

# 3GPP TR 21.916 V16.1.0 (2022-01)

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*Technical Report*

## **3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Release 16 Description; Summary of Rel-16 Work Items (Release 16)**

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Keywords

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## 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 TSG and may change following formal TSG approval. Should TSG modify the contents of the present document, it will be re-released by 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.

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## Introduction

The present document provides a summary of each and every 3GPP Release 16 Feature, and more generally of all Work Items for which a summary has been agreed to be provided.

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 "initial state" of the Features introduced in Release 16, i.e. as they are by the time of publication of this document. Each Feature is subject to be later modified or enhanced, over several years, by the means of Change Requests (CRs). To further outline a feature at a given time, it is recommended to retrieve all the CRs which relate to the given Feature, as explained in Annex C. As a first approach, the list of all the Change Requests related to a Work Item can be retrieved by selecting "TSG Status = Approved" in the Work Item's page of the 3GPP Portal at:

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

E.g. 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>

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# 1 Scope

The present document provides a summary of each Release 16 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.

More information is available by consulting the 3GPP Portal web site, as explained in "Annex C: Process to get further information" and in the introduction section.

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# 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".

[2] TR 21.915: "Release 15 Description".

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

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# 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.

5GS	The 3GPP 5G System
DL	Downlink (network to mobile)
IoT	Internet of Things
KPI	Key Performance Indicator
NB	Narrowband
NR	New Radio (the radio interface of 5G)
Rel	3GPP Release

UL Uplink (mobile to network)

## 4 Rel-16 Executive Summary

Release 16 can be seen as a set of independent improvements of the 5G System, introduced in Rel-15 and described in TR 21.915 [2]. As such, several references are made in the present document to pre-Rel-16 Features and to 5G reference points and network functions.

Other Rel-16 enhancements are for Features that have been introduced several Releases ago, including those related to Mission Critical, or to Conversational services.

The main Rel-16 radio enhancements concern the 5G (NR) radio interface, but also the 4G (LTE) radio, and improving the cooperation between them. For the 5G radio, the end user bit rate has been increased by introducing several configurations of Carrier Aggregations and by adding 256QAM. Other radio enhancements include the NR-based access to unlicensed spectrum, and some enhancements in the fields of mobility and UE Power Saving. These radio enhancements are presented in section 19.

As for the system-wide features, presented in sections 5 to 18, the overall trend in Rel-16 is to make the 3GPP 5G System (5GS) a communication-enabling platform suitable for a wide range of industries (“verticals”), such as e.g. transportation (autonomous driving V2X, Railways, Maritime), automated factories, healthcare, public safety and many more. In this respect, the versatility and reliability of the 5GS has been further increased to make it industry-grade compatible, with enhancements to Ultra-Reliable Low Latency Communications (URLLC), Network Slicing, Edge Computing, Cellular IoT (Internet of Things), Non-Public Networks, Positioning Services and LAN-type services. In addition, the use of 5G as an underlying communication network (i.e. to be used transparently by applications external to the network) has been enhanced, mostly under the work on "Northbound APIs". Besides all these industrial aspects, other Rel-16 enhancements cover the coexistence of 5G with non-3GPP systems, entertainment (e.g. streaming and media distribution) and network optimisations (e.g. user identity).

## 5 Enhancement of Ultra-Reliable and Low Latency Communications (URLLC)

### 5.1 Enhancement of URLLC support in the 5G Core network

830098	<b>Enhancement of URLLC support in the 5G Core network</b>	<b>5G_URLLC</b>	<b>S2</b>	<b>SP-181122</b>	<b>Hui Ni, Huawei</b>
790008	<b>Study on enhancement of URLLC supporting in 5GC</b>	FS_5G_URLLC	S2	SP-180118	Hui Ni, Huawei
810036	<b>Study on the security of URLLC for 5GS</b>	FS_5G_URLLC_SEC	S3	SP-180910	Rong Wu, Huawei Technologies
820019	<b>Stage 2 of 5G_URLLC</b>	5G_URLLC	S2	SP-181122	Hui Ni, Huawei
840026	<b>Security of URLLC for 5GS</b>	5G_URLLC_SEC	S3	SP-190351	Rong Wu, Huawei Technologies
<b>840005</b>	<b>CT Aspects of 5G_URLLC</b>	<b>5G_URLLC</b>	<b>ct</b>	<b>CP-191063</b>	<b>Qi Caixia, Huawei</b>
840060	CT3 Aspects of 5G_URLLC	5G_URLLC	C3	CP-191063	Qi Caixia, Huawei
840061	CT4 Aspects of 5G_URLLC	5G_URLLC	C4	CP-191063	Qi Caixia, Huawei
780030	<i>Stopped - Study on EPC support for Mobility with Low Latency Communication</i>	FS_LLC_Mob	S2	SP-171069	Chris PUDNEY
790009	<i>Stopped - Study on enht of systems using EPS for UR and Availability using commodity equipment</i>	FS_EPS_URACE	S2	SP-180119	Chris Pudney

Summary based on the input provided by Huawei in SP-200295.

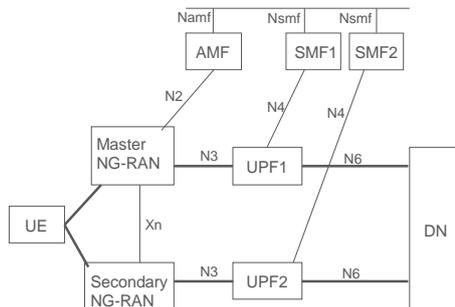
This Feature enhances 5G core network to support ultra-high reliability and low-latency communications (URLLC). The main functionalities introduced here are the support of redundant transmission, QoS monitoring, dynamic division of the Packet Delay Budget, and enhancements of the session continuity mechanism.

#### Redundant transmission for high-reliability communication

Some URLLC services request very high reliability that hardly can be supported in an economical way by a single transport path. To support such services, a redundant transmission mechanism is specified. User packets are duplicated and simultaneously transferred to the receiver via two disjoint user plane paths. The redundant packets are then eliminated at the receiver side. With this, service failure can be avoided even in case the packet transmission via one path occasionally fails or exceeds the delay requirement.

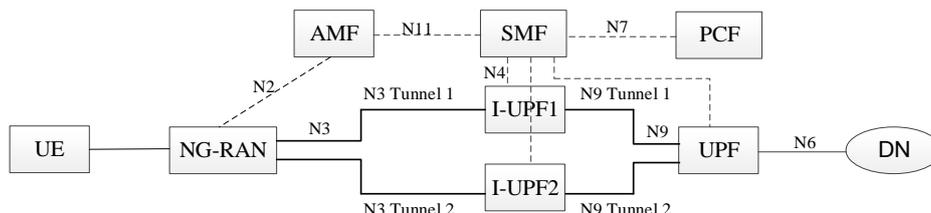
Different options are specified to support redundant transmission at different layers (figures extracted from 23.501):

- Dual-connectivity-based end-to-end redundant user plane paths: two redundant PDU Sessions with independent user plane paths are established between UE and DN. Packet replication and elimination are performed by the upper layer of UE and DN, which are not specified in 3GPP.



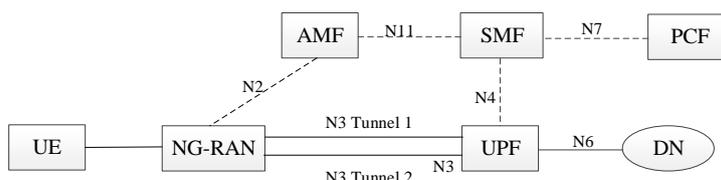
**Figure 1: redundant User Plane paths using Dual Connectivity**

- Support of redundant transmission on N3/N9 interfaces: for a PDU Session used for URLLC services, two redundant N3/N9 tunnels with independent user plane paths are established between UPF and NG-RAN to transfer the duplicated user packets. Packet replication and elimination are performed by NG-RAN and User Plan Function (UPF).



**Figure 2: redundant transmission using two N3 and N9 tunnels between NG-RAN and PSA UPF**

- Support of redundant transmission at transport layer: this approach assumes that the backhaul provides two disjoint transport paths between UPF and RAN. The redundancy functionality within NG-RAN and UPF makes use of the independent paths at transport layer, which is not specified in 3GPP.



**Figure 3: Redundant transmission using two N3 tunnels between the PSA UPF and the NG-RAN node**

QoS Monitoring

QoS Monitoring is defined in this release for the measurement of packet delay between UE and PSA UPF. The NG-RAN is required to provide the QoS Monitoring of UL/DL packet delay at the Uu interface. The QoS Monitoring of UL/DL packet delay between NG-RAN and PSA UPF can be performed at different levels of granularities, i.e. per QoS flow level, or per GTP-U path level.

Dynamic division of Packet Delay Budget

The Packet Delay Budget (PDB) of URLLC services is typically more stringent than for traditional services. To obtain a more accurate delay budget for NG-RAN, SA WG2 decided to allow a dynamic value for the core network PDB (CN PDB), so that the SMF or NG-RAN can dynamically calculate delay budget of NG-RAN based on the CN PDB.

Enhancements of session continuity

When a UE moves, the user plane path of low latency services need to be optimized to reduce the latency and to guarantee session continuity. Several related mechanisms are developed or enhanced in this WI.

PDU Session Anchor (PSA) relocation for Ethernet PDU Session is specified in this release. The target UPF will assist in the update of Ethernet forwarding tables of Ethernet switches in the DN, so that UL/DL traffics will switch to the target UPF once the UE moves.

For Uplink Classifier (ULCL) relocation, a forwarding tunnel between the old and new ULCLs is introduced to avoid packet loss during relocation.

AF-influenced traffic routing mechanism is further enhanced to allow flexible coordination between SMF and AF when user plane change events happen.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830098,790008,810036,820019,840026,840005,840060,840061>

The redundant transmission and QoS monitoring mechanisms are specified in TS 23.501[1], Clause 5.33. Dynamic division of Packet Delay Budget is specified in TS 23.501 [1], Clause 5.7.3.4. Enhancements of session continuity mechanisms are mainly in TS 23.501 [1], Clause 5.6.7, and TS 23.502 [2], Clause 4.3.5 and Clause 4.3.6.

- [1] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [2] TS 23.502: "Procedures for the 5G System; Stage 2".
- [3] TR 23.725: "Study on enhancement of Ultra-Reliable Low-Latency Communication (URLLC) support in the 5G Core network"

## 5.2 Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)

830074	<a href="#">Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)</a>	NR_L1enh_URLLC	R1	RP-191584	Huawei
800095	Study on physical layer enhancements for NR UR Low Latency Cases	FS_NR_L1enh_URLLC	R1	RP-181477	Huawei
830174	Core part: Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)	NR_L1enh_URLLC-Core	R1	RP-190726	Huawei
830274	Perf. part: Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)	NR_L1enh_URLLC-Perf	R4	RP-190726	Huawei

Summary based on the input provided by Huawei in RP-200887.

Basic support for URLLC was introduced in Release 15. It included Transmission Time Interval (TTI) structures for low latency as well as methods for improved reliability. Use cases with tighter requirements, e.g. higher reliability up to  $1E-6$  and short latency in the order of 0.5 to 1ms, have been identified as important areas for NR.

This work item is based on the outcome of the study items resulting in TR 38.824 [2] and TR 38.825 [3]. It specifies PDCCH enhancements, UCI enhancements, PUSCH enhancements, enhanced inter UE TX prioritization/multiplexing and enhanced UL configured grant transmission. More precisely, the following key functionalities were introduced:

### DCI format 0\_2 and DCI format 1\_2

DCI format 0\_2/1\_2 with configurable sizes for most of the DCI fields are introduced, which provides the possibility to improve the reliability by decreasing the DCI size (e.g. ~24 bits) with appropriate RRC configuration of the DCI fields. Details of DCI format 0\_2/1\_2 can be found in [4].

### Enhanced PDCCH monitoring capability

Rel-16 span-based PDCCH monitoring capability is introduced mainly for achieving low latency. A UE can indicate a capability to monitor PDCCH according to one or more of the combinations  $(X, Y) = (2, 2), (4, 3),$  and  $(7, 3)$  per SCS configuration of  $\mu=0$  and  $\mu=1$ . A span is a number of consecutive symbols in a slot where the UE is configured to monitor PDCCH. If a UE monitors PDCCH on a cell according to combination  $(X, Y)$ , the UE supports PDCCH monitoring occasions in any symbol of a slot with minimum time separation of  $X$  symbols between the first symbol of two consecutive spans, and the number of symbols of a span is up to  $Y$ . For each reported combination  $(X, Y)$ , the UE supports the limit  $M_{\text{PDCCH}}^{\text{max}}(X, Y, \mu)$  on the maximum number of monitored PDCCH candidates per PDCCH monitoring span as defined in Table 10.1-2A in [5] and the limit  $C_{\text{PDCCH}}^{\text{max}}(X, Y, \mu)$  on the maximum number of non-overlapped CCEs for channel estimation per PDCCH monitoring span as defined in Table 10.1-3A in [5]. An example of PDCCH monitoring according to combination  $(4, 3)$  is as shown in Figure 1.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Combination (4, 3)	Span 1					Span 2					Span 3			

**Fig. 1. An example of PDCCH monitoring using Rel-16 span based PDCCH monitoring capability.**

Sub-slot based HARQ-ACK feedback

Sub-slot based HARQ-ACK feedback is introduced to support more than one PUCCH for HARQ-ACK transmission within a slot, which is mainly beneficial for achieving low latency. An UL slot consists of a number of sub-slots. No more than one PUCCH carrying HARQ-ACKs starts in a sub-slot. A UE can indicate the supported sub-slot configuration among the candidate values of {7-symbol\*2, 2-symbol\*7 and 7-symbol\*2} for normal CP or { 6-symbol\*2, 2-symbol\*6 and 6-symbol\*2} for extended CP.

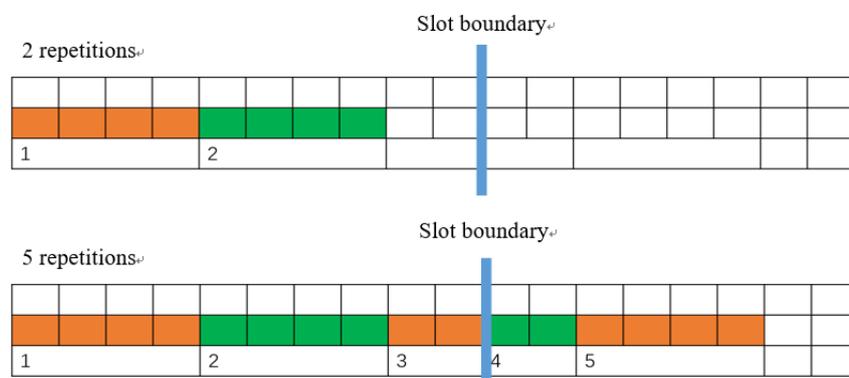
Two HARQ-ACK codebooks constructed simultaneously

This work item specifies the support of two HARQ-ACK codebooks with different priorities to be simultaneously constructed, which is mainly beneficial for improving reliability for service with higher priority. Each of the two HARQ-ACK codebooks can be either slot-based HARQ-ACK codebook or sub-slot-based HARQ-ACK codebook. Separate PUCCH configurations are supported for different HARQ-ACK codebooks. The feature supports two priority levels for HARQ-ACK. Rules are defined for the UE to resolve collisions between UL channels/signals with different priorities.

PUSCH enhancements

This work item specifies PUSCH repetition type B and PUSCH repetition type A for PUSCH enhancements. PUSCH repetition type B is mainly beneficial for achieving low latency. PUSCH repetition type A can improve the spectral efficiency.

For PUSCH repetition type B, for a transport block, one dynamic UL grant or one configured grant schedules two or more PUSCH repetitions that can be in one slot, or across a slot boundary in consecutive available slots. Examples of PUSCH repetition type B are given in Figure 2. Inter-slot frequency hopping and inter-repetition frequency hopping are specified for PUSCH repetition type B. Interaction with DL/UL directions is specified as in Clause 6 in [6].



**Fig. 2. Examples of PUSCH repetition type B.**

PUSCH repetition type A corresponds to PUSCH transmission with Rel-15 behavior with or without slot aggregation. With slot aggregation, the number of repetitions can be dynamically indicated in Rel-16.

Enhanced inter UE Tx prioritization/multiplexing

This work item specifies UL cancellation scheme and enhanced UL power control scheme for enhanced inter UE Tx prioritization/multiplexing, which are mainly beneficial for achieving low latency.

For UL cancellation scheme, DCI format 2\_4 is introduced for notifying the PRB(s) and OFDM symbol(s) where UE cancels the corresponding UL transmission from the UE. An indication by DCI format 2\_4 for a serving cell is applicable to a PUSCH transmission or an SRS transmission on the serving cell.

For UL power control scheme, open-loop power control parameter set indication is included in DCI format 0\_1/0\_2 to indicate the P0 value for PUSCH scheduled dynamically as defined in [5].

### Multiple active configured grant configurations for a BWP

Up to 12 configured grant configurations can be configured in a BWP of a serving cell, which is mainly beneficial for achieving high reliability. Separate RRC parameters can be configured for different configured grant configurations. Separate activation/release can be used for different configured grant Type 2 configurations. In addition, joint release for two or more configured grant Type 2 configurations for a given BWP of a serving cell is also supported.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830074,800095,830174,830274>

- [1] RP-191584, "Revised WID: Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)", Newport Beach, CA, June 3-6, 2019.
- [2] TR 38.824 "Study on physical layer enhancements for NR ultra-reliable and low latency case (URLLC)"
- [3] TR 38.825 "Study on NR industrial Internet of Things (IoT)"
- [4] TS 38.212 "NR; Multiplexing and channel coding"
- [5] TS 38.213 "NR; Physical layer procedures for control"
- [6] TS 38.214 "NR; Physical layer procedures for data"

## 5.3 Support of NR Industrial Internet of Things

830080	<a href="#">Support of NR Industrial Internet of Things (IoT)</a>	NR_IIoT	R2	RP-191561	Nokia
810060	<a href="#">Study on channel modeling for indoor industrial scenarios</a>	FS_IIoT_CM	R1	RP-182138	Ericsson
800098	<a href="#">Study on NR Industrial Internet of Things (IoT)</a>	FS_NR_IIoT	R2	RP-181479	Nokia
830180	<a href="#">Core part: Support of NR Industrial Internet of Things (IoT)</a>	NR_IIoT-Core	R2	RP-190728	Nokia

Summary based on the input provided by Nokia, Nokia Shanghai Bell in RP-200798.

This Work Item evolves the NR system as to better support the use cases of various vertical markets such as factory automation or electrical power distribution. It introduces transmission reliability enhancements, NR support for Time Sensitive Communications (as defined in TS 23.501 [4]), and addressed efficiency of the system where UEs handle a mixture of URLLC and eMBB traffic. This WI focused mainly on Layer 2/3 protocols aspects while PHY layer enhancements for URLLC were introduced as part of Work Item on Physical layer enhancements for NR ultra-reliable and low latency communication (URLLC) [3].

This Work Item has introduced the following enhancements:

1. PDCP packet duplication enhancements – a possibility of multiplication of the packets related to signalling or data radio bearer over three or four logical channels has been specified for the increased reliability of the transmission over the air interface. This is possible for both Carrier Aggregation based packet duplication where the packet is sent over up to four different serving cells of a single gNB and for Dual Connectivity based packet duplication where the packet is sent over serving cells belonging to two different gNBs (e.g. two serving cells in Master Node and two serving cells in Secondary Node or three serving cells in Master Node and one serving cell in Secondary Node etc.). The network dynamically controls which of the configured logical channels are active for duplication at a certain time by utilizing a dedicated MAC CE command.
2. RAN support for higher layer multi-connectivity - The feature introduces also higher reliability for the end to end transmission by using duplication of a PDU session. This functionality allows NG-RAN to ensure the data of the PDU session and its redundant one to utilize two independent transmission paths. The NG-RAN may, for example, use dual connectivity principles with one PDU session delivered through the master node and the redundant one via the secondary node, or the NG-RAN may use independent paths within the same NG-RAN node. Besides, the feature offers the possibility to provide redundancy over N3 tunnel between the UPF and the NG-RAN node on a per QoS flow basis.
3. Support for accurate reference timing delivery – to support strict synchronization accuracy requirements of TSC applications, the delivery of time reference information from the gNB to the UE using unicast or broadcast RRC signalling with a granularity of 10 ns was introduced. UE Assistance Information procedure was extended to allow the UE to indicate its preference to receive such information.
4. Scheduling enhancements – support for up to eight simultaneously active semi-persistent scheduling (SPS) configurations for a given BWP of a UE was specified. Work Item introduced also new logical channel restriction based on physical layer priority level of the grant and a list of Configured Grant (CG) configurations allowed to be utilized by a certain logical channel (support of up to twelve simultaneously active CG configurations in a BWP of a UE was introduced as part of WI on Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication

(URLLC) [3]). UE can now be configured with CG and SPS periodicities of any integer multiple of a slot with maximum periodicity of 640 ms. These enhancements allow, e.g., to more efficiently support, deterministic traffic with a wide range of different periodicities.

5. Time Sensitive Communication Assistance Information (TSCAI): Core Network may provide a gNB with an information about TSC traffic characteristics such as Burst Arrival Time, traffic flow direction and periodicity, to allow for a more efficient scheduling at the gNB.

6. Ethernet Header Compression (EHC): since TSC traffic is often carried over Ethernet frames with a short size (e.g. 20-50 bytes), EHC protocol was specified within PDCP sublayer to increase efficiency of Ethernet frames transmission over the NR air interface. EHC allows to avoid transmission of Ethernet header fields such as DESTINATION ADDRESS, SOURCE ADDRESS, 802.1Q TAG, and LENGTH/TYPE, between the gNB and the UE. EHC was specified for both NR and EUTRA PDCP.

7. Prioritization between overlapping uplink resources of one UE: when multiple UL grants provided to a single UE overlap in time on a serving cell, the UE is now able to consider the priority of the grant and/or the priority of the logical channel that can be carried over the grant when making a decision about which grant to utilize. Similarly, the UE may consider the priority of a scheduling request (SR) as well as priority of the logical channel which triggered the SR when deciding whether to transmit PUSCH or SR when they overlap in time. Furthermore, if two PUCCHs of different PHY priorities or a PUCCH and a PUSCH of different PHY priorities are overlapping in time on a serving cell, the UE is able to cancel the lower priority transmission with the specified cancellation behaviour and related timeline to allow for transmission of the PUSCH or PUCCH of higher PHY priority.

Thanks to the introduced enhancements it is possible to support Industrial IOT applications and Time Sensitive Communications in a more efficient way, allow for extra reliability for URLLC traffic as well optimize handling of a mixture of applications with various priorities and QoS requirements by a single UE.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830080,810060,800098,830180>

- [1] TR 38.825: "Study on NR industrial Internet of Things (IoT)"
- [2] RP-192590: "Revised WID: Support of NR Industrial Internet of Things (IoT)"
- [3] RP-190726: "New WID: Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)"
- [4] TS 23.501: "System architecture for the 5G System (5GS)"

## 6 Support of LAN-type services

### 6.1 NR-based access to unlicensed spectrum

See section 19.1.1

### 6.2 LAN support in 5G

800006	<a href="#">LAN support in 5G</a>	5GLAN	S1	SP-180593	Jose Almodovar, KPN
760007	Study on LAN Support in 5G	FS_5GLAN	S1	SP-170456	Nasielski, Jack, Qualcomm
800047	Stage 1 of 5GLAN	5GLAN	S1	SP-180593	Jose Almodovar, KPN

Summary based on the input provided by KPN in SP-200XYZ.

5G expands the scope and reach of 3GPP-defined technologies. There are multiple market segments in the realm of residential, office, enterprise and factory, where 5G will need to provide services with similar functionalities to Local Area Networks (LANs) but improved with 5G capabilities (e.g., high performance, long distance access, mobility and security).

The main goal of this work is to enable the 5G system to offer 5G LAN-type services and virtual networks:

5G LAN-type service: a service over the 5G system offering private communication using IP and/or non-, i.e. UEs that are members of the same 5G LAN-VN IP type communications.

5G LAN-virtual network: a virtual network capable of supporting 5G LAN-type service.

The requirements needed for the 5G system to support 5G LAN-type services are document in chapter 6.26 in TS 22.261[1], where the following aspects are addressed:

- General service requirements to enable 5G LAN-type services (connections, support for IP and Ethernet, service continuity, discovery, ...)
- 5G LAN-virtual network
- Creation and management
- Security, isolation and privacy
- Traffic types
- Indirect communication for 5G LAN-type service
- Service exposure for 5G LAN-type service

The corresponding Stage 2 is covered by the Vertical\_LAN, described in the next section (Vertical\_LAN includes requirements specified in 5GLAN and other requirements from cyberCAV, such as IEEE TSN).

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800006,760007,800047>

[1] TS 22.261, Service requirements for the 5G system; Stage 1

## 6.3 5GS Enhanced support of Vertical and LAN Services

750004	<a href="#">Study on Communication for Automation in Vertical Domains</a>	FS_CAV	S1	SP-170169	Walewski, Joachim, Siemens AG
800007	<a href="#">Service requirements for cyber-physical control applications in vertical domains</a>	cyberCAV	S1	SP-180321	Joachim W. Walewski (Siemens)
<b>830042</b>	<b><a href="#">5GS Enhanced support of Vertical and LAN Services</a></b>	<b>Vertical_LAN</b>	<b>S2</b>	<b>SP-181120</b>	<b>Devaki Chandramouli, Nokia</b>
800028	<a href="#">Study on 5GS Enhanced support of Vertical and LAN Services</a>	FS_Vertical_LAN	S2	SP-180507	Devaki Chandramouli, Nokia
820017	<a href="#">Stage 2 of Vertical_LAN</a>	Vertical_LAN	S2	SP-181120	Devaki Chandramouli, Nokia
810038	<a href="#">Study on Security for 5GS Enhanced support of Vertical and LAN Services</a>	FS_Vertical_LAN_SEC	S3	SP-180697	Jerichow, Anja (Nokia)
840027	<a href="#">Security for Vertical_LAN</a>	Vertical_LAN_SEC	S3	SP-190352	Jerichow, Anja, Nokia
<b>830010</b>	<b><a href="#">CT aspects of Vertical_LAN</a></b>	<b>Vertical_LAN</b>	<b>ct</b>	<b>CP-191157</b>	<b>WON, Sung Hwan, Nokia</b>
830035	<a href="#">CT1 aspects of Vertical_LAN</a>	Vertical_LAN	C1	CP-191157	WON, Sung Hwan, Nokia
830036	<a href="#">CT3 aspects of Vertical_LAN</a>	Vertical_LAN	C3	CP-191157	WON, Sung Hwan, Nokia
830037	<a href="#">CT4 aspects of Vertical_LAN</a>	Vertical_LAN	C4	CP-191157	WON, Sung Hwan, Nokia
820027	<a href="#">Service Enabler Architecture Layer for Verticals</a>	SEAL	S6	SP-181141	Basavaraj (Basu) Pattan, Samsung

Summary based on the input provided by Nokia, Nokia Shanghai Bell in SP-200296.

The Vertical\_LAN work item introduces support for three new and distinct features:

- 1) Enablers for 5G System deployment in 5G LAN type environment.
- 2) Time-sensitive communication with enablers for 5GS to seamlessly integrate with IEEE TSN, and for 5GS to enable support of time synchronization.
- 3) Enablers for Standalone Non-Public Network and Public-Network-integrated Non-Public Network.

### 5G LAN

The 5G System supports management of 5G VN Group identification and membership as well as 5G VN Group data. The 5G VN Group management can be configured by a network administrator or it can be managed dynamically by an AF. In order to support dynamic management of 5G VN Group identification and membership, the NEF exposes a set of services to manage (e.g. add/delete/modify) 5G VN group and 5G VN members. The NEF also exposes services to dynamically manage 5G VN group data. Furthermore, 5GS supports optimized routing by enabling support for local switching at the UPF without having to traverse the DN for UE-UE communication when the two UE(s) are served by the same UPF.

### Integration with IEEE TSN

TSN is a communication service that supports deterministic and/or isochronous communication with high reliability and availability. It provides packet transport with Quality of Service (QoS) characteristics such as bounded latency and reliability, where end systems and relay/transmit nodes can be strictly synchronized. In Release 16, main focus was on integration with IEEE Time-Sensitive Networking (TSN).

The 5G System also enables support for TSN time synchronization. In order to support time synchronization, the entire E2E 5G system can be considered as an IEEE 802.1AS [104] "time-aware system". UE, gNB, UPF, NW-TT and DS-

TTs are synchronized with the 5G GM (i.e. the 5G internal system clock), which keeps these network elements synchronized. The TTs located at the edge of 5G system provides all functions related to IEEE 802.1AS.

Furthermore, this feature has also introduced TSC assistance parameters were introduced to facilitate optimized QoS scheduling for time sensitive and deterministic traffic.

### Non-Public Network

This work item also addressed the deployment of Non-Public Networks (NPNs). A Non-Public Network (NPN) is a 5GS deployed for non-public use, as defined in TS 22.261 [2]. An NPN may be deployed as:

- a Stand-alone Non-Public Network (SNPN), i.e. operated by an NPN operator and not relying on network functions provided by a PLMN, or
- a Public network integrated NPN, i.e. a non-public network deployed with the support of a PLMN.

SNPN 5GS deployments are based on the architecture depicted in clause 4.2.3, the architecture for 5GC with untrusted non-3GPP access (Figure 4.2.8.2.1-1) for access to SNPN services via a PLMN (and vice versa) and the additional functionality covered in clause 5.30.2.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=750004,800007,830042,800028,820017,810038,840027,830010,830035,830036,830037,820027>

[1] TS 23.501, System Architecture for 5G System; Stage 2

[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 Service Enabler Architecture Layer for Verticals

## 7 Cellular Internet of Things (IoT)

### 7.1 Cellular IoT support and evolution for the 5G System

830043	<a href="#">Cellular IoT support and evolution for the 5G System</a>	5G_CIoT	S2	SP-181118	Sebastian Speicher
770038	<a href="#">Study on 5G_CIoT</a>	FS_CIoT_5G	S2	SP-180614	Sebastian Speicher
820015	<a href="#">Stage 2 of 5G_CIoT</a>	5G_CIoT	S2	SP-181118	Sebastian Speicher
830013	<a href="#">CT aspects of 5G_CIoT</a>	5G_CIoT	ct	CP-111237	Mahmoud Watfa; Qualcomm
830038	CT1 aspects of 5G_CIoT	5G_CIoT	C1	CP-111237	Mahmoud Watfa; Qualcomm
830039	CT3 aspects of 5G_CIoT	5G_CIoT	C3	CP-111237	Mahmoud Watfa; Qualcomm
830040	CT4 aspects of 5G_CIoT	5G_CIoT	C4	CP-111237	Mahmoud Watfa; Qualcomm
830041	CT6 aspects of 5G_CIoT	5G_CIoT	C6	CP-111237	Mahmoud Watfa; Qualcomm
800033	<a href="#">Study on evolution of Cellular IoT security for the 5G System</a>	FS_CIoT_sec_5G	S3	SP-180440	Noamen Ben Henda
760040	<a href="#">Study on MBMS User Services for IoT</a>	FS_MBMS_IoT	S4	SP-170592	Cedric thienot, Expway

Summary based on the input provided by Qualcomm Incorporated in SP-200274.

Substantial E-UTRAN/EPC evolution has been achieved in 3GPP to enable the "Cellular Internet of Things" (CIoT). In particular, eMTC (WB-E-UTRAN) and NB-IoT have been designed in RAN WGs in Rel-13 and enhanced in Rel-14. The corresponding system architecture aspects have been designed for EPC in Rel-13 and Rel-14. These system architecture aspects apply to both NB-IoT and eMTC (WB-E-UTRAN).

The "Cellular IoT support and evolution for the 5G System" work item focused on enabling equivalent functionality for NB-IoT and eMTC connected to 5GC as what has been defined for NB-IoT and eMTC connected to EPC in earlier releases

This section summarizes the key system impacts resulting from the "Cellular IoT support and evolution for the 5G System" work item.

As documented in TS 23.501 [1] clause 5.31, the following CIoT features have been introduced in Rel-16:

- **Control Plane CIoT 5GS Optimisation** (CP CIoT 5GS Optimisation) is used to exchange user data between the UE and the SMF as payload of a NAS message in both uplink and downlink directions, avoiding the establishment of a user plane connection for the PDU Session (i.e. avoiding the need for Data Radio Bearer and

N3 tunnel). Early Data Transmission (EDT), i.e. sending user data in RRC Message 3 is supported for mobile originated Control Plane CIoT 5GS Optimisation.

- **User Plane CIoT 5GS Optimisation** (UP CIoT 5GS Optimisation) supports transfer of user plane data from CM-IDLE without the need for using the Service Request procedure to establish an Access Stratum (AS) context in NG-RAN and UE. UP CIoT 5GS Optimisation is enabled by the Connection Suspend and Connection Resume in CM-IDLE with Suspend procedures. EDT is also supported for UP CIoT 5GS Optimisation.
- UE and network negotiate whether to use CP CIoT 5GS Optimisation and/or UP CIoT 5GS Optimisation as well as N3 data transport and header compression for CP CIoT 5GS Optimisation during the Registration procedure. The UE indicates its **Preferred and Supported Network Behaviour**, i.e. the UE indicates which of the aforementioned features the UE supports and whether it prefers to use CP CIoT 5GS Optimisation or UP CIoT 5GS Optimisation. In response, the network indicates which of those features it supports for this UE.
- **Non-IP Data Delivery** (NIDD) refers to mobile originated (MO) and mobile terminated (MT) communication between UE and an Application Function (AF) where the user data is considered unstructured (also referred to as "non-IP"). NIDD is enabled using an unstructured PDU session between UE and NEF and the NEF's NIDD API on the N33/Nnef reference point for data delivery from/to AF. Alternatively, non-IP data is delivered using an unstructured PDU session between UE and UPF and a Point-to-Point N6 tunnel between UPF and AF. The NEF also supports distribution of mobile terminated messages to a group of UEs based on the NIDD API.
- **Reliable Data Service** (RDS) may be used between UE and NEF or UPF, respectively, for unstructured PDU Sessions. RDS provides a mechanism for the NEF or UPF to determine if the user data was successfully delivered to the UE and for the UE to determine if the data was successfully delivered to the NEF or UPF. When a requested acknowledgement is not received, RDS retransmits the packet.
- **Extended Discontinuous Reception (DRX) for CM-IDLE and CM-CONNECTED with RRC-INACTIVE** enables the UE to reduce its power consumption while still being available for MT data and/or network originated procedures within a certain delay dependent on the negotiated DRX cycle value. In CM-IDLE state the following DRX cycles are supported: up to almost 44 minutes (for eMTC) and up to almost 3 hours (for NB-IoT). In CM-CONNECTED with RRC-INACTIVE, DRX cycles of up to 10.24 seconds are supported.
- Enhancements for the Mobile Initiated Connection Only (**MICO**) mode of rel.15:
  - MICO mode with Extended Connected Time enables an AMF that is aware of pending or expected MT traffic to keep the UE in CM-CONNECTED state and to request the RAN to keep the UE in RRC-CONNECTED state for an Extended Connected Time period to ensure that the downlink data and/or signalling is delivered to the UE before the UE is released.
  - MICO mode with Active Time is similar to the UE Power Saving Mode (PSM) defined for EPS [2], i.e. UE and AMF negotiate an Active Time value, which dictates for how long the UE is reachable for paging upon entering CM-IDLE. Once the Active Time has elapsed, the UE can enter MICO mode, i.e. become unreachable for paging.
  - MICO mode and Periodic Registration Timer Control enables the network to align a UE's Periodic Registration Updates with an expected DL communication schedule for the UE. This is achieved by the Strictly Periodic Registration Timer Indication which the network can provide to the UE to avoid that the Periodic Registration Timer is restarted by the UE when the UE enters CM-CONNECTED.
- **High latency communication** refers to mechanisms that may be used to handle mobile terminated (MT) communication with UEs being unreachable while using power saving functions (e.g. extended DRX or MICO mode with Active or Extended Connected Time). High latency communication is supported by extended buffering of downlink data in the UPF, SMF or NEF when a UE is using power saving functions in CM-IDLE and is not reachable. Alternatively, high latency communication is supported through different AF notifications. An AF may for example subscribe to receive UE reachability notifications so that the AF then waits with sending the data until it gets a notification that the UE has become reachable.
- **Support for Monitoring Events** enables AFs to acquire information such as whether a UE is roaming or to determine when a USIM is changed to a different ME. The complete list of monitoring events is documented in TS 23.502 [3] clause 4.15.3.1.
- **External parameter provisioning** refers to functionality originally defined in Rel-15 already, which enables an AF to provision information such as Expected UE Behaviour parameters or other service parameters to the network (see TS 23.502 [3] clause 4.15.6.1). In Rel-16, additional Expected UE Behaviour parameters were

introduced (e.g. an indication whether the UE is stationary or mobile), which can be used by the AMF and/or SMF for various purposes, e.g. by AMF for paging optimisations. In addition, an AF can provide Network Configuration parameters (e.g. Maximum Response Time) to the network, which in turn can be used to derive parameters for system procedures (e.g. to derive the Active Time or Extended Connected time for MICO mode). The complete list of Expected UE Behaviour parameters and Network Configuration parameters are documented in TS 23.502 [3] clause 4.15.6.3 and 4.15.6.3a, respectively.

- **PDU session handling during inter-RAT idle mode mobility to and from NB-IoT** allows the SMF to maintain a PDU session, disconnect a PDU session with a reactivation request or to disconnect a PDU session without reactivation request when the UE moves between a "broadband" RAT (e.g. NR or WB-E-UTRAN) and a "narrowband" RAT (NB-IoT).
- **System aspects of the Enhanced Coverage RAN feature** as specified in TS 36.300 [4], in particular storage of Paging Assistance Data for UEs supporting Enhanced Coverage and providing of Paging Assistance Data to RAN during paging has been introduced. Specific subscribers can also be restricted to use the Enhanced Coverage feature through Enhanced Coverage Restricted information that is stored in the UDM. Based on the latter, AMF informs UE, RAN and SMF about the use (or not) of the Enhanced Coverage feature.
- The **rate of user data** sent to and from a UE can be controlled in two ways:
  - Serving PLMN rate control allows the serving network to protect its AMF and the Signalling Radio Bearers in the NG-RAN from the load generated by NAS Data PDUs by indicating a limit for the number of NAS Data PDUs per time unit to the UE and UPF/NEF.
  - Small Data Rate Control allows HPLMN operators to offer customer services such as "maximum of Y messages per day" and is also based on indicating a number of packets per time unit limitation to UE and UPF/NEF for enforcement.
- **Congestion control for control plane data transfer** enables the AMF to restrict, e.g. during high-load situations, the use of the control plane for data transmission (i.e. for Control Plane CIoT 5GS Optimisation). In particular, AMF may provide a Control Plane data back-off timer to the UE. While the Control Plane data back-off timer is running, the UE is not allowed to initiate any data transfer via Control Plane CIoT 5GS Optimisation.
- **Service Gap Control** can be used to control the frequency at which UEs can access the network, e.g. to alleviate peak load situations. Service Gap control is realized by AMF indicating a Service Gap Time to a UE; the UE then stays in CM-IDLE mode for at least the whole duration of the Service Gap timer before triggering Mobile Originated user data transmission.
- **Inter-UE QoS for NB-IoT** targets UEs that are using Control Plane CIoT 5GS Optimisation and are accessing the network via NB-IoT. The feature allows NG-RAN to prioritise resource allocation between those UEs based on the subscribed NB-IoT UE Priority that NG-RAN may retrieve from the AMF.
- **Differentiation of Category M UEs** enables the network to identify traffic to/from Category M UEs, e.g. for charging differentiation and subscription based access control. This functionality is based on a Category M indication from UE to NG-RAN during RRC Connection Establishment and subsequently, an LTE-M Indication to the AMF in the Initial UE Message. Based on this, AMF considers the RAT type to be LTE-M and informs SMF, SMSF and PCF accordingly for subsequent use of the LTE-M RAT type, e.g. in CDRs. A subscription parameter for subscription based access restriction for LTE-M is also introduced.
- **Selection, steering and redirection between EPS and 5GS** allows a network that supports CIoT features in both EPC and 5GC to steer UEs from the CN type that the UE is attempting to register with to the other CN type (e.g. from 5GC to EPC) due to operator policy, e.g., due to roaming agreements, Preferred and Supported Network Behaviour, load redistribution, etc. It is assumed that operators configure the steering policies in EPC and 5GC such that steering UEs back and forth between EPC and 5GC is avoided.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830043,770038,820015,830013,830038,830039,830040,830041,800033,760040>

- [1] TS 23.501, "System architecture for the 5G System (5GS)"
- [2] TS 23.401, "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access"

- [3] TS 23.502, "Procedures for the 5G System (5GS)"  
 [4] TS 36.300, " Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2"

## 7.2 Additional enhancements for NB-IoT

800084	<a href="#">Additional enhancements for NB-IoT</a>	NB_IOTenh3	R1	RP-200293	Huawei
800184	<a href="#">Core part: Additional enhancements for NB-IoT</a>	NB_IOTenh3-Core	R1	RP-200293	Huawei
800284	<a href="#">Perf. part: Additional enhancements for NB-IoT</a>	NB_IOTenh3-Perf	R4	RP-200293	Huawei

Summary based on the input provided by FUTUREWEI in RP-201229.

This Feature builds on the successful base NB-IoT feature in Rel-13, and enhancements in Rel-14 and Rel-15, and adds features such as DL/UL transmission efficiency improvement, UE power consumption improvement, scheduling enhancement, network management tool enhancement, latency improvement, enhancement on coexistence with NR and connection to 5GC.

### Improved DL transmission efficiency and UE power consumption

Reduced UE power consumption and improved transmission efficiency are achieved through reduced downlink monitoring and reduced signalling, building on features introduced in earlier releases.

UE-group wake-up signals (GWUS) (FDD):

With the introduction of Rel-15 wake-up signalling (WUS), UE can skip the paging procedures if the wake-up signal is not detected to save power. This feature (UE-group WUS) allows eNB to transmit a UE-group WUS to instruct the UEs in the group that they must monitor NPDCCH for paging. This allows the UE to skip the paging procedures to save more power if eNB sends UE-group WUS to UEs in other groups. The UEs are grouped according to their paging probability and/or their UE ID based on system information configuration.

Mobile-terminated early data transmission (MT-EDT) (FDD):

Rel-15 Mobile Originating Early Data Transmission (MO-EDT) allows one uplink data transmission optionally followed by one downlink data transmission during the random access procedure, avoiding transition to RRC\_CONNECTED mode. Rel-16 Mobile Terminating Early Data Transmission (MT-EDT) allows one downlink data transmission during the random access procedure triggered in response to a paging message. This feature allows the eNB to decide whether to initiate Mobile Terminated EDT procedures towards the UE based on the data size received from the core network. Mobile Terminating Early Data Transmission (MT-EDT) is only supported in EPC.

### Support for Preconfigured uplink resources (PUR) in idle mode (FDD)

In Rel-15, signalling overhead and power consumption reductions were introduced by the (mobile-originated) early data transmission (EDT) feature, where data can be transmitted already in Msg3 during the random-access procedure.

In Rel-16, the earlier transmission of UL data payload has been further enhanced by introducing UL transmission using preconfigured uplink resources (PUR). This feature allows eNB to configure uplink resources, in which a UE in IDLE mode can send UL transmission without performing random access procedures. The UE can be potentially configured with a cyclic shift of DMRS, which allows sharing of the preconfigured resources under which up to two users can transmit NPUSCH simultaneously when the NPUSCH transmission is larger than or equal to 64ms for 12-tone allocation. By skipping the random access procedures, the uplink transmission efficiency can be improved and UE power consumption is reduced. Before performing a PUR transmission, the UE must evaluate the validity of the timing advance (TA) based on either individual or combined usage of any of the following attributes: a) serving cell change, b) TA timer, c) RSRP change. Additionally, it is possible to configure the TA as always valid within a given cell.

### Scheduling of multiple DL/UL transport blocks with single DCI (FDD)

This feature allows the scheduling of up to two transport blocks (TB) with a single DCI for uplink or downlink unicast transmission, where the number of TBs is indicated by DCI. The transmission of multiple TBs can be configured to be contiguous or interleaved. And HARQ bundling can be potentially configured when transmission is configured as interleaved. It also allows the scheduling of up to eight transport blocks with a single DCI for SC-MTCH, where the number of TBs is indicated by DCI. The DCI overhead can be reduced for contiguous UL/DL transmissions.

### Network management tool enhancements - SON (FDD and TDD)

Rel-16 introduces SON features: RACH report, RLF report and ANR for network resource optimisation. The ANR measurements are performed when the UE is in RRC\_IDLE and reported next time the UE enters RRC\_CONNECTED.

The NPRACH configuration of the NB-IoT Cells are exchanged between neighbour eNBs for RACH optimization. And the RLF report from UE is forwarded to the old eNB to determine the nature of the failure.

SON features are only supported in EPC.

#### Improved multicarrier operations - Quality report in Msg3 and connected mode (FDD)

In cells with interference, the coverage level corresponding to the estimate RSRP may be mismatched with the channel quality. This feature allows the eNB to configure a UE in IDLE mode to report the downlink channel quality in Msg3 for non-anchor access. It also allows the UE to report the downlink channel quality in connected mode other than Msg3 for anchor and non-anchor carriers. This allows the eNB to schedule NPDCCH and NPDSCH more accurately, especially in cases with mismatch between coverage level and channel quality.

#### Presence of NRS on a non-anchor carrier for paging (FDD)

This feature allows eNB to transmit NRS in subframes on a non-anchor carrier for paging even when no paging NPDCCH is transmitted. The NRS are present in the first M subframes out of the 10 NB-IoT DL subframes before the Paging Occasion (PO), where the PO can be a subset of POs or a whole set of POs, and the values of M depend on the value of nB as defined in TS 36.304.

When NRS is present on a non-anchor paging carrier and the conditions for NRSRP measurement on non-anchor carrier are met as defined in TS 36.133, the UE may perform serving cell measurements on the non-anchor paging carrier.

#### Mobility enhancements - Idle mode inter-RAT cell selection to/from NB-IoT (FDD and TDD)

With this feature, NB-IoT can provide assistance information for inter-RAT cell selection to E-UTRAN/GERAN and E-UTRAN can provide assistance information for inter-RAT cell selection to NB-IoT. A UE may use the assistance information provided by the network for cell selection to/from NB-IoT.

#### Improved latency - UE Specific DRX (FDD and TDD)

Rel-16 introduces support for UE specific DRX to reduce paging latency. The eNB may broadcast a minimum UE specific DRX value shorter than the cell default DRX value. When UE specific DRX is configured by the upper layers and the minimum UE specific DRX value is broadcast, the UE monitors paging according to the longer of the two values.

#### Coexistence of NB-IoT with NR (FDD and TDD)

This feature allows the configuration of the DL/UL resource reservation in subframe/slot/symbol-levels on non-anchor carriers for unicast transmission to avoid resource overlapping with NR channels/signals. The configuration can be for 10ms or 40ms duration, with a periodicity from {10ms, 20ms, 40ms, 80ms, 160ms} and a start position in a granularity of 10ms, which is independent from legacy configurations. It also allows dynamic indication whether the resource reservation is applied or not.

Three system scenarios have been studied and captured in TR 37.824:

- For NB-IoT operation in NR in-band, RB alignment, power boosting and numerologies have been addressed.
- For NB-IoT operation in NR guard band, RF requirements will not be specified.
- For NB-IoT standalone operation, based on coexistence study, it is concluded that there is no issue for NB-IoT standalone coexistence with NR.

#### Connection to 5GC (FDD and TDD)

Rel-16 introduces support for connection to 5GC reusing eLTE as a baseline, including Unified Access Control (UAC). RRC\_INACTIVE, NR SDAP and NR PDCP are not supported and a maximum of two PDU sessions mapped to two default DRBs is supported.

Rel-16 also introduces support for the CIoT 5GS optimisation, in particular extended DRX (eDRX) in RRC\_IDLE, control plane and user plane CIoT optimisation, MO-EDT for the control plane and user plane CIoT optimisation, RRC Connection Reestablishment for the control plane and restriction of use of Enhanced Coverage.

Similar backhaul signalling to support control plane and user plane CIoT optimisation are introduced over NG interface (between ng-eNB and AMF) and over Xn interface (between ng-eNBs), including e.g. early UE radio capability retrieval from core network after msg3, NB-IoT CP relocation procedures to support connection reestablishment, Paging assistance information exchanging, UE differentiation information exchanging, etc.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800084,800184,800284>

## 7.3 Additional MTC enhancements for LTE

800083	<a href="#">Additional MTC enhancements for LTE</a>	LTE_eMTC5	R1	RP-191356	Ericsson
800183	Core part: <a href="#">Additional MTC enhancements for LTE</a>	LTE_eMTC5-Core	R1	RP-190770	Ericsson
800283	Perf. part: <a href="#">Additional MTC enhancements for LTE</a>	LTE_eMTC5-Perf	R4	RP-190770	Ericsson

Summary based on the input provided by Ericsson in RP-201276.

This work item builds on the LTE features for Machine-Type Communications (MTC) introduced in earlier releases (e.g. low-complexity UE categories M1 and M2, and Coverage Enhancement Modes A and B) by further improving network operation and efficiency in a range of areas.

The following sections describe the new MTC features for LTE in Rel-16. All features are optional for the UE and can be supported by Cat-M1 and Cat-M2 and by normal LTE UEs supporting CE mode unless otherwise stated. All features are applicable to both CE modes (A and B) in all duplex modes (HD-FDD, FD-FDD, and TDD) unless otherwise stated.

### Improved DL transmission efficiency and UE power consumption

Reduced UE power consumption is achieved through reduced downlink monitoring and reduced signalling, building on features introduced in earlier releases.

- **UE-group wake-up signals (GWUS):** Reduced UE power consumption in idle mode was enabled in Rel-15 by the introduction of the wake-up signal (WUS), a compact signal transmitted a configurable time before the paging occasion (PO) when a UE is being paged, allowing the UE to maximize its sleep time during periods when there is no paging. In Rel-16, an enhancement is introduced that allows a WUS to wake up a configurable group of UEs rather than all UEs that happen to monitor the same PO. This helps reduce the power consumption even further. The mapping of GWUS in the time and frequency domains is highly configurable.
- **Mobile-terminated early data transmission (MT-EDT):** For scenarios where the UE only needs to transmit a small amount of data, the early data transmission (EDT) feature in Rel-15 enables the UE to transmit up to (slightly more than) 100 bytes of data already in Msg3 during the random-access procedure, and to receive data already in Msg4. If needed, eNB can order fallback to legacy random-access procedure during the EDT procedure. In Rel-16, an enhancement is introduced that allows not only mobile-originated (MO) EDT access but also mobile-terminated (MT) EDT. When the MME triggers MT-EDT, an indication is included in the paging message, after which the UE triggers random access to resume the connection (in case the UP CIoT EPS optimization is used) or initiate MO-EDT (in case the CP CIoT EPS optimization is used). MT traffic is received in Msg4. MT-EDT is only supported when UE is connected to EPC (not 5GC).
- **Improved DL quality reporting:** Legacy CE mode A supports both periodic and aperiodic CSI reporting which can be used to assist PDSCH link adaptation. In Rel-16, a new type of DL quality reporting is introduced which reflects MPDCCH quality rather than PDSCH quality. The report represents the required number of MPDCCH subframe repetitions for reliable MPDCCH reception. It can be sent in connected mode, but it can also be sent already in Msg3 during the random access procedure, which means that the report can be used for guiding the UE-specific MPDCCH configuration, which helps optimize power consumption, latency, and spectral efficiency.
- **MPDCCH performance improvement:** In legacy LTE-MTC, MPDCCH demodulation is DMRS-based. With this feature, the UE can use a combination of DMRS and CRS for MPDCCH demodulation to improve the MPDCCH performance. The feature takes the configured DMRS-to-CRS power ratio into account. The feature can be used for transmissions in idle mode and/or connected mode. In idle mode, the DMRS-to-CRS mapping is based on precoder cycling, whereas in connected mode, it can be configured to be precoder cycling based, CSI-based, or (in case of TDD) reciprocity-based.

Beside the features listed above, the features described in sections 2.2, 2.3 and 2.6 can also improve UE power consumption and/or transmission efficiency in DL and/or UL.

### Preconfigured uplink resources (PUR)

In Rel-15, signalling overhead and power consumption reductions were introduced by the (mobile-originated) early data transmission (EDT) feature, where data can be transmitted already in Msg3 during the random-access procedure.

In Rel-16, the earlier transmission of UL data payload has been further enhanced by introducing UL transmission using preconfigured uplink resources (PUR). When the feature is configured, both the random-access preamble transmission (Msg1) and the random-access response (Msg2) can be omitted, and the data transmission can be completed in only two messages (i.e., Msg3 and Msg4).

The UE is configured with PUR via dedicated RRC signaling while in connected mode. Configuring a UE with PUR can be triggered by the network or requested by the UE. Before performing a PUR transmission, the UE must evaluate the validity of the timing advance (TA) based on either individual or combined usage of any of the following attributes: a) serving cell change, b) TA timer, c) RSRP change. Additionally, it is possible to configure the TA as always valid within a given cell.

There are two schemes for transmitting using PUR, dedicated PUR and shared PUR, the latter allows up to two users to transmit simultaneously when the number of PUSCH repetitions is greater than or equal to 64 for full-PRB allocation.

#### Scheduling of multiple transport blocks

In legacy LTE-MTC operation, each DCI carried by MPDCCH schedules a single PDSCH or PUSCH transport block (TB). In Rel-16, a possibility to schedule multiple TBs using a single is introduced. This can help improve the resource utilization by reducing the number of physical resource blocks (PRBs) spent on MPDCCH transmission and the number of subframes spent on guard time for DL-to-UL and UL-to-DL transition (in half-duplex FDD operation).

- **Unicast multi-TB scheduling:** When the feature is configured, a single DCI can schedule multi TBs for PDSCH or PUSCH (up to 8 TBs in CE mode A, or up to 4 TBs in CE mode B). The number of TBs is dynamically controlled by the DCI. The TBs can be configured to be transmitted consecutively or subframe interleaved (in case of subframe repetition). For PDSCH multi-TB scheduling, HARQ-ACK bundling can optionally be used to improve the resource utilization further for UEs in good coverage. For PUSCH multi-TB scheduling, early termination of the PUSCH transmission is supported through indication of positive HARQ-ACK in the DCI.
- **Multicast multi-TB scheduling:** When the feature is configured a single DCI can schedule up to 8 TBs for PDSCH for a SC-MTCH, with configurable time gaps between the TBs if desired. The number of TBs is dynamically controlled by the DCI.

#### CE mode improvements for non-Cat-M UEs

The features in this work item can be supported both by Cat-M UEs and non-Cat-M UEs that support CE mode A or B. In addition, the following features have been specified specifically for non-Cat-M UEs that support CE mode A or B.

- **Enhancements to idle mode mobility:** A possibility is introduced for a non-Cat-M UE in a non-standalone LTE-MTC cell to use enhanced coverage functionality to camp in the cell even if the S-criterion indicates that the UE is in normal coverage. This functionality is enabled/disabled by a configuration provided in SIB1. (This is the default behavior for the standalone LTE-MTC case described in the next section in this document.)
- **CSI feedback based on CSI-RS:** In legacy CE mode A, periodic and aperiodic CSI feedback is based on up to 4 CRS antenna ports. This feature introduces support for periodic CSI feedback based on 8 CSI-RS antenna ports in TM9 for non-Cat-M UEs in CE mode A. The feature can help improve the DL link adaptation and hence the DL performance. As a separate UE capability, the feature can also optionally be supported in combination with codebook subset restriction.
- **ETWS/CMAS in connected mode:** In legacy LTE-MTC, ETWS/CMAS notification indication is supported using DCI format 6-2 in MPDCCH common search space Type-1 in idle mode. This feature introduces ETWS/CMAS notification indication using DCI format 6-1A/B in MPDCCH common search space Type-0 in connected mode for non-Cat-M UEs in CE mode A/B. This means that a UE can be notified without releasing the UE to idle mode.

#### Stand-alone deployment

In legacy LTE-MTC operation, the first few OFDM symbols in each DL subframe are unused by LTE-MTC since they are assumed to be occupied by LTE control channels for normal LTE UEs (PCFICH, PDCCH, PHICH). This feature enables transmission of MPDCCH and/or PDSCH to UEs in CE mode A/B in the “LTE control channel region” on carriers that are not used for normal LTE. The feature can be used for transmissions in idle mode and/or connected mode. The potential DL transmission efficiency gain is about 14% (corresponding to 2 out of 14 OFDM symbols) for 1.4 MHz carriers and about 7% (corresponding to 1 out of 14 OFDM symbols) for wider carriers.

#### Mobility enhancements

In Rel-15, two new LTE-MTC signals were introduced, the resynchronization signal (RSS) and the wake-up signal (WUS), and in Rel-16 the following mobility enhancements are introduced which make use of the Rel-15 signals.

- **RSS-based measurements:** In Rel-15, support for a resynchronization signal (RSS) was introduced and its configuration is provided by the serving cell. In Rel-16, signaling of RSS configurations for neighbor cells is introduced. Both broadcasted and dedicated signaling can be used to provide the configurations. The primary purpose of RSS is to improved synchronization performance, but with the Rel-16 signaling, the UE may also use RSS for improved measurement performance for intra-frequency RSRP measurements for neighbor cells in both idle and connected mode.
- **RRM measurement relaxation:** The legacy LTE-MTC UE behavior requires the UE to measure on the serving cell and evaluate the cell selection criterion at least every DRX cycle. The wake-up signal (WUS) introduced in Rel-15 would allow the UE to sleep for multiple paging cycles and wake up to receive paging after a configurable time duration, but the UE power saving gain from WUS cannot be fully utilized since the UE is still required to wake up for measurements. Therefore, an RRM measurement relaxation is introduced in Rel-16, which allows the UE meet the requirements using a longer measurement cycle to save power, where the cycle is configurable under certain conditions.

#### Performance improvement for NR coexistence

Spectrum sharing with legacy (Rel-13/14/15) LTE-MTC is already supported in Rel-15 NR, and the RF coexistence aspects described in TR 37.823. The following features are introduced in Rel-16 LTE-MTC in order to further improve the performance of the coexistence with NR.

- **DL/UL resource reservation:** Legacy LTE-MTC supports configuration of invalid DL/UL subframes, which can be used in order to avoid mapping LTE-MTC transmissions to subframes that are needed for NR transmissions. Rel-16 takes a step further by introducing finer-granularity LTE-MTC resource reservation in both the time domain (with subframe, slot, or symbol level granularity) and the frequency domain (with LTE RBG level granularity) for unicast MPDCCH/PDSCH/PUSCH/PUCCH transmissions in connected mode in CE mode A/B. The resource reservation patterns are configurable using parameter combinations based on bitmaps, periodicities and offsets. For PDSCH/PUSCH, the DCI can indicate that the resource reservation should be overridden, in which case the PDSCH/PUSCH transmission becomes continuous.
- **DL subcarrier puncturing:** In order to achieve PRB alignment between LTE-MTC and NR, a possibility to puncture 1 or 2 DL subcarriers at the lower or higher edge of each 6-PRB narrowband is introduced. The puncturing affects MPDCCH/PDSCH transmissions in connected mode in CE mode A/B. The performance loss from the puncturing should typically be insignificant.

#### Connection to 5GC

In Rel-16, support for connecting LTE-MTC UEs to 5GC is introduced. It resembles the Rel-15 functionality for connecting LTE UEs to 5GC. The RRC\_INACTIVE state is supported and additionally the User Plane CIoT 5GS optimisation is supported in RRC\_IDLE (similar to the corresponding EPC feature). Some features, such as EDT and PUR are supported only in RRC\_IDLE using the UP-optimisation solution and are not supported in RRC\_INACTIVE. Long extended DRX in RRC\_IDLE is supported, and RAN paging cycles of 5.12 s and 10.24 s are supported in RRC\_INACTIVE.

#### **References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800083,800183,800283>

- [1] RP-192875, Rel-16 LTE-MTC work item description
- [2] RP-201275, Rel-16 LTE-MTC work item status report
- [3] RP-192647 & RP-192648 & RP-200196 & RP-200698, RAN1 CR packs
- [4] RP-200360 & RP-201192 & RP-201193, RAN2 CR packs
- [5] RP-201086 & RP-201087, RAN3 CR packs
- [6] RP-193023 & RP-200418 & RP-200962, RAN4 CR packs

## 8 Advanced V2X support

### 8.1 Improvement of V2X service Handling

820024	<a href="#">Improvement of V2X service Handling</a>	V2XIMP	S1	SP-181013	SungDuck Chun; LG Electronics
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Summary based on the input provided by LG Electronics France in SP-200126.

This WI introduces the requirements related to vehicle quality of service support, which enables a V2X application to be timely notified of expected or estimated change of quality of service (QoS). For example, when the communication packet error is expected to increase or decrease, the V2X application such as platooning application can increase or decrease inter-vehicle distance.

This Work Item has mostly concluded that a standardized interface is needed towards external V2X application servers. Using this standardized interface, the V2X application servers can request a specific QoS requirements (and, optionally, related alternative QoS requirements). It can also be notified when the requested QoS requirements (and/or the alternative QoS requirements) can or cannot be met.

The information that is delivered over the interface can be past statistics or future prediction.

With this information, the V2X applications can adapt its behaviour according to the QoS that can be provided by the 3GPP System.

Stage-2/3 works related to this WI were progressed within eV2XARC WI (see below).

## Reference

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820024>

[1] TS 22.186: "Enhancement of 3GPP support for V2X scenarios; Stage 1".

## 8.2 Architecture enhancements for 3GPP support of advanced V2X services

840078	<a href="#">Architecture enhancements for 3GPP support of advanced V2X services</a>	eV2XARC	S2	SP-181121	LaeYoung Kim, LG Electronics
760043	Study on eV2XARC	FS_eV2XARC	S2	SP-180733	LaeYoung Kim, LG Electronics
820018	Stage 2 of eV2XARC	eV2XARC	S2	SP-181121	LaeYoung Kim, LG Electronics
840011	CT aspects of eV2XARC	eV2XARC	ct	CP-191154	Herrero Veron, Christian (Huawei)
840079	CT1 aspects of eV2XARC	eV2XARC	C1	CP-191154	Herrero Veron, Christian (Huawei)
840080	CT3 aspects of eV2XARC	eV2XARC	C3	CP-191154	Herrero Veron, Christian (Huawei)
840081	CT4 aspects of eV2XARC	eV2XARC	C4	CP-191154	Herrero Veron, Christian (Huawei)
840082	CT6 aspects of eV2XARC	eV2XARC	C6	CP-191154	Herrero Veron, Christian (Huawei)

Summary based on the input provided by LG Electronics in SP-200058.

Based on the requirements specified by V2XIMP in TS 22.185 [2] and TS 22.186 [3], the "Architecture enhancements to the 5G System" are specified in TS 23.287 [1] in order to facilitate vehicular communications for Vehicle-to-Everything (V2X) services. The following reference points are defined in the architectural reference models:

- PC5 reference point: NR PC5 RAT, LTE PC5 RAT.
- Uu reference point: NR, E-UTRA.

The Stage 2 of the interworking between EPS V2X and 5GS V2X is also specified .

The various parameters for V2X communications over PC5 and Uu reference points are specified and these parameters may be made available to the UE in following ways:

- pre-configured in the ME; or
- configured in the UICC; or
- preconfigured in the ME and configured in the UICC; or
- provided/updated by the V2X Application Server via PCF and/or V1 reference point; or
- provided/updated by the PCF to the UE.

In addition to PCF initiated Policy Provisioning procedure, the UE may perform UE triggered Policy Provisioning procedure to the PCF when the UE determines the V2X Policy/Parameter is invalid (e.g. Policy/Parameter is outdated, missing or invalid).

Regarding V2X communication over PC5 reference point, two types of PC5 reference points exist: the LTE based PC5 reference point as defined in TS 23.285 [4], and the NR based PC5 reference point as defined in TS 23.287 [1]. A UE may use either type of PC5 or both for V2X communication depending on the services the UE supports. The V2X communication over PC5 reference point supports roaming and inter-PLMN operations. V2X communication over PC5

reference point is supported when UE is "served by NR or E-UTRA" or when the UE is "not served by NR or E-UTRA".

V2X communication over NR based PC5 reference point supports broadcast mode, groupcast mode and unicast mode. For unicast mode, Layer-2 link establishment, Link identifier update, Layer-2 link release, Layer-2 link modification and Layer-2 link maintenance procedures are specified. Per-Flow PC5 QoS Model is introduced for V2X communication over NR based PC5 reference point.

Architecture enhancements for EPS to support V2X communication over NR PC5 reference point are specified in TS 23.285 [4].

For V2X communication over Uu reference point, only unicast is supported. Latency reduction for V2X message transfer via unicast may be achieved by using various mechanisms, including via e.g., edge computing defined in TS 23.501 [5].

Notification on QoS Sustainability Analytics to the V2X Application Server is specified so that the V2X Application Server may request notifications on QoS Sustainability Analytics for an indicated geographic area and time interval in order to adjust the application behaviour in advance with potential QoS change.

To support V2X applications that can operate with different configurations (e.g. different bitrates or delay requirements), the V2X Application Server, acting as the Application Function, can provide, in addition to the requested level of service requirements, Alternative Service Requirements to the 5G System. This enables the 5G System to act on the Alternative Service Requirements and apply them for the extended NG-RAN notification (i.e. Alternative QoS Profiles are provided from SMF to NG-RAN), as described in TS 23.501 [5] and TS 23.503 [6].

In order to facilitate deployment of dedicated network slice for use of, for example, automotive industry and to facilitate roaming support, a new standardized Slice/Service Type (SST) value dedicated for V2X services, i.e. 4 is defined in TS 23.501 [5].

Security aspects of 3GPP support for advanced V2X services are specified in TS 33.536 [7].

Stage 3 normative works made by CT working groups are specified in TS 24.587 [8] and TS 24.588 [9] that are new specifications for V2X as well as many specifications listed in the WID on CT aspects of architecture enhancements for 3GPP support of advanced V2X services [10].

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840078,760043,820018,840011,840079,840080,840081,840082>

- [1] TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".
- [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 23.501: "System Architecture for the 5G System; Stage 2".
- [6] TS 23.503: "Policy and Charging Control Framework for the 5G System; Stage 2".
- [7] TS 33.536: "Security aspects of 3GPP support for advanced Vehicle-to-Everything (V2X) services".
- [8] TS 24.587: "Vehicle-to-Everything (V2X) services in 5G System (5GS); Stage 3".
- [9] TS 24.588: "Vehicle-to-Everything (V2X) services in 5G System (5GS); User Equipment (UE) policies; Stage 3".
- [10] 3GPP CP-192078: "WID: CT aspects of architecture enhancements for 3GPP support of advanced V2X services".

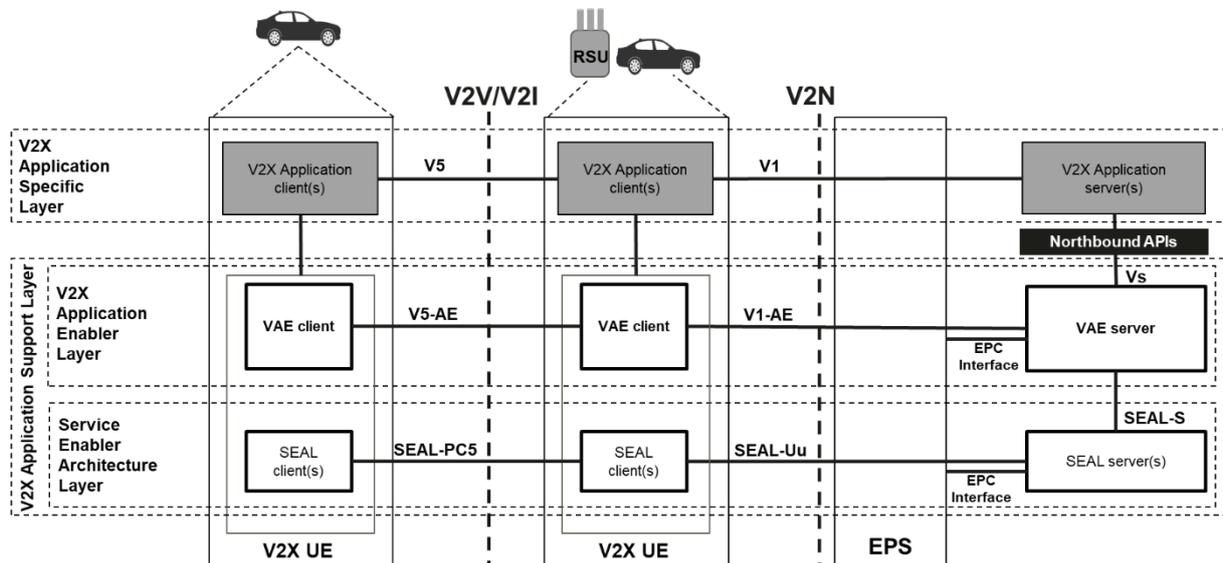
## 8.3 Application layer support for V2X services

840074	<a href="#">Application layer support for V2X services</a>	V2XAPP	S6	SP-180898	Niranth Amogh, Huawei Tel.India
780025	<a href="#">Study on V2XAPP</a>	FS_V2XAPP	S6	SP-171071	Niranth Amogh, Huawei Tel.India
810020	<a href="#">Stage 2 of V2XAPP</a>	V2XAPP	S6	SP-180898	Niranth Amogh, Huawei Tel.India
840010	<a href="#">CT aspects of V2XAPP</a>	V2XAPP	ct	CP-191153	Herrero Veron, Christian (Huawei)
840075	CT1 aspects of V2XAPP	V2XAPP	C1	CP-191153	Herrero Veron, Christian (Huawei)
840076	CT3 aspects of V2XAPP	V2XAPP	C3	CP-191153	Herrero Veron, Christian (Huawei)
840077	CT4 aspects of V2XAPP	V2XAPP	C4	CP-191153	Herrero Veron, Christian (Huawei)

Summary based on the input provided by Huawei in SP-200938.

The V2X application layer can be divided primarily into a V2X application specific layer which consists of V2X specific applications (e.g. Platooning, Vehicle safety) and a V2X application support layer which consists of V2X enabler services (e.g. V2X service discovery, message delivery, service continuity) and common enabler services (e.g. Group management, configuration management, location management).

The following figure provides the high level illustration of the V2X application layer.



**Figure 1: Application layer support for V2X services**

In Release 16, in order to ensure efficient use and deployment of V2X applications on 3GPP network (EPS), a V2X application layer architecture is specified with primary focus on the V2X application support aspects consisting of V2X application enabler (VAE) as specified in TS 23.286 [5] and Service Enabler Architecture Layer (SEAL) as specified in TS 23.434 [6].

In this clause, the enabler services utilized by V2X application specific layer are summarized. The V2X application enabler capabilities takes into consideration the study in TR 23.795 [4], the existing stage 1 and stage 2 work within 3GPP related to V2X in TS 22.185 [1], TS 22.186 [2] and TS 23.285 [3], as well as V2X application standards defined outside 3GPP (e.g. ETSI, SAE).

The V2X application specific layer utilizes the enabler services provided by VAE layer or SEAL. The architecture allows for flexible deployments considering V2X application support layer being deployed centrally or deployed in a distributed manner by either a V2X service provider or PLMN operator or both.

The following features are specified in Rel.16 for the support of V2X application specific layer:

a. The following VAE capabilities are specified in TS 23.286 [5], the related detailed procedures over HTTP protocol between VAE client (V2X UE) and VAE server are specified in TS 24.486 [7] and the RESTful APIs provided by VAE server towards the V2X application specific server is specified in TS 29.486 [8]:

- V2X service discovery to enable V2X UE to discover V2X services provided by V2X application servers via VAE server, V2X UE register at VAE server for receiving V2X services from V2X application specific servers and V2X message distribution/delivery (including group communication) for V2X messages originated from the V2X application specific layer (Uplink and/or Downlink).
- Application level location tracking of the V2X UE(s) as per the geographical information provided by the V2X application specific layer.
- V2X service continuity by dynamically receiving local service information and discovery of appropriate VAE server to serve the V2X UE as per the geographical area corresponding to V2X UE mobility.
- Dynamic group management for scenarios like Platooning where the groups are enabled by V2X application specific server and the related V2V configurations/provisioning to the V2X UE are enabled by VAE server.
- V2X UE subscription and notification of network situation information to support V2X UE level application adaptations.
- Communication of V2X application specific layer requirement to the EPC by translating the application requirements to the network requirements.

- Supporting file distribution from V2X application specific server to the V2X UEs using xMB APIs as specified in TS 26.348 [9].
- b. The following SEAL capabilities specified in TS 23.434 [6] are used by V2X application layer and more details about the following services are provided in clause 9.4:
- Group management service
  - Configuration management service
  - Location management service
  - Network resource management service

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840074,780025,810020,840010,840075,840076,840077>

- [1] TS 22.185: "Service requirements for V2X services; Stage 1".  
 [2] TS 22.186: "Enhancement of 3GPP support for V2X scenarios; Stage 1".  
 [3] TS 23.285: "Architecture enhancements for V2X services".  
 [4] TR 23.795: "Study on application layer support for V2X services".  
 [5] TS 23.286: "Application layer support for Vehicle-to-Everything (V2X) services; Functional architecture and information flows".  
 [6] TS 23.434: "Service enabler architecture layer for verticals; Functional architecture and information flows".  
 [7] TS 24.486: "Vehicle-to-Everything (V2X) Application Enabler (VAE) layer; Protocol aspects; Stage 3".  
 [8] TS 29.486: "V2X Application Enabler (VAE) Services; Stage 3".  
 [9] TS 26.348: "Northbound Application Programming Interface (API) for Multimedia Broadcast/Multicast Service (MBMS) at the xMB reference point".

## 8.4 5G V2X with NR sidelink

830078	<a href="#">5G V2X with NR sidelink</a>	5G_V2X_NRSL	R1	RP-190984	LG Electronics
830178	Core part: 5G V2X with NR sidelink	5G_V2X_NRSL-Core	R1	RP-190766	LG Electronics
830278	Perf. part: 5G V2X with NR sidelink	5G_V2X_NRSL-Perf	R4	RP-190766	LG Electronics

Summary based on the input provided by LG Electronics in RP-200855.

3GPP RAN technology for sidelink communication based on 5G NR was specified through this WI to define the means for providing the advanced V2X services identified by 3GPP SA1. This WI corresponds to 3GPP V2X phase 3, which is the evolution of LTE V2X in Release 14 (phase 1) and 15 (phase 2).

This section provides a summary of the key functionalities of NR sidelink.

### Physical layer structure

Sidelink bandwidth part (BWP) is defined to support the flexible numerologies in operating on various spectrum band such as the intelligent transport system (ITS) dedicated band and the licensed band of frequency range 1 (FR1) and FR2. For sidelink synchronization, GNSS, gNB/eNB and the NR sidelink UE can be used as a synchronization reference source of a UE.

The NR V2X sidelink uses the following physical channels and signals:

- Physical sidelink broadcast channel (PSBCH) and its de-modulation reference signal (DMRS)
- Physical sidelink control channel (PSCCH) and its DMRS
- Physical sidelink shared channel (PSSCH) and its DMRS
- Physical sidelink feedback channel (PSFCH)
- Sidelink primary and secondary synchronization signals (S-PSS and S-SSS)
- Phase-tracking reference signal (PT-RS) in FR2
- Channel state information reference signal (CSI-RS)

Sidelink control information (SCI) in NR V2X is transmitted in two stages. The first-stage SCI is carried on PSCCH and contains information to enable sensing operations, as well as information about the resource allocation of the PSSCH. PSSCH transmits the second-stage SCI and the sidelink shared channel (SL-SCH) transport channel. The second-stage SCI carries information needed to identify and decode the associated SL-SCH, as well as control for hybrid automatic repeat request (HARQ) procedures, and triggers for channel state information (CSI) feedback, etc. SL-SCH carries the transport block (TB) of data for transmission over SL.

PSCCH and PSSCH are multiplexed in time and frequency within a slot for short latency and high reliability. DMRS is frequency multiplexed with PSCCH or PSSCH in the corresponding DMRS symbols. PSFCH, which is used for sidelink HARQ feedback for unicast and groupcast, is transmitted at the end of a slot, which is preceded by an additional guard symbol and an automatic gain control (AGC) symbol. Two multiplexing examples are shown in Figure 1(a) and 1(b).

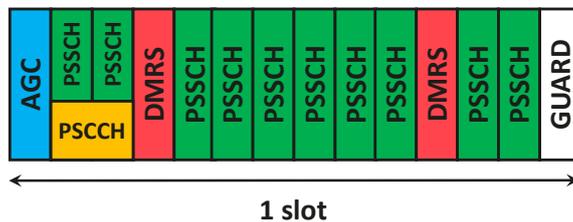


Figure 1(a) Example slot format of 2-symbol PSCCH, 2-symbol PSSCH-DMRS, and no PSFCH.

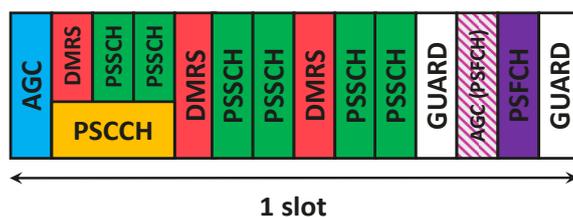


Figure 1(b) Example slot format of 3-symbol PSCCH, 3-symbol PSSCH-DMRS, and PSFCH.

#### Resource allocation

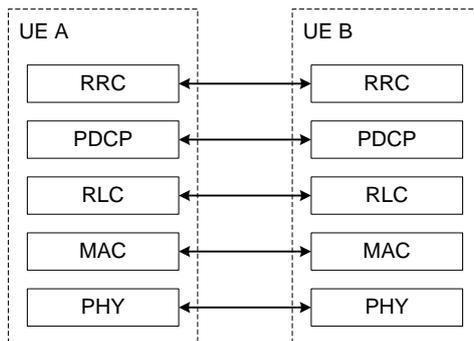
There are two resource allocation modes: mode 1 and mode 2. Mode 1 for resource allocation by gNB and Mode 2 for UE autonomous resource selection are very similar to Mode 3 and Mode 4 in LTE sidelink respectively. For mode 1, gNB schedules to UE the dynamic grant resources by downlink control information (DCI), or the configured grant resource type 1 and type 2 by radio resource control (RRC) signalling and DCI respectively.

In Mode 2, the sensing operation to determine transmission resources by UE comprises 1) sensing within a sensing window, 2) exclusion of the resources reserved by other UEs, and 3) select the final resources within a selection window. In Mode 2, shortly before transmitting in a reserved resource, a sensing UE re-evaluates the set of resources to check whether its intended transmission is still suitable, considering a possible aperiodic transmission after the resource reservation. If the reserved resources would not be part of the set for selection at this time, then new resources are selected from the updated resource selection window. In addition to the re-evaluation, pre-emption is also introduced such that a UE selects new resources even after it announces the resource reservation when it observes resource collision with a higher priority transmission from another UE.

#### Sidelink HARQ feedback, sidelink CSI and PC5-RRC for unicast and groupcast

NR sidelink supports sidelink HARQ-ACK for sidelink unicast and groupcast services for improved reliability. Two sidelink HARQ feedback operations are defined, HARQ-ACK with ACK and NACK, and HARQ-ACK with NACK only. When ACK/NACK operation is used, the sidelink HARQ-ACK procedure is similar to that of Uu for non-codeblock group feedback, i.e. the HARQ-ACK is transmitted based on the success or failure of the whole transport block. NACK-only operation is defined for groupcast to allow a larger number of Rx UEs to share a single PSFCH resource by sending feedback only when a Rx UE receives SCI but fails to decode the transport block. The transmission of NACK-only feedback can be restricted to UEs within given a radius, and any UE beyond it does not provide any HARQ-ACK. This minimum range requirement of a service is provided together with the associated QoS parameters from service layers. For mode 1, sidelink HARQ-ACK information is reported to gNB to indicate whether additional retransmission resources are required or not.

In sidelink unicast transmission, Tx UE can configure aperiodic sidelink CSI reporting from the Rx UE to get information it can use for sidelink link adaptation and rank adaptation. CQI and RI are reported via MAC layer signalling, in a PSSCH transmission for this purpose. In addition, radio link monitoring is adopted to manage a sidelink connection.



**Figure 2 PC5 control plane (PC5-C) protocol stack for RRC.**

To support exchange of the AS layer configuration and UE capability information between UEs, PC5-RRC is defined for unicast sidelink communication. The AS protocol stacks of the control plane for RRC is depicted in Figure 2.

Cross-RAT and in-device coexistence between LTE V2X and NR V2X sidelinks

Depending on the NR V2X and LTE V2X deployment, it is envisaged that an optional UE design can be supported where a device has both an LTE-V2X RAT and an NR-V2X RAT which are able to inter-communicate. 5G V2X defines two Cross-RAT operations. LTE Uu can control NR resource allocation mode 1 by providing configured grant Type 1 configurations via LTE RRC signalling, and resource allocation mode 2 by LTE Uu RRC providing the semi-static configurations relevant to resource pools, sensing, etc. NR Uu can control LTE resource allocation mode 3 by transmitting an NR DCI which contains the information needed to dynamically control the LTE sidelink, and resource allocation mode 4 by NR Uu RRC providing the necessary semi-static configurations within which the LTE-V2X RAT autonomously selects resources for sidelink transmission.

It is envisaged that there will exist devices that support both LTE-V2X and NR-V2X, and which will be operating in both systems concurrently. If the two RATs are widely spaced in frequency, e.g. being in different bands, then there need be no particular issues to consider since it is assumed that a separate RF chain will be provided for each band. If, however, a sufficiently close frequency spacing is deployed, then it is desirable to enable a single RF chain to be used in the implementation. In this case, the simultaneous transmission on both RATs is prevented by the UE's single power budget, and one RAT cannot be received/transmitted while the other RAT is doing the opposite. In this case, one of the RATs may be dropped at times when both occur simultaneously, but that in some cases where the priority of the V2X service on both RATs is known, the higher priority one is automatically selected.

**References**

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830078,830178,830278>

- RP-200129, "Revised WID on 5G V2X with NR sidelink"
- TR37.985, "Overall description of Radio Access Network (RAN) aspects for Vehicle-to-everything (V2X) based on LTE and NR (Release 16)."
- TR38.886, "V2X Services based on NR; User Equipment (UE) radio transmission and reception."
- Last status report in RP-200854

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## 9 Northbound APIs related items

### 9.1 Usage of CAPIF for xMB API

790019	Usage of CAPIF for xMB API	CAPIF4xMB	S4	SP-180031	Thorsten Lohmar, Ericsson LM
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Summary based on the input provided by Ericsson in SP-181187.

The CAPIF4xMB work item resulted in the creation of the xMB specification in TS.26.348 [1]. This TS contains the reference point specification for the external interface towards content providers or other 3GPP defined API invokers.

3GPP SA4 aligned the xMB reference point to the Common API Framework (CAPIF) within the CAPIF4xMB work item targeting Release 16. The xMB reference point exists between Content Providers (as API invoker) and the BM-SC. An API invoker can be a 3rd party provider or other 3GPP defined services.

xMB offers a simple interface to control the MBMS delivery procedure and to ingest the data to be delivered via MBMS. The MBMS usage complexity, e.g. handling of packet losses, etc is handled by the BM-SC.

xMB offers control procedures for different session types, namely generic file delivery, application (timed file streaming like DASH over MBMS), streaming and transport-only (access to a plain IP multicast transport). The xMB reference point offers an extended set of control features for MC Services.

As part of the CAPIF4xMB work item, the xMB Stage 2 architecture and procedures are moved from TS 26.346 to a new TS 26.348, containing the xMB Stage 2 and necessary extensions for CAPIF. The new TS also contains more elaborative guidelines around the usage of the different xMB API features.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=790019>

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

## 9.2 Enhancement of 3GPP Northbound APIs

840013	Enhancement of 3GPP Northbound APIs	eNAPIs	C3	CP-191233	Yali Yan, Huawei
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The 3GPP Northbound APIs (i.e. SCEF Northbound APIs as defined in TS 29.122 [1], NEF Northbound APIs as defined in TS 29.522 [2], CAPIF APIs as defined in TS 29.222 [3] and xMB API as defined in TS 29.116 [4]) have been specified in Release 15 to enable third party Application Servers access the exposed 3GPP network services and capabilities in a secure and controlled manner.

In Release 16, further enhancements and changes to the 3GPP Northbound APIs (i.e. SCEF Northbound APIs, NEF Northbound APIs, CAPIF APIs and xMB API) are necessary. The enhancements specified by this Work Item are:

- a) NEF/SCEF Northbound APIs registration with CAPIF Core Function in order to enable the discovery of the Northbound APIs by 3rd party Application Servers;
- b) 3GPP Northbound APIs optimization;
- c) Further handling of communication failure case, i.e.
  - notification of resource allocation failure during procedures of setting up an AS session with required QoS;
  - notification of unknown RDS port when the port numbers in MO/MT NIDD mismatch with the NIDD configuration;
- d) HTTP-based protocol or OpenAPI file improvements to align with the handling of 5GC APIs, i.e.
  - removal of duplicated OpenAPI definition;
  - optionality of ProblemDetails;
  - storage of YAML files;
  - URI structure definition for N33 APIs, T8 APIs and CAPIF APIs;
  - table update to align with the SBI template; and
- e) Any other necessary improvements and changes missed in Release 15, i.e.
  - support battery indication and traffic profile within the communication parameter set for CpProvisioning API;
  - notification of the actually applied parameters (Maximum Detection Time, Maximum Latency and Maximum Response Time) in MonitoringEvent API and NpConfiguration API;
  - support periodic reporting by MonitoringEvent API;
  - support Loss\_of\_connectivity\_notification feature in MonitoringEvent API;
  - replace the reference IETF RFC 7159 with IETF RFC 8259;
  - merge patch handling of HTTP PATCH operation;
  - introduce Enhanced\_event\_report feature to support detailed event reporting requirement in CAPIF\_Events API;
  - correct the impacted specifications on other improvements or changes, i.e. attribute names, description of procedures, conditions of properties, syntax errors in OpenAPI file.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840013>

- [1] TS 29.122: "T8 reference point for northbound Application Programming Interfaces (APIs)".
- [2] TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".
- [3] TS 29.222: "Common API Framework for 3GPP Northbound APIs".
- [4] TS 29.116: "Representational state transfer over xMB reference point between content provider and BM-SC".

### 9.3 Enhancements for Common API Framework for 3GPP Northbound APIs

830069	Enhancements for Common API Framework for 3GPP Northbound APIs	eCAPIF		SP-181137	Basavaraj Pattan, Samsung
790022	Stage 2 for eCAPIF	eCAPIF	S6	SP-181137	Basavaraj Pattan, Samsung
830022	Security aspects of eCAPIF	eCAPIF	S3	SP-1901240	Rajavelsamy Rajadurai, Samsung

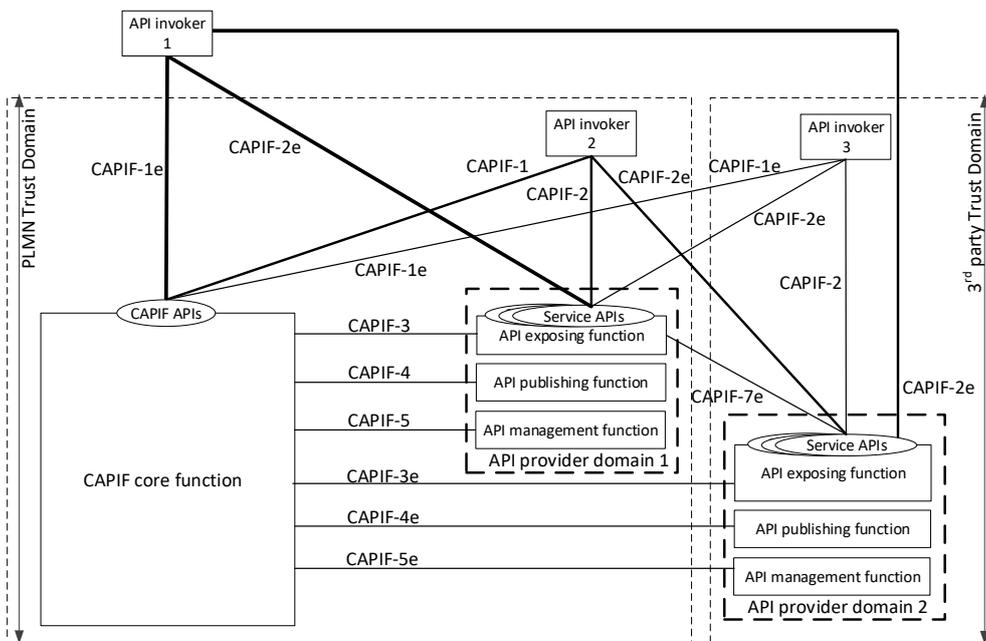
Summary based on the input provided by Samsung in SP-200851.

With the growing interest in 3GPP to develop northbound APIs, it is essential to define a common API framework. A common API framework within 3GPP will allow for a consistent development of northbound APIs across multiple working groups, i.e. when defining northbound APIs to abstract or expose the underlying 3GPP network capabilities to 3rd party applications. Intended users of CAPIF are third-party developers that may not be familiar with 3GPP networks and their underlying complexities.

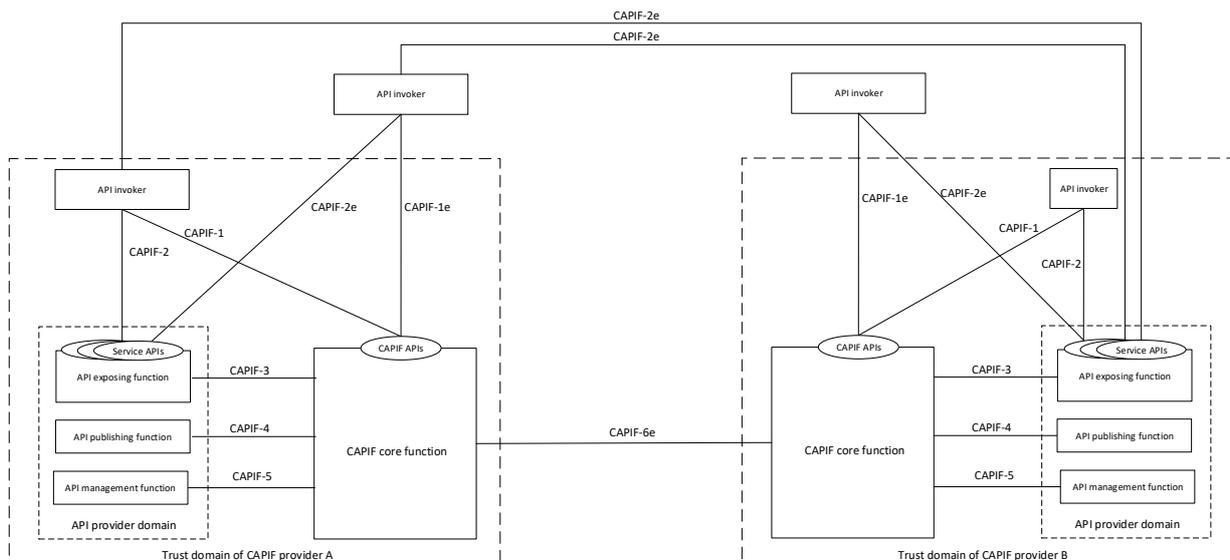
In Release 15, the technical report TR 23.722 was provided to cover key issues, architecture requirements, functional architecture model, and corresponding solutions that are relevant to the definition of a common API framework applicable to any service APIs when used by northbound entities. Subsequently, still in Release 15, a stage-2 Common API Framework for 3GPP Northbound APIs (CAPIF) specification was developed in TS 23.222, based on the solutions and conclusions of TR 23.722. The work item summary for Release 15 CAPIF is available in TS 21.915 [1].

While a basic Common API Framework is made available in 3GPP Rel-15, there are several enhancements that are considered for developing eCAPIF in Rel-16 in TS 23.222 [2], and the key enhancements are listed as follows:

- a. Architecture functional model to support multiple API providers (within and outside the PLMN trust domain) where CAPIF-3, CAPIF-4 and CAPIF-5 were enhanced as CAPIF-3e, CAPIF-4e and CAPIF-5e respectively to enable the API exposing function, the API publishing function and the API management function of the API provider domain within the 3rd party trust domain interaction with the CAPIF core function in the PLMN trust domain. Further, the API exposing function within the PLMN trust domain interacts with the API exposing function in the 3rd party trust domain via CAPIF-7e.



- b. Architectural model for the CAPIF interconnection which allows API invokers of a CAPIF provider to utilize the service APIs from the 3rd party CAPIF provider where the designated CAPIF core function of the CAPIF provider A provides the information about the CAPIF instances and service APIs deployed by the CAPIF provider A to the designated CAPIF core function of the CAPIF provider B and vice versa over CAPIF-6e reference point.



- c. Additional deployment models including distributed deployment of CAPIF considering PLMN trust domain and 3rd party trust domain, multiple CAPIF core functions that may be deployed within the PLMN trust domain.
- d. The procedure to support API topology hiding by dynamically configuring the address of the AEF providing the Service API to the AEF entry point providing the topology hiding. The API publishing function and the API exposing function can be within PLMN trust domain or within 3rd party trust domain.
- e. Procedures to support for CAPIF interconnection including interconnection API publish request from CAPIF core function to CAPIF core function, service API discovery by the API invoker from multiple CCFs, service API discovery between multiple CCFs.
- f. Procedures for updating the API invoker's API list on the CAPIF core function.
- g. Procedure for dynamically routing the service API invocation from the AEF acting as service communication entry point to the destination AEF for handling service API.
- h. Procedure for registering API provider domain functions on the CAPIF core function and for updating the registration information of the API provider domain functions on the CAPIF core function.
- i. Integrated deployment of 3GPP network exposure systems with the CAPIF - The SCEF and the NEF may be integrated with a single CAPIF core function to offer their respective service APIs to the API invokers. The following deployment model is possible for integrated deployment of the SCEF and the NEF with the CAPIF core function.

Security aspects of enhancements for Common API Framework for 3GPP Northbound APIs are specified in TS 33.122 [3].

Stage 3 normative work to support enhancements for Common API Framework for 3GPP Northbound APIs including the OpenAPI specifications made by CT3 working group is specified in TS 29.222 [4].

**References**

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830069,790022,830022>

- [1] TS 21.915: "Release 15 Description; Summary of Rel-15 Work Items".
- [1] TS 23.222: "Functional architecture and information flows to support Common API Framework for 3GPP Northbound APIs; Stage 2".
- [2] TS 33.122: "Security aspects of Common API Framework (CAPIF) for 3GPP northbound APIs".
- [3] TS 29.222: "Common API Framework for 3GPP Northbound APIs".

## 9.4 Service Enabler Architecture Layer for Verticals

850048	<a href="#">Service Enabler Architecture Layer for Verticals (SEAL)</a>	SEAL		SP-181141	Basavaraj (Basu) Pattan, Samsung
820027	Stage 2 of SEAL	SEAL	S6	SP-181141	Basavaraj (Basu) Pattan, Samsung
850019	Security aspects of SEAL	SEAL	S3	SP-190901	Rajavelsamy Rajadurai, Samsung

850006	CT aspects of SEAL	SEAL	CT	CP-192255	Sapan Shah, Samsung Electronics
850049	CT1 aspects of SEAL	SEAL	C1	CP-192255	Sapan Shah, Samsung Electronics
850050	CT3 aspects of SEAL	SEAL	C3	CP-192255	Sapan Shah, Samsung Electronics

Summary based on the input provided by Samsung in SP-200852.

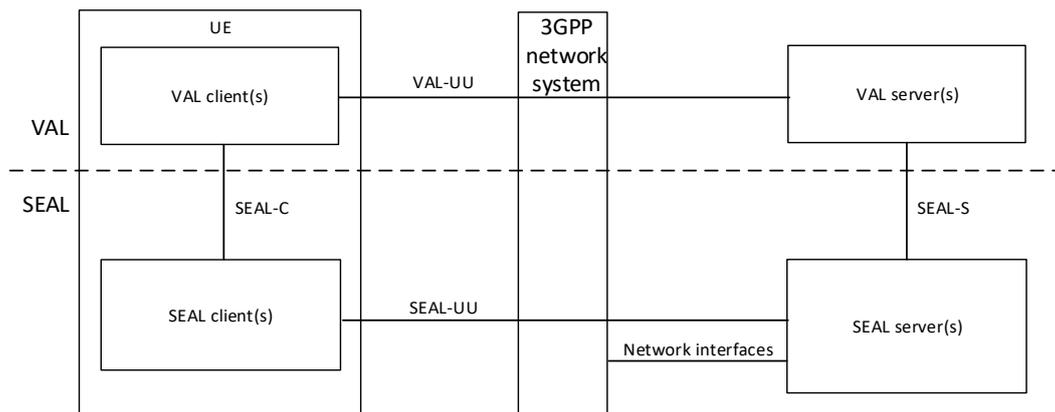
3GPP SA6 specified application layer standards for mission critical services and application layer support for V2X. While developing mission critical services, some core set of capabilities (e.g. group management, configuration management, identity management, key management, location management) were identified to be common across MCPTT, MCDATA and MCVideo services, leading to a separate Common Functional Architecture (CFA) specification. It was identified that V2X applications will also require a similar common set of application layer capabilities as specified in TS 23.286.

Specifying such common capabilities for V2X, independent from those that are defined in existing mission critical specifications could lead to fragmented capabilities and deployments. This approach results in consuming significant development time and delays in timely adoption of 3GPP technologies.

Therefore, a set of common capabilities that can be utilized by V2X applications and potentially by multiple vertical industry applications is developed as service enabler architecture layer (SEAL) over 3GPP networks in TS 23.434 [1].

The Stage-2 SEAL in TS 23.434 specifies the following:

- 1) The architecture requirements for SEAL services.
- 2) The functional model for SEAL is organized into generic SEAL service functional model and specific SEAL service functional models. The generic SEAL service functional model will be used as the reference model for the specific SEAL service functional models. The generic functional model (represented using reference point and service based interface) for SEAL service is in the figure below:

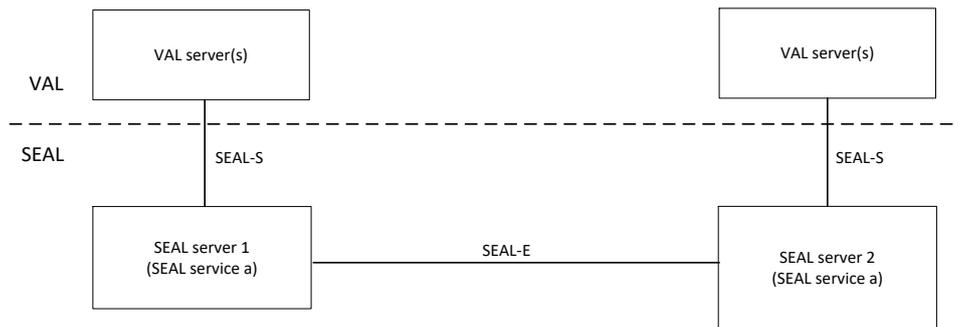


In the vertical application layer, the VAL client communicates with the VAL server over VAL-UU reference point. VAL-UU supports both unicast and multicast delivery modes.

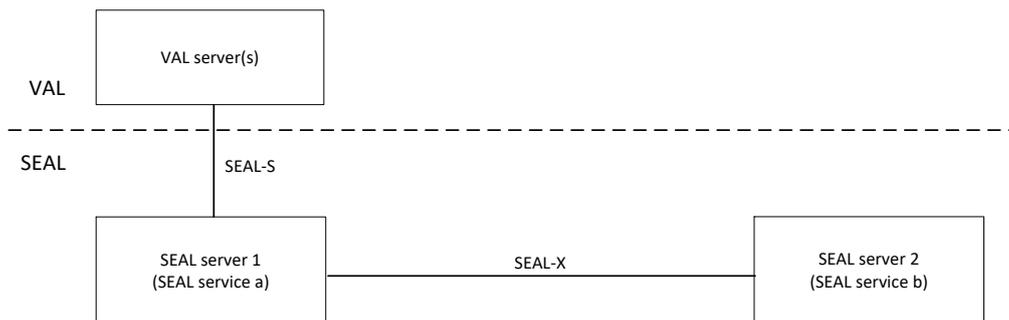
The SEAL functional entities on the UE and the server are grouped into SEAL client(s) and SEAL server(s) respectively. The SEAL consists of a common set of services (e.g. group management, location management) and reference points. The SEAL offers its services to the vertical application layer (VAL).

The SEAL client(s) communicates with the SEAL server(s) over the SEAL-UU reference points. SEAL-UU supports both unicast and multicast delivery modes. The SEAL client(s) provides the service enabler layer support functions to the VAL client(s) over SEAL-C reference points. The VAL server(s) communicate with the SEAL server(s) over the SEAL-S reference points. The SEAL server(s) may communicate with the underlying 3GPP network systems using the respective 3GPP interfaces specified by the 3GPP network system.

- 3) The functional model for interconnection between SEAL servers to support distributed SEAL server deployments, the SEAL server interacts with another SEAL server for the same SEAL service over SEAL-E reference point as shown in the figure below:



4) The functional model for inter-service communication between SEAL servers to support the SEAL server interaction with another SEAL server for inter-service communication over SEAL-X reference point is shown in the figure below:



5) The functional architecture of each SEAL service listed below and corresponding functional entities and reference points along with the procedures and information flows, northbound APIs to expose the SEAL services to the vertical applications in compliance with CAPIF for each SEAL service is listed below:

- Group management (GM): The vertical application specific group communication is one of the essential feature in any vertical application. To enable group communication, each vertical application needs to create and manage the group, group specific policies and group members. The group management service, as provided by SEAL, supports group management operations (i.e. Create, Read, Update, Delete and Notify) by the authorized users or VAL servers. It also supports merging of multiple groups into single group where all the group members of the constituent groups are also members of the merged group.
- Location management (LM): Managing VAL user's location information is a service that is required by multiple vertical specific applications. The location management service, as provided by SEAL, supports sharing location data between client and server for vertical application usage. It also provides support to request for on-demand location reporting by client and location reporting based on configurable triggers. The service also enables VAL servers to query location of any user as well as sharing the network location information obtained from the 3GPP network systems to the vertical applications.
- Configuration management (CM): Most of the vertical applications need to create and maintain configurations. Further, they need to provide the initial configuration to all its users and need to notify as soon as there is any change in configuration. The configuration management service, as provided by SEAL, supports creating and managing UE configuration and user profile configuration for the vertical applications. It also supports subscribe-notify mechanism so that the VAL users can subscribe to any change in configurations.
- Network resource management (NRM): Many vertical applications require managing different radio bearers and switching among them. The network resource management service, as provided by SEAL, supports establishing and modifying unicast and/or multicast bearers. It also supports announcements for multicast bearers and switching from unicast to multicast bearers and vice versa.
- Key management (KM): The security of sensitive data and user's information is important aspect for every vertical application. The key management service, as provided by SEAL, supports generation and secure distribution of encryption keys to VAL users.
- Identity management (IM): The identity management service, as provided by SEAL, supports VAL user's authentication and authorization framework. As per the defined framework, each VAL user sends authentication request using SEAL Identity Management Client (SIM-C) and once the user authentication is successful, the VAL user can

request for access-token. The SEAL Identity Management Server (SIM-S) creates the access token, which is opaque to the VAL clients. The access token contains VAL user's identity. The VAL user presents the access token to VAL server to access VAL service. The VAL server authorizes the VAL user after verifying the validity of the access token.

6) Specifying various deployment models of SEAL services: The SEAL server(s) may be deployed either in the PLMN operator domain or deployed in the VAL service provider domain. The SEAL server(s) connects with the 3GPP network system in one or more PLMN operator domain. The SEAL server(s) may be supporting multiple VAL servers.

7) Service-based interface representation of the functional model for SEAL services as shown in the figure below:

The SEAL function(s) exhibit the service-based interfaces, which are used for providing and consuming SEAL services. The service APIs are specified for each SEAL function enabled over the service-based interface. The service-based interfaces of specific SEAL services are specified in TS 23.434. All the interactions with SEAL are governed based on the reference point interactions of the functional models specified in subclause 6 of TS 23.434. VAL function represents the functionalities of the VAL server.

The service APIs offered by the SEAL function(s) are published and discovered on the CAPIF core function as specified in TS 23.222 [9].

8) SEAL functional model mapping with Common functional architecture (CFA).

Security aspects of 3GPP support for service enabler architecture layer (SEAL) are specified in TS 33.434 [2].

Stage 3 normative work to service enabler architecture layer (SEAL) 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 [6].

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850048,820027,850019,850006,850049,850050>

[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] TS 23.222: "Functional architecture and information flows to support Common API Framework for 3GPP Northbound APIs; Stage 2".

## 9.5 Other APIs-related items

See also:

Cellular IoT support and evolution for the 5G System

Business Role Models for Network Slicing

Enhancing Topology of SMF and UPF in 5G Networks

MBMS APIs for Mission Critical Services

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## 10 Coexistence with Non-3GPP systems

### 10.1 Wireless and Wireline Convergence Enhancement

760044	<a href="#">Study on the Wireless and Wireline Convergence for the 5G system architecture</a>	FS_5WWC	S2	SP-170380	Marco Spini, Huawei Technologies
800031	<a href="#">Study on the security of the Wireless and Wireline Convergence for the 5G system architecture</a>	FS_5WWC_SEC	S3	SP-180438	He Li, Huawei Technologies
830050	<a href="#">Wireless and Wireline Convergence for the 5G system architecture</a>	5WWC		SP-181117	Marco Spini, Huawei

820014	Stage 2 of 5WWC	5WWC	S2	SP-181117	Marco Spini, Huawei
829910	CT aspects of 5WWC	5WWC	ct	CP-191156	Herrero, Christian (Huawei)
829911	CT1 aspects of 5WWC	5WWC	C1	CP-191156	Herrero, Christian (Huawei)
829912	CT3 aspects of 5WWC	5WWC	C3	CP-191156	Herrero, Christian (Huawei)
829914	CT4 aspects of 5WWC	5WWC	C4	CP-191156	Herrero, Christian (Huawei)
830082	NG interface usage for WWC	5WWC-NG_interface	R3	RP-190772	Huawei
830182	Core part: NG interface usage for WWC	5WWC-NG_interface-Core	R3	RP-190999	Huawei
860019	Charging Aspect for 5WWC	5WWC	S5	SP-191188	ZHU, Lei, Huawei

Summary based on the inputs provided by Huawei in SP-200253 for the overall aspects; by Huawei and HiSilicon in RP-200678 for the radio aspects; and by Huawei in SP-200525 for the charging aspects.

### Overall aspects (from SP-200253)

This WI aims to enhance 5G core network to support connection of residential gateway connected via wireline access network and via 3GPP RAN access. Furthermore the WI aims to support Non-3GPP network as Trusted network in contrast with Untrusted network. The main features introduced by the WI includes the specification of new access network node, called W-AGF (Wireline Access Gateway function), the improvement of registration and session management procedures, policy, QoS etc, tailored to the specific characteristic of wireline access network. The main future for supporting Trusted network includes the definition of architecture with new Trusted Gateway Network Function, selection procedure of such gateway, improvement and extension of registration and session procedures, policy, etc for supporting such scenario.

The description of support of Wireline Access Network and Trusted Non-3GPP Access Network are described in the following clauses.

#### Support of wireline access network

The architecture for non-roaming is shown in figure 1, where the Wireline Access Gateway Function (W-AGF) is the access node performing the termination of N2 and N3 reference point, termination of access network interface Y4 and all access network specify functionalities, the relay of N1 to/from the UE., QoS enforcement, etc. The customer device, the UE, is replaced by the Residential Gateway which is augmented to support the 5G functionalities required to connect to 5G systems, such as NAS, URSP, PDU session, etc, called 5G-RG. The specification in TS 23.316 [1] defines the modification to system architecture, procedure and flows, Policy and Charging Control for the 5G System in TS 23.501 [2], TS 23.502 [3] and TS 23.503 [4].

The 5G-RG can also be connected via 3GPP Access basically by means of supporting the specification defined for UE. This scenario is called Fixed Wireless Access (FWA). Furthermore the 5G-RG may simultaneously connect to 3GPP Access and to wireline access by using the Single Access PDU session or supporting ATSSS feature. This scenario is called Hybrid scenario, using a terminology common on wireline access network. The ATSSS is supported as specified in TS 23.501, 23.502 and TS 23.503 where UE is replaced by 5G-RG and the Non-3GPP access (es) is specifically referred to wireline access. In this latter case, TS 23.316 has also specified the support of interworking with EPC via 3GPP Access via a MA PDU session with a PDN Connection as user-plane resource associated with a MA PDU Session.

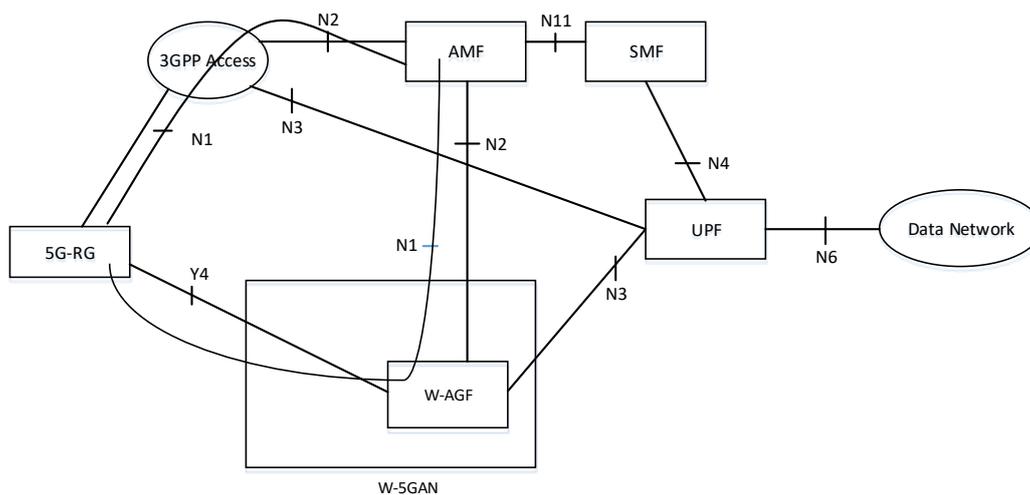
The support of legacy Residential Gateway not supporting 5G capability (FN-RG) is supported via W-AGF terminating the N1 NAS on behalf of UE and acting as a UE in respect the 5G core.

In the case of Wireline Access Network defined in Broadband Forum the W-AGF functionalities is specified in BBF TR-470 [5], BBF TR-456 [6] and BBF TR-457 [7], the 5G-RG is defined in BBF TR-124issue6 [8]. In the case of Wireline Access network defined in Cablelabs the W-AGF and 5G-RG functionalities are defined in CableLabs WR-TR-5WWC-ARCH [9].

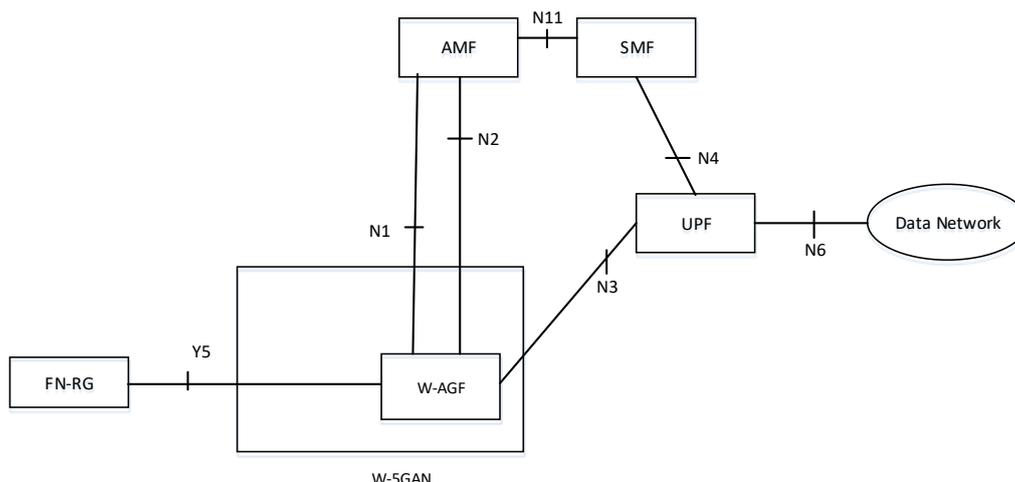
Main impacts on the system by the WWC Work Item for wireline support are the following:

- W-AGF: the access network function which performs the termination of N2 and N3 reference point, termination of access network interface Y4 and all access network specify functionalities, the relay of N1 to/from the UE. QoS enforcement, etc. When the W-AGF facing the FN-RG the W-AGF is supporting the termination of N1 NAS and performs the interworking between 5GC and the legacy wireline access network.
- 5G-RG: end user device replacing the UE which supports 5G capabilities (NAS protocol and procedure, USRP, IMSI, ATSSS) and extension of wireline access layer specific functionalities defined by Broadband forum and CableLabs. The 5G-RG may also support UE capability when connects via 3GPP Access.
- FN-RG: end user device replacing the UE which does not support 5G capabilities.

- Global Line Identifier (GLI): in case of wireline access based on BBF specifications this parameter uniquely identifies the line at which the 5G-RG is connected to within an operator domain.
- Global Cable identifier (GCI): in case of wireline access based on CableLabs specification this parameter uniquely identifies the line at which the 5G-RG is connected to within an operator domain.
- SUPI for FN-RG based on GCI and GLI.
- All procedures defined in TS 23.502 have been modified to introduce the new network elements. The procedures are focused mainly on the part of specification that required improvements and to point out the access network interaction involving the W-AGF, 5G-RG and FN-RG to allow the Broadband Forum and CableLabs to develop the specifications under their responsibility.
- IPTV support: The specification TS 23.316 in clauses 4.9.1 and 7.7.1 defines the support of IPTV via the support of multicast over unicast PDU session by using IGMP/MLD message sent by STB via 5G-RG on PDU session and managed by UPF for adding the requiring 5G-RG to a multicast group and replicating the traffic received on N6 interface to the PDU session. The SMF is improved to control the support of IPTV by the UPF acting as PSA using PDR, FAR, QER, URR. This includes control of which IGMP and MLD requests the UPF is to accept or to deny.
- QoS: the QoS model for wireline network is based on a subscription maximum aggregate bitrate including both GBR and Non-GBR traffic, hence the new parameter RG Total Maximum Bit Rate (RG-TMBR) has been defined. The RG-TMBR limits the aggregate bit rate that can be expected to be provided across all GBR and Non-GBR QoS Flows of a RG. The RG-TMBR is a parameter provided to the W-AGF by the AMF based on the value of the Subscribed RG-TMBR retrieved from UDM. The QoS control on wireline access network (i.e scheduling, rate limiting and traffic class management) is based on the line characteristic included in user subscription, for example different priority of service, different traffic class support by line of the single user, etc, for such reason the new parameter RG Level Wireline Access Characteristics (RG-LWAC) has been introduced. The format and content of RG LWAC is specified by BBF and it is transparently provided by UDM to AMF which may provide to the W-AGF at the time of the RG registration
- mobility restriction based on GLI and GCI
- support of BBF interaction with the Access Configuration System (ACS) to support the provisioning of configuration and remote management of 5G-RG as described in BBF TR-069 [12] or in BBF TR-369 [13].



**Figure 1: Non- roaming architecture for 5G Core Network for 5G-RG with Wireline 5G Access network and NG RAN**



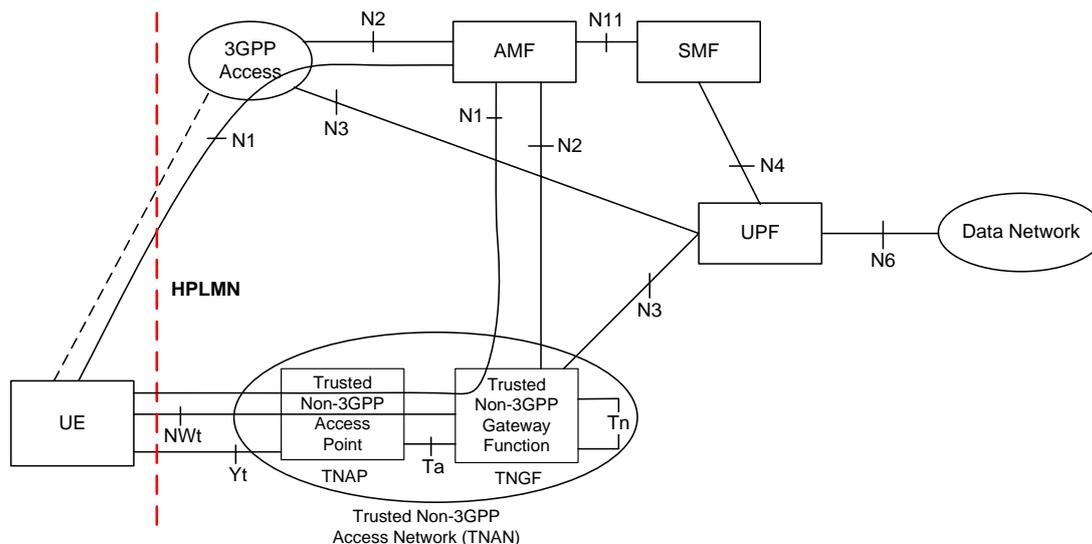
**Figure 2: Non-roaming architecture for 5G Core Network for FN-RG with Wireline 5G Access network and NG RAN**

#### Support of Trusted Access network

The support of Trusted Network addresses the scenario where the Non-3GPP access network has a tighter relationship with 5GC in respect the untrusted scenario. However how the network is considered Trusted or Untrusted is not in the scope of this WID. The architecture for non-roaming is shown in figure 3, where the Trusted Non-3GPP Access Network (TNAN) is the access node performing the termination of N2 and N3 reference point, termination of access network interface, relay of N1 to/from the UE. From 3GPP point of view the TNAN network is composed by the TNGF and the Trusted Non-3GPP Access Point (TNAP) which are interconnected via the reference point Ta. However the detailed definition of TNAN and of Ta is beyond the WID scope. The reference point between the UE and the TNG, the NWt, is specified leveraging the IKEv2 defined for Untrusted. The main difference in contrast to Untrusted is in registration procedure, where it is assumed that EAP-5G can be carried between UE and TNAP directly on access layers, such on IEEE 802.11x and between TNAP and TNGF via Ta and not as part of IKEv2 establishment. From other the point of view of other procedures, such as session management, the same procedure specified for Untrusted Non-3GPP access network can be used with basically the TNGF replacing the N3IWF, and modification that IKEv2 Child SA establishment is requested by TNGF and not by UE side.

Within the context of Trusted Non-3GP network, also the scenario of devices not supporting NAS connected via WLAN is specified. The role of TNGF is replaced the Trusted WLAN Interworking Function (TWIF) with the main difference that TWIF terminates the N1 NAS interface and it play the role of UE in respect the 5GC.

The specification is addressed in TS 23.501 [2], TS 23.502 [3] and TS 23.503 [4]



**Figure 3: Non-roaming architecture for 5G Core Network with trusted non-3GPP access**

**References** (for the general (non-radio) aspects)

- [1] TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".
- [2] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [3] TS 23.502: "Procedures for the 5G System; Stage 2".
- [4] TS 23.203: "Policies and Charging control architecture; Stage 2"..
- [5] BBF WT-470: "5G FMC Architecture".
- [6] BBF WT-456: "AGF Functional Requirements".
- [7] BBF WT-457: "FMIF Functional Requirements".
- [8] BBF TR-124 issue 5: "Functional Requirements for Broadband Residential Gateway Devices".
- [9] CableLabs WR-TR-5WWC-ARCH: "5G Wireless Wireline Converged Core Architecture".
- [10] CableLabs WR-TR-5WWC-ARCH: "5G Wireless Wireline Converged Core Architecture".
- [11] CableLabs WR-TR-5WWC-ARCH: "5G Wireless Wireline Converged Core Architecture".
- [12] BBF TR-069: "CPE WAN Management Protocol".
- [13] BBF TR-369: "User Services Platform (USP)".

**Radio aspects** (from RP-200678)

In Rel-16, the WI "NG interface usage for WWC (Wireless Wireline Convergence)" was approved (The latest WID in RP-190999 [1]). The objective of this WID is to enhance the NG interface protocols specified in TS 29.413 [2], to fulfil the Stage 2 requirements allowing the Trusted Non-3GPP Access and the Wireline Access connectivity with the 5GC as described in the Release 16 of TS 23.316 [3], TS 23.501 [4], TS 23.502 [5] and TS 23.503.

The detailed objective includes:

- The description and enhancement of NG protocols to support the interface between the Trusted Non-3GPP Access Network and the 5GC;
- The description and enhancement of NG protocols to support the interface between the Wireline 5G Access Network and the 5GC.

It is also noted that the possible impact on TS 38.413 and others NG protocols is not precluded.

This document is the summary of the outcome of the WI, and the final agreed BL CRs for TS 29.413 and TS 38.413 can be found in [5, 6].

**General radio aspects**

- Introduce the Trusted Non-3GPP Gateway Function (TNGF), Trusted WLAN Interworking Function (TWIF) to support the Trusted Non-3GPP Access, and Wireline Access Gateway Function (W-AGF) to support Wireline Access in TS 29.413 and TS 38.413.

- Add the Global TNGF ID in the applicable NGAP messages between the TNGF and the AMF; add the Global TWIF ID in the applicable NGAP messages between the TWIF and the AMF; add the Global W-AGF ID in the applicable NGAP messages between the W-AGF and the AMF.
- Add the selected PLMN Identity for trusted non-3GPP access and wireline access in Initial UE Message for Key derivation.
- Add procedural texts that the Security Key IE may include KTNGF, or KTWIF, or KWAGF in TS 29.413.

#### Supporting the Trusted Non-3GPP Access with the 5GC – specific aspects

- Add TNGF Identity Information, TWIF Identity Information in the UPLINK NAS TRANSPORT message containing a list of identifiers of NG-U terminations at TNGF/TWIF for UPF selection.
- Add TNGF related and TWIF related User Location Information in the User Location Information IE.

#### Supporting the Wireline Access connectivity with the 5GC – specific aspects

- Add W-AGF Identity Information in the UPLINK NAS TRANSPORT message containing a list of identifiers of NG-U terminations at W-AGF for UPF selection.
- Add W-AGF related User Location Information in the User Location Information IE.
- Add procedural texts to clarify the UE-AMBR is not used for wireline access in TS 29.413.
- Add RG Level Wireline Access Characteristics in INITIAL CONTEXT SETUP REQUEST messages stored in the UE context by the W-AGF, indicating the wireline access technology specific QoS information corresponding to a specific wireline access subscription.
- Add the Authenticated Indication in INITIAL UE MESSAGE to indicate that the FN-RG has been authenticated by the wireline 5G access network.

#### **References** (for the radio aspects)

- |     |  |
|-----|--|
| [1] | RP-190999 Revised WID on NG interface usage for WWC (Wireless Wireline Convergence), Huawei, HiSilicon |
| [2] | TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".                 |
| [3] | TS 23.501: "System Architecture for the 5G System".  |
| [4] | TS 23.502: "Procedures for the 5G System".   |
| [5] | R3-204444 CR for introducing WWC in RAN, Huawei  |
| [6] | R3-204445 CR for introducing WWC in RAN, Huawei  |

#### **Charging aspects** (from SP-200525)

The work item is to specify charging aspect on Wireless and Wireline Convergence for 5G system architecture (5WWC). The 5WWC is specified in TS 23.501, TS 23.502, TS 23.503 and TS 23.316. The enhancement to charging aspect for 5WWC is considered as part of this series specifications for this 5WWC.

Following charging scenarios are included in charging aspect of 5WWC as following:

- UE Connects to 5G Core via Trusted Non-3GPP access
- 5G-RG connects to 5G Core via NR-RAN and via W-5GAN
- FN-RG connects via W-5GAN

This work item specifies charging requirements, procedures related to charging, charging information and related triggers for chargeable event for 5WWC scenarios.

The specifications related to 5WWC charging include TS 32.255, TS 32.291 and TS 32.298. The subscriber's identifiers and PEI in 5G-RG and FN RG scenarios specified in TS 23.501 and TS 23.361 are used in charging information. The procedures and related triggers in 5WWC charging scenarios are also specified in charging aspect for 5WWC. The related changes to OpenAPI are specified in TS 32.291.

#### **Overall References** (for the radio and non-radio aspects)

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=760044,800031,830050,820014,829910,829911,829912,829914,830082,830182,860019>

## 10.2 Access Traffic Steering, Switch and Splitting support in the 5G system architecture

820044	<a href="#">Access Traffic Steering, Switch and Splitting support in the 5G system architecture</a>	ATSSS		SP-181124	So, Tricci, ZTE
760052	Study on ATSSS	FS_ATSSS	S2	SP-180732	So, Tricci, ZTE
820021	Stage 2 of ATSSS	ATSSS	S2	SP-181124	So, Tricci, ZTE
830016	CT aspects of ATSSS	ATSSS	ct	CP-190201	ZHOU, Xingyue (Joy), ZTE
830057	CT1 aspects of ATSSS	ATSSS	C1	CP-190201	ZHOU, Xingyue (Joy), ZTE
830058	CT3 aspects of ATSSS	ATSSS	C3	CP-190201	ZHOU, Xingyue (Joy), ZTE
830059	CT4 aspects of ATSSS	ATSSS	C4	CP-190201	ZHOU, Xingyue (Joy), ZTE
840999	(IETF) TCP Extensions for Multipath Operation with Multiple Addresses (draft-ietf-mptcp-rfc6824bis)	ATSSS	S2-IETF		
840998	(IETF) 0-RTT TCP Convert Protocol (draft-ietf-tcpm-converters)	ATSSS	S2-IETF		

Summary based on the input provided by ZTE Wistron Telecom AB in SP-200124.

The ATSSS feature enables a multi-access PDU Connectivity Service, which can exchange PDUs between the UE and a data network by simultaneously using one 3GPP access network and one non-3GPP access network and two independent N3/N9 tunnels between the PSA and RAN/AN. The multi-access PDU Connectivity Service is realized by establishing a Multi-Access PDU (MA PDU) Session, i.e. a PDU Session that may have user-plane resources on two access networks, as shown on the figure below, extracted from TR 23.793 [1].

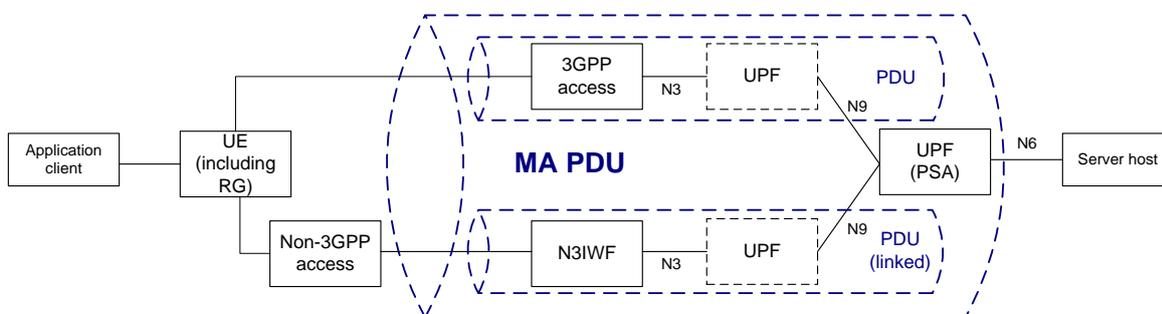


Figure 1: MA PDU session

These following procedures are defined in the context of this Feature:

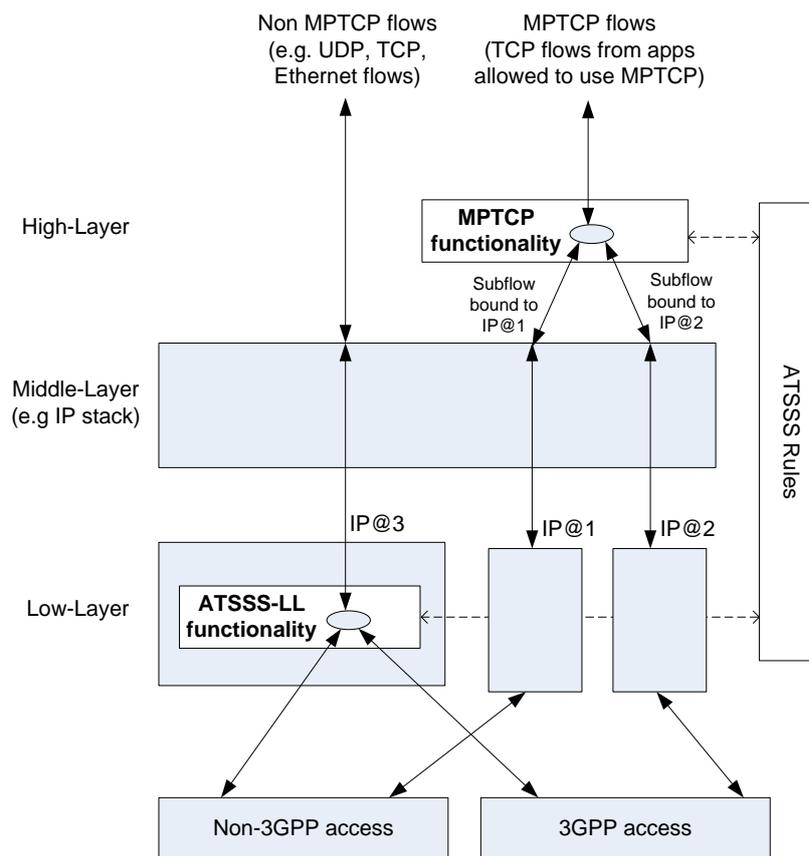
- Access Traffic Steering: it selects an access network for a new data flow and transfers the traffic of this data flow over the selected access network. Access traffic steering is applicable between one 3GPP access and one non-3GPP access.
- Access Traffic Switching: it moves all traffic of an ongoing data flow from one access network to another access network in a way that maintains the continuity of the data flow. Access traffic switching is applicable between one 3GPP access and one non-3GPP access.
- Access Traffic Splitting: it splits the traffic of a data flow across multiple access networks. When traffic splitting is applied to a data flow, some traffic of the data flow is transferred via one access and some other traffic of the same data flow is transferred via another access. Access traffic splitting is applicable between one 3GPP access and one non-3GPP access.

Key concepts of ATSSS supported in Release 16 include the following:

- Multi-access PDU Session is a PDU Session that provides a PDU connectivity service, which can use one access network at a time, or simultaneously one 3GPP access network and one non-3GPP access network and two independent N3/N9 tunnels between the PSA and RAN/AN.
- After the establishment of a MA PDU Session:
  - When there are user-plane resources on both access networks:
    - The UE applies network-provided policy (i.e. ATSSS rules derived by UE’s serving SMF based on ATSSS policy from serving PCF) and considers local conditions (such as network interface availability, signal loss conditions, user preferences, etc.) for deciding how to distribute the uplink traffic across the two access networks.

- Similarly, the UPF anchor of the MA PDU Session applies network-provided policy (i.e. N4 rules derived by UE's serving SMF based on ATSSS policy from serving PCF) and the feedback information received from the UE via the user-plane (such as access network Unavailability or Availability), the UPF then decides how to distribute the downlink traffic across the two N3/N9 tunnels and two access networks.
- When there are user-plane resources on only one access network, the UE applies the ATSSS rules and considers local conditions for triggering the establishment or activation of the user plane resources over another access.
- The type of a MA PDU Session may be one of the following types: i.e. IPv4, IPv6, IPv4v6, and Ethernet. The Unstructured type is not supported in Release 16.
- The ATSSS feature can be supported over 3GPP and non-3GPP accesses, including untrusted and trusted non-3GPP access networks, wireline 5G access networks, etc., as long as a MA PDU Session can be established over the given type of access network
- Two ATSSS steering functionalities are supported:
  - MPTCP functionality, for TCP traffic, with MPTCP proxy in UPF, by using the MPTCP protocol over the 3GPP and/or the non-3GPP user plane; and
  - ATSSS-LL functionality for all types of traffic, including TCP traffic, UDP traffic, Ethernet traffic, etc. ATSSS-LL functionality is mandatory for MA PDU Session of type Ethernet.

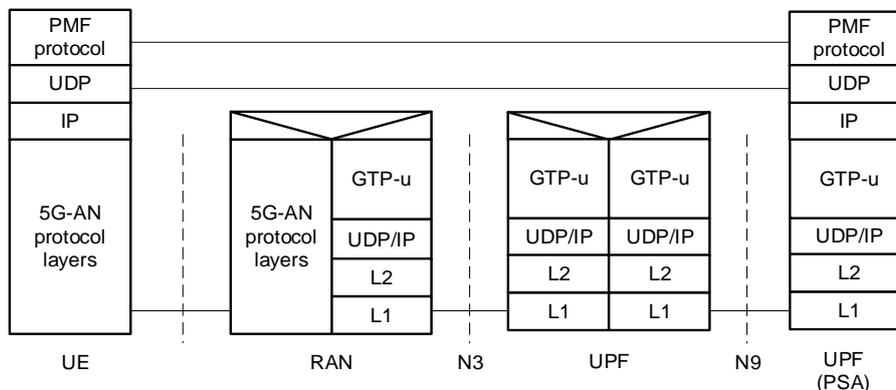
The following presents the example of the ATSSS traffic steering functionality within the UE.



**Figure 2: Steering functionalities in an example UE model**

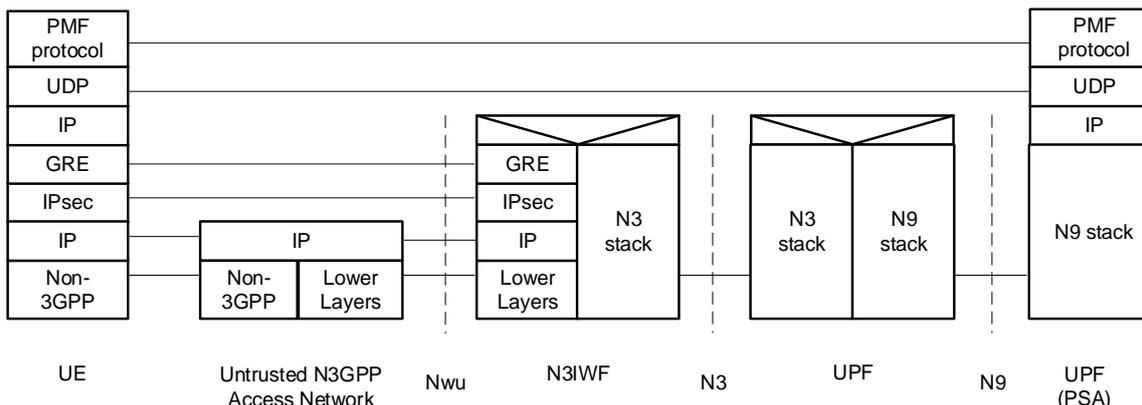
- The Performance Measurement Function (PMF) is supported by UPF and is specific for ATSSS-LL functionality, if enabled. In Release 16, PMF supports two types of measurements between UE and UPF to assist access selection and they are:
  - UE and UPF make RTT measurements per access when the "Smallest Delay" steering mode is used; and
  - UE reports access availability/unavailability to UPF

The following presents the protocol stacks of the PMF for the user plane measurements over 3GPP and non-3GPP accesses respectively.



**Figure 3: UE/UPF measurements related protocol stack for 3GPP access and for an MA PDU Session with type IP**

In the case of an MA PDU Session with type Ethernet, the protocol stack over 3GPP access is that same as the one in the above figure, but the PMF protocol operates on top of Ethernet, instead of UDP/IP.



**Figure 4: UE/UPF measurements related protocol stack for non-3GPP access and for an MA PDU Session with type IP**

In the case of an MA PDU Session with type Ethernet, the protocol stack over non-3GPP access is that same as the one in the above figure, but the PMF protocol operates on top of Ethernet, instead of UDP/IP.

- An ATSSS-capable UE may decide to request a MA PDU Session based on the provisioned URSP rules. In particular, the UE should request a MA PDU Session when the UE applies a URSP rule, which triggers the UE to establish a new PDU Session and the Access Type Preference component of the URSP rule indicates "Multi-Access".
- The 5G QoS model for the Single-Access PDU Session is also applied to the MA PDU Session, i.e. the QoS Flow is the finest granularity of QoS differentiation in the MA PDU Session. One difference compared to the Single-Access PDU Session is that in a MA PDU Session there can be separate user-plane tunnels between the AN and the PSA, each one associated with a different access. The SMF shall provide the same QFI in 3GPP and non-3GPP accesses so that the same QoS is supported in both accesses. Non GBR QoS Flow can be distributed over 3GPP access and non 3GPP access, but GBR QoS Flow is transferred over single access.
- ATSSS is currently not supported when moving to EPC from 5GC, except for the specific case with wireline access integrated to EPC/5GC with 5G-RG; ATSSS with one User Plane leg in E-UTRA/EPC and one User Plane leg in wireline/5GC is supported.

**References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820044,760052,820021,830016,830057,830058,830059,840999,840998>

- [1] TR 23.793: "Study on ATSSS".
- [2] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [3] TS 23.502: "Procedures for the 5G System; Stage 2".
- [4] TS 23.503: "Policy and Charging Control Framework for the 5G System; Stage 2".

## 11 Railways and Maritime

### 11.1 Mobile Communication System for Railways 2

760054	Mobile Communication System for Railways 2	MONASTERY2		SP-170451	Merkel, Juergen, Nokia
760005	Study on MONASTERY2	FS_FRMCS2	S1	SP-170588	Merkel, Juergen, Nokia
790023	Study on application architecture for the Future Railway Mobile Communication System (FRMCS) Phase 2	FS_FRMCS2_SA6	S6	SP-181133	Oettl, Martin, Nokia
760004	Stage 1 of MONASTERY2	MONASTERY2	S1	SP-170451	Merkel, Juergen, Nokia
830007	Application Architecture for MONASTERY2	MONASTERY2	S6	SP-190064	Oettl, Martin, Nokia
840009	CT aspects of MONASTERY2	MONASTERY2	ct	CP-191152	Gkatzikis, Lazaros (Nokia)
840072	CT1 aspects of MONASTERY2	MONASTERY2	C1	CP-191152	Gkatzikis, Lazaros (Nokia)
840073	CT3 aspects of MONASTERY2	MONASTERY2	C3	CP-191152	Gkatzikis, Lazaros (Nokia)

Summary based on the input provided by Nokia in SP-200941.

This Feature introduces a set of additional requirements on top of Rel-15 to support the specific communication needs of railways. It also corrects inconsistencies and clarifies ambiguities.

Amongst others functionality was added to the multi-talker functionality e.g. to allow a MCX User to manually override multi talker requests was introduced and the support of supplementary services for railway communication (private calls). A lot of focus was put on interworking between FRMCS and GSM-R and a lot of refinement effort was spent on the handling and the integration of functional alias into the 3GPP system.

All three stages were affected by this work and work was covered by CRs to TS 22.179, 22.280, 22.281, 22.282, 23.280, 23.281, 23.282, 23.282, 23.379, 24.379, 24.481, 24.483 and 23.484 under the MONASTERY2 Work Item.

#### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=760054,760005,790023,760004,830007,840009,840072,840073>

### 11.2 Further performance enhancement for LTE in high speed scenario

Unique ID	Name	Acronym	WG	WID	WI Rapporteur
800079	Further performance enhancement for LTE in high speed scenario	LTE_high_speed_enh 2	R4	RP- 181482	NTT DOCOMO

Summary based on the input provided by NTT DOCOMO, INC. in RP-192721.

In Rel-13 and 14, the mobility and throughput performance were enhanced to cover high speeds (up to 350 km/h) by specifying the requirements for UE RRM, UE demodulation and base station demodulation, considering the two types of operator's practical deployments shown in Figures 1 and 2. Figure 1 shows the case where no specific installation is deployed to handle high-speed trains, i.e. UEs in the train use the "standard" LTE eNBs. Alternatively, figure 2 shows the case where Single Frequency Network (SFN) are deployed. SFNs use so-called "Remote Radio Heads" (RRH), which are dedicated antennas deployed along the train track. In this case, the baseband unit (BBU) is connected to the RRH, e.g. using fiber.

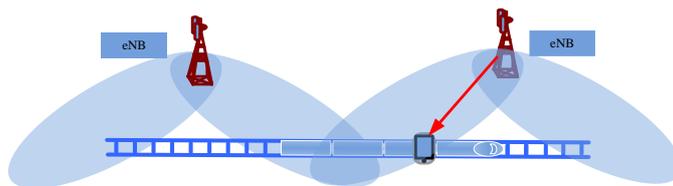


Figure 1. Non-Single Frequency Network (SFN) high speed scenario

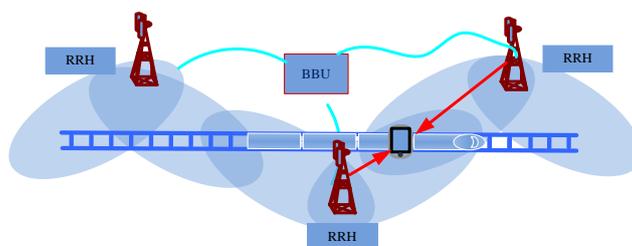


Figure 2. SFN high speed scenario

These Rel-13 and 14 enhancements were conducted both for non-SFN and for SFN, but only for LTE single carrier, i.e. not covering Carrier Aggregation (CA).

This Rel-16 work item further improves the mobility and throughput performance, now considering CA and speeds up to 500 km/h. To this aim, it enhances RRM, UE demodulation and base station demodulation: it specifies enhanced RRM core requirements and corresponding RRC signals in respectively TS 36.133 [2] and TS 36.331 [3].

#### Part 1: RRM requirements enhancements:

In Release 14 cases (limited to 350 km/h and single carrier), the latency requirements under DRX configuration up to 1.28s DRX cycle were enhanced by reducing the cell identification delay in connected mode and cell reselection delay in idle mode [1].

In Rel-16, considering Carrier Aggregation and speeds up to 500km/h, the following enhanced requirements were introduced to achieve good mobility performance and less paging outage:

1. **Enhanced RRM requirements for active SCells (for 350km/h velocity):**  
The same requirements specified in Rel-14 high speed WI are applied to active SCells.
2. **Enhanced RRM requirements for deactivated SCells (for 350km/h velocity):**  
The cell identification delay and measurement period are reduced.
3. **Enhanced RRM requirements in DRX in connected mode (for 500km/h velocity):**  
The cell identification delay and measurement period on 1.28s DRX cycle are further reduced from those in Rel-14 high speed WI.
4. **Enhanced RRM requirements in idle mode (for 500km/h velocity):**  
The cell detection delay is further reduced from those in Rel-14 high speed WI.
5. **Enhanced UL timing adjustment requirements in connected mode (for 500km/h velocity):**  
The larger maximum autonomous time adjustment step is applied when the downlink bandwidth is wider than 10MHz.

#### Part 2: Demodulation enhancements

##### 6. For UE and base station demodulation enhancements

In Release 14, UE and base station demodulation requirements were enhanced [1], for both cases of operator's practical deployments shown in figures 1 and 2.

In Release 16, regarding the CA case in SFN (figure 2), the requirements specified in Rel-14 are expanded to Dual Connectivity's Secondary Cells (SCells) as defined in TS 36.331 [3]. Regarding further high speed up to 500 km/h, additional requirements are introduced to ensure the PDSCH/PUSCH/PRACH demodulation performance with larger Doppler shift.

The impacts on RRC signals to meet the new requirements above are also specified.

#### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800079>

- [1] RP-160172, Rel-14 WID on "Performance enhancements for high speed scenario in LTE"  
 [2] TS 36.133, "Requirements for support of radio resource management."  
 [3] TS 36.331, "Radio Resource Control."

## 11.3 NR support for high speed train scenario

840092	<a href="#">NR support for high speed train scenario</a>	NR_HST	R4	RP-191512	CMCC
840192	Core part: NR support for high speed train scenario	NR_HST-Core	R4	RP-191512	CMCC
840292	Perf. part: NR support for high speed train scenario	NR_HST-Perf	R4	RP-191512	CMCC

Summary based on the input provided by CMCC in RP-200776.

This WI targets to specify the UE RRM requirements, UE/BS demodulation requirements for high speed train scenario. The supported velocity is up to 500km/h and the carrier frequency is up to 3.6GHz covering both TDD and FDD.

In Rel-16 WI on NR support of high speed train scenarios, the enhanced RRM requirements and demodulation requirements were specified to support the speed of up to 500km/h and carrier frequency is up to 3.6GHz.

For RRM, to guarantee the mobility performance for the scenario with velocity up to 500km/h, both enhanced requirements for NR intra-RAT measurement and enhanced requirements for inter-RAT measurement between NR and EUTRA are specified. The enhanced requirements for NR intra-RAT include NR cell re-selection requirements, NR cell identification requirements, beam management requirements. The enhanced requirements for inter-RAT measurement between NR and EUTRA include EUTRA inter-RAT measurement requirements and NR inter-RAT measurement requirements, both idle mode and connected mode are considered.

For UE demodulation, HST-SFN (multiple RRHs are connected to one BBU with fiber), HST single tap and multi-path fading channel are considered. For HST-SFN, the maximum doppler shift is 1667Hz (500km/h + 3.6GHz) and 870Hz for 30KHz SCS and 15KHz SCS respectively. For HST single tap, the maximum doppler shift is 1667Hz and 972Hz for 30KHz SCS and 15KHz SCS respectively. For multi-path fading channel, the maximum doppler shift is 1200Hz and 600Hz for 30KHz SCS and 15KHz SCS respectively. For BS demodulation, at least HST single tap is considered. And the maximum doppler shift is 3334Hz and 1740Hz for 30KHz SCS and 15KHz SCS respectively.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840192,840292>

## 11.4 Maritime Communication Services over 3GPP System

800011	<a href="#">Maritime Communication Services over 3GPP System</a>	MARCOM	S1	SP-180594	Hyouunhee Koo, SyncTechno Inc
730007	Study on Maritime Communication Services over 3GPP system	FS_MARCOM	S1	SP-170453	SyncTechno Inc., Hyouunhee Koo
800051	Stage 1 of MARCOM	MARCOM	S1	SP-180594	Hyouunhee Koo, SyncTechno Inc

Summary based on the input provided by SyncTechno Inc. in SP-200344.

The MARCOM feature introduces service requirements to enable maritime communication services to be supported over 3GPP system in TS 22.119 [1]. With the MARCOM feature, the work on maritime communication services is officially included in the scope of 3GPP standardization so 3GPP enabling technologies can be applicable to for maritime usage from 3GPP Release 16 onwards.

The first 3GPP Technical Specification (TS) 22.119 [1] covering service requirements (Stage 1) is specified for the support of maritime communication (MARCOM) over 3GPP systems.

The maritime domain, one of the 5G vertical domains in 3GPP, is moving forward with the digitalisation and mobilisation of commercial as well as safety fields. Legacy 3GPP-based technologies and solutions can be beneficial to the digitalisation and mobilisation of the maritime domain though some of the legacy 3GPP enabling technologies and solutions may not be able to fully support the performances required by the maritime domain. The maritime radio environment was not originally considered by 3GPP when the technical specifications and solutions were standardised for LTE and 5G.

However, most of the legacy mobile services and IoT services based on capabilities of EPS and 5GS specified in 3GPP specifications are applicable to maritime usage for the support of mobile broadband services, and for the support of IoT services or machine-type communication services in a vessel at sea.

In addition, there are service scenarios and requirements specified in 3GPP specifications based on requirements of other related vertical domains (e.g. public safety domain, automotive domain, factory automation domain, and satellite industrial domain). Some requirements derived by service scenarios from these related vertical domains are applicable to the maritime domain. Thus, it is beneficial to use 3GPP enabling technologies developed to satisfy those requirements for the maritime domain in terms of the economy of scale.

For example, satellite access is one of the 3GPP radio access networks supported over the 5G system, so it is possible to provide seamless maritime mobile services by integrating multiple access technologies including satellite access depending on the service scenarios. In addition, Vertical LAN that can replace Ethernet-based access are applicable to indoor maritime mobile services inside a vessel.

MC Services specified in 3GPP specifications are applicable to commercial and maritime safety fields. Some similarities exist between the public safety domain and the maritime domain in terms of service scenarios that are essentially the same. For example, in some situations, mobile communication services are supported in spite of disconnected networks, i.e. off-network mode, or under isolated conditions.

However, the maritime domain also has specific situations that do not happen in other vertical domains or in the legacy ICT industrial domain. New 3GPP enabling technologies dedicated to the maritime domain can be used to address such specific situations based on requirements derived from maritime use cases. Other vertical domains may benefit from such new 3GPP enabling technologies that consider maritime domain scenarios and may need more robust technologies or solutions than those that currently exist for those vertical domains.

The stage 1 requirements in TS 22.119 [1] are specific to maritime usage over 3GPP system for commercial as well as safety purposes. The stage 1 requirements derived from specific maritime usage but also related to MCX Services are specified in 3GPP technical specifications dedicated to MCX Services [2] [3] [4] [5].

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800011,730007,800051>

[1] TS 22.119, Maritime communication services over 3GPP system

[2] TS 22.179, Mission Critical Push to Talk (MCPTT); Stage 1

[3] TS 22.280, Mission Critical (MC) services common requirements

[4] TS 22.281, Mission Critical (MC) video

[5] TS 22.282, Mission Critical (MC) data

# 12 Mission Critical, Public Warning

## 12.1 Enhancements of Public Warning System

780003	<b>Enhancements of Public Warning System</b>	ePWS		SP-170998	Hyouhee Koo, SyncTechno Inc.
730005	<b>Study on enhancements of Public Warning System</b>	FS_ePWS	S1	SP-160733	SyncTechno Inc., Hyouhee Koo
800052	<b>Stage 1 of ePWS</b>	ePWS	S1	SP-170998	Hyouhee Koo, SyncTechno Inc.
810012	<b>CT aspects of enhancements of Public Warning System</b>	ePWS	ct	CP-191155	Hyouhee Koo, SyncTechno Inc.
810053	Study on stages 2 and 3 of enhancements of ePWS	ePWS	C1	CP-191155	Hyouhee Koo, SyncTechno Inc.
810047	CT1 aspects of ePWS	ePWS	C1	CP-191155	Hyouhee Koo, SyncTechno Inc.
810048	CT4 aspects of ePWS (Possible impacts)	ePWS	C4	CP-191155	Hyouhee Koo, SyncTechno Inc.

Summary based on the input provided by SyncTechno Inc. in SP-200343.

The ePWS feature enhances the Public Warning System by defining behaviours for UEs with no user interface or with a user interface that is incapable of displaying text-based Warning Notifications and providing how to improve the comprehension of a Warning Notification to users with disabilities who have UEs supporting assistive technologies beyond text assistive technologies and users who are not fluent in the language of the Warning Notifications. In addition, additional requirements are specified for PWS-UEs and ePWS-UEs that play the role of a relay UE or a remote UE to conform behaviours when receiving a Warning Notification via the relay functionality. The requirements can be found in TS 22.268 [1] and corresponding solutions in TS 23.041 [2].

Additional requirements for an enhanced Public Warning System (ePWS) are specified as an update to Technical Specification (TS) 22.268 [1].

3GPP Public Warning Systems were first specified in Release 8, allowing for direct warnings to be sent to mobile users on conventional User Equipment (PWS-UE), capable of displaying a text-based and language-dependent Warning Notification.

Since that time, there has been a growth in the number of mobile devices with little or no user interface - including wrist bands, sensors and cameras – many of which are not able to display Warning Notifications. The recent growth in the number of IoT devices - not used by human users – also highlights the need for an alternative to text based Warning Notifications. If those devices can be made aware of the type of incident (e.g. a fire or flood) in some other way than with a text message, then they may take preventive actions (e.g. lift go to ground floor automatically).

The ePWS feature also specifies how graphical symbols or images can now be used to better disseminate Warning Notifications, specifically aimed at the following categories of users:

- Users with disabilities who have UEs supporting assistive technologies beyond text assistive technologies; and
- Users who are not fluent in the language of the Warning Notifications.

Much of the work on enhancing the Public Warning System is set out in the ePWS requirements in TS 22.268 [1] and in ePWS protocol solutions in TS 23.041 [2] in Release 16, covering:

- Specifying Message Identifiers for ePWS-UE, especially IoT devices that are intended for machine type communications
- Enabling language-independent content to be included in Warning Notifications

The work on ePWS in TS 22.268 [1] and TS 23.041 (Release 16) is expected to help manufacturers of User Equipment meet any future regulatory requirements dedicated to such products.

Requirements defined for PWS-UEs in clause 4 of TS 22.268 [1] are applicable for ePWS-UEs unless dedicated ePWS-UE requirements described in clause 9 of TS 22.268 [1] supersede them.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=780003,730005,800052,810012,810053,810047,810048>

[1] TS 22.268, Public Warning System (PWS) requirements

[2] TS 23.041, Technical realization of Cell Broadcast Service (CBS)

## 12.2 MBMS APIs for Mission Critical Services

800053	<a href="#">MBMS APIs for Mission Critical Services</a>	MBMSAPI_MCS	S6	SP-180380	Ling Zhang, TD Tech Ltd.
760051	<a href="#">Study on MBMS APIs for MC Services</a>	FS_MBMSAPI_MC	S6	SP-180237	Ling Zhang, TD Tech Ltd
800020	<a href="#">Stage 2 of MBMS APIs for MC Services</a>	MBMSAPI_MCS	S6	SP-180380	Ling Zhang, TD Tech Ltd.

Summary based on the input provided by CATT, TD-Tech in SP-201001.

This WI defines the system architecture and a set of UE API functions that allow the Mission Critical applications to access the MBMS capabilities without implementing the logic of MBMS operations. The MBMSAPI\_MCS intends to offer the API within the UE to ease the development of Mission Critical Services across different phone platforms, and to provide decoupling between the platform MBMS functions and the mission critical application call control functions.

The WI defines the system architecture for the UE API that complies with GCSE as defined in TS 23.468 [2], and the API functions that support the use of MBMS transmission for Mission Critical services as defined in TS 23.280 [3], TS 23.379 [4], TS 23.281 [5] and TS 23.282 [6].

The following API functions have been specified with the corresponding procedures and parameters for the Mission Critical applications to:

- Obtain the MBMS SAI or cell information of the UE and the relevant updates;
- Perform registration or deregistration for a Mission Critical application for its access to the MBMS service on the UE;
- Exchange information about an announced or de-announced MBMS bearer with the API provider on the UE;
- Get notified about events related to the MBMS bearer availability and quality;
- Start or close the reception of a given media delivered over MBMS;
- Retrieve the capabilities (e.g. FEC and ROHC) from the API provider on the UE.

## References

- [1] SP-180380: "New WID on MBMS APIs for Mission Critical Services".
- [2] TS 23.468: "Group Communication System Enablers for LTE (GCSE\_LTE); Stage 2".
- [3] TS 23.280: "Common functional architecture to support mission critical services; Stage 2".
- [4] TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2".
- [5] TS 23.281: "Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2".
- [6] TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCData); Stage 2".
- [7] TR 23.792: "Study on MBMS APIs for Mission Critical Services".

## 12.3 Mission Critical Services Security Enhancements

800032	Mission Critical Services Security Enhancements	MCXSec	S3	SP-180596	Woodward, Tim, Motorola Solutions, Inc
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Summary based on the input provided by Qualcomm Incorporated in SP-190865.

Mission critical (MC) services security enhancements provide the confidentiality, integrity, user authentication, service authorization and overall security architecture for the Release 16 mission critical features (MCPTT, MCVideo, MCData, MC Location, MC Interworking, MC Interconnection, and MC Railway).

Release 16 expands on the mission critical security architecture already defined in previous releases along with various mission critical security clarifications and corrections.

In this release, mission critical security adds user service authorization for the mission critical location service. Similar to user service authorization for the other MC services, an appropriately scoped access token is obtained from the Identity Management server which permits only authorized users to access the MC location service.

MCData payload protection is enhanced to support separate algorithm types for the MCData payload field and the signalling parameters field, Data signalling payload field and end to end security parameters fields. This allows the architecture to meet varying security needs of the mission critical operator for both on and off network MCData operational scenarios.

Security for interconnection now combines the MC gateway, Interconnection Signalling (IS) proxy and HTTP proxy to provide topology hiding, HTTP protection and signalling protection for inter-domain MCPTT, MCData and MCVideo communications between two disparate mission critical systems for a complete interconnection security solution.

The security foundation for dynamic rekeying of 3GPP interworking mission critical users across the IWF from a Land Mobile Radio system is further enhanced to support pre-provisioning of interworking key management records. The KMS provides these records to the UE (i.e. mission critical user) during service authorization to establish the initial key material needed to support protection of interworking communications.

### References

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800032>

[1] TS 33.180, Security of the mission critical service; (Release 16)

## 12.4 Other Mission critical improvements

### 12.4.1 MCData File Distribution support over xMB

810004	MCData File Distribution support over xMB	MC_XMB	S4	SP-180665	Thiénot Cédric, Expway
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Summary based on the input provided by Expway.

This work item summary reports on standardization of the "xMB extension for mission critical services (MC\_XMB)" specified in [1].

To deliver group communications over MBMS, MCPTT and MCVideo make use of GCSE (Group Communication System Enabler), where MBMS bearers are activated and managed over MB2-C by the mission critical applications servers to transparently transport any packets pushed over MB2-U.

To ensure reliable and efficient transport of files over a unidirectional and lossy channel such as MBMS requires a dedicated protocol stack. SA4, in the conclusion of the TR 26.881 [4], recommends reuse of the MBMS download delivery method for MCDATA file distribution, which is supported by the xMB/MBMS API interfaces.

In the context of this for MCDATA file distribution, different extensions have been required.

First of all, in TS 26.348 [2], several functions to the xMB interfaces have been added:

- QOS management: The ability for a mission critical solution provider to control precisely the allocation of network resources has been added.
- Target geographical management: Geographical area semantics in xMB have been aligned with the MB2-C AVP for mission critical services
- TMGI exposure: the TMGI allocated during the MBMS session creation has been exposed.

Moreover, in TS26.346 [3] a new service announcement mode named “self-contained” mode has been added, indicating that the service announcement metadata for this service is delivered in-band with the data (i.e. in the same MBMS bearer).

All these functions have been integrated to ensure an efficient usage of the MBMS download delivery method for MCDATA file distribution

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810004>

- [1] SP-180665, ” New WID on xMB extension for mission critical services (MC\_XMB)”
- [2] TS 26.348, “Northbound Application Programming Interface (API) for Multimedia Broadcast/Multicast Service (MBMS) at the xMB reference point”
- [3] TS 26.348, “Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs”.
- [4] TR 26.881, “Forward Error Correction (FEC) for Mission Critical Services”

## 12.4.2 Enhanced Mission Critical Communication Interworking with Land Mobile Radio Systems

800021	<a href="#">Enhanced Mission Critical Communication Interworking with Land Mobile Radio Systems</a>	eMCCI	S6	SP-180680	Derek Wells, L3Harris (was Peter Monnes, Harris Corporation)
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Summary based on the input provided by L3Harris.

This Stage 2 work item provides architectural features to support interworking between Mission Critical systems and Land Mobile Radio systems in the specific areas of Group Calls, Emergency Calls, Group Regroups, Unit to Unit Calls, user location, functional aliases and encryption.

The main impacts to the 3GPP MC system architecture introduced by this work item are the enhancements to enable users engaged in public safety scenarios to interwork between MC systems and LMR Radio Systems. Features such as Group Call (one to many), group emergency notifications, grouping of users and grouping of groups (for gathering many users on the same group), and functional aliases are all common in Land Mobile Radio systems and novel to 3GPP MC systems. Features such as unit to unit call, user location and traffic encryption are common to both types of systems but needed integration. This eMCCI work item provides the means to utilize these features across the two types of systems. Other work performed in TS 23.280 and TR 23.379 and various work items enable the features in the 3GPP MC system architecture.

Note: Stage 3 was not completed at the time when this summary was introduced in the present document (Dec. 2020).

## References

- [1] TS 23.283, Mission Critical Communication Interworking with Land Mobile Radio Systems

### 12.4.3 MBMS APIs for Mission Critical Services

800053	<a href="#">MBMS APIs for Mission Critical Services</a>	MBMSAPI_MCS	S6	SP-180380	Ling Zhang, TD Tech Ltd.
760051	<a href="#">Study on MBMS APIs for MC Services</a>	FS_MBMSAPI_MC	S6	SP-180237	Ling Zhang, TD Tech Ltd
800020	<a href="#">Stage 2 of MBMS APIs for MC Services</a>	MBMSAPI_MCS	S6	SP-180380	Ling Zhang, TD Tech Ltd.

Summary based on the input provided by CATT, TD-Tech in SP-201001.

The WI defines the system architecture and a set of UE API functions that allow the Mission Critical applications to access the MBMS capabilities without implementing the logic of MBMS operations. The MBMSAPI\_MCS intends to offer the API within the UE to ease the development of Mission Critical Services across different phone platforms, and to provide decoupling between the platform MBMS functions and the mission critical application call control functions.

The WI defines the system architecture for the UE API that complies with GCSE as defined in TS 23.468 [2], and the API functions that support the use of MBMS transmission for Mission Critical services as defined in TS 23.280 [3], TS 23.379 [4], TS 23.281 [5] and TS 23.282 [6].

The following API functions have been specified with the corresponding procedures and parameters for the Mission Critical applications to:

- Obtain the MBMS SAI or cell information of the UE and the relevant updates;
- Perform registration or deregistration for a Mission Critical application for its access to the MBMS service on the UE;
- Exchange information about an announced or de-announced MBMS bearer with the API provider on the UE;
- Get notified about events related to the MBMS bearer availability and quality;
- Start or close the reception of a given media delivered over MBMS;
- Retrieve the capabilities (e.g. FEC and ROHC) from the API provider on the UE.

#### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800053,760051,800020>

- [1] SP-180380: "New WID on MBMS APIs for Mission Critical Services".
- [2] TS 23.468: "Group Communication System Enablers for LTE (GCSE\_LTE); Stage 2".
- [3] TS 23.280: "Common functional architecture to support mission critical services; Stage 2".
- [4] TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2".
- [5] TS 23.281: "Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2".
- [6] TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCDData); Stage 2".
- [7] TR 23.792: "Study on MBMS APIs for Mission Critical Services".

### 12.4.4 Enhancements to Functional architecture and information flows for Mission Critical Data

830051	<a href="#">Enhancements to Functional architecture and information flows for Mission Critical Data</a>	eMCDData2	S6	SP-180378	Shih, Jerry, AT&T
800018	<a href="#">Stage 2 of eMCDData2</a>	eMCDData2	S6	SP-180378	Shih, Jerry, AT&T
830014	<a href="#">CT aspects of eMCDData2</a>	eMCDData2	C1	CP-190199	Val Oprescu (AT&T)

Summary based on the input provided by at&t in SP-201083.

The following Mission Critical Data functionalities have been introduced in Rel-16:

- (a) A new network-based MCDData message store has been added to allow a MCDData user to store its MCDData communication history permanently by providing secured storage area for each authorized MCDData user having a user account. A user (i.e. a dispatcher) other than the user account holder shall be able to access the account holder's storage area if authorized. A user can synchronize his MCDData message store account with his devices (UEs) to get consistent user experience across all his devices.
- (b) A new network based MCDData content server has been added to allow file distribution indirectly; this function was implemented in the MCDData server in R15. As a standalone network entity, the MCDData content server provides complete functions of shared file cycle management and takes away processing burden from the MCDData server and increasing its MCDData communication capacity.
- (c) IP Connectivity is now supported. The non MCDData clients can use the IP connectivity feature between two MCDData client to exchange data payloads.

- (d) Introduction of MC Gateway server for flexible interconnection.
- (e) Supports of functional alias. A MCDData user can connect to other MCDData users based on the functional alias they are registered.
- (f) Supports of emergency alert function for all MCDData services.
- (g) MBMS supports for file distribution. With file has been uploaded to the MCDData content server, the MCDData server uses MBMS to efficiently deliver the file to the recipients. For any missing parts of the file, the recipient can retrieve it directly from the MCDData content server where the file was uploaded.
- (h) Share of user location information. The sender's location information can be shared with the recipient for all MCDData services.

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

1. The architecture (including information flows, procedures, and configuration) is specified in TS 23.282 and TS 23.280;
2. The security aspects are specified in TS 33.180;
3. The protocol aspects for call control and media plane are specified in TS 24.282 and TS 24.582 respectively;
4. The protocol aspects 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;
5. The protocol aspects for policy and charging control are specified in TS 29.213 and TS 29.214;
6. The protocol aspects for data management related to MC service user profile are specified in TS 29.283;
7. The stage 2 aspects of the Proximity-based services (ProSe) enabler are specified in TS 23.303.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830051,800018,830014>

- [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;
- [4] TS 23.280 Common functional architecture to support mission critical services; Stage 2;
- [5] TS 23.303 Proximity-based services (ProSe); Stage 2;
- [6] TS 23.468 Group Communication System Enablers for LTE (GCSE\_LTE); Stage 2;
- [7] TS 24.282 Mission Critical Data (MCDData) signalling control; Protocol specification;
- [8] TS 24.582 Mission Critical Data (MCDData) media plane control; Protocol specification;
- [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 applications;
- [16] TS 33.180: Security of the mission critical service.

## 12.4.5 MC Communication Interworking

800016	<a href="#">Stage 3 for MC Communication Interworking with Land Mobile Radio Systems</a>	MCCI_CT	C1	CP-190203	Monnes, Peter, Harris Corporation -> Derek Wells (of I3Harris)
820040	<a href="#">Mission Critical system migration and interconnection</a>	MCSMI_CT	C1	CP-190143	Dom Lazara, Motorola Solutions
760050	<a href="#">MC Communication Interworking between LTE and non-LTE Systems</a>				

Summary based on the input provided by Sepura Ltd; L3Harris Technologies in SP-201111.

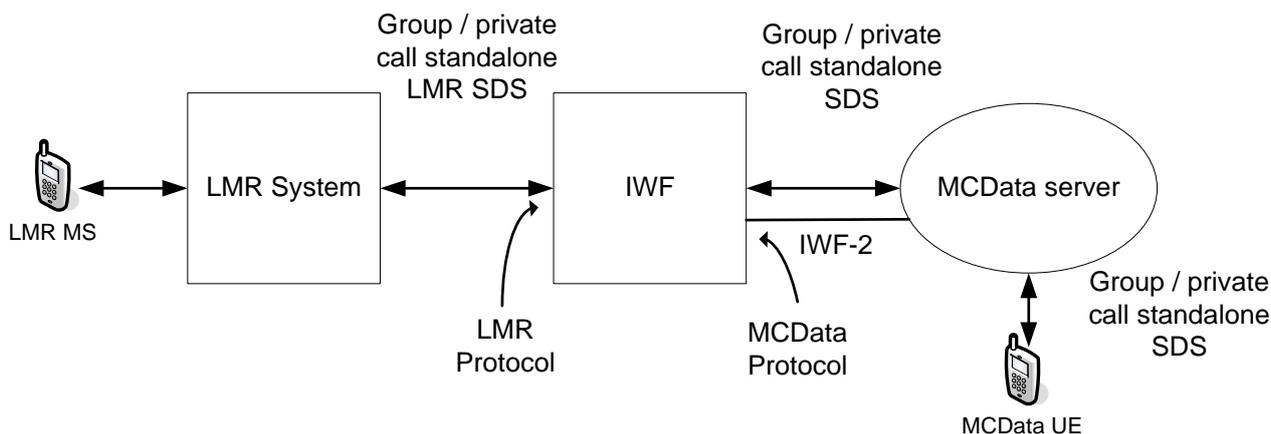
For Release 16 implementation, the MCCI work was contained in two work items: MCCI for stage 2 and MCCI\_CT for stage 3.

Interworking between MC systems and LMR systems allows the systems to be connected for the purpose of carrying calls and data messaging between the participants in both systems.

For Release 16, the purpose of the LMR interworking enhancements to the MC system was to enable interconnection of a MCPTT or MCDData system to an LMR system to support MCPTT and MCDData SDS interworking, based on Stage 3 implementation of the Stage 2 TS 23.283 architectures, procedures and functional flows developed during Release 15.

The general architectural principle was to define a logical Interworking Function (IWF) (representing an LMR system) on a Mission Critical (MCPTT or MCDData) server to allow a server – server based connection between the IWF and the MC system, and develop the procedures and functional flows for an IWF by basing them on those already identified for the corresponding server-server communication within the MC system.

An IWF is composed of two parts: the first is an interface to the relevant MC server: IWF-1 (based on a subset of the MCPTT reference points described in TS 23.379), IWF-2 (based on a subset of the MCDData reference points described in TS 23.282) and IWF-3 between the IWF and the Group Management Server. The second part of the IWF is an interface to the LMR system based on reference points defined by the LMR system. This provides a generic architecture to interwork between LMR systems such as TETRA, P25 and DMR, as well as a framework for interworking with other non-MC systems – e.g. GSM-R. An illustration of this for MCDData interworking is in Figure 1.



**Figure 1: Illustration of Interworking architecture for MCDData SDS**

The subsequent documentation approach in Stage 3 was to document the differences between existing relevant MCPTT / MCDData functionality and the primitives & process needed for the same purpose in interworking. The late completion of the Stage 2 meant that the Release-16 Stage 3 developed initially based on the Release 15 Stage 2 described in TS 23.283.

The features that have been completed are :

- affiliation;
- group calls;
- private calls;
- broadcast calls;
- temporary calls;
- emergency calls and alerts;
- talker location;
- floor control;
- codec negotiation;
- short data service, including status;
- 3GPP encryption; and
- messaging and configuration support for LMR based key management and end-to-end encryption.

The architecture, protocol, and security aspects of MCCI are described in the following specifications:

- The architecture (including information flows, procedures, and configuration) is specified in TS 23.283.
- The protocol aspects for MCPTT call control and media plane are specified in TS 29.379 and TS 29.380 respectively;
- The protocol aspects for MCDData call control are specified in TS 24.952;
- The security aspects are specified in TS 33.180.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800016,820040,760050>

[1] TS 22.179: "Mission Critical Push to Talk (MCPTT); Stage 1";

[2] TS 23.283: "Mission Critical Communication Interworking with Land Mobile Radio Systems; Stage 2";

- [3] TR 24.883: "Mission Critical Systems Connection to LMR";
- [4] TS 29.379: "Mission Critical Push To Talk (MCPTT) call control interworking with Land Mobile Radio (LMR) systems; Stage-3";
- [5] TS 29.380: "Mission Critical Push To Talk (MCPTT) media plane control interworking with Land Mobile Radio (LMR) systems; Stage 3";
- [6] TS 29.582: "Mission Critical Data (MCData) interworking with Land Mobile Radio (LMR) systems; Stage 3";
- [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 23.282: "Functional architecture and information flows to support Mission Critical Data (MCData); Stage 2".
- [10] TS 24.379: "Mission Critical Push To Talk (MCPTT) call control; Protocol specification";
- [11] TS 24.282: "Mission Critical Data (MCData) signalling control; Protocol specification";
- [12] TS 33.180: "Security of the mission critical service".

## 12.4.6 Enhanced Mission Critical Push-to-talk architecture phase 2

80022	Enhanced Mission Critical Push-to-talk architecture phase 2	enh2MCPTT	S6	SP-190068	Dom Lazara; Motorola Solutions
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Summary based on the input provided by Motorola Solutions in SP-201114.

For Release 16, the enhancements to the MCPTT service were contained in three work items: enh2MCPTT for stage 2 (SA6), Enhanced Mission Critical Push-to-talk architecture phase 2; enh2MCPTT-CT for stage 3 (CT1), CT aspects of enh2MCPTT; and MCXSec for stage 2 and 3 (SA3), Mission Critical Services Security Enhancements. The corresponding items which have been completed in Release 16 are described in the following clause.

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

The following features have been newly introduced or enhanced.

### Group and user regrouping using preconfigured group

- Regroup using a preconfigured group refers to the creation of a user or group regroup based on the configuration information associated with an existing group that is referred to as the preconfigured group. This type of regroup takes its entire configuration from the preconfigured group, including initial security information. Since all MCPTT clients participating in the regroup operation are already configured with the preconfigured group information, this allows immediate use of the regroup for a group call upon initiation of the regroup.
- A regroup using a preconfigured group is initiated without the creation of a new group document in the group management server. The advantage of regroup using a preconfigured group is speed of setup of the regroup, especially when large numbers of users (e.g. hundreds) may be involved. Control of the regroup using a preconfigured group is contained in the MCPTT server (namely the controlling MCPTT function). Creation and removal of a regroup is initiated by an authorized MCPTT client. Removal of the regroup can also be initiated by the MCPTT server based on certain criteria.
- A group regroup may be achieved by regrouping MCPTT groups into a new MCPTT regroup group which uses the configuration of a separate preconfigured MCPTT group.
- A user regroup may be achieved by regrouping MCPTT users into a new regroup group which uses the configuration of a separate preconfigured MCPTT group.
- The MCPTT regroup group can be specified to be a broadcast or non-broadcast type according to the configuration of the MCPTT group specified in the regroup request.
- The broadcast type of regroup is used for one-way communication where only an authorized MCPTT user is allowed to transmit and all other regroup users are only allowed to receive the communication (e.g. a call from a dispatcher to all regroup members).
- The non-broadcast type is used for two-way communication where all regrouped users can transmit and receive (i.e. a normal group call).

### Location enhancements for current talker and ambient listening

- Location of a current talker is a feature that allows the initiator of a group or private call transmission to share his current location via the media plane with every transmission (floor request that is granted). Based on privacy settings, the talker's location is delivered to the other affiliated members of the group, or to the receiving user in the private call.

- The ambient listening call is a type of a private MCPTT call that only allows a "listened to" user to transmit media to a "listening" user such that there is no indication on the MCPTT UE of the "listened to" user about the call and the media transmission.
- Remotely initiated ambient listening is initiated by the authorized user (e.g., dispatcher) who wants to listen to another user. In this case, the "listened to" user is the called party, and shall automatically accept the call without causing any indication about the call and transmit the media to the "listening" user.
- Locally initiated ambient listening is initiated by an authorized user who wants another user to listen to the MCPTT UE communication. In this case, the "listened to" user is the calling party and shall automatically transmit the media to the "listening" user without causing any indication about the call processing and media transmission.
- Enhancements have been made to more reliably deliver location via the media plane in the scenarios listed above.

#### Enhancements for entering or existing a geographic area

- Geographical affiliation and de-affiliation is a feature that allows an authorized MCPTT user to define a geographical area for the purposes of causing the target MCPTT client to affiliate to a group when within this geographic area. Upon leaving the geographic area the target MCPTT client is sent an indication to de-affiliate. The MCPTT system keeps track of the target MCPTT user's location and sends an indication to the MCPTT client upon entering or exiting the geographic area.
- Geographical sending of an emergency alert is a feature that allows an authorized MCPTT user to define a geographical area for the purposes of causing the target MCPTT client to send an emergency alert when within this geographic area. Upon leaving the geographic area the target MCPTT client sends an emergency alert cancel. The MCPTT system keeps track of the MCPTT user's location and sends an indication to the target MCPTT client upon entering or exiting the emergency alert area.
- Enhancements have been made to the polygon and ellipsoid-arc definition of area to more reliably define location when entering or existing the geographic area of interest.

#### Secure tunnel between key management server and key management client

- The establishment of a direct secure tunnel between the mission critical key management server and the mission critical key management client is required. Such a direct TLS tunnel needs to be an option for mission critical agencies that require stronger security.

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 MCPTT service architecture (including information flows, procedures, and configuration) is specified in TS 23.379 and TS 23.280;
3. The security aspects of the MCPTT service are specified in TS 33.180;
4. The protocol aspects of the MCPTT service for call control and media plane are specified in TS 24.379 and TS 24.380 respectively;
5. The protocol aspects of the MCPTT service 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;
6. The protocol aspects of the MCPTT service for codecs and media handling are specified in TS 26.179;
7. The protocol aspects of the MCPTT service for policy and charging control are specified in TS 29.213 and TS 29.214;
8. The protocol aspects of the MCPTT service for data management related to MC service user profile are specified in TS 29.283;

#### **References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800022>

[1] TS 22.179 Mission Critical Push To Talk (MCPTT) over LTE; Stage 1

[2] TS 22.280 Mission Critical Services Common Requirements (MCCoRe); Stage 1

[3] TS 23.379 Functional architecture and information flows to support Mission Critical Push-To-Talk (MCPTT); Stage 2

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

## 12.4.7 Other Mission Critical activities

800019	<a href="#">Enhanced Mission Critical System Migration and Interconnection</a>	eMCSMI	S6	SP-180379	Chater-Lea, David; Motorola Solutions
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eMCSMI: Stage-3 for eMCSMI not started after the completion of deadline for Rel-16 Stage 3. Awaiting clarifications on whether this all Feature can be moved to Rel-17.

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# 13 Conversational services, Streaming and TV

## 13.1 Conversational services

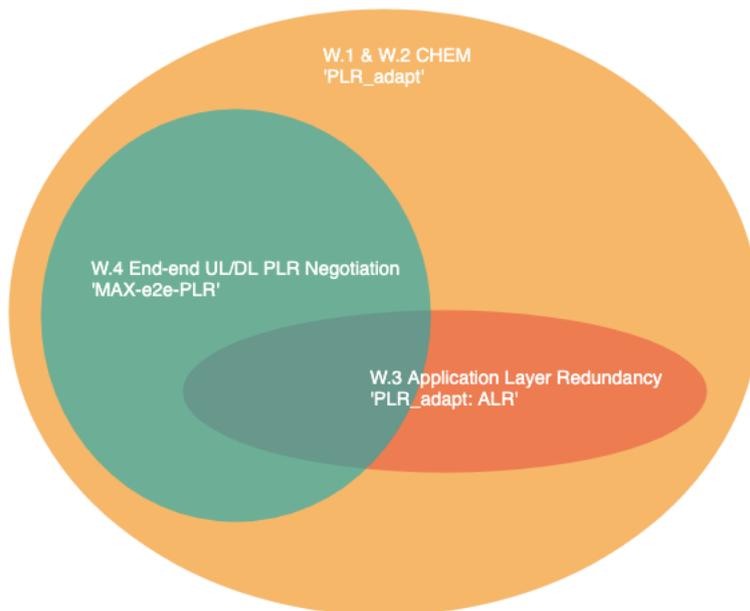
### 13.1.1 Coverage and Handoff Enhancements for Multimedia (CHEM)

810003	<a href="#">Coverage and Handoff Enhancements for Multimedia</a>	CHEM	S4	SP-180664	Nikolai Leung
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Summary based on the input provided by Qualcomm Incorporated in SP-190865.

The Coverage and Handoff Enhancements for Multimedia (CHEM) feature enables the network to delay or reduce handoffs of a Multimedia Telephony Service for IMS ( MTSI) terminal by providing the eNB/gNB additional information about the robustness to packet losses of the negotiated media configurations. The eNB/gNB can set handoff thresholds that allow the MTSI terminal to remain on the current sector, cell, access technology, or domain (packet-switched vs. circuit-switched) and avoid a handoff even when the MTSI terminal experiences higher packet loss on the traffic channel as the media configuration robustness will help mitigate the effects of the additional packet losses.

The feature is structured with a baseline core functionality and some optional enhancements as illustrated in Figure 1. The optional enhancements can be independently used with the core CHEM feature and each other. TR 26.959 [1] has also been updated to explain the operation and interaction of these options and the core feature.



**Figure 1: Core function and optional enhancements of the CHEM feature (references are to clauses in TS 26.114 [6]).**

The core CHEM functionality specified in clauses W.1 and W.2 of TS 26.114 [2] introduces the ‘PLR\_adapt’ SDP attribute that is used to negotiate the CHEM feature between the MTSI clients. MNOs choosing not to enable the feature can remove the attribute in the SDP negotiation. The attribute is also used by the PCRF/PCF to determine whether it can expect the MTSI clients to adapt to the most robust configurations that have been negotiated without relying in application layer redundancy. The PCRF/PCF uses this information to determine the appropriate PLR thresholds, i.e., choosing the PLR of the most robust mode when ‘PLR\_adapt’ is negotiated, and communicate the PLR thresholds to the eNB/gNB.

An optional enhancement specified in clause W.4 of TS 26.114 [2] enables the MTSI clients to indicate the maximum tolerable end-to-end PLRs for particular codec configurations and then negotiate how this end-to-end PLR can be budgeted across their respective uplinks and downlinks. Indicating maximum tolerable end-to-end PLR thresholds can be useful to account for differing client implementations of features, e.g., such as the de-jitter buffer and Packet-Loss-Concealment (PLC) in the media receiver, which can affect the maximum tolerable PLR for achieving a certain Quality of Experience (QoE). This enhancement uses the defined ‘MAX-e2e-PLR’ attribute and associated parameters to perform the necessary indication and negotiation. The PCRF/PCF uses the ‘MAX-e2e-PLR’ attribute information in the SDP answer to determine and communicate the appropriate PLR thresholds to the eNB/gNB.

Another optional enhancement for speech media specified in clause W.3 of TS 26.114 [2] is to support use of application layer redundancy to improve media robustness that, when used with the CHEM feature, can delay or avoid handing off an MTSI terminal. The optional ‘ALR’ parameter for the ‘PLR\_adapt’ attribute has been specified to enable this option and allows the MTSI clients to use newly specified in-band RTP CMR codepoints to request application layer redundancy without having to use RTCP-APP messages. The PCRF/PCF uses the presence of the ‘PLR\_adapt: ALR’ attribute and parameter in the SDP answer to determine the appropriate PLR thresholds based on the maximum tolerable PLRs of the codec configurations (among those that both use, and do not use, application layer redundancy), then communicates this to the eNB/gNB.

An Annex of TS 26.114 [2] provides example PLR values that can be used for different speech codecs and their configurations. The annex also provides SDP examples for using the specified SDP attributes and parameters.

## References

- [1] TR 26.959 “Study on enhanced Voice over LTE (VoLTE) performance”
  - [2] TS 26.114 “IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction”
- CRs related to this Feature: Select "TSG Status = approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810003>

### 13.1.2 Single radio voice continuity from 5GS to 3G

810041	Single radio voice continuity from 5GS to 3G	5G_SRVCC		SP-180737	Chi Ren, China Unicom
790010	Study for single radio voice continuity from 5GS to 3G	FS_5G-SRVCC	S2	SP-180239	Chi Ren, China Unicom
810007	Single radio voice continuity from 5GS to 3G	5G_SRVCC	S2	SP-180897	Chi Ren, China Unicom
820008	Security aspects of single radio voice continuity from 5GS to UTRAN	5GS_UTRAN_SEC	S3	SP-181037	Feng Gao, China Unicom
820069	RAN aspects of 5G_SRVCC	SRVCC_NR_to_UMTS	R2	RP-200151	China Unicom
820169	Core part: Single Radio Voice Call Continuity from 5G to 3G	SRVCC_NR_to_UMTS-Core	R2	RP-200151	China Unicom
830270	Perf. part: Single Radio Voice Call Continuity from 5G to 3G	SRVCC_NR_to_UMTS-Perf	R4	RP-200151	China Unicom
840004	CT aspect of 5G_SRVCC	5G_SRVCC	ct	CP-191062	Chi Ren, China Unicom
840058	CT1 aspect of 5G_SRVCC	5G_SRVCC	C1	CP-191062	Chi Ren, China Unicom
840059	CT4 aspect of 5G_SRVCC	5G_SRVCC	C4	CP-191062	Chi Ren, China Unicom

Summary based on the inputs provided by China Unicom in SP-200129 for global aspects and in RP-200152 for the radio aspects.

The work item of 5G\_SRVCC introduced a mechanism to support single radio voice call continuity (SRVCC) from 5GS to UTRAN for the following scenarios:

- Operators with both 5G Voice over IMS and LTE enabled, but no VoLTE.
- Operators with no LTE (nor VoLTE).
- Operators with both 5G Voice over IMS and VoLTE enabled, but the voice service continuity may not be guaranteed if the VoLTE coverage provided by the operators is not (ideal) complete, i.e. there are some “holes” of VoLTE coverage.

This work item implemented the conclusion of the study for single radio voice continuity from 5GS to 3G (FS\_5G-SRVCC) which is specified in TR 23.756[4]. The main enhancements introduced by this work item are specified in TS 23.216[3].

The architecture of 5G-SRVCC is illustrated in Figure 2-1. A simplified MME function (MME\_SRVCC) was introduced to facilitate session transfer (SRVCC) of the voice component to the CS domain. The support of N26 interface and Sv interface is required for the MME\_SRVCC.

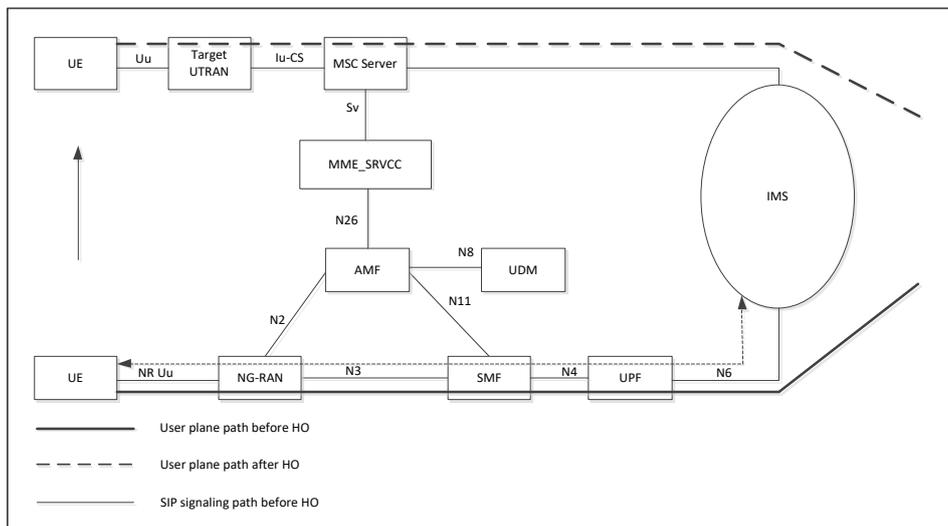


Figure 1: 5G-SRVCC architecture

The 5G-SRVCC mechanism defined by this work item is an indirect SRVCC from NG-RAN to UTRAN. When an UE moves out of the coverage of NG-RAN while a 5G voice session over IMS (either a normal voice session or an emergency session) is ongoing, a PS to CS handover procedure between 5GS and 3G CS is triggered by the NG-RAN. The 5G-SRVCC procedure including two main parts:

- 5GS to EPS handover using N26 procedure triggered by the NG-RAN.
- PS-CS handover procedure initiated by the selected MME\_SRVCC.

No E-UTRAN involved during the whole process. All the PDU sessions is released by the request of AMF at the end of the 5G-SRVCC procedure.

## References for global part

- [1] SP-180897, Single radio voice continuity from 5GS to 3G.
- [2] CP-193014, CT aspect of 5G\_SRVCC.
- [3] TS 23.216, Single Radio Voice Call Continuity (SRVCC); Stage 2.
- [4] TR 23.756, Study for single radio voice continuity from 5G to 3G.

## Radio part

In Rel-16, the WI “Single Radio Voice Call Continuity from 5G to 3G” was approved (latest WID in RP-200151). This work item aims to specify the support of SRVCC from 5GS to UTRAN in RAN. More specifically, the main objectives are as follows:

- Inter-RAT measurement to support voice service continuity from 5GS to UTRAN [RAN2, RAN1].
- Specify that the NG-RAN and UE in NR RRC connected mode support the UTRAN cell measurement procedure, e.g. measurement configuration of target UTRAN cells, and the measurement performing and reporting by UE.
- Indirect Inter-RAT handover procedure to support voice service continuity from 5GS to UTRAN [RAN2, RAN3].
- Specify the procedures of SRVCC (including emergency call) in RAN, which includes handover preparation between gNB and AMF, gNB and UE, and Handover execution between UE to RNS etc.
- Signalling of source RAT to target RAT at incoming SRVCC [RAN3].
- UE capability reporting for supporting SRVCC [RAN2, RAN3].
- Specify the transfer of UE capability information between UE, NG-RAN and AMF.
- RRM requirements to support voice service continuity from 5GS to UTRAN [RAN4].
- Requirements of NR handover to UMTS.
- Requirements of NR- UMTS inter-RAT measurements.

The key functionalities are:

- Support of the UTRAN cell measurement procedure for NR node and UE in NR RRC connected mode. A new measurement object for UTRA is defined to include only UTRA-FDD. - The UE is only required to measurement and report the listed cells. Periodic and event triggered (event B1/B2) reporting for UTRA measurement are both supported. The same measurement gap configuration for UTRA is reused in measurement in NR as in LTE.
- Support of inter-RAT handover procedure of SRVCC. MobilityFromNRCommand message is reused for SRVCC from NR to UTRAN. SRVCC to UTRAN is also supported for UEs configured with NR-DC and NE-DC, network can trigger SRVCC to UTRAN procedure directly irrespective of the whether the bearer for the voice call is anchored in SN or MN. When and how to perform the return procedure from UTRAN to NR after the UE completes the voice service depends on UE implementation.
- Support of Signalling of source RAT to target RAT at incoming SRVCC. Add 5G-SRVCC possible into Initial Context Setup Request, HO Request, Path Switch Request Ack. Clarify the source to target transparent container is source RNC to target RNC Transparent Container in 5G-SRVCC. Clarify the target to source transparent container is Target RNC to Source RNC Transparent Container in 5G-SRVCC.
- Support of UE capability reporting for supporting SRVCC, including SRVCC handover capability with FR1/FR2 and TDD/FDD split, and UTRA-FDD band list is also reported.
- RRM Requirements have also been specified, including measurement gap applicability requirement for SRVCC, Measurement capability, CSSF, UMTS inter-RAT measurement requirements and handover requirements for SRVCC.

## References for the radio part

- |     |            |                                     |                                 |
|-----|------------|-------------------------------------|---------------------------------|
| [1] | R2-2000325 | Introduction of SRVCC from 5G to 3G | Ericsson, ZTE                   |
| [2] | R2-2000335 | Introduction of SRVCC from 5G to 3G | Ericsson                        |
| [3] | R2-2000542 | Introduction of SRVCC from 5G to 3G | Huawei, HiSilicon, China Unicom |

[4]	R2-2000651	Introduction of SRVCC from 5G to 3G	China Unicom, Huawei, HiSilicon
[5]	R3-194169	Support SRVCC from 5G to 3G	Ericsson
[6]	R3-194171	Support SRVCC from 5G to 3G	Ericsson
[7]	R3-200071	Support SRVCC from 5G to 3G	Ericsson
[8]	R3-200073	Support SRVCC from 5G to 3G	Huawei, China Unicom, Ericsson, Nokia, Nokia Shanghai Bell, ZTE, Qualcomm Incorporated

### Overall References, for both the radio and the general parts

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810041,790010,810007,820008,820069,820169,830270,840004,840058,840059>

## 13.1.3 Volume Based Charging Aspects for VoLTE

840066	<a href="#">Volume Based Charging Aspects for VoLTE</a>	VBCLTE	S5	SP-180813	Chen, Ai, China Mobile
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Summary based on the input provided by China Mobile in SP-191277.

Based on the Study Item FS\_VBCLTE (TR 32.848) which has investigated potential charging requirements and possible mechanisms to support volume based charging for VoLTE, the WI VBCLTE is the enhancement of online and offline charging aspects of volume based charging for VoLTE.

Stage 2 work on WI VBCLTE for TS 32.251 [1] and TS 32.260 [4]:

- Clarify that IMS charging only supports duration based charging for VoLTE.
- Introduce volume based charging for VoLTE in PS offline and online charging.
- Introduce VoLTE Information parameter for volume based charging for VoLTE in PGW-CDR.
- Add Bindings of CDR parameter, Information Element and AVP for VoLTE Information parameter.

Stage 3 work on WI VBCLTE for 32.298 [3] and 32.299 [4]:

- Introduce two new values for Change-Condition AVP to indicate the status of VoLTE service delivery.
- Introduce two new reasons of Cause for Record Closing field in the CDR to indicate the status of VoLTE service delivery.
- Introduce VoLTE Information parameter including Caller Information and Callee Information for volume based charging for VoLTE in PS domain CDRs.
- Introduce VoLTE-Information AVP including Calling-Party-Address AVP and Callee-Information AVP for volume based charging for VoLTE in PS domain online charging messages.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840066>

[1]	TS 32.251: "Packet Switched (PS) domain charging"
[2]	TS 32.260: "IP Multimedia Subsystem (IMS) charging"
[3]	TS 32.298: "Charging Data Record (CDR) parameter description"
[4]	TS 32.299: "Diameter charging application"

## 13.1.4 EVS Floating-point Conformance for Non Bit-Exact

820001	<a href="#">EVS Floating-point Conformance for Non Bit-Exact</a>	EVS_FCNE	S4	SP-180983	Fabrice, Plante, Intel
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Summary based on the input provided by Intel in SP-191328.

The EVS\_FCNE work item provides improvements related to the 3GPP EVS codec: this codec is standardized in three code versions such that it can be implemented on processors with either fixed-point (TS 26.442, TS 26.452) or floating-point arithmetic (TS 26.443). Implementations can be conformance-tested using "bit-exact" methods that have

been specified already when the EVS codec was first standardized. These methods are suitable for fixed-point implementations but their applicability is limited for floating-point implementations. EVS\_FCNBE provides methods which enable conformance testing also for “non bit-exact” floating-point implementations.

During Rel-15, the FS\_EVS\_FCNBE study item investigated tools, conformance process, and criteria for EVS floating-point non bit-exact conformance, and documented in TR 26.843 [1] several recommendations. Based on the agreed conclusions and recommendations of TR 26.843, the EVS\_FCNBE work item conducted normative work on TS 26.444 to introduce the non bit-exact conformance process and criteria in the CR 26.444-0027.

The conformance process uses three specific tests:

- Decoder test comparing the implementation decoder with TS 26.443 decoder.
- Encoder test comparing the implementation encoder with TS 26.443 encoder.
- MOS-LQO verification comparing the coder implementation with TS 26.442 coder.

These three tests allow to compare the implementation with the reference floating point code in TS 26.443, and interoperability with the fixed-point code in TS 26.442. All three tests shall pass for the implementation to be declared conformant.

The decoder test relies on a set of signal-based metrics (RMS, SNR, and Spectral Distortion). The encoder test uses a loudness metric. The MOS-LQO test uses a set of metrics using objective quality measurements.

To define a range of acceptable variation for the various metrics, a set of 10 reference implementations (based on mainstream compilers and platforms) has been used to define reference values.

Annex B of CR 26.444-0027 provides details on the tests as well as the conformance process and criteria.

The results obtained during the course of the normative work indicate that this conformance process correctly discriminates implementations with functional code changes and aggressive compiler optimization.

## References

- [1] TR 26.843 “Study on non-bit-exact conformance criteria and tools for floating-point EVS codec”  
List of related CRs: select "TSG Status = Approved" in  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820001>

## 13.1.5 Media Handling Extensions for 5G Conversational Services

810040	Media Handling Extensions for 5G Conversational Services	5G_MEDIA_MTSI_ext	S4	SP-180663	Oyman, Ozgur, Company: Intel
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Summary based on the input provided by Intel in SP-200036.

During Rel-15, the FS\_5G\_MEDIA\_MTSI study item investigated media handling aspects of conversational services in 5G, and documented in TR 26.919 several recommendations on Multimedia Telephony Service over IMS (MTSI) in TS 26.114 around media rate adaptation, NR access and profiles for 5G deployments.

Based on the agreed conclusions and recommendations of TR 26.919, 5G\_MEDIA\_MTSI\_ext conducted normative work, mostly on TS 26.114, to introduce the following functionality:

- For media rate adaptation, the CR 26.114-0436 [2] recommended additional speech and video adaptation capabilities based on access network bitrate recommendation (ANBR) (a.k.a. RAN-assisted codec adaptation) support. In particular, this CR makes ANBR-triggered speech adaptation a recommended feature in MTSI clients for Rel-16 and beyond. Moreover, it provides additional recommendations for MTSI receivers to generate CMR/RTCP-APP (for speech) and TMMBR (for video) and for MTSI senders to generate TMMBN (for video) messages in response to receiving ANBR information.
- On profiles for 5G deployments, the CR 26.114-0438 [3] defined the constrained MTSI client terminal to address codec requirements for IMS/VoLTE/ViLTE/VoNR conversational services in the low end 5G verticals such as wearables and IoT. In particular, this CR relaxed the Rel-15 speech and video codec requirements for these constrained terminals, e.g., resulting in optional support for super-wideband for speech and HEVC for video, exceptionally only for this special category of constrained terminals (support for SWB for speech and HEVC for video is otherwise mandatory for Rel-15 and beyond).

- To realize further RAN-assisted codec adaptation enhancements, the CR 26.114-0461 [4] and CR 26.114-0480 [5] introduced ANBR capability signalling into MTSI. In particular, the CRs standardized a new SDP attribute ‘anbr’ to enable end-to-end signaling and coordination of ANBR capabilities (both at the radio level and application level) across the UEs, Access Networks, and PCRF/PCF. According to the adopted solution, the MTSI client in terminal supporting "anbr" signals this attribute in the SDP only if: (i) MTSI client in terminal supports ANBR at the application layer, including the use of ANBR with dynamic bitrate adaptation. (ii) The UE of the MTSI client in terminal is capable of RAN-assisted codec adaptation at the radio layer, including the ability to query and receive ANBR information (both downlink and uplink ANBR) from its eNB/gNB. (iii) The P-CSCF has indicated to the UE of the MTSI client in terminal its ability to handle this SDP attribute through the respective SIP registration procedures specified in TS 24.229 via the corresponding feature capability indicator g.3gpp.anbr.
- The low and ultra-low latency of 5G will enable new types of use cases with real-time communication and interaction needs where it will be desirable to not only have voice, text and video calling connectivity but also delivery of any kind of data stream and real-time interaction within the same IMS multimedia session. This is already enabled as part of the IMS-based Tele-Presence service in TS 26.223 toward the exchange of CLUE messages and has been introduced to MTSI in TS 26.114 as part of this work item to provide a generic and flexible data channel support for IMS-based multimedia telephony. In particular, CR 26.114-0496 [6] adds necessary UNI procedures to support MTSI data channel based on WebRTC data channel and web scripting techniques as a new MTSI media. This provides a generic and flexible data channel for MTSI in TS 26.114 that allows both UE-to-UE and UE-to-network generic data transfers, in addition to and in parallel with the existing MTSI media such as audio, video, and text. Accordingly, TS 26.223 was also updated via CR 26.223-0013 [7] to align the data channel support of a Tele-Presence (TP) UE with that specified in MTSI.

## References

[1] Tdoc SP-180663, New WID on “Media Handling Extensions for 5G Conversational Services” (5G\_MEDIA\_MTSI\_ext)

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810040>

This includes:

[2] Tdoc SP-180975, CR 26.114-0436, “Recommendations on Media Rate Adaptation”

[3] Tdoc SP-180975, CR 26.114-0438, “MTSI Client Profiles”

[4] Tdoc S4-190489, CR 26.114-0461, “Signaling of ANBR Capabilities”

[5] Tdoc S4-190603, CR 26.114-0480, “Updates on ANBR Capability Signaling”

[6] Tdoc S4-200266, CR 26.114-0496, “Addition of MTSI Data Channel Media”

[7] Tdoc S4-200269, CR 26.223-0013, “Alignment with MTSI on IMS Data Channel Support”

## 13.1.6 VR QoE metrics

840000	VR QoE metrics	VRQoE	S4	SP-190331	Gunnar HEIKKILÄ, Ericsson
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Summary based on the input provided by Ericsson in SP-200128.

The experienced Virtual Reality (VR) quality is dependent on a good service implementation as well as a fast and consistent transport network. To help service providers and operators to measure and optimize aspects related to the delivered VR service quality, specific VR-related metrics are useful.

The VRQoE Work Item added the following functionality:

- Defined VR metrics observation points.
- Metrics describing the characteristics of the VR device, such as resolution, FOV etc.
- Metrics describing the interaction delay, related to the time between head movements and update of the visible content.
- Extensions to the DASH Metrics configuration and reporting to support the new metrics.

Also, the following metrics have been added into TS 26.118 [1]:

- Comparable quality viewport switching latency: Reports the delay from head movement until the media quality is restored to a similar quality level as before the move.
- Rendered viewports: Reports where the user mostly looks during the VR session.

- VR device information: Reports characteristics for the VR device.

The metrics are building on and extending the existing metrics in TS 26.247 [2], and are well aligned with the current proposal in MPEG [3]. Furthermore, a requirement has been added to TS 26.234 [4] specifying that a VR-capable PSS client should also support these metrics.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840000>

- [1] TS 26.118 " Virtual Reality (VR) profiles for streaming applications"
- [2] TS 26.247 "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)"
- [3] ISO/IEC CD 23090-6 "Immersive Media Metrics"
- [4] TS 26.234 "Transparent end-to-end Packet-switched Streaming Service (PSS); Protocols and codecs"

## 13.1.7 Media Handling Aspects of RAN Delay Budget Reporting in MTSI

810039	Media Handling Aspects of RAN Delay Budget Reporting in MTSI	E2E_DELAY	S4	SP-180662	Oyman, Ozgur, Company: Intel
780022	Study on E2E_DELAY	FS_E2E_DELAY	S4	SP-170837	Oyman, Ozgur, Company: Intel,
810001	Stage 2 of E2E_DELAY	E2E_DELAY	S4	SP-180662	Oyman, Ozgur, Company: Intel
830004	CT Aspects of E2E_DELAY	E2E_DELAY	ct	CP-190193	Luetzenkirchen, Thomas, Intel
830066	CT1 Aspects of E2E_DELAY	E2E_DELAY	C1	CP-190193	Luetzenkirchen, Thomas, Intel
830067	CT3 Aspects of E2E_DELAY	E2E_DELAY	C3	CP-190193	Luetzenkirchen, Thomas, Intel
830068	CT4 Aspects of E2E_DELAY	E2E_DELAY	C4	CP-190193	Luetzenkirchen, Thomas, Intel

Summary based on the input provided by Intel in SP-190322.

This summary reports on the normative specification progress accomplished during the course of the E2E\_DELAY work item [1]. The related agreed CRs can be found in Tdocs S4-181176 (CR 26.114-0441) [2], S4-181452 (CR 26.114-0443) [3], S4-190167 (CR 26.114-0448) [4], S4-190497 (CR 26.114-0462) [5] and S4-190498 (CR 26.114-0463) [6].

RAN delay budget reporting is specified in TS 36.331 for E-UTRA and TS 38.331 for NR. RAN delay budget reporting through the use of RRC signalling to eNB / gNB allows UEs to locally adjust air interface delay. Based on the reported delay budget information, a good coverage UE on the receiving end (i.e., the UE that contains the MTSI receiver) can reduce its air interface delay, e.g., by turning off CDRX or via other means. This additional delay budget can then be made available for the sending UE (i.e., the UE that contains the MTSI sender), and can be quite beneficial for the sending UE when it suffers from poor coverage. When the sending UE is in bad coverage, it would request the additional delay from its local eNB / gNB, and if granted, it would utilize the additional delay budget to improve the reliability of its uplink transmissions in order to reduce packet loss, e.g., via suitable repetition or retransmission mechanisms, and thereby improve end-to-end delay and quality performance.

While RAN-level delay budget reporting as defined in TS 36.331 and TS 38.331 allows UEs (i.e., MTSI sender and MTSI receiver) to locally adjust air interface delay, such a mechanism does not provide coordination between the UEs on an end-to-end basis. To alleviate this issue, this work item defined a new RTCP feedback message type in clause 7.3.8 of TS 26.114 to realize the following capabilities on signalling of Delay Budget Information (DBI) across UEs as per CRs 26.114-0443 in Tdoc S4-181452, 26.114-0448 in Tdoc S4-190167 and 26.114-0462 in Tdoc S4-190497: (i) an MTSI receiver can indicate available delay budget to an MTSI sender, and (ii) an MTSI sender can explicitly request delay budget from an MTSI receiver. Such RTCP-based signaling of DBI can also be used by an MTSI receiver to indicate delay budget availability created via other means such as jitter buffer size adaptation. The recipient UE of the RTCP feedback message carrying DBI may then use this information in determining what delay budget adjustments it may request from its eNB / gNB over the RAN interface, e.g. by using RRC signalling based on UEAssistanceInformation as defined in TS 36.331 and TS 38.331.

In addition, the work item specified a few further media handling aspects of RAN delay budget reporting for MTSI in TS 26.114 to address the following:

1. SDP-based exchange of RAN capabilities in regards to delay budget reporting, this is specified in clause 6.2.8 and Annex V.3 of TS 26.114 as per CR 26.114-0441 in Tdoc S4-181176 and CR 26.114-0463 in Tdoc S4-190498. Accordingly, an MTSI client supporting DBI can offer this capability in SDP for all media streams containing speech and/or video by including the `a=rtcp-fb` attribute with the DBI type under the relevant media line scope as expressed with the parameter `3gpp-delay-budget`.

2. Recommendations on when and how the UEs in an MTSI session should use RAN-based delay adjustment mechanisms in an end-to-end fashion also accounting other factors such as local radio conditions, various RAN capabilities and configurations, jitter buffer considerations, and UE battery constraints. These are provided as part of the informative signalling flows in Annex V of TS 26.114, as per CR 26.114-0443 in S4-181452.

3. Recommendations on when and how the various kinds of end-to-end quality metrics and other relevant information in the MTSI client could be used to trigger RAN delay budget reporting. These are provided as part of the informative signalling flows in Annex V of TS 26.114, as per CR 26.114-0443 in S4-181452.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810039,780022,810001,830004,830066,830067,830068>

- [1] Tdoc SP-180662, New WID on “Media Handling Aspects of RAN Delay Budget Reporting in MTSI” (E2E\_DELAY)
- [2] Tdoc S4-181176, CR 26.114-0441, “Signaling of Delay Budget Information”
- [3] Tdoc S4-181452, CR 26.114-0443, “Recommendations on use of RAN Delay Budget Reporting in MTSI”
- [4] Tdoc S4-190167, CR 26.114-0448, “DBI Signaling Recommendations”
- [5] Tdoc S4-190497, CR 26.114-0462, “Additional DBI Signaling Recommendations”
- [6] Tdoc S4-190498, CR 26.114-0463, “SDP Examples on DBI Signaling”
- [7] TS 36.331: "E-UTRA; Radio Resource Control (RRC); Protocol specification".
- [8] TS 38.331: "NR; Radio Resource Control (RRC); Protocol Specification".

## 13.1.8 Removal of H.263 and MPEG-4 Visual from 3GPP Services

Summary based on the input provided by Qualcomm in SP-200801.

This work item has removed any normative statements related to H.263 and MPEG-4 Visual from Rel-16 specifications (including TS 26.114, TS 26.140, TS 26.234, TS 26.346 and TS 26.244).

H.263 was a state-of-the art codec in the last millennium and made mobile video possible and an actual reality. Many 3GPP specs adopted H.263, used for the first mobile video deployments. However, more than 20 years later, this format became obsolete and as such was removed from Rel-16 onwards.

In 2012 (Rel-11), 3GPP already addressed to change the status of H.263 and MPEG-4 Video in several specifications, but did not fully remove the technology for all services. Some leftover H.263 related statements remained, as in TS 26.140. MPEG-4 Visual did not have any status in any spec, but many leftovers still.

"Retiring" older codecs is needed due to the impact of codecs on hardware and/or software including area size, design and testing, and then on the cost. Supporting such codecs on 5G device would have reduced the available space for other, newer, codecs and technologies. One can note that, despite a phone' OS provides a software codec for these formats, not all devices use this OS (e.g. watches do not use it) and hence would have required custom H.263 integration. Similar issues apply to MPEG-4 Visual.

The Technical Report is available in TR 26.928.

## References

- [1] Tdoc SP-200400, “Removal of H.263 and MPEG-4 Visual from 3GPP Services” (RM\_H263\_MP4V)

## 13.2 Streaming

### 13.2.1 Enhancement of LTE for Efficient delivery of Streaming Service

800008	<a href="#">Enhancement of LTE for Efficient delivery of Streaming Service</a>	eLSTR	S1	SP-180322	Xia, Xu, China Telecom
740001	Study on eLSTR	FS_eLESTR	S1	SP-160960	China Telecommunications, XIA Xu
800054	Stage 1 of eLSTR	eLSTR	S1	SP-180322	Xia, Xu, China Telecom

Summary based on the input provided by China Telecom in SP-200XYZ.

Mobile network operators are deciding to use LTE-base system to deliver great stream communication services (eg. Video/HD/AR/VR). As the great stream communication service (eg. video/HD/AR/VR) is a ideal type business to improve operator , but in the reality network, we(operators) find very little users to consume these services on LTE rather to use free wifi. The key factor of enabling the “anywhere, anytime” reachability is to reduce to cost of resource to consume video/HD/AR/VR services. Ideally, RAN may request delay tolerate data from GW or cache or any other entity when RAN has spare resource to save the network transmission resource. However, currently this mechanism is not successfully supported over LTE. The mechanism for OTT video may also need to be studied and defined on backhaul interfaces and potentially SGi interface.

This technical report is to study potential service requirements for optimization of both Over-The-Top and operator managed streaming service considering possible use cases e.g. caching, content-aware service delivery, delay tolerate delivery, local streaming transmission etc. Operators see benefit to include it in a new study.

Support of stream service have been accepted in TS22.115 [2] and TS22.278 [3]. No stage 2 and stage 3 changes were needed.

The work item eLSTR provides the stage 1 specifications to include

- 1) Identifying the potential new service scenarios and requirements for video/HD/AR/VR services over LTE-based system, eg. delay tolerant content delivery; UE caching; Video transmission optimization(video-aware by RAN);
- 2) Identifying related policy, charging and authentication requirements.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800008,740001,800054>

- [1] Tdoc SP-180322, “Enhancement of LTE for Efficient delivery of streaming service (eLSTR)”
- [2] TS 22.115 V16.3.0 (2019-06); “Service aspects; Charging and billing”
- [3] TS 22.278 V16.3.0 (2019-06); “Service requirements for the Evolved Packet System (EPS)”

## 13.2.2 Enhancements to Framework for Live Uplink Streaming

800001	<a href="#">Enhancements to Framework for Live Uplink Streaming</a>	E_FLUS	S4	SP-180285	Lo, Charles, Qualcomm
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Summary not provided

## 13.2.3 Media streaming architecture

820002	<a href="#">Media streaming architecture</a>	5GMSA	S4	SP-180984	Frédéric GABIN, Ericsson
840001	<a href="#">5G Media Streaming Stage 3 (5GMS3)</a>	5GMS3	S4	SP-190464	Paul Szucs, Sony

Summary based on the input provided by Sony Europe B.V. in SP-200848.

This summary reports on the normative specification progress accomplished during the course of the 5GMS3 work item [1]. Three new specifications have been produced as a result of the work in 5GMS3, namely on the following aspects:

- Speech and audio profiles, in TS 26.117 [2];
- Profiles, Codecs and Formats, in TS 26.511 [3];
- Protocols, in TS 26.512 [4].

One change request on the existing specification TS 26.247 [5] has also been produced, which adds the specification of the usage of the Common Media Application Format (CMAF) for segmented media as the baseline container format for 5GMS downlink streaming services.

The work item 5GMS3 provides the stage 3 specifications to enable the realization of media streaming services based on the 5G Media Streaming Architecture, specified in TS 26.501 [6]. The stage 3 specifications cover speech, audio and video media formats and profiles, protocols – which are specified in accordance with the REST/HTTP principles adopted by the CT groups – and the ingest of media content into the 5GMS for downlink unicast content delivery services.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820002.840001>

- [1] Tdoc SP-180322, "Enhancement of LTE for Efficient delivery of streaming service (eLSTR)"
- [2] TS 22.115 V16.3.0 (2019-06); "Service aspects; Charging and billing"
- [3] TS 22.278 V16.3.0 (2019-06); "Service requirements for the Evolved Packet System (EPS)"

- [1] Tdoc SP-190464, "3GPP™ Work Item Description - 5G Media Streaming stage 3 (5GMS3)"
- [2] TS 26.117; 5G Media Streaming (5GMS); Speech and audio profiles
- [3] TS 26.511; 5G Media Streaming (5GMS); Profiles, Codecs and Formats
- [4] TS 26.512; 5G Media Streaming (5GMS); Protocols
- [5] TS 26.247; Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH) (Release 16)
- [6] TS 26.501; 5G Media Streaming (5GMS); General description and architecture

## 14 5G Location and Positioning Services

### 14.1 5G positioning services (5G\_HYPOS)

800049	Stage 1 of 5G_HYPOS - 5G positioning services	5G_HYPOS	S1	SP-180329	Ries, Lionel, ESA
760006	Study on positioning use cases	FS_5G_HYPOS	S1	SP-170589	Ries, Lionel, ESA

Summary based on the input provided by ESA in SP-200943.

Positioning features and high-accuracy are becoming more and more important for many verticals involved with 5G.

This work item specifies functional requirements as well as KPI to support enhanced positioning services in the 5G systems. It addresses a wide variety of services and use cases, including (but not limited to) regulatory requirements in support of emergency calls and first responder operations, new services in multiple verticals covering for instance industry, logistics, eHealth and aerial.

Emphasis has been put, among other, on improving accuracy, seamless positioning in the entire 5G coverage, flexibility, features to further enable and combine multiple positioning technologies RAT-dependent, RAT-independent such as GNSS and TBS). The work also covers energy efficiency of the positioning function, being key for many use cases such as, for instance, asset tracking.

The work item 5G\_HYPOS provides the stage 1 specifications to enable enhanced and more accurate positioning in 5G systems. The positioning services and specifications aim multiple service levels involving different types of UE (e.g. UE for Location Based Services, asset tracking devices, machine-type UE, transportation, etc.), and which can refer to RAT-dependent positioning technologies, RAT-independent positioning technologies (e.g. GNSS, TBS), and/or a combination of several of those.

Functional requirements for positioning services are reported in chapter 6.27 of TS 22.261 [2]. They cover aspects such as configuration of the positioning service capabilities and features, for instance to allow the operators to manage the combination and hybridization of multiple positioning technologies or to report positioning related information to authorized third parties.

KPI for positioning services are reported in chapter 7.3 of TS 22.261 [2]. Several KPIs, such as accuracy, availability, coverage (indoor, outdoor, 5G positioning service area or 5G enhanced positioning service area, etc.) are sorted in 7 Positioning Service Levels, with accuracy ranging from 10 meters for Service Level 1 down to 0.2 meters for Service Level 7. These Service Levels have been coordinated with the needs of industry automation use cases, as specified in TS 22.104 (Service requirements for cyber-physical control applications in vertical domains, [3]), to facilitate the work in subsequent working groups.

Finally, as the work also identified the importance of trusted positioning information to support regulatory and commercial applications, some requirements relating to the integrity and protection of the positioning information and measurements have been introduced in chapter 8.7 of TS 22.261 [2].

The requirements have translated into work in subsequent working groups (SA2, SA3, RAN) and for RAN, in new specifications in: TS 38.215 (NR Physical Layer measurements, [4]), TS 38.305 (Stage 2 functional specification of UE positioning in NG-RAN, [5]), TS 37.355 (LTE Positioning Protocol, [6]), TS 38.455 (NR Positioning Protocol A, [7]) and TS 38.331 (UE radio transmission and reception, [8]) which defines evolution of RAT-dependent technologies for NR, as well as it introduces new features and capabilities in LPP to enable cm-level accuracy positioning with High-

Accuracy GNSS (HAGNSS). These specifications address UE-based, UE-assisted methods, and broadcast of information / corrections using RRC System Information messages.

The performance targets for RAT-dependent techniques in Release 16 NR Positioning are matching the TS 22.261 Service Level 1 (<10m) positioning requirements in the case of outdoor users and the SL2 (<3m) requirements in the case of indoor users. High-accuracy GNSS, based on State Space Representation corrections (SSR), has been added to the list of positioning techniques supported by LPP and it is able to meet service levels captured in TS 22.261 for majority of outdoor users with its expected performance (<1m) .

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800049,760006>

- [1] Tdoc SP-180329, “New WID on 5G positioning services (5G\_HYPOS)”
- [2] TS 22.261 Service requirements for the 5G system; Stage 1
- [3] TS 22.104 Service requirements for cyber-physical control applications in vertical domains; Stage 1
- [4] TS 38.215 “NR Physical Layer measurements”
- [5] TS 38.305 “Stage 2 functional specification of UE positioning in NG-RAN”
- [6] TS 37.355 “LTE Positioning Protocol (LPP)”
- [7] TS 38.455 “NR Positioning Protocol A (NRPPa)”
- [8] TS 38.331 “UE radio transmission and reception”

## 14.2 Enhancement to the 5GC LoCation Services

830102	<a href="#">Enhancement to the 5GC LoCation Services</a>	5G_eLCS	S2	SP-181119	Ming Ai, CATT
780028	<a href="#">Study on Enhancement to the 5GC Location Services</a>	FS_eLCS	S2	SP-180734	Ming Ai, CATT
810035	<a href="#">Study on Security of the enhancement to the 5GC location services</a>	FS_eLCS_Sec	S3	SP-180694	Wei Zhou, CATT
820016	<a href="#">Stage 2 of 5G_eLCS</a>	5G_eLCS	S2	SP-181119	Ming Ai, CATT
830003	<a href="#">CT aspects of 5G_eLCS</a>	5G_eLCS	ct	CP-190014	Tingfang Tang, CATT
830044	<a href="#">CT1 aspects of 5G_eLCS</a>	5G_eLCS	C1	CP-191064	Tingfang Tang, CATT
830045	<a href="#">CT3 aspects of 5G_eLCS</a>	5G_eLCS	C3	CP-191064	Tingfang Tang, CATT
830046	<a href="#">CT4 aspects of 5G_eLCS</a>	5G_eLCS	C4	CP-191064	Tingfang Tang, CATT

Summary based on the input provided by CATT in SP-191223.

This work item defines the stage 2 of the service-based architecture used for location services in the 5G system, and corresponding Network Functions (NFs), NF services and procedures, to meet the service requirements defined in TS 22.261 [1] and TS 22.071 [2].

The Location Services, specified in TS 23.273 [3], include aspects of both regulatory and commercial nature.

The architecture and signalling procedures in NG-RAN are defined in TS 38.305 [4].

Following aspects have been specified for 5G Location Services:

- Service based 5G location architecture, including roaming and non-roaming, Function description of per Network Functions, etc.
- General Concepts, e.g. Type of Location Requests, LCS Quality of services;
- High Level Features, e.g. LMF selection, UE LCS privacy handling;
- Location Service Procedures, which includes
  - 5GC-MT-LR Procedure
  - 5GC-MO-LR Procedure
  - Deferred 5GC-MT-LR Procedure for Periodic, Triggered and UE Available Location Events
  - LMF Change Procedure
  - Unified Location Service Exposure Procedure
  - Low Power Periodic and Triggered 5GC-MT-LR Procedure
  - Bulk Operation of LCS Service Request Targeting to Multiple UEs
  - Procedures to Support Non-3GPP Access
  - Procedures dedicated to Support Regulatory services
  - UE Assisted and UE Based Positioning Procedure
  - Network Assisted Positioning Procedure
  - Obtaining Non-UE Associated Network Assistance Data
  - UE Location Privacy Setting Procedure
  - Procedures with interaction between 5GC and EPC

- Support of Concurrent Location Request;
- Network Function Services, e.g. LMF services, GMLC services.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830102,780028,810035,820016,830003,830044,830045,830046>

- [1] TS 22.261: "5G system; Services, operations and procedures of charging using Service Based Interface (SBI)"
- [2] TS 22.071: "Service requirements for next generation new services and markets; Stage 1"
- [3] TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2"
- [4] TS 38.305: "Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN".

## 14.3 NR positioning support

830077	NR positioning support	NR_pos	R1	RP-191156	Intel
800092	Study on NR positioning support	FS_NR_pos	R1	RP-181399	Intel
830073	Study on local NR positioning in NG-RAN	FS_NR_local_pos	R3	RP-190754	CMCC
830177	Core part: NR positioning support	NR_pos-Core	R1	RP-190752	Intel
830277	Perf. part: NR positioning support	NR_pos-Perf	R4	RP-190752	Intel

Summary based on the input provided by Intel Corporation in RP-201987.

In the presented work item [1] 3GPP defined framework for NR based positioning of UEs, including definition of new reference signals, physical layer measurements, procedures and higher layer protocols for support of NR RAT-dependent and RAT-independent positioning technologies. This completed normative work [2] is a continuation of the 3GPP Rel.16 study item on NR Positioning Support [3]. The main motivation behind this work is to support accurate UE positioning in NR technology by utilizing RAT-dependent and RAT-independent solutions.

### RAT-dependent positioning techniques

In the NR positioning WI 3GPP specified support for the following RAT-dependent positioning techniques (defined in TS 37.355):

- DL TDOA – Downlink Time Difference of Arrival
- DL AoD – Downlink Angle of Departure
- UL TDOA – Uplink Time Difference of Arrival
- UL AoA – Uplink Angle of Arrival (Azimuth and Zenith)
- Multi-RTT – Multi Round Trip Time
- NR E-CID – NR Enhanced Cell ID

These positioning methods may be supported in UE-based, UE-assisted/LMF-based, and NG-RAN node assisted versions.

**Table 1: Supported versions of UE positioning methods (defined in TS38.305)**

Method	UE-based	UE-assisted, LMF-based	NG-RAN node assisted
DL-TDOA	Yes	Yes	No
DL-AoD	Yes	Yes	No
Multi-RTT	No	Yes	Yes
NR E-CID	No	Yes	Yes
UL-TDOA	No	No	Yes
UL-AoA	No	No	Yes

**Physical layer signals and measurements:** In order to support RAT-dependent positioning solutions, the following new reference signals and new physical layer measurements were specified:

- Reference signals (defined in TS 38.211)
  - o DL Positioning Reference Signals (DL PRS)
  - o UL Sounding Reference Signals (SRS) for positioning
- Physical layer measurements (defined in TS 38.215)

- o UE measurements
  - DL PRS-RSRP (downlink positioning reference signals - reference signal receiver power): Applied for DL AoD, DL TDOA, Multi-RTT
  - DL RSTD (downlink reference signal time difference): Applied for DL TDOA
  - UE Rx – Tx time difference: Applied for Multi-RTT
- o NG-RAN (gNB) measurements
  - UL RTOA (uplink relative time of arrival): Applied for UL TDOA
  - UL SRS reference signal received power (UL SRS-RSRP): Applied for UL TDOA, UL AoA, Multi-RTT
  - gNB Rx – Tx time difference: Applied for Multi-RTT
  - UL AoA (uplink angle of arrival): Applied for UL AoA and E-CID

In addition, the existing RRM measurements were reused for NR E-CID support: CSI-RSRP, CSI-RSRQ, SS-RSRP, SS-RSRQ.

**Downlink positioning reference signal (DL PRS):** they are allocated and transmitted periodically with configurable periodicity and time offset with respect to SFN0. The DL PRS configuration is done per DL positioning frequency layer that defines multiple DL PRS resource sets associated with different transmission/reception points (TRPs) and characterized by the same DL PRS subcarrier spacing, transmission bandwidth, cyclic prefix length, DL PRS Point A and offset with respect to DL PRS Point A. DL PRS resource set may contain multiple DL PRS resources, where each DL PRS resource is associated with certain spatial transmission direction of DL PRS from a given TRP (beam) and characterized by configurable number of symbols, resource element pattern, initial comb-offset, offset in slots, symbols and DL PRS sequence ID.

DL PRS is single port signal that can be configured as quasi-collocated with SSB index or other DL PRS resources. The configuration of DL PRS is provided as a part of UE assistance information. DL PRS transmissions can be muted according to configured bitmaps for each DL PRS resource set that control the DL PRS resource set transmission period or DL PRS resource repetition transmission within a DL PRS transmission period.

**Uplink sounding reference signals for positioning:** they are defined based on NR UL SRS with modified staggered RE pattern and disabled frequency hopping. The UL SRS for positioning are defined through configuration of UL SRS resource sets for positioning, where each set may contain multiple UL SRS resources for positioning. UL SRS resource for positioning is characterized by number of symbols, transmission bandwidth, RE pattern, time offset and may be associated with UE TX beam. UL SRS resources for positioning can be spatially related with SSB indexes or DL PRS resource index as well as reference signal for UL open loop power control towards serving and neighbor cells (defined for UL SRS for positioning).

LMF may recommend the spatial relation and pathloss reference to the gNB for SRS configuration. LMF may also request activation and deactivation of non-periodic SRS transmission to the gNB.

**Broadcast of Assistance Data:** this can be included in positioning System Information Blocks (posSIBs) which are carried in RRC System Information (SI) messages. The UE may request posSI by means of on-demand SI request in RRC\_IDLE/RRC\_INACTIVE and also request posSIBs by means of on-demand SI request in RRC\_CONNECTED.

For each assistance data element, a separate posSIB-type is defined. Each posSIB may be ciphered by the LMF using the 128-bit Advanced Encryption Standard (AES) algorithm (with counter mode), either with the same or different ciphering key.

**RAT independent positioning techniques:** PPP and RTK, are already supported in Rel-15 LPP. In Rel-16, LPP is extended to support GNSS SSR (PPP-RTK support) based on the “Compact SSR” definitions specified for QZSS for both LTE and NR. Following additional information are added to be transferred from the LMF to UE:

- SSR Phase Bias
- SSR STEC Corrections
- SSR Gridded Correction
- SSR URA
- SSR Correction Points

**Positioning network architecture:** In the positioning architecture specified in TS 38.305 and TS 38.401, the LMF is connected to the NG-RAN node through the AMF. The NG-RAN node may control several TRPs. Both split (i.e. CU/DU) and non-split NG-RAN architectures are supported. The NRPPa and the F1AP protocols have been extended to support the positioning methods listed above.

**UE DL PRS processing requirements:** For defined physical layer measurements DL-RSTD, DL PRS-RSRP and UE Rx-Tx time difference in Rel16, the requirements on the measurement time were defined. These requirements are

applicable for the case when measurement gap is configured to UE. The UE processing capabilities specified in TS 37.355 are taken into account to derive total DL PRS measurement delay.

**Measurement gaps:** On top of legacy measurement gap patterns, the new measurement gap patterns with > 6ms measurement gap length (MGL) were introduced in Rel16 for NR positioning.

MG length (ms)	MG period (ms)
20	160
10	80

These two gap patterns can be requested by the UE and configured by the network only when the UE is configured via LPP with NR positioning measurements and can only be used during the corresponding positioning measurement period. The supported measurement gaps are applicable for DL PRS and NR/LTE RRM measurements i.e. new gaps are not shared between PRS and 2G/3G RRM measurements.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830077,800092,830073,830177,830277>

- [1] RP-190752, "New WID: NR Positioning Support", Intel Corporation, Ericsson
- [2] RP-201835, "Status Report to TSG on NR Positioning Support", Intel Corporation
- [3] TR 38. 855 "Study on NR positioning support" v16.0.0

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# 15 User Identities, Authentication, multi-device

## 15.1 User Identities and Authentication

800012	User Identities and Authentication	UIA	S1	SP-180328	Bischinger, Kurt; Deutsche Telekom
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Summary based on the input provided by Deutsche Telekom AG in SP-200131.

The feature allows the use of a User Identifier [1], which is independent of existing identifiers relating to a 3GPP subscription or UE, for Network Slice-Specific Authentication and Authorization. [1][2][3]

The actual identity provisioning service with creation, managing and authentication of identities is not specified by 3GPP, but the interworking of the 3GPP system with some external entity to authenticate the User Identity and to authorize the user for access to a specific network slice, in addition to the 3GPP network slice selection and authorization.

Rel. 15 Network slice selection (i.e. the procedure to select an AMF that supports the required Network Slices and establishing PDU Session(s) to the required Data network via the Network Slice instance(s) with its Control Plane and User Plane Network Functions) is based on the NSSAI, which consists of one or more S-NSSAIs.

Now with the Rel. 16 feature, Subscription information allows the indication which S-NSSAIs are subject to Network Slice-Specific Authentication and Authorization (NSSAA). For those S-NSSAIs the AMF invokes an EAP-based Network Slice-Specific authentication procedure in which the AUSF exchanges AAA protocol messages with a potentially external AAA Server (AAA-S) via an optional AAA Proxy (AAA-P) to authenticate and authorize a UE for the network slice. Depending on the result of the procedure a UE is either authorized for a network slice, re-allocated to a different one or deregistered. A re-authentication and re-authorization procedure may be triggered by the AAA Server at any time. [2][3]

Security aspects are specified in detail in [4], UE and network capabilities to support and perform NSSAA in [5], message flows for interworking to the AAA-S in [6], flags to indicate that a slice is subject to NSSAA are defined in [7] as well as [8] and the impact on the AUSF is captured in [9].

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800012>

- [1] TS 22.101, Service aspects; Service principles

- [2] TS 23.501, System architecture for the 5G System (5GS)
- [3] TS 23.502, Procedures for the 5G System (5GS)
- [4] TS 33.501, Security architecture and procedures for 5G System
- [5] TS 24.501, Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3
- [6] TS 29.561, 5G System; Interworking between 5G Network and external Data Networks; Stage 3
- [7] TS 29.503, 5G System; Unified Data Management Services; Stage 3
- [8] TS 29.505, 5G System; Usage of the Unified Data Repository services for Subscription Data; Stage 3
- [9] TS 29.509, 5G System; Authentication Server Services; Stage 3

## 15.2 Multi-device and multi-identity

<b>810044</b>	<b>Multi-device and multi-identity</b>	<b>MuD</b>	<b>S1</b>	<b>SP-180315</b>	<b>Peter Bleckert, Ericsson</b>
800004	Stage 1 of Multi-device and multi-identity	MuD	S1	SP-180315	Peter Bleckert, Ericsson
<b>810010</b>	<b>CT aspects of Multi-device and multi-identity</b>	<b>MuD</b>	<b>ct</b>	<b>CP-182227</b>	<b>Axell, Jörgen, Ericsson</b>
810045	CT1 aspects of Multi-device and multi-identity	MuD	C1	CP-182227	Axell, Jörgen, Ericsson
810046	CT3 aspects of Multi-device and multi-identity	MuD	C3	CP-182227	Axell, Jörgen, Ericsson

Summary based on the input provided by Ericsson in SP-201113.

The "Multi-device and multi-identity" (MUD) Feature enables the realization of the IMS enhancement for Multi-device and multi-identity.

With the increasing number of smart devices having call capabilities, the number of IMS-capable devices a single user can use also increases. GSMA RILTE have been working with specifying multi-device solutions and asked 3GPP to create requirements for all their use cases to be specified. This work item specifies the user experience requirements for a consistent user experience when the user uses these services.

Furthermore, the work also covers use cases where a user can allow another user (or possibly the same user) to use one or more of its identities. One example is for a user wishing to be able to use the work identity for the private phone. I.e. originated calls should show the work identity and terminating calls to the work identity should go to the private phone and include information that the work identity is called. Another example is to use a group identity, where employees can make calls on behalf of the group or firm and calls to the group are distributed to any member of the group.

The Multi-Device (MuD) service is an operator specific service which enables a user to use different UEs that are registered under the same public user identity. The UEs can be of different types (e.g. phone, tablet, wearable device, PC) and can support a communication log.

The Multi-Identity (MiD) service is an operator specific service which enables a user to use different identities. A served user can use a single UE to receive calls addressed to any of its identities and to make calls using any of its identities.

The MuD and MiD services can be used at the same time.

The Stage 1 requirements are document in chapter 4.6 in TS 22.173 [2]. No architecture changes were needed, and stage 3 were defined in the CT1 WID [5] and resulted in TS 24.174 [6] and TS 24.175 [7].

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810044,800004,810010,810045,810046>

- [1] Tdoc SP-180315, "New WID on multi-device and multi-identity (MuD)"
- [2] TS 22.173 "Multimedia Core Network Subsystem (IMS) Multimedia Telephony Service and supplementary services; Stage 1"
- [3] Tdoc SP-180316, CR to TS 22.173, "Multi-device requirements"
- [4] Tdoc SP-180768, CR to TS 22.173, "Update to MUD identities"
- [5] Tdoc CP-182227, WID in CT1 "Multi-device and multi-identity"
- [6] TS 24.174 "Support of multi-device and multi-identity in the IP Multimedia Subsystem (IMS); Stage 3"
- [7] TS 24.175 "Management Object (MO) for multi-device and multi-identity in the IP Multimedia Subsystem (IMS)"

# 16 Slicing

## 16.1 Enhancement of Network Slicing

830103	Enhancement of Network Slicing	eNS	SP-181232	ZTE, Tricci So
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Summary based on the input provided by ZTE Wistron Telecom AB in SP-200125.

The objective of this work item is to address the following aspects:

- Enhance the network slicing interworking support from EPC to 5GC, when UE moves from EPC to 5GC by selecting the proper target serving AMF as well as V-SMF. Note that, the 5GC may not be able to serve all the PDU sessions that the UE intends to move from EPC.
- Provide the network slice based authentication and authorization that uses User Identities and Credentials different from the 3GPP SUPI and that takes place after the primary authentication.

Release 16 Network Slicing addresses two major limitations of Release 15 in 5GC:

(1) Enhancement of interworking between EPC and 5GC when UE moves from EPC to 5GC, the target serving AMF may not be able to serve all the PDU sessions that the UE intends to move to the 5GC. More specifically, the following aspects needs to be addressed:

- Selecting an AMF based on the slices associated to the active PDU connections that serve the UE in the EPC in Connected mode and during the Idle mode mobility
- Selecting an appropriate serving V-SMF based on the slices associated to the active PDN connections that serve the UE in the EPC in Connected Mode

(2) Support for Network Slice Specific Authentication and Authorization (NSSAA)

- Enable the support for separate authentication and authorization per Network Slice. The trigger of NSSAA in the 5GC is based on UE subscription information from UDM and also operator's policy. However, the UE shall indicate its support for NSSAA to its serving 5GC.
- The AMF performs the role of the EAP Authenticator and communicates with the AAA-S via the AUSF. The AUSF undertakes any AAA protocol interworking with the AAA protocol supported by the AAA-S.

### **Enhancement of Interworking Between EPC and 5GC**

During the mobility from EPS to 5GS, in case of CM-IDLE state, the PGW-C+SMF sends PDU Session IDs and related S-NSSAIs to AMF in Registration procedure. The AMF derives S-NSSAI values for the Serving PLMN and determines whether the current AMF is appropriate to serve the UE. If not, the AMF reallocation may need to be triggered. For each PDU Session the AMF determines whether the V-SMF need to be reselected based on the associated S-NSSAI value for the Serving PLMN. If the V-SMF need be reallocated, the AMF trigger the V-SMF reallocation.

In case of CM-CONNECTED state, during handover preparation phase the PGW-C+SMF sends PDU Session IDs and related S-NSSAIs to AMF. Based on the received S-NSSAIs values, the target AMF derives the S-NSSAI values for the Serving PLMN, the target AMF reselects a final target AMF if necessary and forwards the handover request to the final target AMF. When the Handover procedure completes successfully, the UE proceeds with the Registration procedure. For each PDU Session based on the associated derived S-NSSAI values, if the V-SMF need be reallocated, the final target AMF triggers the V-SMF reallocation. The final target AMF sends the S-NSSAI value for the Serving PLMN to V-SMF to update the SM context. The V-SMF updates NG RAN with the S-NSSAI value for the Serving PLMN via N2 SM message.

### **Network Slice-Specific Authentication and Authorization (NSSAA)**

In Release-16, based on UE's 5GMM Core Network Capability and subscription information, the serving AMF will trigger Network Slice-Specific Authentication and Authorization for the S-NSSAIs of the HPLMN. If a UE does not support this feature but requests these S-NSSAIs that are subject to Network Slice-Specific Authentication and Authorization, these S-NSSAIs will be rejected by the PLMN.

If a UE supports this feature and requests these S-NSSAIs, which are subject to Network Slice-Specific Authentication and Authorization, the UE shall leverage the corresponding credentials for these S-NSSAIs for the Network Slice-Specific Authentication and Authorization. As for how to these credentials in the UE are not specified.

To perform the Network Slice-Specific Authentication and Authorization for an S-NSSAI, the AMF invokes an EAP-based Network Slice-Specific authorization procedure for the S-NSSAI.

This procedure can be invoked for a supporting UE by an AMF at any time, e.g. when:

- a. The UE registers with the AMF and one of the S-NSSAIs of the HPLMN which maps to an S-NSSAI in the Requested NSSAI is requiring Network Slice-Specific Authentication and Authorization; or
- b. The Network Slice-Specific AAA Server triggers a UE re-authentication and re-authorization for an S-NSSAI; or
- c. The AMF, based on operator policy or a subscription change, decides to initiate the Network Slice-Specific Authentication and Authorization procedure for a certain S-NSSAI which was previously authorized.

Based on the outcome of the Network Slice-Specific Authentication and Authorization, the Allowed NSSAI for each Access Type will be updated accordingly. It is network policies to decide for which Access Type to be used if both Access Types are subject for the Network Slice-Specific Authentication and Authorization. However, if the Network Slice-Specific Authentication and Authorization fails for all S-NSSAIs in the Allowed NSSAI, the AMF shall execute the Network-initiated Deregistration procedure with the appropriate rejection cause value for each Rejected S-NSSAI.

After a successful or unsuccessful UE Network Slice-Specific Authentication and Authorization, the UE context in the AMF shall retain the authentication and authorization status for the UE for the related specific S-NSSAI of the HPLMN while the UE remains RM-REGISTERED in the PLMN, so that the AMF is not required to execute a Network Slice-Specific Authentication and Authorization for a UE at every Periodic Registration Update or Mobility Registration procedure with the PLMN.

A Network Slice-Specific AAA server may revoke the authorization or challenge the authentication and authorization of a UE at any time. When authorization is revoked for an S-NSSAI that is in the current Allowed NSSAI for an Access Type, the AMF shall provide a new Allowed NSSAI to the UE and trigger the release of all PDU sessions associated with the S-NSSAI, for this Access Type.

The AMF provides the GPSI of the UE related to the S-NSSAI to the AAA Server to allow the AAA server to initiate the Network Slice-Specific Authentication and Authorization, or the Authorization revocation procedure, where the UE current AMF needs to be identified by the system, so the UE authorization status can be challenged or revoked.

The Network Slice-Specific Authentication and Authorization requires that the UE Primary Authentication and Authorization of the SUPI has successfully completed. If the SUPI authorization is revoked, then also the Network Slice-Specific authorization is revoked.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830103>

- [1] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [2] TS 23.502: "Procedures for the 5G System; Stage 2".

## 16.2 Enhancement of 3GPP management system for multiple tenant environment support

850031	Enhancement of 3GPP management system for multiple tenant environment support	MEMTANE	S5	SP-190786	Zhu, Lei, Huawei
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Summary based on the input provided by Huawei Tech in SP-200526.

The work item on enhancement of 3GPP management system for multiple tenant environment support has concluded conceptual descriptions, specific information for tenant and other potential changes to management services. This release 16 work item is a feature to enhance management and orchestration to 5G network and network slicing. This is also a follow up work item to study on tenancy concept in 5G networks and network slicing management, which concluded to enhance management system as following:

- Conception description

- Performance measurement in multiple tenant environment
- Network slice fault supervision in multiple tenant environment

In 3GPP management system, tenant is type of communication service consumer and tenant represents a group of MnS consumers associated with the management capabilities they are allowed to access and consume. The 3GPP management system provides multi-tenancy support, by associating different tenants with different sets of management capabilities. Every tenant may be authorized to access and consume those MnSs that the operator makes available to this tenant based on SLA.

The MnS consumer, acting on behalf of a tenant, may get the performance measurements of a network slice. Performance measurements specified in TS 28.552 can be split into sub-counters per S-NSSAI. 3GPP management system can use these sub-counters to distinguish performance measurements for different tenants, which might be required when performance measurements are exposed as part of Network Slice as a Service (NSaaS) specified in TS 28.530.

## References

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850031>

## 16.3 Business Role Models for Network Slicing

810051	<a href="#">Business Role Models for Network Slicing</a>	BRMNS	S1	SP-180773	Covell, Betsy, Nokia
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Summary based on the input provided by Nokia in SP-200294.

This WI adds requirements to enable a 3GPP system to adequately support the variety of business role models for network slicing that are possible in a 5G system. The requirements address service exposure giving additional control to 3rd parties, impact of SLAs on network slice management, and non-public network access to MNO spectrum. Also addressed are security relationships between

- a UE and a private slice,
- a private slice and a network, and
- a private slice and other slices of the same network.

The requirements are captured in TS 22.261 [1].

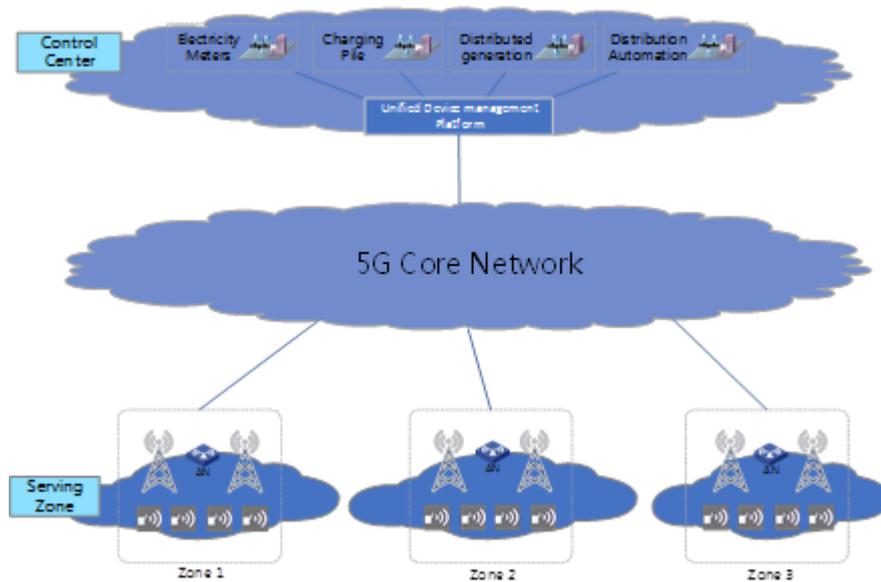
The requirements from the BRMNS WI provide the means to support new business role models in vertical markets introduced for supporting vertical markets. These role models extend the possible interactions between Mobile Network Operators (MNOs) and 3rd parties who use the network and/or own/manage part of the network infrastructure. In particular, the introduction of network slicing allows new opportunities for 3rd parties to exercise additional control over the portions of the network, i.e., the network slice, supporting their network needs. Four key business relationship models were considered.

- Model 3a: MNO provides the virtual/physical infrastructure and V/NFs; a 3rd party uses the functionality provided by the MNO,
- Model 3b: MNO provides the virtual/physical infrastructure and V/NFs; a 3rd party manages some V/NFs via APIs exposed by the MNO,
- Model 3c: MNO provides virtual/physical infrastructure; a 3rd party provides some of the V/NFs,
- Model 3d: a 3rd party provides and manages some of the virtual/physical infrastructure and V/NFs.

Models 3a and 3b are supported by the Rel-15 network slicing requirements, with some enhancements in the Rel-16 APIs and management functions to extend 3rd party access and control of capabilities provided by the MNO, and to do so in a secure manner. In these two models, the 3rd party has greater control over the network capabilities that support its service. However, this control is limited to what is allowed by the MNO through the provided APIs. The Rel-16 enhancements allow the 3rd party to monitor the activities of their UEs when using the network slice and to monitor resource usage within the network slice. These capabilities are added to support SLAs between the MNO and the 3rd party.

As an example of the additional monitoring functionality, a network slice supporting a local smart grid needs additional APIs to monitor activities of many sensors throughout the grid and receive network status information that can be used

to detect and resolve any communications problems that arise within the grid. Figure 2-1 from TR 22.830 [2] illustrates the smart grid role models.



**Figure 2-1: role model scenario between MNO and power grid company**

Models 3c and 3d resulted in the addition of new functionality to support three new network management models.

- 1) MNO manages all virtual/physical infrastructure and all V/NFs including 3rd party's ones,
- 2) 3rd party manages its own virtual/physical infrastructure and/or its own V/NFs; MNO manages the others.
- 3) 3rd party manages virtual/physical infrastructure and/or V/NFs including its own virtual/physical infrastructure and/or V/NFs and some MNO's virtual/physical infrastructure and/or V/NFs; MNO manages the others.

From the 3rd party perspective, the management role models 2 and 3 support the 3rd party management function and provide extended management for the MNO to coordinate with the 3rd party management. The 3rd party may use suitable APIs provided by the MNO to directly manage the V/NFs as well as the infrastructure resources so that it can properly handle when their business requirements are changed.

For models 3c and 3d, additional consideration is needed on the mechanisms to provide the isolation and interfaces that give the 3rd party the appropriate level of control while securing the PLMN. Specifically, where the 3rd party provides V/NFs or provides and manages some of the virtual/physical infrastructure and V/NFs, SLAs may be used to address some trust issues, such as what each party will provide and manage. However, the principles of trust and verification also come into play. The 3rd party must be able to verify, through the management interface, that all terms of the SLA are being met by the MNO. Similarly, the MNO must be able to verify that the 3rd party is managing resources appropriately so that there is no adverse impact to the rest of the network. Appropriate management interfaces are needed to support both the network operator and 3rd party.

Models 3c and 3d allow for additional interactions between non-public networks, private slices, and PLMNs as shown in the following figures from [2].

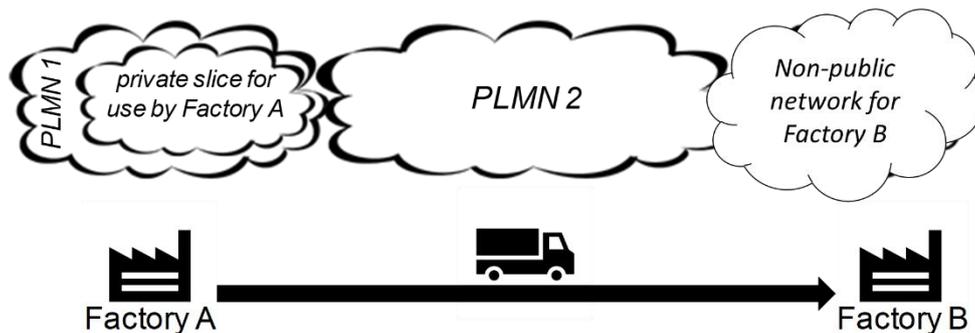


Figure 2-2: Example of enterprise communications using a combination of 5G PLMNs, a private slice, and a non-public network

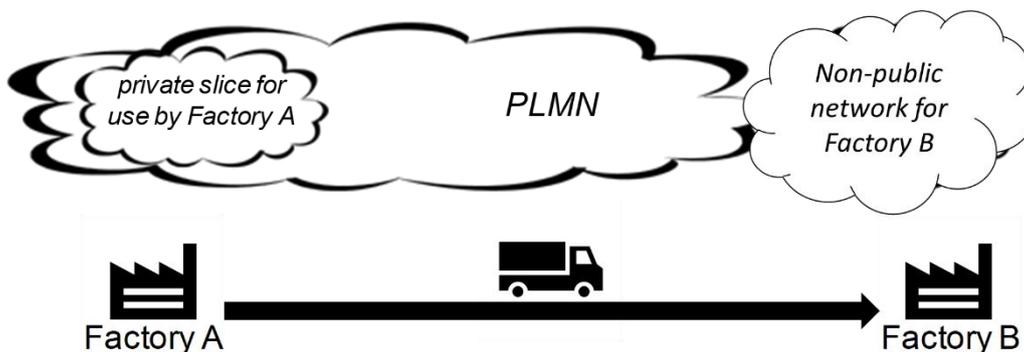


Figure 2-3: Example of enterprise communications using a geographically constrained private slice

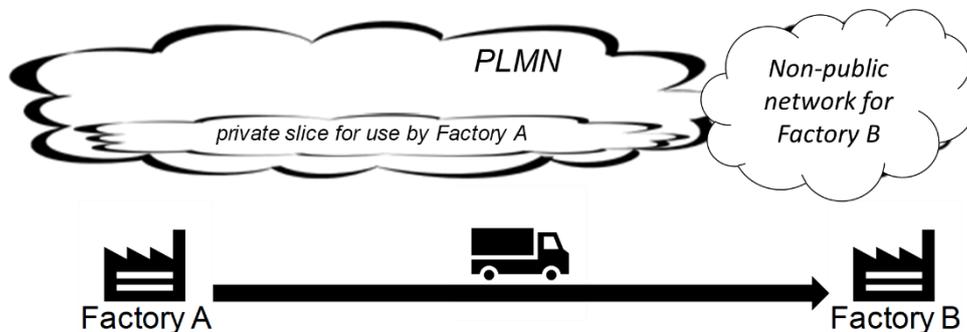


Figure 2-4: Example of enterprise communications using a private slice throughout the PLMN

Support for enterprise communications may be provided by a variety of network configurations, including multiple PLMNs, private slices, and non-public networks. New requirements allow for managing the enterprise communications in a coordinated manner across these various implementation options. New requirements also provide for isolation of private network resources which may be constrained for access within a geographic area such as a factory site or restricted for use only by UEs belonging to the enterprise. As a counterpart, additional requirements provide for restricting some enterprise UEs from accessing a PLMN, this may be useful for example to keep factory equipment connected to the private slice or non-public network when a PLMN covers the same area.

**References**

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810051>

- [1] TS 22.261 Service requirements for the 5G system
- [2] TR 22.830 Feasibility Study on Business Role Models for Network Slicing

## 16.4 Enhancement of performance assurance for 5G networks including network slicing

810031	<a href="#">Enhancement of performance assurance for 5G networks including network slicing</a>	5G_SLICE_ePA	S5	SP-190247	Xiaowei Sun (China Mobile)
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Summary based on the input provided by Intel in SP-200849.

The performance assurance feature has been enhanced with respect to both management services and 5G performance data (including performance measurements and KPIs) in Rel-16.

The threshold monitoring service has been defined for performance assurance in Rel-16. It enables the instant threshold monitoring for cumulative counters, and granularity period-based monitoring for the non-cumulative counters, as specified in TS 28.550 [1]. The instant threshold monitoring for cumulative counters supports to send the threshold crossing notification whenever the (interim) measurement value reaches the threshold within the monitoring granularity period. The threshold monitoring service is configurable by adopting the NRM (Network Resource Model) based solution (See ThresholdMonitor IOC in TS 28.622 [2]) in connection with provisioning related operations (including CreateMOI, ModifyMOIAttributes, DeleteMOI, etc) defined in TS 28.532 [3].

The performance data streaming service has been enhanced to support streaming information management, including adding and deleting streaming information by producer, and getting the streaming information by consumer, see TS 28.550 [1] and TS 28.532 [3]. The streaming information management enables the streaming of performance when there are changes on the measurement jobs, including creation of a new measurement, termination of a measurement job and change of the measurements collected in a measurement job.

The new or enhanced 5G performance measurements are defined for NG-RAN and 5GC in Rel-16 in TS 28.552 [4], covering the aspects described in the following table.

NF	Measurements categories
gNB	Packet delay (interface, node, E2E), packet loss, packet drop, IP latency, radio resource utilization, UE IP throughput, RRC connection, PDU Session Management, Handovers, UE measurement report, Transport Blocks (TB), DRB setup management, QoS flow management, UE Context management, PDCP data volume, DC connectivity, channel quality, RACH, beam.
AMF	Registration, service requests
SMF	PDU session management, QoS flow management
UPF	N3, N6, N4 and N9 interfaces, E2E delay
PCF	AM, SM and UE policy association
UDM	Registered subscribers
N3IWF	PDU session management, QoS flow management via untrusted non-3GPP access
NEF	Application triggering, PFD management
NRF	Service registration, service update, service discovery

The performance measurements for ng-eNB have been also defined in TS 32.425 [5] in Rel-16, with the focus on E-UTRA-NR Dual Connectivity.

The 5G KPIs are enhanced or newly defined in TS 28.554 [6] in Rel-16, for the aspects of QoS flow / DRB retainability, DRB accessibility, NG-RAN handover success rate, NG-RAN UE throughput, PDU session establishment success rate, PDU session establishment time, inter-gNB handover Execution time, registration update numbers and success rate, UL/DL delay in NG-RAN nodes and interfaces, integrated UL/DL delay in NG-RAN, and e2e UL/DL delay.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810031>

- [1] TS 28.550: Management and orchestration; Performance assurance
- [2] TS 28.622: Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)
- [3] TS 28.532: Management and orchestration; Generic management services
- [4] TS 28.552: Management and orchestration; 5G performance measurements

- [5] TS 32.425: Telecommunication management; Performance Management (PM); Performance measurements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN);
- [6] TS 28.554: Management and orchestration; 5G end to end Key Performance Indicators (KPI)

## 17 UE radio capability signalling optimization

### 17.1 Optimisations on UE radio capability signalling

840054	<a href="#">Optimisations on UE radio capability signalling</a>	RACS	S2	RP-191460	Haris Zisimopoulos
800025	Study on RACS	FS_RACS	S2	SP-180599	Haris Zisimopoulos, Qualcomm
830027	Stage 2 of RACS	RACS	S2	SP-190180	Haris Zisimopoulos
840003	CT aspects of RACS	RACS	ct	CP-191061	Chaponniere, Lena, Qualcomm
840055	CT1 aspects of RACS	RACS	C1	CP-191061	Chaponniere, Lena, Qualcomm
840056	CT3 aspects of RACS	RACS	C3	CP-191061	Chaponniere, Lena, Qualcomm
840057	CT4 aspects of RACS	RACS	C4	CP-191061	Chaponniere, Lena, Qualcomm
830079	<a href="#">Optimisations on UE radio capability signalling – NR/E-UTRA Aspects</a>	RACS-RAN	R2	RP-190657	MediaTek
800097	Study on optimisations on UE radio capability signalling – NR/E-UTRA Aspects	FS_RACS_RAN	R2	RP-181459	MediaTek
830179	Core part: Optimisations on UE radio capability signalling – NR/E-UTRA Aspects	RACS-RAN-Core	R2	RP-191088	MediaTek

Summary based on the input provided by Qualcomm Incorporated, MediaTek and CATT in SP-200273 (SP-200273 supersedes RP-201235, which provides the summary only on the RAN part).

This section summarizes the feature “Optimisations of UE radio capability signalling” across 3GPP specifications (RAN, SA, CT).

#### Background

With the increase in the size of UE radio capabilities driven by additional supported bands, the size of the UE Radio Capabilities will significantly grow from Rel-15 onwards, therefore an efficient approach to signal UE Radio Capability information is needed.

SA2 concluded that additional optimisation of UE radio capabilities handling should be investigated as part of a dedicated study towards Release 16. A study item [1] was drafted accordingly, along with a corresponding RAN study item [13]. The SA2 study item conclusions are documented in TR 23.743 [2]. The conclusions of the RAN study item are documented in TR 37.873 [14]. Subsequent to the study items, work items were drafted in SA ([5]) and RAN ([10]) to implement optimisations to the UE radio capability signalling.

The work is divided into two subfeatures, UE radio capability ID and UE capability segmentation.

#### UE Radio Capability ID

The SA2 work item [5] specified system optimisations for the 5GS (documented in TS 23.501 [3]) and for the EPS (documented in TS 23.401 [4]), that apply to both NR and E-UTRA, but not NB-IoT, consisting of using UE Radio Capability IDs as an alternative to signaling the UE Radio Capabilities container in system procedures:

- between the UE and the CN (over Uu)
- between the CN and the RAN (impacting N2/S1 interfaces)
- within the RAN in e.g. the handover procedures (impacting Xn/X2/S1/N2 interfaces)
- within the CN.

Work was done in collaboration with RAN WGs for the related RAN interfaces and CT WGs for the CN interfaces and NFs. Interworking with nodes that support the feature and those that do not support the feature was also defined.

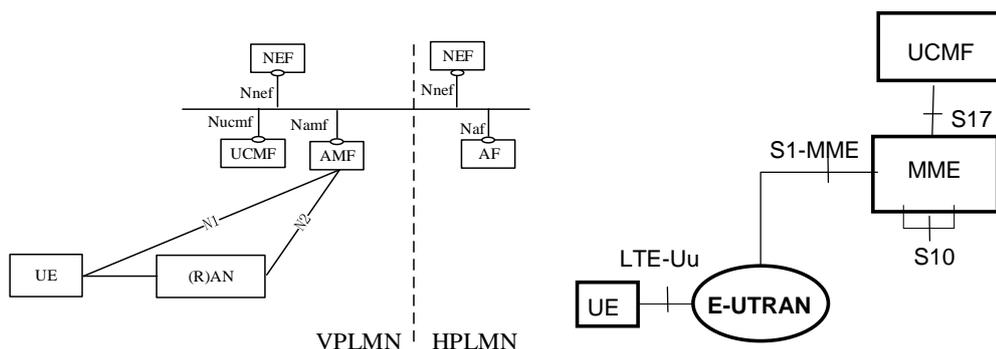
The UE Radio Capability ID format is defined in TS 23.003 [7]. The UE Radio Capability ID is signaled by the UE in NAS as specified in TS 24.501 [8] for the 5GS and as specified in TS 24.301 [9] for the EPS. Two possible options for the assignment of UE Radio Capability ID exist:

- **Manufacturer-assigned:** The UE Radio Capability ID may be assigned by the UE manufacturer in which case it includes a UE manufacturer identification (i.e. a Vendor ID). In this case, the UE Radio Capability ID uniquely identifies a set of UE radio capabilities for a UE by this manufacturer in any network.
- **Network-assigned:** If a manufacturer-assigned UE Radio Capability ID is not used by the UE or the serving network, or it is not recognised by the serving network’s UE Capability Management Function (UCMF), the UCMF may allocate UE Radio Capability IDs for the UE corresponding to each different set of UE radio capabilities which the network may receive from the UE at different times. In this case, the UE Radio Capability IDs which the UE receives

are applicable to the serving network and uniquely identify the corresponding sets of UE radio capabilities in this network. The network-assigned UE Radio Capability ID includes a Version ID in its format. The value of the Version ID is the one configured in the UCMF, at the time when the UE Radio Capability ID value is assigned. The Version ID value makes it possible to detect whether a UE Radio Capability ID is current or outdated.

UE Radio Capability IDs and the mapping to the corresponding UE radio capabilities are stored in a new function called the UE Capability Management Function (UCMF) in the CN. The UCMF is used for:

- storage of dictionary entries corresponding to either Network-assigned or Manufacturer-assigned UE Radio Capability IDs.
- assigning Network-assigned UE Radio Capability ID values.
- provisioning of Manufacturer-assigned UE Radio Capability ID entries in the UCMF performed from an AF that interacts with the UCMF either directly or via the NEF/SCEF (or via Network Management).



**Figure 1: UCMF architecture and related reference points in 5GS (left) and EPS (right)**

System procedures are defined for 5GS in TS 23.502 [6] and for EPS in TS 23.401 [4].

### UE Capability Segmentation

The RAN work item [10] calls for specification of a segmentation mechanism, so that in cases of excessively large UE capability signalling (e.g. capability information messages exceeding the maximum size of a PDCP SDU), the capability can be segmented into multiple RRC messages. Segmentation applies to both NR and E-UTRA and is captured respectively in [11] and [12].

Segmentation is performed in the RRC protocol layer, with a separate RRC PDU for each segment. The UE encodes the capability information message, then divides the encoded message into segments such that the size of each segment does not exceed the maximum size of a PDCP SDU (8188 octets in E-UTRA, 9000 octets in NR); the RAN node (eNB or gNB) receives the segments and reassembles them to reconstruct the original capability information message. Segmentation is applied only in case the size of the encoded capability information message exceeds the maximum size of a PDCP SDU. The signalling formats support up to 16 segments for a single capability information message.

### **References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840054,800025,830027,840003,840055,840056,840057,830079,800097,830179>

- [1] SP-180599, "Study on optimisations on UE radio capability signaling"
- [2] TR 23.743, "Study on optimisations on UE radio capability signaling"
- [3] TS 23.501, "System architecture for the 5G System (5GS)"
- [4] TS 23.401, "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access"
- [5] SP-190180, "Work item on optimisations on UE radio capability signaling"
- [6] TS 23.502, "Procedures for the 5G System (5GS)"
- [7] TS 23.003, "Numbering, addressing and identification"
- [8] TS 24.501, "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3"
- [9] TS 24.301, "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3"
- [10] RP-191088, "Updated WID: Core part: Optimisations on UE radio capability signalling – NR/E-UTRA Aspects"

- [11] TS 38.331, “NR; Radio Resource Control (RRC); Protocol specification”
- [12] TS 36.331, “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification”
- [13] RP-181459, “Study on optimisations on UE radio capability signalling – NR/E-UTRA Aspects”
- [14] TR 37.873, “Study on optimizations of UE radio capability signalling; NR / Evolved Universal Terrestrial Radio Access Network (E-UTRAN) aspects”

## 18 Other system-wide Features

### 18.1 Enablers for Network Automation Architecture for 5G

830047	<b>Enablers for Network Automation for 5G</b>	eNA	S2	SP-181123	Xiaobo Wu, Huawei Technologies
760047	<b>Study of enablers for Network Automation for 5G</b>	FS_eNA	S2	SP-180792	Xiaobo Wu, Huawei Technologies
820020	<b>Stage 2 of eNA</b>	eNA	S2	SP-181123	Xiaobo Wu, Huawei Technologies
830009	<b>CT aspects of eNA</b>	eNA	ct	CP-191111	Yali Yan, Huawei
830048	CT3 aspects of eNA	eNA	C3	CP-191111	Yali Yan, Huawei
830049	CT4 aspects of eNA	eNA	C4	CP-191111	Yali Yan, Huawei

Summary based on the input provided by Huawei in SP-200254.

In order to improve the NWDAF initiated in Rel 15, the eNA (Enablers for Network Automation for 5G) feature specifies the data collected by NWDAF and the NWDAF output (i.e. statistics and predictions) to support network automation.

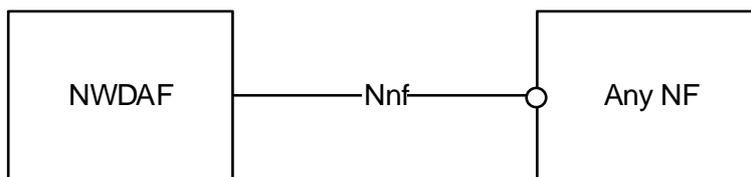
The eNA feature includes:

- Architecture enhancements of 5G System to support network data analytics service
- A framework to enable data collection and provide analytics to consumers
  - Extensions to existing Nnwdaf services to support the analytics that are required.

In addition, the eNA Work Item is applicable to the eV2XARC Work Item in which the V2X Application Server acting as an Application Function (AF) may consume relevant network data analytics provided by NWDAF for the purposes of adjustment of the application.

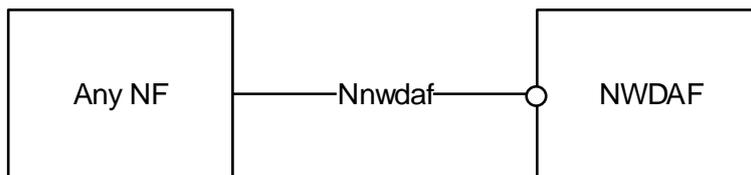
Main impacts on the system by the eNA Work Item are as follows:

- Non-roaming reference architecture for data analytics:
  - Data Collection architecture from any NF:



**Figure 1: Data Collection architecture from any NF**

- Network Data Analytics Exposure architecture:



**Figure 2: Network Data Analytics Exposure architecture**

- General data collection procedures and network data analytics exposure procedures
  - Collection method of data from 5G NFs, from AF via NEF and from OAM;
  - Analytics exposure to the registered Consumer NF, when the NF is an AF located outside the MNO domain, analytics are provided via NEF.

- For each Analytics ID, the following was specified:
  - General description;
  - Input data consumed by NWDAF to derive the network data analytics;
  - Output Analytics including details of the parameters;
  - Procedure for NWDAF providing the network data analytics.
- Possible usage of analytics by some consumer NFs is defined for the following Analytics ID:
  - Analytics ID = "Service experience"
    - If the Consumer NF is PCF, the PCF may check the 5QI values assigned to the Application, and may use this as input to calculate and update the authorized QoS for a service data flow template.
  - Analytics ID = "NF load information"
    - If the Consumer NF is AMF, based on the SMF Load, AMF could select a suitable SMF during the PDU Session Establishment or Modification procedure.
    - If the Consumer NF is SMF, based on the UPF Load, SMF could select a suitable UPF during the PDU Session Establishment or Modification procedure.
  - Analytics ID = "Network Performance"
    - If the Consumer NF is PCF, then PCF could help determine suitable background data transfer policies that fulfills Network Performance requirements t.
  - Analytics ID = "UE mobility"
    - If the Consumer NF is AMF, then AMF may use it to optimize the UE's paging strategy or to learn expected UE behavior parameters for deriving appropriate MICO mode configuration.
    - If the Consumer NF is SMF, based on the UE Moving Trajectory, the SMF could select a suitable UPF during the PDU Session Establishment or Modification procedure.
    - If the Consumer NF is UDM, the UDM may store the UE Mobility analytics as the subscription data for the UE and provision it to the AMF to help monitoring the UE's mobility behavior.
  - Analytics ID = "UE Communication"
    - If the Consumer NF is SMF, based on the UE Communication analytics, the SMF could select a suitable UPF during the PDU Session Establishment or Modification procedure.
    - If the Consumer NF is UDM, the UDM may store the UE Communication analytics as the subscription data for the UE and provision it to the SMF to help monitoring the UE's communication behavior.
  - Analytics ID = "Abnormal behaviour"
    - If the Consumer NF is PCF, based on different Exception IDs in the analytics, the PCF could make different policies, depending on operator defined policies. Some examples are provided for illustration purposes such as the PCF may use "Unexpected UE location" as input to adjust the Service Area Restrictions, "Suspicion of DDoS attack" to request the SMF to terminate the PDU session, "Wrong destination address" to perform gating of a service data flow and "Unexpected long-live/large rate flows" to perform QoS related policies such as gating or policing. In another abnormal behavior example, the AMF based on "Ping-Pong UE" Exception ID, may adjust the UE registration area.
  - Analytics ID = "User Data Congestion"
    - If the Consumer NF is an AF interfacing through NEF, the NEF could provide the User Data Congestion analytics to the AF to help optimize the application information.
  - Analytics ID = "QoS Sustainability"
    - If the Consumer is V2X Application Server acting as an AF, the V2X Application Server can use this analytics for the purposes of adjustment of the application, e.g. adjust inter-vehicle gap, change video codec parameters, etc.
- NWDAF services to expose Network Data Analytics to the Consumer NFs are specified. Two models are defined:
  - Subscribe-Notify model, i.e. Nnwdaf\_AnalyticsSubscription\_Subscribe / Nnwdaf\_analyticsSubscription\_Notify, to allow provide continuous data analytics exposure from NWDAF to the Consumer NF;
  - Request-Response model, i.e. Nnwdaf\_AnalyticsInfo\_Request / Nnwdaf\_AnalyticsInfo\_Request response, to provide a one-time data analytics exposure response from the NWDAF to the requesting Consumer NF.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830047,760047,820020,830009,830048,830049>

- [1] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [2] TS 23.502: "Procedures for the 5G System; Stage 2".
- [3] TS 23.503: "Policy and Charging Control Framework for the 5G System; Stage 2".

- [4] TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".
- [5] TS 28.550: "Management and orchestration; Performance assurance".
- [6] TS 29.520: "5G System; Network Data Analytics Services; Stage 3".
- [7] TS 29.517: "5G System; Application Function Event Exposure Service; Stage 3".

## 18.2 Provision of Access to Restricted Local Operator Services by Unauthenticated UEs

760003	<b>Provision of Access to Restricted Local Operator Services by Unauthenticated UEs</b>	PARLOS		SP-170449	Covell, Betsy Nokia
740002	Study on Stage 1 of PARLOS	FS_PARLOS	S1	SP-160904	Covell, Betsy
760046	Study on Stage 2 for PARLOS	FS_PARLOS_SA2	S2	SP-180501	Nokia (Nicolas Drevon)
800035	Study on Security Aspects of PARLOS	FS_PARLOS_Sec	S3	SP-180442	Greg Schumacher, Sprint
760071	Stage 1 of PARLOS	PARLOS	S1	SP-170449	Covell, Betsy Nokia
810008	Stage 2 of PARLOS	PARLOS	S2	SP-180738	Nokia (Nicolas Drevon)
830012	CT aspects of PARLOS	PARLOS	ct	CP-190197	Liu, Jennifer; Nokia
830062	CT1 aspects of PARLOS	PARLOS	C1	CP-190197	Liu, Jennifer; Nokia
830063	CT3 aspects of PARLOS	PARLOS	C3	CP-190197	Liu, Jennifer; Nokia
830064	CT4 aspects of PARLOS	PARLOS	C4	CP-190197	Liu, Jennifer; Nokia
830065	CT6 aspects of PARLOS	PARLOS	C6	CP-190197	Liu, Jennifer; Nokia

Summary based on the input provided by Nokia in SP-200215.

This WI adds requirements to enhance the 3GPP PS Domain to provide an optional capability to allow unauthenticated UE's to access restricted local operator services based on operator policy and regional regulatory requirements. The requirements address identifying when restricted local operator services are available and enabling a UE to attach to a network for the purpose of accessing a restricted local operator service even if the UE is not able to be authenticated by the network. The requirements can be found in TS 22.101 [1], TS 22.115 [2], and TS 22.228 [3].

The PARLOS WI was driven primarily by FCC regulations for manual roaming as described in [4] and [5]. The ability to provide access to such local services has been available to U.S. operators on a proprietary basis. However, the wide deployment of LTE and corresponding introduction of VoLTE creates demand for a standardized mechanism to allow a UE to access these services such as manual roaming without necessarily being successfully authenticated for access. This optional functionality of supporting access to RLOS services to unauthenticated UEs can be deployed based on operator policy. The RLOS services themselves are out of scope of 3GPP. PARLOS is an LTE capability.

The PARLOS requirements provide for a network to inform UEs using a 3GPP access technology that RLOS services are available and to allow access to the RLOS services when requested by the UE without requiring successful authentication of the UE first. The services are provided in an isolated manner that prevents an unauthenticated UE from accessing any other service or functionality in the network. Additional requirements also provide for collection of charging information related to the use of RLOS services.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=760003,740002,760046,800035,760071,810008,830012,830062,830063,830064,830065>

- [1] TS 22.101 Requirements for access to restricted local operator services
- [2] TS 22.115 Charging for restricted local operator services
- [3] TS 22.228 Requirements for access to restricted local operator services
- [4] Code of Federal Regulations (CFR) Title 47 Chapter 1 Subchapter B Part 20 Section 20.3
- [5] Code of Federal Regulations (CFR) Title 47 Chapter 1 Subchapter B Part 20 Section 20.12 (Resale and Roaming)

## 18.3 Enhancing Topology of SMF and UPF in 5G Networks

820043	<b>Enhancing Topology of SMF and UPF in 5G Networks</b>	ETSUN		SP-181116	Laurent Thiebaut (Nokia)
770039	Study on ETSUN	FS_ETSun	S2	SP-180731	Laurent Thiebaut (Nokia)
820013	Stage 2 of ETSUN	ETSUN	S2	SP-181116	
830002	CT aspects of ETSUN	ETSUN	ct	CP-190192	Landais, Bruno, Nokia
830055	CT3 aspects of ETSUN	ETSUN	C3	CP-190192	Landais, Bruno, Nokia
830056	CT4 aspects of ETSUN	ETSUN	C4	CP-190192	Landais, Bruno, Nokia
850024	Charging aspects of ETSUN	ETSUN	S5	SP-190880	Dong, Jia, China Mobile

Summary based on the input provided by Nokia in SP-200256.

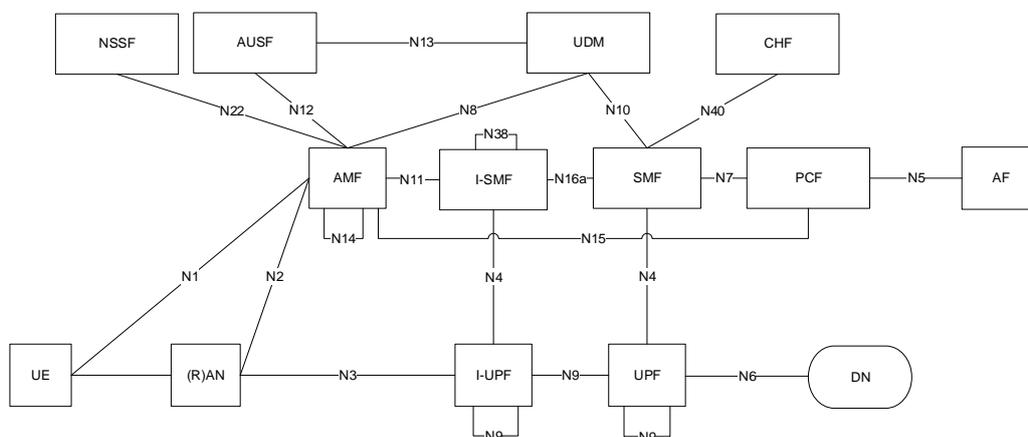
Enhancing Topology of SMF and UPF in 5G Networks (ETSUN) has two goals:

1. Enable the 3GPP system to support deployments where a SMF is not able / allowed to control UPF(s) throughout the same PLMN.
  - This is mostly meant for very big networks which are subdivided into geographical areas with each their own management;
  - This relates with the addition of I-SMF in the architecture but defines also the possibility of changing the V-SMF in case of Home-Routing.
2. Enhance the capability of 5GS architecture for a UPF to be controlled by multiple SMF's (and many UPF's to be controlled by many SMF's) especially for the UE IP address / Prefix allocation

These features couldn't be specified as part of 3GPP R15 Session Management due to lack of time.

Addition of I-SMF in the architecture

When a UE with an established PDU Session is not in a TA served by the SMF of this PDU Session, an intermediate SMF (called I-SMF) is inserted by the AMF in the signalling path of the PDU session to control the intermediate UPF (called I-UPF) terminating the N3 interface with the 5G Access Network.



**Figure 1: Non-roaming architecture with I-SMF insertion to the PDU Session in reference point representation, with no UL-CL/BP**

The I-SMF acts in a similar way than the V-SMF of a Home Routed PDU Session: as long as the UE remains in its own I-SMF service area, the I-SMF handles the transitions between User Plane Active and Inactive for the PDU session, the Hand-Over and controls the local UPF(s) with sometimes relaying of N4 commands received from the SMF. The SMF remains responsible of the interfaces with the PCF and the CHF, of the interface with the UDM and of the overall control of the PDU Session.

When the I-SMF is inserted into a PDU Session, the I-SMF provides to the SMF the list of DNAI it supports. Based on this information received from I-SMF and on PCC rules for the PDU Session, the SMF may provide the DNAI(s) of interest for local traffic steering to the I-SMF for this PDU Session. The I-SMF is thus responsible for the insertion, modification and removal of UPF(s) to ensure local traffic steering: the SMF does not need to know the mapping between DNAI(s) for local traffic offload and local UPF(s). Then the SMF provides N4 rules to the I-SMF for how the traffic for local offload shall be detected, enforced, monitored in UPF(s) controlled by the I-SMF.

When the UE moves out of the service area of the I-SMF, the I-SMF may be changed or the I-SMF is simply removed. Likewise, the V-SMF may be changed upon UE mobility in case of Home-Routing.

UE IP address / Prefix allocation

ETSUN adds the possibility for the SMF to defer to the UPF the UE IP address / Prefix\_allocation or to indicate to the DHCP/DN-AAA server the range (corresponding to the UPF) of IP address / Prefix\_to be allocated : this allows many

SMF(s) to control the same UPF without having to synchronise or divide the UE IP address / Prefix\_space between these SMF(s).

Charging aspects (Summary provided by China Mobile in SP-200266)

SA2, CT3 and CT4 have studied the enhanced topology deployments of SMF and UPF in TR 23.726, TS 23.501 and 23.502. S5 WI ETSUN specify charging support for deployments topologies with specific SMF service areas to line up with the other NF interfaces.

Charing Stage 2 work on WI ETSUN for TS 32.255 [3]:

- Specify charging procedures and functionality enhancement for PDU sessions with Intermediate SMF (I-SMF) and anchor SMF (SMF), based on existing Nchf to SMF.
- Introduction of V-SMF change in Roaming HR principles and message flows.
- Enhance procedures for addition /change/removal of PSA for UL CL or BP controlled by I-SMF.
- Update charging procedures with I-SMF insertion/change/removal.
- Add I-SMF related triggers in SMF.

Charging Stage 3 work on WI ETSUN for 32.291 [4] and 32.298 [5]:

- Add relevant parameters in CHF-CDR to support I-SMF as serving network function.
- Add I-SMF related trigger, trigger types and data type.
- Update Nchf\_ ConvergedCharging API.

## References

For the addition of I-SMF in the architecture, ETSUN is mostly specified in TS 23.501 [1] clause 5.34 and in TS 23.502 [2] clause 4.23 (both clauses are dedicated to ETSUN).

For the aspects related with UE IP address allocation, ETSUN is mostly specified in a CR 0931/0954 (SP-190164) to TS 23.501 [1] clause 5.8.2.2.1.

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820043,770039,820013,830002,830055,830056,850024>

- [1] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [2] TS 23.502: "Procedures for the 5G System; Stage 2".
- [3] TS 32.255: "5G data connectivity domain charging"
- [4] TS 32.291: "5G system, charging service"
- [5] TS 32.298: "Charging Data Record (CDR) parameter description"

## 18.4 Private and Non-Public Network Support for NG-RAN

830081	<a href="#">Private Network Support for NG-RAN</a>	NG_RAN_PRN	R3	RP-200122	China Telecom
830181	Core part: <a href="#">Private Network Support for NG-RAN</a>	NG_RAN_PRN-Core	R3	RP-200122	China Telecom

Summary based on the input provided by China Telecom in RP-200733.

This work item specifies the Private Network (i.e. Stand-alone Non-Public Network (NPN) and PLMN Integrated Non-Public Network) features for gNB with the following functionalities:

Support NPN functionality in NG-RAN:

- CAG/SNPN relevant parameter broadcast from SIB
- CAG/SNPN cell selection/reselection
- CAG/SNPN cell access control
- For CAG, in the case of Intra-RAT intra-system and inter-RAT intra-system, the connected mode mobility support
- The connected mode mobility support within SNPN

For CAG/SNPN, necessary modifications to NG-C and Xn interfaces to communicate the CAG-ID/NID related parameters to NG-RAN nodes, respectively: "Support CAG/SNPN functionality with CU-DU split" and "Support CAG/SNPN functionality with CP-UP split", if any.

The key functionalities of this work item include the following.

#### NPN relevant parameter broadcast from SIB

The NPN IDs (i.e. SNPNs (identified by PLMN ID + NID) and PNI-NPNs (identified by PLMN ID + CAG ID)) were introduced into SIB1 to indicate UEs whether a cell is an NPN cell. Up to 12 different SNPNs or PNI-NPNs or mixed networks can be broadcasted in a cell. SIB1 allows indication of TAC, RANAC, cell Identity per SNPN or per PNI-NPN.

The names of NPNs (HRNN) are broadcasted in SIB10 and the On-demand SI in connected is not supported for SIB10. The HRNN is associated with the Network ID implicitly. The SIB for HRNN shall have the same amount of HRNN elements as the number of CAGs and NIDs in SIB1.

New defined IE 'manualCAGselectionAllowed-r16' is used to indicate whether it is allowed users to manually select a CAG-ID supported by the CAG cell but outside the UE's allowed CAG list.

Only cells supporting CAG(s), including CAG only cells and shared CAG cells, may be listed in the new CAG PCI lists, UE may use knowledge of the CAG PCIs to improve implementation dependent search procedures for CAGs.

#### NPN cell selection/reselection

NPN selection functions similar to normal PLMN selection, when a cell broadcasts any CAG IDs or NIDs, NPN-capable Rel-16 UE can treat the cell with cellReservedForOtherUse = true as a candidate cell during cell selection and cell reselection. UE AS reports the found NPN IDs to NAS. In case of manual selection, the human readable network name (if broadcasted) may also be provided from AS to NAS.

The UE shall scan all RF channels in the NR bands according to its capabilities to find available NPNs. On each carrier, the UE shall at least search for the strongest cell, read its system information and report available NPN identifiers together with their HRNN (if broadcast) to the NAS.

For a UE in NPN access mode, if the highest ranked cell or best cell according to absolute priority reselection rules is a cell which is not suitable for UE access, for licensed spectrum, the UE shall not consider this cell and other cells on the same frequency as candidates for reselection for a maximum of 300 seconds; for unlicensed spectrum, the UE shall not consider this cell as candidate for cell reselection but should continue to consider other cells on the same frequency for cell reselection.

The Rel-15 UEs and Non-NPN-capable Rel-16 UEs treat a cell with cellReservedForOtherUse=true as barred cell.

For Rel-16 and later NPN-capable UEs, if the npn-IdentityInfoList-r16 IE is present in CellAccessRelatedInfo and the cellReservedForOtherUse = true while, a cell is an NPN-only cell that is only available for normal service for NPNs' subscriber.

All the R16 UEs will treat the cell as barred when the legacy IE cellReservedForOtherUse=True and this cell does not broadcast any CAG-IDs or NIDs.

For SNPN, Once the UE has selected an SNPN, cell selection/re-selection is only performed within the SNPN, i.e. a cell is only considered suitable if the broadcasted SNPN identifier matches the selected SNPN.

#### NPN cell access control

There is no preliminary access check for NPN cells in CONNECTED mode. For SNPN, the UAC parameters per SNPN are configured by reusing the existing uac-BarringPerPLMN-List, and for a PNI-NPN the UAC parameter set is selected based on the PLMN ID of PNI-NPNs. The current measurement reporting procedures is extended to include NPN information to support ANR.

During the access procedure, for SNPN, the SNPN ID is included in the RRCSetupComplete and Initial UE Message message, and for PNI-NPN the Allowed CAG list is provided to the gNB by the AMF. A single Cause "NPN access denied" will be sent to users when they fail to access NPN cells.

#### NPN relevant mobility support

At mobility, the source NG-RAN node knows the NPN information supported by the candidate target cells, the target RAN node needs to be informed of the serving SNPN ID or UE allowed CAG ID list which are included in the mobility restriction list. If the serving SNPN ID or UE allowed CAG ID list does not match any of the target cell supported list of SNPN IDs or CAG IDs, target RAN node shall fail the handover.

For mobility in inactive state, the last serving NG-RAN node performs access control check upon the reception of RETRIEVE UE CONTEXT REQUEST, the new NG-RAN node may perform access control check upon the reception of RETRIEVE UE CONTEXT RESPONSE which is implementation dependent.

#### NPN Support over NG/Xn

The list of supported SNPN IDs could be exchanged between NG-RAN node and AMF via NG setup and configuration update procedures while the list of cell supported SNPN IDs and CAG IDs could be exchanged via Xn setup and configuration update procedures.

#### NPN Support over F1/E1

Over F1, the list of supported SNPN IDs can be exchanged between DU and CU, the cell supported list of CAG IDs can be signaled from DU to CU. The NID as part of the UAC Assistance Information could be signalled from gNB-CU to gNB-DU. The gNB-DU is responsible for SIB10 encoding, valueTag and areaScope associated with SIB10, and need to signal the HRNN (SIB 10) to gNB-CD. The general cause value "NPN not supported" is introduced for interface related messages and the general cause value "NPN access denied" is introduced for UE-associated messages. Over E1, the list of SNPN IDs supported by CU-UP could be signalled to CU-CP.

#### NPN support for RAN sharing and Dual connectivity

If NR access is shared, system information broadcast in a shared cell indicates a TAC and a Cell Identity for each subset of PLMNs, PNI NPNs and SNPNs. NR access provides only one TAC and one Cell Identity per cell per PLMN, SNPN or PNI NPN. In Rel-16, a Cell Identity can only belong to one network type among PLMN, PNI-NPN or SNPN.

The NR-DC within a single SNPN or within PNI-NPN or across PLMN and PNI-NPN is supported, EN-DC is not supported for NPN.

#### Emergency Services

For SNPN, Emergency services are not supported.

For a CAG-only cell in PNI-NPN, if the cellReservedForOtherUse = false in gNB, the access attempts of Rel-15 UEs or Rel-16 non-NPN capable UEs for emergency services could be allowed; if the cellReservedForOtherUse = true, the access attempts of Rel-16 NPN capable UEs for emergency services could be allowed.

#### **References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830081,830181>

## 18.5 Service-Based Architecture

### 18.5.1 Enhancements to the Service-Based 5G System Architecture

820045	<a href="#">Enhancements to the Service-Based 5G System Architecture</a>	5G_eSBA	S2	SP-181125	
790007	<a href="#">Study on Enhancements to the Service-Based 5G System Architecture</a>	FS_eSBA	S2	SP-180231	Tao Sun (China Mobile)
820022	<a href="#">Stage 2 of 5G_eSBA</a>	5G_eSBA	S2	SP-181125	Tao Sun (China Mobile)
830001	<a href="#">CT aspects of 5G_eSBA</a>	5G_eSBA	ct	CP-190191	Song Yue (China Mobile)
830060	CT3 aspects of 5G_eSBA	5G_eSBA	C3	CP-190191	Song Yue (China Mobile)
830061	CT4 aspects of 5G_eSBA	5G_eSBA	C4	CP-190191	Song Yue (China Mobile)
780029	<a href="#">Study on Enhanced IMS to 5GC Integration</a>	FS_eIMS5G	S2	SP-180736	Joul, Chris, T-Mobile USA

Summary based on the input provided by China Mobile in [SP-200776].

This WI enhances the service-based architecture of 5G system to improve the service framework and support high reliability. The main features introduced by the WI include:

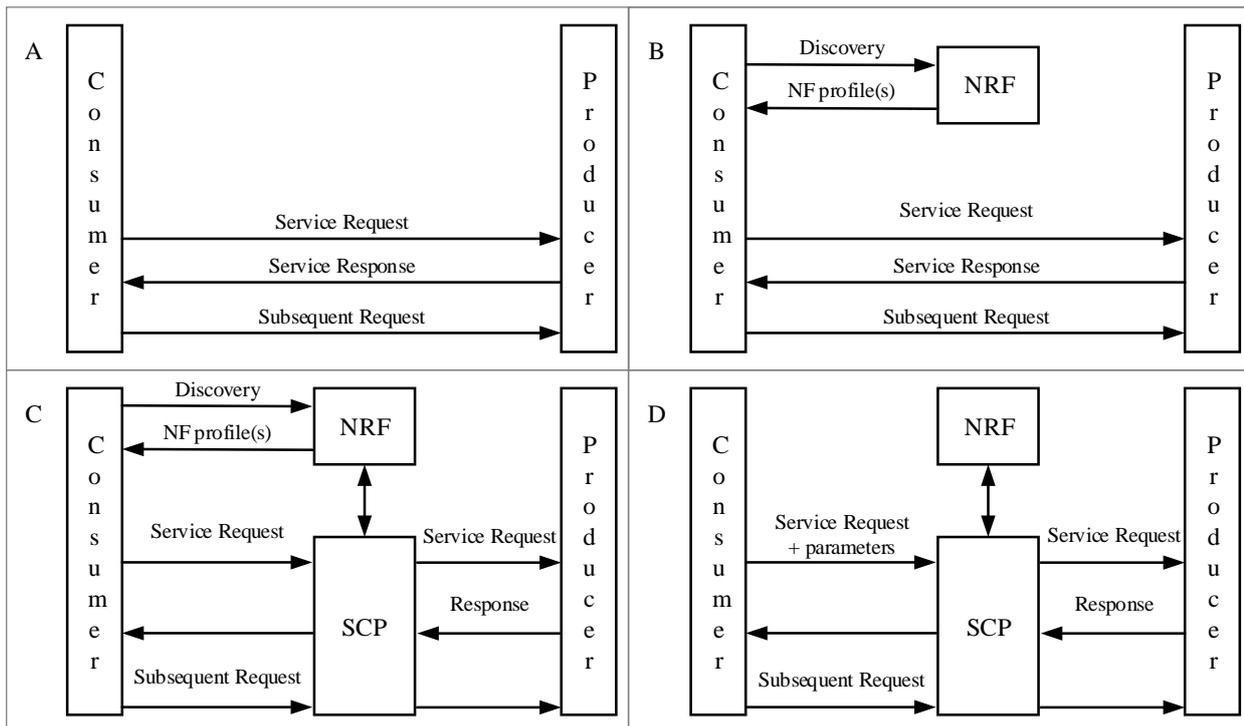
- 1) support of indirect communication models of NF/NF Services via an intermediary function (Service Communication Proxy - SCP),

2) NF/NF service set enabling the grouping of equivalent NF instances/NF service instances. The NF/NF Services within a NF/NF Service set can share the same context data thus improving the resiliency for processing any transaction. and

3) binding mechanism improves the flexibility and efficiency of the service based architecture by allowing the NF producer to dynamically indicate that the NF consumer, for a particular context, should be bound to an NF service instance, NF instance, NF service set or NF set for subsequent transaction depending on local policies or other criteria..

#### Architecture enhancement

The work has resulted in the definition of different communication models that NF and NF services can use to interact which each other via or not via a new NF named SCP as shown in the figure here below from TS 23.501 [1]



**Figure 1: Communication models for NF/NF services interaction**

Model A - Direct communication without NRF interaction: Neither NRF nor SCP are used. Consumers are configured with producers' "NF profiles" and directly communicate with a producer of their choice.

Model B - Direct communication with NRF interaction: Consumers do discovery by querying the NRF. Based on the discovery result, the consumer does the selection. The consumer sends the request to the selected producer.

Model C - Indirect communication without delegated discovery: Consumers do discovery by querying the NRF. Based on discovery result, the consumer does the selection of an NF Set or a specific NF instance of NF instance set. The consumer sends the request to the SCP containing the address of the selected service producer pointing to a NF service instance or a set of NF service instances. The SCP routes the request to the selected NF service producer instance.

Model D - Indirect communication with delegated discovery: Consumers do not do any discovery or selection. The consumer adds any necessary discovery and selection parameters required to find a suitable producer to the service request. The SCP uses the request address and the discovery and selection parameters in the request message to route the request to a suitable producer instance. The SCP can perform discovery with an NRF and obtain a discovery result.

#### NF/NF Service set mechanism

The NF Set and NF Service Set concept has been defined by grouping equivalent control plane NFs into NF Set or grouping multiple NF Service instances into NF Service Set. The NF/NF Services within a NF/NF Service set can share the same context data.

When the NF producer instance is not available, another NF producer instance within the same NF Set is selected. When multiple NF Service instances within a NF Service Set are exposed to the NF Service consumer or SCP and the failure of NF Service instance is detected or notified by the NRF, the NF Service consumer or SCP selects another NF Service instance of the same NF Service Set within the NF instance, if available. Otherwise the NF Service consumer or SCP selects a different NF instance within the same NF Set.

### Binding mechanism

A binding mechanism based on NF/NF Service set was introduced to improve the efficiency of the service-based architecture.

Binding is used to indicate suitable target NF producer instance(s) for NF service instance selection, reselection and routing of subsequent requests associated with a specific NF producer resource (context) and NF service. This allows the NF producer to indicate that the NF consumer, for a particular context, should be bound to an NF service instance, NF instance, NF service set or NF set depending on local policies and other criteria.

Binding is also used by the NF consumer to indicate suitable NF consumer instance(s) for notification target instance reselection and routing of subsequent notification requests associated with a specific notification subscription and for providing Binding Indication for service(s) that the NF consumer produces for the same data context and the NF service producer is subsequently likely to invoke.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820045,790007,820022,830001,830060,830061,780029>

- [1] TS 23.501: "System Architecture for the 5G System; Stage 2". Key reference sections: Clause 6.3.1, Clause 7.1, Annex E, Annex G.
- [2] TS 23.502: "Procedures for the 5G System; Stage 2". Key reference sections: Clauses 4.17.9 - 4.17.12.

## 18.5.2 SBA aspects of enhanced IMS to 5GC integration

840062	<a href="#">SBA aspects of enhanced IMS to 5GC integration</a>	eIMS5G_SBA	S2	SP-190181	T-Mobile USA, Christopher Joul
830028	<a href="#">Stage 2 of eIMS5G_SBA</a>	eIMS5G_SBA	S2	SP-190181	T-Mobile USA, Christopher Joul
840006	<a href="#">CT aspects of eIMS5G_SBA</a>	eIMS5G_SBA	ct	CP-191065	de Gregorio, Jesus. Ericsson
840063	<a href="#">CT3 aspects of eIMS5G_SBA</a>	eIMS5G_SBA	C3	CP-191065	de Gregorio, Jesus. Ericsson
840064	<a href="#">CT4 aspects of eIMS5G_SBA</a>	eIMS5G_SBA	C4	CP-191065	de Gregorio, Jesus. Ericsson

Summary based on the input provided by T-Mobile USA INC in SP-200808

In release 15 Service-Based interfaces were introduced between the functional elements of the new 5G core systems (5GC), however no changes were made to the IMS nodes that interact with the packet core, and so Diameter-based interfaces remained between IMS functions and the 5GC. It was therefore determined that the specification of Service-Based interfaces between the IMS core and the 5GC would enable more efficient implementations. However, to enable operators the flexibility in performing the transition to Service-Based Architecture (SBA), it was determined not to remove (at this time) the option to use Diameter for IMS services interworking with 5GC.

This work resulted in the specification of Service-Based architecture between the IMS and 5GC. The following summarizes the enhancements made:

The first major change to enable SBA was an update to the PCF and Npcf services to allow the IMS functions to use the N5 interface (instead of Rx) when communicating with the PCC functions for QoS interactions. This requires IMS functions to be upgraded to support the SBA procedures and protocols, as well as the SBA protocols themselves to be updated with IMS specific parameters (including IMS public and private identifiers). The IMS functions now use similar capabilities to other SBA functional entities to perform PCF discovery, avoiding the need for interworking to perform this. One added benefit of this is that a new option for P-CSCF discovery using the NRF is provided, this may allow for some network implementations to use a single discovery method (avoiding misalignment between different systems).

One area of significant change was to provide SBA capabilities to the IMS portion of the HSS, this introduces Nhss services to the SBA for IMS interactions with the HSS. Service-Based equivalents to the Cx and Sh interfaces (identified as the N70 and N71 interfaces) enable the CSCF and IMS-AS to use service-based interfaces for subscription and service interactions with the HSS. No changes are made to the non-IMS portions of the HSS so that existing LTE

and UMTS packet cores can continue to interact with the HSS unchanged; this also allows for UDICOM implementations.

The last major change from the Diameter approach to the Service-Based approach was in the method of HSS discovery. To better align with the discovery of other 5GC functional elements, the NRF and the Nnrf protocols were updated, allowing the IMS functions to discover the correct HSS instance to use for the subscription of a specific subscriber. To enable implementations where the mapping between a subscriber identifier and the HSS instance is not stored in the NRF a new service was specified allowing the UDR to store this information and for the NRF to request the mapping. These enhancements can leverage the deployment implementation options introduced with eSBA (e.g. direct or indirect discovery methods) for proxy-based network routing.

As noted earlier, the option to utilize Diameter based interactions between IMS and 5GC was retained, to enable flexible transition to SBA.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840062,830028,840006,840063,840064>

- [1] TS 23.228 "IP Multimedia Subsystem (IMS); Stage 2".
- [2] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [3] TS 23.502: "Procedures for the 5G System (5GS); Stage 2".
- [4] TS 23.503 "Policy and charging control framework for the 5G System (5GS); Stage 2".
- [5] TS 29.563 "Home Subscriber Server (HSS) services for interworking with Unified Data Management (UDM); Stage 3".
- [6] TS 29.562 "5G System; Home Subscriber Server (HSS) services for interworking with the IP Multimedia Subsystem (IMS); Stage 3".
- [7] TS 29.510 "5G System; Network function repository services; Stage 3".
- [8] TS 29.513 "5G System; Policy and Charging Control signalling flows and QoS parameter mapping; Stage 3".

## 18.6 User data interworking, Coexistence and Migration

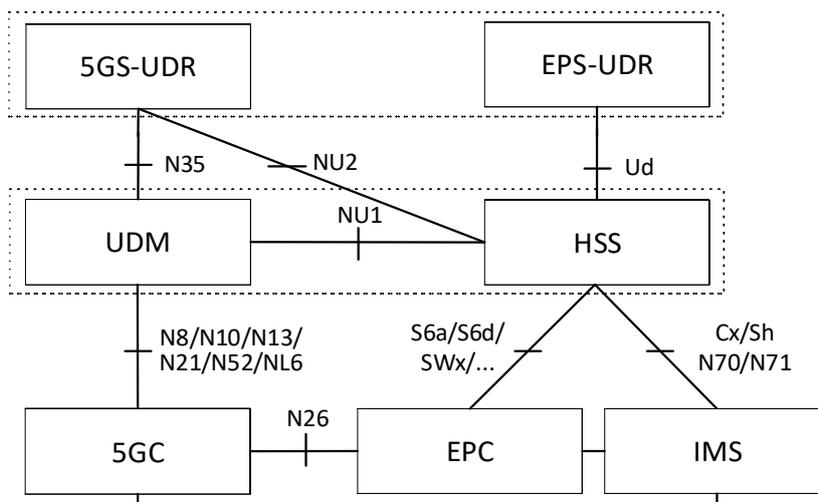
840065	<a href="#">User data interworking, Coexistence and Migration</a>	UDICOM	S2	SP-190182	Alessio Casati, Nokia
800055	Study on UDICOM	FS_UDICoM	S2	SP-190148	Susana Sabater (Vodafone)
830029	Stage 2 of UDICOM	UDICOM	S2	SP-190182	Alessio Casati, Nokia
840007	CT aspects of UDICOM	UDICOM	C4	CP-191066	Wiehe, Ulrich, Nokia

Summary based on the input provided by Nokia.

3GPP SA2 in Release 15 defined the unified data architecture based on UDR. The HSS+UDM were introduced in R15 for migration purposes (in TS 23.501, Section 5.17).

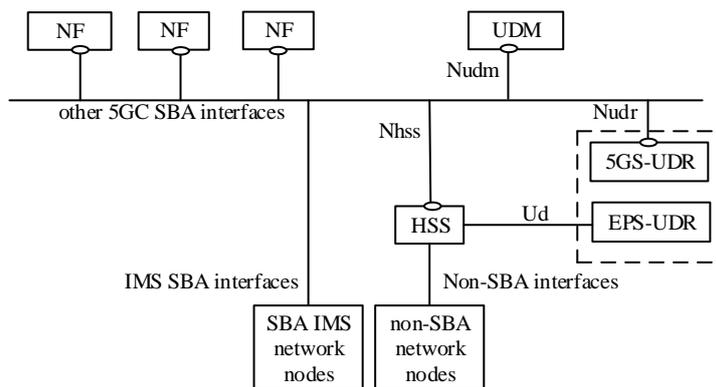
This WI standardises the interaction between UDM and HSS, when these are deployed separately, and coexistence of 5G and 4G subscription data permitting 5G migration towards the UDM/UDR architecture defined for 5GC.

Open interfaces are defined between UDM and HSS (NU1 interface) and HSS and UDR (NU2 interface) and in the figure here below from TS 23.632 [1]



**Figure 1: Architecture for Direct UDM-HSS interworking in reference point representation**

From a Service Based architecture standpoint, the new Nhss services have been added:



**Figure 2: Architecture for Direct UDM-HSS interworking**

The Nudr and Nudm services have been enhanced, also.

The Nhss service has been defined in TS 29.563[2] and the overall architecture and stage two is in TS 23.632. Both are under CT4 responsibility (see the CT WID in CP-193016[5]). TS 23.501[1] and TS 23.502[4] only provide minimal text on the stage two aspects and refer to the CT4 documents as necessary.

The work has no impact on the rest of the system as the interactions defined by this work remain confined between UDM, HSS and UDR (i.e. the deployment of UDICOM in a PLMN is transparent to the rest of the system, in that whether a combined UDM/HSS or a UDICOM enabled separate UDM and HSS are deployed in a PLMN is not detectable e.g. from a MME or a AMF)

**References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840065,800055,830029,840007>

[1] TS 23.632 "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".

- [2] TS 29.563 "Home Subscriber Server (HSS) services for interworking with Unified Data Management (UDM); Stage 3".
- [3] TS 23.501: "System Architecture for the 5G System; Stage 2".
- [4] TS 23.502: "Procedures for the 5G System (5GS); Stage 2".
- [5] 3GPP CP-193016: "WID: User data interworking, Coexistence and Migration".

## 19 Radio Features

### 19.1 NR-related Release 16 Features

#### 19.1.1 NR-based access to unlicensed spectrum

820067	<a href="#">NR-based access to unlicensed spectrum</a>	NR_unlic	R1	RP-191575	Qualcomm
750045	<a href="#">Study on NR-based access to unlicensed spectrum</a>	FS_NR_unlic	R1	RP-181339	Qualcomm
820167	<a href="#">Core part: NR-based access to unlicensed spectrum</a>	NR_unlic-Core	R1	RP-190706	Qualcomm
820267	<a href="#">Perf. part: NR-based access to unlicensed spectrum</a>	NR_unlic-Perf	R4	RP-190706	Qualcomm

Summary based on the input provided by Qualcomm in RP-202753 (previous version in RP-201840)

This work item specifies NR enhancements for a single global solution framework for access to unlicensed spectrum which enables operation of NR in the 5GHz and the 6GHz (e.g., US 5925 – 7125 MHz, or European 5925 – 6425 MHz, or parts thereof) unlicensed bands taking into account regional regulatory requirements and reusing features of NR as much as possible.

This work item supports NR Radio Access operating with shared spectrum channel access to operate in different modes where either PCell, PSCell, or SCells can be in shared spectrum and an SCell may or may not be configured with uplink. The applicable deployment scenarios are described in the following.

- Scenario A: Carrier aggregation between NR in licensed spectrum (PCell) and NR in shared spectrum (SCell);
  - o A.1: SCell is not configured with UL (DL only); A.2: SCell is configured with UL (DL+UL).
- Scenario B: Dual connectivity between LTE in licensed spectrum and NR in shared spectrum (PSCell);
- Scenario C: NR in shared spectrum (PCell);
- Scenario D: NR cell in shared spectrum and uplink in licensed spectrum;
- Scenario E: Dual connectivity between NR in licensed spectrum (PCell) and NR in shared spectrum (PSCell)

#### Physical Layer Signals and Channels

**Initial access signals and channels:** For PRACH, to support larger PRACH transmission power under PSD limitation and/or to meet OCB requirement, longer PRACH sequences of length 1151 and 517 are introduced, applicable to 15kHz SCS and 30kHz SCS, respectively. Legacy length 839 PRACH sequence is not supported in a cell with shared spectrum channel access.

**DL signals and channels:** DCI 2\_0 is enhanced to provide time and frequency domain Channel Occupancy Time (COT) structure. For time domain COT, remaining COT duration can be included in DCI 2\_0. If COT duration field is not configured, the UE can derive the remaining COT duration from SFI field included in DCI 2\_0. For frequency domain COT, a bitmap for available RB sets can be included in DCI 2\_0 to indicate if an RB set is included in the current COT.

Search space set group switching feature is also introduced, such that the UE can be dynamically controlled to perform PDCCH monitoring from two groups of search spaces sets. The search space set group switching can be triggered by explicit bit in DCI 2\_0, a PDCCH decoding event in one of the groups, and a timer expiration.

In Rel-15, only length of 2, 4 and 7 OFDM symbols is supported with PDSCH mapping type B with. Additional lengths (i.e. 2-13 symbols) as well as corresponding additional DMRS positions are specified for unlicensed band operation. The feature is also specified for licensed operation.

In order to facilitate UE monitoring PDCCH on multiple RB sets while not significantly increasing RRC signalling overhead, a search space can be configured with multiple monitoring locations in frequency domain. The configuration of CORESET is replicated on the RB sets where these monitoring locations are located.

**UL signals and channels:** For PUCCH and PUSCH, PRB interlace structure is introduced to meet OCB requirement and boost transmit power under PSD limitation. For 30KHz SCS, M=5 interlaces are defined. For 15KHz SCS, M=10

interlaces are defined.. The interlaces are defined with respect to point A, and one interlace is formed by set of resource blocks M RBs apart.

For PUCCH, Rel.15 NR PUCCH format 0/1/2/3 are extended to PRB interlace waveform similar to PUSCH, but constrained within one RB set. PUCCH format 0/1 in Rel.15 is single RB only, and in Rel.16, they are extended to one interlace with 10 or 11 RBs. PUCCH format 2/3 in Rel.15 are already multiple RBs but in continuous RBs up to 16 RBs. In Rel.16, they are extended to occupy one or two interlaces. If one interlace is used, frequency domain OCC and pre-DFT OCC are introduced for PUCCH format 2 and 3 respectively to improve the multiplexing capacity.

In Rel-15, SRS is restricted to the last 6 symbols in a slot. In Rel-16, UE is able to be configured with SRS transmission on every OFDM symbols in a slot for unlicensed band operation. The feature is also specified for licensed operation.

gNB can schedule multiple contiguous PUSCH(s) by a single DCI format 0\_1.

### **Physical Layer Procedures**

**Channel access procedures:** Rel.16 NR-U supports two channel access operation modes: dynamic channel access mode (corresponds to Load Based Equipment in [1]) and semi-static channel access mode (corresponds to Frame Based Equipment in [1]).

When operating on a wideband (i.e. >20MHz) carrier, clear channel assessment (CCA) is performed in the unit of 20MHz or 10MHz depends on regulation requirements.

For dynamic channel access mode, the following LBT mechanisms are defined:

- Cat 4 LBT with a contention window (Type 1);
- Cat 2 LBT within a 25  $\mu$ s sensing interval (Type 2A); Cat 2 LBT within a 16  $\mu$ s gap (Type 2B)
- Cat 1 LBT with a gap of no more than 16  $\mu$ s without channel sensing (Type 2C)

Both gNB and UE can acquire a COT with Cat 4 LBT, while a gNB or UE can share the COT acquired by the other node with Cat 2 or Cat 1 LBT under different conditions. The only exception is the transmission of discovery RS, which includes the transmission of SSBs and other non-unicast control and data, where under some restriction, Type 2A LTE can be used to acquire the COT.

For semi-static channel access, in Rel.16 NR-U, only gNB can contend for a channel as a fixed frame period boundary and a UE can share the gNB COT for transmission if gNB DL transmission is detected in an earlier part of the same COT.

**Enhancements to initial access procedures:** Discovery RS is a concept introduced for NR-U to deliver critical information including PSS/SSS/PBCH blocks (SSB) and critical system information including System Information Block 1 (SIB1). In NR, for sub-7GHz bands, up to 8 SSBs can be transmitted every 20ms to support beam sweeping with different SSB positions. There is no quasi-colocation (QCL) relationship across up to 8 SSBs within one cycle, but SSBs at the same position in different cycles are assumed to be QCL'ed.

For unlicensed band operation, transmissions are subject to LBT. Hence, there is a chance that SSBs cannot be transmitted due to LBT failure. There are two enhancements introduced to support a more reliable delivery of critical system information:

- Type 2A LBT can be used to start the DRS transmission if the duty cycle of the DRS is no larger than 1/20 and the length of the DRS is no longer than 1ms
- Up to 20 and 10 candidate SSB positions in a half frame are supported for 30kHz SCS and 15kHz SCS, respectively, to allow more transmission opportunities than Rel-15. SSBs on the candidate SSB positions with same SSB index are regarded as QCLed.

The RSSI measurement bandwidth is 20MHz regardless of the carrier bandwidth.

**HARQ enhancements:** For operation in unlicensed band, a major issue with HARQ operation is scheduled ACK/NACK transmission may not happen due to LBT failure. In licensed operation, ACK/NACK transmission failure issue is not severe. If ACK/NACK is not received by the gNB, there is no mechanism to retransmit the ACK/NACK. This was acceptable for Rel-15 since the probability for gNB failing to decode ACK/NACK is small and the gNB can schedule a retransmission of PDSCH to collect ACK/NACK. For unlicensed band operation, since the channel is shared with other nodes, the transmission of PUCCH or PUSCH carrying ACK/NACK is not guaranteed, and the probability that the UE failed ACK/NACK transmission cannot be ignored anymore. To solve this problem, three features have been designed:

- Non-numerical K1 indication for ACK/NACK transmission timing

- Enhanced (Type 2) dynamic codebook for HARQ ACK
- One-shot (Type 3) codebook for HARQ ACK

The non-numerical K1 feature is introduced, such that the gNB does not provide a time to report ACK/NACK when scheduling the PDSCH. Instead a special non-numerical K1 is indicated in the DL grant scheduling the PDSCH. The UE will hold on to the ACK/NACK corresponds to the PDSCH, and report ACK/NACK when a later PDSCH is scheduled with another DL grant with proper K1 timing indicated.

The other two HARQ enhancement features are introduced to support UE ACK/NACK re-transmissions. For enhanced dynamic codebook design, HARQ ACK group is introduced. Within an HARQ ACK group, the already scheduled ACK/NACK (transmitted or failed to transmit) can be triggered to be retransmitted. Rel.16 NR-U also defines a type-3 HARQ ACK codebook. In this codebook design, gNB can trigger the report of ACK/NACK for all configured HARQ processes over all cells by setting a bit in -the DCI.

**Configured grant enhancement:** Rel.16 NR-U enhanced Configured grant UL transmission by allowing the UE to performing retransmission of a TB in a CG-PUSCH resource. A CG-UCI is included to indicate the HARQ process ID, NDI and RVID of the transmission. UE can acquire a COT with Cat 4 LBT for CG-UL transmission and share the COT with gNB for DL transmissions. The COT sharing information is also carried in CG-UCI. When CG is configured, gNB can feedback HARQ-ACK for UL transmission by CG-DFI. When the UE is configured with  $\text{repK} > 1$ , repetition of a TB is mapped within a configuration in the case when an UE is configured with multiple active configurations, the UE repeats the TB in the earliest consecutive transmission occasion candidates within the same configuration instead of consecutive slots, the UE terminates the repetitions if an explicit feedback indicating ACK in the DFI is received for the HARQ process.

**Wideband operation:** The concept of “RB set” is introduced which approximately corresponds to one 20MHz channel. For PUSCH, the resource allocation is defined by continuous RB sets and the set of interlaces. The RB sets are defined by RRC configuring the intra-cell guard band between RB sets. If the intra-cell guard band is not configured, the default values for intra-cell guard band from RAN4 will be applied. It is also possible to configure the intra-cell guard band to be 0.

In a DL BWP with bandwidth larger than 20MHz, gNB may transmit DL channels and signals when LBT is successful on a subset of RB sets (either contiguous or non-contiguous) in the BWP. In a UL BWP with bandwidth larger than 20MHz, UE is allowed to transmit UL channel and signals only if LBT is successful on all RB sets where UL transmission is scheduled/configured and non-zero intra-cell guard is applied in between.

### MAC Enhancements

At the Medium Access Control (MAC) layer, several features were introduced to alleviate the impact of LBT mechanism on MAC procedures. The main ones are: Consistent LBT failure detection and recovery; Changes to RACH procedures; Configured Grant (CG) changes.

A new mechanism to detect and recover from consistent UL LBT failures was introduced. The detection is per Bandwidth Part (BWP) and based on all uplink transmissions within this BWP. Similar to BFD, a timer is re-started with every LBT failure indication from physical layer to MAC; a counter is incremented with every LBT failure and is reset when the timer expires. When the counter exceeds a configured threshold, consistent UL LBT failure is declared on this BWP.

For failures on SCells, the UE reports this to the corresponding gNB (MN for MCG, SN for SCG) via a MAC CE. For SpCell (PCell or PSCell), when consistent uplink LBT failures are detected, the UE switches to another UL BWP with configured RACH resources on that cell, initiates RACH, and reports the failure via MAC CE. If failures happen on all such BWPs, SCG failure for PSCell and RLF for PCell is declared.

If msg1 in 4-step RACH or msgA preamble in 2-step RACH is not transmitted due to LBT failure, the UE does not increment the power of the next attempt. If the UE is configured with the above LBT failure detection/recovery, it also does not increment the transmission counter; in this case, the failure of RACH procedure is handled by the LBT failure detection/recovery.

The LBT failure for transmission of msg2 in 4-step RACH and msgB in 2-step RACH necessitated longer monitoring windows at the UE to receive these messages. The maximum window duration was increased from 10ms in Rel-15 to 40ms. However, this change caused possible ambiguity of determining the correct initial transmission for which the response was intended. To solve this, the gNB signals the last two-bits of SFN corresponding to msg1 transmission time for msg1 or msgA preamble in the corresponding response message.

The changes to configured grant transmission are mainly due to autonomous retransmission on CG resources, autonomous HARQ process ID and RV selection, and LBT failures. 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 UE always prioritizes ongoing retransmissions over new transmissions. Since the UE signals HARQ ID and RV on CG transmissions, their selection is left to the UE implementation. Multiple CGs on a BWP are allowed where they all can use the above retransmission feature and can also share the same HARQ ID pool.

For uplink multi-TTI transmission, the UE is allowed to select a HARQ process and RV to transmit a generated packet to handle the scenario when the LBT fails for the initial TTI occasions. To support transmission of DL HARQ feedback during DRX operation, if the UE receives a non-numerical K1 where the actual DCI for HARQ feedback will be coming later, monitoring of downlink control channel was extended in time.

### Upper Layer Enhancements

For Connected mode mobility, the only change for NR-U is the support of RSSI and Channel Occupancy (CO) measurements similar to LTE-LAA. These can be reported periodically or along with other measurement reports.

For Idle/Inactive mode mobility, the rules for checking other cells for reselection were relaxed to handle the cases when best cell on a frequency belongs to a different PLMN. To further help the UE consider only the cells of the home or equivalent PLMN in reselection, a “white-list” of such neighbor cells is broadcasted.

In Rel-15 NR, the UE has a single Paging Occasion (PO) for every DRX cycle in Idle/Inactive mode. Since LBT may fail during a paging transmission attempt, multiple PDCCH monitoring occasions were introduced for NR-U. This allows the gNB to transmit the paging message when LBT is not successful at the first instance. As monitoring of multiple occasions increases UE power, gNB can let the UE stop further monitoring when there is no page for that UE by transmitting a Short Message on paging channel with a newly introduced bit for this purpose. The UE can also stop monitoring when it detects a paging for other UEs with the assumption that the gNB had access to the channel and thus there is no page for itself.

Channel Access Priority Class (CAPC) can be configured for each data radio bearer (DRB) and SRB2. The signaling bearers (except for SRB2) always use the highest priority CAPC. The gNB assigns the CAPC by taking into account the specified mapping between 5QI (QoS indicator) of QoS flows in a DRB. The UE uses this configuration to determine the CAPC when not signaled by the gNB directly via DCI. This applies to all CG transmissions and some dynamic grants. When signaling data is transmitted, CAPC of the PDU is same as the CAPC of the highest priority signaling bearer. In all other cases, the lowest priority CAPC among the multiplexed data flows is chosen for the CAPC of the PDU

### Targeted spectrum

Two bands have been considered and defined in relation to this work item:

NR operating band	Uplink (UL) <i>operating band</i> BS receive / UE transmit $F_{UL\_low} - F_{UL\_high}$	Downlink (DL) <i>operating band</i> BS transmit / UE receive $F_{DL\_low} - F_{DL\_high}$	Duplex Mode
n46	5150 MHz – 5925 MHz	5150 MHz – 5925 MHz	TDD <sup>13</sup>
n96 <sup>14</sup>	5925 MHz – 7125 MHz	5925 MHz – 7125 MHz	TDD <sup>13</sup>

NOTE 1: This band is restricted to operation with shared spectrum channel access as defined in TS 37.213.

NOTE 2: This band is applicable in the USA only subject to FCC Report and Order [FCC 20-51]

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820067,750045,820167,820267>

- [1] RP-192926, Revised WID on NR-based Access to Unlicensed Spectrum
- [2] RP-202751, Status report for WI on NR-based Access to Unlicensed Spectrum

## 19.1.2 2-step RACH for NR

820068	<a href="#">2-step RACH for NR</a>	NR_2step_RACH	R1	RP-190711	ZTE
820168	<a href="#">Core part: 2-step RACH for NR</a>	NR_2step_RACH-Core	R1	RP-190711	ZTE

820268	Perf. part: 2-step RACH for NR	NR_2step_RACH-Perf	R4	RP-190711	ZTE
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Summary based on the input provided by ZTE Corporation in RP-200087 revised to RP-200623 revised to RP-201225.

The Rel-16 Work Item 2-step RACH for NR achieves the following objectives:

- A simplified random access procedure was developed. This reduces the number of interactions between the UE and network during the connection setup and connection resume, thereby enabling a lower control plane latency. In case of connected mode, a small amount of data can be sent via 2-step RACH procedure thus also enabling a lower latency for UL UP data for connected mode UEs.
- Channel structure of transmitting PRACH and PUSCH in one step (i.e. without an intermediate message from the network) was developed. The PRACH and PUSCH are separated by a pre-configured guard period.
- The above enhancements are applicable to both licensed spectrum and shared spectrum (i.e. NR-U).

The general procedure of 4-step RACH and 2-step RACH are depicted in Figure 1. The first step of 2-step RACH comprises an UL MSGA transmission which includes the equivalent contents of msg1 and msg3 of 4-step RACH. The second step of 2-step RACH is a DL MSGB reception which includes the equivalent content of msg2 and/or msg4 of 4-step RACH, depending on the detection of UL MSGA.

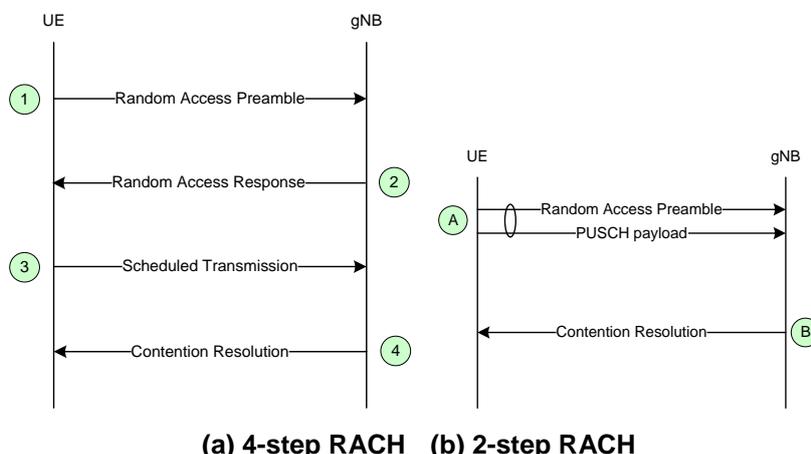


Figure 1 General procedure of 4-step RACH and 2-step RACH

RA type selection

For contention based random access (CBRA), all the triggers for Rel-15 NR 4-step RACH are also applicable to 2-step RACH except when CA is configured, the 2-step RACH is only applicable on PCell. Contention free random access (CFRA) procedure with 2-step RACH is only supported for handover.

The UE selects the type of random access at initiation of the random access procedure based on network configuration:

- when CFRA resources are not configured, an RSRP threshold is used by the UE to select between 2-step RA type and 4-step RA type;
- when CFRA resources for 4-step RA type are configured, UE performs random access with 4-step RA type;
- when CFRA resources for 2-step RA type are configured, UE performs random access with 2-step RA type.

In case of random access in a cell configured with SUL, UE performs carrier selection (between SUL and NUL) before selecting between 2-step and 4-step RA type.

MSGA structure: PRACH

The MSGA in 2-step RACH comprise a PRACH and a PUSCH. The PRACH resources for 2-step RACH in time/frequency domain can be either shared with 4-step RACH or can be configured to be separate. All the preamble formats and the PRACH configuration indexes defined in Rel-15 and in Rel-16 NR-U and TEI can be used. In case of

shared time domain PRACH resources between 4-step RACH and 2-step RACH, different preambles are allocated to differentiate the RA types. The mapping between SSB and PRACH occasion reuses that for 4-step RACH.

MSG structure: PUSCH

2-step RACH uses a specified mapping rule to determine the PUSCH resource of MSGA that is associated with the selected PRACH resource. Each PRACH slot is mapped to a number of PUSCH occasions with associated DMRS resource, once the UE selects a preamble in a PRACH occasion, the corresponding PUSCH occasion and DMRS resource can be determined by a predefined mapping order.

MSGB

After MSGA transmission, the UE monitors the downlink for a response from the network within a configured window. This response from the network is called the MSGB. The contents of MSGB depend on whether or not the gNB is able to successfully detect both the PRACH and the PUSCH parts.

- If the PRACH is detected but the decoding of PUSCH fails, network will include a fallback indication in MSGB and the subsequent UE procedure will be similar to that for a UE monitoring msg2 in the 4 step RACH.
- If both preamble and PUSCH are decoded, network will include a successRAR and reception of this at the UE completes the contention resolution. HARQ feedback is enabled for the successful reception of the successRAR.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820068,820168,820268>

- [1] RP-200085, Revised WID on 2 step RACH for NR
- [2] RP-200622, Status report for WI - NR 2-step RACH

## 19.1.3 UE Power Saving in NR

830075	UE Power Saving in NR	NR_UE_pow_sav	R1	RP-191607	CATT
800094	Study on UE power saving in NR	FS_NR_UE_pow_sav	R1	RP-181463	CATT
830175	Core part: UE Power Saving in NR	NR_UE_pow_sav-Core	R1	RP-190727	CATT
830275	Perf. part: UE Power Saving in NR	NR_UE_pow_sav-Perf	R4	RP-190727	CATT

Summary based on the input provided by CATT in RP-200912.

UE battery life is an important aspect of the user's experience. The RAN1 study of the Rel-16 UE power saving had shown substantial power saving gain comparing to considered Rel-15 NR features such as DRX operation, with UE adaptation in frequency domain, time domain, antenna domain, tight control of DRX operations, and reducing PDCCH monitoring with different traffic types.

The work item of UE power saving in NR includes the power saving techniques, such as DRX adaptation, cross-slot scheduling, and maximum MIMO layer adaptation in CONNECTED state, fast transition out of CONNECTED state, and reduced RRM measurements in idle/inactive states. The UE assistance information is part of the work to enable the UE to feedback its preferred configuration to achieve desired power saving.

The UE power saving work in Rel-16 focuses on the power saving techniques in CONNECTED state, which includes DRX adaptation, cross-slot scheduling, maximum MIMO layer adaptation, and fast transition out of CONNECTED state. The RRM measurement reductions are the power saving techniques specified in idle/inactive states. UE assistance information is supported for the UE to feedback its preferred configuration of the specific power saving technique.

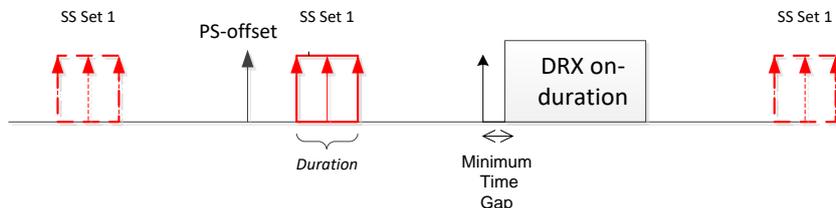
### Power Saving Techniques in CONNECTED state

The power saving techniques are dynamically triggered by L1 signaling indicated from PDCCH-based power saving signal/channel or semi-statically configured by RRC signaling. The PDCCH-based power saving signal/channel reuses the existing PDCCH search space and CORESET configurations with dynamic TCI states with DCI field indicating the adaptation to achieve UE power saving, such as UE wakeup in the DRX operation, cross-slot scheduling, and maximum MIMO layer adaptation through BWP switching.

- DRX adaptation

The DRX adaptation power saving technique is to configure the PDCCH-based power saving signal/channel at the active BWP before the beginning of DRX ON for UE monitoring with the indication of UE wakeup or not depending on whether there is data for UE to receive. A new DCI format 2\_6 is introduced with CRC scrambled by PS-RNTI

(DCP) which contains the wakeup indication as well as SCell dormancy indication if configured. A PS-offset is semi-statically configured before DRX ON defining the start of the interval for the DCP monitor occasion as shown in Figure 1. More than one monitoring occasions could be configured for DCP on PCell for CA and SpCell for DC based on the search space and CORESET configurations. Minimum time gap is specified as the UE processing time as shown in Figure 1. UE is not required to monitor DCP at the interval of minimum time gap and within Active Time.



**Figure 1: DCP Monitoring occasion for DRX adaptation**

When DCP monitoring occasion collides with other procedures with higher priority in PDCCH monitoring, the monitoring occasion is considered invalid. UE follows legacy behavior when all the configured monitoring occasions are invalid. UE is configured by RRC to wake up or not when no DCP is detected with valid monitoring occasions. One DCP can be configured to control PDCCH monitoring during on-duration for one or more UEs independently. UE is also configured by RRC whether to report periodic L1-RSRP or periodic CSI/L1-SINR when UE is not indicated to wake up at the DRX ON.

- Cross slot scheduling

Power saving technique with cross-slot scheduling facilitates UE to achieve power saving with the assumption that it won't be scheduled to receive PDSCH, triggered to receive A-CSI or transmit a PUSCH at the scheduling slot within Active Time. A 1-bit minimum scheduling offset in DCI format 1\_1 and 0\_1 enables dynamic switching of DL and UL minimum scheduling offset values.

- Maximum MIMO Layer Adaptation

UE power saving techniques with the adaptation to the DL maximum number of MIMO layers could be achieved by dynamic switching of BWPs, which the DL maximum number of MIMO layers are configured to be different.

- Fast transition out of CONNECTED state

UE can feed back the assistance information of its preference to be released/suspended for gNB to get UE transitioning out of CONNECTED state quickly when there is no further data arrival.

### **Power Saving Techniques in idle/inactive state**

- Reduced RRM measurements in idle/inactive state

Power saving in RRC\_IDLE and RRC\_INACTIVE can also be achieved by UE relaxing neighbour cells RRM measurements when it meets the criteria determining it is in low mobility and/or not at cell edge.

### **UE assistance information**

UE assistance information allows the UE to feedback its preferred configuration, such as c-DRX configuration, aggregated bandwidth, SCell configuration, MIMO configuration, RRC state, minimum scheduling offset values in order for network to assist UE achieving power saving gain.

### **References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830075.800094.830175.830275>

- |     |   |
|-----|---|
| [1] | RP-200494, "WID: UE power saving in NR", CATT, CAICT                        |
| [2] | TR 38.840 v15.0.0. CATT   |
| [3] | R1-1913657, 38.202CR0014 Introduction of UE power savings, Qualcomm         |
| [4] | R1-1913658, 38.212CR0028 Introduction of UE power savings in 38.212, Huawei |
| [5] | R1-1913659, 38.213CR0076 Introduction of UE power savings, Samsung          |
| [6] | R1-1913660, 38.214CR0056 Introduction of UE power savings, Nokia            |

- [7] R2-2002369, 38.300 CR0193 Introduction of UE Power Saving in NR, CATT
- [8] R2-2005949, 38.304 CR 0158, CR on 38.304 for UE Power saving in NR, vivo
- [9] R2-2005869, 38.321CR0719 MAC CR for Rel-16 UE power savings, Huawei, HiSilicon, Nokia, Nokia Shanghai Bell
- [10] R2-2004943, 38.331 CR1540 CR for 38.331 for power savings. MediaTek
- [11] R2-2004944, 36.331 CR4245 CR for 36.331 for power savings, MediaTek
- [12] R2-2005856, 38.306CR0134 UE capabilities for Rel-16 Power Saving WI, Intel
- [13] R2-2005857, 38.331CR1618 UE capabilities for Rel-16 Power Saving WI, Intel
- [14] R2-2005866, 37.340CR0189 SRB3 for reporting UAI for power saving, OPPO, MediaTek
- [15] R4-2009133 38.133CR0854 Measurement requirements for UEs under power saving mode Ericsson
- [16] R4-2009244 38.133CR0635 CR on minimum requirement at transition period for UE power saving CATT
- [17] R4-200744038.133 CR0736 CR for maximum MIMO layer adaptation vivo, CATT

## 19.1.4 Integrated access and backhaul for NR

820070	Integrated access and backhaul for NR	NR_IAB		RP-191558	Qualcomm
750047	Study on NR_IAB	FS_NR_IAB	R2	RP-181349	Qualcomm
820170	Core part: NR_IAB	NR_IAB-Core	R2	RP-190712	Qualcomm
820270	Perf. Part: NR_IAB	NR_IAB-Perf	R4	RP-190712	Qualcomm
830021	Study on Security for NR_IAB	FS_NR_IAB_Sec	S3	SP-190106	Rajavelsamy Rajadurai, Samsung,

Summary based on the input provided by Qualcomm Incorporated in RP-201757.

This Feature introduces wireless relaying among RAN nodes to 5G. Its objectives closely followed the recommendation of the study item on IAB for NR, which are defined in TR 38.874. The following features are supported:

- Multi-hop backhauling for flexible range extension for both FR1 and FR2.
- Topology adaptation including redundant connectivity to optimize backhauling performance and to respond to backhaul (BH) link failure.
- Mapping of UE bearers to backhaul RLC channels and QoS enforcement over backhaul RLC channels to meet E2E QoS requirements.
- Scalability to a large number of UEs.
- Flexible deployment allowing IAB-node operation in EN-DC mode with EPC or in SA-mode with 5GC.
- Support for NR-NR DC from the UE and IAB-node perspective (see NOTE 1)
- Efficient operation for both inband and out-of-band relaying.
- Over the air (OTA) synchronization across IAB topology.
- Support of Rel-15 UEs.

### IAB architecture

IAB introduces the IAB-node and IAB-donor to 5G RAN. The IAB-node is the relaying node and supports access and backhauling via NR. The IAB-donor is the terminating node of NR backhauling on network side. It represents a gNB with additional functionality to support IAB. Backhauling can occur via a single hop or via multiple hops.

The IAB-node supports gNB-DU functionality to terminate the NR access interface to UEs and next-hop IAB-nodes, and to terminate the F1 protocol to the gNB-CU functionality on the IAB-donor. The gNB-DU functionality on the IAB-node is also referred to as IAB-DU.

In addition to the gNB-DU functionality, the IAB-node also supports a subset of the UE functionality referred to as IAB-MT, which includes, e.g., physical layer, layer-2, RRC and NAS functionality to connect to the gNB-DU of another IAB-node or the IAB-donor, to connect to the gNB-CU on the IAB-donor, and to the core network.

The IAB-MT can access the network using either SA mode or EN-DC. In EN-DC, the IAB-MT connects via E-UTRA to a MeNB, and the IAB-donor terminates X2-C as SgNB.

All IAB-nodes that are connected to an IAB-donor via one or multiple hops form a directed acyclic graph (DAG) topology with the IAB-donor as its root. In this DAG topology, the neighbour node of the IAB-DU or the IAB-donor-DU is referred to as child node and the neighbour node of the IAB-MT is referred to as parent node. The direction toward the child node is referred to as downstream while the direction toward the parent node is referred to as upstream. The IAB-donor performs centralized resource-, topology- and route management for the IAB topology.

### Backhaul transport

The F1 interface between IAB-DU and IAB-donor-CU uses the protocol stack and security protection defined in Rel-15.

On the wireless backhaul, the Backhaul Adaptation Protocol (BAP) has been introduced, which is a L2 sub-layer that carries the IP layer for the F1 interface and enables routing over multiple hops. The IP layer can also be used for non-F1 traffic, such as OAM traffic.

On each backhaul link, the BAP PDUs are carried by BH RLC channels. Multiple BH RLC channels can be configured on each BH link to allow traffic prioritization and QoS enforcement. To support a large quantity of BH RLC channels on each BH link, e.g., for fine-granular QoS support, an extended logical channel ID (eLCID) has been introduced.

The IAB-MT further establishes SRBs (carrying RRC and NAS) with the IAB-donor-CU. For IAB-nodes operating in ENDC, the IAB-MT also establishes one or more DRBs with the IAB-donor-CU, which can be used, e.g., to carry OAM traffic. These SRBs and DRBs are transported between the IAB-MT and its parent node over Uu access channel(s).

On the BAP sublayer, packets are routed based on the BAP routing ID, which is carried in the BAP header. The BAP routing ID consists of BAP address and BAP path ID, where the BAP address indicates the destination node of the packet on the BAP sublayer, and the BAP path ID indicates the routing path the packet should follow to this destination.

The BAP sublayer further supports flow control in downstream direction, where the IAB-node sends feedback information on available buffer size to its parent node.

To reduce UL scheduling latency over multiple hops, the Pre-emptive BSR MAC CE has been introduced, which can be sent by the IAB-node to its parent-node based on expected rather than the buffered data.

For IAB-nodes using ENDC, backhauling is only supported via the NR link.

#### IAB-node integration

A network integration procedure was defined for IAB-nodes. For IAB-nodes using SA mode, this procedure consists of three phases.

In phase 1, the IAB-MT selects a suitable parent node and connects to the network in the same manor as a UE including RRC connection setup with IAB-donor-CU, authentication with the core network, context management and bearer establishment. Prior to connection establishment, The IAB-MT determines if a parent node supports IAB based on an the IAB-support indicator broadcast in SIB1. The IAB-MT further indicates IAB capability to the network during the RRC connection setup. The IAB-donor-CU forwards this indicator to the core network which authorizes IAB operation in return.

In phase 2, the IAB-donor-CU configures BH RLC channels and the BAP sublayer to enable transport of the backhaul to the new IAB-node. Further, IP addresses can be allocated by RAN or OAM. These IP addresses are used by the IAB-DU for backhauling of F1 traffic.

In phase 3, the IAB-DU is established using the Rel-15 F1 setup procedure. The IAB-node includes the BAP address it obtained via RRC in phase 2 into F1-C to indicate collocation of IAB-MT and IAB-DU to the IAB-donor-CU.

The network integration for IAB-nodes using ENDC uses a similar procedure. In phase 1, the IAB-node first connects to an eNB, which selects and adds the IAB-donor as a SN.

#### Topology adaptation

The following procedures have been defined to allow the IAB network to dynamically change its topology under operation:

**IAB-node migration procedure:** This procedure allows the IAB-node to change its parent node underneath the same IAB-donor. The procedure is initiated by the IAB-donor-CU. It leverages handover for the IAB-MT using SA mode and the SN-change procedure for the IAB-MT using ENDC. The IAB-donor further configures BH RLC channels and updates the BAP sublayer so that backhauling can occur via the target path. F1 may be migrated to the new IP addresses that have been allocated to the IAB-DU, if any.

**Topological redundancy procedure:** This procedure enables the establishment and release of redundant paths in the IAB-topology underneath the same IAB-donor-CU. The procedure is initiated by the IAB-donor-CU. It leverages SN-addition for the IAB-MT using SA mode. The IAB-donor further configures BH RLC channels and updates the BAP sublayer so that backhauling can also occur over the SCG link. The IAB-donor can further configure multiple different

routes on the BAP sublayer. This route redundancy may be used for IP multi-homing of F1-C to provide robustness. It may further be used for load balancing, where F1-U GTP tunnels are assigned to separate routes. The routes are configured by the IAB-donor-CU. For IAB-MT using ENDC, user plane traffic can only be exchanged via NR. F1-C, however, can be routed via NR and/or via LTE/X2.

**Backhaul RLF recovery procedure:** This procedure enables IAB-nodes in SA mode to migrate to another parent node underneath the same IAB-donor-CU, when the IAB-MT declares backhaul RLF. The procedure is initiated by the IAB-MT upon observation of BH RLF and uses RRC Connection Reestablishment. When RLF recovery fails, the IAB-MT may send an RLF indication to its child nodes, so that they can try to perform RLF recovery.

#### PHY-layer specifications

The following physical layer procedures have been introduced for the support of IAB:

**Over-the-air time synchronization:** The IAB-nodes and IAB-donor-DUs within the IAB-topology are assumed to operate time-synchronized. The IAB-DU may use the downlink signal received by the collocated IAB-MT from a parent, as a reference to control its downlink timing using TA in conjunction with an additional Tdelta parameter signalled via MAC-CE

**Inter node discovery:** An IAB-node can be configured to transmit and receive SSB signals to discover neighbouring IAB-nodes. The configuration is expected to not create a conflict between the IAB-DU SSB transmissions and the SSB measurement windows configured for the collocated IAB-MT.

**Random Access by IAB-MT:** For IAB-MTs, a separate IAB-specific random access configuration can be provided in addition to the UEs' random access configuration. The IAB-specific random access configuration may be obtained by extending the random access configurations defined for UEs via scaling the periodicity and/or offsetting the position of the RACH occasions.

**IAB Resource configuration:** The IAB-donor-CU can confine the resources used by the schedulers on an IAB-DU or IAB-donor-DU to account for multiplexing constraints among BH and access links in the IAB topology. The configuration assigns an attribute of Hard, Soft or Unavailable to each symbol of each serving cell.

Scheduling can occur for symbols configured as Hard, whereas scheduling cannot occur, except for some special cases, for symbols configured as Unavailable. For symbols configured as Soft, scheduling can occur conditionally based on explicit or implicit indication by the parent node. Explicit indication refers to signalling by the parent node to the collocated IAB-MT via PDCCH, which explicitly permits the usage of a designated Soft resource. Implicit indication refers to the autonomous determination whether a Soft resource can be used by the IAB-DU without creating a conflict for the collocated IAB-MT to follow its parent's scheduling commands.

#### RF and RRM requirements

RAN4 decided to define following RRM requirements for IAB-MT nodes:

**RRC Connected State mobility:** The random access requirements of IAB-MTs were agreed to be same as those of UEs. For defining RRC re-establishment and RRC release with redirection requirements of IAB-MTs, RAN4 used the same requirements of UEs as a starting framework and then modified these further to accommodate higher periodicity of SMTC windows in IAB nodes.

**Timing:** The transmit timing and timing adjust requirements of IAB-MTs are same as those of UE requirements. The cell phase synchronization accuracy requirement of IAB-DUs is same as that for Rel-15 gNBs.

**Signalling Characteristics:** RAN4 agreed to define radio link monitoring, beam failure detection and candidate beam detection requirements for IAB-MTs. To define these requirements, RAN4 used the same requirements for Rel-15 UEs as a starting framework and then relaxed some of the evaluation periods by additional scaling factors because IAB-MTs are static nodes.

#### **References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820070,750047,820170,820270,830021>

- [1] RP-200840: WID on integrated access and backhaul
- [2] RP-200839: Status Report for integrated access and backhaul

## 19.1.5 Dual Connectivity (EN-DC) with 3 bands DL and 3 bands UL

841000	Dual Connectivity (EN-DC) with 3 bands DL and 3 bands UL	DC_R16_LTE_NR_3DL3UL	R4	RP-191598	ZTE
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Summary based on the input provided by ZTE Corporation in RP-200112.

In Release 15, the operating bands are specified for these eligible operations with EN-DC configured. The EN-DC band combinations include at least one E-UTRA operating band and a NR operation band. In moving forward to Release 16, the configuration of EN-DC operation needs to be expanded for more simultaneous uplink and downlink configurations, including band combination of LTE, FR1 and FR2 bands.

New configurations still emerge from existing bands and whenever new band is specified, it will create a potential for several new EN-DC configurations consisting of 3 different bands DL with 3 different bands UL (1 LTE band UL and 2 NR different band UL (i.e. 1 CC LTE band + 1 CC NR FR1 band + NR FR2 band), or 2 LTE different band UL and 1 NR FR2 band UL).

The EN-DC configurations including NR CA will be introduced in a release independent manner based on TS38.307, which will be updated depending on newly introduced EN-DC configurations including NR CA.

All new ENDC configurations including NR with 3 bands will be defined under this WI, where :

- For only 1 NR band included, only NR FR2 band is applied
- For only 2 NR bands included, 1 NR FR1 band and 1 NR FR2 band are included and operated as inter-band CA

The companies can request their interesting ENDC configurations before each 3GPP RAN4 meeting. The WID was started from RAN #84 meeting, and will completed at RAN #88 meeting.

Usually these configurations are the potential NR NSA deployment scenarios for the operators. Each of the requested ENDC configurations includes at least applicable frequencies if necessary, applicable bandwidths and bandwidth sets if necessary, and Downlink ENDC configurations and Uplink ENDC configuration, respectively. More importantly, each ENDC configuration shall be requested with at least three other supporting companies. In addition, these combinations will be introduced in a Rel-independent way starting from Rel-15.

All of the ENDC configurations requested by the companies are all captured in two tables in the WID, shown as follow.

1. EN-DC of 3 different bands DL(LTE 1 band + NR 2 bands) with 3 different bands UL
2. EN-DC of 3 different bands DL(LTE 2 bands + NR 1 band) with 3 different bands UL

For the ENDC configuration in the WID, the RF requirements shall be specified, including:

Analyse combinations that have self-desensitization due to following reasons:

- TX Harmonic and/or intermodulation overlap of receive band
- TX signal overlap of receiver harmonic frequency
- TX frequency being in close proximity of one of the receive bands
- Any other identified reasons such that insufficient cross band isolation, harmonic mixing

For the combination where self-desensitization exists, specify at least needed

- $\Delta TIB, c$  and  $\Delta RIB, c$
- Reference sensitivity exceptions including MSD test cases

All of the study results are captured into TR37.716-33, and for the ENDC configurations will be included in TS38.101-3 specification in the case of these configurations are approved in RAN4 meeting.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=841000>

- [1] RP-192537, Revised WID for Dual Connectivity (EN-DC) with 3 bands DL and 3 bands , ZTE Corporation

- [2] R4-1913627, CR to reflect the completed ENDC combinations for 3 bands DL with 3 bands UL into Rel16 TS 38.101-3, ZTE Corporation
- [3] R4-2000501, CR to reflect the completed ENDC combinations for 3 bands DL with 3 bands UL into Rel16 TS 38.101-3, ZTE Corporation
- [4] R4-1913631, TR 37.716-33 v0.1.0 Dual Connectivity (EN-DC) with 3 bands DL and 3 bands UL, ZTE Corporation
- [5] RP-200110, Revised WID for Dual Connectivity (EN-DC) with 3 bands DL and 3 bands , ZTE Corporation

## 19.1.6 NR mobility enhancements

800087	<b>NR mobility enhancements</b>	NR_Mob_enh	R2	RP-190489	Intel
800187	<b>Core part: NR mobility enhancements</b>	NR_Mob_enh-Core	R2	RP-190489	Intel
800287	<b>Perf. part: NR mobility enhancements</b>	NR_Mob_enh-Perf	R4	RP-190489	Intel

Summary based on the input provided by ZTE Corporation in RP-200170.

The work item on NR mobility enhancements specifies solutions to reduce interruption time during HO (by Dual Active Protocol Stack (DAPS) handover), and to improve HO/SCG change reliability and robustness (by Conditional Handover (CHO), Conditional PSCell Change (CPC) and T312 based fast failure recovery).

The corresponding changes are captured into TS 38-series specifications and TS37.340/TS36.331 in [2]-[5].

### Dual Active Protocol Stack (DAPS) handover

DAPS Handover is a handover procedure that maintains the source gNB connection after reception of RRC message for handover and until releasing the source cell after successful random access to the target gNB.

- The UE maintains DL reception and UL transmission for user data with source upon receiving DAPS HO command before successful RACH in target (UL switching);
- Upon receiving the indication on UL switching, for UL the PDCP layer will only forward the user data to target path;
- The UE will continue the reception of DL from both source and target, and provides UL to both source (PDCP will not forward the user data to low layer) and target node before release of source.
- Upon HO failure, the UE can use source link for recovery instead of reestablishment if the source link is still valid;

### Conditional Handover (CHO)

Conditional Handover (CHO) is a handover procedure that is executed only when the configured execution condition(s) are met.

To improve the robustness, the network can provide the up to 8 candidate cell configuration(s) associated with execution condition (s) to UE. The UE maintains connection with source gNB after receiving CHO configuration, and starts evaluating the CHO execution conditions for the candidate cell(s). If at least one CHO candidate cell satisfies the corresponding CHO execution condition, the UE detaches from the source gNB, applies the stored corresponding configuration for that selected candidate cell, synchronises to that candidate cell and completes the RRC handover procedure by sending RRCReconfigurationComplete message to the target gNB. The UE releases stored CHO configurations after successful completion of RRC handover procedure.

Upon failure, the UE will perform CHO if the selected cell is CHO candidate cell and it is the first time of recovery and if the network allows CHO based recovery.

### Conditional PSCell Change (CPC)

Conditional PSCell Change is a PSCell change procedure that is executed only when PSCell execution condition(s) are met.

To improve the robustness, the network can provide the up to 8 candidate cell configuration(s) associated with execution condition (s) to UE. If CPC is configured in the RRCReconfiguration, the UE maintains connection with source PSCell after receiving CPC configuration, and starts evaluating the CPC execution conditions for the candidate PSCell(s). If at least one CPC candidate PSCell satisfies the corresponding CPC execution condition, the UE detaches from the source PSCell, applies the stored corresponding configuration for the selected candidate PSCell and synchronises to that candidate PSCell. The UE completes the CPC execution procedure by an ULInformationTransferMRDC message to the MN which includes an embedded RRCReconfigurationComplete

message to the new PSCell if SRB3 is not configured, otherwise the UE sends RRCReconfigurationComplete message to the new PSCell directly.

Upon SCG failure, same as MR-DC, the UE will transmit the SCG Failure Information message to the MN.

In Rel-16, conditional handover based NR PSCell addition/change for any architecture option with NR PSCell is supported, but limit to intra SN change without MN involvement.

#### T312 based fast failure recovery

T312 based solution (same as LTE) is used for both PCell and PSCell. The motivation of T312 is to speed up RLF recovery procedure by triggering re-establishment procedure sooner using a shorter timer than T310. T312 on PSCell can be configured for SCG measurement configurations provided over SRB3 or SRB1.

#### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800087,800187,800287>

- [1] RP-192534, Revised WID on NR mobility enhancements, Intel Corporation, RAN#86
- [2] RAN1 CR packets
- [3] RAN2 CR packets
- [4] RAN3 CR packets
- [5] RAN4 CR packets

## 19.1.7 Rel-16 NR inter-band CA/Dual Connectivity for 2 bands DL with x bands UL (x=1, 2)

800074	Rel-16 NR inter-band CA/Dual Connectivity for 2 bands DL with x bands UL (x=1, 2)	NR_CADC_R16_2BDL_xBUL	R4	RP-191565	ZTE
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Summary based on the input provided by ZTE Corporation in RP-200170.

This WI is to introduce the band combinations for inter-band carrier aggregation and dual connectivity for 2 bands DL with up to 2 bands UL into Rel-16 specifications and specify the corresponding configurations and RF requirements.

The study results for each band combination are captured in TR 38.716-02-00, and the configurations and RF requirements are added into the corresponding technical specifications.

This WI includes all target band combinations for both NR CA and DC including the following configurations:

- New NR CA configurations including inter band CA for 2 different bands DL with up to 2 different bands UL
  - o new configurations from exiting bands
  - o new configurations from new band
  - o The NR CA configurations will be introduced in a release independent manner based on TS38.307
- New NR DC configurations including inter band CA for 2 different bands DL with up to 2 different bands UL
  - o Accommodated only until the outcome of Rel-15 late drop handling becomes clear.

The preconditions to propose NR CA/DC configurations including Inter band CA for 2 different bands DL with up to 2 different bands UL in rel-16 are as follows.

- o Constituent NR band and NR Intra band CA shall be completed and specified in advance.
- o NR Band n1 and n2 requirements shall be completed and specified in advanced.

Specification for each band combination includes:

- o Applicable frequencies if necessary
- o Applicable bandwidth and bandwidth sets if necessary
- o Analysis on potential self-desensitization due to following reasons:
  - o TX Harmonic and/or intermodulation overlap of receive band
  - o TX signal overlap of receiver harmonic frequency
  - o TX frequency being in close proximity of one of the receive bands

- o Any other identified reasons
  - o At least the following for the combination where self-desensitization exists
  - o  $\Delta$ TIB, c
  - o  $\Delta$ RIIB, c
  - o Reference sensitivity exceptions including MSD test cases
  - o Add conformance testing in RAN5 specifications (to follow at a later stage)
- The target band combinations are captured in four tables in this WI respectively:
- o CA configurations for 2 different bands DL with 1 band UL
  - o CA configurations for 2 different bands DL with 2 band UL
  - o CA configurations for 2 different bands DL with up to 2 band UL within FR2
  - o DC configurations for 2 different bands DL with 2 band UL within FR1, or within FR2 or including FR2

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800074>

- [1] R4-2000502 Revised WID on Rel-16 NR Inter-band Carrier Aggregation/Dual Connectivity for 2 bands DL with x bands UL (x=1,2), ZTE Corporation
- [2] R4-2000497 CR to reflect the completed NR inter band CA DC combinations for 2 bands DL with up to 2 bands UL into Rel16 TS 38.101-1, ZTE Corporation
- [3] R4-2000498 CR to reflect the completed NR inter band CA DC combinations for 2 bands DL with up to 2 bands UL into Rel16 TS 38.101-3, ZTE Corporation
- [4] R4-2000803 TR 38.716-02-00 v0.9.0, ZTE Corporation
- [5] RP-200168, Revised WID for, ZTE Corporation

## 19.1.8 Rel16 NR inter-band Carrier Aggregation for 3 bands DL with 1 band UL

830095	Rel16 NR inter-band Carrier Aggregation for 3 bands DL with 1 band UL	NR_CA_R16_3BDL_1BUL	R4	RP-191153	CATT
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Summary based on the input provided by ZTE Corporation in RP-200173.

This WI is to introduce the band combinations for inter-band carrier aggregation and dual connectivity for 3 bands DL with 2 bands UL into Rel-16 specifications and specify the corresponding configurations and RF requirements.

The study results for each band combination are captured in TR 38.716-03-02, and the configurations and RF requirements are added into the corresponding technical specifications.

This WI includes all target band combinations for both NR CA and DC including the following configurations:

- New NR CA configurations including inter band CA for 3 different bands DL with 2 different bands UL
  - o new configurations from exiting bands
  - o new configurations from new band
  - o The NR CA configurations will be introduced in a release independent manner based on TS38.307
- New NR DC configurations including inter band CA for 3 different bands DL with 2 different bands UL

The preconditions to propose NR CA/DC configurations including Inter band CA for 3 different bands DL with 2 different bands UL in rel-16 are as follows.

- o Requirements for all concerning bands shall be completed and specified in advanced
- o Constituent NR band and NR intra band CA shall be completed and specified in advance

Specification for each band combination includes:

- o Applicable frequencies if necessary
- o Applicable bandwidth and bandwidth sets if necessary
- o Analysis on potential self-desensitization due to following reasons:
  - o TX Harmonic and/or intermodulation overlap of receive band
  - o TX signal overlap of receiver harmonic frequency
  - o TX frequency being in close proximity of one of the receive bands
- o Any other identified reasons
- o At least the following for the combination where self-desensitization exists

- o ΔTIB, c
- o ΔRIB, c
- o Reference sensitivity exceptions including MSD test cases
- o Add conformance testing in RAN5 specifications (to follow at a later stage)

The target band combinations are captured in two tables in this WI respectively:

- o CA configurations for 3 different bands DL with 2 band UL
- o DC configurations for 3 different bands DL with 2 band UL

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830095>

- [1] R4-2000503 Revised WID on Rel-16 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with 2 bands UL, ZTE Corporation
- [2] R4-2000499 CR to reflect the completed NR inter band CA DC combinations for 3 bands DL with 2 bands UL into Rel16 TS 38.101-1, ZTE Corporation
- [3] R4-2000500 CR to reflect the completed NR inter band CA DC combinations for 3 bands DL with 2 bands UL into Rel16 TS 38.101-3, ZTE Corporation
- [4] R4-2000804 TR 38.716-03-02 v0.4.0, ZTE Corporation
- [5] RP-200171, Revised WID for Rel-16 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with 2 bands UL, ZTE Corporation

### 19.1.9 Add support of NR DL 256QAM for frequency range 2 (FR2)

830088	Add support of NR DL 256QAM for frequency range 2 (FR2)	NR_DL256QAM_FR2	R4	RP-200124	China Telecom
830188	Core part: Add support of NR DL 256QAM for frequency range 2 (FR2)	NR_DL256QAM_FR2-Core	R4	RP-200124	China Telecom
830288	Perf. part: Add support of NR DL 256QAM for frequency range 2 (FR2)	NR_DL256QAM_FR2-Perf	R4	RP-200124	China Telecom

Summary based on the input provided by China Telecom in RP-200727.

In NR\_DL256QAM\_FR2 WI, the RF requirements include BS modulation quality, UE maximum input level and BS conformance test requirements were specified to make RAN4 specification support FR2 DL 256QAM. This will enable the commercial deployment and also guarantee the transceiver performance for the feature of FR2 DL 256QAM from both BS and UE sides.

This WI firstly evaluated the feasibility of FR2 DL 256QAM based on link level simulation, system level simulation and implementation study, and concluded that FR2 DL 256QAM is feasible and beneficial in certain of identified applicable scenarios (see TR 38.883 on "Study on FR2 DL 256QAM").

After the feasibility confirmation, the WI introduced corresponding FR2 DL 256QAM specific RF requirements listed as

- For 38.104: BS modulation quality expressed as Error Vector Magnitude (EVM) requirement which is specified as 3.5%, same required value with FR1.
- For 38.101-2: UE Maximum input level for both single carrier and intra-band CA which reflects the receiver linearity capability, and the related Fixed Reference Channel which is used to test the Maximum input level.
- For 38.141-2: Manufacturers declarations for the output power, Test models, Test procedures and Test EVM requirement.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830088,830188,830288>

### 19.1.10 SON (Self-Organising Networks) and MDT (Minimization of Drive Tests) support for NR

840091	SON (Self-Organising Networks) and MDT (Minimization of Drive Tests) support for NR	NR_SON_MDT	R3	RP-192610	CMCC
840191	Core part: SON (Self-Organising Networks) and MDT (Minimization of Drive Tests) support for NR	NR_SON_MDT-Core	R3	RP-192610	CMCC

Summary based on the input provided by CMCC in RP-200774.

This work item introduces SON and MDT features support in NR, including MRO (Mobility Robustness Optimisation), MLB (Mobility Load Balancing), RACH optimization, MDT (Minimization of Drive Test) and L2 measurements. Specification of these features will help mobile operators reduce the CAPEX/OPEX and improve the use experience.

This work item produces a new specification TS 38.314: L2 measurements for NR.

The key functionalities of this WI are described as below:

**Mobility Robustness Optimisation (MRO)** aims at detecting and enabling correction of mobility related problems including Connection failure due to intra-system or inter-system mobility, Inter-system Unnecessary HO and Inter-system HO ping-pong. MRO also provides means to distinguish the above problems from NR coverage related problems and other problems, not related to mobility.

- Connection failure due to intra-system mobility
  - Intra-system Too Late Handover
  - Intra-system Too Early Handover
  - Intra-system Handover to Wrong Cell
- Connection failure due to inter-system mobility
  - Inter-system/ Too Late Handover
  - Inter-system/ Too Early Handover
- Inter-system Unnecessary HO
- Inter-system Ping-pong

**Mobility load balancing (MLB)** is to distribute load evenly among cells and among areas of cells, or to transfer part of the traffic from congested cell or from congested areas of cells, or to offload users from one cell, cell area, carrier or RAT to achieve network energy saving.

Intra-RAT and intra-system inter-RAT load balancing scenarios are specified and includes the functions of Load reporting, Load balancing action based on handovers and Adapting handover and/or reselection configuration.

The load reporting function is executed by exchanging load information over the Xn/X2/F1/E1 interfaces via Resource Status Reporting Initiation & Resource Status Reporting procedures.

The load metrics that have been specified consist of

- Radio resource usage (per-cell and per SSB area PRB usage: DL/UL GBR PRB usage, DL/UL non-GBR PRB usage, DL/UL total PRB usage, and DL/UL scheduling PDCCH CCE usage);
- TNL capacity indicator (UL/DL TNL offered capacity and available capacity);
- Cell Capacity Class value (UL/DL relative capacity indicator);
- Capacity value (per cell, per SSB area and per slice: UL/DL available capacity);
- HW capacity indicator (offered throughput and available throughput over E1, percentage utilisation over F1);
- RRC connections (number of RRC connections, and available RRC Connection Capacity);
- Number of active UEs.

**RACH optimization** is supported by UE reported information made available at the NG RAN node and by PRACH parameters exchange between NG RAN nodes.

The functionalities supported over the interfaces consist of

- PRACH configuration per served cell is signalled from DU to CU and over Xn
- PRACH configuration of Served Cells over X2
- RACH report from UE over Uu
- RACH report from CU to DU over F1

**NR MDT** takes LTE as baseline and takes NR new features into account, including beam, RRC\_INACTIVE and EN-DC.

The following functionalities are specified:

- MDT network signaling support over S1, X2, NG, Xn, F1 and E1
- Logged MDT for RRC\_IDLE and RRC\_INACTIVE UEs, support event-triggered or periodic logged MDT
- Immediate MDT
- CEF (Connection Establishment Failure) report
- Resume failure report

- Immediate MDT for EN-DC

**L2 measurements.** In this work item, a new spec TS 38.314 was produced to capture the measurements performed by network or the UE that are transferred over the standardised interfaces in order to support NR radio link operations, radio resource management (RRM), network operations and maintenance (OAM), minimization of drive tests (MDT) and self-organising networks (SON).

The specified measurements includes

- Received Random Access Preambles
- Packet delay
- Number of active UEs
- Number of stored inactive UE contexts
- UL PDCP Packet Average Delay by the UE

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840091,840191>

- [1] RP-192610, Revised WID on SON/MDT support for NR, CMCC
- [2] RP-200773, Status report for WI on SON\_MDT support for NR, CMCC
- [3] CRs and new specs
- R2-2006195 draft TS 38.314 CMCC
- R2-2006342 CR to 37.320 to support NR MDT CMCC, Nokia, Nokia Shanghai Bell CRRel-1637.32016.0.0082 1 F NR\_SON\_MDT-Core
- R2-2006336 Corrections on MDT and SON in NR Huawei, Ericsson, HiSilicon CR Rel-16 38.331 16.0.0 1669 2 F NR\_SON\_MDT-Core
- R2-2006337 Corrections on MDT and SON Huawei, Ericsson, HiSilicon CR Re-16 36.331 16.0.0 4323 2F NR\_SON\_MDT-Core
- R2-2006197 UE capabilities for NR MDT and SONvivo, CMCC 38.306CR
- R2-2006198 UE capabilities for NR MDT and SONvivo, CMCC 36.306CR
- R3-204414 BLCR to 38.420: Addition of MDT feature CMCC 38.420
- R3-204415 BLCR to 38.420: Addition of SON feature CMCC 38.420
- R3-204416 BLCR to 38.470: Addition of SON feature CMCC 38.470
- R3-204417 BLCR to 38.460: Addition of SON feature CMCC 38.460
- R3-204421 MDT support for EN-DC Huawei 36.413
- R3-204423 Addition of SON features CMCC, Huawei 38.401
- R3-204425 Addition of SON features Huawei 36.413
- R3-204426 Addition of MDT feature Huawei 38.413
- R3-204427 Addition of MDT features ZTE 38.463
- R3-204428 Addition of MDT features Samsung 38.473
- R3-204478 Addition of SON featureHuawei 36.300
- R3-204479 Addition of SON featureCATT 36.423
- R3-204480 Addition of SON features CMCC, Huawei 38.300
- R3-204481 Addition of SON features Huawei 38.413
- R3-204482 Addition of SON features Samsung 38.423
- R3-204483 Addition of SON features Huawei 38.473
- R3-204484 Addition of MDT features Samsung 38.401
- R3-204485 MDT Configuration support for XnAP Ericsson 38.423
- R3-204496 MDT support for EN-DC Huawei, SAMSUNG36.423
- R3-204502 Addition of SON features Ericsson 38.463

### 19.1.11 Introduction of NR FDD bands with variable duplex and corresponding framework

841001	<a href="#">Introduction of NR FDD bands with variable duplex and corresponding framework</a>	NR_FDD_bands_var duplex	R4	RP-191567	Huawei
841101	Core part: <a href="#">Introduction of NR FDD bands with variable duplex and corresponding framework</a>	NR_FDD_bands_var duplex-Core	R4	RP-191567	Huawei

Summary based on the input provided by Huawei, HiSilicon in RP-201019.

Supplementary downlink (SDL) frequency bands are defined within NR specifications in accordance with regulated licensed bands such as in the 1400-1500MHz range in Europe, and Uplink Sharing is defined as a means to operate NR uplink on the uplink resources of other bands, e.g. sharing the uplink carrier with that of an LTE carrier. Such a

configuration may be particularly useful when there is not a desire to allocate downlink NR resources in a 2nd downlink carrier, e.g. for an EN-DC configuration with the SDL band as part of the secondary cell group (SCG).

This work item allows the uplink and downlink of the introduced bands to be from 2 different licensed spectrum blocks, and new paired bands are defined in the RF specifications as n91, n92, n93 and n94.

### System parameters

System parameters for the new variable duplex FDD bands are defined in all the related RAN4 specifications including, operating bands, channel bandwidth, rasters, Tx-Rx separation, etc.

### Operating bands and NR-ARFCN

Newly introduced variable duplex bands have the same UL frequency parts as in SUL bands either n81 or n82, while they also have the same DL frequency parts as in SDL bands n75 or n76.

n91	832 MHz – 862 MHz	1427 MHz – 1432 MHz	FDD <sup>9</sup>
n92	832 MHz – 862 MHz	1432 MHz – 1517 MHz	FDD <sup>9</sup>
n93	880 MHz – 915 MHz	1427 MHz – 1432 MHz	FDD <sup>9</sup>
n94	880 MHz – 915 MHz	1432 MHz – 1517 MHz	FDD <sup>9</sup>

A note 9 is specified in the table that says ‘Variable duplex operation does not enable dynamic variable duplex configuration by the network, and is used such that DL and UL frequency ranges are supported independently in any valid frequency range for the band’. This comes from the concern that the operator may want to dynamically configure the duplex distance used in the network.

### Channel bandwidth

Since the frequency parts of the variable duplex FDD bands are acquired independently, asymmetric bandwidths must be introduced to accommodate most of the desired deployments.

NR Band	Channel bandwidths for UL (MHz)	Channel bandwidths for DL (MHz)
n91 <sup>1</sup>	10	5
n92 <sup>1</sup>	5	10, 15, 20
	10	15, 20
n93 <sup>1</sup>	10	5
n94 <sup>1</sup>	5	10, 15, 20
	10	15, 20
NOTE 1: The assignment of the paired UL and DL channels are subject to a TX-RX separation as specified in clause 5.4.4.		

Hence other bandwidth configurations of the variable duplex FDD bands follow what was defined for the corresponding UL or DL bands that are consisted of.

### Tx-Rx separation

It is worth noting that Tx-Rx separation is defined in a different way for the variable duplex bands since the default separation no longer applies with them.

NR Operating Band	TX – RX carrier centre frequency separation
n91	570 MHz – 595 MHz (NOTE 2)
n92	575 MHz – 680 MHz ( $\mu = 0$ ) 580 MHz – 675 MHz ( $\mu = 1$ ) (NOTE 2)
n93	517 MHz – 547 MHz (NOTE 2)
n94	522 MHz – 632 MHz ( $\mu = 0$ ) 527 MHz – 627 MHz ( $\mu = 1$ ) (NOTE 2)

Note 2 says that the range of Tx-Rx frequency separation given paired UL and DL channel bandwidths  $BW_{UL}$  and  $BW_{DL}$  is given by the respective lower and upper limit  $F_{DL\_low} - F_{UL\_high} + 0.5(BW_{DL} + BW_{UL})$  and  $F_{DL\_high} - F_{UL\_low} -$

$0.5(BW_{DL} + BW_{UL})$ . The UL and DL channel bandwidth combinations specified in Table 5.3.5-1 and 5.3.6-1 depend on the subcarrier spacing configuration  $\mu$ .

### UE requirements

UE requirements considering the characteristics when operating in the variable duplex bands and band combinations are defined including REFSSENS and related configurations.

#### REFSENS and UL configurations

REFSENS requirements follow the ones defined for n75 and n76 correspondingly for the variable duplex bands but UL configurations are not necessarily the same with those defined for n8 and n20. For n20, additional restrictions on the UL RBs are specified so that the same REFSSENS value can be achieved with such a narrow duplex distance. Since the variable duplex bands have much larger expected Tx-Rx separation, additional restrictions on the UL RB allocations are not specified.

### BS requirements

In this work item, BS requirements span among a series of specifications such as 38.104, 38.141-1, 37.104, 37.105, 37.141, 37.145-1, 37.145-2, 36.104, 36.141, etc. Mainly coexistence requirements are defined in these specs.

#### Additional spurious emission requirements

Respective requirements which correspond to BS spurious limits for co-existence with systems operating in the new variable duplex FDD bands are introduced in the mentioned spec, with maximum measured spurious levels and bandwidth configurations.

#### Out of band blocking requirements

Another set of Tx requirements is also defined with the similar manner as the above one. The requirements apply when co-location with other BS-s operating in the variable duplex FDD bands is observed.

#### Receiver response under co-location requirements

Receiver response requirements are defined in the mentioned specifications that the BS operating in the introduced bands should have the ability to block unwanted interband interferences from any other collocated BS.

For all the above mentioned BS requirements, both conducted and radiated requirements are defined.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=841001,841101>

- [1] RP-192820, "Revised WID: Introduction of NR FDD bands with variable duplex and corresponding framework", Huawei, HiSilicon.
- [2] RP-192818, "Status report for WI: Introduction of NR FDD bands with variable duplex and corresponding framework", Huawei, HiSilicon.

## 19.1.12 Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR

800082	<a href="#">Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR</a>	NR_CLI_RIM	R1	RP-191546	LG Electronics
800182	Core part: Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR	NR_CLI_RIM-Core	R1	RP-190700	LG Electronics
800282	Perf. part: Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR	NR_CLI_RIM-Perf	R4	RP-190700	LG Electronics

Summary based on the input provided by Huawei in RP-190144.

Rel-14 NR study showed that duplexing flexibility with cross-link interference mitigation shows better user throughput compared to static UL/DL operation or dynamic UL/DL operation without interference mitigation in indoor hotspot (4GHz and 30GHz) and urban macro scenarios (4GHz and 2GHz). Furthermore, semi-static and/or dynamic DL/UL resource assignments should also consider coexistence issues particularly among different operators where tight coordination are challenged. For efficient coexistence, not only coexistence requirements need to be understood but also advanced mechanisms to mitigate interference such as TRP-to-TRP measurement and adaptation based on

measurements should be considered. The Rel-16 Work Item Cross Link Interference (CLI) handling to support flexible resource adaptation for unpaired NR cells achieves the following objectives [1]:

- CLI measurements and reporting at a UE (i.e., CLI-RSSI and SRS-RSRP), and network coordination mechanism(s) (i.e., exchange of intended DL/UL configuration) are developed.
- Perform coexistence study to identify conditions of coexistence among different operators in adjacent channels is accomplished.

In NR deployment on lower TDD frequency, the impact of the troposphere bending will continue existing if no special mechanisms are introduced. In the RIM SI, the frameworks for mechanisms for gNBs to start and terminate the transmission/detection of reference signal(s), the functionalities and requirements of the corresponding RS(s) as well as the design of the RS(s), and the backhaul-based coordination mechanisms among gNBs have been studied. It is recommended to specify RIM RS(s) to support identifying remote interference related information, it is also recommended to specify the inter-set RIM backhaul signalling via the core network for backhaul-based solution. The Rel-16 Work Item Remote Interference Management (RIM) to deal with mitigation of the remote interference caused by gNBs achieves the following objectives [1]:

- RIM RS resource and configurations, and the inter-set RIM backhaul signalling via the core network to convey the messages of “RIM-RS detected” and “RIM-RS disappeared” are developed.
- Corresponding OAM functions to support RIM operation is identified.

### CLI handling

Once different TDD UL/DL configurations are applied among neighboring cells, UL transmission from a UE in a cell causes interference to DL reception of some other UEs in the rest of the neighboring cells. The interference is referred as inter-cell UE-to-UE cross link interference (CLI). To mitigate an inter-cell UE-to-UE CLI, gNBs can exchange and coordinate the intended TDD UL/DL configuration over Xn and F1 interfaces. Taking into account the exchanged information, a gNB may decide the transmission and reception pattern in order to avoid CLI to neighboring cell or from neighboring cell.

For CLI handling, two types of CLI measurements and reporting (i.e., CLI-Received Signal Strength Indicator (RSSI) measurement and SRS-Reference Signal Received Power (RSRP) measurement) are specified. For CLI-RSSI measurement, the victim UE measures the total received power over configured CLI-RSSI measurement resource. For SRS-RSRP measurement, the victim UE measures the RSRP over configured SRS resource(s) which is/are transmitted from one or multiple aggressor UE(s). Then, Layer 3 filtering can be applied to the measurement result for both CLI-RSSI measurement and SRS-RSRP measurement. For measurement result reporting for both CLI-RSSI measurement and SRS-RSRP measurement, event triggered and periodic reporting are supported. Furthermore, CLI measurement and reporting can be configured for NR cells in multi-carrier option.

Semi-static and/or dynamic DL/UL resource assignment causes interferers between networks on adjacent channels. It has been tasked to investigate the adjacent channel co-existence effects arising when CLI, or more generically dynamic TDD is operated in an aggressor network. The technical report captures a description of the adjacent channel interference effects that arise with dynamic TDD as well as a simulation investigation of adjacent channel interference in a number of different deployment scenarios [2].

### RIM

Due to the atmospheric ducting phenomenon, the DL signals of an aggressor cell in unpaired spectrum can interfere with the UL signals of a victim cell in the same unpaired spectrum bandwidth that is far away from the aggressor cell. Such interference is termed as remote interference. A remote interference scenario may involve a number of victim and aggressor cells, where the gNBs may execute Remote Interference Management (RIM) coordination on behalf of their respective cells.

To mitigate remote interference, RIM frameworks for coordination between victim and aggressor gNBs are specified. The coordination communication in RIM frameworks can be wireless- or backhaul-based. In both frameworks, all gNBs in a victim set can simultaneously transmit an identical RIM reference signal carrying the victim set ID over the air.

In the wireless framework, RIM-RS (RIM reference signal) type 1 and RIM-RS type 2 are specified. Upon reception of the RIM reference signal (RIM-RS type 1) from the victim set, aggressor gNBs undertake RIM measurement, and may

send back a RIM reference signal (RIM-RS type 2) carrying the aggressor set ID if configured, and may undertake interference mitigation actions. The RIM reference signal (RIM-RS type 2) sent by the aggressor is able to facilitate estimation whether the atmospheric ducting phenomenon between victim and aggressor sets exists.

In the RIM backhaul framework, upon reception of the RIM reference signal (RIM-RS type 1) from the victim set, aggressor gNBs undertake RIM measurement, establish backhaul coordination towards the victim gNB set. The backhaul messages which carry the detection or disappearance indication are aggregated at gNB-CU via F1 interface and sent from individual aggressor gNBs to individual victim gNBs via NG interface, where the signalling is transparent to the core network.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800082,800182,800282>

- [1] RP-193190 “Revised WID on Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR”
- [2] 3GPP TR38.828 “Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR”

## 19.1.13 RF requirements for NR frequency range 1 (FR1)

830087	RF requirements for NR frequency range 1 (FR1)	NR_RF_FR1	R4	RP-193266	Huawei
830187	Core part: RF requirements for NR frequency range 1 (FR1)	NR_RF_FR1-Core	R4	RP-193266	Huawei
830287	Perf. part: RF requirements for NR frequency range 1 (FR1)	NR_RF_FR1-Perf	R4	RP-193266	Huawei

Summary based on the input provided by Huawei in RP-201718.

In Rel-16, several FR1 non-spectrum related topics are included in one WI targeting for UE RF requirements enhancement.

In this WI, RF requirements, corresponding new feature groups and functionalities are introduced for both uplink and downlink enhancements. This enables the 5G commercial deployment requirements on FR1 fulfilled.

In Rel-15, almost-contiguous allocations for CP-OFDM was introduced for power class 3 UE. This allows UE to be scheduled with non-contiguous PUSCH allocation within one carrier which is partitioned by short PUCCH of other users. In Rel-16, RAN4 continues the work and completed RF requirement for HPUE on almost-contiguous CP-OFDM allocations.

FR1 Intra-band contiguous DL CA is up to 200MHz aggregated channel bandwidth in Rel-15. Based on commercial deployment requirement, RAN4 enhances intra-band contiguous DL CA to 300MHz in Rel-16, the corresponding RF requirements are completed within this WI. Meanwhile, intra-band non-contiguous DL CA is introduced considering latest 5G spectrum allocation is some country/region.

In correspondence, FR1 intra-band contiguous and non-contiguous UL CA are also introduced from Rel-16, all RF requirements are completed within the WI. Besides RF requirement, RAN4 also recognized the dependency relation among bandwidth class, PA architecture and MIMO layer for UE capability indicating. Additional DC location reporting UE capability is introduced to improve UL 256QAM performance for intra-band UL CA.

In Rel-15, inter-band UL CA, SA SUL and inter-band EN-DC RF requirements are specified assuming 0us switching period between 2 UL carriers when TDM operated, it leads to that UE cannot support 2Tx transmission when UE switch to one carrier if no switching period is reserved for the UE. In Rel-16, switching period between case 1 and case 2 is 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. For which, time mask including switching period and transient period between 2 carriers are specified. For inter-band UL CA and SA SUL, the switching periods are located in either NR carrier as indicated in RRC signalling, while for inter-band EN-DC, the switching periods are only located in NR carrier. In correspondence, 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.

Time masks for ULSUP-TDM that accounts for UL timing misalignment between the EUTRAN and NR cell groups are further modified in this WI, additional 2.2μs transient is added.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830087,830187,830287>

## 19.1.14 NR RF requirement enhancements for frequency range 2

830089	NR RF requirement enhancements for frequency range 2 (FR2)	NR_RF_FR2_req_enh	R4	RP-191290	Nokia
830189	Core part: NR RF requirement enhancements for frequency range 2 (FR2)	NR_RF_FR2_req_enh-Core	R4	RP-190761	Nokia

Summary based on the input provided by Nokia in RP-201984.

This work item developed various UR RF enhancements for FR2. Basis for the WI was the features that were not developed in REL15 due to lack of time.

The following enhancements were introduced:

1. MPE: UE can report to network how much P-MPR it uses or is going to use because of MPE. Based on this reporting network can take actions to prevent sudden radio link failures.
2. Beam correspondence: Requirements for SSB-based and CSI-RS based BC were developed. This allows network to efficiently deploy different beam widths for SSB and CSI-RS. This enables e.g. to deploy wider SSB based beams for idle mode UEs and narrower CSI-RS based beams for RRC connected mode UEs.
3. Interband DL CA: Requirements were developed for band combination CA\_n260-n261 based on independent beam management.
4. DL Intra-band CA BW Enhancement: New frequency separation classes Fs were introduced for up to 2400 MHz separation. Furthermore frequency separation classes for DL-only spectrum Fsd were introduced. The DL-only frequency spectrum is the width of UE frequency spectrum available to network to configure DL CCs only, and it extends on one-side of the bidirectional spectrum in contiguous manner with no frequency gap between the two.
5. Non-contiguous intra-band uplink CA: Requirements were developed for n260 for up to three uplink sub-blocks.
6. MPR enhancements: Zero dB MPR range was extended to cover more allocations.
7. Output power boost when in-band emissions are suspended: 1 dB boost was introduced for QPSK modulation.
8. Multiband relaxation framework enhancement: Based on RAN5 LS MBR framework was modified. REL15 retains original MBR concept but introduced a relaxation cap. REL16 adopted new concept where relaxation defined per band basis.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830089,830189>

- [1] RP-201606 Revised WID on NR RF Requirement Enhancements for FR2
- [2] RP-201607 SR of NR RF requirement enhancements for frequency range 2 (FR2), RAN#89
- [3] RP-201608 TR 38.831 v1.0.0
- [4] RP-200666 SR of NR RF requirement enhancements for frequency range 2 (FR2), RAN#88
- [5] RP-200247 SR of NR RF requirement enhancements for frequency range 2 (FR2), RAN#87
- [6] RP-192652 SR of NR RF requirement enhancements for frequency range 2 (FR2), RAN#86
- [7] RP-192226 SR of NR RF requirement enhancements for frequency range 2 (FR2), RAN#85

## 19.1.15 NR RRM enhancement

840095	NR RRM enhancement	NR_RRM_enh	R4	RP-191601	Intel
840195	Core part: NR RRM enhancement	NR_RRM_enh-Core	R4	RP-191601	Intel
840295	Perf. part: NR RRM enhancement	NR_RRM_enh-Perf	R4	RP-191601	Intel

Summary based on the input provided by Intel Corporation, ZTE Corporation, Apple in RP-201884.

The work item on NR RRM enhancement [1] introduces a number of enhanced NR RRM requirements on top of the baseline RRM requirements defined in the scope of the Rel-15 NR WI [2]. In particular, the RRM requirements for the following procedures are introduced in the scope of the work item:

- SRS carrier switching
- Multiple Scell activation/deactivation
- CGI reading with autonomous gap for NR capable UE
- BWP switching on multiple CCs

- Inter-band CA requirement for FR2
- Inter-frequency measurement without MG
- Mandatory measurement gap patterns
- Spatial relation switch for uplink
- UE specific channel BW change

The corresponding changes are captured in TS 38-series and 36-series specifications [3]-[8].

#### SRS carrier switching RRM requirements

SRS carrier switching functionality was defined for NR and LTE carriers in the scope of the Rel-15 NR WI [2], however, the respective requirements were not introduced in the Rel-15 scope. In the Rel-16 NR RRM Enhancements WI the specific UE interruption requirements for the SRS carrier switching are defined for the following cases:

- LTE SRS carrier switching impacting NR CC
- NR SRS carrier switching impacting LTE CC
- NR SRS carrier switching impacting NR CC

The corresponding interruption RRM requirements are specified in TS38.133 clause 8.2 and TS36.133 clause 7.32.2.13.

#### Multiple SCell activation/deactivation RRM requirements

In accordance to NR design multiple SCells can be activated/deactivated simultaneously. However, in Rel-15 only single SCell activation/deactivation NR RRM requirements were specified which resulted in an inefficient use of network resources. In the Rel-16 NR RRM Enhancements WI, the SCell activation and deactivation delay and interruption requirements for the case of multiple SCell activation/deactivation in FR1, FR2, and FR1+FR2 are introduced. The corresponding RRM requirements are specified in TS38.133 clause 8.3.7 and 8.3.8.

#### CGI reading with autonomous gap for NR capable UE

In Rel-16, the acquisition of CGI information from a neighbouring cell using autonomous gaps is supported. The NR cell CGI reading requirements are defined for NR capable UE in LTE SA, NR SA UE, EN-DC UE, NE-DC UE, and NR-DC. Besides that, the requirements for LTE cell CGI reading for NR SA UE, EN-DC UE, NE-DC UE, and NR-DC UE are defined. The RRM requirements are specified in TS38.133 clause 8.2, 9 and TS36.133 clause 7.32.2, 7.37, 7.36.2.

#### BWP switching on multiple CCs

The Rel-15 NR UE BWP switching requirements covered the scenario where a network configured BWP switching on a single component carrier. In practice, the network may configure BWP switching on multiple component carriers and a predictable UE behavior is important. In Rel-16 NR RRM Enhancements WI the requirements for both simultaneous and non-simultaneous BWP switching on multiple CCs, covering DCI based, timer based and RRC based BWP switching are defined. The respective RRM requirements are specified in TS38.133 clause 8.6.2A, 8.6.2B and 8.6.3A.

#### Inter-band CA requirement for FR2

The support of the FR2 inter-band CA was introduced in the scope of the FR2 RF WI [9]. In particular, the functionality to support independent beam management on the different CCs was introduced in the scope of [9]. The RRM requirements for inter-band CA requirement for FR2 UE measurement capability of independent Rx beam are defined in the scope of the NR RRM enhancements WI. The RRM requirements are specified in TS38.133 clause 9.2.5 and 9.5.6.

#### Inter-frequency measurement without MG

In Rel-15 NR, all the inter-frequency measurements have to be done within measurement gap. However, from UE implementation perspective inter-frequency measurement can be done without MG (inter-frequency RRM measurement and serving cell data reception/transmission can be done concurrently) under certain conditions. In Rel-16, RAN4 defines conditions under which UE can perform inter-frequency measurement without MG. RAN4 also introduces corresponding RRM requirement for CSSF update, which can be found in TS38.133 clause 9.1.5.

#### Mandatory measurement gap patterns

Only measurement gap patterns 0 and 1 are mandatorily supported in Rel-15. However, some other measurement gap patterns are also very important in balancing gap overhead and measurement performance. In Rel-16 additional mandatory measurement gap patterns were defined in Rel-16.

- GP#17, GP#18 and GP#19 shall be additional mandatory
- GP#2, GP#3 and GP#11 shall be additional mandatory for NR only measurement

Besides, a capability to support measurement gap patterns for NR only measurements was introduced. Definition of NR only measurement gaps can be found in TS38.133 Table 9.1.2-2 and Table 9.1.2-3.

#### Spatial relation switch for uplink

Uplink spatial relation can be changed since Rel-15. However, in Rel-15 RAN4 only specified RRM requirements for downlink spatial relation change. In Rel-16, delay requirements for spatial relation switch for uplink channels and SRS are defined. Corresponding requirements are specified in TS38.133 clause 8.12.

#### UE specific channel BW change

Both active BWP and UE specific channel BW can be dynamically changed in Rel-15. However, in RAN4 RRM only active BWP change requirements were specified in Rel-15. In Rel-16, RRM requirements for UE specific channel BW change are defined. Corresponding requirement can be found in TS38.133 clause 8.2.1.2.11, 8.2.2.2.8 and 8.13.

#### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840095,840195,840295>

[1]	RP-201112	Revised WID: NR RRM enhancement in R16, Intel Corporation, ZTE Corporation, Apple
[2]	RP-191971	Revised WID: New Radio Access Technology
[3]	TS 38.133	
[4]	TS 38.331	
[5]	TS 38.306	
[6]	TS 36.133	
[7]	TS 36.331	
[8]	TS 36.306	
[9]	RP-200668	Revised WID on NR RF Requirement Enhancements for FR2

### 19.1.16 RRM requirement for CSI-RS based L3 measurement in NR

840093	<a href="#">RRM requirement for CSI-RS based L3 measurement in NR</a>	NR_CSIRS_L3meas	R4	RP-191580	CATT
840193	Core part: RRM requirement for CSI-RS based L3 measurement in NR	NR_CSIRS_L3meas-Core	R4	RP-191580	CATT
840293	Perf. part: RRM requirement for CSI-RS based L3 measurement in NR	NR_CSIRS_L3meas-Perf	R4	RP-191580	CATT

Summary based on the input provided by CATT in RP-201942.

Compared to SSB based RRM measurement, CSI-RS based measurement is more refined and flexible in terms of resource usage, mobility enhancement and handover reliability. This WI [1] targets to specify the RRM requirements for CSI-RS based L3 measurement.

In R16 WI on RRM requirements of CSI-RS based L3 measurement, to guarantee the mobility, the RRM requirements including synchronization assumption, applicable CSI-RS configuration, CSI-RS based intra/inter-frequency definition, intra/inter measurement requirements, and UE measurement capability are specified.

#### Synchronization assumption

The CSI-RS based L3 measurement requirements in R16 WI are based on single FFT implementation and UE supports using the serving cell timing for intra-frequency measurements in Rel-16.

**Measurement bandwidth of CSI-RS resources:** The RRM requirements for CSI-RS based L3 measurement in R16 WI are specified based on the CSI-RS configuration  $\{D=3, PRB \geq 48\}$ .

**CSI-RS based intra/inter-frequency definition:** For CSI-RS based L3 measurement, the measurement is defined as a CSI-RS based intra-frequency measurement provided that the centre frequency, SCS and CP type (applied for SCS = 60KHz) of CSI-RS resources on the neighbour cell configured for measurement are the same as the centre frequency,

SCS and CP type of CSI-RS resources on the serving cell indicated for measurement. Otherwise, the measurement is defined as CSI-RS based inter-frequency measurement.

**Scenarios for CSI-RS based L3 measurement requirements:** For CSI-RS based intra-frequency measurement, the RRM requirements in R16 are defined for the scenarios that all CSI-RS resources in the same MO have the same BW and the BW of the CSI-RS on the neighbour cell is within the active BWP of the UE. No requirement is defined when the BW of intra-MO is different from that of the CSI-RS resources configured for the serving cell in Rel-16.

For CSI-RS based inter-frequency measurement, the RRM requirements in R16 are defined for the scenarios that all CSI-RS resources in the same MO have the same BW and the CSI-RS resources to be measured with gap is not confined in the active BWP.

**Intra/inter measurement requirements:** The RRM requirements for CSI-RS based L3 measurement in R16 WI are specified for the case when associated SSB is configured. So the measurement delay consists of cell identification delay, SSB index acquisition time and CSI-RS measurement period.

The RRM requirements for CSI-RS based L3 measurement in R16 are specified based on the assumption that CSI-RS based L3 measurement and SSB based L3 cell detection/measurement share the measurement engines and applied when CSI-RS resources are configured within a 5ms window at any location.

**UE measurement capability:** On top of the legacy measurement capability of SSB based measurement, for the UE supporting CSI-RS based L3 measurement, UE shall be able to measure at least 1 SSB intra-frequency layer and 1 CSI-RS intra-frequency layer per serving cell, 8 NR inter-frequency layers including SSB and CSI-RS in total.

The cells to be monitored based on CSI-RS can be the same set or a subset of the cells monitored based on SSB.

For each intra-frequency layer, during each layer 1 measurement period, the UE shall be capable of performing CSI-RSRP, CSI-RSRQ, and CSI-SINR measurements for at least 32 CSI-RS resources for FR1 and 32 CSI-RS resources for FR2.

For each inter-frequency layer, during each layer 1 measurement period, the UE shall be capable of performing CSI-RSRP, CSI-RSRQ, and CSI-SINR measurements for at least 14 CSI-RS resources for FR1 and 24 CSI-RS resources for FR2.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840093,840193,840293>

- [1] RP-201345 Revised WID on RRM requirements for CSI-RS based L3 measurement, CATT
- [2] RP-201793 Status report for RRM requirements for CSI-RS based L3 measurement, CATT

## 19.1.17 Over the air (OTA) base station (BS) testing TR

860054	<a href="#">Over the air (OTA) base station (BS) testing TR</a>	OTA_BS_testing	R4	RP-193225	Huawei
860254	Perf. Part: <a href="#">Over the air (OTA) base station (BS) testing TR</a>	OTA_BS_testing-Perf	R4	RP-201021	Huawei

Summary based on the input provided by Huawei in RP-202600.

WI on OTA BS testing has introduced new Technical Report TR 37.941 (both Rel-15 and Rel-16) is collecting inputs from multiple existing RAN4-internal Technical Reports treating on AAS BS and NR BS radiated conformance testing aspects (i.e. TR 37.842, TR 37.843, TR 38.817-02), by collecting and aligning Measurement Uncertainty and Test Tolerance derivations methodologies for multiple OTA testing methodologies for directional measurements, TRP measurements, and co-location measurements.

Technical Report for the Work Item on Over The Air (OTA) Base Station (BS) testing covers background information of OTA testing methods, Measurement Uncertainty (MU) and Test Tolerance (TT) values derivation for the radiated conformance testing requirements. This Technical Report covers radiated conformance testing requirements for AAS BS in Frequency Range 1 (FR1), and for NR BS radiated conformance testing in FR1 and FR2:

- Hybrid AAS BS as specified in AAS BS radiated testing specification TS 37.145-2 for the following radio technologies:
  - Hybrid AAS BS in single RAT UTRA operation, TDD
  - Hybrid AAS BS in single RAT UTRA operation, FDD
  - Hybrid AAS BS in single RAT E-UTRA operation
  - Hybrid AAS BS in MSR operation implementing any of the above RATs, including NR operation.

- OTA AAS BS as specified in AAS BS radiated testing specification TS 37.145-2 [4] for the following radio technologies:
  - OTA AAS BS in single RAT UTRA operation, FDD
  - OTA AAS BS in single RAT E-UTRA operation
  - OTA AAS BS in MSR operation implementing any of the above RATs, and/or NR.
- BS type 1-H in single RAT NR operation in FR1, as specified in NR BS radiated testing specification TS 38.141-2,
- BS type 1-O in single RAT NR operation in FR1, as specified in NR BS radiated testing specification TS 38.141-2,
- BS type 2-O in single RAT NR operation in FR2, as specified in NR BS radiated testing specification TS 38.141-2.

TR 37.941 consolidates the OTA measurement related information originating from multiple AAS BS and NR BS internal technical reports. This information is needed to supplement the BS radiated testing specifications as a single, 3GPP external technical report, such that the information can be referred to from external specifications and bodies.

Technical Report in TR 37.941 (both Rel-15 and Rel-16) is collecting inputs from multiple existing RAN4 internal Technical Reports: TR 37.842; TR 37.843 and TR 38.817-02.

Collected inputs were aligned updated to provide consistent information on Measurement Uncertainty (MU) and Test Tolerance (TT) derivations methodologies for directional, TRP and co-location measurements. For the purpose of future references and MU/TT values derivation verification, Excel spreadsheets were attached to the TR (for TX/RX MU values in FR1 and FR2, as well as for the co-location requirements).

The following OTA test methods were captured in Rel-15 version of the TR: IAC; CATR; NF; PWS; 1D and reverb.

TR 37 941 is expected to be further updated with relevant inputs related to the OTA BS testing, e.g. new or extended frequency ranges consideration, new OTA test methodologies, etc.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860054,860254>

## 19.1.18 Enhancement on MIMO for NR (NR\_eMIMO)

800085	Enhancements on MIMO for NR	NR_eMIMO	R1	RP-200474	Samsung
800185	Core part: Enhancements on MIMO for NR	NR_eMIMO-Core	R1	RP-200474	Samsung
800285	Perf. part: Enhancements on MIMO for NR	NR_eMIMO-Perf	R4	RP-200474	Samsung
880070	UE Conformance Test Aspects - Enhancements on MIMO for NR	NR_eMIMO-UEConTest	R5	RP-200895	Huawei

Summary based on the input provided by Samsung in RP-202803, becoming the CR in SP-211558.

### 19.1.18.0 Introduction on NR\_eMIMO

This work item introduces enhanced specification support for several key aspects on multi-input multi-output (MIMO) operation where Rel.15 NR was found deficient in terms of spectral efficiency, downlink/uplink transmit power efficiency, signalling latency, and signalling overhead.

**First**, although high-resolution downlink (DL) channel state information (CSI) can be made available to the gNB by the Type-II CSI (thereby facilitating high DL spectral efficiency), the associated uplink (UL) reporting overhead is prohibitively high. This would burden the system since such high-resolution DL CSI is typically used with large number of users per cell.

**Second**, Rel.15 mainly focuses on single-TRP-based transmission/reception with ideal backhaul from UE perspective. Enhancements for Multi-TRP/panel transmission are to further improve DL data rate and spectral efficiency by fully utilizing multi-TRP/panel simultaneously with non-coherent joint transmission (NCJT) in ideal/non-backhaul conditions, or further exploit spatial diversity with time/frequency domain repetition to improve transmission reliability.

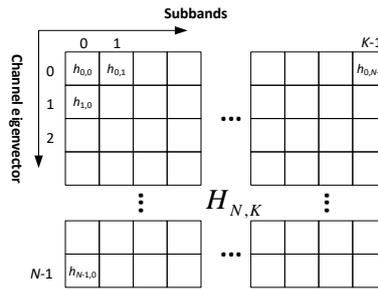
**Third**, although Rel.15 supports flexible beam management (BM) functionality to accommodate various implementation and usage scenarios, Rel.15 BM signaling framework could require a large amount of signaling for updating beam RS and pathloss reference RS for respective DL and UL signals when the best DL-UL beam pair is changed frequently due to UE mobility, rotation, or beam blockage. Therefore, in Rel.16, five features were introduced for the purpose of BM signaling overhead and latency reduction. Additionally, in Rel.15, L1-RSRP-based beam measurement and reporting are supported. To facilitate interference-aware beam selection, L1-SINR-based beam measurement and reporting were introduced. Finally, in Rel.15, beam failure recovery (BFR) is supported only for spCell. To improve the performance and reliability for SCell, BFR for SCell was introduced.

**Fourth**, a high peak to average power ratio (PAPR) issue identified for Rel.15 DM-RS for PDSCH, PUSCH and PUCCH format 3 and 4 was corrected by defining new Rel.16 DM-RS which have the same PAPR as its associated data/control channel.

**Fifth**, in Rel.15 UL codebook-based transmission, the non-coherent and partial-coherent codebook subsets –especially with lower rank transmission– cannot reach the maximum output power (declared by the UE) with power scaling mechanism. Three modes of UL full-power transmission and three UE capabilities are specified to accommodate different power amplifier (PA) architectures.

### 19.1.18.1 MU-MIMO CSI

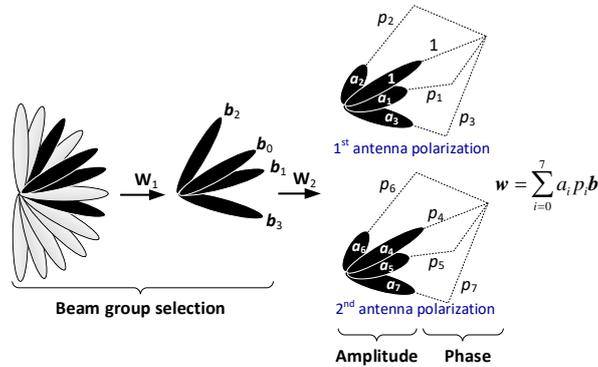
For Multi-User MIMO (MU-MIMO) transmission, the Precoding Matrix Indicator (PMI) codebook is designed to represent dominant channel eigenvectors for multiple SBs with high-resolution. In matrix form, this corresponds to an  $N \times K$  channel matrix  $\mathbf{H}_{N,K}$  as shown in Figure 2, where  $K$  is number of SBs, and the  $k$ -th column of  $\mathbf{H}_{N,K}$  corresponds to channel eigenvector for SB  $k$ .



**Figure 2 Channel matrix.**

The Rel. 15 Type II CSI is based in compressing (columns of)  $\mathbf{H}_{N,K}$  in spatial domain (SD) by performing linear combination (LC) of  $L > 1$  SD basis vectors that comprise columns of matrix  $\mathbf{W}_1$ . In particular, an eigenvector  $\mathbf{e}$  of the channel is expressed as a LC of  $L$  Discrete Fourier Transform (DFT) vectors:  $\mathbf{e} \approx \sum_{i=0}^{L-1} c_i \mathbf{b}_i$ . This is illustrated in Figure 3. The PMI codebook is used to report the following components:

- $\mathbf{W}_1$ : DFT vectors  $\{\mathbf{b}_i\}_{i=0}^{L-1}$  reported common for all SBs (WB reporting); and
- $\mathbf{W}_2$ : amplitude and phase of coefficients  $\{c_i\}_{i=0}^{L-1}$  reported independently for each SB (SB reporting).



**Figure 3 Linear combination based Rel. 15 Type II CSI feedback.**

Although Rel. 15 Type II CSI can offer large performance gain, the overhead (number of bits) to report Type II CSI is  $O(L \times K \times Rank)$  which can be excessively large (cf. Table 1).

**Table 1 Rel. 15 Type II CSI reporting payload (bits) for 10 SBs**

L	W1 (bits)		W2 (bits)		Total (bits)	
	Rank 1	Rank 2	Rank 1	Rank 2	Rank 1	Rank 2
2	22	33	12	24	142	273
4	39	63	24	48	279	543

The Rel.15 Type II CSI compresses (columns of)  $\mathbf{H}_{N,K}$  in SD by performing LC using SD basis matrix  $\mathbf{W}_1$ , and there is no compression across rows of  $\mathbf{H}_{N,K}$  in frequency domain (FD). The LC coefficients that combine columns of  $\mathbf{W}_1$  matrix is given by columns of matrix  $\mathbf{W}_2 = pseudo\_inv(\mathbf{W}_1)\mathbf{H}_{N,K} = \mathbf{W}_1^H \mathbf{H}_{N,K}$ . It is well-known that each row of  $\mathbf{W}_2$

matrix (that corresponds to  $K$  FD components such as frequency SBs) comprises LC coefficients that are correlated. This correlation in FD can be exploited to reduce Type II CSI payload without significant impact on throughput performance.

In the Rel.16 enhanced Type II CSI,  $H_{N,K}$  is compressed in both SD and FD by performing LC using  $L$  SD DFT basis vectors, i.e. columns of  $W_1$  for SD compression, and  $M$  FD DFT basis vectors, i.e. columns of  $W_f = [f_0 \dots f_{M-1}]$  for FD compression. This is illustrated in Figure 4, wherein the SD compression is performed using  $W_1$ , and the resultant  $W_2$  matrix is compressed in FD domain using  $W_f$ . The  $2L \times M$  coefficient matrix after SD/FD compression is  $\tilde{W}_2 = W_2 W_f$ .

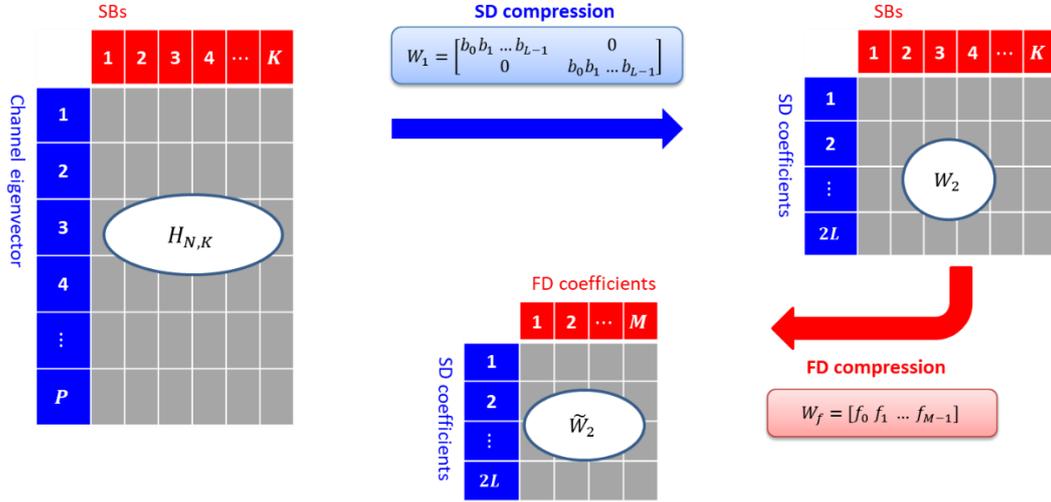


Figure 4 Frequency compression of  $H_{N,K}$ .

The PMI codebook parameterized by  $(L, M, K_0)$  is used to report the following components:

- $W_1$ : SD DFT vectors  $\{b_i\}_{i=0}^{L-1}$  reported common for all SBs (WB reporting);
- $W_f$ : FD DFT vectors  $\{f_m\}_{m=0}^{M-1}$  reported independently for each SBs (SB reporting), where  $M = \lceil p \times K \rceil$ ; and
- $\tilde{W}_2$ : comprises following components
  - Non-zero subset selection:  $K_0$  out of  $2LM$  non-zero (NZ) coefficients of  $\tilde{W}_2$  are selected, and remaining  $2LM - K_0$  coefficients are set to 0, where  $K_0 = \lceil \beta \times 2LM \rceil$ 
    - Restriction: to ensure that the overhead is not too large, the following restriction is applied  $K^{NZ} \leq 2K_0$  and  $K^{NZ,l} \leq K_0$  where  $K^{NZ,l}$  is a number of NZ coefficients for layer  $l$  and  $K^{NZ}$  is a total number of NZ coefficients across all layers
  - Strongest coefficient: 1 out of  $K_0$  NZ coefficients is selected and is set to 1
  - Quantization: amplitude and phase of remaining  $K_0 - 1$  NZ coefficients  $\{c_{i,m}\}$  is reported.

The following add-on features are also supported:

- Amplitude restriction: for each SD index  $i$ , the average power of the NZ coefficients  $c_{i,m}$  is restricted to be within a threshold
- $R$ : for improved performance, the number of precoding matrices reported in each SB can be up to  $R$  where  $R \in \{1,2\}$ ; hence, the total number of precoding matrices can be up to  $N_3 = R \times K$
- Two-step FD basis selection: to reduce overhead of FD basis selection, when  $N_3 > 19$ , the FD DFT vectors  $\{f_m\}_{m=0}^{M-1}$  are selected from an intermediate basis set as shown in Figure 5, where the intermediate basis set comprises a window of  $N'_3$  FD bases and is reported common for all layers.

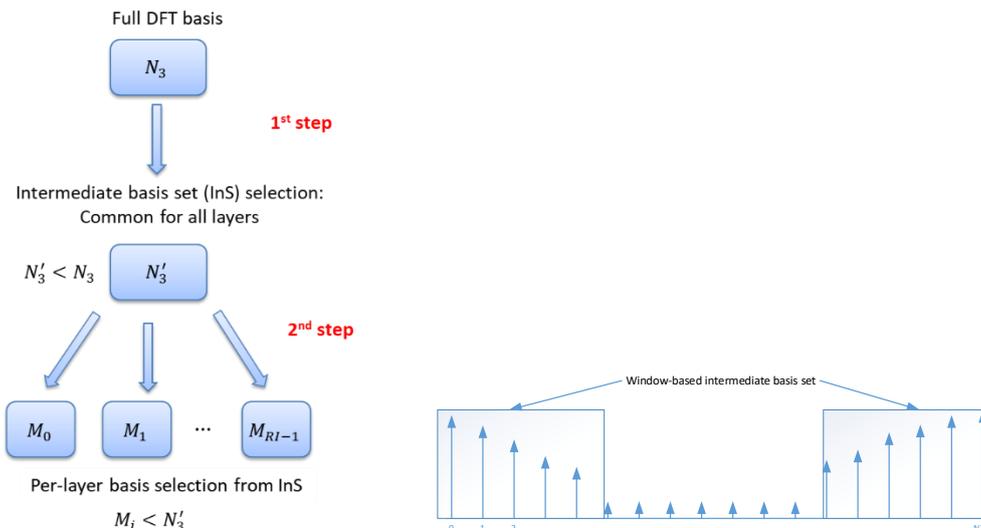


Figure 5 Two-step FD basis selection

The support of the following features is subject to separate UE capability signalling: rank > 2, R=2, L=6, and amplitude restriction.

### 19.1.18.2 Multi-TRP

Enhancements of Multi-TRP/panel transmission intends to improve DL data rate/spectral efficiency and transmission reliability with both ideal and non-ideal backhaul by fully utilizing multi-TRP/panel simultaneously since Rel.15 specification mainly focus on single TRP based transmission/reception, from the UE perspective.

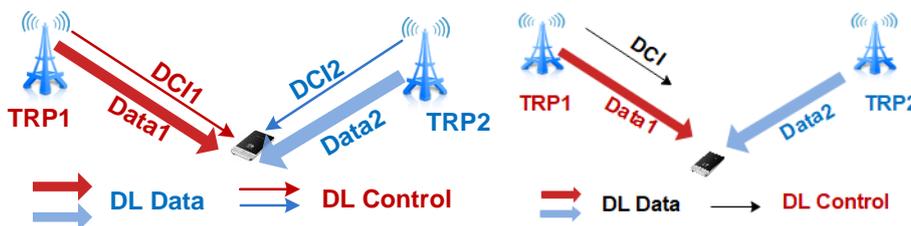


Figure 6 Two-TRP (DL) transmission/reception

To improve DL data rate, both single-DCI and multi-DCI based non-coherent joint transmission (NCJT) are supported.

- For multi-DCI-based NCJT transmission, up to 4 transmission layers per PDSCH, a UE may expect to receive two PDCCHs scheduling two fully/partially/non-overlapped PDSCHs respectively in time and frequency domain with same/different PDSCH scrambling ID(s). When the UE is scheduled with fully or partially overlapping PDSCHs, the UE is not expected to assume DM-RS ports in a CDM group indicated by two TCI states. Some configurations related to two received PDSCHs, e.g. active BWP, etc are expected to be same from UE perspective. The UE can be expected to rate match around configured CRS patterns which are associated with the value of CORESETPoolIndex, i.e. per TRP basis, and applied to the corresponding PDSCH. For PDCCH monitoring, two TRPs are implicitly associated with two CORESET groups, i.e. up to 3 CORESETs per TRP, respectively each of which can be identified by the value of CORESETPoolIndex. The maximum number of BD/CCE in a serving cell can be doubled for two TRPs but the maximum number of BD/CCE per TRP remains to be same as Rel.15. Scheduling timeline can be relaxed to support out-of-ordered PDCCH to PDSCH, PDSCH to HARQ-ACK, and PDCCH to PUSCH depending on UE capability considering different backhaul conditions between two TRPs. Both intra-slot separated HARQ-ACK (per TRP basis) and joint HARQ-ACK feedback (across two TRPs) are supported and specified for type-1 and type-2 HARQ-ACK codebook in order to facilitate different backhaul conditions. Last but not least, the maximum number of active TCI states in a serving cell can be doubled by independent activation from two TRPs but the maximum number of active TCI states per TRP remains the same as Rel.15.

- For single-DCI-based NCJT transmission, up to 8 transmission layers, each TCI code point can correspond to one or two TCI states (so as to 2-port PTRS if applicable) activated by MAC-CE. When 2 TCI states are indicated by DCI, the first TCI state corresponds to the CDM group of the first antenna port indicated by the antenna port indication table (e.g. the first TRP), and the second TCI state corresponds to the other CDM group (e.g. the second TRP). Additional new DMRS entry {0,2,3} with two CDM groups without data is supported to improve the flexibility of NCJT scheduling.

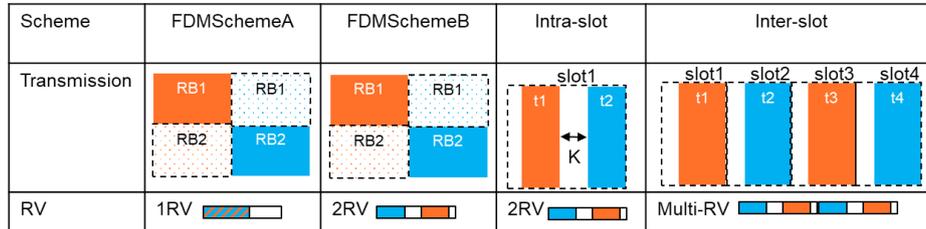


Figure 7 Single-DCI-based NCJT

To improve DL transmission reliability with multi-TRP/panel, following transmission schemes are supported with single DCI and configured by higher layer signalling:

- 'FDMSchemeA': When two TCI states, i.e. two TRPs, are indicated in a DCI and the UE is set to 'FDMSchemeA', the UE shall receive single PDSCH transmission occasion of the TB with each TCI state associated to a non-overlapping frequency domain resource allocation in a manner of comb-like PRGs allocation (or half/half for wideband).
- 'FDMSchemeB': When two TCI states, i.e. two TRPs, are indicated in a DCI and the UE is set to 'FDMSchemeB', the UE shall receive two PDSCH transmission occasions of the same TB with each TCI state associated to non-overlapping frequency domain resource allocation in a manner of comb-like PRGs allocation (or half/half for wideband).
- 'TDMSchemeA' (Intra-slot): When two TCI states are indicated in a DCI and the UE is set to 'TDMSchemeA', the UE shall receive two PDSCH transmission occasions of the same TB with each TCI state associated to a PDSCH transmission occasion which has non-overlapping time domain resource allocation with respect to the other PDSCH transmission occasion. Both PDSCH transmission (corresponding to two TRPs respectively) occasions with mapping Type B only shall be received within a given slot with a symbol-level gap configured by StartingSymbolOffsetK.
- "repetitionNumber-r16" (Inter-slot): When a UE is configured by the higher layer parameter repetitionNumber-r16 in PDSCH-TimeDomainResourceAllocation-r16, the UE may expect to be indicated with one or two TCI states in a codepoint of the TCI field. When two TCI states are indicated in a DCI, the UE may expect to receive multiple slot level PDSCH transmission occasions of the same TB with two TCI states associated to repetitionNumber-r16 consecutive slots (up to 16). Each PDSCH transmission occasion is expected to have the same SLIV. The UE may be configured with either cyclicMapping or sequentialMapping for given TCI state mapping pattern.

Each PDSCH transmission occasion is limited to up to two transmission layers for above transmission schemes targeting at reliability improvement and indicated DMRS port(s) are expected to within one CDM group. The redundancy version for PDSCH transmission occasions associated with the second TCI state is shifted with respect to the value of  $rv_s$  by sequenceOffsetforRV-r16 if applicable.

Additionally, default beam assumptions for FR2 are specified for receiving PDSCH, CSI-RS and PDCCH/PDSCH overlapping in case of single-DCI and multi-DCI based multi-TRP/panel transmission.

### 19.1.18.3 Multi-beam operation

For the purpose of BM signaling overhead/latency reduction, the following features were introduced:

- Default spatial relation/pathloss reference RS
  - Default spatial relation/pathloss reference RS for dedicated PUCCH
  - Default spatial relation/pathloss reference RS for PUSCH
  - Default spatial relation/pathloss reference RS for SRS
- Simultaneous TCI/spatial relation update across multiple CCs
  - Simultaneous TCI state ID activation for CORESET
  - Simultaneous TCI state ID(s) activation for PDSCH
  - Simultaneous spatial relation activation for aperiodic/semi-persistent SRS
- PUCCH spatial relation activation/deactivation per PUCCH resource group

- MAC CE based spatial relation indication for aperiodic/semi-persistent SRS
- MAC CE based pathloss reference RS update for aperiodic/semi-persistent SRS and PUSCH

First, the feature of default spatial relation/pathloss reference RS was introduced to reduce/omit UL specific beam/pathloss reference RS indication signaling, mainly targeting single beam UE that meets DL/UL beam correspondence requirement. In this mode of operation, spatial relation RS, i.e. UL beam RS, and pathloss reference RS does not need to be signalled to UE, and UE shall use a specific DL beam RS, e.g. the DL beam RS for the lowest ID CORESET, as for the spatial relation RS and the pathloss reference RS. Above operation can be enabled for dedicated PUCCH, SRS, and/or PUSCH scheduled by DCI format 0\_0 by respective RRC enablers.

Second, simultaneous update of DL/UL beam RS across multiple CCs was introduced. Up to two CC lists can be configured by RRC for DL and UL, respectively. Once a DL beam RS ID is activated for a CORESET in a CC by MAC CE, the RS(s) with the same RS ID are activated in other CC(s) in the same CC list. Once one or more DL beam RS ID(s) are activated for PDSCH in a CC by MAC CE, the RS(s) with the same RS ID(s) are activated in other CC(s) in the same CC list. Once a spatial relation RS is activated for an aperiodic or semi-persistent SRS resource in a CC by MAC CE, the same RS is activated as spatial relation RS for the SRS resource(s) with the same resource ID in other CC(s) in the same CC list.

Third, in Rel.15, PUCCH spatial relation can be activated/deactivated per resource level, meaning that 128 MAC CEs may need to be signalled to UE for updating spatial relation for all PUCCH resources in the worst case. Based on above motivation, resource grouping based PUCCH spatial relation activation/deactivation was introduced. Up to four PUCCH resource groups can be configured by RRC per BWP, and one MAC CE can activate/deactivate a common spatial relation RS for all the PUCCH resources in the same group.

Fourth, in Rel.15, spatial relation for aperiodic SRS is configured by RRC only, which may lead to unnecessary RRC overhead for configuring a sufficient number of SRS resources or large latency for RRC reconfiguration. Based on above motivation, MAC CE based spatial relation indication for aperiodic/semi-persistent SRS was introduced. One MAC CE can update spatial relation(s) of one SRS resource set, where different spatial relation can be indicated per resource within the resource set.

Fifth, in Rel.15, pathloss reference RSs for UL power control for PUSCH and SRS can only be configured by RRC. Since up to four pathloss RSs can be configured in Rel.15, it could often require RRC reconfiguration according to UE mobility and considering gNB/UE beamforming. Based on above motivation, MAC CE based pathloss reference RS update for aperiodic/semi-persistent SRS and PUSCH was introduced. For this operation, the maximum configurable number of pathloss reference RSs by RRC was increased to 64, and the new MAC CE can activate up to four pathloss reference RSs among them. Two MAC CEs were introduced for SRS and PUSCH, respectively.

To facilitate interference-aware beam selection, L1-SINR-based beam measurement and reporting were introduced. The gNB can configure UE to measure and report L1-SINR based on SSB/CSI-RS. The following resource settings for L1-SINR measurement have been supported:

- L1-SINR measurement based on CSI-RS configured for beam management (BM) as channel measurement resource (CMR) and interference measurement resource (IMR)
- L1-SINR measurement based on SSB as CMR and CSI-IM
- L1-SINR measurement based on CSI-RS configured for BM as CMR and CSI-IM
- L1-SINR measurement based on SSB as CMR and non-zero-power (NZIP) interference measurement resource (IMR)
- L1-SINR measurement based on CSI-RS configured for BM as CMR and NZP-IMR

In addition, to improve performance and reliability for SCell, BFR for SCell was introduced. The procedure for SCell BFR is illustrated in Figure 8 below.

- The beam failure detection (BFD) is based on periodic 1-port CSI-RS for BM, and the procedure is the same as spCell BFD.
- The candidate beam detection (CBD) is based on SSB and CSI-RS for BM, and the procedure is similar to spCell BFD, where cross-CC CBD is supported.
- The BFRQ report can include two steps
  - Step 1: UE sends a SR over PUCCH for BFR (which is dedicatedly configured) to indicate beam failure and request resource for BFR MAC CE report
    - If the SR is not configured, contention based PRACH can be used
    - gNB's response is the same as normal SR procedure
  - Step 2: UE sends a BFR MAC CE to gNB, which conveys the following information
    - Failed CC index
    - Whether a new beam is identified or not
    - RS resource ID representing identified new beam
- After receiving the BFR MAC CE, gNB can send a PDCCH to schedule a new transmission for the same HARQ process used to transmit BFR MAC CE
  - After 28 symbols after UE receives the response, UE can apply the newly identified beam to all CORESETs and PUCCH resources in the CC reported by BFR MAC CE

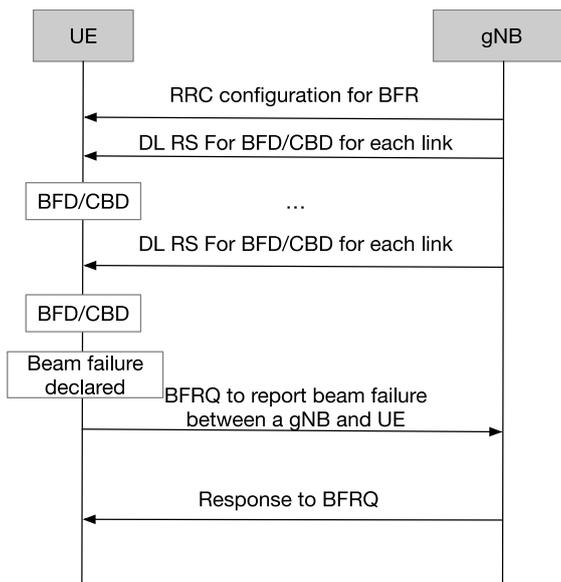


Figure 8 SCell BFR procedure

19.1.18.4 Low PAPR RS

It was identified that Rel.15 DM-RS for the PDSCH/PUSCH using non-transform precoded (CP-) OFDM waveform has a high PAPR issue, for transmissions of rank-2 and above. The issue occurs when DM-RS ports from different DM-RS CDM groups are linearly combined through the same power amplifier. The root cause of the issue was identified to be the use of the same DMRS sequence for all DMRS ports. In addition, for transform precoded OFDM, it was identified that when pi/2-BPSK modulation is used, then the PAPR of the PUSCH or PUCCH is lower than for the associated DM-RS which is a problem as different OFDM symbols will have different PAPR.

In Rel.16, the above issues were resolved as follows:

- For CP-OFDM PDSCH and PUSCH by letting the DM-RS sequence,  $r(m)$ , depend on the antenna port association to the CDM group index  $\lambda$ . This ensured that antenna ports in different CDM groups have different DM-RS sequences and this effectively removes the PAPR issue.
- For transform precoded PUSCH or PUCCH format 3 and 4, in all cases with pi/2-BPSK modulation, the Rel-16 low PAPR DM-RS sequences are introduced by applying a DFT-spread before being mapped to the time-frequency resource grid. In this case, pseudo-random (PRBS) or computer generated based pi/2-BPSK or 8-PSK sequences are used instead of the Rel.15 direct use of (i.e. non-DFT precoded) Zadoff-Chu sequences (see Figure 9). This means that Rel.16 DMRS will have similar sequence characteristics as the associated pi/2-BPSK modulated data/control and by then have similar PAPR, which resolves the high PAPR issue.

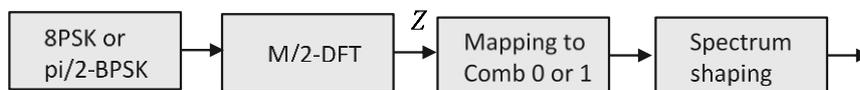


Figure 9 pi/2-BPSK/8-PSK low PAPR DM-RS formation

- Four related UE capabilities were introduced:
  - FG 16-4 Low PAPR DMRS for PDSCH
  - FG 16-6a Low PAPR DMRS for PUSCH without transform precoding
  - FG 16-6b Low PAPR DMRS for PUCCH format 3 and 4 with transform precoding and with pi/2 BPSK
  - FG 16-6c Low PAPR DMRS for PUSCH with transform precoding and with pi/2 BPSK

2.5 Uplink (UL) full-power transmission

Three modes of operation are specified in Rel.16 as optional UE capabilities: fullpower, fullpowerMode1, fullpowerMode2. The UE can report one of the supported modes.

- fullpower: This mode targets the UEs with full-rated PAs. Using a 2-Tx PC3 non-coherent UE as an example, the UE is equipped with two 23dBm PAs. As shown in Figure 10, the UE transmits UL PUSCH using 1 antenna

when the indicated TPMI is  $\{1\ 0\}$  with Rel.16 power scaling factor  $s=1$ . This implies that the transmit power is equally split among non-zero PUSCH antenna(s) thereby enabling the UE to deliver maximum output power.

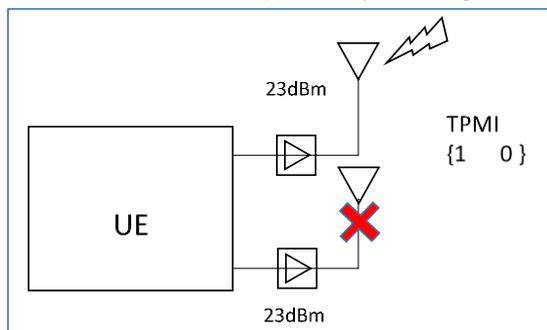


Figure 10 'fullpower' operation

- fullpowerMode1: A new TPMI subset is added. For a UE supporting non-coherent capability, a non-antenna selection TPMI is added with the same power scaling as in Rel.15. Figure 11 shows an example of a 2-Tx PC3 UE where each PA cannot deliver maximum output power. A new codebook subset for rank=1 includes  $\{1\ 0\}$ ,  $\{0\ 1\}$ ,  $\{1\ 1\}$ . With precoder  $\{1\ 1\}$ , the PC3 UE can transmit with total maximum output power of 23dBm on PUSCH. However, similar to Rel.15, precoders  $\{1\ 0\}$  and  $\{0\ 1\}$  do not deliver maximum output power.

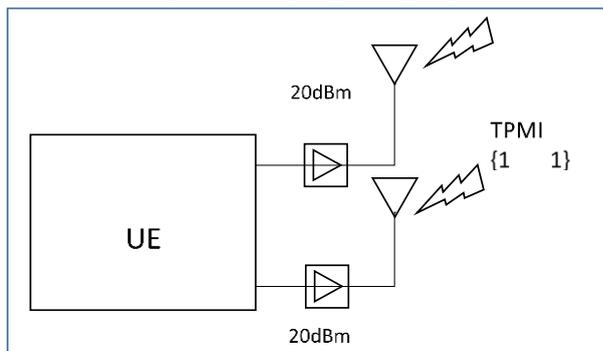


Figure 11 'fullpowerMode1' operation

- fullpowerMode2: To deliver maximum output power through TPMI reporting and antenna virtualization:
  - With multiple SRS resources configured in a set with different number of SRS ports (up to 4 SRS resources can be configured in a set): Using a 2 Tx non-coherent UE as an example, the gNB configures 2 SRS resources in a set where one SRS resource is configured with 1 port and another SRS resource is configured with 2 ports. The gNB indicates SRI corresponding to 1-port SRS while scheduling single layer transmission, and SRI corresponding to 2-port SRS while scheduling two-layer transmission.
  - 2) UE indicating full power TPMI/TPMI groups: Using as an example a 2-Tx non-coherent PC3 UE with PA architecture shown in Figure 12 where one PA is 23dBm and another 20dBm. The UE indicates TPMI=0 (i.e. precoder  $\{1\ 0\}$ ) as full-power TPMI. When the gNB indicates full-power TPMI while scheduling PUSCH, the UE assumes power scaling factor  $s=1$ ; when the gNB indicates non-full-power TPMI while scheduling PUSCH, the UE assumes Rel.15 power scaling mechanism. For 2Tx UE, UE can report 2 bits, bit-map on  $\{TPMI=0, TPMI=1\}$ . For a 4-Tx UE, to support non-coherent and partial-coherent implementations, seven TPMI groups  $\{G0, G1, G2, G3, G4, G5, G6\}$  are specified. A 4-Tx non-coherent UE can report capability to indicate 2-port TPMIs using 2-bit bitmap and one of 4-port non-coherent TPMI groups from  $G0\sim G3$ . A 4-Tx partial coherent UE can report capability to indicate 2-port TPMIs using 2-bit bitmap, one of 4-port non-coherent TPMI groups from  $G0\sim G3$ , and one of 4-port partial-coherent TPMI groups from  $G0\sim G6$ . The TPMI groups  $G0\sim G6$  are defined in TS 38.306.

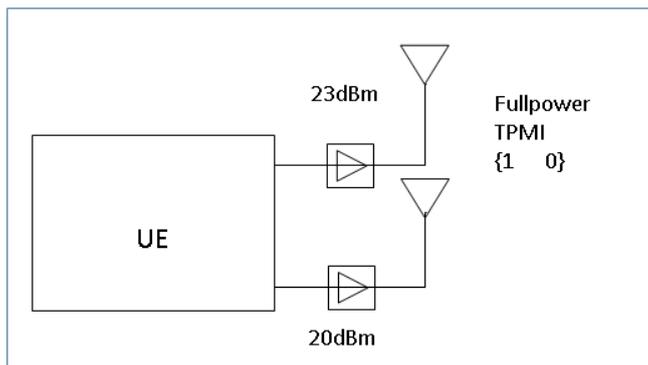


Figure 12 ‘fullpowerMode2’ operation

References

List of related CRs: select "TSG Status = Approved" in: <https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800085,800185,800285,880070>

- [1] R1-1913604, Samsung, RAN1 agreements for NR\_eMIMO

## 19.2 Release 16 Features impacting both LTE and NR

### 19.2.1 Transfer of luan interface specifications from 25-series to 37-series

820071	<a href="#">Transfer of luan interface specifications from 25-series to 37-series</a>	luan_transfer	R3	RP-190160	Huawei
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Summary based on the input provided by Huawei in RP-190144.

This feature transfers the contents of TSs 25.46x into TSs 37.46x (x=0, 1, 2, 6) for releases 8/9/10/11/12/13/14/15, considering the fact these specifications apply to different RAT i.e. UTRA, E-UTRA and NR.

Indeed, 25 series of specifications are dedicated to UMTS only, when the material which was previous there referred to multiple RATs, i.e. UTRA, E-UTRA and NR.

Rel-6/7: UMTS only (no changes needed, also no changes possible as these releases are no longer maintained)

Rel-8/9/10/11/12/13/14: UMTS and E-UTRA/LTE

Rel-15: UMTS, E-UTRA/LTE and NR

Note: The TSs 25.46x are turned into empty specifications referring to the new created TSs 37.46x.

The TSs 25.46x are not withdrawn so references to these specs will lead to the correct specs.

Additional remarks:

1. This transfer of data over 8 releases is an exceptional case: Instead of creating Rel-8 specs and step-by-step upgrade to higher releases via CRs (which would be the normal approach), it was decided with the specs manager to bring v1.N.0 of TS 37.46x for 1-step approval to RAN #83 and instead of approving them to vN.0.0 it was decided to approve them the same version as the last 25.46x version that is created via the CRs.
2. The text shown in TS 37.46x is taken 1:1 from the corresponding TS 25.46x showing changes of the contents via revision marks (note: spec cover and history adaptations are done without revision marks). The changes are mainly to indicate the considered RATs in the scope, to replace 25.46x references by 37.46x references and to correct obvious problems. Further technical changes of the contents of the specifications may rather be considered in a future cat.F CR (and probably just focusing on the latest releases).
3. There is also a TS 25.463 which exists for Rel-6 and Rel-7 only. TS 25.466 replaced TS 25.463 in Rel-7 and future releases. This means for Rel-6 TS 25.463 is still valid and cannot be withdrawn. Rel-7 is no longer maintained i.e. no CRs are possible i.e. 3GPP internal references to TS 25.463 could not be corrected anymore, so also 25.463 Rel-7 will not be withdrawn but it will be clarified on the 3GPP webpage that for Rel-7 TS 25.466 should be considered instead of TS 25.463.

4. References of Rel-16 and higher should refer to TS 37.46x instead of TS 25.46x. Changes of existing references of Rel-8 to Rel-15 specifications of TS 25.46x may be corrected to references to TS 37.46x but such a change is not mandatory as 25.46x Rel-8 to Rel-15 will remain. A further upgrade of 25.46x Iuant specs to Rel-16 and higher will not be considered. Rel-16 and higher specifications shall refer to TS 37.46x.

Following this transfer, RAN3 agreed to transfer the ownership of the clauses currently owned by RAN4 in TS 37.461 back to RAN3. RAN3 informed RAN4 by LS (R3-191145).

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820071>

- [1] R3-190104 Presentation of Specifications to TSG: TS 37.460 v1.N.0, TS 37.461 v1.N.0, TS 37.462 v1.N.0, TS 37.466 v1.N.0 (N=8/9/a/b/c/d/e/f) ETSI MCC, Huawei, Ericsson

## 19.2.2 Introduction of GSM, UTRA, E-UTRA and NR capability set(s) (CS(s)) to the multi-standard radio (MSR) specifications

830086	<a href="#">Introduction of GSM, UTRA, E-UTRA and NR capability set(s) (CS(s)) to the multi-standard radio (MSR) specifications</a>	MSR_GSM_UTRA_LTE_NR	R4	RP-190642	Ericsson
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Summary based on the input provided by Ericsson in RP-191816.

The WI added support for MSR BS including GSM, UTRA, E-UTRA and NR combinations by means of creating two new CS, CS 18 (GSM+E-UTRA+NR) and CS19 (UTRA+E-UTRA+NR).

The WI created two new capability sets, CS 18 (GSM+E-UTRA+NR) and CS19 (UTRA+E-UTRA+NR). A BS with multiple connectors can support all 4 RATs by transmitting CS18 on at least one connector and CS19 on at least one connector. To add these CS, the following was needed:

- Updating of the MSR core specification to include correct OBUE emissions tables for GSM/UTRA when operating together with MSR as well as some fixes to the blocking and RX IM requirements.
- Introduction in the conformance specification of:
  - The new capability sets
  - Test configurations relating to the new capability sets
  - Test applicability rules relating to the new capability sets and test configurations
  - Updated test requirements corresponding to the core requirement updates.

All of the new functionality was introduced in the two approved CRs in [1] and [2].

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830086,830186,830286>

- [1] R4-1908049 Introduction of requirements for NR + UTRA/GSM combinations, Ericsson, Nokia, Nokia Shanghai Bell, Vodafone, ZTE
- [2] R4-1910476 Introduction of requirements for NR + UTRA/GSM combinations, Ericsson, Nokia, Nokia Shanghai Bell, Vodafone, Huawei

## 19.2.3 Direct data forwarding between NG-RAN and E-UTRAN nodes for inter-system mobility

820072	<a href="#">Direct data forwarding between NG-RAN and E-UTRAN nodes for inter-system mobility</a>	Direct_data_fw_NR	R3	RP-182886	Ericsson
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Summary based on the input provided by Ericsson in RP-192162.

This WI specified direct data forwarding per bearer during inter-system mobility between NG-RAN and E-UTRAN nodes in addition to the solution for indirect data forwarding specified in Rel-15 during the NR WI.

This WI continued discussions on direct data forwarding between NG-RAN and E-UTRAN nodes during the Rel-15 discussions on the NR WI. Direct data forwarding encompasses the following two main features:

- While data forwarding between NG-RAN and E-UTRAN nodes in Rel-15 foresees establishing the data forwarding path via the EPC and the 5GC, direct data forwarding allows establishing the data forwarding path directly between the involved RAN nodes, without the need to interact with user plane functions of the EPC and the 5GC.
- Indirect data forwarding for inter-system handover in Rel-15 foresees transporting to be forwarded user plane data between the NG-RAN node and the UPF via PDU Session tunnels. As forwarding paths on the E-UTRAN side are established on a per-E-RAB basis, the Rel-15 solution requires interworking functions at the UPF and the NG-RAN node in order to map per-DRB / per-E-RAB packets to the per-PDU Session tunnel and vice versa. Such interworking is not necessary in case of direct data forwarding.

In the course of the WI RAN3 realised that direct data forwarding tunnel related information may be communicated between the NG-RAN node and the 5GC in a way that the inter-system handover signalling performance benefits from such approach, which was realised in the agreed CRs in [3] and [4].

Further, SA2 and CT4 where contacted to perform necessary work in their areas of responsibility [5].

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820072>

- [1] RP-182886 "New WID: Direct data forwarding for inter-system mobility", approved at RAN#82
- [2] RP-191369 "Status report of WI: Core part: Direct data forwarding between NG-RAN and E-UTRAN nodes for inter-system mobility"
- [3] R3-192626 "Support of Direct Data forwarding for handover between 4G and 5G", agreed CR0041r4 38.413
- [4] R3-193272 "Introduction of direct and indirect data forwarding for inter-system HO between EPS and 5GS", endorsed CR 38.300
- [5] R3-193284 "LS on Finalization of Direct Data Forwarding feature", agreed LS out to SA2 and CT4

## 19.2.4 eNB(s) Architecture Evolution for E-UTRAN and NG-RAN

Unique ID	Name	Acronym	WG	WID	WI Rapporteur
790054	<a href="#">eNB(s) Architecture Evolution for E-UTRAN and NG-RAN</a>	LTE_NR_arch_evo	R3	RP-180531	China Unicom

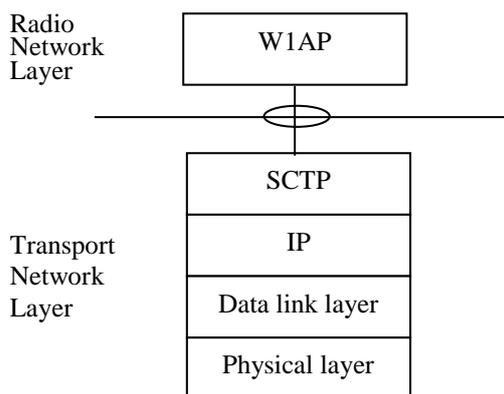
Summary based on the input provided by China Unicom in RP-192964.

In Rel-15, the F1 interface was standardized in the gNB (LTE) to support gNB-CU and gNB-DU split, i.e. to split the Control Unit from the Data Unit (supporting the user data).

Similarly, in Rel-16, the W1 interface is standardized in the ng-eNB (5G) to support ng-eNB-CU and ng-eNB-DU split. These two interfaces adopt the same higher layer split architecture for between PDCP and RLC, with similar functionalities, such as control plan functionalities.

The ng-eNB-CU and gNB-CU could be physically collocated, deployed in a same physical "box". This unification of the , as to unify the ng-eNB and gNB architectures would simplify the network deployment complexity and facilitate hardware upgrades.

The W1 interface specifications includes the general aspects and principles (TS 37.470), W1 layer 1 (TS 37.471), signalling transport (TS 37.472) and W1AP aspects (TS 37.473). The general aspects and principles and W1 layer1 are aligned with F1 interface. For signalling transport, the W1-C signalling bearer aligned with F1 interface, function and protocol stack in figure 1 are defined.



**Figure 1: W1-C signalling bearer protocol stack**

The functionalities of W1 interface are supported over W1-C and W1-U (in a similar way as for the F1 interface). The W1-C functionalities are the following:

- 1 **Interface management:** W1 setup, eNB-CU/eNB-DU configuration update, error indication function, reset function coordination function.
- 2 **system information management:** system information is critical for high layer split architecture, eNB-DU is responsible for transmitting MIB, SIB1, SIB2, SIB3, SIB8 and SIB 16. Other system information is responsible by ng-eNB-DU.
- 3 **Paging function:** The eNB-DU is responsible for transmitting the paging information. While, the eNB-CU provides paging information to enable the eNB-DU to calculate the exact PO and PF.
- 4 **UE context management function:** The W1 UE context management function supports the establishment and modification of the necessary overall UE context.
- 5 **RRC message transfer function:** RRC message transfer function supports the establishment and modification of the necessary overall UE context. This function allows to transfer RRC messages between eNB-CU and eNB-DU.
- 6 **Warning message information transfer function:** This function allows to cooperate with the warning message transmission procedures over NG interface.

The W1-U functionalities are specified as below:

- 1 **Transfer of user data:** The functionalities are used to transfer of user data between ng-eNB-CU and ng-eNB-DU.
- 2 **flow control function:** It is designed for control the downlink user data flow to the ng-eNB-DU.

More detail procedures and IEs for W1 can be founded in TS 37.473 on W1AP specification.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=790054>

- |      |  |
|------|--|
| [1]  | The WID  |
| [2]  | RP-191972 Status report for WI Core part: eNB(s) Architecture Evolution for E-UTRAN and NG-RAN WI (China Unicom) |
| [3]  | R3-187270 pCR to 37.470 on W1AP functions and procedures (Huawei, China Unicom, TIM)                             |
| [4]  | R3-191163 pCR to 37.470 on W1AP functions and procedures (Huawei, TIM, China Unicom)                             |
| [5]  | R3-193174 pCR to 37.470 on W1AP functions and procedures (Huawei, China Unicom, Orange, TIM)                     |
| [6]  | R3-194676 pCR to 37.470 on W1 general aspects and principles (China Unicom)                                      |
| [7]  | R3-194678 pCR to 37.472 on W1 signalling transport (China Unicom)  |
| [8]  | R3-194425 pCR to 37.470 on W1AP functions (Huawei, China Unicom, TIM)  |
| [9]  | R3-194426 pCR for 37.473 on UE context management procedures (Huawei, China Unicom, TIM)                         |
| [10] | R3-194427 pCR for 37.473 on Interface Management procedures (Huawei, China Unicom, TIM)                          |
| [11] | R3-194565 Structure pCR for TS 37.473 (Huawei, China Unicom, TIM)  |
| [12] | R3-194562 pCR to 37.470 on W1AP functions (Huawei, China Unicom, TIM, Orange)                                    |
| [13] | R3-194563 pCR for 37.473 on UE context management procedures (Huawei, China Unicom, TIM, Orange)                 |

- [14] R3-194564 pCR for 37.473 on Interface Management procedures (Huawei, China Unicom, TIM, Orange)
- [15] R3-197544 pCR to 37.473 on ASN.1 completion (Huawei, China Unicom, TIM)
- [16] R3-197636 pCR to 37.473 on miscellaneous correction to contexts (Huawei, China Unicom, Orange, TIM)
- [17] R3-197544 CR to 38.401 on corrections to ng-eNB deployment (Huawei, China Unicom, Orange, TIM)

## 19.2.5 High power UE (power class 2) for EN-DC (1 LTE TDD band + 1 NR TDD band)

820079	High power UE (power class 2) for EN-DC (1 LTE TDD band + 1 NR TDD band)	ENDC_UE_PC2_TDD_TDD	R4	RP-190315	CMCC
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Summary based on the input provided by CMCC in RP-200214.

This WI contains a general part and band specific combination part for high power UE (power class 2) for EN-DC (1 LTE TDD band + 1 NR TDD band). The purpose is to introduce high power UE (power class2) for EN-DC (1 LTE TDD band +1 NR TDD band). The actual requirements are added to the corresponding technical specifications.

The purpose of this WI on High power UE (power class 2) for EN-DC (1 LTE TDD band + 1 NR TDD band) is to improve the UP coverage of 5G UE. In order to reduce the big imbalance between 5G NR uplink and downlink coverage, we can improve uplink coverage by defining high power UE for SA and NSA, and it is a feasible way to improve the uplink coverage. This PC2 EN-DC (TDD+TDD) feature will meet the operator's deployment request for uplink coverage enhancement.

In this work item, we focus on the PC2 EN-DC RF requirements including UE maximum output power, Tx power tolerance, MPR, A-MPR, configured output power, ACLR, SAR and n41-B40 UE-UE co-existence for Power Class 2 EN-DC.

There are two important issues that have been addressed in this topic, and in the end we have resolved them through appropriate solutions

For SAR issue, RAN4 specified UE Tx duty cycle requirements sufficient to prevent exceeding local regulatory limits such as SAR for inter-band PC2 EN-DC UE.

For PC2 EN-DC (TDD+TDD) release independent issue, RAN4 reached a conclusion that PC2 inter-band EN-DC (LTE TDD PC3 + NR TDD PC3) can be supported from Rel-15 in release independence manner.

This WI was completed in the RAN#86 meeting and the complete version of NR Technical Report 37.825 has been approved.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820079>

- [1]R4-1913208 TR 37.825 v0.4.0 Finalization, CMCC, RAN4#93
- [2]R4-1915992 CR for adding solutions for addressing SAR issue for EN-DC PC2 UE, CATT, CMCC, RAN4#93
- [3]R4-1913209 CR for REL-16 TS 38.307 for PC2 EN-DC TDD+TDD, CMCC, RAN4#93
- [4]R4-1913210 CR for REL-15 TS 38.307 for PC2 EN-DC TDD+TDD, CMCC, RAN4#93
- [5]RP-192583Presentation of TR 37.825 V1.0.0, CMCC, RAN#86

## 19.2.6 LTE-NR & NR-NR Dual Connectivity and NR Carrier Aggregation enhancements

800088	LTE-NR & NR-NR Dual Connectivity and NR Carrier Aggregation enhancements	LTE_NR_DC_CA_enh	R2	RP-191600	Ericsson
800188	Core part: LTE-NR & NR-NR Dual Connectivity and NR CA enhancements	LTE_NR_DC_CA_enh-Core	R2	RP-190452	Ericsson
800288	Perf. part: LTE-NR & NR-NR Dual Connectivity and NR CA enhancements	LTE_NR_DC_CA_enh-Perf	R4	RP-190452	Ericsson

Summary based on the input provided by Ericsson in RP-202039.

The LTE and NR Work Item [1] introduces enhancements to Multi-RAT Dual Connectivity (MR-DC) and Carrier Aggregation (CA) operation, mainly focusing on reducing setup delays and improving robustness and deployment

flexibility. This is addressed by introducing idle/inactive measurements for DC/CA, allowing SCG/SCell configuration during transition from idle/inactive state, introducing dormant SCell in NR, introducing fast recovery from MCG link failure, introducing support for asynchronous NR-DC operation and cross carrier scheduling with different numerologies. Changes triggered by the work item are captured into TS 36-, 37- and 38-series specifications.

The key functionalities introduced in this work item include the following:

- Support for asynchronous NR-DC: Allowing non-co-located deployments by relaxing synchronization requirements for gNBs involved in NR-DC operation. Both semi-static and dynamic uplink power control is supported for deployments with bands of the same frequency range in MCG and SCG.
- Idle/inactive measurement reporting: Allowing the eNB to assign UE to do measurements during IDLE or INACTIVE that the network can use for when the UE enters CONNECTED mode.
  - This may include limitations on which cells are measured, how long the measurements are done and in which cells the measurements are applicable.
  - UE can indicate the availability of the measurements at connection setup or resume, and network can decide whether to query them via RRC reporting.
- Direct SCG/SCell configuration: Allowing the network to configure the UE to store the SCG/SCell configuration upon transition to INACTIVE state, so that it can be quickly restored upon transition back to CONNECTED, thus minimizing signaling overhead and latency.
- NR SCell Dormancy: SCell dormancy is introduced for NR. The UE does not monitor PDCCH on the dormant BWP for an SCell, but continues performing RRM/CSI measurements, AGC and beam management, if configured.
  - Switching between dormant and normal operation is network controlled and reuses the existing Bandwidth Part (BWP) framework of NR. One dormant BWP can be configured for an SCell. DCI is used to control entering/leaving the dormant BWP.
  - The SpCell and PUCCH SCell cannot be configured with a dormant BWP.
- Fast MCG link recovery: Support fast recovery from MCG link failure by allowing the UE in MR-DC to send an MCG Failure Information message to the MN via the SCG upon the detection of a radio link failure on the MCG. Based on measurement information received in MCG Failure Information message the network can then determine the correct action to restore the MCG connection, e.g. change of PCell.
  - Fast MCG link recovery requires that both UE and network support the feature, and that the UE is configured with either split SRB or SCG SRB.
  - The UE initiates the RRC connection re-establishment procedure if it does not receive a reconfiguration message from the network within a certain time after fast MCG link recovery was initiated.
- Cross-carrier scheduling with different numerologies: Support for cross carrier scheduling in carrier aggregation, with different numerology on the scheduling and scheduled carriers.
- CA with unaligned frame boundary: Support for NR inter-band carrier aggregation with slot alignment, but with unaligned frame boundary and partial SFN alignment.
- Enhancements to single Tx switched uplink for EN-DC: Various improvements introduced for using the reference TDD pattern, e.g. support is added for LTE TDD PCell and for dual-Tx UL. LTE PRACH operation is not restricted by the reference TDD pattern.
- Aperiodic CSI-RS triggering with different numerologies: Support for triggering Aperiodic CSI-RS with different numerology between CSI-RS and triggering PDCCH is introduced.
- Minimum requirements for NR-DC: RF requirements for both synchronous and asynchronous operations.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800088,800188,800288>

[1] RP-200791, Revised WID on DC and CA enhancements, Ericsson, RAN#88e

## 19.2.7 29 dBm UE Power Class for LTE band 41 and NR Band n41

800078	29 dBm UE Power Class for LTE band 41 and NR Band n41	LTE_NR_B41_Bn41_PC29dBm	R4	RP-201134	Sprint
800178	Core part: 29 dBm UE Power Class for LTE band 41 and NR Band n41	LTE_NR_B41_Bn41_PC29dBm-Core	R4	RP-201134	Sprint

Summary based on the input provided by T-Mobile USA in RP-201905.

This WI created the requirements for 29 dBm PC1.5 for intra-band EN-DC, NR UL MIMO and NR Tx Diversity including MPR and A-MPR and allows for 29 dBm UE transmit power for TDD bands, including:

- The introduction of 29 dBm power class 1.5 for intra-band EN-DC, NR UL MIMO and NR TxD
- MPR for PC1.5 intra-band EN-DC
- A-MPR for PC1.5 intra-band EN-DC for NS\_04 Band 41/n41
- MPR for PC1.5 UL MIMO and Tx Diversity
- A-MPR for PC 1.5 for UL MIMO and Tx Diversity for NS\_04 Band 41/n41
- Additional requirements including EVM, behavior related to PC2, P-Max and maxUplinkDutyCycle, ACLR
- Release independence to Rel-15 for PC1.5 intra-band EN-DC, NR UL MIMO and NR Tx Diversity

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800078,800178>

- [1] TR 38.817-01, "General aspects for User Equipment (UE) Radio Frequency (RF) for NR," 3GPP  
 [2] RP-201904, "Status report for 29 dBm UE Power Class for LTE band 41 and NR Band n41," T-Mobile USA (rapporteur)

## 19.2.8 LTE/NR Dynamic Spectrum Sharing (DSS) in band 48/n48 frequency range

860060	LTE/NR spectrum sharing in band 48/n48 frequency range	NR_n48_LTE_48_coex	R4	RP-201858	Apple
860160	Core part: LTE/NR spectrum sharing in band 48/n48 frequency range	NR_n48_LTE_48_coex	R4	RP-201858	Apple

Summary based on the input provided by Apple Inc. in RP-202581.

Dynamic spectrum sharing (DSS) is an important feature that allows for sharing existing spectrum between the LTE and NR carriers, thus enabling smoother transition from LTE and faster adoption of NR. After the RAN#86 meeting, a new WI was agreed [1] aiming to analyse and introduce, if needed, changes to support dynamic spectrum sharing in band 48/n48 frequency range, which is also known as the CBRS band.

The first version of the WI had the following objectives:

- Channel raster: Confirm that NR channel raster can be aligned with LTE centre frequencies [RAN4];
- UL shift: Specify UL 7.5kHz sub-carrier shift for 15kHz SCS. Investigate whether the 7.5kHz sub-carrier shift has any impact on the needed guard between LTE and 30kHz SCS NR. Specify the shift only if there is a clear benefit [RAN4];
- Sync raster: Check mechanisms to avoid overlapping transmissions between NR SSB and LTE CRS. Apply changes to ensure non overlap of NR SSB and LTE CRS if determined that solutions with existing specifications are insufficient [RAN4].

Referring to the sync raster discussion, no consensus was reached by the RAN4#96 meeting on whether e.g. the sync pattern B can be added into band n48 definition to mitigate the negative impact of colliding NR SSB and 4-port LTE CRS transmission. The majority of companies preferred not to introduce this change at least to band n48. And even though some companies could accept sync pattern related modifications if a new band is introduced, there were concerns on whether adding a new band is a right way forward. It was decided to remove this aspect from the scope of the WI.

For the UL 7.5kHz shift, it was concluded to introduce this functionality into band n48 following the CBRS Alliance agreement to add 15kHz SCS as one of the mandatory deployment options. Following the outcome of similar discussions for band n38 and n40, the UL shift is enabled only for 15kHz SCS and is not supported for 30kHz SCS.

As for the DL channel raster alignment, RAN4 conclusion was that it is possible to shift, if needed, the centre frequency by +/-100kHz to align LTE and NR sub-carriers when SAS allocates the channel which is not on the common 300kHz raster point. RAN4 also concluded that there is no specification impact for DL transmission, i.e. it is up to the base

station how to ensure emission requirements when the centre frequency is shifted by  $\pm 100$  kHz. For the UL transmission, RAN4 discussed how to ensure UE emission requirements and concluded that "for the dynamic spectrum sharing operation in band 48/n48 frequency range, what is supported in NR for both BS and UE can ensure UE emission requirements through appropriate configuration/scheduling".

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860060,860160>

- [1] RP-192427, "New WID: LTE/NR spectrum sharing in band 48/n48 frequency range", Apple Inc
- [2] RP-202580, "Status report for LTE/NR spectrum sharing in band 48/n48 frequency range", RAN WG4

## 19.3 LTE-related Release 16 Features

### 19.3.1 LTE-based 5G terrestrial broadcast

830076	LTE-based 5G terrestrial broadcast	LTE_terr_bcast	R1	RP-190732	Qualcomm
800091	Study on LTE-based 5G terrestrial broadcast	FS_LTE_terr_bcast	R1	RP-181342	Qualcomm
830176	Core part: LTE-based 5G terrestrial broadcast	LTE_terr_bcast-Core	R1	RP-190732	Qualcomm
830276	Perf. part: LTE-based 5G terrestrial broadcast	LTE_terr_bcast-Perf	R4	RP-190732	Qualcomm

Summary based on the input provided by Qualcomm Incorporated in RP-200850.

The work item on "LTE-based 5G terrestrial broadcast" [1] specified enhancements on top of Rel-14 MBMS [2] to meet the 5G requirements for broadcast systems [3]. These enhancements, obtained as a result of the study in [4], are summarized as follows:

- Introduction of a new numerology for PMCH with 100us cyclic prefix and 2.5kHz subcarrier spacing for support of high mobility scenarios (up to 250km/h).
- Introduction of a new numerology for PMCH with 300us cyclic prefix and approximately 0.37kHz subcarrier spacing for support of rooftop reception.
- Enhancements to PBCH and PDCCH to increase robustness in low SINR scenarios.

This work item also produced a TR [5] summarizing the overall aspects of LTE-based 5G terrestrial broadcast.

#### Numerology for high speed reception

A new numerology for PMCH with 100us cyclic prefix, 400us OFDM core symbol duration, and 2.5kHz subcarrier spacing is introduced to support high mobility scenarios (up to 250km/h). With this numerology, each OFDM symbol uses one slot (0.5ms), and a transport block is mapped to two OFDM symbols (1ms).

Associated to this new numerology, a single reference signal pattern (MBSFN-RS) is introduced with a time-stagger length of 2, and a frequency separation (after de-staggering) of 4 subcarriers, which gives a maximum theoretical equalization interval of 200us.

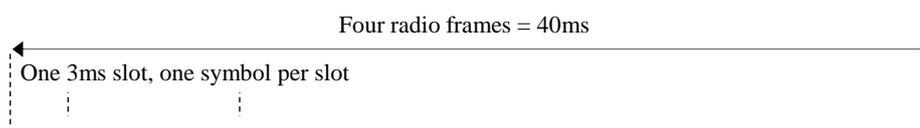
#### Numerology for rooftop reception

A new numerology for PMCH with 300us cyclic prefix, 2700us OFDM core symbol duration, and approximately 0.37kHz subcarrier spacing is introduced to support rooftop reception, especially tailored for deployments with large inter-site distance (e.g. HPHT-1 as defined in [4], with an inter-site distance of 125km).

With this new numerology, a new variation of frame structure type 1 is introduced. This frame structure consists of, every 40ms:

- One subframe (1ms) with 15kHz SCS, containing synchronization and system information, also named "cell acquisition subframe" (CAS)
- 13 slots (3ms each) carrying the PMCH with 0.37kHz SCS. Note that the time-transmission interval (TTI) for a transport block is extended to 3ms.

This frame structure is depicted in Figure 1



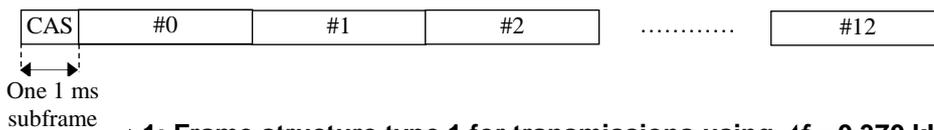


Figure 1: Frame structure type 1 for transmissions using  $\Delta f = 0.370$  kHz.

Two reference signal patterns are introduced associated with this new numerology, with a stagger length of 2 and 4 OFDM symbols. Both of them have a frequency separation (after de-staggering) of 3 subcarriers, which gives a maximum theoretical equalization interval of 900us.

Enhancements to cell acquisition subframes

As shown in [4], in some deployment scenarios the CAS will experience significantly lower SINR than PMCH due to the former being based on 15kHz subcarrier spacing. Several enhancements are introduced to enhance the performance of the CAS, and are detailed as follows:

- Semistatic CFI: A semistatic value for CFI (which determines the number of symbols to be used for PDCCH in a given subframe) is indicated in MIB. This allows the UE to skip PCFICH decoding, which can become the bottleneck in low SINR conditions.
- Aggregation level 16: Before Rel-16, the maximum aggregation level for PDCCH was 8. Rel-16 introduces aggregation level 16 (only for MBMS dedicated cells) to enhance performance in low SINR conditions.
- PBCH repetition: Similar to the scheme defined for eMTC (but with additional symbol-level rotation for interference randomization), PBCH is repeated in CAS.

**References**

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=830076,800091,830176,830276>

- [1] RP-193050: “Revised WID on LTE-based 5G terrestrial broadcast”, RAN#86
- [2] RP-160675, “New WID: eMBMS enhancements for LTE”
- [3] TR 38.913: "Study on scenarios and requirements for next generation access technologies"
- [4] TR 36.776: “Evolved Universal Terrestrial Radio Access (E-UTRA); Study on LTE-based 5G terrestrial broadcast”
- [5] TR 36.976: “Overall description of LTE-based 5G broadcast”

**19.3.2 Support for NavIC Navigation Satellite System for LTE**

850072	Support for NavIC Navigation Satellite System for LTE	LCS_NAVIC	R2	RP-192408	Reliance Jio
850172	Core part: Support for NavIC Navigation Satellite System for LTE	LCS_NAVIC-Core	R2	RP-192408	Reliance Jio
850272	Perf. part: Support for NavIC Navigation Satellite System for LTE	LCS_NAVIC-Perf	R4	RP-192408	Reliance Jio

Summary based on the input provided by Reliance Jio in RP-200604.

The LCS\_NAVIC feature introduces NavIC satellite system specific assistance data support used by the location server to enable UE-based and UE-assisted A-GNSS positioning methods in E-UTRAN. This is applicable to both Control plane and User plane positioning. Before this work item EUTRAN A-GNSS methods supported assistance data for only for GPS, Galileo, GLONASS, BDS, SBAS & QZSS constellations.

Introduction of NavIC satellite system assistance data speeds up positioning performance, improves receiver sensitivity and helps to conserve battery power.in UEs supporting NavIC RNSS for positioning.

The LCS\_NAVIC feature is applicable only to LTE UEs using L5 band GNSS reception for positioning and has been standardized starting from Rel-16.

3GPP TSG RAN has introduced A-GNSS support for BDS, Galileo, GLONASS, GPS, SBAS & QZSS to cellular positioning systems. The LCS\_NAVIC feature introduces NavIC constellation support under the existing framework of A-GNSS.

The key updates introduced under this feature are as follows:

- 1) The support for NavIC satellite system has been added to the A-GNSS specifications by assignment of new 'GNSS ID', 'GNSS Signal ID', and 'GNSS Time ID', together with ASN.1 extensions to existing assistance data elements.
- 2) NavIC specific New Clock Model, Orbit Model, Almanac Model, UTC model update, Differential corrections and Ionospheric Model have been added to existing assistance data elements.
- 3) The GNSS-GenericAssistData used by the location server to aid data for a specific GNSS has been updated by introducing NavIC satellite system specific Differential corrections & Grid model.
- 4) Positioning assistance data broadcast has been extended to include NavIC satellite system specific generic assistance data by introduction of two new Positioning System Information Block Type 2 as listed below:

	<i>posSibType</i>	<i>assistanceDataElement</i>
GNSS Generic Assistance Data	<i>posSibType2-24</i>	<i>NavIC-DifferentialCorrections</i>
	<i>posSibType2-25</i>	<i>NavIC-GridModelParameter</i>

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850072,850172,850272>

- [1] TS 37.355: LTE Positioning Protocol (LPP); Protocol specification  
 [2] RP-200439: SR LCS\_NAVIC, Reliance Jio

## 19.3.3 Even further mobility enhancement in E-UTRAN

800089	<a href="#">Even further mobility enhancement in E-UTRAN</a>	LTE_feMob	R2	RP-200148	China Telecom
800189	Core part: <a href="#">Even further mobility enhancement in E-UTRAN</a>	LTE_feMob-Core	R2	RP-200148	China Telecom
800289	Perf. part: <a href="#">Even further mobility enhancement in E-UTRAN</a>	LTE_feMob-Perf	R4	RP-200148	China Telecom

Summary based on the input provided by China Telecom in RP-200738.

The work item on Even further mobility enhancement in E-UTRAN [1] studies solutions to meet both the reliability and very low HO interruption time requirements in the Study Phase, and specifies the chosen solutions, i.e., Dual Active Protocol Stack (DAPS) handover to reduce interruption time during HO and Conditional Handover (CHO) to improve HO reliability and robustness in the Work Phase.

The corresponding changes are captured into TS 36-series specifications.

### Dual Active Protocol Stack (DAPS) handover

DAPS Handover is a handover procedure that maintains the source eNB connection after reception of RRC message for handover and until releasing the source cell after successful random access to the target eNB.

- If DAPS handover is configured, the UE continues the downlink user data reception from the source eNB until releasing the source cell and continues the uplink user data transmission to the source eNB until successful random access procedure to the target eNB.
- Upon reception of the handover command, the UE:
  - Creates a MAC entity for target cell;
  - Establishes the RLC entity and an associated DTCH logical channel for target cell for each DRB configured with DAPS;
  - For the DRB(s) configured with DAPS, reconfigures the PDCP entity to configure DAPS with separate security and ROHC functions for source and target and associates them with the RLC entities configured for source and target respectively;
  - Retains rest of the source link configurations until release of the source.
  - When DAPS handover fails, the UE falls back to source cell configuration, resumes the connection with source cell, and reports the DAPS handover failure via the source without triggering RRC connection re-establishment if the source link is still available; Otherwise, RRC re-establishment is performed;

### Conditional Handover (CHO)

A Conditional Handover (CHO) is defined as a handover that is executed by the UE when one or more handover execution conditions are met.

- UE maintains connection with source eNB after receiving CHO configuration, and starts evaluating the CHO execution condition(s) for the CHO candidate cell(s) and executes the HO command once the execution condition(s) are met for a CHO candidate cell.
- To improve the robustness, the network can provide the up to 8 candidate cell configuration(s) associated with execution condition (s) to UE. If at least one CHO candidate cell satisfies the corresponding CHO execution condition, the UE detaches from the source eNB, applies the stored corresponding configuration for that candidate cell and synchronises to that candidate cell. UE stops evaluating the execution condition(s) for other candidate cells once the handover is triggered.
- The UE accesses to the target eNB and completes the handover procedure by sending RRCConnectionReconfigurationComplete message to target eNB. The UE releases stored CHO configurations after successful completion of RRC handover procedure.
- When initial CHO execution attempt fails or HO fails, if network configured the UE to try CHO after HO/CHO failure and the UE performs cell selection to a CHO candidate cell, the UE attempts CHO execution to that cell; Otherwise, RRC re-establishment is performed.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800089,800189,800289>

### 19.3.4 DL MIMO efficiency enhancements for LTE

800086	<a href="#">DL MIMO efficiency enhancements for LTE</a>	LTE_DL_MIMO_EE	R1	RP-182901	Huawei
800186	Core part: DL MIMO efficiency enhancements for LTE	LTE_DL_MIMO_EE-Core	R1	RP-182901	Huawei
800286	Perf. part: DL MIMO efficiency enhancements for LTE	LTE_DL_MIMO_EE-Perf	R4	RP-182901	Huawei

Summary based on the input provided by Huawei, HiSilicon in RP-200885.

MIMO is an effective technique to improve spectral efficiency and increase overall network capacity. SRS can be utilized to improve DL MIMO performance, especially for massive MIMO in TDD. In this WI [1], SRS capacity and coverage are enhanced by introducing more than one SRS symbol in a UL normal subframe and introducing virtual cell ID for SRS [2].

#### More than one symbol for SRS in a UL normal subframe

With the introduction of more than one SRS symbol in a UL normal subframe, the SRS capacity and coverage can be increased. These additional SRS symbol(s) are referred to as trigger type 2 SRS.

1 to 13 symbols of the first 13 symbols of a UL normal subframe can be configured to a UE for aperiodically triggered SRS transmission. Intra-subframe repetition, frequency hopping and antenna switching of the additional SRS symbols can be supported. A guard period of one SC-FDMA symbol can be configured for frequency hopping and antenna switching.

The number of repetitions can be configured from the set {1, 2, 3, 4, 6, 7, 8, 9, 12, 13}. If a UE has more receive antennas than transmit chains (e.g. 1T2R), the UE can be configured to transmit the additional SRS with antenna switching. And a UE can additionally be configured with frequency hopping for the additional SRS. The number of antennas (pairs) to switch is:

- 2 for 1T2R, or the number of pairs is configured as 2 for 2T4R
- 3 if the number of pairs is configured as 3 for 2T4R
- 4 for 1T4R

Both legacy SRS and additional SRS can be configured to the same UE, and transmission of legacy SRS and additional SRS symbol(s) in the same subframe for the UE is supported.

For sequence generation, per-symbol group hopping and sequence hopping are supported.

Independent open loop and close loop power control is supported for additional SRS, and DCI formats 3/3A/3B are used for close loop power control.

UEs not configured with SPUCCH/SPUSCH are not expected to be triggered with additional SRS in the same subframe as PUSCH/PUCCH in the same serving cell. UEs configured with SPUCCH/SPUSCH drop the SRS transmission in the symbols colliding with SPUCCH/SPUSCH in the same serving cell.

The additional SRS transmission in the symbols colliding with PUSCH/PUCCH of another serving cell in the same TAG, the same band and with the same CP, is dropped.

The additional SRS transmission in the symbols colliding with PUSCH/PUCCH of another serving cell in the different TAG is dropped if the total transmission power exceeds the PCMAX in any overlapping portion.

#### Virtual cell ID

Virtual cell ID within the range from 0 to 503 can be configured for SRS to increase SRS capacity.

The virtual cell ID can be configured to only additional SRS symbol(s) or both legacy and additional SRS symbol(s). If virtual cell ID is not configured, the physical cell ID is used.

#### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=800086,800186,800286>

- [1] RP-192766, "WID Revision: DL MIMO efficiency enhancements for LTE", Huawei, HiSilicon, RAN#86, Sitges, Spain, December, 2019.
- [2] R1-1913596, RAN1 agreements for DL MIMO efficiency enhancements for LTE, WI rapporteur (Huawei), RAN1#99, Reno, USA, November, 2019.

### 19.3.5 Other LTE-only items

Further performance enhancement for LTE in high speed scenario: Covered in the section on Railways.

## 20 All other Release 16 Features

### 20.1 Service Interactivity

770020	<a href="#">Service Interactivity</a>	SerInter	S4	SP-170796	Lo, Charles, Qualcomm
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Summary based on the input provided by Qualcomm Incorporated in SP-191247.

This summarizes the progress of the normative specifications accomplished during the course of the SerInter work item [1]. The related agreed CRs can be found in the Tdocs [2], [3], [4], [5] and [6].

The service interactivity feature enables dynamic user engagement and resulting auxiliary content presentation during the consumption of a streaming service or content item, received over unicast or broadcast. Interactive service capabilities can be further personalized to the end user consuming the service. Examples of service interactivity functionality include voting, rating, purchasing, online chats, and reception of targeted advertisements and other content, in real-time during the viewing of a streaming program.

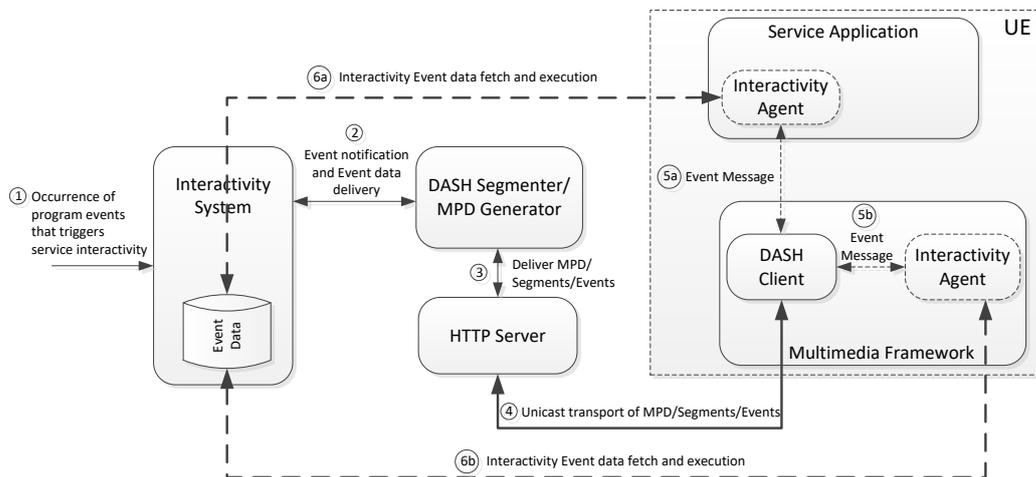
Technical functionality to enable and support dynamic and personalized service interactivity are added to TS 26.247 [7], TS 26.346 [8] and TS 26.347 [9] and comprise the following components:

- Signaling of upcoming interactivity events to native or Web app based interactivity applications. Such interactivity event signaling, which could be sent at specific and potentially arbitrary times during the consumption of an associated 3GPP User Service, contain metadata of upcoming interactivity events and which enable an interactivity application to perform its intended task. The interactivity event signaling is defined by the DASH Industry Forum upon request from 3GPP, and is implemented as either a DASH Event stream, or as samples of a ISOBMFF timed metadata track.
- Processing model and rules for the 3GP-DASH Client to extract metadata contained in interactivity event signaling.
- WebIDL APIs exposed by the 3GP-DASH Client to an interactivity application, for the subscription by and delivery to, the application, of interactivity event metadata.

(The above functionalities are defined by the DASH Industry Forum, based on request from 3GPP to support the Service Interactivity work item, in the specification “DASH Player’s Application Events and Timed Metadata Processing Model and APIs” [10].)

- For DASH-formatted streaming services, signaling via the DASH MPD of the intended measurement and reporting of interactivity-related usage by the user/device. This signaling enables the service provider to: a) specify the parameters and criteria regarding interactivity consumption reporting; b) specify the type of interactivity usage report to be submitted by the DASH client, and c) employ either random or selective control of the user/device population to perform the reporting. In addition, the XML-based interactivity usage report format and HTTP POST based reporting protocol are defined. The above functionality are specified in TS 26.247 [7].
- Clarifications to the MBMS APIs specification TS 26.347 [9] that an MBMS-Aware Application providing an auxiliary service interactivity feature is expected to acquire, from the MBMS client, a multiplicity of Application User Services. These Application User Services provide the media content of the DASH-over-MBMS application service as well as media content and/or metadata of adjunct application service(s) that provide the service interactivity functionality.

An architecture illustrating the high level interactions between the relevant entities, in the delivery of DASH-formatted content and interactivity event signaling from the network to the 3GP-DASH Client, forwarding of event signaling data from the 3GP-DASH Client to the interactivity application, and subsequent execution by the application of its interactivity task, is shown in the diagram below, which is copied from TR 26.953 [11].



## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=770020>

- [1] Tdoc SP-170796, “New WID on Service Interactivity” (SerInter).
- [2] Tdoc S4-180854, CR 26.247-0145, “Signaling and Reporting of Interactivity Usage in 3GP-DASH”.
- [3] Tdoc S4-190182, CR 26.346-0625, “TS 26.346 Changes Pertaining to Service Interactivity Feature”.
- [4] Tdoc S4-190196, CR 26.347-0006, “Changes Pertaining to Service Interactivity”.
- [5] Tdoc S4-191314, CR 26.247-0163, “Support for Service Interactivity via Event Signaling and DASH APIs”.
- [6] Tdoc S4-191318, CR 26.346-0629, “Service Interactivity Support in DASH-over-MBMS Service”.
- [7] TS 26.247 “Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)”.
- [8] TS 26.346 “Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs”.
- [9] TS 26.347 “Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL”.

- [10] DASH Industry Forum specification “DASH Player’s Application Events and Timed Metadata Processing Model and APIs”.
- [11] TR 26.953 “(MBMS and PSS) Interactivity Support for 3GPP-Based Streaming and Download Services”.

## 20.2 RTCP Verification for Real-Time Services

850003	<a href="#">RTCP Verification for Real-Time Services</a>	RTCPVer	S4	SP-190639	Burman, Bo, Ericsson LM
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Summary based on the input provided by Ericsson LM in SP-200034.

This summarizes the progress of the new, normative specification accomplished during the course of the RTCPVer work item [1].

The RTCP verification for real-time services feature enables verification of the most important parts of the RTP/RTCP and SRTP/SRTCP protocols used by current 3GPP conversational and real-time services.

Technical functionality to enable and support this verification are added to a new TS 26.139 [2] and comprise the following aspects:

- Explicitly allowing for and describing examples of different, possible test architectures.
- Test cases needed to ensure an adequate level of RTP operation and RTP stream monitoring.
- Test methods capable to verify that information contained in the RTP header and in RTCP is correct and consistent with the observed characteristics of the related RTP streams:
  - o Between RTP/RTCP within the scope of a single RTP stream (e.g. between an RTP stream and the corresponding RTCP reporting from the remote party, or between an RTP stream and the corresponding RTCP metadata, e.g. for sampling clock accuracy compensation between RTP sender and RTP receiver).
  - o Between RTP/RTCP across RTP streams in the same RTP session (e.g. between sent and received RTP streams, or between audio RTP streams and video RTP streams).
- Requirements on what constitutes acceptable RTP/RTCP protocol field values, including RTP payload header and RTP payload length, based on the observed characteristics of the related RTP streams.
- A method for an RTP/RTCP implementation to announce that it has passed the necessary tests and conforms to the new specification at call setup and during the call.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850003>

- [1] Tdoc SP-190639, "New WID on ‘RTP/RTCP Verification for Real-Time Services’" (RTCPVer).
- [2] TS 26.139 "Real-time Transport Protocol (RTP) / RTP Control Protocol (RTCP) verification procedures".

## 20.3 Stage-3 SAE Protocol Development for Rel16

820042	<a href="#">Stage-3 SAE Protocol Development for Rel16</a>	SAES16	C1	CP-183088	Aghili, Behrouz, InterDigital Communications
820038	<a href="#">IMS Stage-3 IETF Protocol Alignment</a>	IMSProtoc16	C1	CP-183084	Leis, Peter, Nokia

The description of these WIDs has not changed at all from its predecessors, e.g. SAES6, SAES5, etc.

The contents of the WID are exact copies of the ones before as it is an “ongoing” WID at CT1, meaning that it keeps existing for every new release until CT1 makes a decision that it is no longer needed. The only thing that happened this time, i.e. for the Rel-16 version, was that we decided to align the “x” in SAESx with the corresponding release so, as of Rel-16, the WID is called SAES16 and it will be SAES17 for Rel-17.

Same with IMSProtocolx.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820042,820038>

## 20.4 Reliable Data Service Serialization Indication

840017	Reliable Data Service Serialization Indication	RDSSI	S2	SP-190446	Michael Starsinic, Convida Wireless LLC
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Summary based on the input provided by Convida Wireless LLC in SP-200057.

This work item enhances the Reliable Data Service by adding support to the Reliable Data Service for indicating the serialization format of the data that will be sent in a NIDD session

The Reliable Data Service was added to EPS in Rel-14 as part of the “Extended architecture support for Cellular Internet of Things” work item and added to 5GS in Rel-16 as part of the “Cellular IoT support and evolution for the 5G System” work item.

The work was motivated by an LS from oneM2M and resulted in TS 23.682, TS 23.501, and TS 23.502 CRs which added support to the Reliable Data Service for indicating the serialization format of the data that will be sent in a NIDD session. The CRs also updated the NIDD Configuration procedure so that the SCS/AS can indicate to the SCEF or NEF the serialization format(s) that are supported by the SCS/AS.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840017>

- [1] S2-1903031, NIDD RDS API enhancement, LS from oneM2M Technical Plenary to CT3
- [2] S2-1903039, LS Reply on NIDD RDS API enhancement, LS from CT3 to SA2 and oneM2M Technical Plenary
- [3] S2-1906025, Adding Support for Indicating Serialization Format in RDS, TS 23.682 CR, Convida Wireless LLC, Intel, Deutsche Telekom, AT&T
- [4] S2-1906027, Adding Support for Indicating Serialization Format in RDS, TS 23.502 CR, Convida Wireless LLC, Intel, Deutsche Telekom, AT&T
- [5] S2-1906162, Adding Support for Indicating Serialization Format in RDS, TS 23.501 CR, Convida Wireless LLC, Intel, Deutsche Telekom, AT&T

## 20.5 Shared Data Handling on Nudm and Nudr

800046	Shared Data Handling on Nudm and Nudr	Shared_Data	C4	CP-181136	Wiehe, Ulrich, Nokia
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Summary based on the input provided by Nokia, Nokia Shanghai Bell in CP-200143.

The problem of potential signalling floods on Nudm and Nudr service based interfaces that are caused by (identical) subscription data changes for a huge set of subscriptions (e.g. MTC devices) is solved by the concept of shared data.

Subscription data that are retrieved by serving nodes (AMF, SMF, SMSF) from the UDM (and by the UDM from the UDR) may contain a subset that is shared by a huge number of subscriptions (e.g. 1000 specific MTC devices). A simple example for such a subset is e.g. a subscribed periodic registration time with a value of 300 seconds. When the operator decides to modify the value for all these MTC devices to e.g. 400 seconds, a single notification per serving node is sent to update the shared subset; there is no need to send 1000 notifications addressing each single subscription.

The solution is a pure stage 3 signalling optimization issue and is not based on specific stage1 or stage 2 requirements.

CT4#84 decided to implement the solution already in Rel-15.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=840046>

Impacted TSs:

TS 29.503: "Unified Data Management Services".

TS 29.504: "5G System; Unified Data Repository Services; Stage 3".

TS 29.505: "5G System; Usage of the Unified Data Repository Services for Subscription Data; Stage 3".

Main CRs:

29.503 CR 0008r4 C4-186497

29.504 CR 0010r1 C4-187507

29.505 CR 0019r1 C4-187506

## 20.6 New Services and Markets Technology Enablers – Phase 2

790001	New Services and Markets Technology Enablers – Phase 2	SMARTER_Ph2	S1	SP-180589	Li, Alice, Vodafone
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Summary based on the input provided by Vodafone in SP-200224.

There are strong interests among 3GPP network operators not only on addressing various existing and emerging markets and services to increase and diversify revenue streams, but also on enabling new business models and different operational schemes to maximise the use of the operators' networks.

TS 22.261 [1] specifies the requirements that define a 5G system in order to support new deployment scenarios to address diverse market segments, while the requirements for 5G E-UTRA-NR Dual Connectivity in E-UTRAN connected to EPC (i.e. "option 3") are included in TS 22.278 [2]. This WI allows refinement of the identified stage 1 requirements in both specifications, including clarifications and extension due to the stage 2 developments in other WGs.

The clarifications and alignments are made with stage 2/3 progress in other WGs on the requirements carried forward from Release 15. The main updates include:

- For the 5G system service requirements specified in TS 22.261
  - o A statement is added to the Scope to clarify that TS 22.261 provides requirements related to a 5G Core, i.e., specifically excluding Option 3.
  - o Clarifications are added on the performance requirements for low-latency and high-reliability scenarios.
  - o Clarifications are added on unified access control requirements.
  - o Support of legacy USIM in 5G is added.
  - o Clarifications are added on communication service availability and reliability.
  - o Alignments are added on higher-accuracy positioning.
- For the requirements for 5G E-UTRA-NR Dual Connectivity in E-UTRAN connected to EPC (i.e. "option 3") specified in TS 22.278
  - o A statement is added to the Scope to clarify that TS 22.278 provides requirements related to 5G Option 3.
  - o Added the 5G URLLC KPIs from Release 15 onwards to align with stage 2 agreements.
  - o New service requirements are added corresponding to the enhancements developed in CIoT to align with stage2/3 progress.
  - o Added the 5G requirements on service continuity.
  - o Added the 5G requirements on context aware network.

### References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=790001>

- [1] TS 22.261, "Service requirements for the 5G system"  
 [2] TS 22.278, "Service requirements for the Evolved Packet System (EPS)"

## 20.7 Ambient noise test methodology for evaluation of acoustic UE performance

870010	Ambient noise test methodology for evaluation of acoustic UE performance	ANTeM	S4	SP-200051	Jan Reimes, HEAD acoustics GmbH
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Summary based on the input provided by China Mobile in SP-200265.

The work item ANTeM [1] was subsequently initiated to the feasibility study FS\_ANTeM [2] in order to follow the conclusion of TR 26.921 [3] regarding handset speech quality testing under ambient noise conditions. Results of the round robin test conducted in FS\_ANTeM indicated that an alternative noise field simulation provides test results equivalent to the currently specified method, while having a more efficient equalization procedure and less variance across labs at the same time. To include this new method in TS 26.132 [4], a corresponding change request [5] was agreed.

For speech quality evaluation of UEs under ambient noise conditions, the technical specification TS 26.132 [4] provides test methodologies. For measurements in handset mode, the background noise playback system according to ETSI ES 202 396-1 [6] is used. Within the study item FS\_ANTeM, the applicability of the more recent ambient noise simulation according to ETSI TS 103 224 [7] was investigated, which provides the advantage of a fully automated calibration routine.

The so-called "flexible configurations" of ETSI TS 103 224 [7] were found to be useful, since they can be used in conjunction with the currently specified binaural noise types of TS 26.132 [4] to provide backward compatibility with the currently used simulation according to ETSI ES 202 396-1 [6].

The equivalency of the two noise field simulation systems was also shown by almost identical measurement results in the round robin test (comprehensive results of this study are provided in TR 26.921 [3]). The resulting CR [5] specified the flexible configurations of ETSI TS 103 224 [7] as an additional and preferred simulation method.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=870010>

- [1] S4-200192: "New WID on Ambient noise test methodology for evaluation of acoustic UE performance".
- [2] S4-181230: "New SID on ambient noise test methodology for acoustic performance evaluation of UEs".
- [3] TR 26.921: "Investigations on ambient noise reproduction systems for acoustic testing of terminals".
- [4] TS 26.132: "Speech and video telephony terminal acoustic test specification".
- [5] S4-200305: "Alternative noise field simulation method for terminal testing" (CR 0102 to TS 26.132).
- [6] ETSI ES 202 396-1: "Speech and multimedia Transmission Quality (STQ); Speech quality performance in the presence of background noise; Part 1: Background noise simulation technique and background noise database".
- [7] ETSI TS 103 224: "Speech and multimedia Transmission Quality (STQ); A sound field reproduction method for terminal testing including a background noise database".

## 20.8 KPI reporting

810031	<a href="#">Enhancement of performance assurance for 5G networks including network slicing</a>	5G_SLICE_ePA	S5	SP-190247	Xiaowei Sun (China Mobile)
850055	<a href="#">Overall aspects of 5G_SLICE_ePA</a>	5G_SLICE_ePA	S5	SP-190247	Xiaowei Sun (China Mobile)
850029	<a href="#">KPI reporting</a>	5G_SLICE_ePA-KPI	S5	SP-190881	ZHU, Weihong, ZTE Corporation

Summary based on the input provided by ZTE in SP-200520.

The work item KPI reporting is the building block of work item 5G\_SLICE\_ePA (Enhancement of performance assurance for 5G networks including network slicing), it defined the use cases and requirements of KPI reporting, and enhanced the performance measurement job control related operations, performance measurement control NRM fragment and KPI template to enable the capability of KPI reporting.

The work item KPI reporting finished the enhancement on the performance measurement mechanism to enable the capability of KPI reporting, which includes:

- add the use cases and requirements of KPI reporting
- enhance the performance assurance Management Service (MnS) to support KPI collection and reporting
- enhance the KPI template and definitions to support KPI collection and reporting
- enhance the performance measurement control NRM fragment to support KPI collection and reporting

The work item resulted in a number of CRs on TS 28.550, 28.554, 28.622 and 28.623.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810031,850055,850029>

- [1] WID: SP-190881  
 [2] CRs: S5-196410, S5-196748, S5-197571, S5-197572, S5-197575, S5-201522, S5-201581, S5-201582

## 21 Telecom Management

### 21.1 Network and Service Management

#### 21.1.1 5G Management capabilities

860023	5G Management capabilities	5GMNC	S5	SP-191195	Jean-Michel Cornily, Orange
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Summary based on the input provided by Orange in SP-200535.

In addition to generic management services, 5G management capabilities are needed to support the management and orchestration of 5G networks. This Rel-16 work item focuses on the heartbeat management capability.

This Work Item has produced TS 28.537: Management and orchestration; Management capabilities.

TS 28.537 [1] is a placeholder for the specification of 5G management capabilities. In Rel-16, only the heartbeat management capability is addressed.

The heartbeat management capability is needed to monitor the communication between Management Service (MnS) producers and MnS consumers, and to discover communication link breaks between them as early as possible.

TS 28.537 [1] captures use cases, requirements and procedures for the heartbeat management capability.

#### References

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860023>

[1] TS 28.537: Management and orchestration; Management capabilities

#### 21.1.2 Energy Efficiency of 5G

810023	Energy Efficiency of 5G	EE_5G	S5	SP-191193	Jean-Michel Cornily, Orange
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Summary based on the input provided by Orange in SP-200228.

The term 'Energy Efficiency' (EE) is to be understood as covering two areas:

1. Definition of EE KPI, required performance measurements and method(s) to collect them;
2. Definition of use cases, requirements and solutions to optimize Energy Efficiency – this is also sometimes referred to as Energy Saving.

Both aspects have been addressed in SA5 for pre-5G radio access technologies, focusing on how OA&M can provide support to them. This work item (EE\_5G) addresses NG-RAN.

This Work Item has produced the Rel-16 TS 28.310 "Management and orchestration; Energy efficiency of 5G", as well as CRs 0055 and 0111 to TS 28.552 and CR 0032 to TS 28.554.

TS 28.310 [1] captures use cases, requirements and procedures for collecting performance measurements (namely data volume measurements and PEE (Power, Energy and Environment) parameters from 5G base stations. The EE KPI for 5G base stations is obtained thanks to these measurements. Those measurements are collected by the OSS thanks to the usage of generic management services defined in TS 28.532. Data Volume (DV) measurements, at PDCP layer, have been introduced in TS 28.552 [2], as well as PEE parameters definition (amongst which the Energy Consumption (EC) of the base station). A new KPI, named EE KPI, calculated by dividing Data Volume (DV) by Energy Consumption (EC) has been defined in TS 28.554 [5]. All this is fully aligned with baseline ETSI TC EE (Environmental Engineering) specifications ES 203 228 [7] and ES 202 336-12 [8].

Some intra- and inter-RAT energy saving use cases and requirements have been specified in TS 28.310 [1]. The 5G Network Resource Model (TS 28.541 [9]) has been augmented with an Energy Saving NRM fragment enabling the management of both centralized and distributed energy saving modes.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810023>

- [1] TS 28.310: Management and orchestration; Energy efficiency of 5G
- [2] TS 28.552: Management and orchestration; 5G performance measurements
- [3] SP-190755: Add Power, Energy and Environmental (PEE) measurements and related use case description
- [4] SP-190119: Add PDCP data volume measurements for EE
- [5] TS 28.554: Management and orchestration; 5G end to end Key Performance Indicators (KPI)
- [6] SP-191165: Add 5G Energy Efficiency KPI
- [7] ETSI ES 203 228: Environmental Engineering (EE); Assessment of mobile network energy efficiency
- [8] ETSI ES 202 336-12: Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment (power, cooling and building environment systems used in telecommunication networks); Part 12: ICT equipment power, energy and environmental parameters monitoring information model
- [9] TS 28.541: Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3

### 21.1.3 OAM aspects of LTE and WLAN integration

810024	<a href="#">OAM aspects of LTE and WLAN integration</a>	OAM_LTE_WLAN	S5	SP-180820	Yizhi Yao, Intel Corporation
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Summary based on the input provided by Intel Corporation in SP-191252.

The OAM\_LTE\_WLAN work item defined the requirements and solutions for management aspects of LWA (LTE-WLAN aggregation) and LWIP (LTE WLAN integration with IPsec tunnel) features defined by 3GPP RAN WGs. The management aspects of LWA and LWIP addressed by this work item include:

- Configurations to eNB to support LWA and LWIP;
- Management model for WT for co-located and non-co-located LWA deployment scenarios; and
- Performance measurements to monitor the LWA (including co-located and non-co-located scenarios) and LWIP.

The work item resulted in a number of CRs on TS 32.425, 28.657, 28.658, and 28.659 based on the preceding TR 32.868.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810024>

### 21.1.4 Methodology for 5G management specifications

810026	Methodology for 5G management specifications	METHOGY	S5	SP-180822	Jan Groenendijk, Ericsson
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Summary based on the input provided by Ericsson in SP-200531.

This work item documents the methodology used to document the various specification artefacts, such as requirements and solutions, of the network management services. The target group for the methodology specification is the specification authors for the OAM specifications.

The methodologies include template(s) and network resource model repertoire.

This work item resulted in several CR's to update network resource model repertoire TS 32.156 [1] and a new specification;

- TS 32.160: Management and orchestration: Management service template

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=810026>

[1] TS 32.156: Telecommunication management; Fixed Mobile Convergence (FMC) model repertoire

## 21.1.5 Closed loop SLS Assurance

850026	Closed loop SLS Assurance	COSLA	S5	SP-190781	Jan Groenendijk, Ericsson
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Summary based on the input provided by Ericsson in SP-200532.

This work item specifies a closed loop assurance solution that helps an operator to continuously deliver the expected level of communication service quality. The closed loop assurance solution allows an operator to create a closed loop management service that automatically adjusts and optimizes the services provided by NG-RAN and 5GC based on the various performance management and QoE input data, and the state of the 5G network, using data analytics. To be able to deploy SLS assurance solutions number of areas need are addressed:

- key management control loops in SLS assurance, key entities in the loops (e.g. MDAS)
- describe important data and enable efficient data collection [for SLS assurance] from NG-RAN and 5GC (includes NWDAF information) to consumers in OAM, e.g. performance management and configuration data
- describe coordination and management of the management functions involved in SLS assurance loops.
- placement and role of management analytics functions in the OAM framework.

This work item resulted in several CR's to update architecture framework TS 28.533 [1] and two new specifications:

- TS 28.535: Management and orchestration: Management Services for Communication Service Assurance; Requirements
- TS 28.536: Management and orchestration: Management Services for Communication Service Assurance; Stage 2 and stage 3

### Reference:

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=850026>

[1] TS 28.533: Management and orchestration: Architecture framework

## 21.1.6 Trace Management in the context of Services Based Management Architecture and Streaming Trace reporting

820036	Trace Management in the context of Services Based Management Architecture	TB_SBMA	S5	SP-181073	Anatoly Andrianov, Nokia
850027	Streaming Trace reporting	OAM_RTT	S5	SP-190782	Anatoly Andrianov, Nokia

Summary based on the input provided by Ericsson in SP-200532.

The combination of the 3GPP Rel-16 Trace features ("Trace management in the context of Services Based Management Architecture (SBMA)" and "Streaming Trace reporting") transformed the legacy, partially outdated trace functionality into a modern flexible and powerful toolset.

As SA5 no longer mandates the functional management architecture focused on interactions between IRPManager and IRPAgent over Itf-N, a new way of trace management was necessary. The concept of "configurable trace" has been introduced where the management trace activation is represented by the act of Managed Object Instance (MOI) creation. The new TraceJob Information Object Class (IOC) also known as "Trace control NRM fragment" has been specified for this purpose in the Generic NRM TSs 28.622 [1] and 28.623 [2]. The creation, deletion and modification of the MOIs based on the new IOC does not require a dedicated API and is performed by the means of Provisioning Management Service (Provisioning MnS) specified in TS 28.532 [3]. The corresponding content (concepts, requirements, definitions) has been added to the family of trace specifications (TSs 32.421 [4] and 32.422 [5]), while all the dependencies on the legacy Trace Management IRP and legacy functional architecture have been eliminated.

TR 28.806 [8] identified and documented use cases for collecting Cell and UE data for analytics, and for Collecting subscriber and equipment trace data for near-real-time diagnostics and troubleshooting. It established that enabling the capabilities for trace data to be delivered to the consumer(s) while it's still relevant to the analytics, diagnostics and

troubleshooting tasks performed by the consumer is important. The normative work on streaming trace data reporting leveraged the model-driven approach to the trace management and SBMA framework (TS 28.533 [7]). It added the new use cases and requirements for streaming trace to TS 32.421 [4], addressed all relevant trace control and configuration management aspects in TS 32.422 [5] and specified the serialization format for the streaming trace records in TS 32.423 [6]. The initial work on a dedicated Streaming Trace data reporting MnS has been further extended and generalized into support of additional streaming data types such as Streaming PM, Streaming Analytics and proprietary data. The new Streaming data reporting MnS has been fully specified in TS 28.532 [3] it includes a RESTful HTTP based solution set for streaming connection establishment and connection/stream meta-data exchange and an efficient protocol stack for high volume/high speed streaming data reporting based on WebSockets. The use of SBMA framework does not limit the consumers and producers of the new MnS to 3GPP Management Functions and supports the use cases where 3GPP Network Element (NE) reports management data (Trace, PM, Analytics and proprietary) to any authorized MnS consumer.

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820036,850027>

- [1] TS 28.622 "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"
- [2] TS 28.623 "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions"
- [3] TS 28.532 "Management and orchestration; Generic management services"
- [4] TS 32.421 "Telecommunication management; Subscriber and equipment trace; Trace concepts and requirements"
- [5] TS 32.422 "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management"
- [6] TS 32.423 "Telecommunication management; Subscriber and equipment trace; Trace data definition and management"
- [7] TS 28.533 "Management and orchestration; Architecture framework"
- [8] TS 28.806 "Study on non-file-based trace reporting"

## 21.1.7 Management of QoE measurement collection

760058	<a href="#">Management of QoE measurement collection</a>	QOED	S5	SP-181069	Petersen, Robert, Ericsson
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Summary based on the input provided by Ericsson in SP-200872.

This work item specifies the function Management of QoE measurement collection for a specified area in UMTS and LTE.

An operator or an automated management function can request that DASH or MTSI measurements are collected (when those applications are used in UEs that has the capability of reporting them) and send them to a specified collection entity, which can use them for calculating KPIs or take part in automated functions etc.

Use cases and requirements are specified.

The e2e functionality is described according to the TS 26.247, TS 26.114, TS 27.007, TS 25.331, TS 25.413, TS 36.331, 36.413 and TS 28.308.

The output report is specified according to the TS 26.247, TS 26.114.

The management interfaces over Itf-N are specified in an Integration Reference Point (IRP).

This work item resulted in six specifications:

- TS 28.307: Management of Quality of Experience (QoE) measurement collection Integration Reference Point (IRP); Requirements
- TS 28.308: Management of Quality of Experience (QoE) measurement collection Integration Reference Point (IRP); Information Service (IS)
- TS 28.309: Management of Quality of Experience (QoE) measurement collection Integration Reference Point (IRP); Solution Set (SS) definition
- TS 28.404: Quality of Experience (QoE) measurement collection; Concepts, use cases and requirements
- TS 28.405: Quality of Experience (QoE) measurement collection; Control and configuration
- TS 28.406: Quality of Experience (QoE) measurement collection; Information definition and transport

References

List of related CRs: select "TSG Status = Approved" in:  
<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=760058>

### 21.1.8 Network Resource Model (NRM) enhancement

820032	<a href="#">NRM enhancements</a>	eNRM	S5	SP-190140	Jing Ping, Nokia
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Summary based on the input provided by Nokia, Nokia Shanghai Bell in SP-201117.

This Work Item extends the 5G Network Resource Model to support the Service-Based Architecture (SBA) of 5G Core (5GC) and several new features of NG Radio Access Network (NG-RAN), together with enhancements of the stage 3 Solution Set (SS).

1. Support of 5GC Service-Based Architecture (SBA)

In the Rel-16 NRM, ManagedNFService InformationObjectClass (IOC) is introduced to represent a Network Function (NF) Service as defined in TS 23.501. This enhancement enables configuration management, performance management, fault management, state management, as well as lifecycle management on more granular NF Service level.

Figure 1 shows containment and inheritance relationship between the ManagedNFService IOC and other existing NRM IOCs (defined in TS 28.622 [1]).

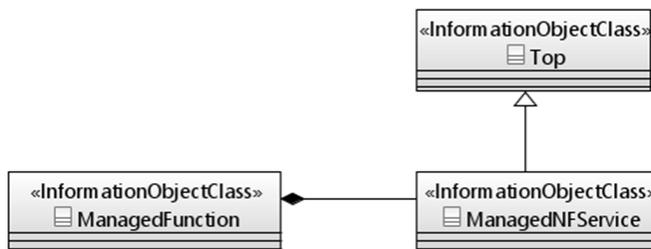
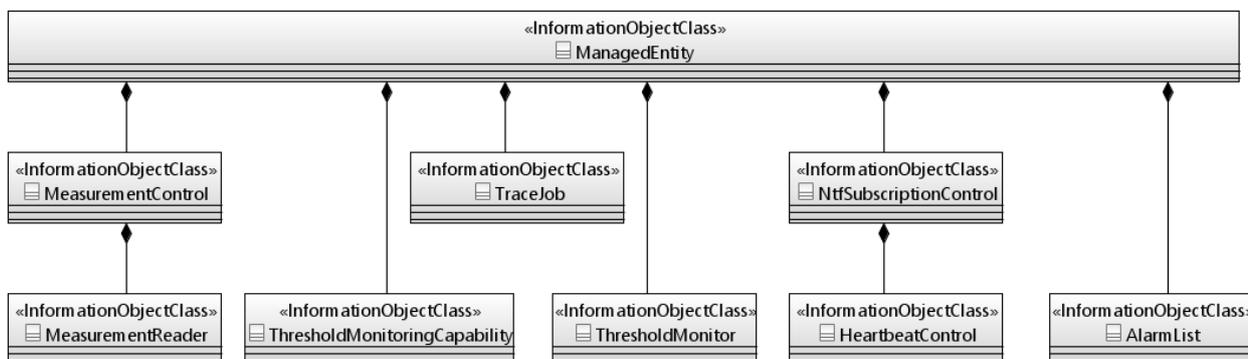


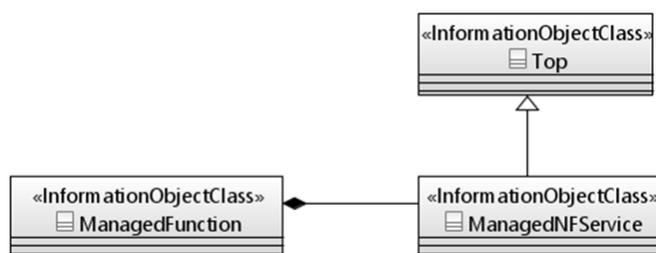
Figure 1: Managed NF Service NRM fragment diagram

In addition, TS 28.541 [3] is enhanced to support NF Service configuration and registration.

2. Support of model driven approach

To align with the Service Based Management Architecture (SBMA) since Rel-15, configurable Performance Management (PM), Fault Management (FM), TM (Trace Management), etc., are introduced to fully support a model driven approach. Several NRM fragments were added in TS 28.622 [1] (stage 2 definition) and TS 28.623 [2] (stage 3 definition), including Performance measurement control NRM fragment, Measurement threshold monitoring control fragment, Heartbeat notification control fragment, Notification subscription control fragment and Trace control NRM fragment. Please see the overall diagram below.





**Figure 2: Overall diagram of NRM fragment for FM, PM, TM control**

Note: Managed Entity can be a subnetwork, managed network element or network function

### 3. 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. Remote Interference Management, Radio Resource Management policy for radio resources sharing between network slices and operators, New Radio (NR) Automatic Neighbour Relation (NAR), QoS monitoring, configurable 5QI, and transport related information model to support end to end network slice management. Refer to TS 28.541[3]

### 4. Enhancement of stage 3 codes to follow style guideline

Refact stage 3 YAML and YANG codes in TS 28.541[3] and 28.623[2] to align with new code style guideline defined in TS 32.158 [4] and TS 32.160 [5].

### 5. Publication and validation in 3GPP Forge

Stage 3 codes, including YAML and YANG solution sets, are uploaded to 3GPP Forge for validation and the OpenAPI code (including YAML code defined NRM) and YANG code is published. Please refer the below link for the SA5 Forge repository: <https://forge.3gpp.org/rep/sa5/data-models>

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820032>

- [1] TS 28.622 "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"
- [2] TS 28.623 "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions"
- [3] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and Stage 3".
- [4] TS 32.158: "Management and orchestration; Design rules for REpresentational State Transfer (REST) Solution Sets (SS) ".
- [5] TS 32.160: "Management and orchestration; Management service template".

## 21.2 Charging Management

### 21.2.1 Charging Enhancement of 5GC interworking with EPC

820031	<a href="#">Charging Enhancement of 5GC interworking with EPC</a>	5GIEPC_CH	S5	SP-181067	Chen Shan, Huawei
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Summary based on the input provided by Huawei in SP-190855.

The WI 5GIEPC\_CH is the enhancement of the WI 5GS\_Ph1-SBI\_CH and 5GS\_Ph1-DCH (handover with N26 scenario) on charging aspect of 5GC interworking with EPC, to specify procedure, parameter and Open API impact for the handover cancel and handover without N26 scenarios.

Stage 2 work on WI 5GIEPC\_CH for TS 32.255 [1] and TS 32.290 [2]:

- New message flow for EPS to 5GS handover for roaming in Home routed scenario, reflecting the "Visited created Charging Id, Home provided Charging ID" conveyed between VPLMN and HPLMN, and their use within each PLMN.
- Definition of charging information for interworking with EPC: use of 5G attributes and CDR fields extended with EPC specific ones in the new Interworking Annex.
- Handover triggers for handover cancel and handover without N26 scenarios.
- Stage 3 work on WI 5GIEPC\_CH for 32.291 [3] and 32.298 [4]:
- TS 32.291 Nchf\_ConvergedCharging API
- Extensions of Data model
- Update OpenAPI
- TS 32.298 ASN.1 CHF CDR with "charging Ids" and extended EPC parameters

## References

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

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=820031>

- [1] TS 32.255: "5G data connectivity domain charging"
- [2] TS 32.290: "5G system; Services, operations and procedures of charging using Service Based Interface (SBI)"
- [3] TS 32.291: "5G system; Charging service, stage 3"
- [4] TS 32.298: "Charging Data Record (CDR) parameter description"

## 21.3 Other charging and management items

The other charging and management items are reported under the Feature they relate to.

E.g. "Charging Aspect for 5WWC" is reported under "5WWC" rather than under "Charging".

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## 22 Other items

### 22.1 Items not (fully) completed in Rel-16

These items have not been officially moved to the next Release at the time of writing this document but are not implementable in Rel-16.

#### 22.1.1 Remote Identification of Unmanned Aerial Systems

810049	<a href="#">Remote Identification of Unmanned Aerial Systems</a>	ID_UAS		SP-180771	Eddy HALL, Qualcomm
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This item was moved to Rel-17.

#### 22.1.2 5G message service

810050	<a href="#">5G message service</a>	5GMSG	S1	SP-180772	Zheng, Jianping, China Mobile
770004	<a href="#">Study on 5G message service for MIoT</a>	FS_5GMSG	S1	SP-170704	Zheng, Jianping, China Mobile
810014	<a href="#">Message Service Within the 5G System requirements</a>	MSGin5G	S1	SP-180920	Zheng, Jianping, China Mobile

Summary based on the input provided by China Mobile in SP-200265.

This work item specifies the service level requirements of the MSGin5G Service and the new requirements of the 5G System to support the MSGin5G Service [1].

The MSGin5G Service is basically designed and optimized for massive IoT device communication including thing-to-thing communication and person-to-thing communication. The MSGin5G Service enables various message communication models including point-to-point, application-to-point, group and broadcast message communication, with advanced service capabilities and performance, e.g. very low end-to-end latency and high reliability of message delivery, in a resource efficient manner to optimize the resource usage of the both control plane and user plane in the network, and power saving in the user devices.

Stage 2 work of the MSGin5G Service is undergoing in SA6 with a SI [2] [3].

## References

- [1] TS 22.262, Message Service within the 5G System; Stage 1
- [2] SP-190478, SID on Study on support of the 5GMSG Service
- [3] TR23.700-24, Study on support of the 5GMSG Service

## 22.1.3 Integration of Satellite Access in 5G

0	Satellite Access in 5G	-		-	-
800010	Integration of Satellite Access in 5G	5GSAT	S1	SP-180326	MICHEL, Cyril, Thales
770002	Study on using Satellite Access in 5G	FS_5GSAT	S1	SP-170702	MICHEL, Cyril
800048	Stage 1 of 5GSAT	5GSAT	S1	SP-180326	MICHEL, Cyril, Thales
800026	Study on architecture aspects for using satellite access in 5G	FS_5GSAT_ARCH	S2	SP-181253	MICHEL, Cyril
800099	Study on solutions for NR to support non-terrestrial networks (NTN)	FS_NR_NTN_solutions	R3	RP-190710	Thales
830025	Study on management and orchestration aspects with integrated satellite components in a 5G network	FS_5GSAT_MO	S5	SP-190138	MICHEL, Cyril, THALES

Only Stage 1 was defined in the Rel-16 time-frame. This is not consistent with the 3GPP methodology, where all aspects of a given Feature (Stages 1, 2, 3, charging, security, etc) have to be completed within the same Release. As a consequence, the work completed for Stage 1 in Rel-16 will be moved to a future Release.

# Annex A: Full Rel-16 Work Plan

Full structure of the Work Plan as of Dec 2019. This is a non-updated guide to construct this TR. Features added after Dec 2019 have been included in the main part of this TR but are not shown below.

UID	Name	Acronym	WG	WID	Rapporteur
0	<b>Release 16 Features and related studies</b>	-		-	-
0	Enhancement of Ultra-Reliable (UR) Low Latency Communications (URLLC)	-		-	-
830098	Enhancement of URLLC support in the 5G Core network	5G_URLLC	S2	SP-181122	Hui Ni, Huawei
790008	Study on enhancement of URLLC supporting in 5GC	FS_5G_URLLC	S2	SP-180118	Hui Ni, Huawei
810036	Study on the security of URLLC for 5GS	FS_5G_URLLC_SEC	S3	SP-180910	Rong Wu, Huawei Technologies
820019	Stage 2 of 5G_URLLC	5G_URLLC	S2	SP-181122	Hui Ni, Huawei
840026	Security of URLLC for 5GS	5G_URLLC_SEC	S3	SP-190351	Rong Wu, Huawei Technologies
840005	CT Aspects of 5G_URLLC	5G_URLLC	ct	CP-191063	Qi Caixia, Huawei
840060	CT3 Aspects of 5G_URLLC	5G_URLLC	C3	CP-191063	Qi Caixia, Huawei
840061	CT4 Aspects of 5G_URLLC	5G_URLLC	C4	CP-191063	Qi Caixia, Huawei
780030	Stopped - Study on EPC support for Mobility with Low Latency Communication	FS_LLC_Mob	S2	SP-171069	Chris PUDNEY
790009	Stopped - Study on enht of systems using EPS for UR and Availability using commodity equipment	FS_EPS_URACE	S2	SP-180119	Chris Pudney
830074	Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)	NR_L1enh_URLLC	R1	RP-191584	Huawei
800095	Study on physical layer enhancements for NR UR Low Latency Cases	FS_NR_L1enh_URLLC	R1	RP-181477	Huawei
830174	Core part: Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)	NR_L1enh_URLLC-Core	R1	RP-190726	Huawei
830274	Perf. part: Physical Layer Enhancements for NR Ultra-Reliable and Low Latency Communication (URLLC)	NR_L1enh_URLLC-Perf	R4	RP-190726	Huawei
830080	Support of NR Industrial Internet of Things (IIoT)	NR_IIOT	R2	RP-191561	Nokia
810060	Study on channel modeling for indoor industrial scenarios	FS_IIOT_CM	R1	RP-182138	Ericsson
800098	Study on NR Industrial Internet of Things (IIoT)	FS_NR_IIOT	R2	RP-181479	Nokia
830180	Core part: Support of NR Industrial Internet of Things (IIoT)	NR_IIOT-Core	R2	RP-190728	Nokia
820999	5GS Enhanced support of Vertical and LAN Services	-		-	-
750004	Study on Communication for Automation in Vertical Domains	FS_CAV	S1	SP-170169	Walewski, Joachim, Siemens AG
800007	Service requirements for cyber-physical control applications in vertical domains	cyberCAV	S1	SP-180321	Joachim W. Walewski (Siemens)
830042	5GS Enhanced support of Vertical and LAN Services	Vertical_LAN	S2	SP-181120	Devaki Chandramouli, Nokia
800028	Study on 5GS Enhanced support of Vertical and LAN Services	FS_Vertical_LAN	S2	SP-180507	Devaki Chandramouli, Nokia
820017	Stage 2 of Vertical_LAN	Vertical_LAN	S2	SP-181120	Devaki Chandramouli, Nokia
810038	Study on Security for 5GS Enhanced support of Vertical and LAN Services	FS_Vertical_LAN_SEC	S3	SP-180697	Jerichow, Anja (Nokia)
840027	Security for Vertical_LAN	Vertical_LAN_SEC	S3	SP-190352	Jerichow, Anja, Nokia
830010	CT aspects of Vertical_LAN	Vertical_LAN	ct	CP-191157	WON, Sung Hwan, Nokia
830035	CT1 aspects of Vertical_LAN	Vertical_LAN	C1	CP-191157	WON, Sung Hwan, Nokia
830036	CT3 aspects of Vertical_LAN	Vertical_LAN	C3	CP-191157	WON, Sung Hwan, Nokia
830037	CT4 aspects of Vertical_LAN	Vertical_LAN	C4	CP-191157	WON, Sung Hwan, Nokia
820027	Service Enabler Architecture Layer for Verticals	SEAL	S6	SP-181141	Basavaraj (Basu) Pattan, Samsung
820067	NR-based access to unlicensed spectrum	NR_unlic	R1	RP-191575	Qualcomm
750045	Study on NR-based access to unlicensed spectrum	FS_NR_unlic	R1	RP-181339	Qualcomm
820167	Core part: NR-based access to unlicensed spectrum	NR_unlic-Core	R1	RP-190706	Qualcomm
820267	Perf. part: NR-based access to unlicensed spectrum	NR_unlic-Perf	R4	RP-190706	Qualcomm
800006	LAN support in 5G	5GLAN	S1	SP-180593	Jose Almodovar, KPN
760007	Study on LAN Support in 5G	FS_5GLAN	S1	SP-170456	Nasielski, Jack, Qualcomm
800047	Stage 1 of 5GLAN	5GLAN	S1	SP-180593	Jose Almodovar, KPN
830024	Study on non-public networks management	FS_OAM_NPN	S5	SP-190137	ZHANG, Kai, Huawei
0	Cellular IoT support and evolution	-		-	-
830043	Cellular IoT support and evolution for the 5G System	5G_CIoT	S2	SP-181118	Sebastian Speicher
770038	Study on 5G_CIoT	FS_CIoT_5G	S2	SP-180614	Sebastian Speicher
820015	Stage 2 of 5G_CIoT	5G_CIoT	S2	SP-181118	Sebastian Speicher
830013	CT aspects of 5G_CIoT	5G_CIoT	ct	CP-111237	Mahmoud Watfa; Qualcomm
830038	CT1 aspects of 5G_CIoT	5G_CIoT	C1	CP-111237	Mahmoud Watfa; Qualcomm
830039	CT3 aspects of 5G_CIoT	5G_CIoT	C3	CP-111237	Mahmoud Watfa; Qualcomm
830040	CT4 aspects of 5G_CIoT	5G_CIoT	C4	CP-111237	Mahmoud Watfa; Qualcomm
830041	CT6 aspects of 5G_CIoT	5G_CIoT	C6	CP-111237	Mahmoud Watfa; Qualcomm
800033	Study on evolution of Cellular IoT security for the 5G System	FS_CIoT_sec_5G	S3	SP-180440	Noamen Ben Henda
760040	Study on MBMS User Services for IIoT	FS_MBMS_IIoT	S4	SP-170592	Cedric thienot, Expway
800083	Additional MTC enhancements for LTE	LTE_eMTC5	R1	RP-191356	Ericsson
800183	Core part: Additional MTC enhancements for LTE	LTE_eMTC5-Core	R1	RP-190770	Ericsson
800283	Perf. part: Additional MTC enhancements for LTE	LTE_eMTC5-Perf	R4	RP-190770	Ericsson
800084	Additional enhancements for NB-IoT	NB_IoTenh3	R1	RP-191576	Huawei
800184	Core part: Additional enhancements for NB-IoT	NB_IoTenh3-Core	R1	RP-190757	Huawei
800284	Perf. part: Additional enhancements for NB-IoT	NB_IoTenh3-Perf	R4	RP-190757	Huawei
810050	5G message service	5GMSG	S1	SP-180772	Zheng, Jianping, China Mobile
770004	Study on 5G message service for MIIoT	FS_5GMSG	S1	SP-170704	Zheng, Jianping, China Mobile
810014	Message Service Within the 5G System requirements	MSGin5G	S1	SP-180920	Zheng, Jianping, China Mobile
0	Advanced V2X support	-		-	-

790002	<a href="#">Study on Improvement of V2X Service Handling</a>	FS_V2XIMP	S1	SP-180247	SungDuck Chun; LG Electronics
820024	<a href="#">Improvement of V2X service Handling</a>	V2XIMP	S1	SP-181013	SungDuck Chun; LG Electronics
<b>840074</b>	<a href="#">Application layer support for V2X services</a>	<b>V2XAPP</b>	<b>S6</b>	<b>SP-180898</b>	<b>Niranth Amogh, Huawei Tel.India</b>
780025	<a href="#">Study on V2XAPP</a>	FS_V2XAPP	S6	SP-171071	Niranth Amogh, Huawei Tel.India
810020	<a href="#">Stage 2 of V2XAPP</a>	V2XAPP	S6	SP-180898	Niranth Amogh, Huawei Tel.India
<b>840010</b>	<a href="#">CT aspects of V2XAPP</a>	<b>V2XAPP</b>	<b>ct</b>	<b>CP-191153</b>	<b>Herrero Veron, Christian (Huawei)</b>
840075	CT1 aspects of V2XAPP	V2XAPP	C1	CP-191153	Herrero Veron, Christian (Huawei)
840076	CT3 aspects of V2XAPP	V2XAPP	C3	CP-191153	Herrero Veron, Christian (Huawei)
840077	CT4 aspects of V2XAPP	V2XAPP	C4	CP-191153	Herrero Veron, Christian (Huawei)
<b>840078</b>	<a href="#">Architecture enhancements for 3GPP support of advanced V2X services</a>	<b>eV2XARC</b>	<b>S2</b>	<b>SP-181121</b>	<b>LaeYoung Kim, LG Electronics</b>
760043	<a href="#">Study on eV2XARC</a>	FS_eV2XARC	S2	SP-180733	LaeYoung Kim, LG Electronics
820018	<a href="#">Stage 2 of eV2XARC</a>	eV2XARC	S2	SP-181121	LaeYoung Kim, LG Electronics
<b>840011</b>	<a href="#">CT aspects of eV2XARC</a>	<b>eV2XARC</b>	<b>ct</b>	<b>CP-191154</b>	<b>Herrero Veron, Christian (Huawei)</b>
840079	CT1 aspects of eV2XARC	eV2XARC	C1	CP-191154	Herrero Veron, Christian (Huawei)
840080	CT3 aspects of eV2XARC	eV2XARC	C3	CP-191154	Herrero Veron, Christian (Huawei)
840081	CT4 aspects of eV2XARC	eV2XARC	C4	CP-191154	Herrero Veron, Christian (Huawei)
840082	CT6 aspects of eV2XARC	eV2XARC	C6	CP-191154	Herrero Veron, Christian (Huawei)
800096	<a href="#">Study on NR Vehicle-to-Everything (V2X)</a>	FS_NR_V2X	R1	RP-190224	LG Electronics
770029	<a href="#">Study on V2X Media Handling and Interaction</a>	FS_mV2X	S4	SP-170799	Jung, Kyunghun, Samsung Electronics Co., Ltd
830023	<a href="#">Study on Security Aspects of 3GPP support for Advanced V2X Services</a>	FS_eV2X_Sec	S3	SP-190108	Joonwoong Kim, LG Electronics
<b>830078</b>	<a href="#">5G V2X with NR sidelink</a>	<b>5G_V2X_NRSL</b>	<b>R1</b>	<b>RP-190984</b>	<b>LG Electronics</b>
830178	Core part: 5G V2X with NR sidelink	5G_V2X_NRSL-Core	R1	RP-190766	LG Electronics
830278	Perf. part: 5G V2X with NR sidelink	5G_V2X_NRSL-Perf	R4	RP-190766	LG Electronics
0	<a href="#">5G Location and Positioning Services</a>	-	-	-	-
<b>800013</b>	<a href="#">5G positioning services</a>	<b>5G_HYPOS</b>	<b>S1</b>	<b>SP-180329</b>	<b>Ries, Lionel, ESA</b>
760006	<a href="#">Study on positioning use cases</a>	FS_5G_HYPOS	S1	SP-170589	Ries, Lionel, ESA
800049	<a href="#">Stage 1 of 5G_HYPOS</a>	5G_HYPOS	S1	SP-180329	Ries, Lionel, ESA
830102	<a href="#">Enhancement to the 5GC Location Services</a>	<b>5G_eLCS</b>	<b>S2</b>	<b>SP-181119</b>	<b>Ming Ai, CATT</b>
780028	<a href="#">Study on Enhancement to the 5GC Location Services</a>	FS_eLCS	S2	SP-180734	Ming Ai, CATT
810035	<a href="#">Study on Security of the enhancement to the 5GC location services</a>	FS_eLCS_Sec	S3	SP-180694	Wei Zhou, CATT
820016	<a href="#">Stage 2 of 5G_eLCS</a>	5G_eLCS	S2	SP-181119	Ming Ai, CATT
<b>830003</b>	<a href="#">CT aspects of 5G_eLCS</a>	<b>5G_eLCS</b>	<b>ct</b>	<b>CP-190014</b>	<b>Tingfang Tang, CATT</b>
830044	CT1 aspects of 5G_eLCS	5G_eLCS	C1	CP-191064	Tingfang Tang, CATT
830045	CT3 aspects of 5G_eLCS	5G_eLCS	C3	CP-191064	Tingfang Tang, CATT
830046	CT4 aspects of 5G_eLCS	5G_eLCS	C4	CP-191064	Tingfang Tang, CATT
<b>830077</b>	<a href="#">NR positioning support</a>	<b>NR_pos</b>	<b>R1</b>	<b>RP-191156</b>	<b>Intel</b>
800092	<a href="#">Study on NR positioning support</a>	FS_NR_pos	R1	RP-181399	Intel
830073	<a href="#">Study on local NR positioning in NG-RAN</a>	FS_NR_local_pos	R3	RP-190754	CMCC
830177	Core part: NR positioning support	NR_pos-Core	R1	RP-190752	Intel
830277	Perf. part: NR positioning support	NR_pos-Perf	R4	RP-190752	Intel
0	<a href="#">UE radio capability signalling optimization</a>	-	-	-	-
<b>840054</b>	<a href="#">Optimisations on UE radio capability signalling</a>	<b>RACS</b>	<b>S2</b>	<b>RP-191460</b>	<b>Haris Zisimopoulos</b>
800025	<a href="#">Study on RACS</a>	FS_RACS	S2	SP-180599	Haris Zisimopoulos, Qualcomm
830027	<a href="#">Stage 2 of RACS</a>	RACS	S2	SP-190180	Haris Zisimopoulos
<b>840003</b>	<a href="#">CT aspects of RACS</a>	<b>RACS</b>	<b>ct</b>	<b>CP-191061</b>	<b>Chaponniere, Lena, Qualcomm</b>
840055	CT1 aspects of RACS	RACS	C1	CP-191061	Chaponniere, Lena, Qualcomm
840056	CT3 aspects of RACS	RACS	C3	CP-191061	Chaponniere, Lena, Qualcomm
840057	CT4 aspects of RACS	RACS	C4	CP-191061	Chaponniere, Lena, Qualcomm
<b>830079</b>	<a href="#">Optimisations on UE radio capability signalling – NR/E-UTRA Aspects</a>	<b>RACS-RAN</b>	<b>R2</b>	<b>RP-190657</b>	<b>MediaTek</b>
800097	<a href="#">Study on optimisations on UE radio capability signalling – NR/E-UTRA Aspects</a>	FS_RACS_RAN	R2	RP-181459	MediaTek
830179	Core part: Optimisations on UE radio capability signalling – NR/E-UTRA Aspects	RACS-RAN-Core	R2	RP-191088	MediaTek
0	<a href="#">Satellite Access in 5G</a>	-	-	-	-
<b>800010</b>	<a href="#">Integration of Satellite Access in 5G</a>	<b>5GSAT</b>	<b>S1</b>	<b>SP-180326</b>	<b>MICHEL, Cyril, Thales</b>
770002	<a href="#">Study on using Satellite Access in 5G</a>	FS_5GSAT	S1	SP-170702	MICHEL, Cyril
800048	<a href="#">Stage 1 of 5GSAT</a>	5GSAT	S1	SP-180326	MICHEL, Cyril, Thales
800026	<a href="#">Study on architecture aspects for using satellite access in 5G</a>	FS_5GSAT_ARCH	S2	SP-181253	MICHEL, Cyril
800099	<a href="#">Study on solutions for NR to support non-terrestrial networks (NTN)</a>	FS_NR_NTN_solutions	R3	RP-190710	Thales
830025	<a href="#">Study on management and orchestration aspects with integrated satellite components in a 5G network</a>	FS_5GSAT_MO	S5	SP-190138	MICHEL, Cyril, THALES
0	<a href="#">Enablers for Network Automation Architecture for 5G</a>	-	-	-	-
<b>830047</b>	<a href="#">Enablers for Network Automation for 5G</a>	<b>eNA</b>	<b>S2</b>	<b>SP-181123</b>	<b>Xiaobo Wu, Huawei Technologies</b>
760047	<a href="#">Study of enablers for Network Automation for 5G</a>	FS_eNA	S2	SP-180792	Xiaobo Wu, Huawei Technologies
820020	<a href="#">Stage 2 of eNA</a>	eNA	S2	SP-181123	Xiaobo Wu, Huawei Technologies
<b>830009</b>	<a href="#">CT aspects of eNA</a>	<b>eNA</b>	<b>ct</b>	<b>CP-191111</b>	<b>Yali Yan, Huawei</b>
830048	CT3 aspects of eNA	eNA	C3	CP-191111	Yali Yan, Huawei
830049	CT4 aspects of eNA	eNA	C4	CP-191111	Yali Yan, Huawei
0	<a href="#">Wireless and Wireline Convergence Enhancement</a>	-	-	-	-
760044	<a href="#">Study on the Wireless and Wireline Convergence for the 5G system architecture</a>	FS_5WWC	S2	SP-170380	Marco Spini, Huawei Technologies
800031	<a href="#">Study on the security of the Wireless and Wireline Convergence for the 5G system architecture</a>	FS_5WWC_SEC	S3	SP-180438	He Li, Huawei Technologies
<b>830050</b>	<a href="#">Wireless and Wireline Convergence for the 5G system architecture</a>	<b>5WWC</b>		<b>SP-181117</b>	<b>Marco Spini, Huawei Technologies</b>

820014	Stage 2 of 5WWC	5WWC	S2	SP-181117	Marco Spini, Huawei Technologies
<b>829910</b>	<b>CT aspects of 5WWC</b>	<b>5WWC</b>	<b>ct</b>	<b>CP-191156</b>	<b>Herrero Veron, Christian (Huawei)</b>
829911	CT1 aspects of 5WWC	5WWC	C1	CP-191156	Herrero Veron, Christian (Huawei)
829912	CT3 aspects of 5WWC	5WWC	C3	CP-191156	Herrero Veron, Christian (Huawei)
829914	CT4 aspects of 5WWC	5WWC	C4	CP-191156	Herrero Veron, Christian (Huawei)
<b>830082</b>	<b>NG interface usage for WWC</b>	<b>5WWC-NG_interface</b>	<b>R3</b>	<b>RP-190772</b>	<b>Huawei</b>
830182	Core part: NG interface usage for WWC	5WWC-NG_interface-Core	R3	RP-190999	Huawei
0	Mission Critical, Public Warning, Railways and Maritime	-	-	-	-
790024	Study on MC services access aspects	FS_MCSAA	S6	SP-181135	Joakim Åkesson, Ericsson
800024	Study into discreet listening and logging for mission critical services	FS_MCLOG	S6	SP-181138	Chater-Lea, David, Motorola Solutions
810055	Study on location enhancements for mission critical services	FS_enhMCLoc	S6	SP-180921	Dom Lazara, Motorola Solutions
800022	Enhanced Mission Critical Push-to-talk architecture phase 2	enh2MCPTT	S6	SP-190068	Dom Lazara; Motorola Solutions
<b>830051</b>	<b>Enhancements to Functional architecture and information flows for Mission Critical Data</b>	<b>eMCDData2</b>	<b>S6</b>	<b>SP-180378</b>	<b>Shih, Jerry, AT&amp;T</b>
800018	Stage 2 of eMCDData2	eMCDData2	S6	SP-180378	Shih, Jerry, AT&T
830014	CT aspects of eMCDData2	eMCDData2	C1	CP-190199	Val Oprescu (AT&T)
800023	Study on Mission Critical services support over 5G System	FS_MCOver5GS	S6	SP-181136	Verweij, Kees, The Police of the Netherlands
810004	MCData File Distribution support over xMB	MC_XMB	S4	SP-180665	Thiénot Cédric, Expway
810011	Protocol enhancements for Mission Critical Services	MCProtoc16	C1	CP-182110	AXELL, Jörgen
<b>800053</b>	<b>MBMS APIs for Mission Critical Services</b>	<b>MBMSAPI_MCS</b>	<b>S6</b>	<b>SP-180380</b>	<b>Ling Zhang, TD Tech Ltd.</b>
760051	Study on MBMS APIs for MC Services	FS_MBMSAPI_MC	S6	SP-180237	Ling Zhang, TD Tech Ltd
800020	Stage 2 of MBMS APIs for MC Services	MBMSAPI_MCS	S6	SP-180380	Ling Zhang, TD Tech Ltd.
840013	Enhancement of 3GPP Northbound APIs	eNAPIs	C3	CP-191233	Yali Yan, Huawei
800019	Enhanced Mission Critical System Migration and Interconnection	eMCSMI	S6	SP-180379	Chater-Lea, David; Motorola Solutions
<b>810054</b>	<b>Enhanced Mission Critical Communication Interworking with Land Mobile Radio Systems</b>	<b>eMCCI</b>			<b>Monnes, Peter, Harris Corporation</b>
800021	Enhanced Mission Critical Communication Interworking with Land Mobile Radio Systems	eMCCI	S6	SP-180680	Monnes, Peter, Harris Corporation
800016	Stage 3 for MC Communication Interworking with Land Mobile Radio Systems	MCCI_CT	C1	CP-190203	Monnes, Peter, Harris Corporation
820040	Mission Critical system migration and interconnection	MCSMI_CT	C1	CP-190143	Dom Lazara, Motorola Solutions
800032	Mission Critical Services Security Enhancements	MCXSec	S3	SP-180596	Woodward, Tim, Motorola Solutions, Inc
<b>780003</b>	<b>Enhancements of Public Warning System</b>	<b>ePWS</b>		<b>SP-170998</b>	<b>Hyouhee Koo, SyncTechno Inc.</b>
730005	Study on enhancements of Public Warning System	FS_ePWS	S1	SP-160733	SyncTechno Inc., Hyouhee Koo
800052	Stage 1 of ePWS	ePWS	S1	SP-170998	Hyouhee Koo, SyncTechno Inc.
<b>810012</b>	<b>CT aspects of enhancements of Public Warning System</b>	<b>ePWS</b>	<b>ct</b>	<b>CP-191155</b>	<b>TaeHyeon Kim, SyncTechno Inc.</b>
810053	Study on stages 2 and 3 of enhancements of ePWS	ePWS	C1	CP-191155	TaeHyeon Kim, SyncTechno Inc.
810047	CT1 aspects of ePWS	ePWS	C1	CP-191155	TaeHyeon Kim, SyncTechno Inc.
810048	CT4 aspects of ePWS (Possible impacts)	ePWS	C4	CP-191155	TaeHyeon Kim, SyncTechno Inc.
<b>760054</b>	<b>Mobile Communication System for Railways 2</b>	<b>MONASTERY2</b>		<b>SP-170451</b>	<b>Merkel, Juergen, Nokia</b>
760005	Study on MONASTERY2	FS_FRMCS2	S1	SP-170588	Merkel, Juergen, Nokia
790023	Study on application architecture for the Future Railway Mobile Communication System (FRMCS) Phase 2	FS_FRMCS2_SA6	S6	SP-181133	Oettl, Martin, Nokia
760004	Stage 1 of MONASTERY2	MONASTERY2	S1	SP-170451	Merkel, Juergen, Nokia
830007	Application Architecture for MONASTERY2	MONASTERY2	S6	SP-190064	Oettl, Martin, Nokia
<b>840009</b>	<b>CT aspects of MONASTERY2</b>	<b>MONASTERY2</b>	<b>ct</b>	<b>CP-191152</b>	<b>Gkatzikis, Lazaros (Nokia)</b>
840072	CT1 aspects of MONASTERY2	MONASTERY2	C1	CP-191152	Gkatzikis, Lazaros (Nokia)
840073	CT3 aspects of MONASTERY2	MONASTERY2	C3	CP-191152	Gkatzikis, Lazaros (Nokia)
<b>840092</b>	<b>NR support for high speed train scenario</b>	<b>NR_HST</b>	<b>R4</b>	<b>RP-191512</b>	<b>CMCC</b>
840192	Core part: NR support for high speed train scenario	NR_HST-Core	R4	RP-191512	CMCC
840292	Perf. part: NR support for high speed train scenario	NR_HST-Perf	R4	RP-191512	CMCC
<b>800011</b>	<b>Maritime Communication Services over 3GPP System</b>	<b>MARCOM</b>	<b>S1</b>	<b>SP-180594</b>	<b>Hyouhee Koo, SyncTechno Inc</b>
730007	Study on Maritime Communication Services over 3GPP system	FS_MARCOM	S1	SP-170453	SyncTechno Inc., Hyouhee Koo
800051	Stage 1 of MARCOM	MARCOM	S1	SP-180594	Hyouhee Koo, SyncTechno Inc
0	Streaming and TV	-	-	-	-
<b>800008</b>	<b>Enhancement of LTE for Efficient delivery of Streaming Service</b>	<b>eLSTR</b>	<b>S1</b>	<b>SP-180322</b>	<b>Xia, Xu, China Telecom</b>
740001	Study on eLSTR	FS_eLESTR	S1	SP-160960	China Telecommunications, XIA Xu
800054	Stage 1 of eLSTR	eLSTR	S1	SP-180322	Xia, Xu, China Telecom
800001	Enhancements to Framework for Live Uplink Streaming	E_FLUS	S4	SP-180285	Lo, Charles, Qualcomm
810003	Coverage and Handoff Enhancements for Multimedia	CHEM	S4	SP-180664	Nikolai Leung
770027	Study on QoE metrics for VR	FS_QoE_VR	S4	SP-170614	Ericsson (Gunnar Heikkilä)
760039	Study on 5G enhanced Mobile Broadband Media Distribution	FS_5GMedia_Distribution	S4	SP-170334	Bouazizi, Imed, Samsung Electronics Co., Ltd.,
820002	Media streaming architecture	5GMSA	S4	SP-180984	Frédéric GABIN
<b>810040</b>	<b>Media Handling Extensions for 5G Conversational Services</b>	<b>5G_MEDIA_MTSI_ext</b>	<b>S4</b>	<b>SP-180663</b>	<b>Oyman, Ozgur, Company: Intel</b>
760041	Study on Media Handling Aspects of Conversational Services in 5G Systems	FS_5G_MEDIA_MTSI	S4	SP-170336	Oyman, Ozgur, Company: Intel
810002	Media Handling Extensions for 5G Conversational Services	5G_MEDIA_MTSI_ext	S4	SP-180663	Oyman, Ozgur, Company: Intel
770031	Study on EVS Float Conformance Non Bit-Exact	FS_EVS_FCNBE	S4	SP-170618	Fabrice Plante, Intel
820001	EVS Floating-point Conformance for Non Bit-Exact	EVS_FCNBE	S4	SP-180983	Fabrice, Plante, Intel
800003	Addition of HLG HDR to TV Video Profiles	HLG_HDR	S4	SP-180287	Paul Szucs, Sony Europe Limited
0	User Identities, Authentication, multi-device	-	-	-	-
<b>800012</b>	<b>User Identities and Authentication</b>	<b>UIA</b>	<b>S1</b>	<b>SP-180328</b>	<b>Bischinger, Kurt; Deutsche Telekom</b>

780004	<b>Study on a Layer for User Centric Identifiers and Authentication</b>	FS_LUCIA	S1	SP-170995	Bischinger, Kurt; Deutsche Telekom
800050	<b>Stage 1 of User Identities and Authentication</b>	UIA	S1	SP-180328	Bischinger, Kurt; Deutsche Telekom
<b>810044</b>	<b>Multi-device and multi-identity</b>	<b>MuD</b>	<b>S1</b>	<b>SP-180315</b>	<b>Peter Bleckert, Ericsson</b>
800004	<b>Stage 1 of Multi-device and multi-identity</b>	MuD	S1	SP-180315	Peter Bleckert, Ericsson
<b>810010</b>	<b>CT aspects of Multi-device and multi-identity</b>	<b>MuD</b>	<b>ct</b>	<b>CP-182227</b>	<b>Axell, Jörgen, Ericsson</b>
810045	CT1 aspects of Multi-device and multi-identity	MuD	C1	CP-182227	Axell, Jörgen, Ericsson
810046	CT3 aspects of Multi-device and multi-identity	MuD	C3	CP-182227	Axell, Jörgen, Ericsson
0	<b>Slicing</b>	-		-	-
<b>830103</b>	<b>Enhancement of Network Slicing</b>	<b>eNS</b>		<b>SP-181232</b>	<b>ZTE, Tricci So</b>
790011	<b>Study on Enhancement of Network Slicing</b>	FS_eNS	S2	SP-180503	ZTE, Tricci So
820023	<b>Stage 2 of eNS</b>	eNS	S2	SP-181232	ZTE, Tricci So
<b>830011</b>	<b>CT aspects of eNS</b>	<b>eNS</b>	<b>ct</b>	<b>CP-190196</b>	<b>Fei Lu, ZTE</b>
830052	CT1 aspects of eNS	eNS	C1	CP-190196	Fei Lu, ZTE
830053	CT3 aspects of eNS	eNS	C3	CP-190196	Fei Lu, ZTE
830054	CT4 aspects of eNS	eNS	C4	CP-190196	Fei Lu, ZTE
<b>810051</b>	<b>Business Role Models for Network Slicing</b>	<b>BRMNS</b>	<b>S1</b>	<b>SP-180773</b>	<b>Covell, Betsy, Nokia</b>
770005	<b>Study on Business Role Models for Network Slicing</b>	FS_BMNS	S1	SP-180169	Covell, Betsy, Nokia
810015	<b>Business Role Models for Network Slicing</b>	BRMNS	S1	SP-180773	Covell, Betsy, Nokia
810034	<b>Study on Security aspects of Enhancement of Network Slicing</b>	FS_eNS_SEC	S3	SP-180692	
810022	<b>Study on tenancy concept in 5G networks and network slicing management</b>	FS_TENANCY	S5	SP-180815	ZHU, Lei (Huawei)
810031	<b>Enhancement of performance assurance for 5G networks including network slicing</b>	5G_SLICE_ePA	S5	SP-190247	Xiaowei Sun (China Mobile)
820029	<b>Study on Charging Aspects of Network Slicing</b>	FS_NETSLICE_CH	S5	SP-181065	Chen Shan, Huawei
0	<b>Other cross-TSG Release 16 Features</b>	-		-	-
<b>760003</b>	<b>Provision of Access to Restricted Local Operator Services by Unauthenticated UEs</b>	<b>PARLOS</b>		<b>SP-170449</b>	<b>Covell, Betsy Nokia</b>
740002	<b>Study on Stage 1 of PARLOS</b>	FS_PARLOS	S1	SP-160904	Covell, Betsy
760046	<b>Study on Stage 2 for PARLOS</b>	FS_PARLOS_SA2	S2	SP-180501	Nokia (Nicolas Drevon)
800035	<b>Study on Security Aspects of PARLOS</b>	FS_PARLOS_Sec	S3	SP-180442	Greg Schumacher, Sprint
760071	<b>Stage 1 of PARLOS</b>	PARLOS	S1	SP-170449	Covell, Betsy Nokia
810008	<b>Stage 2 of PARLOS</b>	PARLOS	S2	SP-180738	Nokia (Nicolas Drevon)
<b>830012</b>	<b>CT aspects of PARLOS</b>	<b>PARLOS</b>	<b>ct</b>	<b>CP-190197</b>	<b>Liu, Jennifer; Nokia</b>
830062	CT1 aspects of PARLOS	PARLOS	C1	CP-190197	Liu, Jennifer; Nokia
830063	CT3 aspects of PARLOS	PARLOS	C3	CP-190197	Liu, Jennifer; Nokia
830064	CT4 aspects of PARLOS	PARLOS	C4	CP-190197	Liu, Jennifer; Nokia
830065	CT6 aspects of PARLOS	PARLOS	C6	CP-190197	Liu, Jennifer; Nokia
<b>820043</b>	<b>Enhancing Topology of SMF and UPF in 5G Networks</b>	<b>ETSUN</b>		<b>SP-181116</b>	<b>Laurent Thiebaut (Nokia)</b>
770039	<b>Study on ETSUN</b>	FS_ETSUN	S2	SP-180731	Laurent Thiebaut (Nokia)
820013	<b>Stage 2 of ETSUN</b>	ETSUN	S2	SP-181116	
<b>830002</b>	<b>CT aspects of ETSUN</b>	<b>ETSUN</b>	<b>ct</b>	<b>CP-190192</b>	<b>Landais, Bruno, Nokia</b>
830055	CT3 aspects of ETSUN	ETSUN	C3	CP-190192	Landais, Bruno, Nokia
830056	CT4 aspects of ETSUN	ETSUN	C4	CP-190192	Landais, Bruno, Nokia
<b>820044</b>	<b>Access Traffic Steering, Switch and Splitting support in the 5G system architecture</b>	<b>ATSSS</b>		<b>SP-181124</b>	<b>So, Tricci, ZTE</b>
760052	<b>Study on ATSSS</b>	FS_ATSSS	S2	SP-180732	So, Tricci, ZTE
820021	<b>Stage 2 of ATSSS</b>	ATSSS	S2	SP-181124	So, Tricci, ZTE
<b>830016</b>	<b>CT aspects of ATSSS</b>	<b>ATSSS</b>	<b>ct</b>	<b>CP-190201</b>	<b>ZHOU, Xingyue (Joy), ZTE</b>
830057	CT1 aspects of ATSSS	ATSSS	C1	CP-190201	ZHOU, Xingyue (Joy), ZTE
830058	CT3 aspects of ATSSS	ATSSS	C3	CP-190201	ZHOU, Xingyue (Joy), ZTE
830059	CT4 aspects of ATSSS	ATSSS	C4	CP-190201	ZHOU, Xingyue (Joy), ZTE
840999	(IETF) TCP Extensions for Multipath Operation with Multiple Addresses (draft-ietf-mptcp-rfc6824bis)	ATSSS	S2-IETF		
840998	(IETF) 0-RTT TCP Convert Protocol (draft-ietf-tcpm-converters)	ATSSS	S2-IETF		
<b>810041</b>	<b>Single radio voice continuity from 5GS to 3G</b>	<b>5G_SRVCC</b>		<b>SP-180737</b>	<b>Chi Ren, China Unicom</b>
790010	<b>Study for single radio voice continuity from 5GS to 3G</b>	FS_5G-SRVCC	S2	SP-180239	Chi Ren, China Unicom
810007	<b>Single radio voice continuity from 5GS to 3G</b>	5G_SRVCC	S2	SP-180897	Chi Ren, China Unicom
820008	<b>Security aspects of single radio voice continuity from 5GS to UTRAN</b>	5GS_UTRAN_SEC	S3	SP-181037	Feng Gao, China Unicom
<b>820069</b>	<b>RAN aspects of 5G_SRVCC</b>	<b>SRVCC_NR_to_UMTS</b>	<b>R2</b>	<b>RP-190713</b>	<b>China Unicom</b>
820169	Core part: Single Radio Voice Call Continuity from 5G to 3G	SRVCC_NR_to_UMTS-Core	R2	RP-190713	China Unicom
830270	Perf. part: Single Radio Voice Call Continuity from 5G to 3G	SRVCC_NR_to_UMTS-Perf	R4	RP-190713	China Unicom
<b>840004</b>	<b>CT aspect of 5G_SRVCC</b>	<b>5G_SRVCC</b>	<b>ct</b>	<b>CP-191062</b>	<b>Chi Ren, China Unicom</b>
840058	CT1 aspect of 5G_SRVCC	5G_SRVCC	C1	CP-191062	Chi Ren, China Unicom
840059	CT4 aspect of 5G_SRVCC	5G_SRVCC	C4	CP-191062	Chi Ren, China Unicom
<b>810049</b>	<b>Remote Identification of Unmanned Aerial Systems</b>	<b>ID_UAS</b>		<b>SP-180771</b>	<b>Eddy HALL, Qualcomm</b>
790005	<b>Study on Remote Identification of Unmanned Aerial Systems</b>	FS_ID_UAS	S1	SP-180172	Eddy Hall, Qualcomm
810013	<b>Stage 1 of Remote Identification of Unmanned Aerial Systems</b>	ID_UAS	S1	SP-180771	Eddy HALL, Qualcomm
800034	<b>Study on Security Aspects of the 5G Service Based Architecture</b>	FS_SBA_Sec	S3	SP-180598	Hans Christian Rudolph, Deutsche Telekom AG
<b>820045</b>	<b>Enhancements to the Service-Based 5G System Architecture</b>	<b>5G_eSBA</b>	<b>S2</b>	<b>SP-181125</b>	
790007	<b>Study on Enhancements to the Service-Based 5G System Architecture</b>	FS_eSBA	S2	SP-180231	Tao Sun (China Mobile)
820022	<b>Stage 2 of 5G_eSBA</b>	5G_eSBA	S2	SP-181125	Tao Sun (China Mobile)
<b>830001</b>	<b>CT aspects of 5G_eSBA</b>	<b>5G_eSBA</b>	<b>ct</b>	<b>CP-190191</b>	<b>Song Yue (China Mobile)</b>
830060	CT3 aspects of 5G_eSBA	5G_eSBA	C3	CP-190191	Song Yue (China Mobile)
830061	CT4 aspects of 5G_eSBA	5G_eSBA	C4	CP-190191	Song Yue (China Mobile)
780029	<b>Study on Enhanced IMS to 5GC Integration</b>	FS_eIMS5G	S2	SP-180736	Joul, Chris, T-Mobile USA
<b>840062</b>	<b>SBA aspects of enhanced IMS to 5GC integration</b>	<b>eIMS5G_SBA</b>	<b>S2</b>	<b>SP-190181</b>	<b>T-Mobile USA, Christopher Joul</b>
830028	<b>Stage 2 of eIMS5G_SBA</b>	eIMS5G_SBA	S2	SP-190181	T-Mobile USA, Christopher Joul

840006	CT aspects of eIMS5G_SBA	eIMS5G_SBA	ct	CP-191065	de Gregorio, Jesus. Ericsson
840063	CT3 aspects of eIMS5G_SBA	eIMS5G_SBA	C3	CP-191065	de Gregorio, Jesus. Ericsson
840064	CT4 aspects of eIMS5G_SBA	eIMS5G_SBA	C4	CP-191065	de Gregorio, Jesus. Ericsson
830081	<b>Private Network Support for NG-RAN</b>	<b>NG_RAN_PRN</b>	<b>R3</b>	<b>RP-190729</b>	<b>China Telecom</b>
830181	Core part: Private Network Support for NG-RAN	NG_RAN_PRN-Core	R3	RP-191563	China Telecom
810039	<b>Media Handling Aspects of RAN Delay Budget Reporting in MTSI</b>	<b>E2E_DELAY</b>	<b>S4</b>	<b>SP-180662</b>	<b>Oyman, Ozgur, Company: Intel</b>
780022	Study on E2E_DELAY	FS_E2E_DELAY	S4	SP-170837	Oyman, Ozgur, Company: Intel,
810001	Stage 2 of E2E_DELAY	E2E_DELAY	S4	SP-180662	Oyman, Ozgur, Company: Intel
830004	CT Aspects of E2E_DELAY	E2E_DELAY	ct	CP-190193	Luetzenkirchen, Thomas, Intel
830066	CT1 Aspects of E2E_DELAY	E2E_DELAY	C1	CP-190193	Luetzenkirchen, Thomas, Intel
830067	CT3 Aspects of E2E_DELAY	E2E_DELAY	C3	CP-190193	Luetzenkirchen, Thomas, Intel
830068	CT4 Aspects of E2E_DELAY	E2E_DELAY	C4	CP-190193	Luetzenkirchen, Thomas, Intel
830069	<b>Enhancements for Common API Framework for 3GPP Northbound APIs</b>	<b>eCAPIF</b>		<b>SP-181137</b>	<b>Basavaraj Pattan, Samsung</b>
790022	Stage 2 for eCAPIF	eCAPIF	S6	SP-181137	Basavaraj Pattan, Samsung
830022	Security aspects of eCAPIF	eCAPIF	S3	SP-1901240	Rajavelsamy Rajadurai, Samsung
790019	Usage of CAPIF for xMB API	CAPIF4xMB	S4	SP-180031	Thorsten Lohmar, Ericsson LM
840065	<b>User data interworking, Coexistence and Migration</b>	<b>UDICOM</b>	<b>S2</b>	<b>SP-190182</b>	<b>Alessio Casati, Nokia</b>
800055	Study on UDICOM	FS_UDICOM	S2	SP-190148	Susana Sabater (Vodafone)
830029	Stage 2 of UDICOM	UDICOM	S2	SP-190182	Alessio Casati, Nokia
840007	CT aspects of UDICOM	UDICOM	C4	CP-191066	Wiehe, Ulrich, Nokia
0	<b>NR-related Release 16 Features</b>	-		-	-
830075	<b>UE Power Saving in NR</b>	<b>NR_UE_pow_sav</b>	<b>R1</b>	<b>RP-191607</b>	<b>CATT</b>
800094	Study on UE power saving in NR	FS_NR_UE_pow_sav	R1	RP-181463	CATT
830175	Core part: UE Power Saving in NR	NR_UE_pow_sav-Core	R1	RP-190727	CATT
830275	Perf. part: UE Power Saving in NR	NR_UE_pow_sav-Perf	R4	RP-190727	CATT
820070	<b>Integrated access and backhaul for NR</b>	<b>NR_IAB</b>		<b>RP-191558</b>	<b>Qualcomm</b>
750047	Study on NR_IAB	FS_NR_IAB	R2	RP-181349	Qualcomm
820170	Core part: NR_IAB	NR_IAB-Core	R2	RP-190712	Qualcomm
820270	Perf. Part: NR_IAB	NR_IAB-Perf	R4	RP-190712	Qualcomm
830021	Study on Security for NR_IAB	FS_NR_IAB_Sec	S3	SP-190106	Rajavelsamy Rajadurai, Samsung,
800072	<b>Band combinations for SA NR supplementary uplink (SUL), NSA NR SUL, NSA NR SUL with UL sharing from the UE perspective (ULSUP)</b>	<b>NR_SUL_combos_R16</b>	<b>R4</b>	<b>RP-191126</b>	<b>Huawei</b>
800172	Core part: 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_R16-Core	R4	RP-190714	Huawei
800272	Perf. part: 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_R16-Perf	R4	RP-190714	Huawei
800057	<b>NR intra-band Carrier Aggregation</b>				
800073	<b>Rel-16 NR intra band CA for xCC DL/yCC UL including contiguous and non-contiguous spectrum (x&gt;=y)</b>	<b>NR_CA_R16_intra</b>	<b>R4</b>	<b>RP-191194</b>	<b>Ericsson</b>
800173	Core part: Rel-16 NR intra band CA for xCC DL/yCC UL including contiguous and non-contiguous spectrum (x>=y)	NR_CA_R16_intra-Core	R4	RP-190689	Ericsson
800273	Perf. part: Rel-16 NR intra band CA for xCC DL/yCC UL including contiguous and non-contiguous spectrum (x>=y)	NR_CA_R16_intra-Perf	R4	RP-190689	Ericsson
800074	<b>Rel-16 NR inter-band CA/Dual Connectivity for 2 bands DL with x bands UL (x=1, 2)</b>	<b>NR_CADC_R16_2BDL_xBUL</b>	<b>R4</b>	<b>RP-191565</b>	<b>ZTE</b>
800174	Core part: Rel-16 NR inter-band CA/Dual Connectivity for 2 bands DL with x bands UL (x=1, 2)	NR_CADC_R16_2BDL_xBUL-Core	R4	RP-190494	ZTE
800274	Perf. part: Rel-16 NR inter-band CA/Dual Connectivity for 2 bands DL with x bands UL (x=1, 2)	NR_CADC_R16_2BDL_xBUL-Perf	R4	RP-190494	ZTE
830099	<b>NR inter-band Carrier Aggregation</b>				
830083	<b>UE Conformance Test Aspects - Rel-16 NR CA and DC; and NR and LTE DC Configurations</b>	<b>NR_CADC_NR_LTE_DC_R16-UEConTest</b>	<b>R5</b>	<b>RP-190321</b>	<b>CMCC</b>
830095	<b>Rel16 NR inter-band Carrier Aggregation for 3 bands DL with 1 band UL</b>	<b>NR_CA_R16_3BDL_1BUL</b>	<b>R4</b>	<b>RP-191153</b>	<b>CATT</b>
830195	Core part: Rel16 NR inter-band Carrier Aggregation for 3 bands DL with 1 band UL	NR_CA_R16_3BDL_1BUL-Core	R4	RP-190692	CATT
830295	Perf. part: Rel16 NR inter-band Carrier Aggregation for 3 bands DL with 1 band UL	NR_CA_R16_3BDL_1BUL-Perf	R4	RP-190692	CATT
830096	<b>Rel-16 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with 2 bands UL</b>	<b>NR_CADC_R16_3BDL_2BUL</b>	<b>R4</b>	<b>RP-191566</b>	<b>ZTE</b>
830196	Core part: Rel-16 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with 2 bands UL	NR_CADC_R16_3BDL_2BUL-Core	R4	RP-190693	ZTE
830296	Perf. part: Rel-16 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with 2 bands UL	NR_CADC_R16_3BDL_2BUL-Perf	R4	RP-190693	ZTE
831000	<b>New bands for New Radio</b>		<b>R4</b>		<b>Dish Network</b>
800077	<b>Band 65 for New Radio</b>	<b>NR_band_n65</b>	<b>R4</b>	<b>RP-190360</b>	<b>Dish Network</b>
800177	Core part: Band 65 for New Radio	NR_band_n65-Core	R4	RP-190360	Dish Network
800277	Perf. part: Band 65 for New Radio	NR_band_n65-Perf	R4	RP-190360	Dish Network
820073	<b>Introduction of NR band n18</b>	<b>NR_n18</b>	<b>R4</b>	<b>RP-191556</b>	<b>KDDI</b>
820173	Core part: Introduction of NR band n18	NR_n18-Core	R4	RP-190173	KDDI
820273	Perf. part: Introduction of NR band n18	NR_n18-Perf	R4	RP-190173	KDDI
820077	<b>Introduction of NR band n48</b>	<b>NR_n48</b>	<b>R4</b>	<b>RP-190908</b>	<b>US Cellular</b>
820177	Core part: Introduction of NR band n48	NR_n48-Core	R4	RP-182865	US Cellular
830271	Perf. part: Introduction of NR band n48	NR_n48-Perf	R4	RP-190140	Nokia
830090	<b>Introduction of NR band n14</b>	<b>NR_n14</b>	<b>R4</b>	<b>RP-190965</b>	<b>AT&amp;T</b>
830190	Core part: Introduction of NR band n14	NR_n14-Core	R4	RP-190165	AT&T
830290	Perf. part: Introduction of NR band n14	NR_n14-Perf	R4	RP-190165	AT&T
830091	<b>Introduction of NR band n30</b>	<b>NR_n30</b>	<b>R4</b>	<b>RP-190967</b>	<b>AT&amp;T</b>
830191	Core part: Introduction of NR band n30	NR_n30-Core	R4	RP-190166	AT&T
830291	Perf. part: Introduction of NR band n30	NR_n30-Perf	R4	RP-190166	AT&T
830097	<b>Introduction of NR band n259</b>	<b>NR_n259</b>	<b>R4</b>	<b>RP-191416</b>	<b>Ericsson</b>

830197	Core part: Introduction of NR band n259	NR_n259-Core	R4	RP-190765	Ericsson
830297	Perf. part: Introduction of NR band n259	NR_n259-Perf	R4	RP-190765	Ericsson
<b>840097</b>	<b>Introduction of NR supplementary DL band n29</b>	<b>NR_n29</b>	<b>R4</b>	<b>RP-191474</b>	<b>Dish Network</b>
840197	Core part: Introduction of NR supplementary DL band n29	NR_n29-Core	R4	RP-191474	Dish Network
840297	Perf. part: Introduction of NR supplementary DL band n29	NR_n29-Perf	R4	RP-191474	Dish Network
<b>831001</b>	<b>New Radio Band-related topics</b>		<b>R4</b>		<b>Nokia</b>
<b>830087</b>	<b>RF requirements for NR frequency range 1 (FR1)</b>	<b>NR_RF_FR1</b>	<b>R4</b>	<b>RP-191114</b>	<b>Huawei</b>
830187	Core part: RF requirements for NR frequency range 1 (FR1)	NR_RF_FR1-Core	R4	RP-191114	Huawei
830287	Perf. part: RF requirements for NR frequency range 1 (FR1)	NR_RF_FR1-Perf	R4	RP-191114	Huawei
<b>830088</b>	<b>Add support of NR DL 256QAM for frequency range 2 (FR2)</b>	<b>NR_DL256QAM_FR2</b>	<b>R4</b>	<b>RP-190925</b>	<b>China Telecom</b>
830188	Core part: Add support of NR DL 256QAM for frequency range 2 (FR2)	NR_DL256QAM_FR2-Core	R4	RP-190760	China Telecom
830288	Perf. part: Add support of NR DL 256QAM for frequency range 2 (FR2)	NR_DL256QAM_FR2-Perf	R4	RP-190760	China Telecom
<b>830089</b>	<b>NR RF requirement enhancements for frequency range 2 (FR2)</b>	<b>NR_RF_FR2_req_enh</b>	<b>R4</b>	<b>RP-191290</b>	<b>Nokia</b>
830189	Core part: NR RF requirement enhancements for frequency range 2 (FR2)	NR_RF_FR2_req_enh-Core	R4	RP-190761	Nokia
<b>830092</b>	<b>Introduction of an NR SUL (supplemental uplink) band with same uplink frequency range as NR band n5</b>	<b>NR_SUL_UL_n5</b>	<b>R4</b>	<b>RP-191116</b>	<b>Huawei</b>
830192	Core part: Introduction of an NR SUL (supplemental uplink) band with same uplink frequency range as NR band n5	NR_SUL_UL_n5-Core	R4	RP-191116	Huawei
830292	Perf. part: Introduction of an NR SUL (supplemental uplink) band with same uplink frequency range as NR band n5	NR_SUL_UL_n5-Perf	R4	RP-191116	Huawei
<b>820074</b>	<b>Adding wider channel bandwidths in NR band n7</b>	<b>NR_n7_BW</b>	<b>R4</b>	<b>RP-190137</b>	<b>BT</b>
820174	Core part: Adding wider channel bandwidths in NR band n7	NR_n7_BW-Core	R4	RP-190137	BT
<b>830093</b>	<b>Addition of wider channel bandwidth in NR band n38</b>	<b>NR_n38_BW</b>	<b>R4</b>	<b>RP-191472</b>	<b>Huawei</b>
830193	Core part: Addition of wider channel bandwidth in NR band n38	NR_n38_BW-Core	R4	RP-190392	Huawei
830293	Perf. part: Addition of wider channel bandwidth in NR band n38	NR_n38_BW-Perf	R4	RP-190392	Huawei
<b>820075</b>	<b>Addition of 30MHz channel bandwidth for NR band n41</b>	<b>NR_n41_BW</b>	<b>R4</b>	<b>RP-191569</b>	<b>KDDI</b>
820175	Core part: Addition of 30MHz channel bandwidth for NR band n41	NR_n41_BW-Core	R4	RP-190174	KDDI
820275	Perf. part: Addition of 30MHz channel bandwidth for NR band n41	NR_n41_BW-Perf	R4	RP-190174	KDDI
<b>820076</b>	<b>Adding wider channel bandwidths in NR band n50</b>	<b>NR_n50_BW</b>	<b>R4</b>	<b>RP-182829</b>	<b>Huawei</b>
820176	Core part: Adding wider channel bandwidths in NR band n50	NR_n50_BW-Core	R4	RP-182829	Huawei
<b>800085</b>	<b>Enhancements on MIMO for NR</b>	<b>NR_eMIMO</b>	<b>R1</b>	<b>RP-182863</b>	<b>Samsung</b>
800185	Core part: Enhancements on MIMO for NR	NR_eMIMO-Core	R1	RP-182863	Samsung
800285	Perf. part: Enhancements on MIMO for NR	NR_eMIMO-Perf	R4	RP-182863	Samsung
<b>800087</b>	<b>NR mobility enhancements</b>	<b>NR_Mob_enh</b>	<b>R2</b>	<b>RP-190489</b>	<b>Intel</b>
800187	Core part: NR mobility enhancements	NR_Mob_enh-Core	R2	RP-190489	Intel
800287	Perf. part: NR mobility enhancements	NR_Mob_enh-Perf	R4	RP-190489	Intel
<b>820068</b>	<b>2-step RACH for NR</b>	<b>NR_2step_RACH</b>	<b>R1</b>	<b>RP-190711</b>	<b>ZTE</b>
820168	Core part: 2-step RACH for NR	NR_2step_RACH-Core	R1	RP-190711	ZTE
820268	Perf. part: 2-step RACH for NR	NR_2step_RACH-Perf	R4	RP-190711	ZTE
<b>840091</b>	<b>SON (Self-Organising Networks) and MDT (Minimization of Drive Tests) support for NR</b>	<b>NR_SON_MDT</b>	<b>R3</b>	<b>RP-191594</b>	<b>CMCC</b>
840191	Core part: SON (Self-Organising Networks) and MDT (Minimization of Drive Tests) support for NR	NR_SON_MDT-Core	R3	RP-191594	CMCC
<b>840093</b>	<b>RRM requirement for CSI-RS based L3 measurement in NR</b>	<b>NR_CSIRS_L3meas</b>	<b>R4</b>	<b>RP-191580</b>	<b>CATT</b>
840193	Core part: RRM requirement for CSI-RS based L3 measurement in NR	NR_CSIRS_L3meas-Core	R4	RP-191580	CATT
840293	Perf. part: RRM requirement for CSI-RS based L3 measurement in NR	NR_CSIRS_L3meas-Perf	R4	RP-191580	CATT
<b>840094</b>	<b>NR performance requirement enhancement</b>	<b>NR_perf_enh</b>	<b>R4</b>	<b>RP-191587</b>	<b>China Telecom</b>
840294	Core part: NR performance requirement enhancement	NR_perf_enh-Core	R4	RP-191587	China Telecom
<b>840095</b>	<b>NR RRM enhancement</b>	<b>NR_RRM_enh</b>	<b>R4</b>	<b>RP-191601</b>	<b>Intel</b>
840195	Core part: NR RRM enhancement	NR_RRM_enh-Core	R4	RP-191601	Intel
840295	Perf. part: NR RRM enhancement	NR_RRM_enh-Perf	R4	RP-191601	Intel
<b>840096</b>	<b>Rel-16 NR inter-band Carrier Aggregation for 4 bands DL with 1 band UL</b>	<b>NR_CA_R16_4BDL_1BUL</b>	<b>R4</b>	<b>RP-191196</b>	<b>Ericsson</b>
840196	Core part: Rel-16 NR inter-band Carrier Aggregation for 4 bands DL with 1 band UL	NR_CA_R16_4BDL_1BUL-Core	R4	RP-191196	Ericsson
840296	Perf. part: Rel-16 NR inter-band Carrier Aggregation for 4 bands DL with 1 band UL	NR_CA_R16_4BDL_1BUL-Perf	R4	RP-191196	Ericsson
<b>840098</b>	<b>Addition of wider channel bandwidth in NR band n1</b>	<b>NR_n1_BW</b>	<b>R4</b>	<b>RP-191595</b>	<b>Ericsson</b>
840198	Core part: Addition of wider channel bandwidth in NR band n1	NR_n1_BW-Core	R4	RP-191595	Ericsson
840298	Perf. part: Addition of wider channel bandwidth in NR band n1	NR_n1_BW-Perf	R4	RP-191595	Ericsson
<b>840099</b>	<b>Addition of channel bandwidths in Band n77 and n78</b>	<b>NR_n77_n78_BW</b>	<b>R4</b>	<b>RP-191606</b>	<b>Huawei</b>
840199	Core part: Addition of channel bandwidths in Band n77 and n78	NR_n77_n78_BW-Core	R4	RP-191606	Huawei
<b>841000</b>	<b>Dual Connectivity (EN-DC) with 3 bands DL and 3 bands UL</b>	<b>DC_R16_LTE_NR_3DL3UL</b>	<b>R4</b>	<b>RP-191598</b>	<b>ZTE</b>
841100	Core part: Dual Connectivity (EN-DC) with 3 bands DL and 3 bands UL	DC_R16_LTE_NR_3DL3UL-Core	R4	RP-191598	ZTE
841200	Perf. part: Dual Connectivity (EN-DC) with 3 bands DL and 3 bands UL	DC_R16_LTE_NR_3DL3UL-Perf	R4	RP-191598	ZTE
<b>841001</b>	<b>Introduction of NR FDD bands with variable duplex and corresponding framework</b>	<b>NR_FDD_bands_var duplex</b>	<b>R4</b>	<b>RP-191567</b>	<b>Huawei</b>
841101	Core part: Introduction of NR FDD bands with variable duplex and corresponding framework	NR_FDD_bands_var duplex-Core	R4	RP-191567	Huawei
<b>841002</b>	<b>Common RF requirement configured output power for EN-DC with 3 uplink CC and 2 different bands (2CC LTE, 1CC NR FR1)</b>	<b>DC_Pcmax_3UL_CC</b>	<b>R4</b>	<b>RP-191604</b>	<b>Huawei</b>
841102	Core part: Common RF requirement configured output power for EN-DC with 3 uplink CC and 2 different bands (2CC LTE, 1CC NR FR1)	DC_Pcmax_3UL_CC-Core	R4	RP-191604	Huawei
<b>800082</b>	<b>Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR</b>	<b>NR_CLI_RIM</b>	<b>R1</b>	<b>RP-191546</b>	<b>LG Electronics</b>
800182	Core part: Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR	NR_CLI_RIM-Core	R1	RP-190700	LG Electronics
800282	Perf. part: Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NR	NR_CLI_RIM-Perf	R4	RP-190700	LG Electronics
0	Release 16 Features impacting both LTE and NR	-	-	-	-

800088	<b>LTE-NR &amp; NR-NR Dual Connectivity and NR Carrier Aggregation enhancements</b>	LTE_NR_DC_CA_enh	R2	RP-191600	Ericsson
800188	Core part: LTE-NR & NR-NR Dual Connectivity and NR CA enhancements	LTE_NR_DC_CA_enh-Core	R2	RP-190452	Ericsson
800288	Perf. part: LTE-NR & NR-NR Dual Connectivity and NR CA enhancements	LTE_NR_DC_CA_enh-Perf	R4	RP-190452	Ericsson
820079	<b>High power UE (power class 2) for EN-DC (1 LTE TDD band + 1 NR TDD band)</b>	ENDC_UE_PC2_TDD_TDD	R4	RP-190315	CMCC
820061	Study on high power UE (power class 2) for EN-DC (1 LTE FDD band + 1 NR TDD band)	FS_ENDC_UE_PC2_FDD_TDD	R4	RP-190167	China Unicom
820179	Core part: High power UE (power class 2) for EN-DC (1 LTE TDD band + 1 NR TDD band)	ENDC_UE_PC2_TDD_TDD-Core	R4	RP-190315	CMCC
820279	Perf. part: Power class 2 UE for EN-DC (1 LTE TDD band + 1 NR TDD band)	ENDC_UE_PC2_TDD_TDD-Perf	R4	RP-190315	CMCC
790054	<b>eNB(s) Architecture Evolution for E-UTRAN and NG-RAN</b>	LTE_NR_arch_evo	R3	RP-180531	China Unicom
790154	Core part: eNB(s) Architecture Evolution for E-UTRAN and NG-RAN	LTE_NR_arch_evo-Core	R3	RP-181375	China Unicom
820080	<b>LTE/NR spectrum sharing in Band 41/n41 frequency range</b>	NR_n41_LTE_41_coex	R4	RP-191588	KDDI
820180	Core part: LTE/NR spectrum sharing in Band 41/n41 frequency range	NR_n41_LTE_41_coex-Core	R4	RP-190175	KDDI
800078	<b>29 dBm UE Power Class for LTE band 41 and NR Band n41</b>	LTE_NR_B41_Bn41_PC29dBm	R4	RP-190502	Sprint
800178	Core part: 29 dBm UE Power Class for LTE band 41 and NR Band n41	LTE_NR_B41_Bn41_PC29dBm-Core	R4	RP-190502	Sprint
800058	<b>Dual Connectivity (EN-DC)</b>		R4		Ericsson
800066	<b>Dual Connectivity (EN-DC) of 1 LTE band (1UL/1DL) and 1 NR band (1DL/1UL)</b>	DC_R16_1BLTE_1BNR_2DL2UL	R4	RP-191568	NTT DOCOMO
800166	Core part: Dual Connectivity (EN-DC) of 1 LTE band (1UL/1DL) and 1 NR band (1DL/1UL)	DC_R16_1BLTE_1BNR_2DL2UL-Core	R4	RP-190705	NTT DOCOMO
800266	Perf. part: Dual Connectivity (EN-DC) of 1 LTE band (1UL/1DL) and 1 NR band (1DL/1UL)	DC_R16_1BLTE_1BNR_2DL2UL-Perf	R4	RP-190705	NTT DOCOMO
800067	<b>Dual Connectivity (EN-DC) of 2 bands LTE inter-band CA (2DL/1UL) and 1 NR band (1DL/1UL)</b>	DC_R16_2BLTE_1BNR_3DL2UL	R4	RP-191124	Huawei
800167	Core part: Dual Connectivity (EN-DC) of 2 bands LTE inter-band CA (2DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_2BLTE_1BNR_3DL2UL-Core	R4	RP-190379	Huawei
800267	Perf. part: Dual Connectivity (EN-DC) of 2 bands LTE inter-band CA (2DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_2BLTE_1BNR_3DL2UL-Perf	R4	RP-190379	Huawei
800068	<b>Dual Connectivity (EN-DC) of 3 bands LTE inter-band CA (3DL/1UL) and 1 NR band (1DL/1UL)</b>	DC_R16_3BLTE_1BNR_4DL2UL	R4	RP-191195	Ericsson
800168	Core part: Dual Connectivity (EN-DC) of 3 bands LTE inter-band CA (3DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_3BLTE_1BNR_4DL2UL-Core	R4	RP-190159	Ericsson
800268	Perf. part: Dual Connectivity (EN-DC) of 3 bands LTE inter-band CA (3DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_3BLTE_1BNR_4DL2UL-Perf	R4	RP-190159	Ericsson
800069	<b>Dual Connectivity (EN-DC) of 4 bands LTE inter-band CA (4DL/1UL) and 1 NR band (1DL/1UL)</b>	DC_R16_4BLTE_1BNR_5DL2UL	R4	RP-191205	Nokia
800169	Core part: Dual Connectivity (EN-DC) of 4 bands LTE inter-band CA (4DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_4BLTE_1BNR_5DL2UL-Core	R4	RP-190294	Nokia
800269	Perf. part: Dual Connectivity (EN-DC) of 4 bands LTE inter-band CA (4DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_4BLTE_1BNR_5DL2UL-Perf	R4	RP-190294	Nokia
800070	<b>Dual Connectivity (EN-DC) of 5 bands LTE inter-band CA (5DL/1UL) and 1 NR band (1DL/1UL)</b>	DC_R16_5BLTE_1BNR_6DL2UL	R4	RP-180997	Samsung
800170	Core part: Dual Connectivity (EN-DC) of 5 bands LTE inter-band CA (5DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_5BLTE_1BNR_6DL2UL-Core	R4	RP-180997	Samsung
800270	Perf. part: Dual Connectivity (EN-DC) of 5 bands LTE inter-band CA (5DL/1UL) and 1 NR band (1DL/1UL)	DC_R16_5BLTE_1BNR_6DL2UL-Perf	R4	RP-180997	Samsung
800071	<b>Dual Connectivity (EN-DC) of x bands (x=1, 2, 3, 4) LTE inter-band CA (xDL/1UL) and 2 bands NR inter-band CA (2DL/1UL)</b>	DC_R16_xBLTE_2BNR_yDL2UL	R4	RP-190949	LG Electronics
800171	Core part: Dual Connectivity (EN-DC) of x bands (x=2, 3, 4) LTE inter-band CA (xDL/1UL) and 2 bands NR inter-band CA (2DL/1UL)	DC_R16_xBLTE_2BNR_yDL2UL-Core	R4	RP-190151	LG Electronics
800271	Perf. part: Dual Connectivity (EN-DC) of x bands (x=2, 3, 4) LTE inter-band CA (xDL/1UL) and 2 bands NR inter-band CA (2DL/1UL)	DC_R16_xBLTE_2BNR_yDL2UL-Perf	R4	RP-190151	LG Electronics
0	<b>LTE-related Release 16 Features</b>	-		-	-
790057	<b>E-UTRA 2.4 GHz TDD Band for US</b>	LTE_TDD_2400_US	R4	RP-182405	Globalstar
790157	Core part: E-UTRA 2.4 GHz TDD Band for US	LTE_TDD_2400_US-Core	R4	RP-182405	Globalstar
790257	Perf. part: E-UTRA 2.4 GHz TDD Band for US	LTE_TDD_2400_US-Perf	R4	RP-182405	Globalstar
820063	<b>UE Conformance Test Aspects - E-UTRA 2.4 GHz TDD Band for US (Band 53)</b>	LTE_TDD_2400_US-UEConTest	R5	RP-182406	Globalstar
800059	<b>LTE intra-band Carrier Aggregation (CA)</b>		R4		Qualcomm
800060	<b>Rel-16 LTE intra-band CA for x CC DL/y CC UL including contiguous and non-contiguous spectrum (x&gt;=y)</b>	LTE_CA_R16_intra	R4	RP-191193	Ericsson
800160	Core part: Rel-16 LTE intra-band CA for x CC DL/y CC UL including contiguous and non-contiguous spectrum (x>=y)	LTE_CA_R16_intra-Core	R4	RP-190157	Ericsson
800260	Perf. part: Rel-16 LTE intra-band CA for x CC DL/y CC UL including contiguous and non-contiguous spectrum (x>=y)	LTE_CA_R16_intra-Perf	R4	RP-190157	Ericsson
800061	<b>Rel-16 LTE inter-band CA for 2 bands DL with 1 band UL</b>	LTE_CA_R16_2BDL_1BUL	R4	RP-191085	Qualcomm
800161	Core part: Rel-16 LTE inter-band CA for 2 bands DL with 1 band UL	LTE_CA_R16_2BDL_1BUL-Core	R4	RP-191085	Qualcomm
800261	Perf. part: Rel-16 LTE inter-band CA for 2 bands DL with 1 band UL	LTE_CA_R16_2BDL_1BUL-Perf	R4	RP-191085	Qualcomm
800062	<b>Rel-16 LTE inter-band CA for 3 bands DL with 1 band UL</b>	LTE_CA_R16_3BDL_1BUL	R4	RP-191120	Huawei
800162	Core part: Rel-16 LTE inter-band CA for 3 bands DL with 1 band UL	LTE_CA_R16_3BDL_1BUL-Core	R4	RP-191120	Huawei
800262	Perf. part: Rel-16 LTE inter-band CA for 3 bands DL with 1 band UL	LTE_CA_R16_3BDL_1BUL-Perf	R4	RP-191120	Huawei
800063	<b>Rel-16 LTE inter-band CA for x bands DL (x=4, 5) with 1 band UL</b>	LTE_CA_R16_xBDL_1BUL	R4	RP-190906	Nokia
800163	Core part: Rel-16 LTE inter-band CA for x bands DL (x=4, 5) with 1 band UL	LTE_CA_R16_xBDL_1BUL-Core	R4	RP-190138	Nokia
800263	Perf. part: Rel-16 LTE inter-band CA for x bands DL (x=4, 5) with 1 band UL	LTE_CA_R16_xBDL_1BUL-Perf	R4	RP-190138	Nokia
800064	<b>Rel-16 LTE inter-band CA for 2 bands DL with 2 band UL</b>	LTE_CA_R16_2BDL_2BUL	R4	RP-190377	Huawei
800164	Core part: Rel-16 LTE inter-band CA for 2 bands DL with 2 band UL	LTE_CA_R16_2BDL_2BUL-Core	R4	RP-190377	Huawei
800264	Perf. part: Rel-16 LTE inter-band CA for 2 bands DL with 2 band UL	LTE_CA_R16_2BDL_2BUL-Perf	R4	RP-190377	Huawei
800065	<b>Rel-16 LTE inter-band CA for x bands DL (x= 3, 4, 5) with 2 band UL</b>	LTE_CA_R16_xBDL_2BUL	R4	RP-190946	LG Electronics

800165	Core part: Rel-16 LTE inter-band CA for x bands DL (x= 3, 4, 5) with 2 band UL	LTE_CA_R16_xBDL_2BUL-Core	R4	RP-190150	LG Electronics
800265	Perf. part: Rel-16 LTE inter-band CA for x bands DL (x= 3, 4, 5) with 2 band UL	LTE_CA_R16_xBDL_2BUL-Perf	R4	RP-190150	LG Electronics
810061	<b>UE Conformance Test Aspects – Rel-16 LTE CA configurations</b>	LTE_CA_R16-UEConTest	R5	RP-182648	Ericsson
<b>830076</b>	<b>LTE-based 5G terrestrial broadcast</b>	<b>LTE_terr_bcast</b>	<b>R1</b>	<b>RP-190732</b>	<b>Qualcomm</b>
800091	<b>Study on LTE-based 5G terrestrial broadcast</b>	FS_LTE_terr_bcast	R1	RP-181342	Qualcomm
830176	<b>Core part: LTE-based 5G terrestrial broadcast</b>	LTE_terr_bcast-Core	R1	RP-190732	Qualcomm
830276	<b>Perf. part: LTE-based 5G terrestrial broadcast</b>	LTE_terr_bcast-Perf	R4	RP-190732	Qualcomm
<b>830094</b>	<b>Power class 2 UE for LTE bands 31 and 72</b>	<b>LTE_PC2_B31_B72</b>	<b>R4</b>	<b>RP-191285</b>	<b>Nokia</b>
830194	<b>Core part: Power class 2 UE for LTE bands 31 and 72</b>	LTE_PC2_B31_B72-Core	R4	RP-190665	Nokia
830294	<b>Perf. part: Power class 2 UE for LTE bands 31 and 72</b>	LTE_PC2_B31_B72-Perf	R4	RP-190665	Nokia
<b>800056</b>	<b>Additional LTE bands</b>		R4		<b>Ericsson</b>
<b>800075</b>	<b>Additional LTE bands for UE category M1 and/or NB1 in Rel-16</b>	<b>LTE_bands_R16_M1_NB1</b>	<b>R4</b>	<b>RP-190332</b>	<b>Ericsson</b>
800175	Core part: Additional LTE bands for UE category M1 and/or NB1 in Rel-16	LTE_bands_R16_M1_NB1-Core	R4	RP-190332	Ericsson
800275	Perf. part: Additional LTE bands for UE category M1 and/or NB1 in Rel-16	LTE_bands_R16_M1_NB1-Perf	R4	RP-190332	Ericsson
<b>800076</b>	<b>Additional LTE bands for UE category M2 and/or NB2 in Rel-16</b>	<b>LTE_bands_R16_M2_NB2</b>	<b>R4</b>	<b>RP-190333</b>	<b>Ericsson</b>
800176	Core part: Additional LTE bands for UE category M2 and/or NB2 in Rel-16	LTE_bands_R16_M2_NB2-Core	R4	RP-190333	Ericsson
<b>800079</b>	<b>Further performance enhancement for LTE in high speed scenario</b>	<b>LTE_high_speed_enh2</b>	<b>R4</b>	<b>RP-181482</b>	<b>NTT DOCOMO</b>
800179	Core part: Further performance enhancement for LTE in high speed scenario	LTE_high_speed_enh2-Core	R4	RP-181482	NTT DOCOMO
800279	Perf. part: Further performance enhancement for LTE in high speed scenario	LTE_high_speed_enh2-Perf	R4	RP-181482	NTT DOCOMO
<b>800086</b>	<b>DL MIMO efficiency enhancements for LTE</b>	<b>LTE_DL_MIMO_EE</b>	<b>R1</b>	<b>RP-182901</b>	<b>Huawei</b>
800186	Core part: DL MIMO efficiency enhancements for LTE	LTE_DL_MIMO_EE-Core	R1	RP-182901	Huawei
800286	Perf. part: DL MIMO efficiency enhancements for LTE	LTE_DL_MIMO_EE-Perf	R4	RP-182901	Huawei
<b>820071</b>	<b>Transfer of luan interface specifications from 25-series to 37-series</b>	<b>luan_transfer</b>	<b>R3</b>	<b>RP-190160</b>	<b>Huawei</b>
820171	Core part: Transfer of luan interface specifications from 25-series to 37-series	luan_transfer-Core	R3	RP-190160	Huawei
<b>820072</b>	<b>Direct data forwarding between NG-RAN and E-UTRAN nodes for inter-system mobility</b>	<b>Direct_data_fw_NR</b>	<b>R3</b>	<b>RP-182886</b>	<b>Ericsson</b>
820172	Core part: Direct data forwarding between NG-RAN and E-UTRAN nodes for inter-system mobility	Direct_data_fw_NR-Core	R3	RP-182886	Ericsson
<b>800089</b>	<b>Even further mobility enhancement in E-UTRAN</b>	<b>LTE_feMob</b>	<b>R2</b>	<b>RP-190921</b>	<b>China Telecom</b>
800189	Core part: Even further mobility enhancement in E-UTRAN	LTE_feMob-Core	R2	RP-190272	China Telecom
800289	Perf. part: Even further mobility enhancement in E-UTRAN	LTE_feMob-Perf	R4	RP-190272	China Telecom
<b>820078</b>	<b>410 - 430 MHz E-UTRA FDD Band(s) for LTE PPDR and PMR/PAMR in Europe</b>	<b>LTE410_Europe_PPDR</b>	<b>R4</b>	<b>RP-191287</b>	<b>Nokia</b>
820178	Core part: 410 - 430 MHz E-UTRA FDD Band(s) for LTE PPDR and PMR/PAMR in Europe	LTE410_Europe_PPDR-Core	R4	RP-182898	Nokia
820278	Perf. part: 410 - 430 MHz E-UTRA FDD Band(s) for LTE PPDR and PMR/PAMR in Europe	LTE410_Europe_PPDR-Perf	R4	RP-182898	Nokia
0	All other Release 16 Features	-		-	-
<b>830086</b>	<b>Introduction of GSM, UTRA, E-UTRA and NR capability set(s) (CS(s)) to the multi-standard radio (MSR) specifications</b>	<b>MSR_GSM_UTRA_LTE_NR</b>	<b>R4</b>	<b>RP-190642</b>	<b>Ericsson</b>
830186	Core part: Introduction of GSM, UTRA, E-UTRA and NR capability set(s) (CS(s)) to the multi-standard radio (MSR) specifications	MSR_GSM_UTRA_LTE_NR-Core	R4	RP-190642	Ericsson
830286	Perf. part: Introduction of GSM, UTRA, E-UTRA and NR capability set(s) (CS(s)) to the multi-standard radio (MSR) specifications	MSR_GSM_UTRA_LTE_NR-Perf	R4	RP-190642	Ericsson
<b>840066</b>	<b>Volume Based Charging Aspects for VoLTE</b>	<b>VBCLTE</b>	<b>S5</b>	<b>SP-180813</b>	<b>Chen, Ai, China Mobile</b>
810021	Stage 2 of VBCLTE	VBCLTE	S5	SP-180813	Chen, Ai, China Mobile
<b>840012</b>	<b>CT aspects of VBCLTE</b>	<b>VBCLTE</b>	<b>ct</b>	<b>CP-191110</b>	<b>Huang Zhenning (China Mobile)</b>
840067	CT1 aspects of VBCLTE	VBCLTE	C1	CP-191110	Huang Zhenning (China Mobile)
840068	CT3 aspects of VBCLTE	VBCLTE	C3	CP-191110	Huang Zhenning (China Mobile)
790003	<b>Enhancements to IMS for new real time communication services</b>	enIMS	S1	SP-180137	China Mobile, Hui Cai
820028	<b>Enhancement of 5G PCC related services</b>	en5GPccSer	C3	CP-183246	Xiaoyun Zhou, Huawei
810023	<b>Energy efficiency of 5G</b>	EE_5G	S5	SP-180819	CORNILY, Jean-Michel, ORANGE
820039	<b>Signalling Improvements for Network Efficiency in 5GS</b>	SINE_5G	C1	CP-190142	Shu, Lin
790001	<b>New Services and Markets Technology Enablers – Phase 2</b>	SMARTER_Ph2	S1	SP-180589	Li, Alice, Vodafone
780055	<b>5G Voice Service Continuity</b>	5GVSC	S1	SP-171077	Qun Wei, China Unicom
790015	<b>Security Assurance Specification for 5G</b>	SCAS_5G	S3	SP-180689	Marcus Wong, Huawei Technologies
<b>840069</b>	<b>5GS Transfer of Policies for Background Data Transfer</b>	<b>xBDT</b>	<b>S2</b>	<b>SP-180509</b>	<b>Takeshi Usui KDDI</b>
800030	Stage 2 of xBDT	xBDT	S2	SP-180509	Takeshi Usui KDDI
<b>840014</b>	<b>CT aspects of xBDT</b>	<b>xBDT</b>	<b>ct</b>	<b>CP-191113</b>	<b>Yan Xiaojian, ZTE</b>
840070	CT1 aspects of xBDT	xBDT	C1	CP-191113	Yan Xiaojian, ZTE
840071	CT3 aspects of xBDT	xBDT	C3	CP-191113	Yan Xiaojian, ZTE
770020	<b>Service Interactivity</b>	SerInter	S4	SP-170796	Lo, Charles, Qualcomm
770024	<b>EVS Codec Extension for Immersive Voice and Audio Services</b>	IVAS_Codec	S4	SP-170611	Gibbs, Jon, Huawei Technologies Co Ltd
800002	<b>Alternative EVS implementation using updated fixed-point basic operators</b>	Alt_FX_EVS	S4	SP-180286	Pawate, Raj, Cadence Design Systems Inc
800046	<b>Shared Data Handling on Nudm and Nudr</b>	Shared_Data	C4	CP-181136	Wiehe, Ulrich, Nokia
800009	<b>Policy delivery to UE for background data transfer</b>	PDBDT	S1	SP-180324	Takatsugu Kito, KDDI
790004	<b>QoS Monitoring</b>	QoS_MON	S1	SP-180141	Amar Deol
800005	<b>Inter-RAT Mobility requirements for real time service</b>	MOBRT	S1	SP-180592	Yang Xu, Oppo
760058	<b>Management of QoE measurement collection</b>	QOED	S5	SP-181069	Petersen, Robert, Ericsson
760059	<b>Study on network policy management for mobile networks based on NFV scenarios</b>	FS_NETPOL	S5	SP-170593	China Mobile Jinglei Liu
810025	<b>Network policy management for mobile networks based on NFV scenarios</b>	NETPOL	S5	SP-180821	China Mobile Hao Zhang

810027	<a href="#">Intent driven management service for mobile network</a>	IDMS_MN	S5	SP-180899	Zou Lan, Huawei
810024	<a href="#">OAM aspects of LTE and WLAN integration</a>	OAM_LTE_WLAN	S5	SP-180820	Yizhi Yao, Intel Corporation
810026	<a href="#">Methodology for 5G management specifications</a>	METHOGY	S5	SP-180822	Groenendijk, Jan, Ericsson
820030	<a href="#">Nchf Online and Offline charging services</a>	OFSBI_CH	S5	SP-181066	Zhu Lei, Huawei
820031	<a href="#">Charging Enhancement of 5GC Interworking with EPC</a>	5GIEPC_CH	S5	SP-181067	Chen Shan, Huawei
820032	<a href="#">NRM enhancements</a>	eNRM	S5	SP-190140	Jing Ping, Nokia
820033	<a href="#">Network Exposure Charging in 5G System Architecture</a>	5GS_Ph1_NEFCH	S5	SP-181070	Tornkvist, Robert, Ericsson
820034	<a href="#">Charging AMF in 5G System Architecture Phase 1</a>	5GS_Ph1_AMFCH	S5	SP-181071	Gardella, Maryse, Nokia
820035	<a href="#">Discovery of management services in 5G</a>	5GDMS	S5	SP-181072	Attila Horvat, Huawei Technologies Sweden AB
820036	<a href="#">Trace Management in the context of Services Based Management Architecture</a>	TM_SBMA	S5	SP-181073	Andrianov, Anatoly, Nokia
820005	<a href="#">Lawful Interception Rel-16</a>	LI16	S3LI	SP-181210	Alex Leadbeater, BT
820038	<a href="#">IMS Stage-3 IETF Protocol Alignment</a>	IMSProtoc16	C1	CP-183084	Leis, Peter, Nokia
<b>820041</b>	<a href="#">Stage-3 5GS NAS protocol development</a>	<b>5GProtoc16</b>	<b>C1</b>	<b>CP-183087</b>	<b>Sedlacek, Ivo, Ericsson</b>
820049	<a href="#">Stage-3 5GS NAS protocol development general aspects</a>	5GProtoc16	C1	CP-183087	Sedlacek, Ivo, Ericsson
820050	<a href="#">Stage-3 5GS NAS protocol development for support for non-3GPP accesses</a>	5GProtoc16-non3GPP	C1	CP-183087	Sedlacek, Ivo, Ericsson
<b>820042</b>	<a href="#">Stage-3 SAE Protocol Development for Rel16</a>	<b>SAES16</b>	<b>C1</b>	<b>CP-183088</b>	<b>Aghili, Behrouz, InterDigital Communications</b>
820046	<a href="#">Stage-3 SAE Protocol Development for Rel16 general aspects</a>	SAES16	C1	CP-183088	Aghili, Behrouz, InterDigital Communications
820047	<a href="#">Stage-3 SAE Protocol Development for Rel16 for CS Fallback in EPS</a>	SAES16-CSFB	C1	CP-183088	Aghili, Behrouz, InterDigital Communications
820048	<a href="#">Stage-3 SAE Protocol Development Rel16 for support for non-3GPP accesses</a>	SAES16-non3GPP	C1	CP-183088	Aghili, Behrouz, InterDigital Communications
840017	<a href="#">Reliable Data Service Serialization Indication</a>	RDSSI	S2	SP-190446	Starsinic, Michael, Convida Wireless LLC
840018	<a href="#">S6b Optional for ePDG connected to 5GS</a>	5GS_S6b_Optional	S2	SP-190447	Irfan Ali, Cisco
<b>840002</b>	<a href="#">Service Based Interface Protocol Improvements</a>	<b>SBIProtoc16</b>	<b>ct</b>	<b>CP-191060</b>	<b>Yue Song, China Mobile</b>
840052	<a href="#">CT3 aspects of SBIProtoc16</a>	SBIProtoc16	C3	CP-191060	Yue Song, China Mobile
840053	<a href="#">CT4 aspects of SBIProtoc16</a>	SBIProtoc16	C4	CP-191060	Yue Song, China Mobile
840008	<a href="#">Withdrawal of TS 24.323 from Rel-11, Rel-12, Rel-13</a>	ISAT-MO-WITHDRAW	C1	CP-191151	Dawes, Peter, Vodafone
840051	<a href="#">Lawful Interception Report Rel-16</a>	LIR16	S3LI	SP-190342	Nag Rao, Nokia
<b>770050</b>	<a href="#">(Small) Technical Enhancements and Improvements for Rel-16 (IETF) The Transport Layer Security (TLS) Protocol Version 1.3 (RFC 8446)</a>	<b>TEI16</b>			
800100	<a href="#">(IETF) The Transport Layer Security (TLS) Protocol Version 1.3 (RFC 8446)</a>	TEI16	S3-IETF		

## Annex B: Process to get further information

### B.1 General

Since the present document is limited to provide an overview of each Feature, this chapter explains how to get additional information, in particular how to retrieve all the Specifications (TSs) and Reports (TRs) as well as all the CRs which relate to a given Work Item.

The Unique Identifier (UID) is the key to get additional information on a given Work Item. It can be found in the table located just below the clause's header. The table has the following format:

**Table B-1: table format**

Unique Identifier (UID)	Name	Acronym	Outline Level (1=Feature, 2=Building Block, 3=Work Task)	Responsible Working Group	Work Item Description
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For readability reasons, the table headers are omitted in the continuation of the present document.

For instance, for the "Mission Critical Push to Talk over LTE Realignment", the table has to be understood as:

**Table B-2: Example of table at the introduction of each Feature**

Unique Identifier (UID)	Name	Acronym	Outline Level	Responsible Working Group	Work Item Description
700029	<b>Mission Critical Push to Talk over LTE Realignment</b>	MCImp-MCPTTR	2	S1	SP-150821

Thus, the UID for this Work Item is 700029.

Two methods are now possible to retrieve more information on a given feature: the "Step by step method" and the "Direct method". The "direct method" is faster but implies to know the hierarchical structure of the Work Items. The "step by step method" is slower but is easier to use, in particular when the hierarchical structure is unknown.

For instance, for retrieving all the CRs that relate to "Enhancements for Mission Critical Push To Talk", the search has to be done on UID 740022 but also potentially on its children Work Items (UID 720056, 740023 and 740024).

**Table B-3: Example of a hierarchical structure and its consequences on the search procedure**

740022	<b>Enhancements for Mission Critical Push To Talk</b>	MCImp-eMCPTT		SP-160490
720056	Stage 2 of Enhancements for Mission Critical Push To Talk	MCImp-eMCPTT	S6	SP-160490
740023	Stage 3 of Enhancements for Mission Critical Push To Talk	MCImp-eMCPTT-CT	CT	CP-160824
740024	CT1 aspects of Enhancements for Mission Critical Push To Talk	MCImp-eMCPTT-CT	C1	CP-160824

These two methods are described in the following clauses.

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## B.2 Direct method

The links below lead to the pages containing respectively all the Specifications and all the Change Requests (CRs) linked to a given Feature:

[https://portal.3gpp.org/Specifications.aspx?q=1&WiUid=\[UID\]](https://portal.3gpp.org/Specifications.aspx?q=1&WiUid=[UID])

[https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=\[UID\]](https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=[UID])

where "[UID]" has to be preplaced by the UID value.

Using the example provided in the table 4.1-3, the specification linked to "Stage 2 of Enhancements for Mission Critical Push To Talk" can be found in:

<https://portal.3gpp.org/Specifications.aspx?q=1&WiUid=720056>

And all the related Change Requests are listed in:

<https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=720056>

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## B.3 Step by step method

This method is to be used when the hierarchical structure is not known or when the "direct method" above does not show the expected results.

In this case, the 3GPP Ultimate web site has to be used:

<https://portal.3gpp.org>

As a preliminary step, it is essential that the "Customized Selection" is set to "All TSGs" (otherwise, a filter would be applied).

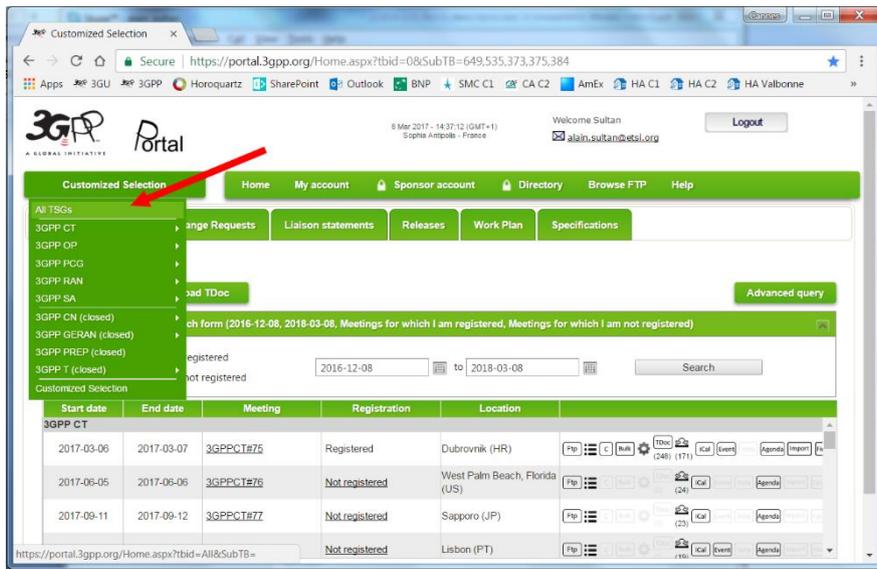


Figure B.3-1: Selecting "All TSGs" in "Customized Selection" as to remove any potential filter on the Search

Then select the "Work Plan" tab (upper red arrow in the figure below).

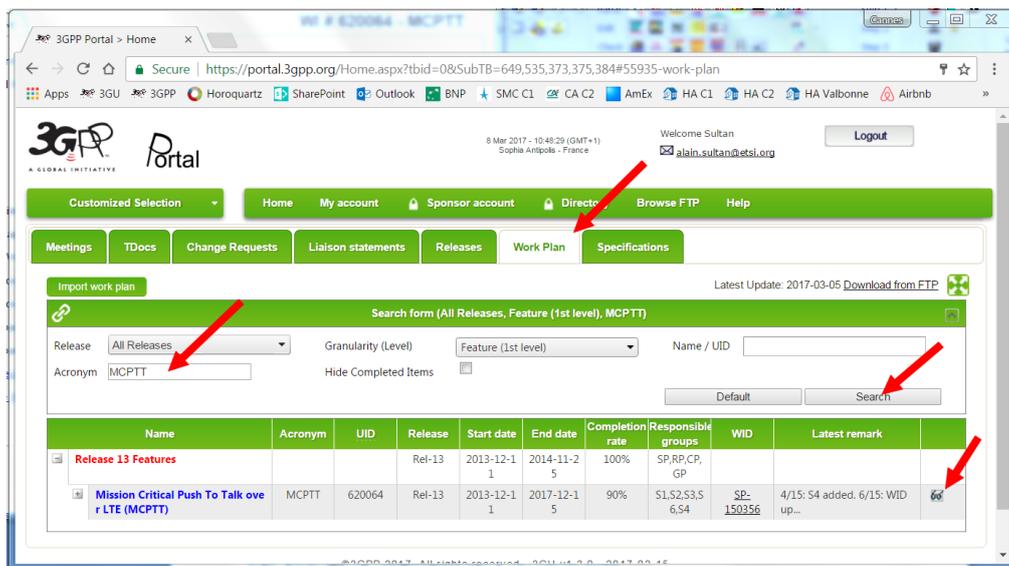


Figure B.3-2: Using the 3GU Portal to retrieve more information on a given Feature

Then the search might be performed by either typing the Acronym (as shown by the left red arrow on the figure above, using the example "MCPTT"), or by the name or UID (right box) then by clicking on the "Search" button. Watch the "Granularity (Level)" field, which is a filter to return only the Items which level is specified here.

In the results, the icon depicting some binoculars has to be hit (lower right red arrow on the figure above).

This will lead to the page shown in the figure below:

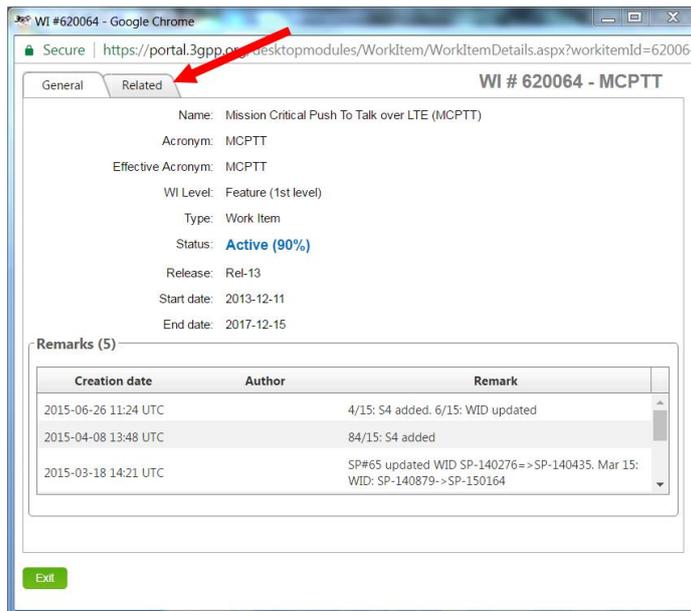


Figure B.3-3: Window resulting from a "Search"

On this window, the "Related" tab has to be clicked, as pointed by the red arrow in the figure above. This will lead to the window depicted in the figure below.

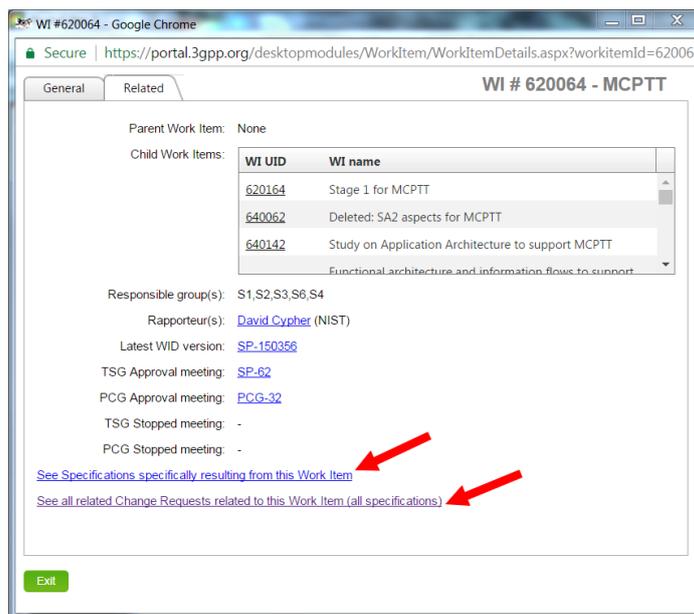


Figure B.3-4: "Related" tab in a Work Item search, with links to all related Specifications and Change Requests

The two links pointed by the red arrows in the figure above lead to the pages containing respectively all the Specifications and all the Change Requests (CRs) linked to this Feature.

## Annex C: Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2019-09	TSG#85					Initial draft, call for contributions (Note: in TSG CT and RAN, up to meeting 88e included, summaries were minuted as "Noted" instead of "Endorsed")	0.1.0
2019-12	TSG#86					<p>Summaries received:</p> <p>RP-190144 : Transfer of luant interface specifications from 25-series to 37-series</p> <p>RP-191816 Introduction of GSM, UTRA, E-UTRA and NR capability set(s) (CS(s)) to the multi-standard radio (MSR) specifications</p> <p>RP-192162 Direct data forwarding between NG-RAN and E-UTRAN nodes for inter-system mobility</p> <p>SP-190855 Charging Enhancement of 5GC interworking with EPC</p> <p>SP-190865 Coverage and Handoff Enhancements for Multimedia</p> <p>SP-191223 Summary for 5G_eLCS CATT</p> <p>SP-191229 Summary for RDSSI Convida Wireless LLC</p> <p>SP-191247 Summary for 'Service Interactivity' Qualcomm Incorporated</p> <p>SP-191252 Summary for 'OAM aspects of LTE and WLAN integration' Intel</p> <p>SP-191277 Summary for Volume Based Charging Aspects for VoLTE China Mobile</p> <p>SP-191328 Summary for 'EVS Float Conformance for Non Bit-exact EVS_FCNBE Rapporteur (Intel)</p>	0.2.0
2020-01	SA1#89					<p>Summaries received from RAN#86:</p> <p>RP-192721 Summary for: Further performance enhancement for LTE in high speed scenario DOCOMO Communications Lab.</p> <p>RP-192964 Summary for:eNB(s) Architecture Evolution for E-UTRAN and NG-RAN China Unicom</p>	0.3.0

2020-03	SA1#90			<p>Summaries received from SA#86:</p> <p>SP-191223 Summary for 5G_eLCS CATT (SP-191229 Summary for RDSSI Convida Wireless LLC-&gt; replaced by SP-200057)</p> <p>SP-191247 Summary for 'Service Interactivity' Qualcomm Incorporated</p> <p>SP-191252 Summary for 'OAM aspects of LTE and WLAN integration' Intel</p> <p>SP-191277 Summary for Volume Based Charging Aspects for VoLTE China Mobile</p> <p>SP-191328 Summary for 'EVS Float Conformance for Non Bit-exact EVS_FCNBE Rapporteur (Intel)</p> <p>Summaries received from TSG#87e:</p> <p>RP-200087 Summary for 2-step RACH ZTE Corporation</p> <p>RP-200112 Summary for Dual Connectivity (EN-DC) with 3 bands DL and 3 bands UL ZTE Corporation</p> <p>RP-200152 Summary for: Single Radio Voice Call Continuity from 5G to 3G China Unicom</p> <p>RP-200170 Summary for inter-band CA/DC for 2 bands DL with up to 2 bands UL ZTE Corporation</p> <p>RP-200173 Summary for inter-band CA/DC for 3 bands DL with 2 bands UL ZTE Corporation</p> <p>RP-200214 Summary for High power UE (power class 2) for EN-DC (1 LTE TDD band + 1 NR TDD band) CMCC</p> <p>SP-200034 Summary for 'RTCP Verification for Real-Time Services' Ericsson LM</p> <p>SP-200036 Summary for "Media Handling Extensions for 5G Conversational Services" (5G_MEDIA_MTSI_ext) Intel (Rapporteur)</p> <p>SP-200057 Summary for RDSSI Convida Wireless LLC</p> <p>SP-200058 Summary for Rel-16 eV2XARC LG Electronics</p> <p>SP-200124 Summary for ATSSS ZTE Wistron Telecom AB</p> <p>SP-200125 Summary for eNS ZTE Wistron Telecom AB</p> <p>SP-200126 Summary for Rel-16 V2XIMP LG Electronics France</p> <p>SP-200128 Summary for "VR QoE Metrics" Ericsson LM=&gt; NOT INCLUDED, SAID TO BE REL-17 in the Work Plan</p> <p>SP-200129 Summary for 5G_SRVCC China Unicom</p> <p>SP-200131 Summary for User Identities and Authentication Deutsche Telekom AG</p> <p>SP-200217 Summary for Business Role Models for Network Slicing Nokia</p> <p>CP-200143 Summary for Shared Data Handling on Nudm and Nudr Nokia, Nokia Shanghai Bell</p> <p>RP-202581 WID summary for LTE/NR spectrum sharing in band 48/n48 frequency range Apple Inc.</p> <p>RP-202600 WI summary for WI Perf. Part.: Over the air (OTA) base station (BS) testing TR RAN4</p> <p>RP-202753 WI summary for NR-U QUALCOMM Europe Inc. - Spain</p>	0.4.0
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2020-07	SA#88e			<p>Summaries endorsed (marked as "noted") by RAN#87e:                  Already included in v.0.4.0 (note that RP-201225 "Summary for: 2-step RACH for NR" from ZTE Corporation was superseded at following RAN meeting)</p> <p>Summaries endorsed by CT#87e:                  Already included in v.0.4.0</p> <p>Summaries endorsed by SA#87e:                  Already included in v.0.4.0: SP-200034; SP-200036; SP-200057; SP-200058; SP-200124; SP-200125; SP-200126; SP-200128(not included, Rel-17); SP-200129; SP-200131                  New SA#87e summaries in v.0.5.0:                  SP-200215 Summary for Provision of Access to Restricted Local Operator Services by Unauthenticated UEs Nokia                  SP-200224 Summary for SMARTER-Ph2 VODAFONE Group Plc                  SP-200228 Summary for Energy Efficiency of 5G Orange                  SP-200253 Summary for 5WWC Huawei                  SP-200254 Summary for eNA Huawei                  SP-200256 Summary for 'ETSUN' Nokia Japan                  SP-200265 Summary for 5GMSG China Mobile                  SP-200266 Summary for Charging aspects of ETSUN China Mobile                  SP-200273 Summary for RACSQualcomm Incorporated, MediaTek                  SP-200274 Summary for 'Cellular IoT support and evolution for the 5G System' Qualcomm Incorporated                  SP-200294 Summary for Business Role Models for Network Slicing Nokia                  SP-200295 Summary for 5G_URLLC Huawei                  SP-200296 Summary for Vertical_LAN Nokia Japan</p> <p>Summaries endorsed (marked as "noted") by RAN#88e:                  RP-200604 Summary for: Support for NavIC Navigation Satellite System in LTE Reliance Jio                  RP-200678 Summary for: NG interface usage for WWC (Wireless Wireline Convergence) Huawei, HiSilicon                  RP-200727 Summary for Add support of NR DL 256QAM for frequency range 2 (FR2) China Telecom                  RP-200733 Summary for Private Network Support for NG-RAN China Telecom                  RP-200738 Summary for Even further mobility enhancement in E-UTRANChina Telecom                  RP-200774 Summary for SON (Self-Organising Networks) and MDT (Minimization of Drive Tests) support for NRCMCC                  RP-200776 Summary for NR support for high speed train scenario CMCC                  RP-200798 Summary for Support of NR Industrial Internet of Things (IoT) Nokia, Nokia Shanghai Bell                  RP-200850 Summary for LTE-based 5G terrestrial broadcast QUALCOMM Europe Inc. - Italy                  RP-200855 Summary for 5G V2X with NR sidelink LG Electronics                  RP-200885 Summary for DL MIMO efficiency enhancements for LTE Huawei, HiSilicon                  RP-200887 Summary for Physical layer enhancements for NR ultra-reliable and low latency case (URLLC) Huawei, HiSilicon                  RP-200912 Summary for UE Power Saving in NR CATT                  RP-201019 Summary for Introduction of NR FDD bands with variable duplex and corresponding framework Huawei, HiSilicon                  RP-201225 Summary for 2-step RACH for NR ZTE Corporation                  RP-201229 Summary for Additional enhancements for NB-IoT Futurewei Technologies                  RP-201235 Summary for Core part: Optimisations on UE radio capability signalling – NR/E-UTRA Aspects Mediatek                  RP-201274 Summary for NR mobility enhancements Intel Corporation                  RP-201276 Summary for Additional MTC enhancements for LTE Ericsson                  RP-201280 Summary for Cross Link Interference (CLI) handling and Remote Interference Management (RIM) for NRLG Electronics</p> <p>Summaries endorsed by CT#88e:                  None</p> <p>Summaries endorsed by SA#88e:                  SP-200343 Summary for Enhancements of Public Warning System (ePWS)SyncTechno Inc. (Rapporteur)</p>	0.5.0
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2020-09	TSG#89e				<p>Summaries endorsed by SA#86:</p> <p>SP-190322 WI_summary E2E_DELAY (was unintentionally skipped earlier) Intel</p>	0.6.0

2020-12	TSG#89e				<p>Included: Summaries received at TSG#89e: CT#89e: CP-202027 Work Item Summary for eNAPIs Huawei SA#89e: SP-200776 Work Item Summary for 5G_eSBA China Mobile SP-200777 Work Item Summary for Rel-16 UDICOM Nokia Korea SP-200801 Summary for Work Item on "Removal of H.263 and MPEG-4 Visual from 3GPP Services" Qualcomm Incorporated SP-200808 Work Item Summary for Rel-16 eIMS5G_SBA T-Mobile USA Inc. SP-200848 Work item Summary for 5GMS3Sony (Rapporteur) SP-200849 Work item Summary for Enhancement of performance assurance for 5G Intel (Rapporteur) SP-200851 Work Item Summary for Rel-16 eCAPIF Samsung SP-200852 Work Item Summary for Rel-16 SEAL Samsung RAN#89e: RP-201531 Summary of WI on Multi-RAT Dual-Connectivity and Carrier Aggregation enhancements (LTE, NR) Ericsson RP-201718 WI summary: RF requirements for NR frequency range 1 (FR1) Huawei, HiSilicon RP-201757 WI summary for WI: Integrated Access and Backhaul for NR (NR_IAB) Qualcomm Incorporated RP-201829 Summary for WI UE Conformance Test Aspects - Mission Critical Improvements NIST RP-201836 WI summary for WI: NR positioning support Intel Corporation RP-201840 WI summary for NR-based Access to Unlicensed Spectrum QUALCOMM Europe Inc. - Spain RP-201884 WI summary: NR RRM enhancement in R16 Intel Corporation RP-201905 WI Summary for 29 dBm UE Power Class for LTE Band 41 and NR Band n41 T-Mobile USA RP-201942 WI summary on RRM requirement for CSI-RS Based L3 measurement CATT Received by e-mail but not submitted to TSG#89e: eNAPI</p> <p>Other Summaries received by TSG#89 and included: SP-200872 WI summary for QOED SP-200XYZ WI summary for LAN support in 5G SP-200XYZ WI summary for eLSTR SP-200938 WI summary for V2XAPP Huawei Telecommunication India SP-200941 Summary for work item 'Mobile Communication System for Railways 2 (MONASTERY2)' Nokia, Nokia Shanghai Bell SP-200943 Summary for work item '5G positioning services (5G_HYPOS)' ESA SP-201001 summary for WI MBMSAPI_MCS CATT, TD-Tech SP-201083 WI summary for eMCDATA2 AT&amp;T GNS Belgium SPRL SP-201111 WI summary for MCCI Sepura Ltd SP-201113 Summary for work item 'Multi-device and multi-identity (MUD)' Ericsson SP-201114 Summary of enh2MCPTT feature in Release 16 Motorola Solutions UK Ltd. SP-201117 Summary for Work Item Network Resource Model (NRM) enhancements Nokia, Nokia Shanghai Bell</p>	1.0.0
2021-06					<p>No more summary received since December, closing of the document Link added to all sections to provide the link to all corresponding CRs</p>	2.0.0
2021-06	SA#92	SP-210496			Raised to v.16.0.0 following SA's approval	16.0.0
2021-09	-	-			Add "3GPP" before "TR 21.916" in the very first line of this document	16.0.1
2022-01	SA#94	SP-211558	0001	- B	Summary for WI: Enhancement on MIMO for NR	16.1.0