2DL2UL-Perf	R4	RP-212096	CHTTL
880099	Dual Connectivity (DC) of 2 bands LTE inter-band CA (2DL/1UL) and 1 NR band (1DL/1UL)	DC_R17_2BLTE_1BNR_3DL2UL		RP-212174	Huawei
880199	Core part: DC_R17_2BLTE_1BNR_3DL2UL	DC_R17_2BLTE_1BNR_3DL2UL-Core	R4	RP-212174	Huawei
890263	Perf. part: DC_R17_2BLTE_1BNR_3DL2UL	DC_R17_2BLTE_1BNR_3DL2UL-Perf	R4	RP-212174	Huawei
881000	Dual Connectivity (DC) of 3 bands LTE inter-band CA (3DL/1UL) and 1 NR band (1DL/1UL)	DC_R17_3BLTE_1BNR_4DL2UL		RP-211758	Ericsson
881100	Core part: DC_R17_3BLTE_1BNR_4DL2UL	DC_R17_3BLTE_1BNR_4DL2UL-Core	R4	RP-211758	Ericsson
881200	Perf. part: DC_R17_3BLTE_1BNR_4DL2UL	DC_R17_3BLTE_1BNR_4DL2UL-Perf	R4	RP-211758	Ericsson
881001	Dual Connectivity (DC) of 4 bands LTE inter-band CA (4DL/1UL) and 1 NR band (1DL/1UL)	DC_R17_4BLTE_1BNR_5DL2UL		RP-212532	Nokia
881101	Core part: DC_R17_4BLTE_1BNR_5DL2UL	DC_R17_4BLTE_1BNR_5DL2UL-Core	R4	RP-212532	Nokia
881201	Perf. part: DC_R17_4BLTE_1BNR_5DL2UL	DC_R17_4BLTE_1BNR_5DL2UL-Perf	R4	RP-212532	Nokia
881002	Dual Connectivity (DC) of x bands (x=1,2,3,4) LTE inter-band CA (xDL/1UL) and 2 bands NR inter-band CA (2DL/1UL)	DC_R17_xBLTE_2BNR_yDL2UL		RP-211750	LG Electronics
881102	Core part: DC_R17_xBLTE_2BNR_yDL2UL	DC_R17_xBLTE_2BNR_yDL2UL-Core	R4	RP-211750	LG Electronics
881202	Perf. part: DC_R17_xBLTE_2BNR_yDL2UL	DC_R17_xBLTE_2BNR_yDL2UL-Perf	R4	RP-211750	LG Electronics
881003	Dual Connectivity (DC) of x bands (x=1,2) LTE inter-band CA (xDL/xUL) and y bands (y=3-x) NR inter-band CA (yDL/yUL)	DC_R17_xBLTE_yBNR_3DL3UL		RP-211803	ZTE
881103	Core part: DC_R17_xBLTE_yBNR_3DL3UL	DC_R17_xBLTE_yBNR_3DL3UL-Core	R4	RP-211803	ZTE
881203	Perf. part: DC_R17_xBLTE_yBNR_3DL3UL	DC_R17_xBLTE_yBNR_3DL3UL-Perf	R4	RP-211803	ZTE
881004	Dual Connectivity (DC) of x bands (x=1,2,3) LTE inter-band CA (xDL/1UL) and 3 bands NR inter-band CA (3DL/1UL)	DC_R17_xBLTE_3BNR_yDL2UL		RP-211805	ZTE
881104	Core part: DC_R17_xBLTE_3BNR_yDL2UL	DC_R17_xBLTE_3BNR_yDL2UL-Core	R4	RP-211805	ZTE
881204	Perf. part: DC_R17_xBLTE_3BNR_yDL2UL	DC_R17_xBLTE_3BNR_yDL2UL-Perf	R4	RP-211805	ZTE
881012	band combinations for SA NR supplementary uplink (SUL), NSA NR SUL, NSA NR SUL with UL sharing from the UE perspective (ULSUP)	NR_SUL_combos_R17		RP-212178	Huawei
881112	Core part: NR_SUL_combos_R17	NR_SUL_combos_R17-Core	R4	RP-212178	Huawei
881212	Perf. part: NR_SUL_combos_R17	NR_SUL_combos_R17-Perf	R4	RP-212178	Huawei
900056	UE Conformance - Rel-17 NR CA and DC; and NR and LTE DC Configurations	NR_CADC_NR_LTE_DC_R17-UEConTest	R5	RP-211357	Huawei

## 13.2 NR and LTE enhancements other than layer 1

### 13.2.1 Enhanced eNB(s) architecture evolution for E-UTRAN and NG-RAN

860052	Enhanced eNB(s) architecture evolution for E-UTRAN and NG-RAN	LTE_NR_arch_evo_enh		RP-211409	China Unicom
860152	Core part: LTE_NR_arch_evo_enh	LTE_NR_arch_evo_enh-Core	R3	RP-211409	China Unicom

Summary based on the input provided by China Unicom in RP-220560.

This WI specifies the interface, reusing E1 interface, interconnecting an eNB-CP (control plane and L2/L1 part of an eNB) and an eNB-UP (user plane part of an eNB) within E-UTRAN, or interconnecting an ng-eNB-CU-CP (control plane part of an ng-eNB central unit) and an ng-eNB-CU-UP (user plane part of an ng-eNB central unit) within NG-RAN[1]. In Release 16, E1 interface was limited to support interconnecting a gNB-CU-CP (control plane part of the gNB central unit) and a gNB-CU-UP (user plane part of the gNB central unit) in NG-RAN.

In the WI, a split of eNB into an eNB-CP and an eNB-UP is defined for E-UTRAN, and a split of ng-eNB-CU into an ng-eNB-CU-CP and an ng-eNB-CU-UP is defined for NG-RAN. The eNB-CP hosts the RRC/ RLC/MAC/PHY and the control plane part of the PDCP protocol, and the eNB-UP hosts the user plane part of the PDCP protocol [3]. The split of ng-eNB-CU into an ng-eNB-CU-CP and an ng-eNB-CU-UP are defined for NG-RAN [4]. The ng-eNB-CU-CP hosts the RRC and the control plane part of the PDCP protocol of the ng-eNB-CU, and the ng-eNB-CU-UP hosts hosting the user plane part of the PDCP protocol and the SDAP protocol of the ng-eNB-CU. The E1 interface is used between an eNB-CP and an eNB-UP as shown in Figure 1, or between an ng-eNB-CU-CP and an ng-eNB-CU-UP as shown in Figure 2. The ng-eNB-CU-CP is connected with the ng-eNB-DU via the W1-C interface, while the ng-eNB-CU-UP is connected with the ng-eNB-DU through the W1-U interface.

The architectures in Figure 1 and 2 enable the following deployment scenarios.

- An eNB may consist of an eNB-CP and multiple eNB-UPs.
- The eNB-UP is connected to the eNB-CP, while one eNB-UP is connected to only one eNB-CP.
- The eNB-CP and the eNB-UP terminates the UP interface used to convey E-UTRA or NR PDCP PDUs. NR user plane protocol, as defined in TS 38.425 [5], is used for this interface.
- An ng-eNB may consist of an ng-eNB-CU-CP, one or more multiple ng-eNB-CU-UP(s) and one or more multiple ng-eNB-DU(s).
- One ng-eNB-DU is connected to only one ng-eNB-CU-CP, while one ng-eNB-CU-UP is connected to only one ng-eNB-CU-CP.
- One ng-eNB-DU can be connected to multiple ng-eNB-CU-UPs under the control of the same ng-eNB-CU-CP;
- One ng-eNB-CU-UP can be connected to multiple ng-eNB-DUs under the control of the same ng-eNB-CU-CP;
- An ng-eNB-CU-CP and an ng-eNB-CU-UP is connected via the E1 interface.
- An ng-eNB-DU is connected to an ng-eNB-CU-CP via the W1-C interface, and to an ng-eNB-CU-UP via the W1-U interface.

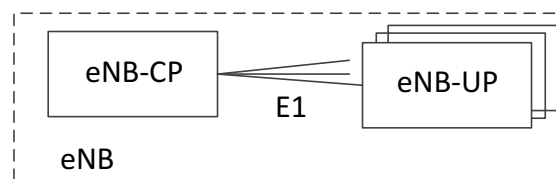
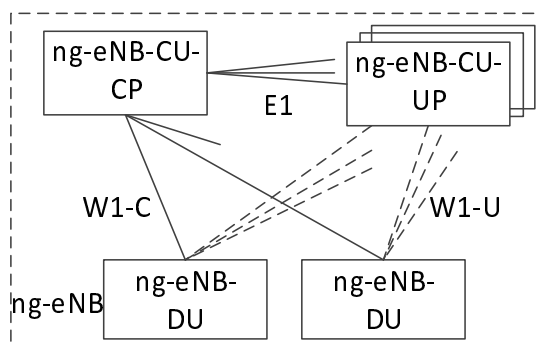


Figure 1: Overall architecture for separation of eNB-CP and eNB-UP



**Figure 2: Overall architecture for separation of ng-eNB-CU-CP and ng-eNB-CU-UP**

The general aspects and principles for E1 interface is specified in TS 37.480 [6], and layer 1 of E1 is specified in TS 37.481 [7]. The E1 signalling transport supporting for ng-eNB-CU-CP/ng-eNB-CU-UP, eNB-CP/eNB-UP, which is based on the SCTP/IP protocol stack, are described in TS 37.482 [8]. The E1 application protocol (E1AP) supporting for ng-eNB-CU-CP/ng-eNB-CU-UP, eNB-CP/eNB-UP is specified in TS 37.483 [9], including the relevant descriptions of E1 interface management procedures and E1AP elements, which allow to setup the E1 interface, exchange the relevant configuration data and data usage report in MR-DC between ng-eNB-CU-CP and ng-eNB-CU-UP, or between eNB-CP and eNB-UP.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860052,860152>

- [1] RP-22xxxx, "Status report of Enhanced eNB(s) architecture evolution for E-UTRAN and NG-RAN", China Unicom
- [2] R3-214487 CR to 36.401: Baseline CR for introducing Rel-17 Enhanced eNB Architecture Evolution Ericsson, Huawei, Nokia, Nokia Shanghai Bell
- [3] R3-214488 Further discussions on logical entities and corresponding definitions Huawei, Ericsson
- [4] TS 38.425 v16.3.0 NG-RAN; NR user plane protocol
- [5] TS 37.480 v1.1.0 E1 general aspects and principles
- [6] TS 37.481 v1.0.0 E1 layer 1

## 13.2.2 Further Multi-RAT Dual-Connectivity enhancements

860049	<b>Further Multi-RAT Dual-Connectivity enhancements</b>	LTE_NR_DC_enh2		RP-201040	Huawei
860149	<b>Core part: Further Multi-RAT Dual-Connectivity enhancements</b>	LTE_NR_DC_enh2 -Core	R2	RP-201040	Huawei
860249	<b>Perf. part: Further Multi-RAT Dual-Connectivity enhancements</b>	LTE_NR_DC_enh2 -Perf	R4	RP-201040	Huawei

Summary based on the input provided by Huawei, HiSiliconin RP-220410.

This WI introduces the following enhancements:

- for Carrier Aggregation, faster SCell activation
- for EN-DC and for NR DC: a mechanism to deactivate and activate the NR Secondary Cell Group
- support of inter-SN Conditional PSCell Change and of Conditional PSCell Addition

The enhancement to SCell activation allows faster usage of SCells. For traffic consisting primarily in short bursts, this allows deactivating SCells while there is not traffic, and reduce the UE power consumption, and having the additional carrier more quickly available when the next traffic burst appears.

The new SCG deactivation/activation mechanism allows keeping the NR SCG while saving UE power when the data traffic is lower and to activate the SCG again when needed due to increased traffic. This is also useful for bursty or variable data traffic.

Conditional PSCell Change was introduced in Rel-16 but limited to intra-SN PSCell change. This WI is adding the support inter-SN Conditional PSCell Change, thus extending the benefits to wider areas. In addition, Conditional PSCell Addition is supported, so that a PSCell can be added as soon as allowed by radio conditions.

### Efficient SCell activation

To enable fast SCell activation when Carrier Aggregation is configured, for each configured SCell, the network can configure a number of aperiodic CSI-RS for tracking for fast SCell activation. A new MAC Control Element (CE) that indicates SCell activation can indicate the aperiodic CSI-RS for tracking that is activated by the network to assist the UE for activation of the SCell. This aperiodic CSI-RS can be used to assist Automatic Gain Control (AGC) and time/frequency synchronization.

### SCG deactivation/activation

SCG deactivation/activation applies to an NR SCG, in EN-DC and in NR-DC.

UE behaviour while the SCG is deactivated

When the SCG is deactivated, UE activities on the SCG are reduced:

- the UE does not transmit or receive any data via the SCG;
- the UE does not perform/report any physical layer measurements;
- all SCG SCells are deactivated.

However, other activities remain:

- if configured to do so, the UE performs radio link monitoring and beam failure detection on the PSCell
- the UE performs measurements for mobility, including measurements for SCG mobility configured by the SN;
- the UE can exchange RRC signalling with the SN via the MCG as in Rel-15 (e.g. to report SCG radio link/beam failure, mobility measurement results);
- in case of PSCell change, the UE does not perform random access towards the new PSCell if the SCG is to remain deactivated.

Data transmission while the SCG is deactivated

When the SCG is deactivated:

- data can be transmitted or received via MCG bearers or via the MCG leg of split bearers;
- SCG bearers can remain configured;
- if there are uplink data to transmit on an SCG bearer, the UE indicates it to the network via RRC signalling.

### SCG activation/deactivation

The network activates or deactivates the SCG by sending an RRC reconfiguration message to the UE.

For SCG activation, if the PSCell hasn't changed since the SCG deactivation, the timing advance is still valid and beam/radio link failure was not detected, it is possible to perform SCG activation without random access, i.e. the UE starts monitoring PDCCH and can receive downlink assignments and uplink grants. Otherwise, random access is necessary.

On the network side, SCG activation and SCG deactivation is coordinated between the MN and the SN using the existing procedure for SN addition and SN modification. Both the MN and the SN can request SCG activation or SCG deactivation and the other node can accept or reject the request.

### Conditional PSCell Addition/Change

From the UE perspective, inter-SN conditional PSCell change is very similar to intra-SN conditional PSCell change, with a few main differences:

- the conditional reconfiguration is received from the MCG;
- the conditional reconfiguration can include a reconfiguration of both MCG and SCG;
- the associated execution condition may refer to a conditional measurement configured by the MN (if initiated by the MN) or to a conditional measurement configured by the SN;
- at CPC execution, the UE indicates to the MN which conditional reconfiguration was applied.

On the network side, there are a number of new procedures.

For instance, CPA and inter-SN CPC preparation requires exchanges between the MN, the SN and candidate target SN(s):

- the initiating node (MN or SN) indicates a list of candidate target PSCells and associated execution conditions;
- the MN provides this information to candidate target SN(s);
- candidate target SN(s) provide conditional reconfigurations for all or a subset of the candidate target PSCells;

- the MN transmits the conditional configurations to the UE, possibly with a MCG and SCG reconfiguration, as for any reconfiguration.

After CPA or CPC is prepared:

- the initiating node can request candidate target SNs to update their conditional reconfigurations according to a new UE configuration, or to release them;
- candidate target SN can initiate a modification or release already configured conditional reconfigurations.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860049,860149,860249>

- [1] RP-220409, Status report for WI: Multi-Radio Dual-Connectivity enhancements, Huawei, HiSilicon;

## 13.2.3 Further Multi-RAT Dual-Connectivity enhancements

UID	Name	Acronym	WG	WID	WI rapporteur name/company
860049	<b>Further Multi-RAT Dual-Connectivity enhancements</b>	LTE_NR_DC_enh2		RP-201040	Huawei
860149	Core part: Further Multi-RAT Dual-Connectivity enhancements	LTE_NR_DC_enh2 -Core	R2	RP-201040	Huawei
860249	Perf. part: Further Multi-RAT Dual-Connectivity enhancements	LTE_NR_DC_enh2 -Perf	R4	RP-201040	Huawei

# 14 LTE-only enhancements

## 14.1 LTE inter-band Carrier Aggregation

UID	Name	Acronym	WG	WID	WI rapporteur name/company
880087	<b>LTE iterbCA for 2 bands DL with 1 band UL</b>	LTE_CA_R17_2BD L_1BUL		RP-211859	Qualcomm
880187	Core part: LTE_CA_R17_2BDL_1BUL	LTE_CA_R17_2BD L_1BUL-Core	R4	RP-211859	Qualcomm
880287	Perf. part: LTE_CA_R17_2BDL_1BUL	LTE_CA_R17_2BD L_1BUL-Perf	R4	RP-211859	Qualcomm
880088	<b>LTE iterbCA for 3 bands DL with 1 band UL</b>	LTE_CA_R17_3BD L_1BUL		RP-212192	Huawei
880188	Core part: LTE_CA_R17_3BDL_1BUL	LTE_CA_R17_3BD L_1BUL-Core	R4	RP-212192	Huawei
880288	Stopped - Perf. part: LTE iterbCA for 3 bands DL with 1 band UL	LTE_CA_R17_3BD L_1BUL-Perf	R4	RP-202615	Huawei
880089	<b>LTE iterbCA Core for x bands DL (x=4, 5, 6) with 1 band UL</b>	LTE_CA_R17_xBD L_1BUL		RP-211885	Nokia
880189	Core part: LTE_CA_R17_xBDL_1BUL	LTE_CA_R17_xBD L_1BUL-Core	R4	RP-211885	Nokia
880289	Perf. part: LTE_CA_R17_xBDL_1BUL	LTE_CA_R17_xBD L_1BUL-Perf	R4	RP-211885	Nokia
880090	<b>LTE iterbCA for 2 bands DL with 2 bands UL</b>	LTE_CA_R17_2BD L_2BUL		RP-212194	Huawei
880190	Core part: LTE_CA_R17_2BDL_2BUL	LTE_CA_R17_2BD L_2BUL-Core	R4	RP-212194	Huawei
880290	Perf. part: LTE_CA_R17_2BDL_2BUL	LTE_CA_R17_2BD L_2BUL-Perf	R4	RP-212194	Huawei
880091	<b>LTE iterbCA for x bands DL (x= 3, 4, 5) with 2 bands UL</b>	LTE_CA_R17_xBD L_2BUL		RP-211748	LG
880191	Core part: LTE_CA_R17_xBDL_2BUL	LTE_CA_R17_xBD L_2BUL-Core	R4	RP-211748	LG
880291	Perf. part: LTE_CA_R17_xBDL_2BUL	LTE_CA_R17_xBD L_2BUL-Perf	R4	RP-211748	LG



## 14.2 LTE new/modified bands

### 14.2.1 New bands and bandwidth allocation for 5G terrestrial broadcast - part 1

911020	<a href="#">New bands and bandwidth allocation for 5G terrestrial broadcast - part 1</a>	LTE_terr_bcast_bands_part1	R1	RP-211144	EBU
911120	<a href="#">New bands and bandwidth allocation for 5G terrestrial broadcast - part 1</a>	LTE_terr_bcast_bands_part1	R1	RP-211144	EBU

Summary based on the input provided by EBU, Qualcomm Incorporated in RP-220445.

Before Rel-17, 5G terrestrial broadcast only supports the same system bandwidths as traditional LTE (1.4, 3, 5, 10, 15, 20MHz). Broadcast UHF spectrum, however, is channelized typically in channels of 6/7/8MHz (depending on the region). The objective of this work item [1] is to introduce support of PMCH bandwidths of 6/7/8MHz in MBMS-dedicated cells to enable deployment of 5G terrestrial broadcast in broadcast UHF spectrum.

The detailed operation to enable the above feature is as follows:

- The eNB indicates in MIB a system bandwidth of 5MHz (25PRBs) or 3MHz (15PRBs).
- In system information, the eNB indicates, per MBSFN area, whether the PMCH in that MBSFN area uses a bandwidth larger than the system bandwidth. The possible values for this bandwidth are 6MHz (30PRBs), 7MHz (35PRBs) and 8MHz (40PRBs).
- The PMCH and MBSFN-RS are received with the indicated bandwidth.

A figure depicting the operation is shown below:

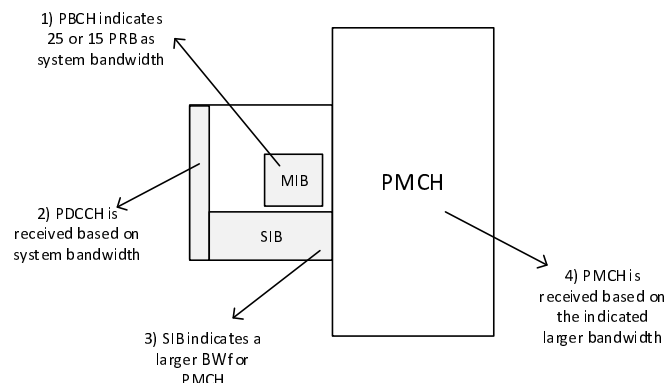


Figure 1: High level description of operation with 6/7/8MHz for PMCH

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=911020,911120>

## 14.3 Other LTE bands-related aspects

UID	Name	Acronym	WG	WID	WI rapporteur name/company
880079	<a href="#">Additional LTE bands for UE categories M1/M2/NB1/NB2</a>	LTE_bands_R17_M1_M2_NB1_NB2		<b>RP-211857</b>	Ericsson
880179	Core part: LTE_bands_R17_M1_M2_NB1_NB2	LTE_bands_R17_M1_M2_NB1_NB2-Core	R4	<b>RP-211857</b>	Ericsson
880279	Perf. part: LTE_bands_R17_M1_M2_NB1_NB2	LTE_bands_R17_M1_M2_NB1_NB2-Perf	R4	<b>RP-211857</b>	Ericsson
880081	<a href="#">Modification of LTE Band 24 Specifications to comply with updated regulatory emission limits</a>	LTE_B24_mod		<b>RP-211507</b>	Ligado Networks
880181	Core part: LTE_B24_mod	LTE_B24_mod-Core	R4	RP-211507	Ligado Networks
880281	Perf. part: LTE_B24_mod	LTE_B24_mod-Perf	R4	<b>RP-211507</b>	Ligado Networks

920067	UE Conformance - Modification of LTE Band 24 Specifications to comply with updated regulatory emission limits	LTE_B24_mod-UEConTest	R5	RP-212497	Ligado Networks
--------	---	-----------------------	----	-----------	-----------------

## 15 User plane improvements

### 15.1 Immersive Teleconferencing and Telepresence for Remote Terminals

820003	<a href="#">Support of Immersive Teleconferencing and Telepresence for Remote Terminals</a>	ITT4RT	S4	SP-180985	Ozgur Oyman, Intel
770024	<a href="#">EVS Codec Extension for Immersive Voice and Audio Services</a>	IVAS_Codec	S4	SP-170611	Bin Wang, Huawei Technologies Co Ltd

Summary based on the input provided by Nokia Corporation in SP-220275.

This Work Item extends the functionality of Multimedia Telephony Service for IMS (MTSI) in TS 26.114 by adding the Virtual Reality (VR) unidirectional video transmission capability.

Earlier TS 26.114 was capable of handling real-time multimedia communications of traditional media (e.g., audio and video). The completed WI on ITT4RT enables, on top of the mentioned specification, new VR use cases and allows transmitting and receiving, in addition to traditional media, also unidirectional 360-degree video that can be viewed using Head Mounted Displays and 5G devices. This makes the end-user experience more compelling and immersive.

In addition, two more documents have been produced as part of this WI: TR 26.962 (Immersive Teleconferencing and Telepresence for Remote Terminals (ITT4RT) Operation and Usage Guidelines) and TR 26.862 (Immersive Teleconferencing and Telepresence for Remote Terminals (ITT4RT) Use Cases, Requirements and Potential Solutions).

The ITT4RT WI adds to TS 26.114 the following:

- Support of still images, image sequences and still 360-degree background
- Support of 360-degree video for H.265
- Support of overlays on top of 360-degree video
- Support of multiple video projection formats
- Support for fisheye video
- Support of camera calibration for Network-based Stitching
- Support of picture packing for 360-degree video
- Support of viewport dependent processing
- Support of improved feedback for 360-degree video
- Support of captured content replacement for screen sharing
- Recommended audio mixing gains
- Examples SDP offers and answers for 360-degree video.

#### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820003>

- [1] TR 26.962. S4-220269
- [2] TR 26.862. S4-220323

### 15.2 8K Television over 5G

920011	<a href="#">8K Television over 5G</a>	8K_TV_5G	S4	SP-210381	Thomas Stockhammer
890009	<a href="#">Points for 8K VR 360 Video over 5G</a>	8K_VR_5G	S4	SP-200667	Ozgur Oyman, Company: Intel

Summary based on the input provided by Qualcomm in SP-220300

Since the initial development and last update of TV Video Profiles defined in TS 26.116, TV and mobile device capabilities have improved and nowadays they support higher decoding capabilities. In particular, new TV sets and 5G mobile devices entering the market since 2020 support up to 8K video decoding as well as 8K display capabilities.

8K is recently trialled and introduced in several services. In addition, other ecosystem support is happening, such as 8K encoders are announced, 8K TV sets are shipped and content is produced in 8K. Furthermore, it is evident that distribution of 8K TV content is feasible with 5G. In order to provide full interoperability for 8K TV services in the context of 5G, this work item specifies an HEVC-based 8K TV operation point in TS 26.116 as well as the corresponding media decoding capabilities for 5GMS in TS 26.511 in order to enable support for up to 8K video.

More specifically, this work item completed the following work:

- Defined new 8K TV operation point(s) for TV Video profiles with conforming bitstream requirement based on H.265/HEVC Main-10 Profile Main Tier Profile in TS 26.116 [1]
- Defined the relevant ISO BMFF encapsulation, CMAF media profile and DASH signalling for the new 8K TV operation point in TS 26.116 [1].
- Included the newly defined decoding capabilities and associated profiles and operation points into 5G Media Streaming for TV Services in TS 26.511 [2].
- Documented typical traffic characteristics of 8K TV video services in TR 26.925 [3].

The work was carried out in close collaboration with MPEG CMAF and DVB to align the media profiles.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920011>

- [1] TS 26.116, "Virtual Reality (VR) profiles for streaming applications"
- [2] TS 26.511, "5G Media Streaming (5GMS); Profiles, codecs and formats."
- [3] TR 26.925, "Typical traffic characteristics of media services on 3GPP networks"

## 15.3 5G Video Codec Characteristics

870011	5G Video Codec Characteristics	FS_5GVideo	S4	SP-200052	Qualcomm
--------	--------------------------------	------------	----	-----------	----------

Summary based on the input provided by Qualcomm in SP-220637.

The Technical Report provides a full characterization framework for video codecs in the context of 5G services. This framework permits the evaluation of the performance of existing 3GPP codecs, and also permits the identification of potential benefits of new codecs.

Note: Although Studies are usually not reported in this document, it was estimated by the rapporteur that this study deserves a summary.

The framework fulfils the following aspects:

- A comprehensive set of scenarios relevant to 3GPP services is described in clause 6. For each scenario the anchors for existing 3GPP codecs (H.264/AVC and H.265/HEVC), the version of the reference software for the anchors, and their associated configurations are defined.
- A set of reference sequences is identified per scenario and each sequence is described in more details in Annex C.
- For each scenario, one or more performance metrics are defined. Each metric is described in more details in clause 5.5.
- The overall characterization framework process is defined in clause 5 and in Annex B, D, E, F, and G.
- New codecs, namely H.266/VVC, MPEG-5 EVC and AOMedia AV1 are identified in clause 8. For each scenario, a version of their respective reference software is identified and configurations as close as possible to the anchor configurations are defined.
- For all codecs, metrics are computed and documented as part of the Technical Report. The report only documents objective metrics.
- According to Figure 1, all of those metrics are used in order to characterize test codecs against anchor codecs using the Bjöntegard-Delta (BD)-Rate gain expressing the bitrate savings in percentage of the new codec against the existing one.
- The TR is supported by a huge set of data that is available here: <https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/> including raw video sequences, anchor and test bitstreams, results, png plots and annotation, etc as well as a fully functional set of scripts that allow to replicate the setup and results.

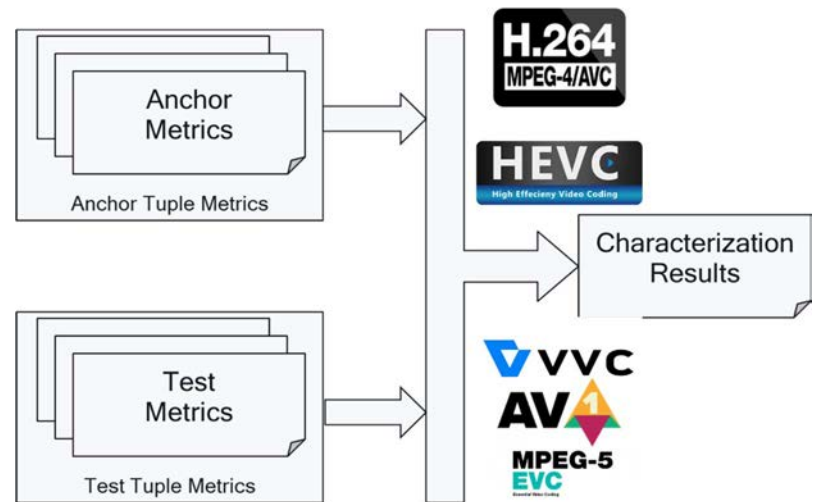


Figure 1: Characterization Framework

This is the first time that 3GPP has done such an extensive baseline work for video codec evaluation and characterization. The study item was backed and supported by 23 3GPP members. While the framework is comprehensive, it was also identified that it clearly has some limitations; for example, encoder configurations for each scenario may have not been stringent enough in their definition, leading to results that may not be fully comparable. Furthermore, the encoders used for the evaluation of the various codecs have different maturity and features. Results in this document should always be considered with a clear understanding of the characterization conditions and these results were derived. The framework does not include subjective evaluation; it is purely based on objective metrics.

One important outcome of the work documented in this Technical Report is the characterization and evaluation of H.265/HEVC against relevant scenarios and its characterization against H.264/AVC. Also, a first understanding of H.265/HEVC performances versus new codecs was developed. From the scenarios and results in this Technical Report it is observed that:

- H.265/HEVC does not show any functional deficiencies or gaps, nor does it lack any relevant features.
- In terms of compression efficiency, H.265/HEVC, evaluated based on the HM, performs sufficiently well for all the scenarios in this technical report.

Providing consistent HEVC-based interoperability in 3GPP services, for traditional and new scenarios, is definitely beneficial. It is recommended that 3GPP consider upgrading specifications to support profiles, levels, and possibly features available in HEVC. Features may include better support for screen content and computer-generated content, XR/AR type of services, as well as low and very low latency services.

The framework and the initial results for new codecs demonstrate coding performance improvements over H.265/HEVC for some codecs of up to 50%. However, the initial results are not considered mature enough to support concrete recommendations on adding new codecs. The potential addition of any new codec in 3GPP services and specifications requires diligent preparation, including the identification of needs and requirements for different scenarios, as well as a complete characterization against existing codecs. The information in this TR, as well as any new developments in 3GPP with respect to codecs in latest specifications, could serve as a baseline for future work. Such an effort may lead to conclusions on the potential addition of any new codec in 3GPP services and specifications. However, no immediate need has been identified to initiate such follow-up work.

References

Related CRs: set "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860063,860163>

- [1] Tdoc SP-200052, Feasibility Study on "5G Video Codec Characteristics"
- [2] TR 26.955, "5G Video codec characteristics"

15.4 Handsets Featuring Non-Traditional Earpieces

This work item improves the acoustic test methods in TS 26.132 [1] by providing proper guidance on how to setup a UE featuring a non-traditional earpiece.

The acoustic performance of UEs is evaluated by tests defined in [1]. The tests were originally developed for handsets featuring a traditional earpiece, i.e., one in which sound radiates through an acoustic port outlet directed at the user's ear canal. Recently, UEs have come to market featuring other means of radiating sound to the user, e.g., through vibrating displays, necessitating an update of 3GPP test specifications.

The HaNTE work item developed new test methods and assessed those methods through round-robin testing and listening experiments. Ultimately, the test methods in [1] were improved to specify how to mount a HaNTE UE for testing.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860012>

[1] TS 26.132, "Speech and video telephony terminal acoustic test specification".

## 15.5 Extension for headset interface tests of UE

880012	<a href="#">Extension for headset interface tests of UE</a>	HlnT	S4	SP-200398	Jan Reimes, HEAD acoustics GmbH,
--------	---	------	----	-----------	----------------------------------

Summary based on the input provided by HEAD acoustics GmbH and Orange in SP-211417.

This work item extends the audio test specifications in TS 26.131 [1] and TS 26.132 [2] to analogue (wired) and digital (wired and wireless) electrical interfaces, which were so far not considered. The introduced test methods and requirements ensure proper interoperability (from an audio/acoustic point of view) between the interface and headsets.

The acoustic performance of UEs is evaluated by terminal tests defined in the test suite in TS 26.131 (requirements) / 26.132 (test methods). It is relevant to extend these tests to also use the electrical interface (e.g., audio jack, Bluetooth or USB-C), as today's market users can purchase compatible headsets or other products that use standardized connections with mobile phones.

The changes to these specifications introduced by the work item considered the following aspects:

- Test setup for analogue and digital electrical interface was introduced, based on related work in Recommendation ITU-T P.381 [3] and P.383 [4].
- Test methods, performance requirements and objectives were determined in a unified and highly comparable way for analogue and digital electrical interfaces.
- Test methods, performance requirements and objectives were derived from existing ones for handset/headset UE, as well as from related work in Recommendation ITU-T P.381 [3] and P.383 [4].
- Performance requirements and objectives as well as the applicability of the new test methods were validated in measurement series.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=880012>

- [1] TS 26.131, "Terminal acoustic characteristics for telephony; Requirements".
- [2] TS 26.132, "Speech and video telephony terminal acoustic test specification".
- [3] Recommendation ITU-T P.381 (10/20), "Technical requirements and test methods for the universal wired headset or headphone interface of digital mobile terminals".
- [4] Recommendation ITU-T P.383 (06/21), "Technical requirements and test methods for multi-microphone wired headset or headphone interfaces of digital wireless terminals".

## 15.6 Media Streaming AF Event Exposure

920008	<a href="#">5GMS AF Event Exposure</a>	EVEX	S4	SP-210374	Lo, Charles, Qualcomm Inc.,
920009	<a href="#">Edge Extensions to the 5G Media Streaming Architecture</a>	5GMS_EDGE	S4	SP-210375	Bouazizi, Imed, Qualcomm Inc.

Summary based on the input provided by Qualcomm in SP-220635

This work item [1] relates to the support of generic UE data collection, reporting and event exposure, and the 5G Media Streaming instantiation of the generic functionality. It is related to two other 3GPP Rel-17 work items:

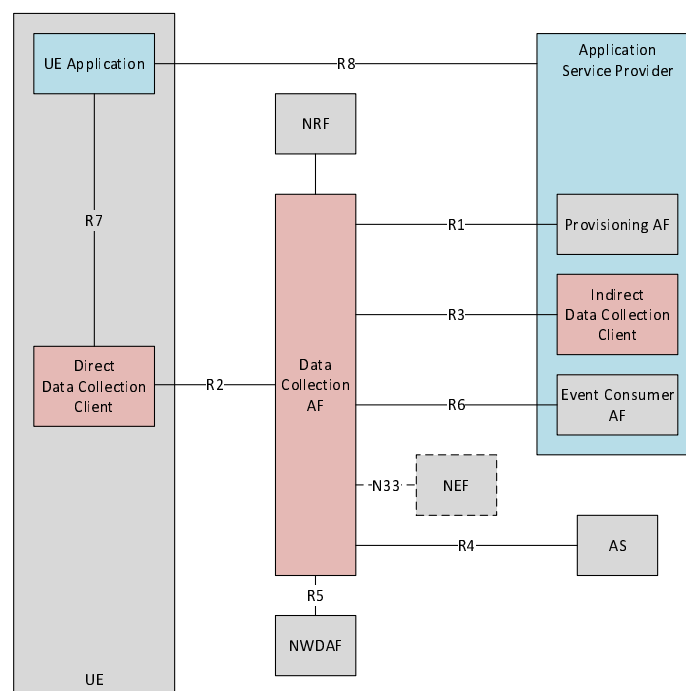
- SA2 work item "eNA\_Ph2" with regards to UE data collection and event exposure by an AF to event consumers such as the NWDAF, and
- CT3 work item "EVEX" with regards to extending relevant stage 3 specifications in support of event exposure and NEF mediation of interactions pertaining to UE data collection, reporting and event exposure functionality specific to 5G Media Streaming.

#### SA4 specifications on generic UE data collection, reporting and event exposure

The SA4 specifications on UE data collection, reporting and event exposure describe and define the mechanisms whereby different types of data collection clients, such as a UE, an application server in the network, or a server entity of an Application Service Provider, to collect and report a variety of application-level UE information, in accordance with their respective configurations, to a Data Collection AF (Application Function). The Data Collection AF can subsequently process its collected UE data to be offered, as Event Exposure services, to external entities for device, network and service performance monitoring and data analytics purposes.

The system architecture, reference points, and high-level procedures regarding generic UE data collection, reporting and event exposure are described in the stage 2 specification TS 26.531 [2]. The stage 3 specification TS 26.532 [3] defines the detailed procedures and associated APIs for the generic UE data collection and reporting functionality.

Figure 1 depicts the generic UE data collection, reporting and event exposure architecture.



**Figure 1 – Reference architecture for generic UE data collection, reporting and event exposure**

The functional entities and reference points pertaining to EVEX in figure 1 are described below:

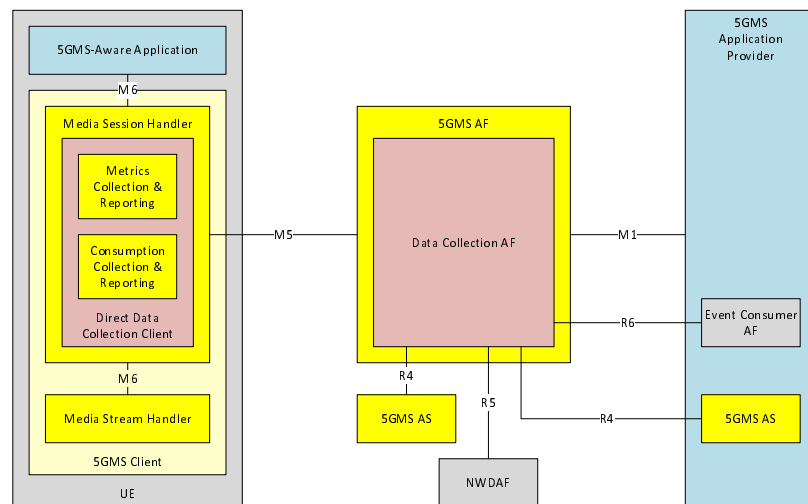
- *Data collection clients* including the Direct Data Collection Client in the UE, Indirect Data Collection Client of the Application Service Provider, and the AS (Application Server, which contains and delivers user plane data to end-user devices). These entities obtain their UE data collection and reporting configuration from, and reports collected UE data to, the Data Collection Client, at the R2, R3 and R4 reference points, respectively.
- *Data Collection AF* – This entity is provisioned with its UE data collection, reporting and event exposure configuration by the Provisioning AF of the Application Service Provider at the R1 reference point. It utilizes that information to provide data collection and reporting configuration(s) to relevant data collection clients. Subsequently, the Data Collection AF processes UE data reports received from the data collection client(s) for event exposure services to eligible consumer entities (e.g., the NWDAF and Event Consumer AF of the Application Service Provider, at reference points R5 and R6, respectively) according to its event exposure restriction configuration.



- *Provisioning AF* – This entity provisions the Data Collection AF with UE data collection, reporting and event exposure information via reference point R1. A portion of that configuration information is intended to be forwarded by the Data Collection AF to data collection clients.
- *UE Application* – This optional entity in the UE, if instantiated, is responsible for interacting with the Direct Data Collection Client, via reference point R7, to obtain a UE data collection and reporting configuration, and subsequently send collected UE data reports to the Direct Data Collection Client to be in turn reported to the Data Collection AF.
- *NEF* – This entity is optionally present to mediate the configuration, reporting and event exposure related interactions between associated pairs of the above-described entities when those reside in separate trust domains.

#### SA4 specifications on 5G Media Streaming specific data collection, reporting and event exposure

Instantiation of the generic UE data collection, reporting and event exposure architecture for 5G Media Streaming is specified in TS 26.501 [4], as shown in figure 2.



**Figure 2 – Instantiation of generic data collection, reporting and event exposure for 5G Media Streaming**

As shown in figure 2, the Data Collection AF is instantiated as a subfunction of the 5GMS Media Streaming Application Function (5GMS AF). The Direct Data Collection Client for 5GMS is instantiated as a subfunction of the 5GMS Client's Media Session Handler. The AS in figure 1 is instantiated as the 5GMS AS and could either reside within the 5G System or is hosted externally in the Application Service Provider domain.

It should be noted that in the 5G Media Streaming instantiation of the generic UE data collection, reporting and event exposure architecture, the 5GMS-specific reference points M1 and M5, and whose APIs are specified in TS 26.512 [5], are employed instead of R1 and R2, to support the provisioning of the Data Collection AF, and the configuration and reporting related interactions between the Data Collection AF and data collection clients. In particular, the M1 API in [5] has been extended to support event exposure restriction configuration in the form of Data Access Profiles to enable the Application Service Provider to control the granularity of access by subscriber entities to UE data related event information by the dimensions of user, time, and location.

#### CT3 specifications on 5G Media Streaming specific data collection, reporting and event exposure

Three CT3 specifications are extended in Rel-17 in support of EVEX:

- TS 29.517 [6], which defines the stage 3 protocol, message flows and Service Based Interface (SBI) of the Application Function Exposure (Naf\_EventExposure) Services offered by the AF to NF service consumers (e.g. NWDAF, NEF). The Application Function Exposure Service are usually defined in SA2 specifications TS 23.502 [9] and TS 23.288 [10]), as indicated in clause 4 of TS 29.517. However, for producing stage 3 protocol and API specification in TS 29.517 for 5G Media Streaming specific event exposure services, SA2 has directed CT3 to reference stage 2 and stage 3 specifications in TS 26.501 [4] and TS 26.512 [5] from SA4. The 5G Media Streaming related Naf\_EventExposure service comprise the following components: QoE metrics; Consumption reports; Network Assistance invocations; Dynamic charging and policy invocations; and Media streaming access activity.

- TS 29.522 [7], which defines the NEF Northbound interfaces between the NEF and AF and the associated RESTful/RPC APIs that allow an external AF to access the services and capabilities provided by 3GPP network entities via secure exposure by the NEF. Like the case of TS 29.517 [6], in accordance with SA2 directive, the SA4 EVEX specifications in TS 26.531 [2] and TS 26.532 [3] are referenced in the TS 29.522 specification of the Nnef\_DataReportingProvisioning and Nnef\_DataReporting service APIs, which are functionally equivalent to the Ndcaf\_DataReportingProvisioning and Ndcaf\_DataReporting services and associated APIs specifications in [2] and [3].
- TS 29.591 [8], which provides the stage 3 protocol definitions and message flows and specifies the API for each service offered by the NEF. It is extended with the various 5G Media Streaming specific event types as defined in TS 26.501 [4] and TS 26.512 [5].

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920008>

- |      |  |
|------|--|
| [1]  | Tdoc SP-201374, "New WID on 5GMS AF Event Exposure (EVEX)".  |
| [2]  | Tdoc S4-220807, "Presentation of Specification to TSG: TS 26.531, Version 2.1.0".                      |
| [3]  | Tdoc S4-220819, "Presentation of Specification to TSG: TS 26.532, Version 2.0.0".                      |
| [4]  | TS 26.501, "5G Media Streaming (5GMS); General description and architecture".                          |
| [5]  | TS 26.512, "5G Media Streaming (5GMS); Protocols".   |
| [6]  | TS 29.517, "5G Systems; Application Function Event Exposure Service; Stage 3".                         |
| [7]  | TS 29.522, "5G Systems; Network Exposure Function Northbound APIs; Stage 3".                           |
| [8]  | TS 29.591, "5G Systems; Network Exposure Function Southbound Services; Stage 3".                       |
| [9]  | TS 23.502, "5G; Procedures for the 5G System (5GS)".   |
| [10] | TS 23.288, "Architecture enhancements for 5G System (5GS) to support network data analytics services". |

## 15.7 Restoration of PDN Connections in PGW-C/SMF Set

900002	<a href="#">Restoration of PDN Connections in PGW-C/SMF Set</a>	RPCPSET	C4	CP-203020	LANDAIS, Bruno, Nokia
--------	---	---------	----	-----------	-----------------------

Summary based on the input provided by Nokia in CP-220149.

This Work Item extends the functionality of Multimedia Telephony Service for IMS (MTSI) in TS 26.114 by adding the Virtual Reality (VR) unidirectional video transmission capability.

The work item defines PDN connection restoration procedures that enable to restore PDN connections in EPC after a PGW-C/SMF failure, restart or scale-in operation, by allowing to move PDN connections to a different PGW-C/SMF of the PGW-C/SMF set.

SMF scalability and resiliency can be supported for PDU sessions in 5GS by deploying an SMF set, i.e. a set of SMF instances that are functionally equivalent and inter-changeable and that share the same contexts (as defined in Release 16). This enables e.g. an AMF, PCF or UPF to reselect a different SMF in the same SMF set when the SMF serving a PDU session fails, restarts or is removed from the SMF set (scale-in operation), without interrupting the services and the PDN connectivity of the PDU session.

Inter-system mobility between 5GS and EPS relies on combo PGW-C/SMF. Combo PGW-C/SMF can be deployed in a PGW-C/SMF set. The work item defines PDN connection restoration procedures to restore the PDN connections served by a PGW-C/SMF, when a PGW-C/SMF in a PGW-C/SMF set fails, restarts or is removed from the PGW-C/SMF set. This allows to fully leverage the benefits of deploying PGW-C/SMF set by enabling:

- to scale-in a PGW-C/SMF set without tearing down and re-establishing all the PDN connections of the PGW-C/SMF that is removed from the set;
- an MME or ePDG to reselect a different PGW-C/SMF in the PGW-C/SMF set for an on-going PDN connection or a group of PDN connections, when the PGW-C/SMF that was serving the PDN connection or the group of PDN connections fails or restarts, and to maintain the services and PDN connectivity of the PDN connection or group of PDN connections; and
- a PGW-C/SMF to instruct an MME, ePDG and/or PGW-U/UPF to use a new PGW-C/SMF for an on-going PDN connection or group of PDN connections, when e.g. a PCF or PGW-U/UPF reselects a different PGW-C/SMF from the PGW-C/SMF set.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900002>

## 15.8 Other media and user plane aspects

830005	<a href="#">Terminal Audio quality performance and Test methods for Immersive Audio Services</a>	ATIAS	S4	SP-190040	Stéphane Ragot, Orange
--------	--	-------	----	-----------	------------------------

See "Enhancement on the GTP-U entity restart".

See "User Plane Integrity" in "Security standalone aspects".

## 16 Standalone Security aspects

### 16.1 Introduction

This section presents all the standalone security functionalities. Security aspects related to other features are reported in the relevant section.

### 16.2 Authentication and key management for applications based on 3GPP credential in 5G (AKMA)

UID	Name	Acronym	WG	WID	WI rapporteur name/company
890030	<a href="#">Authentication and key management for applications based on 3GPP credential in 5G</a>	AKMA		SP-190711	Xiaoting Huang, China Mobile
850021	SA3 aspects of AKMA	AKMA	S3	SP-190711	Xiaoting Huang, China Mobile
890008	CT aspects of AKMA	AKMA-CT	ct	CP-203107	Huang Zhenning (China Mobile)
890031	CT1 aspects of AKMA	AKMA-CT	C1	CP-203107	Huang Zhenning (China Mobile)
890032	CT3 aspects of AKMA	AKMA-CT	C3	CP-203107	Huang Zhenning (China Mobile)
890033	CT4 aspects of AKMA	AKMA-CT	C4	CP-203107	Huang Zhenning (China Mobile)

Summary based on the input provided by China Mobile in SP-220289.

Authentication and key management for applications based on 3GPP credential in 5G (AKMA) is a cellular-network-based delegated authentication system specified for the 5G system, helping establish a secure tunnel between the end user and the application server. Using AKMA, a user can log in to an application service only based on the 3GPP credential which is the permanent key stored in the user's tamper-resistant smart card UICC. The application service provider can also delegate the task of user authentication to the mobile network operator by using AKMA.

The AKMA architecture and procedures are specified by SA3 in TS 33.535 [1], with the related study showing how its general principles are derived documented in TR 33.835 [2]. The AKMA feature introduces a new Network Function into the 5G system, which is the AKMA Anchor Function (AAnF). Its detailed services and API definitions are specified by CT3 in TS 29.535[3]. Earlier generations of cellular networks include two similar standards specified by SA3, which are generic bootstrapping architecture (GBA) and battery-efficient security for very low throughput machine type communication devices (BEST). Since the AKMA feature is deemed as a successor of these systems, the work is launched by SA3 without the involvement of stage 1.

#### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890030,850021,890008,890031,890032,890033>

- [1] TS 33.535: "Authentication and Key Management for Applications (AKMA) based on 3GPP credentials in the 5G System (5GS)"
- [2] TR 33.835: "Study on authentication and key management for applications based on 3GPP credential in 5G"
- [3] TS 29.535: "5G System; AKMA Anchor Services; Stage 3"

### 16.3 AKMA TLS protocol profiles

950043	<a href="#">AKMA TLS protocol profiles</a>	AKMA_TLS	S3	SP-210424	Escott, Adrian, Qualcomm
920027	Security aspects of AKMA_TLS	AKMA_TLS	S3	SP-210424	Escott, Adrian, Qualcomm
950010	CT aspects of AKMA_TLS	AKMA_TLS	C1	CP-220307	Chaponniere, Lena, Qualcomm Incorporated

Summary based on the input provided by Qualcomm in SP-220620.

The work on AKMA TLS protocol profiles provides the details on how to use the newly introduced AKMA key (see [4]) to provide secure TLS connection between the UE and an Application Function (AF) in the network.

The AKMA WID [4] introduced a method of generating keys for use between a UE and an Application Function (AF) in the network. These keys are generated from a key derived by an authentication run over the 5G core (see [2]). The "AKMA TLS protocol profiles" work item specifies how to use these AKMA key to provide secure TLS connections, either using certificate-based TLS and HTTP Digest with the AKMA key in the TLS tunnel or using symmetric key TLS using the AKMA key. The specification of the profiles is based on the methods standardised to utilise GBA keys in TS 33.222 [1] and TS 24.109 [3].

The stage 2 of the AKMA TLS protocol profiles work is specified in TS 33.535 [2] while the stage 3 is contained in TS 24.109 [3].

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950043,920027,950010>

- [1] TS 33.222: "Generic Authentication Architecture (GAA); Access to network application functions using Hypertext Transfer Protocol over Transport Layer Security (HTTPS)"
- [2] TS 33.535: "Authentication and Key Management for Applications (AKMA) based on 3GPP credentials in the 5G System (5GS)"
- [3] TS 24.109: "Bootstrapping interface (Uu) and network application function interface (Uu); Protocol details"
- [4] Authentication and key management for applications based on 3GPP credential in 5G (SP-190711)

## 16.4 User Plane Integrity Protection for LTE

910025	<a href="#">User Plane Integrity Protection for LTE</a>	UIP_SEC_LTE	S3	SP-210105	Evans, Tim, Vodafone
820006	<a href="#">Study on User Plane Integrity Protection</a>	FS_UP_IP_Sec	S3	SP-181035	Evans, Tim, Vodafone
890012	<a href="#">Enhancements to User Plane Integrity Protection Support in 5GS</a>	eUIP_SEC	S3	SP-200719	Anand Palanigounder, Qualcomm

Summary based on the input provided by Vodafone in RP-221340.

Release 15 NR and 5G Core enabled optional support for the integrity protection of user plane data. In Release 16, it was made mandatory for UEs to support User Plane Integrity Protection (UIP) in NR at the full data rate that the UE supports in both the Uplink and Downlink. This provides protection against certain security attacks but only for NR capable devices while using NR and the 5G Core.

In Release 17, the SA 3 work item "User Plane Integrity Protection for LTE" was agreed in SP-210105 with the intention of protecting LTE devices from these security attacks. Subsequently, in RP-213669, TSG-RAN agreed the Building Block WID "User Plane Integrity Protection support for EPC connected architectures" to enable full data rate Uu interface UIP for EPS, but only on EN-DC capable devices. This provides useful protection to NR capable smartphones in case they are, for example, forced off NR and onto an E-UTRA-only connection or an EN-DC connection.

The overall security architecture is specified in TS 33.401 and system architecture details are specified in TS 23.501 and TS 23.401.

The UE indicates its support for EPS UIP in the UE Network Capability sent in NAS signalling (TS 24.301) from the UE to the MME. The MME stores this UIP support information and sends it to the eNB in the S1AP Initial Context Setup Request and Handover Request messages. The eNB uses this indication (and not any information in the UE Radio Access Capabilities IE) to determine whether the UE supports EPS UIP.

The SMF+PGW-C may supply the MME with a security policy (UIP required/preferred/not needed). The MME stores this policy information and passes it onto the eNB on a per-EPS bearer basis in the Security Indication IE. If the eNB does not receive any security policy, the eNB can be configured with a default UIP policy to use (e.g. "UIP preferred").

X2AP (TS 36.423), and S1AP (TS 36.413) signalling supports UIP continuity at handover. X2AP supports the use of UIP in the SgNB when EN-DC is in use. E1AP interface signalling (TS 37.483) supports UIP when the eNB is split into eNB-Control Plane and eNB-User Plane functions.

At X2, S1 (intra and inter-MME) and inter-RAT handovers, mechanisms are specified in X2AP and S1AP to ensure that EPS bearers with a security policy of "UIP required" are not handed over to eNBs that do not support UIP.

RRC signalling (TS 36.331 and TS 38.331) enables the use of UPIP with the UE in both EN-DC and LTE-only configurations. As described in the LS from RAN2 to SA3 in R2-2203663:

UIP for the EPC connected architectures uses NR PDCP and is configured in following way:

- (as is done for legacy LTE UE) an LTE algorithm code point is configured in field integrityProtectionAlgorithm in IE SecurityAlgorithmConfig in the TS 36.331 SecurityModeCommand message, and this is used to derive KUPint (and also to derive KUPenc, as for legacy LTE UE).
- The NR algorithm code point (corresponding to the LTE algorithm code point used in the SecurityModeCommand) indicated by the integrityProtAlgorithm included in the securityConfig in the TS 38.331 RadioBearerConfig is used to configure the UP IP algorithm applied by NR PDCP to perform integrity protection.
- The integrityProtection indicated in pdcp-Config in the DRB-ToAddMod(list) in the TS 38.331 RadioBearerConfig is used to activate the UP IP for a DRB using the configured algorithm, which can be done only at DRB setup. Consequently, UP IP activation/deactivation for a DRB can be changed only by DRB-release-and-add.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910025>

## 16.5 Non-Seamless WLAN offload authentication in 5GS

950040	<a href="#">Non-Seamless WLAN offload authentication in 5GS</a>	NSWO_5G	S3	SP-211358	Ranganathan Mavureddi Dhanasekaran, Nokia
910091	<a href="#">Study on Non-Seamless WLAN offload authentication in 5GS using 3GPP credentials</a>	FS_NSWO_5G	S3	SP-210262	Nair, Suresh, Nokia
940011	Security aspects of NSWO	NSWO_5G	S3	SP-211358	Ranganathan Mavureddi Dhanasekaran, Nokia
950041	CT1 aspects of NSWO	NSWO_5G	C1	CP-220095	Wiehe, Ulrich, Nokia
950002	CT4 aspects of NSWO	NSWO_5G	C4	CP-220095	Wiehe, Ulrich, Nokia
950042	CT6 aspects of NSWO	NSWO_5G	C6	CP-220095	Wiehe, Ulrich, Nokia

Summary based on the input provided by Nokia in SP-220426 (which replaced CP-220150).

Non-seamless WLAN offload (NSWO) is an optional capability of a UE supporting WLAN radio access. A UE supporting non-seamless WLAN offload may, while connected to WLAN access, route specific IP flows via the WLAN access without traversing the 3GPP core network.

For authentication 5G NSWO uses EAP-AKA' as specified in IETF RFC 5448.

A new network function, called NSWOF, supports authentication for NSWO in 5GS. The NSWOF interfaces the WLAN access network via SWa and the AUSF via the Nausf service-based interface (SBI). The AUSF retrieves NSWO-specific authentication information from the UDM via the Nudm service-based interface. In addition, the USIM and/or ME can be configured to use 5G NSWO.

5G NSWO co-existence with EPS NSWO is considered. Also, different configurations for NSWO roaming are described.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950040,910091,940011,950041,950002,950042>

## 16.6 Generic Bootstrapping Architecture (GBA) into 5GC

910090	<a href="#">Integration of Generic Bootstrapping Architecture (GBA) into 5GC</a>	GBA_5G		SP-190714	Vlasios Tsiatsis, Ericsson
850023	Security aspects of Integration of GBA into 5GC	GBA_5G	S3	SP-190714	Vlasios Tsiatsis, Ericsson
910004	CT aspects of Integration of GBA into SBA	GBA_5G	C4	CP-210283	de Gregorio, Jesús (Ericsson)
910047	<a href="#">Integration of Generic Bootstrapping Architecture (GBA) into 5GC</a>	GBA_5G	S3	SP-190714	Vlasios Tsiatsis, Ericsson

Summary based on the input provided by Ericsson in SP-220321.

The existing Generic Bootstrapping Architecture (GBA) was firstly introduced in Rel-6 and prior to Rel-17 the architecture included network functions interacting with each other via dedicated reference point interfaces. The integration of the Generic Bootstrapping Architecture (GBA) to the 5G Core (5GC) introduces Service Based Interfaces



(SBA) for the related GBA Network Functions as well as specific GBA services for the User Data Management (UDM) network function in 5GC. In this way GBA can be used in 5GC deployments.

The 3GPP authentication infrastructure employed in GBA includes Home Network (HN) functions User Equipment (UE) functions and the 3GPP AKA (Authentication and Key Agreement) protocol. This infrastructure is a very valuable asset of 3GPP operators and could be leveraged to enable application functions in the network and on the User Equipment (UE) side to establish shared cryptographic material based on 3GPP credentials. This is the motivation and purpose of the Generic Bootstrapping Architecture (GBA) and GBA Push features developed in 3GPP since Rel-6.

The GBA architecture in releases prior to Rel-17 includes a Bootstrapping Server Function (BSF) which is the anchor of the cryptographic key hierarchy, the Home Subscriber System (HSS), which handles the user subscriptions and provides authentication vectors to the BSF, UE applications and Network Application Functions (NAFs). GBA includes a bootstrapping protocol for authentication and key agreement for a root security key between the UE and BSF and a framework of application session protocols (Ua protocols) to establish an application security key between a UE and a NAF. The application security key is derived from the bootstrapping key. The GBA Push feature includes a protocol between the NAF and the UE in order to establish the application security key with a more efficient message exchange suitable for constrained devices. GBA is specified to support at least the following Diameter-based reference point interfaces: (a) Zh between the BSF and HSS for mutual authentication between the HN and the UE, (b) Zn between the BSF and NAF for the application security key establishment and (c) Zpn between the BSF and a GBA Push enabled NAF (Push-NAF) for a combined mutual authentication and application security key establishment. The use of these interfaces has allowed GBA to be used in 3G and also in 4G core networks since the HSS in 3G and 4G supported Diameter-based interfaces.

With the advent of 5G, the 5G Core (5GC) has introduced Network Functions which expose SBA interfaces and among other network functions a new subscription management network function, the User Data Management (UDM). Enabling GBA and GBA Push functionality to be used in 5GC, resulted in the inclusion of the GBA and GBA Push functions in SBA as well as the specification of the SBA interfaces for the BSF, HSS and UDM. More specifically, a Service Based Interface (SBI) capable BSF exposes not only the aforementioned reference point interfaces but also SBA interfaces towards an SBI capable NAF. An SBI capable HSS provides an SBA interface for the BSF to retrieve authentication vectors and other GBA related subscription information for the GBA and GBA Push procedures. Finally, the UDM exposes a new service operation for an SBI capable BSF to retrieve authentication vectors provided by the UDM.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910090,850023,910004>

- [1] TS 23.501: "System architecture for the 5G System (5GS)".
- [2] TS 33.501: "Security architecture and procedures for 5G System".
- [3] TS 33.220: "Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA)".
- [4] TS 33.223: "Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA) Push function".
- [5] TS 23.510: "5G System; Network function repository services; Stage 3".
- [6] TS 23.562: "5G System; Home Subscriber Server (HSS) services; Stage 3".

## 16.7 Security Assurance Specification for 5G

860016	<a href="#">Assurance Specification for IMS</a>	SCAS_IMS	S3	SP-191128	Bo Zhang, Huawei Technologies
<b>870020</b>	<b><a href="#">Security Assurance Specification for 5G (eSCAS_5G)</a></b>	<b>eSCAS_5G</b>	<b>S3</b>	<b>SP-200149</b>	<b>Rong Wu, Huawei Technologies Co.</b>
890013	<a href="#">eSCAS_5G for Network Slice-Specific Authentication and Authorization Function (NSSAAF)</a>	SCAS_5G_NSSAAF	S3	SP-200720	Rong Wu, Huawei Technologies Co., Ltd.
870017	<a href="#">eSCAS_5G for Non-3GPP InterWorking Function</a>	SCAS_5G_N3IWF	S3	SP-200146	Feng Gao, China Unicom
870018	<a href="#">eSCAS_5G for 5G NWDAF</a>	SCAS_5G_NWDAF	S3	SP-200147	Qi Minpeng, China Mobile
870019	<a href="#">eSCAS_5G for Service Communication Proxy</a>	SCAS_5G_SECOP	S3	SP-200148	Wei Lu, Nokia
880003	<a href="#">eSCAS_5Gfor Inter PLMN UP Security</a>	SCAS_5G_IPUPS	S3	SP-200348	Jin PENG, ZTE Corporation

## 16.8 Adapting BEST for use in 5G networks

900019	<a href="#">Adapting BEST for use in 5G networks</a>	BEST_5G	S3	SP-201020	Keesmaat, Iko, KPN
--------	--	---------	----	-----------	--------------------

Summary based on the input provided by KPN in SP-221202.



This work item updates the BEST feature (Battery Efficient Security for very low Throughput Machine Type Communication (MTC) devices) for use in 5G networks. The original BEST feature (based on WI 730050 BEST\_MTC\_Sec) was defined for LTE and made use of LTE architecture and a UMTS based key agreement procedure.

The result of the work item is a BEST feature applicable to a range of architectures and key agreement procedures:

- the original LTE architecture using UMTS based key agreement procedure;
- an updated LTE architecture using LTE based key agreement procedure;
- a 5G architecture using 5G based key agreement procedure;
- an LTE or 5G architecture using GBA as key agreement procedure;
- a 5G architecture using AKMA as key agreement procedure; and
- a 5G architecture using a proprietary key agreement procedure.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900019>

- [1] TS 33.163: Battery Efficient Security for very low Throughput Machine Type Communication (MTC) devices (BEST)

## 16.9 Other security aspects

930031	User Consent for 3GPP services	FS_UC3S	S3	SP-200885	Rong Wu, Huawei Technologies
890037	Study on User Consent for 3GPP services	FS_UC3S	S3	SP-200885	Rong Wu, Huawei Technologies
930006	Security aspects on User Consent for 3GPP services	UC3S_SEC	S3	SP-210836	Rong Wu, Huawei Technologies
910024	Enhancements of 3GPP profiles for cryptographic algorithms and security protocols	eCryptPr	S3	SP-210107	Pinar Comak, Ericsson
860025	Lawful Interception Rel-17	LI17	S3	SP-190983	Alex Leadbeater, BT
850047	(Small) Technical Enhancements and Improvements for Rel-17	TEI17			

## 17 Signalling optimisations

### 17.1 Enhancement for the 5G Control Plane Steering of Roaming for UE in Connected mode

880049	Enhancement for the 5G Control Plane Steering of Roaming for UE in Connected mode	eCPSOR_CON		CP-210148	Minokuchi, Atsushi, NTT DOCOMO
850039	Stage 1 of eCPSOR_CON	eCPSOR_CON	S1	SP-190941	Minokuchi, Atsushi, NTT DOCOMO
880022	Stage 3 (CT1) of eCPSOR_CON	eCPSOR_CON	C1	CP-210148	Al-Bakri Ban, NTT DOCOMO
900036	Stage 3 (CT4) of eCPSOR_CON	eCPSOR_CON	C4	CP-210148	Al-Bakri Ban, NTT DOCOMO
920061	Stage 3 (CT6) of eCPSOR_CON	eCPSOR_CON	C6	CP-210148	Al-Bakri Ban, NTT DOCOMO

Summary based on the input provided by NTT DOCOMO in SP-220260.

Steering of roaming (SOR) allows the Home PLMN (HPLMN) operator to steer a UE to a visited PLMN (VPLMN) on which the HPLMN wants the UE to register, when the UE registers on another VPLMN. This capability may be needed for reasons such as reselection to a higher priority PLMN based on business arrangements (TS22.261 – clause 6.30.1).

Steering of Roaming (SOR) is used since GSM, and the requirements are provided in TS22.011.

In 5G, the Control Plane SOR solution (CP-SOR) was introduced using the same requirements in TS22.011.

In Rel-17, additional requirements specific for CP-SOR were provided in TS22.261 that allows the HPLMN to control the timing when a UE registered on a VPLMN, in automatic mode (see clause 3.1 of TS 23.122 [25]) and currently in CONNECTED mode, enters IDLE mode and initiates higher priority PLMN selection based on the type of ongoing communication.

Upon receiving CP-SOR information defined in Rel-15 and Rel-16, while the UE is in CONNECTED mode, the UE waits until it moves to idle mode before performing SOR and attempting to obtain service on a higher priority PLMN.

The UEs in 5G may stay in connected mode for a rather long time, whole day or longer, without going to idle mode. The HPLMN operator may have means to evaluate what is more convenient to provide the service for the user (e.g., based on their subscription profile, more efficient economically from wholesale perspective, allow users to use dedicated "economical" retail plans on specific VPLMN, etc.) and decide which VPLMN is more appropriate for the user to register on. Therefore, new requirements are introduced to allow the HPLMN to enforce the interruption of the ongoing sessions for the sake of performing SOR and moving the UE to another VPLMN to obtain service on a higher priority PLMN.

This feature introduces means to send additional steering of roaming information, called steering of roaming connected mode control information (SOR-CMCI) that enables the HPLMN to control the timing of a UE in connected mode to move to idle mode to perform the steering of roaming. The UE shall support the SOR-CMCI. The support and use of SOR-CMCI by the HPLMN is based on the HPLMN's operator policy.

The SOR-CMCI is provided by the HPLMN operator using different means, a specific application function (SOR-AF) or the information can be stored in the repository system (UDR). This information can be provided to the UE during registration procedure or after the registration (triggered by some parameters in the SOR-AF or the UDR).

The UE's type of ongoing communication / session(s) should be taken into consideration. The high priority services and emergency services are exempted from being interrupted (i.e. this feature is not applicable).

The new SOR related information is to be exchanged between the HPLMN UDM and the UE in a secured manner therefore the HPLMN data management application function ensures the security of the information using the Authentication Server Function (AUSF). The SOR information is transparent for the VPLMN, and if the VPLMN manipulates the information then the security of the information will break. To ensure the security of the information, the HPLMN may request the UE to provide an acknowledgement that the information is received securely.

This feature is optional for the HPLMN. This means that if this optional feature is not selected by the HPLMN operator, then there shall be no impact on the existing SOR functionality.

This feature is applicable only when the UE is in automatic network selection mode (see TS 23.122).

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=880049,850039,880022,900036,920061>

- [1] TS 22.011: "Service accessibility".
- [2] TS 22.261: "Service requirements for the 5G system; Stage 1".
- [3] TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode".
- [4] TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

## 17.2 Same PCF selection for AMF and SMF

910044	Same PCF Selection For AMF and SMF	TEI17_SPSFAS		SP-200447	Heng, Nie, China Telecom
880016	Stage 2 for TEI17_SPSFAS	TEI17_SPSFAS	S2	SP-200447	Heng, Nie, China Telecom
910003	CT aspects on TEI17_SPSFAS	TEI17_SPSFAS	ct	CP-211184	Yue Sun, China Telecom
910045	CT3 aspects on TEI17_SPSFAS	TEI17_SPSFAS	C3	CP-211184	Yue Sun, China Telecom
910046	CT4 aspects on TEI17_SPSFAS	TEI17_SPSFAS	C4	CP-211184	Yue Sun, China Telecom

Summary based on the input provided by China Telecom in SP-220261.

Binding the Access and Mobility Management (AM) and the Session Management (SM) policies provides several benefits, such as the change of RAT/Frequency Selection Priority (RFSP) values for a UE when the quota for the Data Network Name (DNN) for enhanced Mobile Broadband (eMBB) reaches the limit, or simplify the network deployment. A simple way to achieve such binding is to select the same Policy Control Function (PCF) for the AMF and the SMF.

In Rel 15 and 16, the same PCF selection for the AMF and the SMF is achieved by the mechanism of AMF optionally forwarding the selected PCF to SMF instance(s) during the PDU Session Establishment procedure(s), and the SMF may select the received PCF for SM Policy Control based on local policies. But it is applicable only in the UE initially accessing via 5GS scenario.

This Rel 17 work item specifies a mechanism to achieve the same PCF selection for AMF and SMF in the EPS to 5GS mobility scenario, where the PCF selection for AMF may be performed after the PCF selection for SMF/PGW-C. In this WI, subscription data is expanded to assist the same PCF selection, to offer more flexibility for operation of corresponding service.

The mechanism in this WI is based on the PGW-C+SMF registration of the selected PCF for SM Policy Control into the UDM+HSS. When performing PCF selection, based on subscription data for the PCF selection received from the UDM, the AMF determines that the same PCF for AMF and the SMF serving a specific DNN and/or S-NSSAI needs to be selected, then it selects the PCF ID serving the specific DNN and/or S-NSSAI received from UDM before initiating the Establishment of AM Policy Association. It is applicable for EPS to 5GS Mobility.

For the scenario of pure 5GS, based on subscription data for the PCF selection received from the UDM, the AMF determines that the same PCF for AMF and SMF serving a specific DNN and/or S-NSSAI needs to be selected, then it forwards the PCF ID for AM policies to the SMF and may additionally indicate to the SMF that the same PCF should be selected for SM Policy Control.

## References

List of related CRs:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910044,880016,910003,910045,910046>

- [1] TS 23.501: "System architecture for the 5G System (5GS)"
- [2] TS 23.502: "Procedures for the 5G System; Stage 2"
- [3] TS 29.502: "5G System; Session Management Services; Stage 3"
- [4] TS 29.503: "5G System; Unified Data Management Services; Stage 3"
- [5] TS 29.513: "5G System; Policy and Charging Control signalling flows and QoS parameter mapping; Stage 3"

## 17.3 Enhancement of Inter-PLMN Roaming

900037	<a href="#">Enhancement of Inter-PLMN Roaming</a>	EoIPR	C4	CP-203021	Caixia Qi, Huawei
--------	---	-------	----	-----------	-------------------

Summary based on the input provided by Huawei in CP-220152.

The work item defines some enhancements on the interfaces between vNSSF and hNSSF, vNRF and hNRF, vSEPP and hSEPP in stage3 for inter PLMN roaming in 5GC scenario.

Inter PLMN roaming is deployed for a user roaming into a vPLMN which has a roaming agreement with the UE's hPLMN. Some enhancements in stage3 are specified with regards to Inter PLMN roaming scenarios:

- The NSSF in the vPLMN can invoke the Nnssf\_NSSelection service provided by the NSSF in the hPLMN, TS 29.531 specification for the interface between vNSSF and hNSSF is updated to specify the condition/procedure to support the communication.
- Multiple NRFs can be deployed in a vPLMN and/or an hPLMN. TS 29.510 specification for the interface between vNRF and hNRF is updated to support the modification or removal of the subscription in the hNRF if multiple NRFs are deployed in hPLMN.
- TS 29.573 specification for the interface between vSEPP and hSEPP is updated based on the requirements from GSMA and SA3 on the enhancements to the roaming.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=900037>

## 17.4 Enhancement on the GTP-U entity restart

940003	Enhancement on the GTP-U entity restart	EGTPUR	C4	CP-213097	YONG YANG, Ericsson
--------	---	--------	----	-----------	---------------------

Summary based on the input provided by Ericsson in CP-220212.

A remote GTP-U restart will lead massive amount of signalling in the network (for reporting GTP-U Error Indication and PFCP Session Modification Signalling messages) over Sx/N4 interface.

To avoid that, this work item specifies following enhancements:

- procedures to detect and report the peer GTP-U entity restart;
- protocol support in GTP-U to enable to detect peer GTP-U entity restart;
- protocol support in PFCP to enable User Plane function to report the peer GTP-U entity restart to the Control Plane function.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940003>

## 17.5 Packet Flow Description management enhancement

880032	<a href="#">Packet Flow Description (PFD) management enhancement</a>	pfdManEnh	C3	CP-210183	Xiaoyun Zhou, Huawei
--------	--	-----------	----	-----------	----------------------

Summary based on the input provided by Huawei in CP-210183.

An optimize solution to reduce the load of signalling for pull mode in EPS and 5GS is defined. A notification push solution for push mode in 5GS is defined.

In stage 3, we define the GET method to retrieve the PFD for the application(s) by the client, the server responds a whole representation of the resource for the requested application identifier(s) even in the case that the client requests the PFDs when the caching timer expires and the PFD(s) is not changed at the server. It brings a large signalling load if the whole set of the PFD(s) are always returned by considering that the number of the PFD(s) is very large in the deployment.

For push mode, in order to protect the PCEF/TDF from overload, CT3 introduces the notification push for the Push mode in EPS, i.e. the PFDF sends a request with notification flag to the PCEF/TDF and then PCFE/TDF initiates separate pull requests to retrieve the PFDs for different application identifier(s) immediately or within the allowed-delay by considering the load of the PCEF/TDF. But this optimized solution is not defined in 5GS.

CT3#110e decided to implement the solution to resolve the above identified issues.

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=880032>

- [1] TS 29.251: "Gw and Gwn reference points for sponsored data connectivity".
- [2] TS 29.551: "5G System; Packet Flow Description Management Service; Stage 3".
- [3] TS 29.513: "5G System; Policy and Charging Control signalling flows and QoS parameter mapping; Stage 3".

## 17.6 PAP/CHAP protocols usage in 5GS

890070	<a href="#">PAP/CHAP protocols usage in 5GS</a>	PAP_CHAP	ct	CP-202251	Mingxue Li, China Telecom
890071	CT1 aspects of PAP/CHAP protocols usage in 5GS	PAP_CHAP	C1	CP-202251	Mingxue Li, China Telecom
890072	CT3 aspects of PAP/CHAP protocols usage in 5GS	PAP_CHAP	C3	CP-210188	Mingxue Li, China Telecom

Summary based on the input provided by China Telecom in CP-202251.

This work item enables the support of the (Extended) Protocol Configuration Options [(e)PCO] parameters related to the Password Authentication Protocol (PAP) / Challenge Handshake Authentication Protocol (CHAP) over 5GS.

This is needed in the following cases:

- migration from EPS to 5GS and potential requirements related to legacy deployments for access to corporate networks, e.g. support of PAP/CHAP in DN-AAA server owned by 3rd parties,
- access to corporate networks by early 5GS deployments (e.g. with standalone SMF), e.g. to support PAP/CHAP in DN-AAA server or LNS owned by 3rd parties.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=890070,890071,890072>

- [1] TS 29.561: "Interworking between 5G Network and external Data Networks"
- [2] TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS)"
- [3] TS 24.526: "User Equipment (UE) policies for 5G System (5GS)"

## 17.7 Start of Pause of Charging via User Plane

910007	Start of Pause of Charging via User Plane	SPOCUP	C4	CP-210076	YONG, YANG, Ericsson, frank
--------	---	--------	----	-----------	-----------------------------

Summary based on the input provided by Ericsson in CP-220211.

The work item defines a User Plane (GTP-U) based solution to start pause of charging for a PDN connection or a PDU session to reduce the Charging Data Record discrepancies between SGW or I/V-SMF and PGW or (h)SMF caused by the control plane signalling latency in existing solution.

PGW/SMF Pause of Charging feature is to limit a mismatch between PGW-C/SMF and SGW/I/V-SMF charging volume and packet counts. To further reduce charging discrepancies due to control plane signalling latency, the work item specifies following enhancements to enable start of pause of charging via user plane path:

- a new feature "Notify Start Pause of Charging via user plane feature" (NSPOC) is introduced in PFCP to enable CP function ((SGW-C and PGW-C for EPC, I/V-SMF and (H-)SMF for 5GC) to instruct UP function (SGW-U and PGW-U for EPC, I/V-UPF and PSA UPF), to trigger pause of charging at the upstream GTP-U entity via sending one or more GTP-U Tunnel Status messages, so that the upstream GTP-U entity can stop usage measurement for those URRs applicable for charging; and
- a new mechanism to stop/resume the usage measurement in PFCP when NSPOC is supported; and
- a new GTP-U message "Tunnel Status" is introduced in GTP-U protocol to be used to notify the upstream GTP-U entity to start pause of charging; and
- the support of NSPOC feature is exchanged via control plane signalling between PGW-C/SMF and SGW/I/V-SMF respectively.

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910007>

## 17.8 Enhancement of Handover Optimization

880029	Enhancement of Handover Optimization	E_HOO	S5	SP-200466	Elmdahl, Per, Ericsson
--------	--------------------------------------	-------	----	-----------	------------------------

Summary based on the input provided by Ericsson in SP-220586.

This Work Item added management support for the optimization of Conditional Handover (CHO) and Dual Active Protocol Stack (DAPS) handover. It gives the operator the ability to control and observe CHO and DAPS handover. CHO and DAPS HO were specified by RAN2 and RAN3 under the Work Item NR\_Mob\_enh-Core.

Conditional Handover (CHO) is a new feature defined by RAN2 and RAN3. CHO is different from legacy handover in that the source cell may prepare handovers to one or many target cells, but the execution of the handover is not done by the source cell but by the UE.

Dual Active Protocol Stack (DAPS) handover is a new feature define by RAN2 and RAN3. DAPS handover is different from legacy handover in that the UE sets up a connection to the target cell before the connection to the source cell is taken down, sometimes called "make before break".

For legacy handover, 3GPP SA5 have previously defined management support for Mobility Robustness Optimization (MRO), under the Self Organizing Network (SON) umbrella.

The Enhancement of Handover Optimization Work Item has supplemented the existing MRO management features with enhancements for CHO and DAPS handover. These enhancements include support for configuring CHO and DAPS handover. This support consists of enabling and disabling CHO and DAPS handover. Furthermore, new Performance Measurements for CHO and DAPS handover were added. In addition, a new Key Performance Indicator (KPI) for handover success rate was specified. This new KPI includes legacy handover, CHO and DAPS handover.

For the configuration, Stage 1 is specified in TS 28.313 [1], and Stage 2 and 3 is specified in TS 28.541 [2]. For Performance Measurements, Stage 1 is in TS 28.313 [1], and Stage 2 is in TS 28.552 [3]. For the new KPI, Stage 2 is in TS 28.554 [4].

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870029>

- [1] TS 28.313 Management and orchestration; Self-Organizing Networks (SON) for 5G networks
- [2] TS 28.541 Management and orchestration; 5G Network Resource Model (NRM); Stages 2 & 3



- [3] TS 28.552 Management and orchestration; 5G performance measurements  
 [4] TS 28.544 Management and orchestration; 5G end to end Key Performance Indicators (KPI)

## 17.9 Restoration of Profiles related to UDR

940002	<a href="#">Restoration of Profiles related to Unified Data Repository (UDR)</a>	ReP_UDR	C4	CP-213070	Ishikawa, Hiroshi, NTT DOCOMO
--------	--	---------	----	-----------	-------------------------------

Summary based on the input provided by NTT DOCOMO in CP-220343.

This Work Item enables restoration of profiles between UDR and related NF consumers, to maintain the status up to date as much as possible even in case data stored in UDR is lost or corrupted.

Data stored in UDR is automatically updated in normal operation. Some data is stored in volatile storage units due to its nature, such as location of UE, subscription data, policy data, and loss or corruption of storage containing such data could negatively impact the service to subscribers. Replication of volatile storage units and periodic back-up of data are used to avoid loss or corruption, however further procedures are required in case the integrity of data in UDR cannot be ensured, especially when relying on replicated data.

Following enhancements are specified to fulfil these required procedures:

- Preparation of profile in NF consumers
- Path and contents of notification sent from UDR to NF consumers when loss or corruption at UDR is detected
- Procedure for synchronization initiated by the NF consumer upon receiving notification of loss or corruption

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940002>

## 17.10 IP address pool information from UDM

870006	<a href="#">IP address pool information from Unified Data Manager (UDM)</a>	TEI17_IPU	S2	<a href="#">SP-200454</a>	Stefan Rommer
--------	---	-----------	----	---------------------------	---------------

Summary based on the input provided by Ericsson in SP-220588.

Separate IP address pools are used in many enterprise use cases, general management of network IP space resources and/or for UPF selection. This WI has added support for providing IP pool information ("IP Index") from UDM to SMF as part of a Session Management subscription data. The SMF can use the subscriber's IP Index to assist in selecting how the IP address is to be allocated when multiple allocation methods, or multiple instances of the same method are supported. The IP Index can e.g. be used to select between different IP pools. The feature is described in TS 23.501 [1], TS 23.502 [2] and TS 29.503 [3].

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870006>

- [1] TS 23.501: "System architecture for the 5G System (5GS)"  
 [2] TS 23.502: "Procedures for the 5G System (5GS)"  
 [3] TS 29.503: "5G System; Unified Data Management Services"

## 17.11 Dynamic management of group-based event monitoring

910084	<a href="#">Dynamic management of group-based event monitoring</a>	TEI17_GEM		<a href="#">SP-200455</a>	Qian XB Chen, Ericsson
870007	<a href="#">Stage 2 for TEI17_GEM</a>	TEI17_GEM	S2	<a href="#">SP-200455</a>	Qian XB Chen, Ericsson
910010	<a href="#">CT aspects on TEI17_GEM</a>	TEI17_GEM	ct	<a href="#">CP-212165</a>	Maria Tianmei, Liang, Ericsson
910085	<a href="#">CT3 aspects on TEI17_GEM</a>	TEI17_GEM	C3	<a href="#">CP-212165</a>	Maria Tianmei, Liang, Ericsson
910086	<a href="#">CT4 aspects on TEI17_GEM</a>	TEI17_GEM	C4	<a href="#">CP-212165</a>	Maria Tianmei, Liang, Ericsson

Summary based on the input provided by Ericsson in SP-220589.

This function improves the dynamic handling of event configuration for cancellation or adding of an individual member or a sub-set of members in a group with active event configuration. The function is to ensure that event cancellation/adding of some member(s) does not affect other members in the group.

For a UE belonging to a group which has an active group-based event configuration, the UE's event monitoring can be cancelled due to different reasons (e.g. the UE is removed from the group by AS/AF, the UE's subscription is deleted



from the HSS/UDM while monitoring is active, etc.). It's also possible that AS or AF adds a new UE into an existing group which has active event configuration.

The specifications are improved to specify that event configuration can be updated with event cancellation/adding can be sent from AS/AF for individual UE or a sub-set of the UEs (i.e. the external identifiers or MSISDNs of the UEs) in a group which has an active event configuration.

The specifications also specify the event cancellation triggered by HSS/UDM for individual UE or sub-set of the UEs in a group. HSS/UDM informs AS/AF of these individual UE or a sub-set of the UEs (i.e. the external identifiers or MSISDNs of the UEs) via SCEF/NEF.

The function is described in TS 23.682, 23.502, TS 29.122, TS 29.336, TS 29.503, TS 29.518 and TS 29.522.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910084,870007,910010,910085,910086>

- [1] TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".
- [2] TS 23.502: "Procedures for the 5G System (5GS)".
- [3] TS 29.122: "T8 reference point for northbound Application Programming Interfaces (APIs)".
- [4] TS 29.336: "Home Subscriber Server (HSS) diameter interfaces for interworking with packet data networks and applications".
- [5] TS 29.503: "5G System; Unified Data Management Services; Stage 3".
- [6] TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".
- [7] TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".

## 17.12 Dynamically Changing AM Policies in the 5GC

910081	Dynamically Changing AM Policies in the 5GC	TEI17_DCAMP		SP-200446	Pancorbo, Belen (Ericsson)
870005	Stage 2 for TEI17_DCAMP	TEI17_DCAMP	S2	SP-200446	Pancorbo, Belen (Ericsson)
910009	CT aspects on TEI17_DCAMP	TEI17_DCAMP	ct	CP-212163	Garcia Azorero, Fuencisla. Ericsson
910082	CT3 aspects on TEI17_DCAMP	TEI17_DCAMP	C3	CP-212163	Garcia Azorero, Fuencisla. Ericsson
910083	CT4 aspects on TEI17_DCAMP	TEI17_DCAMP	C4	CP-212163	Garcia Azorero, Fuencisla. Ericsson

Summary based on the input provided by Ericsson in SP-220590.

This Work Item provides the capability for an Application Function (AF) to request for a UE either service area coverage or the indication that high throughput is desired or both. It specifies two methods:

- a) The AF requests a service area coverage for the UE and/or indicates that high throughput is desired, knowing that certain conditions are met, i.e., the application traffic needs a change of service area coverage or high throughput.
- b) The AF provides the service area coverage and/or the indication that high throughput is desired for one or multiple UEs that may or may not already be registered or fulfil certain conditions related to application traffic.

In method a) the AF contacts the NEF then the NEF contacts the BSF to retrieve the identity of the PCF serving the UE. In method b) the AF contacts the NEF then the NEF stores the AF request in the UDR as Data Set "Application Data" and Data Subset "AM influence information".

In both methods, the AF provides the service area coverage that the PCF takes as input for policy decisions then to determine whether the service area restrictions need to be updated. The AF provides the indication that high throughput is desired that is considered by the PCF to decide if the RFSP value index for a UE needs to be changed. The PCF reports to the AF that the request was executed. The specification work applies for non-roaming scenarios.

## References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910081,870005,910009,910082,910083>

- [1] TS 23.503: "Policy and charging control framework for the 5G System (5GS)"
- [2] TS 23.502: "Procedures for the 5G System (5GS)"

## 17.13 Other aspects

840019	<a href="#">5G System Enhancement for Advanced Interactive Services</a>	5G_AIS	S2	SP-190564	Lei Yixue, Tencent
--------	---	--------	----	-----------	--------------------

Summary based on the input provided by Tencent in SP-220897.

5G-AIS aims to enable 5G system to provide QoS provisioning for advanced interactive services such as cloud gaming, XR etc. According to SA1 requirements, QoS enhancements for advanced interactive services have been specified in TS 23.501/502/503.

According to SA1 requirements within clause 7.6 of TS 22.261[1], QoS enhancements including new QoS parameters e.g. new standardized 5QI(s) corresponding to QoS requirements from SA1 have been specified in TS 23.501[2], TS 23.502[3] and TS 23.503[4].

In TS 23.501[1], it was captured that Interactive services that require high data rate and low latency communication, e.g. cloud gaming and AR/VR services are documented in TS 22.261 [2]. Standardized 5QI characteristics for such services are provided in Table 5.7.4-1. There have been LS exchanges between SA2, RAN1 and SA4 to confirm these new standardized 5QIs.

87		25	5 ms (NOTE 4)	$10^{-3}$	500 bytes	2000 ms	Interactive Service - Motion tracking data, (see TS 22.261 [2])
88		25	10 ms (NOTE 4)	$10^{-3}$	1125 bytes	2000 ms	Interactive Service - Motion tracking data, (see TS 22.261 [2])
89		25	15 ms (NOTE 4)	$10^{-4}$	17000 bytes	2000 ms	Visual content for cloud/edge/split rendering (see TS 22.261 [2])
90		25	20 ms (NOTE 4)	$10^{-4}$	63000 bytes	2000 ms	Visual content for cloud/edge/split rendering (see TS 22.261 [2])

Meanwhile, in TS 23.501[1], it was specified that TSCAI can be used to describe the related traffic characteristics as defined in clause 5.27.2.

In TS 23.502[2], procedure enhancements are specified including adding time domain between PCF and NEF and new procedure for AF to send TSC and non-TSC QoS requirements for AIS.

In TS 23.503[3], PCC support for AIS is specified and TSCAI is extended to integrate TSN and AIS.

### References

Related CRs: set "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910081,870005,910009,910082,910083>

- [1] 3GPP TS 22.261, Requirements for 5G System; Stage 1
- [2] 3GPP TS 23.501, System Architecture for 5G System; Stage 2
- [2] 3GPP TS 23.502, Procedures for 5G System; Stage 2
- [3] 3GPP TS 23.503, Policy and Charging Control Framework for the 5G System; Stage 2

No summary was provided for these aspects:

911037	<a href="#">Reliable Data Service Serialization Indication</a>	RDSSI		SP-190446	Starsinic, Michael, Convida Wireless LLC
840017	Stage 2 of RDSSI	RDSSI	S2	SP-190446	Starsinic, Michael, Convida Wireless LLC
900005	CT aspects of RDSSI	RDSSI	C1	CP-203234	Vivek Gupta, Intel
930002	<a href="#">IMS voice service support and network usability guarantee for UE s E-UTRA capability disabled scenario in SA 5GS</a>	ING_5GS	ct	CP-212231	Mingxue Li, China Telecom
930047	CT1 aspects of ING_5GS	ING_5GS	C1	CP-212231	Mingxue Li, China Telecom
930046	CT6 aspects of ING_5GS	ING_5GS	C6	CP-212231	Mingxue Li, China Telecom
920060	<a href="#">NPN support of PWS</a>	NPN_PWS	S1	SP-210585	Francesco Pica, Qualcomm
840044	<a href="#">Network Controlled Interactive Service</a>	NCIS		SP-190303	Ning YANG, oppo
800015	Study on NCIS	FS_NCIS	S1	SP-180341	YANG Ning, Oppo

840030	Stage 1 of NCIS	NCIS	S1	SP-191039	Ning YANG, oppo
880043	Multi-Device and multi-identity Enhancements (MuDE)	MuDE		SP-190823	Adrian.buckley@vivo.com
850041	Stage 1 of MuDE	MuDE	S1	SP-190823	Adrian.buckley@vivo.com
880018	Stage 3 of MuDE	MuDE	C1	CP-201162	Adrian Buckley
920055	Best Practice of Packet Forwarding Control Protocol (PFCP)	BEPoP	ct	CP-212024	Song Yue, China Mobile
920056	CT3 aspects of BEPoP	BEPoP	C3	CP-212024	Song Yue, China Mobile
880014	CT4 aspects of BEPoP	BEPoP	C4	CP-212024	Song Yue, China Mobile
840016	Supporting Flexible Local Area Data Network	FLADN	S2	SP-190563	LG Electronics, Hyunsook Kim
830017	Verification-modified Calling Name Display	VMOD_DISPLAY	S1	SP-190085	Hala Mowafy, Ericsson
850038	Enhanced Calling Name Service Analytics Interworking	eCNAM_An	S1	SP-190940	Hala.Mowafy@ericsson.com
860008	IMS emergency support for Stand-alone Non-Public Network (SNPN)	IESNPN	S1	SP-191038	Wong, Curt;
870003	IMS Optimization for HSS Group ID in an SBA environment	TEI17_IMSGID	S2	SP-200452	Foti, George, Ericsson
930036	System enhancement for Redundant PDU Session	TEI17_SE_RPS		SP-200448	Devaki Chandramouli
880017	Stage 2 for TEI17_SE_RPS	TEI17_SE_RPS	S2	SP-200448	Devaki Chandramouli
930001	CT aspects of TEI17_SE_RPS	TEI17_SE_RPS	ct	CP-212099	WON, Sung Hwan, Nokia
930037	CT1 aspects of TEI17_SE_RPS	TEI17_SE_RPS	C1	CP-212099	WON, Sung Hwan, Nokia
930038	CT3 aspects of TEI17_SE_RPS	TEI17_SE_RPS	C3	CP-212099	WON, Sung Hwan, Nokia
930039	CT4 aspects of TEI17_SE_RPS	TEI17_SE_RPS	C4	CP-212099	WON, Sung Hwan, Nokia
910078	Support for Signed Attestation for Priority and Emergency Sessions	TEI17_SAPES		SP-200453	Foti, George, Ericsson
870004	Stage 2 for TEI17_SAPES	TEI17_SAPES	S2	SP-200453	Foti, George, Ericsson
910020	CT aspects on TEI17_SAPES	TEI17_SAPES	ct	CP-210272	Axell, Jörgen, Ericsson
910079	CT1 aspects on TEI17_SAPES	TEI17_SAPES	C1	CP-210272	Axell, Jörgen, Ericsson
910080	CT3 aspects on TEI17_SAPES	TEI17_SAPES	C3	CP-210272	Axell, Jörgen, Ericsson
920041	Support of different slices over different Non 3GPP access	TEI17_N3SLICE		SP-200456	Laurent Thiebaut, Nokia
870008	Stage 2 for TEI17_N3SLICE	TEI17_N3SLICE	S2	SP-200456	Laurent Thiebaut, Nokia
930099	CT1 aspects of TEI17_N3SLICE	TEI17_N3SLICE	C1	CP-211089	LANDAIS, Bruno, Nokia
920001	CT4 aspects of TEI17_N3SLICE	TEI17_N3SLICE	C4	CP-211089	LANDAIS, Bruno, Nokia
910087	N7/N40 Interfaces Enhancements to Support GERAN and UTRAN	TEI17_NIESGU		SP-200457	Aihua, Li, China Mobile
870009	Stage 2 for TEI17_NIESGU	TEI17_NIESGU	S2	SP-200457	Aihua, Li, China Mobile
890019	SA5 aspects of N40 Interface Enhancements to Support GERAN and UTRAN	TEI17_NIESGU	S5	SP-200854	Dong, Jia, China Mobile
910011	CT3 aspects of N7 Interfaces Enhancements to Support GERAN and UTRAN	TEI17_NIESGU	C3	CP-211194	Huang Zhenning (China Mobile)
920082	CT4 aspects of N7 Interfaces Enhancements to Support GERAN and UTRAN	TEI17_NIESGU	C4	CP-211194	Huang Zhenning (China Mobile)

## 18 Standalone Management Features

### 18.1 Introduction

This section presents all the standalone management functionalities. Management aspects related to other features are reported in the relevant section. For instance, OAM for "Industrial IoT" is reported in the section on "Industrial IoT" and not here.

### 18.2 Enhanced Closed loop SLS Assurance

870030	Enhanced Closed loop System Level Synthesis (SLS) Assurance	eCOSLA	S5	SP-200196	Groenendijk, Jan, Ericsson
--------	---	--------	----	-----------	----------------------------

Summary based on the input provided by Ericsson in SP-220308.

This Work Item added enhancements to the Closed loop SLS Assurance solution specified in TS 28.535 [1] and TS 28.536 [2]. The enhancements add more advanced monitoring solutions that helps an operator to continuously deliver the expected level of communication service quality when deploying a NetworkSlice or a NetworkSliceSubnet.

A closed control loop automatically adjusts and optimizes the services provided over an NG-RAN and 5GC network based on the various performance management, QoE input data, and the state of the 5G network, using data analytics. The solution has the following features:

- it can have existing KPI's and measurements as input and make predictions and depending on the parameter(s) to be assured the appropriate KPI's and measurements can be obtained.

- it can use existing provisioning capabilities to perform actions based on predicted goal status and depending on which network characteristics are predicted the appropriate actions can be provisioned
- it can configure assurance goal by extraction of the appropriate parameter values from the ServiceProfile or SliceProfile of the NetworkSlice or NetworkSliceSubnet which service is assured.
- it can collect the assurance goal status of a closed control loop based on domains and depending on which network characteristics are to be assured for a domain the appropriate actions can be provisioned.
- it can ascertain the assurance goal status of a closed control loop based on location and depending on which network characteristics are to be assured the appropriate actions can be provisioned.

The solution separates the goals that a closed control loop needs to fulfil from the results of the operation of a closed control loop. The results (fulfilment status of a goal) for a closed control loop are provided in a report including the observed fulfilment and predicted fulfilment. The goals for a closed control loop are derived from the service requirements that are specified in a ServiceProfile or SliceProfile.

To be able to deploy SLS assurance solutions the following objectives are addressed:

- Add new service assurance management related use cases and requirements according to deployment, assurance aspects.
- Enhance the descriptions on closed loop and related interactions which are important for service assurance.
- Describe new information in NRM which support the service assurance.

This work item resulted in several CRs to update the communication services assurance solution specified in TS 28.535 [1] and TS 28.536 [2]

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870030>

- |     |   |
|-----|---|
| [1] | TS 28.535: Management and orchestration: Management Services for Communication Service Assurance; Requirements        |
| [2] | TS 28.536: Management and orchestration: Management Services for Communication Service Assurance; Stage 2 and stage 3 |

## 18.3 Enhancement of QoE Measurement Collection

870027	<a href="#">Enhancement of QoE Measurement Collection</a>	eQoE	S5	SP-200193	Petersen, Robert, Ericsson
--------	---	------	----	-----------	----------------------------

Summary based on the input provided by Ericsson in SP-220308.

This work item specifies Quality of Experience (QoE) measurement collection in UMTS, LTE and 5G networks. It extended eQoE to support NR. It also added Signalling Based Activation (SBA) for UTRAN and LTE functions. LTE is also aligned with RAN specifications.

Functions that are added for NR includes: Management Based Activation (MBA), Deactivation of QoE measurement collection job, temporary stop and restart during RAN overload and new NR service Virtual Reality (VR). Signalling Based Activation and Handling QoE measurement collection during handover are also added.

Management Based Activation allows for QoE measurement collection from UEs in a specified area. The operator has capability to deactivate the collection of QoE measurement job. Temporary stop and restart during RAN overload: provides capability to RAN that temporarily stops and restarts QoE measurement reporting at RAN overload.

By supporting NR service Virtual Reality the QoE measurements for Virtual Reality can also be collected. Signalling Based Activation provides capability to request collection of end user service performance information for one specific UE.

Signalling Based Activation is also added for UTRAN and LTE. Handling QoE measurement collection during handover provides capability to handle QoE measurement collection during handover.

QMCjob added to the network resource information to enable QoE measurement collection between an Management Service (MnS) producer and Management Service consumer in deployment scenarios using the Service Based Management.

## References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870027>

- [1] TS 28.404: "Quality of Experience (QoE) measurement collection; Concepts, use cases and requirements".
- [2] TS 28.405: "Quality of Experience (QoE) measurement collection; Control and configuration".
- [3] TS 28.622: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

## 18.4 Plug and connect support for management of Network Functions

910029	<a href="#">Plug and connect support for management of Network Functions</a>	PACMAN	S5	SP-210260	Per Elmdahl, Ericsson
--------	--	--------	----	-----------	-----------------------

Summary based on the input provided by Ericsson in SP-210310.

This work item specifies Plug and Connect support for NFs. It extended Plug and Connect (PnC) to support Service Based Architecture (SBMA). It added support of IPv6, DHCPv6 and Dual stack and extended PnC to be useful for all generations of NEs, e.g., NR and LTE. Support of virtualized nodes are not in the scope of this work item.

PnC is the procedure by which a NE gets basic connectivity information after it is powered up and gets connected to its management system.

After PnC, Self-Configuration procedures are used to complete Plug and Play (PnP).

This work item only covers PnC. A new Rel-18 work item "Self-configurations of RAN NEs" was created to document the self-configuration management of RAN NEs of NR and future RAT technology if possible in the context of SBMA.

Prior to this work item, 3GPP PnP specifications do not support NR. Those specifications restrict the PnP to eNB only. They also miss some updates from IETF RFCs regarding IPv6 and DHCPv6 support.

There are three new specifications for PnC are created as result of this work item. They are the full set of specifications covering stage 1 (TS 28.314), stage 2 (TS 28.315), and stage 3 (TS 28.316) of PnC. The new specifications added support of IPv6, DHCPv6 and dual stack for PnC and extended the PnC to support SBMA. The restriction to PnC on eNB was removed, the scope of the PnC is extended to support network element (NE) including LTE and NR radio network nodes. Other types of nodes might also be compliant and use this PnC procedure. The same level of security support as for eNB is provided in the new specifications for NE.

This work item also removed PnC clauses for 5G from TS 28.313 and referred them to the new specifications TS 28.314 and TS 28.315.

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910029>

- [1] TS 28.314: "Management and orchestration; Plug and Connect; Concepts and Requirements".
- [2] TS 28.315: "Management and orchestration; Plug and Connect; Procedure flows".
- [3] TS 28.316: "Management and orchestration; Plug and Connect; Data formats".
- [4] TS 28.313: "Management and orchestration; Self-Organizing Networks (SON) for 5G network".

## 18.5 Management of MDT enhancement in 5G

870025	<a href="#">Management of MDT enhancement in 5G</a>	e_5GMDT	S5	SP-200191	Ayani, Zhulia, Ericsson
--------	---	---------	----	-----------	-------------------------

Summary based on the input provided by Ericsson in SP-210311.

This WI is an enhancement of the Rel-16 WI "5GMDT". During release 17, the MDT measurement configuration and reporting enhancement in NR has been defined to be aligned with RAN2/RAN3/CT4.

The MDT (minimization of driving test) feature in NR has been defined in RAN2 and RAN3. The e\_5GMDT is part of the MDT feature from management point of view. This e-5GMDT work item has added the following features and addressed the following issues in release 17:

- MDT measurement configuration and reporting in a RAN split architecture in NR
- The MR-DC including EN-DC related configuration and measurement impacts from the management point of view.
- Measurement and configuration enhancement for logged and immediate MDT.



- Enhancement of reporting to be aligned with internode communication specified in RAN2 and RAN3

## References

Related CRs: set "TSG Status = Approved" in :

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870025>

- [1] TS 32.421: "Telecom management; Subscriber and equipment trace; Trace concepts and requirements".
- [2] TS 32.422: "Telecom management; Subscriber and equipment trace; Trace control and configuration management".
- [3] TS 32.423: "Telecom management; Subscriber and equipment trace: Trace data definition and management".
- [4] TS 28.622: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
- [5] TS 28.623: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".

## 18.6 Management Aspects of 5G Network Sharing

900021	<a href="#">Management Aspects of 5G Network Sharing</a>	MANS	S5	SP-201080	Mingrui Sun, China Unicom
920018	<a href="#">Study on Management Aspects of 5G Network Sharing</a>	FS_MANS	S5	<b>SP-210387</b>	Mingrui Sun, China Unicom

This WID mainly focuses on enhancement of management aspects 5G MOCN network sharing, including clarification of use cases, requirements and enhancement of NR NRM. It evaluates and specifies corresponding management features to support 5G network sharing scenarios in release 17. The SID is to make recommendations and potential enhancement for NR NRM to support MOCN network sharing scenarios

This WID, management aspects of network sharing, is primarily to specify the concept, requirements and use cases for 5G MOCN network sharing scenarios on management aspects.

This WID specifies which information or parameters in configuration management with different authorities need to be configured per operator, such as adding PLMN granularity for number of active UEs measurements and adding PLMN granularity for Radio resource utilization measurements. What's more, one of the important objectives is to enhance NR NRM to fulfil the requirements of 5G MOCN network sharing scenarios (including all NG-RAN deployment scenarios). Detailed scenarios have been captured in SID of FS\_MANS including potential requirements and solutions. Evaluate existing trace/PM/FM solutions to ensure that the 5G MOCN network sharing is supported.

Based on MANS, normative work is specified in TS 32.130, TS 28.552, TS 28.554 and TS 28.541.

## References

- [1] TS 32.130: "Telecom management; Network sharing; Concepts and requirements"
- [2] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3"
- [3] TS 28.552: "Management and orchestration; 5G performance measurements"
- [4] TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)"

## 18.7 Discovery of management services in 5G

820035	<a href="#">Discovery of management services in 5G</a>	5GDMS	S5	SP-200770	Brendan Hassett, Huawei Technologies Sweden AB
--------	--	-------	----	-----------	--

Summary based on the input provided by Huawei in SP-220566.

5G network and network slicing management supports a service-based management architecture where deployed management service instances are exposed by management service producers. This WI adds the capability for management service consumers to discover the exposed management services in the 3GPP management system.

The high-level requirement is described in TS 28.530 [1]. The management service producer profile is described in TS 23.533 [2]. Use cases and requirements are described in TS 28.537 [3]. The Network Resource Model in TS 28.622 [4] is extended to add new data to support discovery of management services. OpenAPI and YANG solution sets in TS 28.623 [5] are extended to comply with the extended Network Resource Model.

## References



- [1] TR 28.530: "Management and orchestration; Concepts, use cases and requirements"
- [2] TR 28.533: "Management and orchestration; Architecture framework"
- [3] TR 28.537: "Management and orchestration; Management capabilities"
- [4] TR 28.622: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"
- [5] TR 28.623: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions"
- [6] SP-190753 S5-195931: "Rel-16 CR TS 28.530 Add use case MnS query and related requirement"
- [7] SP-191152 S5-197606: "Rel-16 CR 32.533 Introduce a MnS profile"
- [8] SP-210152 S5-211367: "Rel-17 CR 28.537 Add DMS use cases and requirements"
- [9] SP-210864 S5-214594: "Remove unnecessary stage 2 details for discovery of management services"
- [10] SP-210864 S5-214610: "Rel-17 CR 28.537 Add support for discovery of management services"
- [11] SP-211467 S5-215531: "Rel-17 CR 28.533 Remove MnS Discovery use case and requirement"
- [12] SP-211467 S5-215532: "Rel-17 CR 28.622 Add support for MnS Discovery"
- [13] SP-211467 S5-215533: "Rel-17 CR 28.623 Add support for MnS Discovery"
- [14] SP-211467 S5-215560: "Rel-17 CR TS28.537 clarifications into existing use cases"
- [15] SP-211467 S5-216299: "Clarifications into existing requirements"
- [16] SP-220163 S5-221597: "Rel-17 CR 28.622 Add support for discovery of managed entities"
- [17] SP-220163 S5-221598: "Rel-17 CR 28.623 Add support for discovery of managed entities"

## 18.8 Management of the enhanced tenant concept

880026	Management of the enhanced tenant concept	eMENTANE	S5	SP-200463	Zhu, Lei, Huawei
--------	---	----------	----	-----------	------------------

Summary based on the input provided by Huawei in SP-220567.

Management of the enhanced tenant concept provides conceptual description on tenant as MnS consumer in 3GPP management system. The management system is required to provide management capability for reporting performance monitoring and alarm notifications for the tenant based on management and orchestration for network slicing.

The management and orchestration for network slicing supports performance measurement per S-NSSAI (see TS 28.552) and alarm notification with slice identifier(s). The clarification is provided in this work item, to provide the conceptual description in 28.533 and TS 28.532 on how those management information are provided by 3GPP management system to vertical MnS consumers. So the clarifications to use MnS for performance monitoring and alarm notifications are provided in TS 28.533, TS 28.532 and TS 28.552.

Management of the enhanced tenant concept provides some discussion and not pursued change requests in network slice NRM on tenant information IOC and use in slice NRM in TS 28.541. Those changes are related to the provisioning service exposed to tenant MnS consumers, which are also in the scope of ongoing R18 study item on management capability exposure in SA5.

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=880026>

## 18.9 Intent driven management service for mobile network

810027	Intent driven management service for mobile network	IDMS_MN	S5	SP-180899	Zou Lan, Huawei
--------	---	---------	----	-----------	-----------------

Summary based on the input provided by Huawei in SP-220568.

An intent driven system will be able to learn the behaviour of networks and services and allows a customer to provide the desired state as intent (an intent specifies the expectations including requirements, goals and constraints for a specific service or network management workflow), without detailed knowledge of how to get to the desired state. Thus, the intent driven management is introduced to reduce the complexity of management without getting into the intricate detail of the underlying network resources. This WI specifies the concept, use cases, requirements and solutions for the intent driven management for service or network management.

Following content is specified in TS 28.312 [1].

1. The concept for intent and intent driven management service (Intent-driven MnS) in the context of Service based management architecture (SBMA).

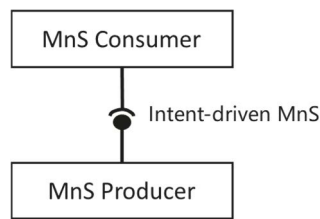


Figure 1 intent-driven MnS

2. Typical use cases and corresponding requirements for intent driven management, including
- Intent containing an expectation for delivering radio network;
  - Intent containing an expectation for delivering a radio service;
  - Intent containing an expectation for delivering a service;
  - Intent containing an expectation on coverage performance to be assured;
  - Intent containing an expectation on RAN UE throughput performance to be assured;
3. Intent driven management service definition, including
- Management operation for Intent. The operations and notifications of generic provisioning MnS will be used for intent lifecycle management.
  - Information model definition for intent, including the following generic Information model definition and two scenario specific IntentExpectation definition: Radio Network Expectation and Service Support Expectation.

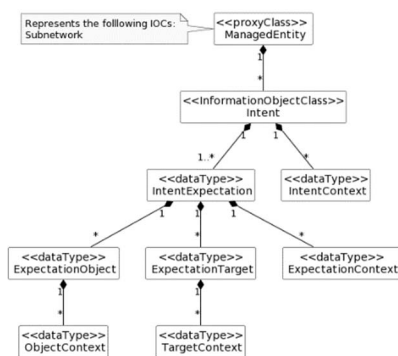


Figure 2: Generic Information model definition

4. OpenAPI solution set for Intent driven management service.

References

[1]TR 28.812: "Study on scenarios for Intent driven management services for mobile networks"

[2]TS 28.312: "Intent driven management services for mobile networks"

18.10 Improved support for NSA in the service-based management architecture

930032	Improved support for NSA in the service-based management architecture	NSA_SBMA	S5	SP-211121	Lan Zou, Huawei
910031	Study on Enhancement of service-based management architecture	FS_eSBMA	S5	SP-210136	Lan Zou, Huawei
930009	Improved support for NSA in the service-based management architecture	NSA_SBMA	S5	SP-210858	Lan Zou, Huawei

Summary based on the input provided by Huawei in SP-220569.

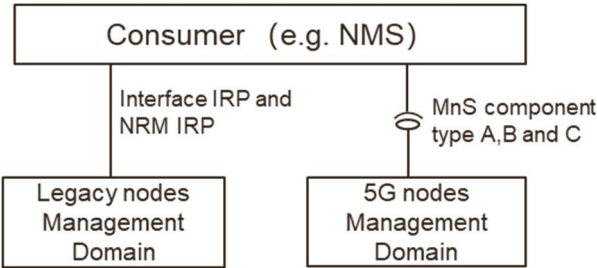
SA5 service based management architecture supporting management of 5G SA and NSA scenarios have two options for the management of both legacy nodes and 5G nodes.

Description

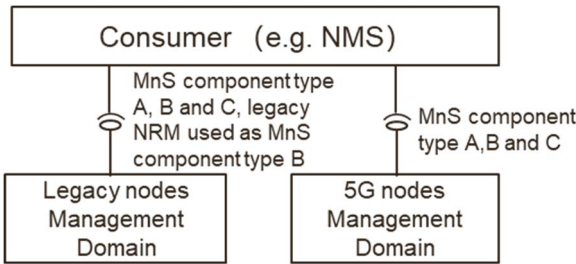
Following content is specified in TS 28.530 [1].

The management of 5G SA and NSA could be classified to the following two management options with using interface IRP, NRM IRP and MnS.

Option#A (interface IRP and NRM IRP are used for management of legacy nodes)



Option#B (MnS is used for management of legacy nodes)



References

[1] TS 28.530: " Management and orchestration; Concepts, use cases and requirements"

18.11 Additional Network Resource Model features

870026	<b>Additional Network Resource Model (NRM) features</b>	adNRM	S5	SP-200192	Jing Ping, Nokia
--------	---	-------	----	-----------	------------------

Summary based on the input provided by Nokia, Nokia Shanghai Bell in SP-220578.

This WID extends the 5G Network Resource Model to support several new features of 5G Core (5GC) and NG Radio Access Network (NG-RAN), together with enhancements of the stage 3 Solution Set (SS):

- Support of NG RAN and 5GC features. The 5G NRM is extended to support new or existing features or functionalities of NG RAN and 5GC, e.g. 5G Core SMF, 5G Core managed NFs Profile, the UDM function, Edge Application Server Discovery Function (EASDF) , local NEF selection, Network Slice Admission Control Function (NSACF) in 5GC (including adding Max number of PDU sessions and serving area information), networkSliceSubnetType for NetworkSliceSubnet, configuration of AMF, DDNMF, N33, N5, N70 and N71 interfaces, NRM definition enhancement for the NWDAF, and transport related information model to support end to end network slice management, refer to TS 28.541[1]. Requirement for NR NRM to suport the RAN sharing scenario is added in TS 28.540[2].
- To support monitoring the progress of the file download in a downloading job, a "ProgressMonitor" DatatType is added, refer to TS 28.622[3] and TS 28.623 [4].
- YANG solution set is enhanced to support containment mapping, add code begin/end markers and increase prefix length in TS 32.160 [5].
- Stage 3 codes, including YAML and YANG solution sets, are uploaded to 3GPP Forge for validation and then published. Please refer the below link for the SA5 Forge repository: <https://forge.3gpp.org/rep/sa5/MnS>

References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870026>

- [1] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3"
- [2] TS 28.540: "Management and orchestration of 5G networks; Network Resource Model (NRM); Stage 1."
- [3] TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
- [4] TS 28.623: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".
- [5] TS 32.160: "Management and orchestration; Management Service Template".

## 18.12 Charging for Local breakout roaming of data connectivity

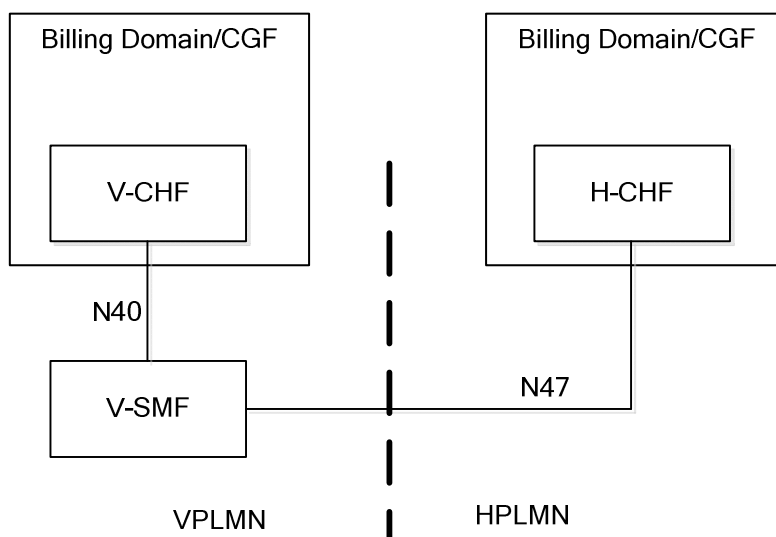
950037	<a href="#">5G Charging for Local breakout roaming of data connectivity</a>	CHROAM	S5	SP-220156	Ericsson
--------	---	--------	----	-----------	----------

Summary based on the input provided by Ericsson in SP-220585.

This Work Item enables charging for roaming local breakout scenario. It also supports some scenarios involving non-roaming MVNO (with its own CHF).

To support charging for roaming local breakout the following has been introduced from the SMF in the visited MNO:

- Collection of charging information for the purpose of wholesale charging towards the home MNO
- Collection of charging information and conveying it to the home MNO network for the purpose of retail charging



**Figure 1: 5G data connectivity converged charging architecture in Local breakout scenario reference point representation**

The N40 reference point is defined for the interactions between V-SMF and V-CHF, the N47 reference point is defined for the interactions between V-SMF and H-CHF, specified in TS 32.255 [2]. Wherever the V-SMF will use only N40, or both N40 and N47, depends on agreement and SMF configuration. Both reference points use the NchfConvergedCharging service, specified in TS 32.290 [3] and TS 32.291 [4], however online charging is only possible on the N47 when both N40 and N47 is used for the same chargeable data connectivity session.

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950037>

- [1] TS 32.240: "Telecommunication management; Charging management; Charging architecture and principles"
- [2] TS 32.255: "Telecommunication management; Charging management; 5G data connectivity domain charging; Stage 2"
- [3] TS 32.290: "Telecommunication management; Charging management; 5G system; Services, operations and procedures of charging using Service Based Interface (SBI)"

- [4] TS 32.291: "Telecommunication management; Charging management; 5G system, charging service; Stage 3"

## 18.13 File Management

910030	<a href="#">File Management</a>	FIMA	S5	SP-210135	Pollakowski, Olaf, Nokia
--------	---------------------------------	------	----	-----------	--------------------------

Summary based on the input provided by Nokia in SP-220631.

In network management files are used for storing and transferring different kinds of data (performance measurements, trace data, etc.). Files are transferred between Network Functions and Management Functions or between Management Functions, depending on the use case. Two different types of file transfer are addressed:

- File retrieval from a MnS producer by a MnS consumer
- File download from a MnS consumer to a MnS producer

Fully standardized and interoperable solutions are provided. The solutions follow a model driven approach, where only Network Resource Model (NRM) fragments are standardized and the existing Create, Read, Update and Delete (CRUD) operations are used.

Stage 1 requirements and use cases are specified in TS 28.537 [1].

Stage 2 definitions of the NRM fragments are specified in TS 28.622 [2].

Stage 3 definitions of the NRM fragments are specified in TS 28.623 [3].

For File retrieval the File retrieval NRM fragment is defined. Files are represented by "File" objects that are contained in "Files" collections. MnS consumers can retrieve the files using a normal Read operation. Notifications are emitted upon creation of new "File" objects to inform subscribed MnS consumers about the availability of new files for retrieval.

For File download the File download NRM fragment is defined. It contains the definition of the "FileDownloadJob". The MnS consumer creates these objects on the MnS producer to request the MnS producer to download a file from the MnS consumer or some file server. The download job features a "ProgressMonitor" allowing to monitor the progress of the file download. After completion of the file download the job object is deleted.

### References

Related CRs: set "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910030>

- [1] TS 28.537: "Management and orchestration; Management capabilities".
- [2] TS 28.622: " Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
- [3] TS 28.623: " Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".

## 18.14 Management data collection control and discovery

880028	<a href="#">Management data collection control and discovery</a>	MADCOL	S5	SP-200465	Pollakowski, Olaf, Nokia
--------	--	--------	----	-----------	--------------------------

Summary based on the input provided by Nokia in SP-220841.

This work item enhances existing and specifies new methods for controlling management data production, collection, coordination, and discovery. Management data includes data from RAN network functions, core network functions and UEs.

In this work item, requirements for producing, reporting, storing and discovery of management data are specified in TS 28.537[1].

Besides the existing data collection jobs, where the management data is requested from specific target managed object instances based on the managed object tree (as defined in the SA5 Network Resource Models), this WI introduces a method to request management data based on one or multiple selection criteria namely area of interest (list of cells, list of tracking areas or geographical area), domain (RAN or Core), traffic type (user plane or control plane) or slice type (e.g. eMBB, URLLC), see TS 28.622[2], TS 28.623[3]. The introduced data collection job allows to request for Trace data, MDT (Minimization of Drive Test) data, RLF (Radio Link Failure) reports, RCEF (RRC Connection Establishment Failure) reports, PM (performance measurements), KPI (end-to-end key performance indicators) or a combination of these. Furthermore, the management production can be requested for a certain time window.

In the context of management data discovery, the supported management data which can be provided by a network function has been enhanced to include trace metrics besides performance metrics. In this context the metric identifier for trace metrics, covering Immediate MDT, Logged MDT, Logged MBSFN MDT, Trace, RLF reports and RCEF reports, has been introduced in TS 32.422[4].

The methods of file-based reporting of performance metrics are enhanced to allow implicit notification subscriptions for notifyFileReady notifications indicating the availability of new performance metric reports, see TS 28.622[2], TS 28.623[3].

## References

List of related CRs: select "TSG Status = Approved" in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=880028>

- [1] TS 28.537: "Management and orchestration; Management capabilities"
- [2] TS 28.622: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"
- [3] TS 28.623: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions"
- [4] TS 32.422: "Subscriber and equipment trace; Trace control and configuration management"

## 18.15 Other charging and management aspects

900022	<a href="#">Study on Charging Aspect of 5G LAN-type Services</a>	FS_5GLAN_CH	S5	SP-201081	CHEN SHAN, Huawei
--------	--	-------------	----	-----------	-------------------

Summary based on the input provided by Huawei in SP-220572.

Note: Although Studies are usually not reported in this document, it was estimated by the rapporteur that this study deserves a summary.

As per the 5G LAN-type service requirements specified in TS 22.261 and the 5G LAN-type Services specified in the TS 23.501 and TS 23.502, the 5G Virtual Network (VN) group consists of a set of UEs using private communication for 5G LAN-type services. The WID 5GLAN\_CH specifies the charging principle, charging requirements, service operations and charging information for 5G VN group service charging, including:

- 5G VN group management charging: NEF and CEF support the group management (e.g. creation, modification and deletion) charging in TS 32.254.
- 5G VN group communication charging: SMF supports the charging information collection and reporting per PDU session in TS 32.255.

The corresponding Open API and ASN.1 for 5G LAN VN group service charging are specified in the TS 32.291 and TS 32.298.

## References

- [1] TS32.255: "Charging management; 5G Data connectivity domain charging; stage 2".
- [2] TS 32.240: "Charging management; Charging architecture and principles".
- [3] TS 32.254: "Charging management; Exposure function Northbound Application Program Interfaces (APIs) charging".
- [4] TS 32.291: "Charging management; 5G system; Charging service, stage 3".
- [5] TS 32.298: "Charging management; Charging Data Record (CDR) parameter description".

870024	<a href="#">Enhancement on Management Aspects of 5G Service-Level Agreement</a>	EMA5SLA	S5	SP-210860	SHI, Xiaonan, CMCC
840028	<a href="#">IMS Charging in 5G System Architecture</a>	5GSIMSCH	S5	SP-190367	Jahangir, Zeeshan, T-Mobile USA
860024	<a href="#">Network policy managementfor 5G mobile networks</a>	NPM	S5	SP-191211	China Mobile Shasha Guo
850028	<a href="#">Study on enhancement of Management Data Analytics Service</a>	FS_eMDAS	S5	SP-190930	Yao, Yizhi, Intel
910027	<a href="#">Enhancements of Management Data Analytics Service</a>	eMDAS	S5	SP-210132	Yao, Yizhi, Intel
880025	<a href="#">Enhancements of 5G performance measurements and KPIs</a>	ePM_KPI_5G	S5	SP-200462	Yizhi Yao, Intel
<b>930033</b>	<a href="#">Access control for management service</a>	<b>MSAC</b>	<b>S5</b>	<b>SP-210859</b>	<b>Jing Ping, Nokia</b>
890016	<a href="#">Study on access control for management service</a>	FS_MNSAC	S5	SP-200853	Jing Ping, Nokia
930010	<a href="#">Access control for management service</a>	MSAC	S5	SP-210859	Jing Ping, Nokia



## 19 Features without summary

The Features listed below are not summarised in this document because their output is not significant enough. It can e.g. be some minor protocol enhancements.

The corresponding CR(s), if any, can be found by replacing [UID] by the actual UID in the link below, selecting "TSG Status = Approved" in the page:

[https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=\[UID\]](https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=[UID])

The UID is the left-most number in the table below.

880020	<a href="#">Protocol enhancements for Mission Critical Services</a>	MCProtoc17	C1	CP-202193	AXELL, Jörgen
<b>880019</b>	<a href="#">Stage-3 5GS NAS protocol development 17</a>	<b>5GProtoc17</b>	<b>C1</b>	<b>CP-201163</b>	<b>Sedlacek, Ivo, Ericsson</b>
880044	Stage-3 5GS NAS protocol development 17 general aspects	5GProtoc17	C1	CP-201163	Sedlacek, Ivo, Ericsson
880045	Stage-3 5GS NAS protocol development 17 non-IETF aspects	5GProtoc17-non3GPP	C1	CP-201163	Sedlacek, Ivo, Ericsson
<b>880021</b>	<a href="#">Stage-3 SAE Protocol Development</a>	<b>SAES17</b>	<b>C1</b>	<b>CP-201165</b>	<b>Aghili, Behrouz, InterDigital Communications</b>
880046	Stage-3 SAE Protocol Development general aspects	SAES17	C1	CP-201165	Aghili, Behrouz, InterDigital Communications
880047	Stage-3 SAE Protocol Development CSFB aspects	SAES17-CSFB	C1	CP-201165	Aghili, Behrouz, InterDigital Communications
880048	Stage-3 SAE Protocol Development non 3GPP aspects	SAES17-non3GPP	C1	CP-201165	Aghili, Behrouz, InterDigital Communications
<b>911034</b>	<a href="#">IMS Stage-3 IETF Protocol Alignment</a>	<b>IMSProtoc17</b>	<b>ct</b>	<b>CP-201167</b>	<b>Gkatzikis, Lazaros(Nokia)</b>
880023	CT1 aspects of IMS Stage-3 IETF Protocol Alignment	IMSProtoc17	C1	CP-201167	Gkatzikis, Lazaros(Nokia)
911035	CT3 aspects of IMS Stage-3 IETF Protocol Alignment	IMSProtoc17	C3	CP-201167	Gkatzikis, Lazaros(Nokia)
<b>880013</b>	<a href="#">Service Based Interface Protocol Improvements Release 17</a>	<b>SBIProtoc17</b>		CP-211088	<b>Song Yue, China Mobile</b>
880053	CT3 aspects of SBIProtoc17	SBIProtoc17	C3	CP-211088	Song Yue, China Mobile
880054	CT4 aspects of SBIProtoc17	SBIProtoc17	C4	CP-211088	Song Yue, China Mobile

---

## Annex A:

### Change history

Change history						
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment
2021-11	TSG#94					Initial draft, call for contributions
2022-01	-					Clean-up of skeleton
2022-03	TSG#95e					Incorporation of: SP-220019 WI Summary for Mission critical security enhancements phase 2 (MCXSec2) Motorola Solutions Danmark A/S SP-220020 Summary for Edge Computing Management Samsung R&D Institute UK SP-220075 Summary for Network Slice charging based on 5G Data Connectivity MATRIX Software SP-220089 EMCData3 WI Summary AT&T GNS Belgium SPRL SP-220260 Summary for Enhancement for the 5G Control Plane Steering of Roaming for UE in CONNECTED mode (eCPSOR_CON) NTT DOCOMO INC. SP-220261 WI Summary for TEI17_SPSFAS China Telecommunications SP-220275 Summary for WI Support of Immersive Teleconferencing and Telepresence for Remote Terminals (ITT4RT) Nokia Corporation (Rapporteur) SP-220277 Summary for eV2XARC_Ph2 LG Electronics SP-220285 Summary for 5GMARCH China Mobile Com. Corporation SP-220289 Summary for Authentication and key management for applications based on 3GPP credential in 5G China Mobile CP-220021 Template for Feature Summary for inclusion in TR 21.917 (Rel-17 Description) MCC/Alain CP-220110 Summary for Stage 3 aspects of eMCCIFirstNet CP-220111 Summary for Stage 3 aspects of enh3MCPTT FirstNet CP-220149 Summary for Restoration of PDN Connections in PGW-C/SMF Set Nokia, Nokia Shanghai Bell CP-220150 Summary for Non-Seamless WLAN offload authentication in 5GS Nokia, Nokia Shanghai Bell CP-220152 Summary for Enhancement of Inter-PLMN Roaming Huawei CP-220211 Summary for Start of Pause of Charging via User Plane Ericsson CP-220212 Summary for Enhancement on the GTP-U entity restart Ericsson CP-220321 Summary for PFD management enhancement Huawei CP-220322 Summary for enhancement of 5G PCC related services in Rel-17 Huawei CP-220343 Summary for Restoration of Profiles related to UDR NTT DOCOMO INC. CP-220347 Summary for Rel-17 Enhancements of 3GPP Northbound Interfaces and Application Layer APIs Huawei CP-220368 Summary for PAP/CHAP protocols usage in 5GS China Telecommunication Corp.

2022-04					<p>Incorporation of:</p> <p>RP-220142 WI summary for WI NR Uplink Data Compression (UDC) CATT</p> <p>RP-220154 WI summary for WI NR small data transmissions in INACTIVE state (Rel-17) ZTE Corporation (rapporteur)</p> <p>RP-220165 Summary for SI Study on band combination handling in RAN4 ZTE Corporation</p> <p>RP-220191 WI summary for WI Introduction of DL 1024QAM for NR FR1; rapporteur: Ericsson, Nokia Ericsson</p> <p>RP-220211 WI summary for WI NR Sidelink Relay OPPO</p> <p>RP-220316 WI summary for NR support for high speed train scenario in frequency range 2 (FR2) Samsung</p> <p>RP-220408 WI summary for WI NR Multicast and Broadcast Services Huawei, HiSilicon</p> <p>RP-220410 WI summary for WI Multi-Radio Dual-Connectivity enhancements Huawei, HiSilicon</p> <p>RP-220445 WI summary for WI New bands and bandwidth allocation for 5G terrestrial broadcast (part 1) EBU, Qualcomm Incorporated (Rapporteur)</p> <p>RP-220464 WI summary for Rel17 WI on NR Dynamic spectrum sharing (DSS) Ericsson</p> <p>RP-220521 WI summary for WI NR sidelink enhancement LG Electronics</p> <p>RP-220530 WI summary for WI Additional enhancements for NB-IoT and LTE-MTC Huawei, HiSilicon</p> <p>RP-220544 WI summary for WI NR Repeaters Qualcomm Incorporated</p> <p>RP-220556 WI summary for WI NR QoE management and optimizations for diverse services China Unicom</p> <p>RP-220560 WI summary for WI Enhanced eNB(s) architecture evolution for E-UTRAN and NG-RAN China Unicom</p> <p>RP-220562 WI summary for WI Enhancement of Private Network Support for NG-RAN China Telecom</p> <p>RP-220564 WI summary for WI NR coverage enhancements China Telecom</p> <p>RP-220604 WI summary for WI Core part: Support for Multi-SIM devices for LTE/NR vivo (WI Rapporteur)</p> <p>RP-220606 WI summary for WI: Introduction of UE TRP (Total Radiated Power) and TRS (Total Radiated Sensitivity) requirements and test methodologies for FR1 (NR SA and EN-DC) vivo (WI Rapporteur)</p> <p>RP-220631 WI summary for WI: Enhanced NR support for high speed train scenario for frequency range 1 (FR1) CMCC</p> <p>RP-220682 WI summary for WI: RF requirements enhancement for NR frequency range 1 (FR1) Huawei, HiSilicon</p> <p>RP-220752 WI summary for WI NR and MR-DC measurement gap enhancements Rapporteur (MediaTek Inc., Intel)</p> <p>RP-220802 WI summary for WI Core part: Further enhancements on MIMO for NR Samsung</p> <p>RP-220822 WI summary for WI Enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR standalone and MR-DC (Multi-Radio Dual Connectivity) CMCC</p> <p>RP-220919 WI summary for WI Core part: NR positioning enhancements Intel</p> <p>RP-220923 WI summary for WI UE RF requirements for Transparent Tx Diversity (TxD) for NR Qualcomm Incorporated</p>	0.4.0
2022-04					<p>Inclusion of:</p> <p>880012 Extension for headset interface tests of UE</p> <p>Update of the table of expected summaries</p> <p>Update of the template for contributing</p>	0.5.0
2022-05					<p>Inclusion of:</p> <p>SP-220300 Qualcomm Summary for Work Item on "8K Television over 5G (8K_TV_5G)"</p> <p>SP-210890 ZTE Summary for Work Item on "Enhancement of Network Slicing Phase 2" eNS_Ph2 (UID: 900011)</p> <p>SP-220321 Ericsson Summary for Integration of the Generic Bootstrapping Architecture (GBA) into 5GC (GBA_5G)</p> <p>UIC Summary for MCOVer5GS</p>	0.6.0

2022-06					<p><b>Summaries incorporated:</b></p> <p>SP-220300 Summary for Work Item on '8K Television over 5G (8K_TV_5G)' Qualcomm Haris Zisimopoulos</p> <p>SP-220308 Summary for Enhanced Closed loop SLS Assurance Ericsson LM Thomas Tovinger</p> <p>SP-220309 Summary for Enhancement of QoE Measurement Collection Ericsson LM Thomas Tovinger</p> <p>SP-220310 Summary for Plug and connect support for management of Network Ericsson LM Thomas Tovinger</p> <p>SP-220311 Summary for Management of MDT enhancement in 5G Ericsson LM Thomas Tovinger</p> <p>SP-220320 Summary for MC services support in the Isolated Operation for Public Safety (IOPS) mode of operation (MCIOPS) Ericsson Krister Sällberg</p> <p>SP-220321 Summary for Integration of the Generic Bootstrapping Architecture (GBA) into 5GC (GBA_5G) Ericsson Krister Sällberg</p> <p>SP-220326 WI summary for SA WG5 EE5GPLUS SA WG5 EE5GPLUS Rapporteur Jean Michel Cornily</p> <p>SP-220357 Summary for eV2XARC_Ph2 LG Electronics Laeyoung Kim</p> <p>WI summaries available at TSG#96 but not yet included in this version:</p> <p>RP-221163 Summary of WI on support of reduced capability (RedCap) NR devices</p> <p>RP-221178 WI summary for Enhancements to IAB for NR</p> <p>RP-221197 Summary for REL-17 WI Enhanced IoT and URLLC support for NR</p> <p>RP-221201 Feature Summary to High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands</p> <p>RP-221206 Feature summary to Further enhancements of NR RF requirements for frequency range 2 (FR2)</p> <p>RP-221286 WI summary for WI: Further enhancement on NR demodulation performance</p> <p>RP-221340 Summary for Building Block Work Item: User Plane Integrity Protection support for EPC connected architectures</p> <p>RP-221376 Summary for WI enhancement of RAN slicing for NR</p> <p>RP-221384 Summary for WI: Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) requirements for NR UEs</p> <p>RP-221505 WI summary for Introduction of 6GHz NR licensed bands</p> <p>RP-221544 WI Summary: UE Power Saving Enhancements for NR [Rel-17]</p> <p>RP-221547 WI Summary: NB-IoT/eMTC support for Non-Terrestrial Networks (NTN) [Rel-17]</p> <p>RP-221589 Summary for WI Increasing UE power high limit for CA and DC</p> <p>RP-221698 WI summary of R17 further RRM enhancement for NR and MR-DC</p> <p>CP-221272 WI Summary: NB-IoT/eMTC Non-Terrestrial Networks in EPS</p> <p>SP-220425 Summary for IIoT</p> <p>SP-220426 Summary for Non-Seamless WLAN offload authentication in 5GS</p> <p>SP-220448 Summary for 5G_ProSe</p> <p>SP-220450 Summary for Management Aspects of 5G Network Sharing</p> <p>SP-220455 WI Summary: NB-IoT/eMTC Non-Terrestrial Networks in EPS</p> <p>SP-220458 Summary for eCAV (enhancements for cyber-physical control applications in vertical domains)</p> <p>SP-220484 Summary for MINT</p> <p>SP-220485 Summary for eMONASTERY2</p> <p>SP-220566 SA WG5 Rel-17 WID Summary for discovery of management services in 5G</p> <p>SP-220567 SA WG5 Rel-17 WID Summary for Management of the enhanced tenant concept</p> <p>SP-220568 SA WG5 Rel-17 WID Summary for intent driven management service for mobile network</p> <p>SP-220569 SA WG5 Rel-17 WID Summary for improved support for NSA in the service based management architecture</p> <p>SP-220570 SA WG5 Rel-17 WID Summary for management of non-public networks</p> <p>SP-220571 SA WG5 Rel-17 WID Summary for Charging Enhancement for URLLC</p> <p>SP-220572 SA WG5 Rel-17 WID Summary for 5G LAN Charging</p> <p>SP-220573 SA WG5 Rel-17 WID Summary for Charging enhancements for 5GS CIoT</p> <p>SP-220574 Summary for System support for Multi-USIM devices</p>	0.7.0
---------	--	--	--	--	--	-------

					SP-220577 WI summary of eEdge_5GC SP-220578 SA WG5 Rel-17 WID Summary for Additional NRM features SP-220580 Rel-17 WI Summary for Autonomous network levels SP-220584 Summary for Enhanced support of Non-Public Networks SP-220585 Summary for 5G Charging for Local breakout roaming of data connectivity SP-220586 Summary for Enhancement of Handover Optimization SP-220587 WI summary of 5MBS SP-220588 Summary for IP address pool information from UDM SP-220589 Summary of Dynamic management of group-based event monitoring (TEI17_GEM) SP-220590 Summary for Dynamically Changing AM Policies in the 5GC SP-220591 Summary for Access Traffic Steering, Switching and Splitting support in the 5G system architecture; Phase 2 SP-220619 Summary for Remote Identification of Uncrewed Aerial Systems SP-220620 Summary for AKMA TLS protocol profiles SP-220622 Work Item Summary for Rel-17 EDGEAPP SP-220623 Work Item Summary for Rel-17 eSEAL SP-220626 Summary for WI Handsets Featuring Non-Traditional Earpieces (HaNTE) SP-220628 SA WG5 Rel-17 WID Summary for 5G ProSe Charging SP-220629 Summary for eNA_Ph2 SP-220630 WI_summary_Charging aspects of ARCH_NR_REDCAP SP-220631 Summary for File management SP-220635 Summary for WI EVEX 5GMS Event Exposure SP-220636 Summary for Work Item on 5G Multicast-Broadcast Protocols SP-220651 Summary for Application layer support for Uncrewed Aerial System (UAS) SP-220652 WI Summary - CMED SP-220653 Summary for Enhanced application layer support for V2X services SP-220655 Summary of enh3MCPTT feature in Release 17 SP-220656 Summary of MCSML_CT feature in Release 17 SP-220650 Summary for FS_NPN4AVProd Study on Media Production over 5G NPN SP-220646 Summary of Study on Multicast Architecture Enhancement for 5G Media Streaming FS_5GMS_Multicast SP-220637 Summary for Feasibility Study on 5G Video Codec Characteristics	
2022-08					Deep Editor (MCC) review of the document: corrections, content alignments, re-arrangements of sections, etc.	0.8.0
2022-09					Inclusion of: RP-221946 Draft Summary for NR support for Non-Terrestrial Networks (NTN) THALES RP-222107 WI summary for Introduction BCS4 Ericsson RP-222478 WI Summary for Extending current NR operation to 71GHz Qualcomm CDMA Technologies SP-220841 Summary for Management data collection control and discovery Nokia (MADCOL Rapporteur) SP-220897 Summary for 5G-AIS Tencent SP-220899 Summary for 5G_eLCS_ph2 CATT	1.0.0
2022-12	TSG#98e	SP-221286 / CP-223242 / RP-223427			Inclusion of: SP-221202 Summary for Adapting BEST for use in 5G networks KPN SP-221269 WI Summary - 5MBUSA 5G Multicast-Broadcast User Service Architecture TELUS	2.0.0
2022-12	TSG#98e	SP-221286 / CP-223242 / RP-223427			Raised to v.17.0.0 following SA#98 approval	17.0.0
2023-01	-	-			Corrected version number (was "19.0.0")	17.0.1



---

# History

Document history		
V17.0.1	January 2023	Publication