**3GPP TSG-SA5 Meeting #143-e *S5-223134***

**Online, , 9th May 2022 - 17th May 2022**

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| *CR-Form-v12.2* |
| **CHANGE REQUEST** |
|  |
|  | **28.552** | **CR** | **0365** | **rev** | **-** | **Current version:** | **17.6.0** |  |
|  |
| *For* ***[HE](http://www.3gpp.org/3G_Specs/CRs.htm%22%20%5Cl%20%22_blank)******[LP](http://www.3gpp.org/3G_Specs/CRs.htm%22%20%5Cl%20%22_blank)*** *on using this form: comprehensive instructions can be found at <http://www.3gpp.org/Change-Requests>.* |
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|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network |  | Core Network | **X** |

|  |
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|  |
| ***Title:***  | Rel-17 CR for TS28.552 editorialCorrections |
|  |  |
| ***Source to WG:*** | ZTE Corporation |
| ***Source to TSG:*** | SA5 |
|  |  |
| ***Work item code:*** | TEI17 |  | ***Date:*** | 2022-04-28 |
|  |  |  |  |  |
| ***Category:*** | F |  | ***Release:*** | Rel-17 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19)* |
|  |  |
| ***Reason for change:*** | Delete redundant measurement family line; Adjust directory of QoS flow management via untrusted non-3GPP access |
|  |  |
| ***Summary of change:*** | Editorial corrections |
|  |  |
| ***Consequences if not approved:*** | Confusion of QoS flow management via untrusted non-3GPP access |
|  |  |
| ***Clauses affected:*** | 3.3, 5.1.1.6.1.4, 5.8.3, 5.8.4 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ...  |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

#### Start of changes

## 3.3 Measurement family

The measurement names defined in the present document are all beginning with a prefix containing the measurement family name. This family name identifies all measurements which relate to a given functionality and it may be used for measurement administration.

The list of families currently used in the present document is as follows:

- DRB (measurements related to Data Radio Bearer).

- RRC (measurements related to Radio Resource Control).

- UECNTX (measurements related to UE Context).

- RRU (measurements related to Radio Resource Utilization).

- RM (measurements related to Registration Management).

- SM (measurements related to Session Management).

- GTP (measurements related to GTP Management).

- IP (measurements related to IP Management).

- PA (measurements related to Policy Association).

- MM (measurements related to Mobility Management).

- VR (measurements related to Virtualized Resource).

- CARR (measurements related to Carrier).

- QF (measurements related to QoS Flow).

- AT (measurements related to Application Triggering).

- SMS (measurements related to Short Message Service).

- PEE (measurements related to Power, Energy and Environment).

- NFS (measurements related to NF service).

- PFD (measurements related to Packet Flow Description).

- RACH (measurements related to Random Access Channel).

- MR (measurements related to Measurement Report).

- L1M (measurements related to Layer 1 Measurement).

- NSS (measurements related to Network Slice Selection).

- PAG (measurements related to Paging).

- NIDD (measurements related to Non-IP Data Delivery).

- EPP (measurements related to external parameter provisioning).

- TI (measurements related to traffic influence).

- CE (measurements related to Connection Establishment).

- SPP (measurements related to Service Parameter Provisioning).

- BDTP (measurements related to Background Data Transfer Policy).

- DM (measurements related to Data Management).

- AFQ (measurements related to AF session with QoS).

- UCM (measurements related to UE radio Capability Management).

- PAU (measurements related to Policy Authorization).

- EEX (measurements related to Event Exposure).

- SDM (measurements related to subscriber data management).

- PPV (measurements related to parameter provisioning).

- DIS (measurements related to discovery).

- Location Management (measurements related to Location Management).

#### Second change

###### 5.1.1.6.1.4 Number of requested legacy handover resource allocations

a) This measurement provides the number of legacy handover resource allocation requests received by the target NR cell CU.

b) CC.

c) On receipt of HANDOVER REQUEST message (see TS 38.413 [1]) by the NR cell CU from the AMF, or receipt of HANDOVER REQUEST message (see TS 38.423 [13]) , where the message denotes a legacy handover, by the target NR cell CU from the source NR cell CU, for requesting the preparation of resources for handover.

d) A single integer value.

e) MM.HoResAlloInterReq.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

#### Third change

3GPP TS 28.552 V17.6.0 (2022-03)

Technical Specification

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Management and orchestration;

5G performance measurements

(Release 17)

 ** 

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***3GPP***

Postal address

3GPP support office address

650 Route des Lucioles - Sophia Antipolis

Valbonne - FRANCE

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

Internet

http://www.3gpp.org

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# Foreword

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

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

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

This document specifies the performance measurements for 5G networks including network slicing. Performance measurements for NG-RAN are defined in this document (clause 5.1), and some L2 measurement definitions are inherited from TS 38.314 [29]. The performance measurements for 5GC are all defined in this document (clause 5.2 to 5.6). Related KPIs are defined to those measurements are defined in TS 28.554 [8].

The performance measurements for NG-RAN applies also to NR option 3 in many cases, but not to the RRC connection related measurements which are handled by E-UTRAN for NR option 3 (those are measured according to TS 32.425 [9] and related KPIs in TS 32.451 [10]).

The performance measurements are defined based on the measurement template as described in TS 32.404 [3].

# 2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 32.401: "Telecommunication management; Performance Management (PM); Concept and requirements".

[3] 3GPP TS 32.404: "Performance Management (PM); Performance measurements - Definitions and template".

[4] 3GPP TS 23.501: "System Architecture for the 5G System".

[5] IETF RFC 5136: "Defining Network Capacity".

[6] 3GPP TS 38.473: "NG-RAN; F1 Application Protocol (F1AP)".

[7] 3GPP TS 23.502: "Procedures for the 5G System".

[8] 3GPP TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)".

[9] 3GPP TS 32.425: "Performance Management (PM); Performance measurements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN)".

[10] 3GPP TS 32.451: "Key Performance Indicators (KPI) for Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Requirements".

[11] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[12] Void.

[13] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP)".[14] 3GPP TS 29.502: "5G System; Session Management Services; Stage 3".

[15] Void.

[16] 3GPP TS 29.244: "Technical Specification Group Core Network and Terminals; Interface between the Control Plane and the User Plane Nodes; Stage 3".

[17] ETSI GS NFV-IFA027 v2.4.1: "Network Functions Virtualisation (NFV); Management and Orchestration; Performance Measurements Specification".

[18] Void.

[19] 3GPP TS 38.214: "NR; Physical layer procedures for data".

[20] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[21] 3GPP TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".

[22] 3GPP TS 29.413: "Application of the NG Application Protocol (NGAP) to non-3GPP access".

[23] 3GPP TS 29.122: "Technical Specification Group Core Network and Terminals; T8 reference point for Northbound APIs".

[24] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

[25] ETSI ES 202 336-12 V1.2.1: "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".

[26] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

[27] 3GPP TS 29.274: "Evolved General Packet Radio Service (GPRS); Tunnelling Protocol for Control plane (GTPv2-C); Stage 3".

[28] 3GPP TS 29.510: "5G System; Network function repository services; Stage 3".

[29] 3GPP TS 38.314: "NR; layer 2 measurements".

[30] 3GPP TS 38.313: "Self-Organizing Networks (SON) for 5G networks".

[31] 3GPP TS 38.415: "NG-RAN; PDU session user plane protocol".

[32] 3GPP TS 38.321: "NR MAC protocol specification".

[33] 3GPP TS 38.214: "NR; Physical layer procedures for data".

[34] 3GPP TS 38.215: "NR; Physical layer measurements".

[35] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[36] 3GPP TS 33.501: "Security architecture and procedures for 5G system".

[37] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in Idle mode and RRC Inactive state".

[38] 3GPP TS 28.530: "Management and orchestration; Concepts, use cases and requirements".

[39] 3GPP TS 29.507: "5G System; Access and Mobility Policy Control Service; Stage 3".

[40] 3GPP TS 29.512: "5G System; Session Management Policy Control Service; Stage 3".

[41] 3GPP TS 29.531: "5G System; Network Slice Selection Services".

[42] 3GPP TS 29.281: "General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)".

[43] 3GPP TS 29.540: "5G System; SMS Services; Stage 3".

[44] 3GPP TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".

[45] 3GPP TS 29.541: "5G System; Network Exposure FunctionServices for Non-IP Data Delivery (NIDD); Stage 3".

[46] 3GPP TS 23.503: "Policy and charging control framework for the 5G System (5GS); Stage 2".

[47] 3GPP TS 29.504: "5G System; Unified Data Repository Services; Stage 3".

[48] 3GPP TS 29.554: "5G System; Background Data Transfer Policy Control Service; Stage 3".

[49] 3GPP TS 38.300: "NR and NG-RAN Overall description; Stage-2".

[50] 3GPP TS 28.538: "Management and orchestration; Edge Computing Management".

[51] 3GPP TS 29.503: "5G System; Unified Data Management Services; Stage 3".

[52] 3GPP TS 23.558: "Architecture for enabling Edge Applications".

[53] 3GPP TS 23.273: "5G System (5GS); Location Services (LCS); Stage 2".

[54] 3GPP TS 29.572: "5G System (5GS); Location Management Services; Stage 3".

# 3 Definitions, abbreviations and measurement family

## 3.1 Definitions

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

**Conditional handover:** A handover which is executed by the UE.

**Dual Active Protocol Stack:** A procedure for handovers where the UE connects to the target before it releases the connection to the source.

**IP latency:** the time it takes to transfer a first/initial packet in a data burst from one point to another.

**Legacy handover**: A handover that is executed by the source gNB, in contrast to Conditional Handover.

**Mapped 5QI:** 5QI that is used for a DRB within the gNB when a single 5QI is assigned to the DRB.

NOTE1: In this case the mapped 5QI is used for separating certain measurements per QoS class.

NOTE 2: Individual QoS flows into a common 5QI is specified in TS 38.473 [6].

**Packet delay:** the time it takes to transfer any packet from one point to another.

**Packet drop rate:** share of packets that were not sent to the target due to high traffic load or traffic management and should be seen as a part of the packet loss rate.

**Packet loss rate:** share of packets that could not be received by the target, including packets droped, packets lost in transmission and packets received in wrong format.

**Performance indicators**: The performance data aggregated over a group of NFs which is derived from the performance measurements collected at the NFs that belong to the group, according to the aggregation method identified in the Performance Indicator definition.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1], TS 23.501 [4] 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] and TS 23.501 [4].

CHO Conditional Handover

DAPS Dual Active Protocol Stack

HO Handover

kbit kilobit (1000 bits)

LHO Legacy Handover

MN Master Node.

NG-RAN Next Generation Radio Access Network

PI Performance Indicator

SN Secondary Node.

TEID Tunnel Endpoint IDentifier

## 3.3 Measurement family

The measurement names defined in the present document are all beginning with a prefix containing the measurement family name. This family name identifies all measurements which relate to a given functionality and it may be used for measurement administration.

The list of families currently used in the present document is as follows:

- DRB (measurements related to Data Radio Bearer).

- RRC (measurements related to Radio Resource Control).

- UECNTX (measurements related to UE Context).

- RRU (measurements related to Radio Resource Utilization).

- RM (measurements related to Registration Management).

- SM (measurements related to Session Management).

- GTP (measurements related to GTP Management).

- IP (measurements related to IP Management).

- PA (measurements related to Policy Association).

- MM (measurements related to Mobility Management).

- VR (measurements related to Virtualized Resource).

- CARR (measurements related to Carrier).

- QF (measurements related to QoS Flow).

- AT (measurements related to Application Triggering).

- SMS (measurements related to Short Message Service).

- PEE (measurements related to Power, Energy and Environment).

- NFS (measurements related to NF service).

- PFD (measurements related to Packet Flow Description).

- RACH (measurements related to Random Access Channel).

- MR (measurements related to Measurement Report).

- L1M (measurements related to Layer 1 Measurement).

- NSS (measurements related to Network Slice Selection).

- PAG (measurements related to Paging).

- NIDD (measurements related to Non-IP Data Delivery).

- EPP (measurements related to external parameter provisioning).

- TI (measurements related to traffic influence).

- CE (measurements related to Connection Establishment).

- SPP (measurements related to Service Parameter Provisioning).

- BDTP (measurements related to Background Data Transfer Policy).

- DM (measurements related to Data Management).

- BDTP (measurements related to Background Data Transfer Policy).

- AFQ (measurements related to AF session with QoS).

- UCM (measurements related to UE radio Capability Management).

- PAU (measurements related to Policy Authorization).

- EEX (measurements related to Event Exposure).

- SDM (measurements related to subscriber data management).

- PPV (measurements related to parameter provisioning).

- DIS (measurements related to discovery).

- Location Management (measurements related to Location Management).

# 4 Concepts and overview

## 4.1 Performance indicators

Performance indicators are the performance data aggregated over a group of NFs, such as, for example, average latency along the network slice. The Performance Indicators can be derived from the performance measurements collected at the NFs that belong to the group. The aggregation method is identified in the performance indicator definition

Performance indicators at the network slice subnet level can be derived from the performance measurements collected at the NFs that belong to the network slice subnets or to the constituent network slice subnets. The performance indicators at the network slice subnet level can be made available via the corresponding performance management service for network slice subnet.

The performance indicators at the network slice level, can be derived from the network slice subnet level Performance Indicators collected at the constituent network slice subnets and/or NFs. The network slice level performance indicators can be made available via the corresponding performance management service for network slice.

When providing a communication service to a tenant, the performance indicators can be derived from corresponding performance indicators related to network slice, network slice subnet and NFs and they can be made available via the corresponding performance management service, consumed by a tenant. Tenant(s) may be associated with S-NSSAI or sNSSAIList in which case, the performance indicators are split into subcounters per S-NSSAI for individual tenant.

## 4.2 Filters and filter naming

### 4.2.0 General

In case a performance measurement is defined for more than one sub-counter, it is convenient to use *Filter* to define the performance measurement of interest.

### 4.2.1 Filters

Performance measurements may be sub-divided by use of applicable filters to form new Performance measurements (or sub counters). Any applicable *Filter(s)* are identified in each performance measurements definition. Performance measurements may also be defined without any applied *Filter*.

When no *Filter* is applied the performance measurement should exclude the *Filter* extension.

Example of possible *Filter* values:

- 5QI

- QCI

- SNSSAI, where SNSSAI represents the S-NSSAI

- PLMN, where PLMN represents the PLMN ID

### 4.2.2 Filter naming

For the Performance measurements that indicate *Filters*, the resulting Performance measurement name will take the form: Performance measurement\_*Filter*

If combination of *Filters* is used the name will take the form: Performance measurement\_*Filter1\_Filter2*

If no *Filter* is used the name will take the form: Performance measurement

Example: DRB.PdcpF1DelayDl\_*Filter,* Where *Filter* is a combination of *PLMN* and *5QI* and *SNSSAI*.

- Single *Filter* value applied: DRB.PdcpF1DelayDl\_*Filter1*, where *Filter* could be any of the possible *Filter* value defined for the performance measurement:

- Sub counter name: DRB.PdcpF1DelayDl.*5QI*

- Multiple (two) *Filter* values applied: DRB.PdcpF1DelayDl\_*Filter1\_Filter2*, where *Filter1* and *Filter2* could be any of the possible *Filter* value defined for the performance measurement:

- Sub counter name: DRB.PdcpF1DelayDl.*PLMN.5QI.*

- No *Filter* value applied: Counter name: DRB.PdcpF1DelayDl

For *Filters* the separator '\_' is used to append the filter name(s) to the measurement name. For multiple *Filters* the order in the resulting name is not important.

# 5 Performance measurements for 5G network functions

## 5.1 Performance measurements for gNB

### 5.1.0 Relation to RAN L2 measurement specification

When it comes to Layer 2 measurement definitions, some of the L2 measurement definitions used in the present document are referring to TS 38.314 [29]. The L2 measurement definitions in TS 38.314 [29] and in the present document have some differences:

- The measurement definitions in TS 38.314 [29] are often defined to be reported 'per UE or per DRB', to support MDT and Trace use cases.

- The measurements defined in the present document define L2 measurements that is aggregated and often reported per a Managed Object class (e.g. NRCellDU).

Thus, for those L2 measurements, the definition in TS 38.314 [29] is re-used in the present document, but without requirement of 'per UE or per DRB' reporting to be performed.

### 5.1.1 Performance measurements valid for all gNB deployment scenarios

#### 5.1.1.1 Packet Delay

##### 5.1.1.1.1 Average delay DL air-interface

a) This measurement provides the average (arithmetic mean) time it takes for packet transmission over the air-interface in the downlink direction. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1)

c) This measurement is obtained as: sum of (point in time when the last part of an RLC SDU packet was sent to the UE which was consequently confirmed by reception of HARQ ACK from UE for UM mode or point in time when the last part of an RLC SDU packet was sent to the UE which was consequently confirmed by reception of RLC ACK for AM mode, minus time when corresponding RLC SDU part arriving at MAC layer) divided by total number of RLC SDUs transmitted to UE successfully. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.AirIfDelayDl\_Filter,
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.1.2 Distribution of delay DL air-interface

a) This measurement provides the distribution of the time it takes for packet transmission over the air-interface in the downlink direction. The measurement is calculated per PLMN ID andper QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1)

c) This measurement is obtained by 1) calculating the DL delay for an RLC SDU packet by: point in the time when the last part of an RLC SDU packet was sent to the UE which was consequently confirmed by reception of HARQ ACK for UM mode or point in time when the last part of an RLC SDU packet was sent to the UE which was consequently confirmed by reception of RLC ACK for AM mode, minus the time when corresponding RLC SDU part arriving at MAC layer; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the counters. If the RLC SDU needs retransmission (for Acknowledged Mode) the delay will still include only one contribution (the original one) to this measurement. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer representing the number of RLC SDU packets measured with the delay within the range of the bin. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) DRB.AirIfDelayDist.Bin\_Filter, where Bin indicates a delay range which is vendor specific;

Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.1.3 Average delay UL on over-the-air interface

a) This measurement provides the average (arithmetic mean) over-the-air packet delay on the uplink. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1)

c) This measurement is obtained according to the definition in TS 38.314 [29], named "Average over-the-air interface packet delay in the UL per DRB per UE". The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.AirIfDelayUl\_Filter,

Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.1.4 Average RLC packet delay in the UL

a) This measurement provides the average (arithmetic mean) RLC packet delay on the uplink, ie the delay within the gNB-DU. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1)

c) This measurement is obtained according to the definition in TS 38.314 [29], named "Average RLC packet delay in the UL per DRB per UE". The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in the unit 0.1 milliseconds. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.RlcDelayUl\_Filter,

Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.1.5 Average PDCP re-ordering delay in the UL

a) This measurement provides the average (arithmetic mean) PDCP re-ordering delay on the uplink, ie the delay within the gNB-CU-UP. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1)

c) This measurement is obtained according to the definition in TS 38.314 [29], named "Average PDCP re-ordering delay in the UL per DRB per UE. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a real representing the mean delay in the unit 0.1 milliseconds. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpReordDelayUl\_Filter,

Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.1.6 Distribution of DL delay between NG-RAN and UE

a) This measurement provides the distribution of DL packet delay between NG-RAN and UE, which is the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface. This measurement is calculated per PLMN ID and per 5QI and per supported S-NSSAI.

b) DER (n=1).

c) The measurement is obtained by the following method:

 The gNB performs the GTP PDU packet delay measurement for QoS monitoring per the GTP PDU monitoring packets received from UPF, and records the following time stamps and information included in the GTP-U header of each GTP PDU monitoring response packet (packet i) sent to UPF (see 23.501 [4] and 38.415 [31]):

- The DL Delay Result from NG-RAN to UE indicating the downlink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (see 38.415 [31], and the DL Delay Result is denoted by in the present document);

- The 5QI and S-NSSAI associated to the GTP PDU monitoring response packet.

 The gNB increments the corresponding bin with the delay range where the falls into by 1 for the counters.

 The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer representing the number of GTP PDUs measured with the delay within the range of the bin.The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) DRB.DelayDlNgranUeDist.Bin\_Filter, where Bin indicates a delay range which is vendor specific;

Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellCU (for non-split and 2-split scenario);
GNBCUUPFunction (for 3-split scenario).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.1.1.1.7 Distribution of UL delay between NG-RAN and UE

a) This measurement provides the distribution of UL packet delay between NG-RAN and UE, which is the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface. This measurement is calculated per PLMN ID and per 5QI and per supported S-NSSAI.

b) DER (n=1).

c) The measurement is obtained by the following method:

 The gNB performs the GTP PDU packet delay measurement for QoS monitoring per the GTP PDU monitoring packets received from UPF, and records the following time stamps and information included in the GTP-U header of each GTP PDU monitoring response packet (packet i) sent to UPF (see 23.501 [4] and 38.415 [31]):

- The UL Delay Result from UE to NG-RAN indicating the uplink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (see 38.415 [31], and the UL Delay Result is denoted by in the present document);

- The 5QI and S-NSSAI associated to the GTP PDU monitoring response packet.

 The gNB increments the corresponding bin with the delay range where the falls into by 1 for the counters.

 The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer representing the number of GTP PDUs measured with the delay within the range of the bin. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) DRB.DelayUlNgranUeDist.Bin\_Filter, where Bin indicates a delay range which is vendor specific;
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.
Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellCU (for non-split and 2-split scenario);
GNBCUUPFunction (for 3-split scenario).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.1.1.1.8 DL packet delay between NG-RAN and PSA UPF

5.1.1.1.8.1 Average DL GTP packet delay between PSA UPF and NG-RAN

a) This measurement provides the average DL GTP packet delay between PSA UPF and NG-RAN. This measurement is split into subcounters per 5QI and subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF samples the GTP packets for QoS monitoring based on the policy provided by OAM or SMF.

NOTE: The sampling rate may vary for different S-NSSAI and different 5QIs, and the specific sampling rate is up to implementation unless given by the QoS monitoring policy.

 For each DL GTP PDU (packet i) encapsulated with QFI, TEID, and QMP indicator for QoS monitoring, the gNB records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T1 received in the GTP-U header indicating the local time that the DL GTP PDU was sent by the PSA UPF;

- T2 that the DL GTP PDU was received by NG-RAN;

- The 5QI and S-NSSAI associated to the DL GTP PDU.

 The gNB counts the number (N) of DL GTP PDUs encapsulated with QFI, TEID, and QMP indicator for each 5QI and each S-NSSAI respectively, and takes the following calculation for each 5QI and each S-NSSAI:

d) Each measurement is a real representing the average delay in microseconds.

e) GTP.DelayDlPsaUpfNgranMean.*5QI, where 5QI* identifies the 5QI;
GTP.DelayDlPsaUpfNgranMean.*SNSSAI, where SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by GNBCUUPFunction).

g) Valid for packet switched traffic.

h) 5GS.

5.1.1.1.8.2 Distribution of DL GTP packet delay between PSA UPF and NG-RAN

a) This measurement provides the distribution of DL GTP packet delay between PSA UPF and NG-RAN. This measurement is split into subcounters per 5QI and subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF samples the GTP packets for QoS monitoring based on the policy provided by OAM or SMF.

NOTE: The sampling rate may vary for different S-NSSAI and different 5QIs, and the specific sampling rate is up to implementation unless given by the QoS monitoring policy.

 For each DL GTP PDU (packet i) encapsulated with QFI, TEID, and QMP indicator for QoS monitoring, the gNB records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T1 received in the GTP-U header indicating the local time that the DL GTP PDU was sent by the PSA UPF;

- T2 that the DL GTP PDU was received by NG-RAN;

- The 5QI and S-NSSAI associated to the DL GTP PDU.

 The gNB 1) takes the following calculation for each DL GTP PDU (packet i) encapsulated with QFI, TEID, and QMP indicator for each 5QI and each S-NSSAI respectively, and 2) increment the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounters per 5QI and subcounters per S-NSSAI.

d) Each measurement is an integer representing the number of GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayDlPsaUpfNgranDist.*5QI*.*Bin,* Where *Bin* indicates a delay range which is vendor specific, and *5QI* identifies the 5QI;
GTP.DelayDlPsaUpfNgranDist.*SNSSAI.bin,* Where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by GNBCUUPFunction).

g) Valid for packet switched traffic.

h) 5GS.

#### 5.1.1.2 Radio resource utilization

##### 5.1.1.2.1 DL Total PRB Usage

a) This measurement provides the total usage (in percentage) of physical resource blocks (PRBs) on the downlink for any purpose.

b) SI

c) This measurement is obtained as: , where is the DL total PRB usage, which is percentage of PRBs used, averaged during time period  with value range: 0-100%; is a count of full physical resource blocks and all PRBs used for DL traffic transmission shall be included; is total number of PRBs available for DL traffic transmission during time period ; and is the time period during which the measurement is performed.

d) A single integer value from 0 to 100.

e) RRU.PrbTotDl, *which indicates the DL PRB Usage for all traffic*

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the load of the radio physical layer.

##### 5.1.1.2.2 UL Total PRB Usage

a) This measurement provides the total usage (in percentage) of physical resource blocks (PRBs) on the uplink for any purpose.

b) SI

c) This measurement is obtained as: , where is the UL total PRB usage, which is percentage of PRBs used, averaged during time period  with value range: 0-100%; is a count of full physical resource blocks and all PRBs used for UL traffic transmission shall be included; is total number of PRBs available for UL traffic transmission during time period ; and is the time period during which the measurement is performed

d) A single integer value from 0 to 100.

e) RRU.PrbTotUl, *which indicates the UL PRB Usage for all traffic*

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the load of the radio physical layer.

##### 5.1.1.2.3 Distribution of DL Total PRB Usage

a) This measurement provides the distribution of samples with total usage (in percentage) of physical resource blocks (PRBs) on the downlink in different ranges. This measurement is a useful measure of whether a cell is under high loads or not in the scenario which a cell in the downlink may experience high load in certain short times (e.g. in a millisecond) and recover to normal very quickly.

b) CC

c) Each measurement sample is obtained as: , where is total PRB usage at sample n for DL, which is a percentage of PRBs used, averaged during time period tn (e.g. a millisecond) with value range: 0-100%; is a count of full physical resource blocks and all PRBs used for DL traffic transmission shall be included;is the total number of PRBs available for DL traffic transmission during time period tn and n is the sample with time period tn during which the measurement is performed.

d) Distribution of total PRB usage is calculated in the time-frequency domain only. The reference point is the Service Access Point between MAC and L1. The distribution of PRB usage provides the histogram result of the samples collected during time period tn.

e) Depending on the value of the sample, the proper bin of the counter is increased. The number of samples during one measurement period is provided by the operator.

f) A set of integers. Each representing the (integer) number of samples with a DL total PRB percentage usage in the range represented by that bin.

g) RRU.PrbTotDlDist.BinX, which indicates the distribution of DL PRB Usage for all traffic.

h) NRCellDU

i) Valid for packet switched traffic

j) 5GS

k) One usage of this measurement is for monitoring the load of the radio physical layer.

##### 5.1.1.2.4 Distribution of UL total PRB usage

a) This measurement provides the distribution of samples with total usage (in percentage) of physical resource blocks (PRBs) on the uplink in different usage ranges. This measurement is a useful measure of whether a cell is under high loads or not in the scenario which a cell in the uplink may experience high load in certain short times (e.g. in a millisecond) and recover to normal very quickly.

b) CC

c) Each measurement sample is obtained as: , where is total PRB usage at sample n for UL, which is a percentage of PRBs used, averaged during time period tn (e.g. a millisecond) with value range: 0-100%; is a count of full physical resource blocks and all PRBs used for UL traffic transmission shall be included;is the total number of PRBs available for UL traffic transmission during time period tn and n is the sample with time period tn during which the measurement is performed.

Distribution of total PRB usage is calculated in the time-frequency domain only. The reference point is the Service Access Point between MAC and L1. The distribution of PRB usage provides the histogram result of the samples collected during time period tn.

Depending on the value of the sample, the proper bin of the counter is increased. The number of samples during one measurement period is provided by the operator.

d) A set of integers, each representing the (integer) number of samples with a UL PRB percentage usage in the range represented by that bin.

e) RRU.PrbTotUlDist.BinX, which indicates the distribution of UL PRB Usage for all traffic.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the load of the radio physical layer.

##### 5.1.1.2.5 Mean DL PRB used for data traffic

a) This measurement provides the number of physical resource blocks (PRBs) in average used in downlink for data traffic. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI and subcounters per supported PLMN ID.

b) SI.

c) Each measurement is obtained as the averagenumber (arithmetic mean) of all PRBs used for DL data traffic transmission per S-NSSAI and per PLMN ID during a time period *T.*

d) Each measurement is a single integer value. If the optional measurements are perfomed, the number of measurements is equal to the number of QoS levels and the number of supported S-NSSAIs and the number of supported PLMN.

e) RRU.PrbUsedDl, or optionally RRU.PrbUsedDl.*QoS,* where the *QoS* identifies the target quality of service class and RRU.PrbUsedDl.*SNSSAI*, where SNSSAI identifies the S-NSSAI, and RRU.PrbUsedDl.PLMN, where PLMN identifies the PLMN ID.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the DL PRB load of the radio physical layer per S-NSSAI.

##### 5.1.1.2.6 DL total available PRB

a) This measurement provides the total number of physical resource blocks (PRBs) in average available downlink.

b) SI.

c) The measurement is obtained as the average (arithmetic mean) of total availible count of PRBs available for DL traffic transmission during time period *T.*

d) One measurement, (average number of DL PRBs) is a single integer value. e) RRU.PrbAvailDl*.*

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the total number of available PRBs in average for DL traffic.

##### 5.1.1.2.7 Mean UL PRB used for data traffic

a) This measurement provides the number of physical resource blocks (PRBs) in average used in uplink for data traffic. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI and subcounters per supported PLMN ID.

b) SI

c) Each measurement is obtained as the average number (arithmetic mean) of all PRBs used for UL data traffic transmission per S-NSSAI and per PLMN ID during a time period *T.*

d) Each measurement (number of PRBs) is a single integer value. If the optional measurements are perfomed, the number of measurements is equal to the number of QoS levels and the number of supported S-NSSAIs and the number of supported PLMN.

e) RRU.PrbUsedUl, or optionally RRU.PrbUsedUl.*QoS,* where the *QoS* identifies the target quality of service class *and* RRU.PrbUsedUl.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI, and RRU.PrbUsedUl.PLMN, where PLMN identifies the PLMN ID.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the UL PRB load of the radio physical layer per S-NSSAI.

##### 5.1.1.2.8 UL total available PRB

a) This measurement provides the total number of physical resource blocks (PRBs) available uplink.

b) SI.

c) The measurement is obtained as the average number (arithmetic mean) of total available count of PRBs available for UL traffic transmission during time period *T.*

d) One measurement, (average of total number of UL PRBs) that is a single integer value.

e) RRU.PrbAvailUl, which indicates the UL PRB available.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the total number of available PRBs in average UL.

##### 5.1.1.2.9 Peak DL PRB used for data traffic

a) This measurement provides the maximum number of PRBs used in downlink for data traffic. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI.

b) SI.

c) Each measurement is obtained by sampling at a pre-defined interval, the PRBs used for DL data traffic transmission per S-NSSAI during a time period *T*, and selecting the sample with the maximum value from the samples collected in a given period.

d) Each measurement is a single integer value. If the optional measurements are perfomed, the number of measurements is equal to the number of QoS levels and the number of supported S-NSSAIs.

e) RRU.MaxPrbUsedDl, or optionally RRU.MaxPrbUsedDl.*QoS,* where the *QoS* identifies the target quality of service class and RRU.MaxPrbUsedDl.*SNSSAI*, where SNSSAI identifies the S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the DL PRB load of the radio physical layer per S-NSSAI to support RRM resources optimization (see TS 28.313 [30]).

##### 5.1.1.2.10 Peak UL PRB used for data traffic

a) This measurement provides the number of PRBs used in uplink for data traffic. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI.

b) SI

c) Each measurement is obtained by sampling at a pre-defined interval, the PRBs used for UL data traffic transmission per S-NSSAI during a time period *T*, and selecting the sample with the maximum value from the samples collected in a given period.

d) Each measurement (number of PRBs) is a single integer value. If the optional measurements are perfomed, the number of measurements is equal to the number of QoS levels and the number of supported S-NSSAIs.

e) RRU.MaxPrbUsedUl, or optionally RRU.MaxPrbUsedUl.*QoS,* where the *QoS* identifies the target quality of service class *and* RRU.MaxPrbUsedUl.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the UL PRB load of the radio physical layer per S-NSSAI to support RRM resources optimization (see TS 28.313 [30]).

##### 5.1.1.2.11 PDSCH PRB Usage per cell for MIMO

a) This measurement provides the total usage (in percentage) of physical resource blocks (PRBs) per cell for MIMO with time domain averaged maximum scheduled layer number as spatial factor in the downlink.

b) SI

c) This measurement is obtained as:

 

Where

 denotes total PDSCH PRB usage per cell which is percentage of PRBs used, averaged during time period 𝑇 with integer value range: 0-100;

 denotes the number of PDSCH PRBs multiplexed by *i* MIMO layers at sampling occasion *j*.

 denotes total number of PDSCH PRBs available for sampling occasion j on single MIMO layer per cell;

*LM(T)* denotes the time-domain averaged maximum scheduled layer number of PDSCH in time period T defined in clause 5.1.1.30.3 of the present document;

NOTE: At every sampling occasion the maximum scheduled layer number of all PRBs included in PDSCH is collected as a sampling value and at the end of statistical duration the average of all non-zero sampling values is the measuremnt result as defined in clause 5.1.1.30.3 of the present document.

*T* denotes the time period during which measurement is performed;

*i* is an integer denoting a MIMO layer number that is scheduled in time period T;

*j* denotes sampling occasion (e.g. 1 slot) during time period T.

d) A single integer value from 0 to 100.

e) RRU.PrbTotDlMimo, *which indicates the PDSCH PRB Usage per cell for MIMO*

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the load of the radio physical layer under MIMO scenario.

##### 5.1.1.2.12 PUSCH PRB Usage per cell for MIMO

a) This measurement provides the total usage (in percentage) of physical resource blocks (PRBs) per cell for MIMO with time domain averaged maximum scheduled layer number as spatial factor in the uplink.

b) SI

c) This measurement is obtained as:

,

Where

 denotes total PUSCH PRB usage per cell which is percentage of PRBs used, averaged during time period 𝑇 with integer value range: 0-100;

 denotes the number of PUSCH PRBs multiplexed by *i* MIMO layers at sampling occasion *j*.

 denotes total number of PUSCH PRBs available for sampling occasion j on single MIMO layer per cell;

*LM(T)* denotes the time-domain averaged maximum scheduled layer number of PUSCH in time period T defined in clause 5.1.1.30.4 of the present document;

NOTE: At every sampling occasion the maximum scheduled layer number of all PRBs included in PUSCH is collected as a sampling value and at the end of statistical duration the average of all non-zero sampling values is the measuremnt result as defined in clause 5.1.1.30.4 of the present document.

*T* denotes the time period during which measurement is performed;

*i* is an integer denoting a MIMO layer number that is scheduled in time period T;

*j* denotes sampling occasion (e.g. 1 slot) during time period T.

d) A single integer value from 0 to 100.

e) RRU.PrbTotUlMimo, *which indicates the PUSCH PRB Usage per cell for MIMO*

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the load of the radio physical layer under MIMO scenario.

##### 5.1.1.2.13 SDM PDSCH PRB Usage

a) Due to MIMO technology (strong Space Division Multiplexing ability), the cell capacity has been improved obviously. This measurement provides the total usage (in percentage) of PDSCH physical resource blocks (PRBs), based on statistical MIMO layers. The objective is to measure the usage of cell DL capacity in MIMO scenario. A use-case is wireless network workload observation.

b) SI

c) This measurement is defined according to "PDSCH PRB Usage based on statistical MIMO layer in the DL per cell " in TS 38.314 [29] as:

Where

 denotes total PDSCH PRB usage per cell which is percentage of PRBs used, averaged during time period with integer value.

 denotes a count of PDSCH PRBs used for traffic transmission for UE on single MIMO layer per cell at sampling occasion . Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carriers).

 denotes the number of MIMO layers scheduled for UE at sampling occasion .

denotes a UE that is scheduled during time period .

 denotes sampling occasion during time period . A sampling occasion is 1 symbol.

 denotes total number of PDSCH PRBs available for sampling occasion *j* on single MIMO layer per cell.

 denotes the time period during which the measurement is performed to calculate , e.g. 15min, 1 hour, etc.

 is a variable factor for MIMO layers assigned with the maximum during time period 2 with float value 1.00-100.00. For this measurement, the same β value is used for the entire duration of T1.

 is the "Average value of scheduled MIMO layers per PRB on the DL", during time period with float value 1.00-100.00, as defined in 5.1.1.30.

 denotes time period during which the measurement is performed to calculate , as defined in 5.1.1.30.

 is the time period during which the measurement is performed to calculate , e.g.1 week, etc.

d) A single integer value from 0 to 100.

e) RRU.PrbTotSdmDl, which indicates the DL SDM PRB Usage in a Cell supporting MIMO.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the DL Radio Resource Utilization in a cell supporting MIMO.

##### 5.1.1.2.14 SDM PUSCH PRB Usage

a) Due to MIMO technology (strong Space Division Multiplexing ability), the cell capacity has been improved obviously. This measurement provides the total usage (in percentage) of PUSCH physical resource blocks (PRBs), based on statistical MIMO layers. The objective is to measure the usage of cell UL capacity in MIMO scenario. A use-case is wireless network workload observation.

b) SI

c) This measurement is defined according to "PUSCH PRB Usage based on statistical MIMO layer in the UL per cell " in TS 38.314 [29] as:

Where

 denotes total PUSCH PRB usage per cell which is percentage of PRBs used, averaged during time period with integer value.

 denotes a count of PUSCH PRBs used for traffic transmission for UE on single MIMO layer per cell at sampling occasion . Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carriers).

 denotes the number of MIMO layers scheduled for UE at sampling occasion.

 denotes a UE that is scheduled during time period .

 denotes sampling occasion during time period . A sampling occasion is 1 symbol.

 denotes total number of PUSCH PRB available for sampling occasion *j* on single MIMO layer per cell.

 denotes the time period during which the measurement is performed to calculate , e.g. 15min, 1 hour, etc.

 is a variable factor for MIMO layers assigned with the maximum during time period 2 with float value 1.00-100.00. For this measurement, the same β value is used for the entire duration of T1.

 is the "Average value of scheduled MIMO layers per PRB on the UL", during time period with float value 1.00-100.00, as defined in 5.1.1.30.

 denotes time period during which the measurement is performed to calculate , as defined in 5.1.1.30.

 is the time period during which the measurement is performed to calculate , e.g.1 week, etc.

d) A single integer value from 0 to 100.

e) RRU.PrbTotSdmUl, which indicates the UL SDM PRB Usage in a Cell supporting MIMO.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the UL Radio Resource Utilization in a cell supporting MIMO.

#### 5.1.1.3 UE throughput

##### 5.1.1.3.1 Average DL UE throughput in gNB

a) This measurement provides the average UE throughput in downlink. This measurement is intended for data bursts that are large enough to require transmissions to be split across multiple slots. The UE data volume refers to the total volume scheduled for each UE regardless if using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI, and subcounters per PLMN ID.

b) DER(N=1)

c) This measurement is obtained according to the following formula based on the "ThpVolDl" and "ThpTimeDl" defined below. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI, and for each PLMN ID.

If , ×1000 [kbit/s]

If , 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission, , otherwise 

|  |  |
| --- | --- |
| ThpTimeDl | The time to transmit a data burst excluding the data transmitted in the slot when the buffer is emptied. A sample of "ThpTimeDl" for each time the DL buffer for one DataRadioBearer (DRB) is emptied. |
|  | The point in time after T2 when data up until the second last piece of data in the transmitted data burst which emptied the RLC SDU available for transmission for the particular DRB was successfully transmitted, as acknowledged by the UE.  |
|  | The point in time when the first transmission begins after a RLC SDU becomes available for transmission, where previously no RLC SDUs were available for transmission for the particular DRB. |
|  | The RLC level volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolDl is the data volume, counted on RLC SDU level, in kbit successfully transmitted (acknowledged by UE) in DL for one DRB during a sample of ThpTimeDl. (It shall exclude the volume of the last piece of data emptying the buffer). |

d) Each measurement is a real value representing the throughput in kbit per second. The number of measurements is equal to one. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.

e) The measurement name has the form
DRB.UEThpDl, or optionally DRB.UEThpDl.*QOS,* where *QOS* identifies the target quality of service class, and DRB.UEThpDl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI, and DRB.UEThpDl.*PLMN,* where *PLMN* identifies the PLMN ID..

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.3.2 Distribution of DL UE throughput in gNB

a) This measurement provides the distribution of the UE throughput in downlink. This measurement is intended for data bursts that are large enough to require transmissions to be split across multiple slots. The UE data volume refers to the total volume scheduled for each UE regardless if using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSA, and subcounters per PLMN IDI.

b) CC

c) Considering there are n samples during measurement time T and each sample has the same time period tn, the measurement of one sample is obtained by the following formula for a measurement period tn:

If , ×1000 [kbit/s]

If , 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission, , otherwise 

|  |  |
| --- | --- |
| ThpTimeDl | The time to transmit a data burst excluding the data transmitted in the slot when the buffer is emptied. A sample of "ThpTimeDl" for each time the DL buffer for one DataRadioBearer (DRB) is emptied. |
|  | The point in time after T2 when data up until the second last piece of data in the transmitted data burst which emptied the RLC SDU available for transmission for the particular DRB was successfully transmitted, as acknowledged by the UE.  |
|  | The point in time when the first transmission begins after a RLC SDU becomes available for transmission, where previously no RLC SDUs were available for transmission for the particular DRB. |
|  | The RLC level volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolDl is the data volume, counted on RLC SDU level, in kbit successfully transmitted (acknowledged by UE) in DL for one DRB during a sample of ThpTimeDl. (It shall exclude the volume of the last piece of data emptying the buffer). |

Alternatively, for small data bursts, that are successfully transmitted in any given slot (i.e. the requirement that data bursts need to span across several slots excluding transmission of the last piece of the data in a data burst does not apply). where all buffered data is included in one initial HARQ transmission, fraction of the slot time ( may be counted and obtained by the formula:



|  |  |
| --- | --- |
| *slot* | Duration of the slot |
| *TBVol* | Volume of the TB related to one slot burst |
| *PaddingVol* | Volume of padding bits added into Transport Block related to one slot burst. |

For each measurement sample, the bin corresponding to the DL throughput experienced by the UE is incremented by one. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI.

d) A set of integers, each representing the (integer) number of samples with a DL UE throughput in the range represented by that bin. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.

e) The measurement name has the form
DRB.UEThpDlDist.Bin where Bin represents the bin, or optionally DRB.UEThpDlDist.Bin.*QOS,* where *QOS* identifies the target quality of service class, and DRB.UEThpDlDist.Bin*.SNSSAI,* where *SNSSAI* identifies the S-NSSAI, and DRB.UEThpDlDist.Bin.*PLMN,* where *PLMN* identifies the PLMN ID.

NOTE: Number of bins and the range for each bin is left to implementation

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.3.3 Average UL UE throughput in gNB

a) This measurement provides the average UE throughput in uplink. This measurement is intended for data bursts that are large enough to require transmissions to be split across multiple slots. The UE data volume refers to the total volume scheduled for each UE regardless if using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI, and subcounters per PLMN ID.

B) DER(N=1)

c) This measurement is obtained according to the following formula based on the "ThpVolUl" and "ThpTimeUl" defined below. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI, and for each PLMN ID.

If , ×1000 [kbit/s]

If , 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission otherwise:



|  |  |
| --- | --- |
| ThpTimeUl | The time to transmit a data burst excluding the data transmitted in the slot when the buffer is emptied. A sample of "ThpTimeUl" for each time the UL buffer for one DataRadioBearer (DRB) is emptied. |
|  | The point in time when the data up until the second last piece of data in data burst has been successfully received for a particular DRB  |
|  | The point in time when transmission is started for the first data in data burst for a particular DRB. |
|  | The RLC level volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolUl is the data volume counted on RLC SDU level in kbit received in UL for one DRB during a sample of ThpTimeUl, (It shall exclude the volume of the last piece of data emptying the buffer). |

d) Each measurement is a real value representing the throughput in kbit per second. The number of measurements is equal to one. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.

e) The measurement name has the form
DRB.UEThpUl, or optionally DRB.UEThpUl.*QOS,* where *QOS* identifies the target quality of service class and DRB.UEThpUl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI, and DRB.UEThpUl.*PLMN,* where *PLMN* identifies the PLMN ID.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.3.4 Distribution of UL UE throughput in gNB

a) This measurement provides the distribution of the UE throughput in uplink. This measurement is intended for data bursts that are large enough to require transmissions to be split across multiple slots. The UE data volume refers to the total volume scheduled for each UE regardless if using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI, and subcounters per PLMN ID.

b) CC

c) Considering there are n samples during measurement time T and each sample has the same time period tn, the measurement of one sample is obtained by the following formula for a measurement period tn:

If , ×1000 [kbit/s]

If , 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission otherwise:



|  |  |
| --- | --- |
| ThpTimeUl | The time to transmit a data burst excluding the data transmitted in the slot when the buffer is emptied. A sample of "ThpTimeUl" for each time the UL buffer for one DataRadioBearer (DRB) is emptied. |
| T1 | The point in time when the data up until the second last piece of data in data burst has been successfully received for a particular DRB  |
| T2 | The point in time when transmission is started for the first data in data burst for a particular DRB. |
| ThpVolUL | The RLC level volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolUl is the data volume counted on RLC SDU level in kbit received in UL for one DRB during a sample of ThpTimeUl, (It shall exclude the volume of the last piece of data emptying the buffer). |

Alternatively, for small data bursts, that are successfully transmitted in any given slot (i.e. the requirement that data bursts need to span across several slots excluding transmission of the last piece of the data in a data burst does not apply). where all buffered data is included in one initial HARQ transmission, fraction of the slot time ( may be counted and obtained by the formula:



|  |  |
| --- | --- |
| *slot* | Duration of the slot |
| *TBVol* | Volume of the TB related to one slot burst |
| *PaddingVol* | Volume of padding bits added into Transport Block related to one slot burst. |

For each measurement sample, the bin corresponding to the UL throughput experienced by the UE is incremented by one. Separate counters are maintained for each mapped 5QI (or QCI for option 3) and for each supported S-NSSAI, and for each PLMN ID.

d) A set of integers, each representing the (integer) number of samples with a UL UE throughput in the range represented by that bin. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.

e) The measurement name has the form
DRB.UEThpUlDist.Bin where Bin represents the bin, or optionally DRB.UEThpUlDist.Bin.*QOS,* where *QOS* identifies the target quality of service class, and DRB.UEThpUlDist.Bin.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI, and DRB.UEThpUlDist.Bin.*PLMN,* where *PLMN* identifies the PLMN ID.

NOTE: Number of bins and the range for each bin is left to implementation

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.3.5 Percentage of unrestricted DL UE data volume in gNB

a) This measurement provides the percentage of DL data volume for UEs in the cell that is classified as unrestricted, i.e., when the volume is so low that all data can be transferred in one slot and no UE throughput sample could be calculated. The UE data volume refers to the total volume scheduled for each UE regardless if using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI, and subcounters per PLMN ID.

b) SI.

c) For periods when no data is transferred at all *Percentage Unrestricted Volume DL = 0*, otherwise:

 

|  |  |
| --- | --- |
| ThpUnresVolDl | The volume of a data burst that is transmitted in the slot when the buffer is emptied (which could be the only slot needed to transmit the data burst) and not included in the UE throughput measurement. A sample for ThpUnresVolDl is the data volume counted on RLC SDU level in kbits sent in DL for one DRB. |
| ThpVolDl | The volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolDl is the data volume counted on RLC SDU level in kbits sent in DL for one DRB.  |

d) Each measurement is a single integer value from 0 to 100. The number of measurements is equal to one. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are perfomed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.

e) The measurement name has the form
DRB.UEUnresVolDl or optionally DRB.UEUnresVolDl.*QOS,* where *QOS* identifies the target quality of service class, or DRB.UEUnresVolDl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI, and DRB.UEUnresVolDl.*PLMN,* where *PLMN* identifies the PLMN ID.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.3.6 Percentage of unrestricted UL UE data volume in gNB

a) This measurement provides the percentage of UL data volume for UEs in the cell that is classified as unrestricted, i.e., when the volume is so low that all data can be transferred in one slot and no UE throughput sample could be calculated. The UE data volume refers to the total volume scheduled for each UE regardless if using only primary- or also supplemental aggregated carriers. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI, and subcounters per PLMN ID.

b) SI

c) For periods when no data is transferred at all *Percentage Unrestricted Volume UL = 0*, otherwise:



|  |  |
| --- | --- |
| ThpUnresVolUl | The volume of a data burst that is transmitted in the slot when the buffer is emptied (which could be the only slot needed to transmit the data burst) and not included in the UE throughput measurement. A sample for ThpUnresVolUl is the data volume counted on RLC SDU level in kbits received in UL for one DRB. |
| ThpVolUl | The volume of a data burst, excluding the data transmitted in the slot when the buffer is emptied. A sample for ThpVolUl is the data volume counted on RLC SDU level in kbits received in UL for one DRB.  |

d) Each measurement is a single integer value from 0 to 100. The number of measurements is equal to one. If the optional QoS level subcounter and S-NSSAI subcounter and PLMN ID subcounter measurements are performed, the number of measurements is equal to the number of mapped 5QIs and the number of supported S-NSSAIs, and the number of PLMN IDs.

e) The measurement name has the form
DRB.UEUnresVolUl or optionally DRB.UEUnresVolUl.*QOS,* where *QOS* identifies the target quality of service class , and DRB.UEUnresVolUl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI, and DRB.UEUnresVolUl.*PLMN,* where *PLMN* identifies the PLMN ID.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

#### 5.1.1.4 RRC connection number

##### 5.1.1.4.1 Mean number of RRC Connections

a) This measurement provides the mean number of users in RRC connected mode for each NR cell during each granularity period. The measurement is optionally split into subcounters per PLMN ID.

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval, the number of users in RRC connected mode for each NR cell and for each PLMN ID, and then taking the arithmetic mean.

d) Each measurement is a single integer value. If the optional measurement is perfomed, the number of measurements is equal to the number of supported PLMNs.

e) RRC.ConnMean, or optionally RRC.ConnMean.PLMN, where PLMN identifies the PLMN ID.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the number of RRC connections in connected mode during the granularity period.

##### 5.1.1.4.2 Max number of RRC Connections

a) This measurement provides the maximum number of users in RRC connected mode for each NR cell during each granularity period. The measurement is optionally split into subcounters per PLMN ID.

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval, the number of users in RRC connected mode for each NR cell and for each PLMN ID, and then taking the maximum.

d) Each measurement is a single integer value. If the optional measurement is perfomed, the number of measurements is equal to the number of supported PLMNs.

e) RRC.ConnMax, or optionally RRC.ConnMax.PLMN, where PLMN identifies the PLMN ID.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the number of RRC connections in connected mode during the granularity period.

##### 5.1.1.4.3 Mean number of stored inactive RRC Connections

a) This measurement provides the mean number of users in RRC inactive mode for each NR cell during each granularity period. The measurement is optionally split into subcounters per PLMN ID.

b) SI

c) This measurement is defined according to measurement "Mean number of stored inactive UE contexts" in TS 38.314 [29]. Separate counters are optionally maintained for each PLMN ID.

d) Each measurement is a real representing the mean number. If the optional measurement is perfomed, the number of measurements is equal to the number of supported PLMNs.

e) The measurement name has the form RRC.InactiveConnMean, or optionally RRC.InactiveConnMean.PLMN, where PLMN identifies the PLMN ID.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the memory allocation due to storage of inactive RRC connections.

##### 5.1.1.4.4 Max number of stored inactive RRC Connections

a) This measurement provides the max number of users in RRC inactive mode during each granularity period.

b) SI

c) This measurement is defined according to measurement "Max number of stored inactive UE contexts" in TS 38.314 [29].

d) The number of measurements is equal to one

e) The measurement name has the form RRC.InactiveConnMax

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the memory allocation due to storage of inactive RRC connections.

#### 5.1.1.5 PDU Session Management

##### 5.1.1.5.1 Number of PDU Sessions requested to setup

a) This measurement provides the number of PDU Sessions by the gNB. This measurement is split into subcounters per S-NSSAI.

b) CC.

c) On receipt of PDU SESSION RESOURCE SETUP REQUEST message, INITIAL CONTEXT SETUP REQUEST message (see TS 38.413 [11]) by the gNB from the AMF. Each PDU Session requested to setup increments the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionSetupReq.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

##### 5.1.1.5.2 Number of PDU Sessions successfully setup

a) This measurement provides the number of PDU Sessions successfully setup by the gNB from AMF. This measurement is split into subcounters per S-NSSAI.

b) CC.

c) On transmission of PDU SESSION RESOURCE SETUP RESPONSE message, INITIAL CONTEXT SETUP RESPONSE message containing the "PDU Session Resource Setup Response List" IE (see TS 38.413 [11]) by the gNB to the AMF. Each PDU Session listed in the "PDU Session Resource Setup Response List" IE increments the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionSetupSucc.*SNSSAI.*

 Where *SNSSAI* identifies the *S-NSSAI*.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

##### 5.1.1.5.3 Number of PDU Sessions failed to setup

a) This measurement provides the number of PDU Sessions failed to setup by the gNB. This measurement is split into subcounters per failure cause.

b) CC.

c) On transmission of PDU SESSION RESOURCE SETUP RESPONSE message, INITIAL CONTEXT SETUP FAILURE message containing the "PDU Session Resource Failed to Setup List" IE (see TS 38.413 [11]) by the gNB to the AMF. Each PDU Session listed in the "PDU Session Resource Failed to Setup List" IE increments the relevant subcounter per failure cause (see clause 9.3.1.2 of TS 38.413 [11]) by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionSetupFail.*Cause.*

 Where *Cause* identifies the cause of the PDU Sessions Resource Setup failure, per the "PDU Session Resource Setup Unsuccessful Transfer" IE. Encoding of the Cause is defined in clause 9.3.1.2 of TS 38.413 [11].

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

##### 5.1.1.5.4 Mean number of PDU sessions being allocated

a) This measurement provides the mean number of PDU sessions that have been allocated in the NRCellCU. This measurement is split into subcounters per S-NSSAI.

b) SI.

c) Each measurement is obtained by sampling at a pre-defined interval, the number of PDU sessions being allocated in the NRCellCU, and taking the arithmetic mean of the samples.

d) Each subcounter is an integer value.

e) SM.MeanPDUSessionSetupReq.*SNSSAI.*

Where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance to support RRM resources optimization (see TS 28.313 [30]).

##### 5.1.1.5.5 Peak number of PDU sessions being allocated

a) This measurement provides the peak number of PDU sessions that have been allocated in the NRCellCU. This measurement is split into subcounters per S-NSSAI.

b) SI.

c) Each measurement is obtained by sampling at a pre-defined interval, the number of PDU sessions being allocated in the NRCellCU, and selecting the sample with the maximum value from the samples collected in a given period.

d) Each subcounter is an integer value.

e) SM.MaxPDUSessionSetupReq.*SNSSAI.*

Where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance to support RRM resources optimization (see TS 28.313 [30]).

#### 5.1.1.6 Mobility Management

##### 5.1.1.6.1 Inter-gNB handovers

###### 5.1.1.6.1.1 Number of requested legacy handover preparations

a) This measurement provides the number of legacy handover preparations requested by the source gNB.

b) CC.

c) On transmission of HANDOVER REQUIRED message (see TS 38.413 [11]) by the NR cell CU to the AMF, or transmission of HANDOVER REQUEST message (see TS 38.423 [13]) , where the message denotes a legacy handover, by the source NR cell CU to target NR cell CU, for requesting the preparation of resources at the target NR cell CU.

d) A single integer value.

e) MM.HoPrepInterReq.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.1.2 Number of successful legacy handover preparations

a) This measurement provides the number of successful legacy handover preparations received by the source NR cell CU.

b) CC.

c) On receipt of HANDOVER COMMAND message by the NR cell CU from the AMF (see TS 38.413 [11]), or receipt of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13]) , where the message corresponds to a previously sent legacy handover HANDOVER REQUEST message, by the source NR cell CU from the target NR cell CU, for informing that the resources for the handover have been prepared at the target NR cell CU.

d) A single integer value.

e) MM.HoPrepInterSucc.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.1.3 Number of failed legacy handover preparations

a) This measurement provides the number of failed legacy handover preparations received by the source NR cell CU. This measurement is split into subcounters per failure cause.

b) CC.

c) On receipt of HANDOVER PREPARATION FAILURE message (see TS 38.413 [11]) by the NR cell CU from the AMF, or receipt of HANDOVER PREPARATION FAILURE message (see TS 38.423 [13]) , where the message corresponds to a previously sent legacy handover HANDOVER REQUEST message, by the source NR cell CU from the target NR cell CU, for informing that the preparation of resources at the target NR cell CU has failed. Each received HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.HoPrepInterFail.*cause.*

 Where *cause* identifies the failure cause of the handover preparations.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.1.4 Number of requested . handover resource allocations

a) This measurement provides the number of legacy handover resource allocation requests received by the target NR cell CU.

b) CC.

c) On receipt of HANDOVER REQUEST message (see TS 38.413 [1]) by the NR cell CU from the AMF, or receipt of HANDOVER REQUEST message (see TS 38.423 [13]) , where the message denotes a legacy handover, by the target NR cell CU from the source NR cell CU, for requesting the preparation of resources for handover.

d) A single integer value.

e) MM.HoResAlloInterReq.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.1.5 Number of successful legacy handover resource allocations

a) This measurement provides the number of successful legacy handover resource allocations at the target NR cell CU for the handover.

b) CC.

c) On transmission of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.413 [11]) by the NR cell CU to the AMF, or transmission of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13]) , where the message corresponds to a previously received legacy handover HANDOVER REQUEST message, by the target NR cell CU to the source NR cell CU, for informing that the resources for the handover have been prepared.

d) A single integer value.

e) MM.HoResAlloInterSucc.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.1.6 Number of failed legacy handover resource allocations

a) This measurement provides the number of failed legacy handover resource allocations at the target NR cell CU for the handover. This measurement is split into subcounters per failure cause.

b) CC.

c) On transmission of HANDOVER FAILURE message (see TS 38.413 [11]) by the NR cell CU to the AMF, or transmission of HANDOVER PREPARATION FAILURE message (see TS 38.423 [13]) , where the message corresponds to a previously sent legacy handover HANDOVER REQUEST message, by the target NR cell CU to the source NR cell CU, for informing that the preparation of resources has failed. Each transmitted HANDOVER FAILURE message or HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.HoResAlloInterFail.*cause.*

 Where *cause* identifies the failure cause of the legacy handover resource allocations.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.1.7 Number of requested legacy handover executions

a) This inter gNB handover measurement provides the number of outgoing legacy handover executions requested by the source gNB.

b) CC.

c) On transmission of *RRCReconfiguration* message, where the message denotes a legacy handover, to the UE triggering the inter gNB legacy handover from the source NRCellCU to the target NRCellCU, indicating the attempt of an outgoing inter gNB legacy handover (see TS 38.331 [20]), the counter is stepped by 1.

d) A single integer value.

e) MM.HoExeInterReq.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.1.8 Number of successful legacy handover executions

a) This inter gNB handover measurement provides the number of successful legacy handover executions received by the source gNB.

b) CC.

c) On receipt at the source gNB of UE CONTEXT RELEASE [13] over Xn from the target gNB following a successful handover, where the message denotes a legacy handover, or, if handover is performed via NG, on receipt of UE CONTEXT RELEASE COMMAND [11] from AMF following a successful inter gNB handover, where the message denotes a legacy handover, the counter is stepped by 1.

d) A single integer value.

e) MM.HoExeInterSucc.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.1.9 Number of failed legacy handover executions

a) This inter gNB handover measurement provides the number of failed legacy handover executions for asource gNB.

b) CC.

c) This counter is incremented when handover execution failures occur. It is assumed that the UE context is available in the source gNB. The following events are counted:

1) On reception of NGAP UE CONTEXT RELEASE COMMAND [11] from AMF indicating an unsuccessful inter gNB handover;

2) On reception of RrcReestablishmentRequest [20] where the reestablishmentCause is handoverFailure, from the UE in the source gNB, where the reestablishment occurred in the source gNB;

3) On expiry of a Handover Execution supervision timer in the source gNB;

4) On reception of XnAP RETRIEVE UE CONTEXT REQUEST [13] in the source gNB, when the reestablishment occurred in another gNB.

The failure causes for UE CONTEXT RELEASE COMMAND are listed in [11] clause 9.3.1.2. An event increments the relevant subcounter by 1. For MM.HoExeInterFail.UE\_CONTEXT\_RELEASE\_COMMAND, an event increments the relevant subcounter per failure cause by 1. ¨

As one handover failure might cause more than one of the above events, duplicates need to be filtered out.

d) Each subcounter is an integer value.

e) MM.HoExeInterFail.UeCtxtRelCmd.*cause;*

*MM.HoExeInterFail.RrcReestabReq;*

*MM.HoExeInterFail.HoExeSupTimer;*

*MM.HoExeInterFail.RetrUeCtxtReq;*

Where *cause* identifies the failure cause of the UE CONTEXT RELEASE COMMAND message.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.1.10 Mean Time of requested legacy handover executions

a) This measurement provides the mean time of inter gNB legacy handover executions during each granularity period. The measurement is split into subcounters per S-NSSAI.

b) DER(n=1).

c) This measurement is obtained by accumulating the time interval for every successful inter gNB handover executions procedure per S-NSSAI between the receipt by the source NG-RAN from the target NG-RAN of a "Release Resource" and the sending of a "N2 Path Switch Request" message from source NG-RAN to the target NG-RAN over a granularity period using DER, for legacy handovers. The end value of this time will then be divided by the number of inter gNB legacy handovers observed in the granularity period to give the arithmetic mean, the accumulator shall be reinitialised at the beginning of each granularity period.

d) Each measurement is an integer value, in milliseconds.

e) MM.HoExeInterReq.TimeMean.*SNSSAI.*

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the mean time of inter gNB handovers during the granularity period.

###### 5.1.1.6.1.11 Max Time of requested legacy handover executions

a) This measurement provides the max time of inter gNB legacy handover executions during each granularity period. The measurement is split into subcounters per S-NSSAI.

b) DER(n=1).

c) This measurement is obtained by measuring the time interval for every successful inter gNB handover executions procedure per S-NSSAI between the receipt by the source NG-RAN from the target NG-RAN of a "Release Resource" and the sending of a "N2 Path Switch Request" message from source NG-RAN to the target NG-RAN over a granularity period using DER, for legacy handovers. The high tide mark of this time will be stored in a gauge, the gauge shall be reinitialised at the beginning of each granularity period.

d) Each measurement is an integer value, in milliseconds.

e) MM.HoExeInterReq.TimeMax.*SNSSAI.*

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for monitoring the max time of inter gNB handovers during the granularity period.

###### 5.1.1.6.1.12 Number of successful handover executions per beam pair

a) This inter gNB handover measurement provides the number of successful handover executions received by the source gNB per beam pair, i.e. beam in the source and beam in the target cell.

b) CC

c) On receipt at the source gNB of UE CONTEXT RELEASE [13] over Xn from the target gNB following a successful handover, or, if handover is performed via NG, on receipt of UE CONTEXT RELEASE COMMAND [11] from AMF following a successful inter gNB handover, the counter is stepped by 1.

d) A single integer value.

e) MM.HoExeInterSSBSucc

f) Beam.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.1.13 Number of failed handover executions per beam pair

a) This inter gNB handover measurement provides the number of failed handover executions received by the source gNB per beam pair. This measurement is split into subcounters per failure cause.

b) CC.

c) On receipt at the source gNB of UE CONTEXT RELEASE [13] over Xn from the target gNB indicating an unsuccessful inter gNB handover, or, if handover is performed via NG, on receipt of UE CONTEXT RELEASE COMMAND [11] from AMF indicating an unsuccessful inter gNB handover.

The failure causes are listed for the UE CONTEXT RELEASE in [13] and for UE CONTEXT RELEASE COMMAND in [11]. Each received message increments the relevant subcounter per failure cause by 1.

FFS how the beam pair is identified

d) Each subcounter is an integer value.

e) MM.HoExeInterSSBFail.*cause.*

Where *cause* identifies the failure cause of the UE CONTEXT RELEASE or UE CONTEXT RELEASE COMMAND message.

f) Beam.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

##### 5.1.1.6.2 Inter-gNB DAPS handovers

###### 5.1.1.6.2.1 Number of requested DAPS handover preparations

a) This measurement provides the number of DAPS handover preparations requested by the source gNB.

b) CC.

c) On transmission of HANDOVER REQUIRED message (see TS 38.413 [11]) by the NR cell CU to the AMF, or transmission of HANDOVER REQUEST message (see TS 38.423 [13]), where the message denotes a DAPS handover, by the source NR cell CU to target NR cell CU, for requesting the preparation of resources at the target NR cell CU.

d) A single integer value.

e) MM.DapsHoPrepInterReq.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.2.2 Number of successful DAPS handover preparations

a) This measurement provides the number of successful DAPS handover preparations received by the source NR cell CU.

b) CC

c) On receipt of HANDOVER COMMAND message by the NR cell CU from the AMF (see TS 38.413 [11]), or receipt of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13]), where the message denotes a DAPS handover, by the source NR cell CU from the target NR cell CU, for informing that the resources for the handover have been prepared at the target NR cell CU.

d) A single integer value.

e) MM.DapsHoPrepInterSucc.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.2.3 Number of failed DAPS handover preparations

a) This measurement provides the number of failed DAPS handover preparations received by the source NR cell CU. This measurement is split into subcounters per failure cause.

b) CC

c) On receipt of HANDOVER PREPARATION FAILURE message (see TS 38.413 [11]) by the NR cell CU from the AMF, or receipt of DAPS HO not accepted in DAPS Response Indicator of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13]), or receipt of HANDOVER PREPARATION FAILURE message (see TS 38.423 [13]) by the source NR cell CU from the target NR cell CU, where the message denotes a DAPS handover, for informing that the preparation of resources at the target NR cell CU has failed. Each received HANDOVER PREPARATION FAILURE or DAPS HO not accepted message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.DapsHoPrepInterFail.*cause.*

 Where *cause* identifies the failure cause of the handover preparations.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.2.4 Number of requested DAPS handover resource allocations

a) This measurement provides the number of DAPS handover resource allocation requests received by the target NR cell CU.

b) 1CC

c) On receipt of HANDOVER REQUEST message (see TS 38.413 [1]) by the NR cell CU from the AMF, or receipt of HANDOVER REQUEST message (see TS 38.423 [13]) by the target NR cell CU], where the message denotes a DAPS handover, from the source NR cell CU, for requesting the preparation of resources for handover.

d) A single integer value.

e) MM.DapsHoResAlloInterReq.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.2.5 Number of successful DAPS handover resource allocations

a) This measurement provides the number of successful DAPS handover resource allocations at the target NR cell CU for the handover.

b) CC.

c) On transmission of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.413 [11]) by the NR cell CU to the AMF, or transmission of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13]) by the target NR cell CU to the source NR cell CU, where the message denotes a DAPS handover, for informing that the resources for the handover have been prepared.

d) A single integer value.

e) MM.DapsHoResAlloInterSucc

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.2.6 Number of failed DAPS handover resource allocations

a) This measurement provides the number of failed DAPS handover resource allocations at the target NR cell CU for the handover. This measurement is split into subcounters per failure cause.

b) CC

c) On transmission of HANDOVER FAILURE message (see TS 38.413 [11]) by the NR cell CU to the AMF, or transmission of HANDOVER PREPARATION FAILURE message (see TS 38.423 [13]) by the target NR cell CU to the source NR cell CU, where the message denotes a DAPS handover, for informing that the preparation of resources has failed. Each transmitted HANDOVER FAILURE message or HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.DapsHoResAlloInterFail.*cause*

 Where *cause* identifies the failure cause of the handover resource allocations.

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.2.7 Number of requested DAPS handover executions

a) This inter gNB handover measurement provides the number of outgoing DAPS handover executions requested by the source gNB.

b) CC.

c) On transmission of *RRCReconfiguration* message to the UE triggering the inter gNB handover from the source NRCellCU to the target NRCellCU, indicating the attempt of an outgoing inter-gNB DAPS handover (see TS 38.331 [20]), the counter is stepped by 1.

d) A single integer value.

e) MM.DapsHoExeInterReq.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.2.8 Number of successful DAPS handover executions

a) This inter gNB handover measurement provides the number of successful DAPS handover executions received by the source gNB.

b) CC

c) On receipt at the source gNB of UE CONTEXT RELEASE [13] over Xn from the target gNB following a successful DAPS handover, or, if handover is performed via NG, on receipt of UE CONTEXT RELEASE COMMAND [11] from AMF following a successful inter gNB DAPS handover, the counter is stepped by 1.

d) A single integer value.

e) MM.DapsHoExeInterSucc.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.2.9 Number of failed DAPS handover executions

a) This inter gNB handover measurement provides the number of failed DAPS handover executions.

b) CC.

c) This counter is incremented when handover execution failures occur. It is assumed that the UE context is available in the source gNB. The following events are counted:

1) On reception of NGAP UE CONTEXT RELEASE COMMAND [11] from AMF indicating an unsuccessful inter gNB DAPS handover;

2) On reception of *RrcReestablishmentRequest* [20] where the reestablishmentCause is handoverFailure, from the UE in the source gNB, where the reestablishment occurred in the source gNB, for a DAPS handover;

3) On expiry of a Handover Execution supervision timer in the source gNB for a DAPS handover;

4) On reception of XnAP RETRIEVE UE CONTEXT REQUEST [13] in the source gNB, for a DAPS handover, when the reestablishment occurred in another gNB;

5) On reception of *FailureInformation* [20] where *failureType-r16* is set to *daps-failure*.

The failure causes for UE CONTEXT RELEASE COMMAND are listed in [11] clause 9.3.1.2. An event increments the relevant subcounter by 1. For MM.DapsHoExeInterFail.UE\_CONTEXT\_RELEASE\_COMMAND, an event increments the relevant subcounter per failure cause by 1.

As one handover failure might cause more than one of the above events, duplicates need to be filtered out.

d) Each subcounter is an integer value.

e) MM.DapsHoExeInterFail.UeCtxtRelCmd.*cause*;
MM.DapsHoExeInterFail.RrcReestabReq;MM.DapsHoExeInterFail.HoExeSupTimer;MM.DapsHoExeInterFail.RetrUeCtxtReq;
MM.DapsHoExeInterFail.FailInfo.

Where *cause* identifies the failure cause of the UE CONTEXT RELEASE COMMAND message.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

##### 5.1.1.6.3 Intra-gNB DAPS handovers

###### 5.1.1.6.3.1 Number of requested handovers

a) This measurement provides the number of outgoing intra-gNB DAPS handovers requested by the source NRCellCU.

b) CC.

c) On transmission of *RRC Reconfiguration* message to the UE triggering the handover from the source NRCellCU to the target NRCellCU, indicating the attempt of an outgoing intra-gNB DAPS handover (see TS 38.331 [20]), the counter is stepped by 1.

d) A single integer value.

e) MM.DapsHoExeIntraReq.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.3.2 Number of successful DAPS handovers

a) This measurement provides the number of successful intra-gNB DAPS handovers received by the source NRCellCU.

b) CC.

c) On reception of *RRC ReconfigurationComplete* message from the UE to the target NRCellCU indicating a successful intra-gNB DAPS handover (see TS 38.331 [20]), the counter is stepped by 1.

d) A single integer value.

e) MM.DapsHoExeIntraSucc.

f) NRCellCU,
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

##### 5.1.1.6.4 Intra-gNB handovers

###### 5.1.1.6.4.1 Number of requested legacy handover executions

a) This measurement provides the number of outgoing intra gNB legacy handover executions requested by the source NRCellCU.

b) CC.

c) On transmission of *RRC Reconfiguration* message to the UE triggering the legacy handover from the source NRCellCU to the target NRCellCU, indicating the attempt of an outgoing intra-gNB legacy handover (see TS 38.331 [20]), the counter is stepped by 1.

d) A single integer value.

e) MM.HoExeIntraReq.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.4.2 Number of successful legacy handover executions

a) This measurement provides the number of successful intra gNB legacy handover executions received by the source NRCellCU.

b) CC.

c) On reception of *RRC ReconfigurationComplete* message from the UE to the target NRCellCU indicating a successful intra gNB legacy handover (see TS 38.331 [20]), the counter is stepped by 1.

d) A single integer value.

e) MM.HoExeIntraSucc.

f) NRCellCU;
NRCellRelation.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

##### 5.1.1.6.5 Handovers between 5GS and EPS

###### 5.1.1.6.5.1 Number of requested preparations for handovers from 5GS to EPS

a) This measurement provides the number of preparations requested by the source gNB for the outgoing handovers from 5GS to EPS.

b) CC

c) Transmission of HANDOVER REQUIRED message containing the "Handover Type" IE set to "5GStoEPS" (see TS 38.413 [11]) by the gNB-CU to the AMF.

d) A single integer value.

e) MM.HoOut5gsToEpsPrepReq.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.2 Number of successful preparations for handovers from 5GS to EPS

a) This measurement provides the number of successful preparations received by the source gNB for the outgoing handovers from 5GS to EPS.

b) CC

c) Receipt of HANDOVER COMMAND message by the gNB-CU from the AMF (see TS 38.413 [11]), for informing that the resources have been successfully prepared at the target E-Utran Cell for the handover from 5GS and EPS.

d) A single integer value.

e) MM.HoOut5gsToEpsPrepSucc.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.3 Number of failed preparations for handovers from 5GS to EPS

a) This measurement provides the number of failed preparations received by the source gNB for the outgoing handovers from 5GS to EPS. This measurement is split into subcounters per failure cause.

b) CC

c) Receipt of HANDOVER PREPARATION FAILURE message (see TS 38.413 [11]) by the gNB-CU from the AMF, for informing that the preparation of resources have been failed at the target E-Utran Cell for the handover from 5GS and EPS. Each received HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.HoOut5gsToEpsPrepFail.*cause*

 Where *cause* identifies the failure cause of the handover preparations.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.4 Number of requested resource allocations for handovers from EPS to 5GS

a) This measurement provides the number of resource allocation requests received by the target gNB for handovers from EPS to 5GS.

b) CC

c) Receipt of HANDOVER REQUEST message containing the "Handover Type" IE set to "EPSto5GS" (see TS 38.413 [11]) by the gNB-CU from the AMF.

d) A single integer value.

e) MM.HoIncEpsTo5gsResAlloReq.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.5 Number of successful resource allocations for handovers from EPS to 5GS

a) This measurement provides the number of successful resource allocations at the target gNB for handovers from EPS to 5GS.

b) CC.

c) Transmission of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.413 [11]) by the gNB-CU to the AMF, for informing that the resources for the handover from EPS to 5GS have been allocated.

d) A single integer value.

e) MM.HoIncEpsTo5gsResAlloSucc.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.5.6 Number of failed resource allocations for handovers from EPS to 5GS

a) This measurement provides the number of failed resource allocations at the target gNB for handovers from EPS to 5GS. This measurement is split into subcounters per failure cause.

b) CC

c) Transmission of HANDOVER FAILURE message (see TS 38.413 [11]) by the gNB-CU to the AMF, for informing that the allocation of resources for the handover from EPS to 5GS has failed. Each transmitted HANDOVER FAILURE message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.HoIncEpsTo5gsResAlloFail.*cause*

 Where *cause* identifies the failure cause of the handover resource allocations.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS

###### 5.1.1.6.5.7 Number of requested executions for handovers from 5GS to EPS

a) This measurement provides the number of executions requested by the source gNB for handovers from 5GS to EPS.

b) CC.

c) Transmission of *MobilityFromNRCommand* message to the UE triggering the handover from the source NR Cell to the target E-UTRAN cell for the handover from 5GS to EPS (see TS 38.331 [20]).

d) A single integer value.

e) MM.HoOutExe5gsToEpsReq.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.8 Number of successful executions for handovers from 5GS to EPS

a) This measurement provides the number of successful executions at the source gNB for handovers from 5GS to EPS.

b) CC

c) Receipt of UE CONTEXT RELEASE COMMAND message by the gNB-CU from AMF (see TS 38.413 [11]) following a successful handover from 5GS to EPS.

d) A single integer value.

e) MM.HoOutExe5gsToEpsSucc.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.9 Number of failed executions for handovers from 5GS to EPS

a) This measurement provides the number of failed executions at the source gNB for handovers from 5GS to EPS. This measurement is split into subcounters per failure cause.

b) CC

c) Receipt of UE CONTEXT RELEASE COMMAND at the source gNB-CU from AMF (see TS 38.413 [11]) indicating an unsuccessful handover from 5GS to EPS. Each received message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.HoOutExe5gsToEpsFail.*cause.*

Where *cause* identifies the failure cause in the UE CONTEXT RELEASE COMMAND message.

f) EutranRelation (contained by NRCellCU),
NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.10 Number of requested preparations for EPS fallback handovers

a) This measurement provides the number of EPS fallback preparations requested by the source gNB for the outgoing handovers from 5GS to EPS.

b) CC

c) Transmission of HANDOVER REQUIRED message containing the "Handover Type" IE set to "5GStoEPS" by the gNB-CU to the AMF after the source gNodeB sends the AMF a PDU Session modification response in which "PDUSessionResourceModifyUnsuccessfulTransfer" carries the failure cause "IMS voice EPS fallback or RAT fallback triggered" (see TS 38.413 [11]) .

d) A single integer value.

e) MM.HoOut5gsToEpsFallbackPrepReq.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.11 Number of successful preparations for EPS fallback handovers

a) This measurement provides the number of successful EPS fallback preparations received by the source gNB for the outgoing handovers from 5GS to EPS.

b) CC

c) Receipt of HANDOVER COMMAND message by the gNB-CU from the AMF,after the source gNodeB sends the AMF a PDU Session modification response in which "PDUSessionResourceModifyUnsuccessfulTransfer" carries the failure cause "IMS voice EPS fallback or RAT fallback triggered" (see TS 38.413 [11]), for informing that the resources have been successfully prepared at the target E-Utran Cell for the EPS fallback handover from 5GS and EPS (see TS 38.413 [11]).

d) A single integer value.

e) MM.HoOut5gsToEpsFallbackPrepSucc.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.12 Number of failed preparations for EPS fallback handovers

a) This measurement provides the number of failed preparations received by the source gNB for the outgoing handovers from 5GS to EPS. This measurement is split into subcounters per failure cause.

b) CC

c) Receipt of HANDOVER PREPARATION FAILURE message by the gNB-CU from the AMF after the source gNodeB sends the AMF a PDU Session modification response in which "PDUSessionResourceModifyUnsuccessfulTransfer" carries the failure cause "IMS voice EPS fallback or RAT fallback triggered", for informing that the preparation of resources have been failed at the target E-Utran Cell for the handover from 5GS and EPS. Each received HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1 (see TS 38.413 [11]).

d) Each subcounter is an integer value.

e) MM.HoOut5gsToEpsFallbackPrepFail.*cause*

 Where *cause* identifies the failure cause of the handover preparations.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.13 Number of successful executions for EPS fallback handovers

a) This measurement provides the number of successful EPS fallback executions at the source gNB for handovers from 5GS to EPS.

b) CC

c) Receipt of UE CONTEXT RELEASE COMMAND message by the gNB-CU from AMF following a successful handover from 5GS to EPS,after the source gNodeB sends the AMF a PDU Session modification response in which "PDUSessionResourceModifyUnsuccessfulTransfer" carries the failure cause "IMS voice EPS fallback or RAT fallback triggered"(see TS 38.413 [11]).

d) A single integer value.

e) MM.HoOutExe5gsToEpsFallbackSucc.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.14 Number of failed executions for EPS fallback handovers

a) This measurement provides the number of failed EPS fallback executions at the source gNB for handovers from 5GS to EPS. This measurement is split into subcounters per failure cause.

b) CC

c) Receipt of UE CONTEXT RELEASE COMMAND at the source gNB-CU from AMF indicating an unsuccessful handover from 5GS to EPS,after the source gNodeB sends the AMF a PDU Session modification response in which "PDUSessionResourceModifyUnsuccessfulTransfer" carries the failure cause "IMS voice EPS fallback or RAT fallback triggered". Each received message increments the relevant subcounter per failure cause by 1 (see TS 38.413 [11]).

d) Each subcounter is an integer value.

e) MM.HoOutExe5gsToEpsFallbackFail.*cause.*

Where *cause* identifies the failure cause in the UE CONTEXT RELEASE COMMAND message.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.6.5.15 Mean Time of EPS fallback handover

a) This measurement provides the mean time of EPS fallback whole handover during each granularity period.

b) DER (n=1)

c) This measurement is obtained by accumulating the time interval for every successful EPS fallback handover procedure between the receipt by the NG-RAN from the EPS of a "UE CONTEXT RELEASE COMMAND" and the sending of a "HANDOVER REQUIRED" message from NG-RAN to the EPS over a granularity period using DER. The end value of this time will then be divided by the number of EPS fallback handovers observed in the granularity period to give the arithmetic mean, the accumulator shall be reinitialised at the beginning of each granularity period.

d) A single integer value (in milliseconds)

e) MM.Ho5gsToEpsFallbackTimeMean.

f) NRCellCU.

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the mean time of EPS fallback handovers during the granularity period.

###### 5.1.1.6.5.16 Mean Time of EPS fallback handover executions

a) This measurement provides the mean time of EPS fallback handover executions during each granularity period.

b) DER (n=1)

c) This measurement is obtained by accumulating the time interval for every successful EPS fallback handover executions procedure between the receipt by the NG-RAN from the EPS of a "UE CONTEXT RELEASE COMMAND" and the sending of  *the MobilityFromNRCommand* message to the UE over a granularity period using DER. The end value of this time will then be divided by the number of EPS fallback handovers observed in the granularity period to give the arithmetic mean, the accumulator shall be reinitialised at the beginning of each granularity period.

d) Each measurement is an integer value (in milliseconds)

e) MM.HoExeHo5gsToEpsFallbackTimeMean.

f) NRCellCU.

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the mean time of EPS fallback handover executions during the granularity period.

##### 5.1.1.6.6 RRC redirection measurement

5.1.1.6.6.1 number of EPS fallback redirection

a) This measurement provides the number of RRC release for EPS fallback redirection.

b) SI

c) Transmission of a "RRCRelease" message to UE, which contains "redirectedCarrierInfo" IE and "voiceFallbackIndication" IE indication EPS fallback for IMS voice. (see TS 38.331 [20]).

d) A single integer value.

e) MM.Redirection.5gsToEpsFallback.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

##### 5.1.1.6.7 Intra/Inter-frequency Handover related measurements

###### 5.1.1.6.7.1 Number of requested intra-frequency handover executions

a) This measurement provides the number of outgoing intra-frequency handover executions requested by the source NRCellCU.

b) CC.

c) On transmission of *RRCReconfiguration* message to the UE triggering the handover from the source NRCellCU to the target NRCellCU, indicating the attempt of an outgoing intra-frequency handover (see TS 38.331 [20]), the counter is steped by 1.

d) A single integer value.

e) MM.HoExeIntraFreqReq.

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.7.2 Number of successful intra-frequency handover executions

a) This measurement provides the number of successful intra-frequency handover executions received by the source NRCellCU.

b) CC.

c) On reception of *RRCReconfigurationComplete* message from the UE to the target NRCellCU indicating a successful intra-frequency intra gNB handover (see TS 38.331 [20]), or, on reception of UE CONTEXT RELEASE [13] over Xn from the target gNB following a successful intra-frequency inter gNB handover, or, if handover is performed via NG, on reception of UE CONTEXT RELEASE COMMAND [11] from AMF following a successful intra-frequency inter gNB handover, the counter is stepped by 1.

d) A single integer value.

e) MM.HoExeIntraFreqSucc.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.7.3 Number of requested inter-frequency handover executions

a) This measurement provides the number of outgoing inter-frequency handover executions requested by the source NRCellCU.

b) CC.

c) On transmission of *RRCReconfiguration* message to the UE triggering the handover from the source NRCellCU to the target NRCellCU, indicating the attempt of an outgoing inter-frequency handover (see TS 38.331 [20]), the counter is steped by 1.

d) A single integer value.

e) MM.HoExeInterFreqReq.

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.7.4 Number of successful inter-frequency handover executions

a) This measurement provides the number of successful inter-frequency handover executions received by the source NRCellCU.

b) CC.

c) On reception of *RRCReconfigurationComplete* message from the UE to the target NRCellCU indicating a successful inter-frequency intra gNB handover (see TS 38.331 [20]), or, on reception of UE CONTEXT RELEASE [13] over Xn from the target gNB following a successful inter-frequency inter gNB handover, or, if handover is performed via NG, on reception of UE CONTEXT RELEASE COMMAND [11] from AMF following a successful inter-frequency inter gNB handover, the counter is stepped by 1.

d) A single integer value.

e) MM.HoExeInterFreqSucc.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

##### 5.1.1.6.8 Inter-gNB conditional handovers

###### 5.1.1.6.8.1 Number of requested conditional handover preparations

a) This measurement provides the number of conditional handover preparations requested by the source gNB.

b) CC.

c) On transmission of HANDOVER REQUEST message (see TS 38.423 [13] clause 8.2.1) where the message denotes a conditional handover preparation, by the source NR cell CU to target NR cell CU, for requesting the preparation of resources at the target NR cell CU.

d) A single integer value.

e) MM.ChoPrepInterReq

f) NRCellCU
NRCellRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.8.2 Number of successful conditional handover preparations

a) This measurement provides the number of successful conditional handover preparations received by the source NR cell CU.

b) CC

c) On receipt of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13] clause 8.2.1) where the message corresponds to a previously sent conditional handover HANDOVER REQUEST message, by the source NR cell CU from the target NR cell CU, for informing that the resources for the conditional handover have been prepared at the target NR cell CU.

d) A single integer value.

e) MM.ChoPrepInterSucc

f) NRCellCU
NRCellRelation

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.8.3 Number of failed conditional handover preparations

a) This measurement provides the number of failed conditional handover preparations received by the source NR cell CU. This measurement is split into subcounters per failure cause.

b) CC

c) On receipt of HANDOVER PREPARATION FAILURE message (see TS 38.423 [13] clause 8.2.1.3) where the message corresponds to a previously sent conditional handover HANDOVER REQUEST message, by the source NR cell CU from the target NR cell CU, for informing that the preparation of resources at the target NR cell CU has failed. Each received HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.ChoPrepInterFail.*cause*

 Where *cause* identifies the failure cause of the conditional handover preparations.

f) NRCellCU
NRCellRelation

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurements is for performance assurance

5.1.1.6.8.4 Number of requested conditional handover resource allocations

a) This measurement provides the number of conditional handover resource allocation requests received by the target NR cell CU.

b) CC

c) On receipt of HANDOVER REQUEST message (see TS 38.423 [13] clause 8.2.1), where the message denotes a conditional handover, by the target NR cell CU from the source NR cell CU, for requesting the preparation of resources for handover.

d) A single integer value.

e) MM.ChoResAlloInterReq

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

5.1.1.6.8.5 Number of successful conditional handover resource allocations

a) This measurement provides the number of successful conditional handover resource allocations at the target NR cell CU for the handover.

b) CC.

c) On transmission of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13] clause 8.2.1), where the message corresponds to a previously received conditional handover HANDOVER REQUEST message, by the target NR cell CU to the source NR cell CU, for informing that the resources for the handover have been prepared.

d) A single integer value.

e) MM.ChoResAlloInterSucc

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

5.1.1.6.8.6 Number of failed conditional handover resource allocations

a) This measurement provides the number of failed conditional handover resource allocations at the target NR cell CU for the handover. This measurement is split into subcounters per failure cause.

b) CC

c) On transmission of HANDOVER PREPARATION FAILURE message (see TS 38.423 [13] clause 8..2.1.3), where the message corresponds to a previously sent conditional handover HANDOVER REQUEST message, by the target NR cell CU to the source NR cell CU, for informing that the preparation of resources has failed. Each HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value.

e) MM.ChoResAlloInterFail.*cause*

 Where *cause* identifies the failure cause of the conditional handover resource allocations.

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.8.7 Number of configured conditional handover candidates

a) This inter gNB handover measurement provides the number of outgoing conditional handover candidates requested by the source gNB.

b) CC.

c) On transmission of *RRCReconfiguration* message (TS 38.331 [20] clause 5.3.5), where the message denotes a conditional handover configuration, to the UE configuring an inter-gNB conditional handover from the source NRCellCU to the target NRCellCU. The counter on NRCellCU is incremented by the number of candidates configured in the *conditionalReconfiguration* IE. The counter on NRCellRelation is incremented by 1 for each relation that is present in the *conditionalReconfiguration* IE.

d) A single integer value.

e) MM.ConfigInterReqCho

f) NRCellCU
NRCellRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.8.8 Number of UEs configured with conditional handover.

a) This inter-gNB handover measurement provides the number of UEs that has been configured with conditional handover by the source gNB.

b) CC.

c) On transmission of *RRCReconfiguration* message (TS 38.331 [20] clause 5.3.5), where the message denotes a conditional handover configuration, to the UE configured with an inter-gNB conditional handover from the source NRCellCU to the target NRCellCU, the counter is stepped by 1. The counter shall only be stepped by 1 even is several configurations are sent to the UE during a cell dwelling time.

d) A single integer value.

e) MM.ConfigInterReqChoUes

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.8.9 Number of successful conditional handover executions

a) This inter-gNB handover measurement provides the number of successful conditional handover executions received by the source gNB.

b) CC

c) On receipt at the source gNB of UE CONTEXT RELEASE (TS 38.423 [13] clause 8.2.7) over Xn from the target gNB following a successful inter-gNB conditional handover, the counter is stepped by 1.

d) A single integer value.

e) MM.ChoExeInterSucc

f) NRCellCU
NRCellRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.8.10 Void

###### 5.1.1.6.8.11 Mean Time of requested conditional handover executions

a) This measurement provides the mean time of inter-gNB conditional handover executions during each granularity period. The measurement is split into subcounters per S-NSSAI.

b) DER(n=1)

c) This measurement is obtained by accumulating the time interval for every successful Inter-gNB handover executions procedure per S-NSSAI between the receipt by the Source NG-RAN from the Target NG-RAN of a "Release Resource" and the sending of a "N2 Path Switch Request" message from Source NG-RAN to the Target NG-RAN over a granularity period using DER, for conditional handovers. The end value of this time will then be divided by the number of inter-gNB conditional handovers observed in the granularity period to give the arithmetic mean, the accumulator shall be reinitialised at the beginning of each granularity period.

d) Each measurement is an integer value (in milliseconds.)

e) MM.ChoExeInterReq.TimeMean.*SNSSAI*

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the mean time of Inter-gNB handovers during the granularity period.

###### 5.1.1.6.8.12 Max Time of requested conditional handover executions

a) This measurement provides the max time of inter-gNB conditional handover executions during each granularity period. The measurement is split into subcounters per S-NSSAI.

b) DER(n=1)

c) This measurement is obtained by measuring the time interval for every successful Inter-gNB handover executions procedure per S-NSSAI between the receipt by the source NG-RAN from the target NG-RAN of a "Release Resource" and the sending of a "N2 Path Switch Request" message from Source NG-RAN to the Target NG-RAN over a granularity period using DER, for conditional handovers. The high tide mark of this time will be stored in a gauge, the gauge shall be reinitialised at the beginning of each granularity period.

d) Each measurement is an integer value (in milliseconds.)

e) MM.ChoExeInterReq.TimeMax.*SNSSAI*

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the mean time of Inter-gNB handovers during the granularity period.

###### 5.1.1.6.8.13 Number of UEs for which conditional handover preparations are requested

a) This measurement provides the number of UEs for which conditional handover preparations were requested by the source gNB.

b) CC.

c) On transmission of HANDOVER REQUEST message (see TS 38.423 [13] clause 8.2.1) where the message denotes a conditional handover preparation, by the source NR cell CU to target NR cell CU, for requesting the preparation of resources at the target NR cell CU. The counter is incremented by 1 for each UE, even if HANDOVER REQUEST messages were sent to several cells.

d) A single integer value.

e) MM.ChoPrepInterReqUes.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.8.14 Number of UEs for which conditional handover preparations were successful

a) This measurement provides the number of UEs for which successful conditional handover preparations were received by the source NR cell CU.

b) CC.

c) On receipt of HANDOVER REQUEST ACKNOWLEDGE message (see TS 38.423 [13] clause 8.2.1) where the message corresponds to a previously sent conditional handover HANDOVER REQUEST message, by the source NR cell CU from the target NR cell CU, for informing that the resources for the conditional handover have been prepared at the target NR cell CU. The counter is incremented by 1 for each UE, even if HANDOVER REQUEST ACKNOWLEDGE messages were received from several cells.

d) A single integer value.

e) MM.ChoPrepInterSuccUes.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

###### 5.1.1.6.8.15 Number of UEs for which conditional handover preparations failed

a) This measurement provides the number of UEs for which conditional handover preparations failed, as received by the source NR cell CU. This measurement is split into subcounters per failure cause.

b) CC.

c) On receipt of HANDOVER PREPARATION FAILURE message (see TS 38.423 [13] clause 8.2.1.3) where the message corresponds to a previously sent conditional handover HANDOVER REQUEST message, by the source NR cell CU from the target NR cell CU, for informing that the preparation of resources at the target NR cell CU has failed. Each received HANDOVER PREPARATION FAILURE message increments the relevant subcounter per failure cause by 1. The counter is incremented by 1 for each UE, even if HANDOVER PREPARATION FAILURE messages were received from several cells.

d) Each subcounter is an integer value.

e) MM.ChoPrepInterFailUes.*cause*.

 where *cause* identifies the failure cause of the conditional handover preparations.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance

##### 5.1.1.6.9 Intra-gNB conditional handovers

###### 5.1.1.6.9.1 Number of configured conditional handover candidates

a) This measurement provides the number of outgoing intra-gNB conditional handover candidates requested by the source NRCellCU.

b) CC.

c) On transmission of *RRCReconfiguration* message (TS 38.331 [20] clause 5.3.5), where the message denotes a conditional handover configuration, to the UE configuring an intra-gNB conditional handover from the source NRCellCU to the target NRCellCU. The counter on NRCellCU is incremented by the number of candidates configured in the *conditionalReconfiguration* IE. The counter on NRCellRelation is incremented by 1 for each relation that is present in the *conditionalReconfiguration* IE.

d) A single integer value.

e) MM.ConfigIntraReqCho

f) NRCellCU
NRCellRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.9.2 Number of UEs configured with conditional handover

a) This intra-gNB handover measurement provides the number of UEs that has been configured with conditional handover by the source cell.

b) CC.

c) On transmission of *RRCReconfiguration* message (TS 38.331 [20] clause 5.3.5), where the message denotes a conditional handover configuration, to the UE configured with an intra-gNB conditional handover from the source NRCellCU to the target NRCellCU, the counter is stepped by 1. The counter shall only be stepped by 1 even is several configurations are sent to the UE during a cell dwelling time.

d) A single integer value.

e) MM.ConfigIntraReqChoUes

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.1.6.9.3 Number of successful handover executions

a) This measurement provides the number of successful intra-gNB handover executions received by the source NRCellCU.

b) CC.

c) On reception of *RRC ReconfigurationComplete* message (see TS 38.331 [20] clause 5.3.5)from the UE to the target NRCellCU indicating a successful intra-gNB handover, the counter is stepped by 1.

d) A single integer value for each subcounter.

e) MM.ChoExeIntraSucc

f) NRCellCU
NRCellRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

#### 5.1.1.7 TB related Measurements

##### 5.1.1.7.1 Total number of DL initial TBs

a) This measurement provides the total number of initial TBs transmitted on the downlink in a cell. HARQ re-transmissions are excluded from this measurement.This measurement is optionally split into subcounters per modulation schema.

b) CC.

c) On transmission by the gNB of TB to UE during the period of measurement.This measurement is optionally split into subcounters per modulation schema.

d) A single integer value.

e) The measurement name has the form TB.TotNbrDlInitial, TB.TotNbrDlInitial.Qpsk, TB.TotNbrDlInitial.16Qam.

TB.TotNbrDlInitial.64Qam, TB.TotNbrDlInitial.256Qam.

f) NRCellDU.

g) Valid for packet switched traffic .

h) 5GS.

##### 5.1.1.7.2 Intial error number of DL TBs

a) This measurement provides the number of initial faulty TBs transmitted on the downlink in a cell.This measurement is optionally split into subcounters per modulation schema.

b) CC.

c) On receipt by the gNB of a NACK or DTX from UE which indicates a faulty reception of TB by UE at first HARQ feedback during the period of measurement. This measurement is optionally split into subcounters per modulation schema.

d) A single integer value.

e) The measurement name has the form TB.IntialErrNbrDl, TB.IntialErrNbrDl.Qpsk, TB.IntialErrNbrDl.16Qam

TB.IntialErrNbrDl.64Qam, TB.IntialErrNbrDl.256Qam.

 f) NRCellDU.

 g) Valid for packet switched traffic .

 h) 5GS.

##### 5.1.1.7.3 Total number of DL TBs

a) This measurement provides the total number of TBs transmitted on the downlink in a cell.The measurement is split into subcounters per layer at MU-MIMO case. This measurement includes all transmitted TBs (including the successful and failed TBs during initial transmission and HARQ re-transmission).

b) CC.

c) On transmission by the gNB of TB to UE during the period of measurement.The measurement is split into subcounters per Layer at MU-MIMO case.A single integer value. .

d) Each measurement is an integer.

e) TB.TotNbrDl.X

Where X identified by DL MU-MIMO maximum layer.

f) NRCellDU.

g) Valid for packet switched traffic .

h) 5GS.

##### 5.1.1.7.4 Total error number of DL TBs

a) This measurement provides the number of total faulty TBs transmitted on the downlink in a cell .The measurement is split into subcounters per layer at MU-MIMO case.This measurement include all transmitted faulty TBs of initial transmission and re-transmission .

b) CC.

c) On receipt by the gNB of a NACK or DTX from UE which indicates a faulty reception of TB by UE during the period of measurement. The measurement is split into subcounters per Layer at MU-MIMO case.

d) Each measurement is an integer.

e) TB.ErrToltalNbrDl.X.

Where X identified by DL MU-MIMO maximum layer.

 f) NRCellDU.

 g) Valid for packet switched traffic .

 h) 5GS.

##### 5.1.1.7.5 Residual error number of DL TBs

a) This measurement provides the number of final faulty TBs transmitted on the downlink in a cell at last HARQ re-transmissions.

b) CC.

c) On receipt by the gNB of a NACK or DTX from UE which indicates a faulty reception of TB by UE at the last HARQ feedback during the period of measurement.

d) A single integer value.

e) TB.ResidualErrNbrDl.

f) NRCellDU.

g) Valid for packet switched traffic

h) 5GS.

##### 5.1.1.7.6 Total number of UL initial TBs

a) This measurement provides the total number of initial TBs on the uplink in a cell.This measurement is optionally split into subcounters per modulation schema.

b) CC

c) On receipt by the gNB of TB from UE during the period of measurement.This measurement is optionally split into subcounters per modulation schema.

d) A single integer value.

e) The measurement name has the form TB.TotNbrUlInit, TB.TotNbrUlInit.Qpsk, TB.TotNbrUlInit.16Qam,

f) TB.TotNbrUlInit.64Qam, TB.TotNbrUlInit.256Qam.

g) NRCellDU.

h) Valid for packet switched traffic .

i) 5GS.

##### 5.1.1.7.7 Error number of UL initial TBs

a) This measurement provides the number of initial faulty TBs on the uplink in a cell. This measurement is optionally split into subcounters per modulation schema.

b) CC

c) On receipt by the gNB of a initial TB on which CRC fails or DTX from UE during the period of measurement.This measurement is optionally split into subcounters per modulation schema.

d) A single integer value.

e) The measurement name has the form TB.ErrNbrUlInitial, TB.ErrNbrUlInitial.Qpsk, TB.ErrNbrUlInitial.16Qam

TB.ErrNbrUlInitial.64Qam, TB.ErrNbrUlInitial.256Qam.

f) NRCellDU.

g) Valid for packet switched traffic .

h) 5GS.

##### 5.1.1.7.8 Total number of UL TBs

a) This measurement provides the total number of TBs on the uplink in a cell.The measurement is split into subcounters per layer at MU-MIMO case.This measurement includes all transmitted TBs (including the successful and failed TBs during initial transmission and HARQ re-transmission).

b) CC

c) On receipt by the gNB of TB from UE during the period of measurement.The measurement is split into subcounters per Layer at MU-MIMO case.A single integer value. The sum value identified by the *.sum* suffix.

d) Each measurement is an integer.

e) TB.TotNbrUl.X

Where X identified by UL MU-MIMO maximum layer.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.1.1.7.9 Total error number of UL TBs

a) This measurement provides the number of total faulty TBs on the uplink in a cell. The measurement is split into subcounters per layer at MU-MIMO case.This measurement include all transmitted faulty TBs of initial and re-transmission .

b) CC

c) On receipt by the gNB of a TB on which CRC fails or DTX from UE during the period of measurement. The measurement is split into subcounters per Layer at MU-MIMO case.A single integer value.

d) Each measurement is an integer.

e) TB.ErrToltalNbrUl.X

Where X identified by UL MU-MIMO maximum layer.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.1.1.7.10 Residual error number of UL TBs

a) This measurement provides the number of final faulty TBs on the uplink in a cell.

b) CC

c) On receipt by the gNB of a TB on which CRC fails or DTX at last HARQ re-transmissions from UE during the period of measurement.

d) A single integer value.

e) TB.ResidualErrNbrUl .

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.1.1.8 Void

#### 5.1.1.9 Void

#### 5.1.1.10 DRB related measurements

##### 5.1.1.10.1 Number of DRBs attempted to setup

a) This measurement provides the number of DRBs attempted to setup to support all requested QoS flows in the PDU sessions to be setup by the INITIAL CONTEXT SETUP REQUESTs, PDU SESSION RESOURCE SETUP REQUESTs and PDU SESSION RESOURCE MODIFY REQUEST message received by the gNB from AMF. This measurement is split into subcounters per mapped 5QI and per S-NSSAI.

b) CC.

c) On receipt of "PDU Session Resource Setup Request List" IE in a INITIAL CONTEXT SETUP REQUEST message, PDU SESSION RESOURCE SETUP REQUEST message (see TS 38.413 [11]) or a by the PDU SESSION RESOURCE MODIFY REQUEST message to gNB from the AMF. Each DRB that is needed to setup in the transmitted RRCReconfiguration message increments the relevant subcounter per mapped 5QI by 1, and the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) DRB.EstabAtt.*5QI,* where *5QI* identifies mapped 5QI and

DRB.EstabAtt.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

##### 5.1.1.10.2 Number of DRBs successfully setup

a) This measurement provides the number of DRBs successfully setup to support all requested QoS flows in the PDU sessions to be setup by the INITIAL CONTEXT SETUP REQUESTs, PDU SESSION RESOURCE SETUP REQUESTs and PDU SESSION RESOURCE MODIFY REQUEST message received by the gNB from AMF. This measurement is split into subcounters per mapped 5QI and per S-NSSAI.

b) CC.

c) On transmission of INITIAL CONTEXT SETUP RESPONSE, PDU SESSION RESOURCE SETUP RESPONSE message containing the "PDU Session Resource Setup Response List" IE (see TS 38.413 [11]) or by the PDU SESSION RESOURCE MODIFY REQUEST message from the gNB to the AMF.The counter increases by the number of DRBs that was successfully setup indicated by the RRCReconfigurationComplete message from the UE, as the response to the transmitted RRCReconfiguration message that contains the DRBs to add (see TS 38.331[20]). Each DRB that was successfully setup to the UE increments the relevant subcounter per mapped 5QI by 1, and the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) DRB.EstabSucc.*5QI,* where *5QI* identifies mapped 5QI and

DRB.EstabSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

##### 5.1.1.10.3 Number of released active DRBs

a) This measurement provides the number of abnormally released DRBs that were active at the time of release. DRBs with bursty flow are seen as being active if there is user data in the PDCP queue in any of the directions or if any DRB data on a Data Radio Bearer (UL or DL) has been transferred during the last 100 ms. DRBs with continuous flow are seen as active DRBs in the context of this measurement, as long as the UE is in RRC connected state. DRBs used in 3GPP option 3 shall not be covered in this measurement
The measurement is split into sub counters per mapped 5QI and per S-NSSAI.

b) CC

c) On

- transmission by the NG-RAN of a PDU SESSION RESOURCE RELEASE RESPONSE message for the PDU release initiated by the AMF with the exception of corresponding PDU SESSION RESOURCE RELEASE COMMAND message with "Cause" equal to "Normal Release" or "User inactivity", "Load balancing TAU required", "Release due to CN-detected mobility", "O&M intervention", or-

- transmission by the NG-RAN of a PDU SESSION RESOURCE MODIFY RESPONSE message for the PDU modification initiated by the AMF with the exception of corresponding PDU SESSION RESOURCE MODIFY REQUEST message with the "Cause" equal to "Normal Release", or

- transmission by the NG-RAN of a UE CONTEXT RELEASE COMPLETE for the UE context release initiated by the NG-RAN with the exception of the corresponding UE CONTEXT RELEASE REQUEST message with the cause equal to "Normal Release" or "User inactivity", "Partial handover", "Successful handover", or

- transmission by the NG-RAN of a UE CONTEXT RELEASE COMPLETE message for the UE context release initiated by the AMF with the exception of the corresponding UE CONTEXT RELEASE COMMAND message with "Cause" equal to "Normal Release", "Handover Cancelled" or a successful mobility activity (e.g., cause "Successful Handover", or "NG Intra system Handover triggered"), or

- receipt by the NG-RAN of a PATH SWITCH REQUEST ACKNOWLEDGE or PATH SWITCH REQUEST FAILED message by which some or all DRBs in the corresponding PATH SWITCH REQUEST need to be released, or

- transmission of a NG RESET ACKNOWLEDGE message to AMF; or

- receipt of a NG RESET ACKNOWLEDGE message from AMF,

Any of the UL or DL DRBs release using the RRCReconfiguration message (see TS 38.331[20]) sent to the UE, triggers the corresponding counter to increment by 1.

DRBs with bursty flow are considered active if there is user data in the PDCP queue in any of the directions or if any data (UL or DL) has been transferred during the last 100 ms. DRBs with continuous flow are seen as active DRBs in the context of this measurement, as long as the UE is in RRC connected state. Each corresponding DRB to release is added to the relevant measurement per mapped 5QI and S-NSSAI.

A particular DRB is defined to be of type continuous flow if the mapped 5QI is any of {1, 2, 65, 66}.

d) Each measurement is an integer value. The number of measurements is equal to the number of mapped 5QI levels plus the number of S-NSSAIs.

e) The measurements name has the form DRB.RelActNbr.*5QI,* where *5QI* identifies the mapped 5QIandDRB.RelActNbr.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) This measurement is to support the Retainability KPI "DRB Retainability" defined in TS 28.554 [8].

##### 5.1.1.10.4 In-session activity time for DRB

a) This measurement provides the aggregated active session time for DRBs in a cell. The measurement is split into sub counters per mapped 5QI and per S-NSSAI. DRBs used in 3GPP option 3 shall not be covered in this measurement.

b) CC

c) Number of "in session" seconds aggregated for DRBs with a certain mapped 5QI level or for a certain S-NSSAI, where "in session" has the following definitions:

- DRBs with bursty flow is said to be "in session" if there is user data in the PDCP queue in any of the directions or if any data (UL or DL) has been transferred during the last 100 ms for that DRB.

- DRBs with continuous flow are seen as being "in session" in the context of this measurement, as long as the UE is in RRC connected state, and the session time is increased from the first data transmission on the DRB until 100 ms after the last data transmission on the DRB.

A particular DRB is defined to be of type continuous flow if the mapped 5QI is any of {1, 2, 65, 66}.

d) Each measurement is an integer value. The number of measurements is equal to the number of mapped 5QI levels plus the number of S-NSSAIs.

e) The measurement name has the form DRB.SessionTime.*5QI,* where *5QI* identifies the mapped 5QIandDRB.SessionTime.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) This measurement is to support the Retainability KPI "DRB Retainability" defined in TS 28.554 [8].

5.1.1.10.5 Number of Initial DRBs attempted to setup

a) This measurement provides the number of initial DRBs attempted to setup to support all requested QoS flows in the PDU sessions to be setup by the INITIAL CONTEXT SETUP REQUEST messages received by the gNB from AMF. This measurement is optionally split into subcounters per mapped 5QI and per S-NSSAI.

b) CC.

c) On receipt of "PDU Session Resource Setup Request List" IE in an INITIAL CONTEXT SETUP REQUEST message (see TS 38.413 [11]) to gNB from the AMF. Each DRB that is needed to setup in the transmitted RRCReconfiguration message increments the relevant subcounter per mapped 5QI by 1, and optionally the relevant subcounter per S-NSSAI by 1.

d) Each measurement is an integer value.

e) The measurement name has the form.

DRB.InitialEstabAtt.*5QI* where *5QI* identifies the mapped 5QI and

DRB.InitialEstabAtt.*SNSSAI,* where SNSSAIidentifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

5.1.1.10.6 Number of Initial DRBs successfully setup

a) This measurement provides the number of initial DRBs successfully setup to support all requested QoS flows in the PDU sessions to be setup by the INITIAL CONTEXT SETUP REQUEST messages received by the gNB from AMF. This measurement is optionally split into subcounters per mapped 5QI and per S-NSSAI.

b) CC.

c) On transmission of INITIAL CONTEXT SETUP RESPONSE message containing the "PDU Session Resource Setup Response List" IE (see TS 38.413 [11]) from the gNB to the AMF. The counter increases by the number of DRBs that was successfully setup indicated by the RRCReconfigurationComplete message from the UE, as the response to the transmitted RRCReconfiguration message that contains the DRBs to add (see TS 38.331[20]). Each DRB that was successfully setup to the UE increments the relevant subcounter per mapped 5QI by 1, and optionally the relevant subcounter per S-NSSAI by 1.

d) Each measurement is an integer value.

e) The measurement name has the form:

DRB.InitialEstabSucc.*5QI* where *5QI* identifies the mapped 5QI and

DRB.InitialEstabSucc.*SNSSAI* where SNSSAIidentifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance.

##### 5.1.1.10.7 Number of DRBs attempted to be resumed

a) This measurement provides the number of DRBs attempted to be resumed. This measurement is split into subcounters per mapped 5QI and per S-NSSAI.

b) CC.

c) On Receipt of the *RRCResumeRequest* message or *RRCResumeRequest1* corresponding number of DRBs that are identified by gNB as to be resumed for the UE is counted. The identified DRBs related to consequent RRC connection resume fallback to RRC connection establishment initiated by gNB are excluded from the counting.

d) Each subcounter is an integer value.

e) DRB.ResumeAtt.*5QI,* where *5QI* identifies mapped 5QI and

DRB.ResumeAtt.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.10.8 Number of DRBs successfuly resumed

a) This measurement provides the total successful number of DRBs successfuly resumed. This measurement is split into subcounters per mapped 5QI and per S-NSSAI.

b) CC.

c) On Receipt of a *RRCResumeComplete* message the corresponding number of DRBs successfuly resumed for the UE is counted.

d) Each subcounter is an integer value.

e) DRB.ResumeSucc.*5QI,* where *5QI* identifies mapped 5QI and

DRB.ResumeSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.10.9 Mean number of DRBs being allocated

a) This measurement provides the mean number of DRBs that have been allocated. The measurement is split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI.

b) SI.

c) Each measurement is obtained by sampling at a pre-defined interval, the number of DRBs being allocated, and taking the arithmetic mean of the samples.

d) Each subcounter is an integer value.

e) DRB.MeanEstabSucc.*5QI,* where *5QI* identifies mapped 5QI and

 DRB.MeanEstabSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance to support RRM resources optimization (see TS 28.313 [30]).

##### 5.1.1.10.10 Peak number of DRBs being allocated

a) This measurement provides the peak number of DRBs that have been allocated. The measurement is split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI.

b) SI.

c) Each measurement is obtained by sampling at a pre-defined interval, the number of DRBs being allocated, and selecting the sample with the maximum value from the samples collected in a given period.

d) Each subcounter is an integer value.

e) DRB.MaxEstabSucc.*5QI,* where *5QI* identifies mapped 5QI and

 DRB.MaxEstabSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance to support RRM resources optimization (see TS 28.313 [30]).

#### 5.1.1.11 CQI related measurements

##### 5.1.1.11.1 Wideband CQI distribution

a) This measurement provides the distribution of Wideband CQI (Channel Quality Indicator) reported by UEs in the cell.

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin when a wideband CQI value is reported by a UE in the cell. When spatial multiplexing is used, CQI for both rank indicator should be considered. When different *CSI-ReportConfig* is used, different 4-bit CQI tables defined in TS 38.214 [19] should be considered.

d) Each measurement is a single integer value.

e) CARR.WBCQIDist.BinX.BinY.BinZ, where X represents the index of the CQI value (0 to 15). Y represents the index of rank value (1 to 8), Z represents the index of table value (1 to 3).

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.12 MCS related Measurements

##### 5.1.1.12.1 MCS Distribution in PDSCH

a) This measurement provides the distribution of the MCS scheduled for PDSCH RB by NG-RAN.

b) CC

c) This measurement is obtained by incrementing the appropriate measurement bin with the number of the PDSCH RBs according to the MCS scheduled by NG-RAN. When single user spatial multiplexing (ie SU-MIMO) is used, MCS for both rank indicator should be considered. Different *MCS index tables for PDSCH* should be considered when the configuration is different as defined in clause 5.1.3.1, TS 38.214 [19]. The RBs used for broadcast should be excluded.

d) Each measurement is a single integer value.

e) CARR.PDSCHMCSDist.BinX.BinY.BinZ, where X represents the index of rank value (1 to 8), Y represents the index of table value (1 to 3), and Z represents the index of the MCS value (0 to 31).

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.12.2 MCS Distribution in PUSCH

a) This measurement provides the distribution of the MCS scheduled for PUSCH RB by NG-RAN.

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin with the number of the PUSCH RBs according to the MCS scheduled by NG-RAN. When single user spatial multiplexing (ie SU-MIMO)is used, MCS for both rank indicator should be considered. Different *MCS index tables for PUSCH with transform precoding and 64QAM* should be considered when the configuration is different as defined in clause 6.1.4.1, TS 38.214 [19].

d) Each measurement is a single integer value.

e) CARR.PUSCHMCSDist.BinX.BinY.BinZ, , where X represents the index of rank value (1 to 8), Y represents the index of table value (1 to 2), and Z represents the index of the MCS value (0 to 31).

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.12.3 PDSCH MCS Distribution for MU-MIMO

a) This measurement provides the distribution of the MCS scheduled for PDSCH RB by NG-RAN in MU-MIMO scenario.

b) CC

c) This measurement is obtained by incrementing the appropriate measurement bin with the number of the PDSCH RBs according to the MCS scheduled by NG-RAN for MU-MIMO. The RBs used for broadcast should be excluded.

d) Each measurement is a single integer value.

e) CARR.MUPDSCHMCSDist.BinX, where X represents the index of the MCS value (0 to 31).

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.12.4 PUSCH MCS Distribution for MU-MIMO

a) This measurement provides the distribution of the MCS scheduled for PUSCH RB by NG-RAN in MU-MIMO scenario.

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin with the number of the PUSCH RBs according to the MCS scheduled by NG-RAN for MU-MIMO.

d) Each measurement is a single integer value.

e) CARR. MUPUSCHMCSDist.BinX, where X represents the index of the MCS value (0 to 31).

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

#### 5.1.1.13 QoS flow related measurements

##### 5.1.1.13.1 QoS flow release

5.1.1.13.1.1 Number of released active QoS flows

a) This measurement provides the number of released QoS flows that were active at the time of release. QoS flows with bursty flow are seen as being active when there is user data in the queue in any of the directions. QoS flows with continuous flow are seen as active QoS flows in the context of this measurement, as long as the UE is in RRC connected state.
The measurement is split into subcounters per QoS level.

b) CC.

c) On transmission by the NG-RAN of a PDU SESSION RESOURCE RELEASE RESPONSE message for the PDU release initiated by the AMF with the exception of corresponding PDU SESSION RESOURCE RELEASE COMMAND message with "Cause" equal to "Normal Release" or "User inactivity", "Load balancing TAU required", "Release due to CN-detected mobility", "O&M intervention", or on transmission by the PDU SESSION RESOURCE MODIFY RESPONSE message for the PDU modification initiated by the AMF with the exception of corresponding PDU SESSION RESOURCE MODIFY REQUEST message with the "Cause" equal to "Normal Release", or on transmission by the NG-RAN of UE CONTEXT RELEASE COMPLETE for the UE context release initiated by the NG-RAN with the exception of the corresponding UE CONTEXT RELEASE REQUEST message with the cause equal to "Normal Release" or "User inactivity", "Partial handover", "Successful handover", or on transmission by the NG-RAN of UE CONTEXT RELEASE COMPLETE message for the UE context release initiated by the AMF with the exception of the corresponding UE CONTEXT RELEASE COMMAND message with "Cause" equal to "Normal Release", "Handover Cancelled" or a successful mobility activity (e.g., cause "Successful Handover", or "NG Intra system Handover triggered"), or on receipt by the NG-RAN of a PATH SWITCH REQUEST ACKNOWLEDGE or PATH SWITCH REQUEST FAILED message by which some or all QoS flows in the corresponding PATH SWITCH REQUEST need to be released , or on transmission of a NG RESET ACKNOWLEDGE message to AMF; or on receipt of a NG RESET ACKNOWLEDGE message from AMF, if any of the UL or DL are considered active in TS 38.413 [11].

QoS flows with bursty flow are considered active if there is user data in the PDCP queue in any of the directions or if any data (UL or DL) has been transferred during the last 100 ms.QoS flows with continuous flow are seen as active QoS flows in the context of this measurement, as long as the UE is in RRC connected state. Each corresponding QoS flows to release is added to the relevant measurement per QoS level (5QI), the possible 5QIs are described in TS 23.501 [4]. The sum of all supported per QoS flow measurements shall equal the total number of QoS flows attempted to release when the QoS flows is active according to the definition of bursty flow/continuous flow. In case only a subset of per QoS flows measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of QoS flows plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form QF.RelActNbr.*QoS.*

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) This measurement is to support the Retainability KPI "QoS flow Retainability" defined in TS 28.554 [8].

###### 5.1.1.13.1.2 Number of QoS flows attempted to release

a) This measurement provides the number of QoS flows attempted to release. The measurement is split into subcounters per QoS level and per S-NSSAI.

b) CC.

c) On receipt by the gNB of an PDU SESSION RESOURCE RELEASE COMMAND or PDU SESSION RESOURCE MODIFY REQUEST message, or on gNB send the message of UE CONTEXT RELEASE REQUEST or PDU SESSION RESOURCE NOTIFY to AMF, each requested QoS Flow release Item in the message is release to the relevant measurement per QoS level, the possible QoS levels are included in TS 38.413. The sum of all supported per QoS level measurements shall equal the total number of Qos FlowS attempted to setup plus the number of S-NSSAI. In case only a subset of per QoS level measurements is supported, a sum subcounter will be provided first. Measurements are subcounters per 5QI and subcounters per S-NSSAI.

d) A single integer value.

e) The measurement name has the form:

QF.ReleaseAttNbr.*5QI* where *5QI* identifies the 5QI and

QF.ReleaseAttNbr.*SNSSAI* identifies the S-NSSAI

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.1.1.13.2 QoS flow activity

5.1.1.13.2.1 In-session activity time for QoS flow

a) This measurement provides the aggregated active session time for QoS flow in a cell. The measurement is split into subcounters per QoS level .

b) CC.

c) Number of "in session" seconds aggregated for QoS flows with a certain QoS level. , where "in session" has the following definitions:
- QoS flows with bursty flow is said to be "in session" for a UE if there is user data in the PDCP queue in any of the directions or if any QoS flow data (UL or DL) has been transferred during the last 100 ms for that 5QI
- QoS flows with continuous flow are seen as being "in session" in the context of this measurement as long as the UE is in RRC connected state, and the session time is increased from the first data transmission on the QoS flow until 100 ms after the last data transmission on the QoS flow.

The sum of all supported per QoS flow measurements shall equal the total session seconds. In case only a subset of per QoS flow measurements is supported, a sum subcounter will be provided first.

A particular QoS flow is defined to be of type continuous flow if the 5QI is any of {1, 2, 65, 66}.

d) Each measurement is an integer value. The number of measurements is equal to the number of QoS levels plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form QF.SessionTimeQoS.*QoS.*

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) This measurement is to support the Retainability KPI "QoS flow Retainability" defined in TS 28.554 [8].

5.1.1.13.2.2 In-session activity time for UE

a) This measurement provides the aggregated active session time for UEs in a cell.

b) CC.

c) Number of session seconds aggregated for UEs in a cell.
For QoS flows with bursty flow, a UE is said to be "in session" if there is user data in the PDCP queue in any of the directions or if any QoS flow data on a Data Radio Bearer (UL or DL) has been transferred during the last 100 ms.
For QoS flows with continuous flow, the QoS flows (and the UE) is seen as being "in session" in the context of this measurement as long as the UE is in RRC connected state, and the session time is increased from the first data transmission on the QoS flow until 100 ms after the last data transmission on the QoS flow.

A particular QoS flow is defined to be of type continuous flow if the 5QI is any of {1, 2, 65, 66}.

d) Each measurement is an integer value.

e) The measurement name has the form QF.SessionTimeUE

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) This measurement is to support the Retainability KPI "QoS flow Retainability" defined in TS 28.554 [8].

##### 5.1.1.13.3 QoS flow setup

###### 5.1.1.13.3.1 Number of QoS flow attempted to setup

a) This measurement provides the number of QoS flows attempted to setup. The measurement is split into subcounters per QoS level (5QI).

b) CC.

c) On receipt by the NG-RAN of a PDU SESSION RESOURCE SETUP REQUEST message, or receipt by the NG-RAN of a INITIAL CONTEXT SETUP REQUEST message, or receipt by the NG-RAN of a PDU SESSION RESOURCE MODIFY REQUEST message, each requested QoS flow in the message is added to the relevant measurement per QoS level (5QI) and per S-NSSAI, the possible 5QIs are included in TS 23.501 [4]. The sum of all supported per QoS level measurements shall equal the total number of QoS flows attempted to setup. In case only a subset of per QoS level measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of QoS levels plus the number of S-NSSAIs, plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form.

QF. EstabAttNbr.*5QI* where *5QI* identifies the 5QI and

QF. EstabAttNbr.*SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.13.3.2 Number of QoS flow successfully established

a) This measurement provides the number of QoS flows successfully established. The measurement is split into subcounters per QoS level and per S-NSSAI.

b) CC.

c) On transmission by the NG-RAN of a PDU SESSION RESOURCE SETUP RESPONSE message, or transmission by the NG-RAN of a INITIAL CONTEXT SETUP RESPONSE message, or transmission by the NG-RAN of a PDU SESSION RESOURCE MODIFY RESPONSE message, each QoS flow successfully established is added to the relevant measurement per QoS level (5QI) and per S-NSSAI, the possible 5QIs are included in TS 23.501 [4]. The sum of all supported per QoS level measurements shall equal the total number of QoS flows successfully setup. In case only a subset of per QoS level measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of QoS levels plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form:

 QF.EstabSuccNbr.*5QI* where *5QI* identifies the 5QI and

QF. EstabSuccNbr.*SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.13.3.3 Number of QoS flow failed to setup

a) This measurement provides the number of QoS flows failed to setup. The measurement is split into subcounters per failure cause.

b) CC.

c) On transmission by the NG-RAN of a PDU SESSION RESOURCE SETUP RESPONSE message, or transmission by the NG-RAN of a INITIAL CONTEXT SETUP RESPONSE message, or transmission by the NG-RAN of a PDU SESSION RESOURCE MODIFY RESPONSE message, each QoS flow failed to establish is added to the relevant measurement per cause, the possible causes are included in TS 38.413 [11]. The sum of all supported per cause measurements shall equal the total number of additional QoS flows failed to setup. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form QF. EstabFailNbr.*Cause*
where *Cause* identifies the cause resulting in the QoS flow setup failure.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

5.1.1.13.3.4 Number of Initial QoS flow attempted to setup

a) This measurement provides the number of Initial QoS flows attempted to setup. The measurement is split into subcounters per QoS level (5QI).

b) CC.

c) On receipt by the NG-RAN of a INITIAL CONTEXT SETUP REQUEST message, each requested QoS flow in the message is added to the relevant measurement per QoS level (5QI) and per S-NSSAI, the possible 5QIs are included in TS 23.501 [4]. The sum of all supported per QoS level measurements shall equal the total number of Initial QoS flows attempted to setup. In case only a subset of per QoS level measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of QoS levels plus the number of S-NSSAIs, plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form.

QF. InitialEstabAttNbr.*5QI* where *5QI* identifies the 5QI and

QF.InitialEstabAttNbr.*SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

5.1.1.13.3.5 Number of Initial QoS flow successfully established

a) This measurement provides the number of Initial QoS flows successfully established. The measurement is split into subcounters per QoS level and per S-NSSAI.

b) CC.

c) On transmission by the NG-RAN of a INITIAL CONTEXT SETUP RESPONSE message,each QoS flow successfully established is added to the relevant measurement per QoS level (5QI) and per S-NSSAI, the possible 5QIs are included in TS 23.501 [4]. The sum of all supported per QoS level measurements shall equal the total number of Initial QoS flows successfully setup. In case only a subset of per QoS level measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of QoS levels plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form:

QF.InitialEstabSuccNbr.*5QI* where *5QI* identifies the 5QI and

QF. InitialEstabSuccNbr.*SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

5.1.1.13.3.6 Number of Initial QoS flow failed to setup

a) This measurement provides the number of Initial QoS flows failed to setup. The measurement is split into subcounters per failure cause.

b) CC.

c) On transmission by the NG-RAN of a INITIAL CONTEXT SETUP RESPONSE message, each QoS flow failed to establish is added to the relevant measurement per cause, the possible causes are included in TS 38.413 [18]. The sum of all supported per cause measurements shall equal the total number of Initial QoS flows failed to setup. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form QF. InitialEstabFailNbr.*Cause*
where *Cause* identifies the cause resulting in the QoS flow setup failure.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.1.1.13.4 QoS flow modification

###### 5.1.1.13.4.1 Number of QoS flows attempted to modify

a) This measurement provides the number of QoS flows attempted to modify. The measurement is split into subcounters per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) On receipt by the gNB of a PDU SESSION RESOURCE MODIFY REQUEST message (see TS 38.413 [11]), each QoS flow requested to modify in this message is added to the relevant subcounter per QoS level (5QI) and relevant subcounter per S-NSSAI. In case the 5QI of the QoS flow is to be modified, the QoS flow is counted to the subcounter for the target 5QI.

d) Each measurement is an integer value.

e) QF.ModNbrAtt.*5QI,* where *5QI* identifies the 5QI, and

 QF.ModNbrAtt.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.13.4.2 Number of QoS flows successfully modified

a) This measurement provides the number of QoS flows successfully modified. The measurement is split into subcounters per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) On transmission by the gNB of a PDU SESSION RESOURCE MODIFY RESPONSE message (see TS 38.413 [11]), each QoS flow successfully modified is added to the relevant subcounter per QoS level (5QI) and relevant subcounter per S-NSSAI. In case the 5QI of the QoS flow is modified, the QoS flow is counted to the subcounter for the target 5QI.

d) Each measurement is an integer value.

e) QF.ModNbrSucc.*5QI,* where *5QI* identifies the 5QI, and

 QF.ModNbrSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

###### 5.1.1.13.4.3 Number of QoS flows failed to modify

a) This measurement provides the number of QoS flows failed to modify. The measurement is split into subcounters per failure cause.

b) CC.

c) On transmission by the gNB of a PDU SESSION RESOURCE MODIFY RESPONSE message (see TS 38.413 [11]), each QoS flow failed to modify is added to the relevant subcounter per cause.

d) Each measurement is an integer value.

e) QF.ModNbrFail.*cause,* where *cause* identifies the cause (see TS 38.413 [11]).

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.1.1.14 Void

#### 5.1.1.15 RRC connection establishment related measurements

##### 5.1.1.15.1 Attempted RRC connection establishments

a) This measurement provides the number of RRC connection establishment attempts for each establishment cause.

b) CC

c) Receipt of an RRCSetupRequest message by the gNB from the UE. Each RRCSetupRequest message received is added to the relevant per establishment cause measurement. RRCSetupRequests that are received while a setup procedure is already ongoing for this UE are excluded. RRCSetupRequests that are received during AMF Overload action (see clause 9.3.1.105 in TS 38.413) are effectively to be excluded from the measurement. The possible establishmentCause are included in TS 38.331 [20] (clause 6.2.2). The sum of all supported per cause measurement values shall be equal the total number of RRCSetupRequest.

d) Each measurement is an integer value. The number of measurements is equal to the number of establishment causes.

e) RRC.ConnEstabAtt.*Cause* where *Cause* identifies the establishment cause.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance within accessibility area.

##### 5.1.1.15.2 Successful RRC connection establishments

a) This measurement provides the number of successful RRC establishments for each establishment cause.

b) CC

c) Receipt by the gNB of an RRCSetupComplete message following a RRC connection setup request. Each RRCSetupComplete message received is added to the relevant per establishment cause measurement. The possible causes are included in TS 38.331 [20] (clause 6.2.2). The sum of all supported per cause measurements shall be equal the total number of RRCSetupComplete messages.

d) Each measurement is an integer value. The number of measurements is equal to the number of establishment causes.

e) RRC.ConnEstabSucc.*Cause* where *Cause* identifies the establishment cause.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance within accessibility area.

##### 5.1.1.15.3 Failed RRC connection establishments

a) This measurement provides the number of failed RRC establishments, this measurmenet is split into subcounters per failure cause.

b) CC

c) On transmission of *RRCReject* message from the gNB to UE or the expected *RRCSetupComplete* message was not received by the gNB from UE after the *RRCSetup message* (see TS 38.331 [20]). Each *RRCReject* message transmitted from gNB to UE is added to the subcounter for the cause '*NetworkReject*'; Each expected *RRCSetupComplete* message unreceived by the gNB after the *RRCSetup message* is added to the subcounter for cause '*NoReply*'; and each failed RRC connection establishment caused by the other reasons is added to measurement cause '*Other*'.

d) Each measurement is an integer value.

e) RRC.ConnEstabFailCause.*NetworkReject*RRC.ConnEstabFailCause.*NoReply*RRC.ConnEstabFailCause.*Other*

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurements is for performance assurance within accessibility area.

#### 5.1.1.16 UE-associated logical NG-connection related measurements

##### 5.1.1.16.1 Attempted UE-associated logical NG-connection establishment from gNB to AMF

a) This measurement provides the number of attempted UE-associated logical NG-connection establishments from gNB to AMF, for each RRCSetupRequest establishment cause. The possible causes are included in TS 38.331 [20] (clause 6.2.2).

b) CC.

c) On transmission of an INITIAL UE MESSAGE by the gNodeB to the AMF (See 38.413 [11], clause 8.6.1), the relevant per RRCSetupRequest establishment cause measurement is incremented by 1.

d) Each subcounter is an integer value. The number of measurements is equal to the number of establishment causes.

e) UECNTX.ConnEstabAtt.*Cause* where *Cause* identifies the establishment cause.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance within accessibility area.

##### 5.1.1.16.2 Successful UE-associated logical NG-connection establishment from gNB to AMF

a) This measurement provides the number of successful UE-associated logical NG-connection establishments from gNB to AMF, for each RRCSetupRequest establishment cause. The possible causes are included in TS 38.331 [20] (clause 6.2.2).

b) CC.

c) On receipt by the gNB of first message from AMF which succeeds INITIAL UE MESSAGE message on an UE-associated logical NG-connection (See 36.413 11], clause 8.6.1), the relevant per RRCSetupRequest establishment cause measurement is incremented by 1.

d) Each subcounter is an integer value. The number of measurements is equal to the number of establishment causes.

e) UECNTX.ConnEstabSucc.*Cause* where *Cause* identifies the establishment cause.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurements is for performance assurance within accessibility area.

#### 5.1.1.17 RRC Connection Re-establishment

##### 5.1.1.17.1 Number of RRC connection re-establishment attempts

a) This measurement provides the number of RRC connection re-establishment attempts.

b) CC.

c) On Receipt of *RRCReestablishmentRequest* message from UE (see TS 38.331[20]).

d) Each measurement is an integer value.

e) The measurement name has the form RRC.ReEstabAtt.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.17.2 Successful RRC connection re-establishment with UE context

a) This measurement provides the successful number of RRC connection re-establishment when UE context can be retrieved.

b) CC.

c) On Receipt of a *RRCReestablishmentComplete* message from UE for RRC connection re-establishment (see TS 38.331[20]).

d) Each measurement is an integer value.

e) The measurement name has the form RRC.ReEstabSuccWithUeContext.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.17.3 Successful RRC connection re-establishment without UE context

a) This measurement provides the successful number of RRC connection re-establishment when UE context can not be retrieved.

b) CC.

c) On Receipt of a *RRCSetupComplete* message from UE for RRC connection re-establishment (see TS 38.331[20]).

d) Each measurement is an integer value.

e) The measurement name has the form RRC.ReEstabSuccWithoutUeContext.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.17.4 Number of RRC connection re-establishment attempts followed by RRC Setup

a) This measurement provides the number of RRC connection re-establishment attempts where no UE context could be retrieved and therefore fallback to RRC Setup procedure was attempted.

b) CC.

c) On transmission of *RRCSetup* message to UE, after first having received *RRCReestablishmentRequest* message from that UE (see TS 38.331[20]).

d) Each measurement is an integer value.

e) The measurement name has the form RRC.ReEstabFallbackToSetupAtt.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

#### 5.1.1.18 RRC Connection Resuming

##### 5.1.1.18.1 Number of RRC connection resuming attempts

a) This measurement provides the number of RRC connection resuming attempts.

b) CC.

c) On Receipt of the *RRCResumeRequest* message or *RRCResumeRequest1* from UE.Each *RRCResumeRequest* is added to the relevant subcounter per resume cause.

d) Each subcounter is an integer value.

e) The measurement name has the form RRC.ResumeAtt.*cause*

 Where *cause* indicates the resume cause defined in clause 6.2.2 of TS 38.331 [20].

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.18.2 Successful RRC connection resuming

a) This measurement provides the total successful number of RRC connection resuming.

b) CC.

c) On Receipt of a *RRCResumeComplete* message from UE for RRC connection resuming. Each successful RRC connection resumingis added to the relevant subcounter per resume cause.

d) Each subcounter is an integer value.

e) The measurement name has the form RRC.ResumeSucc.*cause*

 Where *cause* indicates the resume cause defined in clause 6.2.2 of TS 38.331 [20].

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.18.3 Successful RRC connection resuming with fallback

a) This measurement provides the successful number of RRC connection resuming by fallback to RRC connection establishment.

b) CC.

c) On Receipt of a *RRCSetupComplete* message from UE for RRC connection resuming by fallback to RRC connection establishment. Each successful RRC connection resumingis added to the relevant subcounter per resume cause.

d) Each subcounter is an integer value.

e) The measurement name has the form RRC.ResumeSuccByFallback.*cause.*

 Where *cause* indicates the resume cause defined in clause 6.2.2 of TS 38.331 [20].

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.18.4 RRC connection resuming followed by network release

a) This measurement provides the number of RRC connection resuming followed by network release.

b) CC.

c) On Transmission of a *RRCRelease* message to UE after RRC connection resuming request.

d) Each measurement is an integer value.

e) The measurement name has the form RRC.ResumeFollowedbyNetworkRelease.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.18.5 RRC connection resuming followed by network suspension

a) This measurement provides the number of RRC connection resuming followed by network suspension.

b) CC.

c) On Transmission of a *RRCRelease* with suspension configuration message to UE after RRC connection resume request.

d) Each measurement is an integer value.

e) The measurement name has the form RRC.ResumeFollowedbySuspension.

f) NRCellCU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.18.6 Number of RRC connection resuming attempts followed by RRC Setup

a) This measurement provides the number of RRC connection resuming attempts where no UE context could be retrieved and therefore fallback to RRC Setup procedure was attempted.

b) CC.

c) On transmission of *RRCSetup* message to UE, after first having received *RRCResumeRequest* message or *RRCResumeRequest1* from UE, the relevant subcounter per resume cause is stepped.

d) Each subcounter is an integer value.

e) The measurement name has the form RRC.ResumeFallbackToSetupAtt*.cause*.

 Where *cause* indicates the RRC resume cause defined in clause 6.2.2 of TS 38.331 [20].

f) NRCellCU.

g) Valid for packet switching.

h) 5GS

#### 5.1.1.19 Power, Energy and Environmental (PEE) measurements

##### 5.1.1.19.1 Applicability of measurements

The PEE related measurements defined here are valid for a 5G Physical Network Function (PNF). The NR NRM is defined in TS 28.541 [26].

##### 5.1.1.19.2 PNF Power Consumption

###### 5.1.1.19.2.1 Average Power

a) This measurement provides the average power consumed over the measurement period.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clauses 4.4.3.1, 4.4.3.4, Annex A.

d) A real value in watts (W).

e) The measurement name has the form PEE.AvgPower

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

###### 5.1.119.2.2 Minimum Power

a) This measurement provides the minimum power consumed during the measurement period

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clauses 4.4.3.1, 4.4.3.4, Annex A.

d) A real value in watts (W).

e) The measurement name has the form PEE.MinPower

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

###### 5.1.1.19.2.3 Maximum Power

a) This measurement provides the maximum power consumed during the measurement period.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clauses 4.4.3.1, 4.4.3.4, Annex A.

d) A real value in watts (W).

e) The measurement name has the form PEE.MaxPower

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.19.3 PNF Energy consumption

a) This measurement provides the energy consumed.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clauses 4.4.3.1, 4.4.3.4, Annex A.

d) A real value in kilowatt-hours (kWh).

e) The measurement name has the form PEE.Energy

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.19.4 PNF Temperature

###### 5.1.1.19.4.1 Average Temperature

a) This measurement provides the average temperature over the measurement period.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clause 4.4.3.4, Annex A.

d) A real value in degrees Celsius (°C).

e) The measurement name has the form PEE.AvgTemperature

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

###### 5.1.1.19.4.2 Minimum Temperature

a) This measurement provides the minimum temperature during the measurement period.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clause 4.4.3.4, Annex A.

d) A real value in degrees Celsius (°C).

e) The measurement name has the form PEE.MinTemperature

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

###### 5.1.1.19.4.3 Maximum Temperature

a) This measurement provides the maximum temperature during the measurement period.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clause 4.4.3.4, Annex A.

d) A real value in degrees Celsius (°C).

e) The measurement name has the form PEE.MaxTemperature

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.19.5 PNF Voltage

a) This measurement provides the voltage.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – Clauses 4.4.3.3, 4.4.3.4, Annex B.

d) A real value in volts (V).

e) The measurement name has the form PEE.Voltage.

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.19.6 PNF Current

a) This measurement provides the current.

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – Clauses 4.4.3.3, 4.4.3.4, Annex B.

d) A real value in amperes (A).

e) The measurement name has the form PEE.Current.

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.19.7 PNF Humidity

a) This measurement provides the percentage of humidity during the measurement period

b) SI.

c) This measurement is obtained according to the method defined in ETSI ES 202 336-12 [25] – clause 4.4.3.3, Annex B.

d) An integer value from 0 to 100.

e) The measurement name has the form PEE.Humidity.

f) ManagedElement

g) Valid for packet switching.

h) 5GS.

#### 5.1.1.20 Received Random Access Preambles

##### 5.1.1.20.1 Received Random Access Preambles per cell

a) This measurement provides the average (arithmetic mean) number of RACH preambles received in a cell. Separate counts are provided for dedicated preambles, randomly chosen preambles in group A (aka "low range") and randomly chosen preambles in group B (aka "high range").

b) DER (n=1)

c) This measurement is obtained by collecting the measurements of "Received Random Access Preambles per cell" where the unit of measured value is per second, as defined in 38.314 [29] in the granularity period, and then taking the arithmetic mean of these measurements. Separate measurements will be obtained based on the following measurements contained in "Received Random Access Preambles per cell" measurement:

- Dedicated preambles

- Randomly selected preambles in the low range

- Randomly selected preambles in the high range.

d) Each counter is an integer value. The number of measurements is equal to three.

e) RACH.PreambleDedCell

RACH.PreambleACell

RACH.PreambleBCell

f) NRCellDU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and to support RACH optimization (see TS 28.313 [30]).

##### 5.1.1.20.2 Received Random Access Preambles per SSB

a) This measurement provides the average (arithmetic mean) number of RACH preambles received in a cell per SSB. Separate counts are provided for dedicated preambles, randomly chosen preambles in group A (aka "low range") and randomly chosen preambles in group B (aka "high range").

b) DER (n=1)

c) This measurement is obtained by collecting the measurements of "Received Random Access Preambles per SSB" where the unit of measured value is per second, as defined in 38.314 [29] in the granularity period, and then taking the arithmetic mean of these measurements. Separate measurements will be obtained based on the following measurements contained in "Received Random Access Preambles per cell" measurement:

- Dedicated preambles

- Randomly selected preambles in the low range

- Randomly selected preambles in the high range.

d) Each counter is an integer value. The number of measurements is equal to three times the number of SSB beams defined in the cell.

e) RACH.PreambleDed.*Ssb,* where *Ssb* represents the subcounter associated with SSB.

RACH.PreambleA.*Ssb,* where *Ssb* represents the subcounter associated with SSB.

RACH.PreambleB.*Ssb,* where *Ssb* represents the subcounter associated with SSB.

f) NRCellDU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and to support RACH optimization (see TS 28.313 [30]).

##### 5.1.1.20.3 Distribution of number of RACH preambles per cell

a) This measurement provides the distribution of the number of RACH preambles sent by the UE when successfully accessing the network, as reported by the UEs inside the *RA-ReportList-r16* IE in the *UEInformationResponse-r16* message. The measurement is incremented each time a *UEInformationResponse-r16* message containing a *RA-ReportList-r16* IE (see TS 38.331 [20]) is received.

b) CC.

c) Each of the *RA-Report-r16* IEs in the *RA-ReportList-r16* increments the measurement bin that is identified by *Bin*, where *Bin* corresponds to the number of RACH preambles sent to the cell denoted by *cellId-r16* before a successful connection establishment. The number of RACH preambles is equal to:

, where

"*n*" equals to the number of *numberOfPreamblesSentOnSSB-r16 IEs* in all *PerRASSBInfo-r16 IEs* in the *RA-Report-r16*,

 "*numOfPreamblesPerSSB"* equals to *numberOfPreamblesSentOnSSB-r16* attribute in *PerRASSBInfo-r16* IE, See TS 38.331 [20] clause 6.2.2.

d) Each measurement is an integer value.

e) RACH.PreambleDist.*Bin*

where *Bin* is to identify the bins associated with the number of preambles sent.

NOTE: The number of *Bin*s and the range for each bin is left to implementation.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is to support RACH optimization management, see TS 28.313 [30].

##### 5.1.1.20.4 Distribution of RACH access delay

a) This measurement provides an estimate of the distribution of the RACH access delay, that is the interval from the time a UE sends its first RACH preamble until the UE is connected to the network. The measurement is incremented each time a *UEInformationResponse-r16* message containing a *RA-ReportList-r16* IE (see TS 38.331 [20]) is received.

b) CC.

c) Each of the *RA-Report-r16* IEs in the *RA-ReportList-r16* increments the measurement bin that is identified by *Bin*, where *Bin* corresponds to the UE RACH access delay for that particular *RA-Report-r16* received from UE. The access delay is estimated based on the value of *numberOfPreamblesSentOnSSB-r16* IE and *contentionDetected-r16* IE in *PerRAAttemptInfo-r16*, where *numberOfPreamblesSentOnSSB-r16* IE and *PerRAAttemptInfo-r16* IE are contained in *PerRASSBInfo-r16* IE. See TS 38.331 [20] clause 6.2.2.

NOTE: The estimate of the access delay is left to implementation.

d) Each measurement is an integer value.

e) RACH.AccessDelayDist.*Bin*

where *Bin* is to identify the bins associated with the RACH access delay.

NOTE: *Bin* and the range for each bin is left to implementation.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is to support RACH optimization management, see TS 28.313 [30].

#### 5.1.1.21 Intra-NRCell SSB Beam switch Measurement

##### 5.1.1.21.1 Number of requested Intra-NRCell SSB Beam switch executions

a) This measurement provides the number of outgoing intra-NRCell SSB Beam switch executions requested by the source SSB Beam in an NRCell in case the beam switch function is enabled (see TS 38.331[20]).

b) CC.

c) On transmission of *tci-StatesPDCCH-ToAddList* in MAC CE to the UE triggering the switch from the source SSB Beam to the target SSB Beam, indicating the attempt of an outgoing intra-NRCell SSB Beam switch (see TS 38.321 [32]), the counter is stepped by 1.

d) A single integer value.

e) MR.IntraCellSSBSwitchReq

f) Beam

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance. This measurement is only applicable when the beam switch function is activated.

##### 5.1.1.21.2 Number of successful Intra-NRCell SSB Beam switch executions

a) This measurement provides the number of successful intra-NRcell SSB Beam switch executions received by the source SSB Beam in case the beam switch function is enabled (see TS 38.331[20]).

b) CC

c) On reception of *HARQ ACK in MAC CE* from the UE to the target SSB Beam indicating a successful intra-NRCell SSB Beam switch (see TS 38.321 [32]), the counter is stepped by 1.

d) A single integer value.

e) MR.IntrCellSuccSSBSwitch

f) Beam

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance. This measurement is only applicable when the beam switch function is activated.

#### 5.1.1.22 RSRP Measurement

##### 5.1.1.22.1 SS-RSRP distribution per SSB

a) This measurement provides the distribution of SS-RSRP per SSB (see TS 38.215 [34]) received by gNB from UEs in the cell when SS-RSRP is used for L1-RSRP as configured by reporting configurations as defined in TS 38.214 [33], in case the L1-RSRP report function is enabled.

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin using measured quantity value (See Table 10.1.6.1-1 in TS 38.133 [35]) when a RSRP value is reported by a UE when SS-RSRP is used for L1-RSRP as configured by reporting configurations as defined in TS 38.214 [33].

d) Each subcounter is an integer.

e) L1M.SS-RSRP.Bin

where Bin represents the range of reported SS-RSRP value (0 to 127 dBm)

NOTE: Number of bins and the range for each bin is left to implementation.

f) Beam

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is to support MDA.

##### 5.1.1.22.2 SS-RSRP distribution per SSB of neighbor NR cell

a) This measurement provides the distribution of SS-RSRP per SSB (see TS 38.215 [34]) of a neighbour NR cell received by gNB from UEs when SS-RSRP is used for L1-RSRP as configured by reporting configurations as defined in TS 38.214 [33], in case the L1-RSRP report function is enabled.

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin using measured quantity value (See Table 10.1.6.1-1 in TS 38.133 [35]) when a RSRP value for the SSB beam of the neighbour NR cell is reported by a UE to the gNB via RRC *MeasurementReport* message (see TS 38.331 [20]).

d) Each subcounter is an integer.

e) L1M.SS-RSRPNrNbr.*SSBIndex*.*Bin*

where *SSBIndex* identifies the SSB beam of the neighbor NR cell; and
the *Bin* represents the range of reported SS-RSRP value (0 to 127).

NOTE: Number of bins and the range for each bin is left to implementation.

f) NRCellRelation

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is to support MDA.

##### 5.1.1.22.3 RSRP distribution per neighbor E-UTRAN cell

a) This measurement provides the distribution of RSRP per neighbour E-UTRA cell received by gNB from UEs (see 38.331 [20])

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin using measured quantity value (see Table 10.1.6.1-1 in TS 38.133 [35]) when a RSRP value for the neighbour E-UTRA cell is reported by a UE to the gNB via RRC *MeasurementReport* message (see TS 38.331 [20]).

d) Each subcounter is an integer.

e) L1M.RSRPEutraNbr.*Bin*

where the *Bin* represents the range of reported RSRP value to 97).

NOTE: Number of bins and the range for each bin is left to implementation.

f) EUtranCellRelation

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is to support MDA.

#### 5.1.1.23 Number of Active Ues

##### 5.1.1.23.1 Mean number of Active UEs in the DL per cell

a) This measurement provides the mean number of active DRBs for UEs in an NRCellDU. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or/and QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1).

c) This measurement is obtained by aggregating the measurement " Mean number of Active UEs in the DL per DRB per cell " (see clause 4.2.1.3.2 in TS 38.314 [29]). The measurement is performed per PLMN ID and per QoS level (mapped 5QI or/and QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a single integer value. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.MeanActiveUeDl\_Filter,
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or/and QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.23.2 Max number of Active UEs in the DL per cell

a) This measurement provides the max number of active DRBs for UEs in an NRCellDU. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or/and QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1).

c) This measurement is defined according to measurement " Max number of Active UEs in the DL per DRB per cell " (see clause 4.2.1.3.3 in TS 38.314 [29]). The measurement is performed per PLMN ID and per QoS level (mapped 5QI or/and QCI in NR option 3) and per supported S-NSSAI. d) Each measurement is a single integer value. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.MaxActiveUeDl\_Filter,
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or/and QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.23.3 Mean number of Active UEs in the UL per cell

a) This measurement provides the mean number of active DRBs for UEs in an NRCellDU. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or/and QCI in NR option 3) and per supported S-NSSAI.

b) DER (n=1)

c) This measurement is obtained by aggregating the measurement " Mean number of Active UEs in the UL per DRB per cell " (see clause 4.2.1.3.4 in TS 38.314 [29]). The measurement is performed per PLMN ID and per QoS level (mapped 5QI or/and QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is a single integer value. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.MeanActiveUeUl\_Filter,
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or/and QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.1.23.4 Max number of Active UEs in the UL per cell

a) This measurement provides the max number of active DRBs for UEs in an NRCellDU. The measurement is optionally split into subcounters per QoS level (mapped 5QI or/and QCI in NR option 3) and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is defined by the measurement " Max number of Active UEs in the UL per DRB per cell " (see clause 4.2.1.3.5 in TS 38.314 [29]). Separate counters are optionally maintained for each mapped 5QI (or/and QCI for option 3) and for each S-NSSAI.

d) The number of measurements is equal to one. If the optional QoS level measurement is perfomed, the number of measurements is equal to the number of mapped 5QIs (or/and number of QCI for option 3), and the number of S-NSSAIs.

e) The measurement name has the form DRB.MaxActiveUeUl,
DRB.MaxActiveUeUl.*QOS* where *QOS* identifies the target quality of service class, and
DRB.MaxActiveUeUl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

#### 5.1.1.24 5QI 1 QoS Flow Duration Monitoring

##### 5.1.1.24.1 Average Normally Released Call (5QI 1 QoS Flow) Duration

a) This measurement provides the average value of normally released call (5QI 1 QoS Flow) duration.

b) CC

c) The measurement is done as an arithmetical average of the samples of normally released calls (5QI 1 QoS Flows) duration at the end of measurement period. Each sample is measured from the point in time the 5QI 1 QoS Flow has been successfully established via initial Context setup procedure (INITIAL CONTEXT SETUP RESPONSE message sent by NR CU cell to AMF according to TS 38.413 [11]) or additional 5QI 1 QoS Flow setup procedure (PDU SESSION RESOURCE SETUP RESPONSE or a PDU SESSION RESOURCE MODIFY RESPONSE message sent by NR CU cell to AMF according to TS 38.413 [11]) or incoming handover (HANDOVER REQUEST ACKNOWLEDGE sent by target NR CU cell to AMF in case of NG intra/inter-system handover or sent by target to source NR CU cell via Xn in case of Xn based handover according to TS 38.413 [11]) till the point in time the 5QI 1 QoS Flow is released via gNB (UE CONTEXT RELEASE REQUEST message sent by NR CU cell to AMF according to TS 38.413 [11]) or AMF initiated release procedure (UE CONTEXT RELEASE COMMAND or PDU SESSION RESOURCE RELEASE COMMAND or PDU SESSION RESOURCE MODIFY REQUEST message sent by AMF to NR CU cell according to TS 38.413 [11)) or successful outgoing handover (UE CONTEXT RELEASE over Xn received from the target NG CU cell in case of Xn based handover or UE CONTEXT RELEASE COMMAND message sent by AMF to NR CU cell in case of NG intra/inter-system handover according to TS 38.413 [11]) due to normal release cause.

d) Each measurement is an integer value (in milliseconds).

e) The measurement name has the form 5QI1QoSflow.Rel.Average.NormCallDuration.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) Possible normal release causes according to TS 38.413 [11] are the following ones: "Normal Release", "Deregister", "User inactivity", "Release due to CN-detected mobility", "Handover Cancelled", "Partial handover", "Successful handover".

##### 5.1.1.24.2 Average Abnormally Released Call (5QI 1 QoS Flow) Duration

a) This measurement provides the average value of abnormally released call (5QI 1 QoS Flow) duration.

b) CC

c) The measurement is done as an arithmetical average of the samples of abnormally released calls (5QI 1 QoS Flows) duration at the end of measurement period. Each sample is measured from the point in time the 5QI 1 QoS Flow has been successfully established via initial Context setup procedure (INITIAL CONTEXT SETUP RESPONSE message sent by NR CU cell to AMF according to TS 38.413 [11]) or additional 5QI 1 QoS Flow setup procedure (PDU SESSION RESOURCE SETUP RESPONSE or a PDU SESSION RESOURCE MODIFY RESPONSE message sent by NR CU cell to AMF according to TS 38.413 [11]) or incoming handover (HANDOVER REQUEST ACKNOWLEDGE sent by target NR CU cell to AMF in case of NG intra/inter-system handover or sent by target to source NR CU cell via Xn in case of Xn based handover according to TS 38.413 [11]) till the point in time the 5QI 1 QoS Flow is released via gNB (UE CONTEXT RELEASE REQUEST message sent by NR CU cell to AMF according to TS 38.413 [11]) or AMF initiated release procedure (UE CONTEXT RELEASE COMMAND, PDU SESSION RESOURCE RELEASE COMMAND or PDU SESSION RESOURCE MODIFY REQUEST message sent by AMF to NR CU cell according to TS 38.413 [11)) due to abnormal release cause.

d) Each measurement is an integer value (in milliseconds).

e) The measurement name has the form 5QI1QoSflow.Rel.Average.AbnormCallDuration.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) Possible abnormal release causes are given in TS 38.413 [11] except for the following causes: "Normal Release", "Deregister", "User inactivity", "Release due to CN-detected mobility", "Handover Cancelled", "Partial handover", "Successful handover".

#### 5.1.1.24.3 Distribution of Normally Released Call (5QI 1 QoS Flow) Duration

a) This measurement provides the histogram result of the samples related to normally released call (5QI 1 QoS Flow) duration collected during measurement period duration.

b) CC

c) Each sample is measured from the point in time the 5QI 1 QoS Flow has been successfully established via initial Context setup or additional 5QI 1 QoS Flow setup procedure or incoming handover till the point in time the 5QI 1 QoS Flow is released via gNB or AMF initiated release procedure or successful outgoing handover due to normal release cause (refer to 5QI1QoSflow.Rel.Average.NormCallDuration part c) in clause 5.1.1.24.1 for detailed sampling). Triggering is done for the bin the given sample falls in.

d) Each measurement is an integer value.

e) The measurement name has the form 5QI1QoSflow.Rel.NormCallDurationBinX where X denotes the X-th bin from total number of N configured bins. X-th bin stands for the normal call duration which is within the range from tx-1 to tx.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) Each histogram function is represented by the configured number of bins with configured bin width by operator.

#### 5.1.1.24.4 Distribution of Abnormally Released Call (5QI 1 QoS Flow) Duration

a) This measurement provides the histogram result of the samples related to abnormally released call (5QI 1 QoS Flow) duration collected during measurement period duration.

b) CC

c) Each sample is measured from the point in time the 5QI 1 QoS Flow has been successfully established via initial Context setup or additional 5QI 1 QoS Flow setup procedure or incoming handover till the point in time the 5QI 1 QoS Flow is released via gNB or AMF initiated release procedure due to abnormal release cause (refer to 5QI1QoSflow.Rel.Average.AbnormCallDuration part c) in clause 5.1.1.24.2 for detailed triggering). Triggering is done for the bin the given sample falls in.

d) Each measurement is an integer value.

e) The measurement name has the form 5QI1QoSflow.Rel.AbnormCallDurationBinX where X denotes the X-th bin from total number of N configured bins. X-th bin stands for the abnormal call duration which is within the range from tx-1 to tx.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

i) Each histogram function is represented by the configured number of bins with configured bin width by operator.

#### 5.1.1.25 Measurements related to MRO

##### 5.1.1.25.1 Handover failures related to MRO for intra-system mobility

a) This measurement provides the number of handover failure events related to MRO detected during the intra-system mobility within 5GS, see TS 38.300 [49] clause 15.5.2. The measurement includes separate counters for various handover failure types, classified as "Intra-system too early handover", "Intra-system too late handover" and "Intra-system handover to wrong cell".

b) CC.

c) The measurements of too early handovers, too late handovers and handover to wrong cell events are obtained respectively by accumulating the number of failure events detected by gNB during the intra-system mobility within 5GS.

d) Each measurement is an integer value.

e) HO.IntraSys.TooEarly

a) HO.IntraSys.TooLate

b) HO.IntraSys.ToWrongCell

f) NRCellCU.

NRCellRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is to support MRO (see TS 28.313 [30]).

##### 5.1.1.25.2 Handover failures related to MRO for inter-system mobility

a) This measurement provides the number of handover failure events delated to MRO detected during the inter-system mobility from 5GS to EPS, see TS 38.300 [49] clause 15.5.2. The measurement includes separate counters for various handover failure types, classified as "Inter-system too early handover" and "Inter-system too late handover".

b) CC.

c) The measurements of too early handovers and too late handovers events are obtained respectively by accumulating the number of failure events detected by gNB during the inter-system mobility from 5GS to EPS.

d) Each measurement is an integer value.

e) HO.InterSys.TooEarly

a) HO.InterSys.TooLate

f) NRCellCU.

EutranRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is to support MRO (see TS 28.313 [30]).

##### 5.1.1.25.3 Unnecessary handovers for Inter-system mobility

a) This measurement provides the number of unnecessary handover events detected during the inter-system mobility from 5GS to EPS, see TS 38.300 [49] clause 15.5.2. An example of unnecessary handover occurred when a UE handed over from NG-RAN to other system (e.g. UTRAN) even though quality of the NG-RAN coverage was sufficient.

b) CC.

c) The measurement of unnecessary handovers is obtained by accumulating the number of failure events detected gNB during the inter-system mobility from 5GS to EPS.

d) Each measurement is an integer value.

e) HO.InterSys.Unnecessary

f) NRCellCU.

EutranRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is to support MRO (see TS 28.313 [30]).

##### 5.1.1.25.4 Handover ping-pong for inter-system mobility

a) This measurement provides the number of handover ping-pong events detected during the inter-system mobility from 5GS to EPS, see TS 38.300 [49] clause 15.5.2. An example of handover ping-pong occurred when a UE is handed over from a cell in a source system (e.g. NG-RAN) to a cell in a target system different from the source system (e.g. E-UTRAN), then within a predefined limited time the UE is handed over back to a cell in the source system, while the coverage of the source system was sufficient for the service used by the UE.

b) CC.

c) The measurement of handover ping-pong events is obtained by accumulating the number of failure events detected by gNB during the inter-system mobility from 5GS to EPS.

d) Each measurement is an integer value.

e) HO.InterSys.Ping-pong

f) NRCellCU.

EutranRelation

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is to support MRO (see TS 28.313 [30]).

##### 5.1.1.25.5 Handover failures per beam-cell pair related to MRO for intra-system mobility

a) This measurement provides the number of handover failure events per beam-cell pair (source beam, i.e., the last beam before failure, and target cell) related to MRO detected during the intra-system mobility within 5GS. The measurement includes separate counters for various handover failure types, classified as "Intra-system too early handover per beam”, "Intra-system too late handover per beam " and "Intra-system handover to wrong cell per beam ". The handovers considered are inter-cell handovers.

b) CC.

c) The measurements of too early handovers for the beam per adjacent cell, too late handovers for the beam per adjacent cell and handover to wrong cell for the beam per adjacent cell events are obtained respectively by accumulating the number of failure events detected by gNB during the intra-system mobility within 5GS, where adjacent cells are identified by their NR Cell Identity (NCI).

d) Each measurement is an integer value.

e) HO.IntraSys.bTooEarly.NCI
HO.IntraSys.bTooLate.NCI
HO.IntraSys.bToWrongCell.NCI

f) Beam

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is to support MRO (see TS 28.313 [30]).

#### 5.1.1.26 PHR Measurement

##### 5.1.1.26.1 Type 1 power headroom distribution

a) This measurement provides a bin distribution (histogram) of Type 1 power headroom (See in TS 38.321 [32]) measurements.

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin using Type1 power headroom value when GNB received Type1 power headroom contained in Single Entry PHR MAC CE or Multiple Entry PHR MAC CE (See in TS 38.321 [32]) for period headroom report from UE.

d) A set of integer.

e) L1M.PHR1.BinX

where X represents the range of PHR value (-32 ...+38 dB) (See in TS 38.133 [32])

NOTE: Number of bins and the range for each bin is left to implementation.

f) NRCELLDU

g) Valid for packet switched traffic

h) 5GS

#### 5.1.1.27 Paging Measurement

##### 5.1.1.27.1 Number of CN Initiated paging records received by the gNB-CU

a) This measurement provides number of CN Initiated paging records received by the gNB-CU.

b) CC.

c) Reception of a PAGING message from AMF, (See in TS 38.413 [11]).

d) A single integer value.

e) PAG.ReceivedNbrCnInitiated.

f) GNBCUCPFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.1.1.27.2 Number of NG-RAN Initiated paging records received by the gNB-CU

a) This measurement provides numbeof NR RAN Initiated paging records received by the gNB-CU.

b) CC.

c) Reception of a RAN PAGING message from NR RAN (See inTS 38.304 [37] and TS 38.423 [13]).

d) A single integer value.

e) PAG.ReceivedNbrRanIntiated.

f) GNBCUCPFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.1.1.27.3 Number of paging records received by the NRCellDU

a) This measurement provides number of paging records received by gNB-DU which shall perform paging of the UE in cells which belong to cells as indicated in the *Paging Cell List* IE (See in TS 38.473 [6]).

b) CC.

c) Reception of a PAGING message from gNB-CU, (See in TS 38.473 [6]).

d) A single integer value.

e) PAG.ReceivedNbr.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

##### 5.1.1.27.4 Number of CN Initiated paging records discarded at the gNB-CU

a) This measurement provides number of CN Initiated paging records discarded at the gNB-CU.

b) CC.

c) Reception of a PAGING message from AMF, (See in TS 38.413 [11]) that is discarded at the gNB-CU.

d) A single integer value.

e) PAG.DiscardedNbrCnInitiated

f) GNBCUCPFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.1.1.27.5 Number of NG-RAN Initiated paging records discarded at the gNB-CU

a) This measurement provides number of NG-RAN Initiated paging records discarded at the gNB-CU.

b) CC.

c) Reception of a RAN PAGING message from NG-RAN (See inTS 38.304 [37] and TS 38.423 [13]) that is discarded at the gNB-CU.

d) A single integer value.

e) PAG.DiscardedNbrRanInitiated

f) GNBCUCPFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.1.1.27.6 Number of paging records discarded at the NRCellDU

a) This measurement provides number of paging records discarded at gNB-DU in cells as indicated in the *Paging Cell List* IE (See in TS 38.473 [6]).

b) CC.

c) Reception of a PAGING message from gNB-CU, (See in TS 38.473 [6]) that is discarded at the gNB-DU

d) A single integer value.

e) PAG.DiscardedNbr

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

#### 5.1.1.28 SSB beam related Measurement

##### 5.1.1.28.1 Number of UE related the SSB beam Index (mean)

a) This measurement provides number of UE related the SSB beam index.

b) CC.

1. c) The measurement is obtained by sampling at a pre-defined interval, the number of UE related SSB beam index, and then taking the arithmetic mean. The UE related beam index which maintained by UE random access and handover and beam switch in case the beam switch function is enabled (see TS 38.331[20]).

d) A single integer value.

e) L1M.SSBBeamRelatedUeNbr.

f) Beam

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance. This measurement is only applicable when the beam switch function is activated.

#### 5.1.1.29 Transmit power utilization measurements

##### 5.1.1.29.1 Maximum transmit power of NR cell

a) This measurement provides the maximum carrier transmit power in the measurement granularity interval.

b) SI.

c) This measurement is obtained by retaining the maximum value of the total carrier power transmitted in the cell within the measurement granularity period. The power includes all radio power transmitted, included common channels, traffic channels, control channels. The value is expressed in dBm.

d) Float in dBm.

e) CARR.MaxTxPwr

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.1.1.29.2 Mean transmit power of NR cell

a) This measurement provides the mean carrier transmit power in the measurement granularity interval.

b) SI.

c) This measurement is obtained by retaining the mean value of the total carrier power transmitted in the cell within the measurement granularity period. The power includes all radio power transmitted, included common channels, traffic channels, control channels. The value is expressed in dBm.

d) Float in dBm.

e) CARR.MeanTxPwr

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.1.1.30 MU-MIMO related measurements

##### 5.1.1.30.1 Scheduled PDSCH RBs per layer of MU-MIMO

a) This measurement provides the distribution of the scheduled PDSCH RBs per MU-MIMO layer by NG-RAN in MU-MIMO scenario.

b) CC

c) This measurement is obtained by incrementing the appropriate measurement bin with the number of the PDSCH RBs according to the DL MU-MIMO layer. (For example, if two layers multiplex one RB, add one to CARR.MUPDSCHRB.BIN2.) The retransmitted RBs should be included, and the RBs used for broadcast should be excluded.

d) Each measurement is a single integer value.

e) CARR.MUPDSCHRB.BINX, where X represents the MU-MIMO layer value (2 to n).

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.30.2 Scheduled PUSCH RBs per layer of MU-MIMO

a) This measurement provides the distribution of the scheduled PUSCH RBs per MU-MIMO layer by NG-RAN in MU-MIMO scenario.

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin with the number of the PUSCH RBs according to the MU-MIMO layer. (For example, if two layers multiplex one RB, add one to CARR.MUPUSCHRB.BIN2.) The retransmitted RBs should be included.

d) Each measurement is a single integer value.

e) CARR.MUPUSCHRB.BINX, where X represents the MU-MIMO layer value (2 to n).

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

##### 5.1.1.30.3 PDSCH Time-domain average Maximum Scheduled Layer Number of cell for MIMO scenario

a) This measurement provides the Time-domain average maximum scheduled layer number for PDSCH under MIMO scenario in the downlink.

b) SI

c) This measurement is obtained as:

Where *LM(T)* denotes the Time-domain average of maximum scheduled layer number for PDSCH under MIMO scenario in the downlink in the time period T. denotes the maximum number of scheduled layer of PDSCH at sampling occasion j; *K(T)* denotes the number of sampling occasions at which is not 0; *T* denotes the time period during which the measurement is performed; and *j* denotes the sampling occasion during time period T, for example, a sampling occasion is 1 slot.

d) A single real value.`

e) RRU.MaxLayerDlMimo, *which indicates the PDSCH* *Time-domain average maximum scheduled layer number for MIMO scenario in the downlink.*

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

i) One usage of this measurement is evaluate the actural spatial capability of a cell in the downlink under MIMO scenario.

##### 5.1.1.30.4 PUSCH Time-domain average Maximum Scheduled Layer Number of cell for MIMO scenario

a) This measurement provides the Time-domain average maximum scheduled layer number for PUSCH under MIMO scenario in the uplink.

b) SI

c) This measurement is obtained as:

Where *LM(T)* denotes the Time-domain average of maximum scheduled layer number for PUSCH under MIMO scenario in the uplink in the time period T. denotes the maximum number of scheduled layer of PUSCH at sampling occasion j; *K(T)* denotes the number of sampling occasions at which is not 0; *T* denotes the time period during which the measurement is performed; and *j* denotes the sampling occasion during time period T, for example, a sampling occasion is 1 slot.

d) A single real value.

e) RRU.MaxLayerUlMimo, *which indicates the PUSCH* *Time-domain average maximum scheduled layer number for MIMO scenario in the uplink.*

f) NRCellDU.

g) Valid for packet switching.

h) 5GS.

i) One usage of this measurement is evaluate the actural spatial capability of a cell in the uplink under MIMO scenario.

##### 5.1.1.30.5 Average value of scheduled MIMO layers per PRB on the DL

a) This measurement provides the average value of allocated MIMO layers on the downlink per PRB per cell, for MIMO scenario within the measurement period.

b) SI.

c) This measurement is obtained by computing the average value of scheduled MIMO layers among all used PRBs that are used within the measurement period in the cell. The average value is obtained by this formula:

 ,

 where denotes the average value of scheduled MIMO layers per PRB per cell on the DL. denotes the measurement period (e.g. 1 hour). And denotes the sampling occasion (e.g. 1 symbol). And denotes the number of kinds of MIMO layers (e.g. 2 kinds). denotes the number of MIMO layers (e.g. 1 layers, 4layers, etc.) scheduled for traffic transmission at sampling occasion . denotes the number of PDSCH PRBs used for transmission corresponding to , at sampling occasion . For example, a cell has 10 PRBs in total for one sampling occasion (=1), within which 9 PRBs are used and 1 left spare. Among 9 used PRBs, one is multiplexed by 4 layers, three is multiplexed by 2 layers, and five only has 1 layer (no multiplexing). So the in this case is: (1\*4+3\*2+5\*1)/(1+3+5) = 1.67 layers per PRB.

d) Each measurement is a real value.

e) The measurement name has the form CARR.AverageLayersDl

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i）One usage of this measurement is to monitor the cell capacity for MIMO scenario, on the DL.

##### 5.1.1.30.6 Average value of scheduled MIMO layers per PRB on the UL

a) This measurement provides the average value of allocated MIMO layers on the uplink per PRB per cell, for MIMO scenario within the measurement period.

b) SI.

c) This measurement is obtained by computing the average value of scheduled MIMO layers among all used PRBs that are used within the measurement period in the cell. The average value is obtained by this formula:

 ,

 where denotes the average value of scheduled MIMO layers per PRB per cell on the UL. denotes the measurement period (e.g. 1 hour). And denotes the sampling occasion (e.g. 1 symbol). And denotes the number of kinds of MIMO layers (e.g. 2 kinds). denotes the number of MIMO layers (e.g. 1 layers, 4layers, etc.) scheduled for traffic transmission at sampling occasion . denotes the number of PUSCH PRBs used for transmission corresponding to , at sampling occasion . For example, a cell has 10 PRBs in total for one sampling occasion (=1), within which 9 PRBs are used and 1 left spare. Among 9 used PRBs, one is multiplexed by 4 layers, three is multiplexed by 2 layers, and five only has 1 layer (no multiplexing). So the in this case is: (1\*4+3\*2+5\*1)/(1+3+5) = 1.67 layers per PRB.

d) Each measurement is a real value.

e) The measurement name has the form CARR.AverageLayersUl

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i）One usage of this measurement is to monitor the cell capacity for MIMO scenario, on the UL.

#### 5.1.1.31 RSRQ measurement

a) This measurement provides the distribution of SS-RSRQ received by gNB from UEs in the cell. The periodical UE measurement reports towards all of the UEs need to be triggered by gNB in the measured New Radio cell (See in TS 38.331[20]).

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin using measured quantity value (See Table 10.1.11.1-1 in TS 38.133 [35], clause 5.1.3 SS reference signal received quality (SS-RSRQ) in 38.215[34] ) when a RSRQ value is reported by a UE when RSRQ is used for *MeasQuantityResults* IE that is in *resultsSSB-Cell* IE within the *measResult* IE as configured by *MeasurementReport* configurations as defined in TS 38.331 [20].

d) A set of integer.

e) MR.NRScSSRSRQ.BinX

where X represents the range of Measured quantity SS-RSRQ value (-43 to 20 dB)

NOTE: Number of bins and the range for each bin is left to implementation.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

#### 5.1.1.32 SINR measurement

a) This measurement provides the distribution of SS-SINR received by gNB from UEs in the cell. The periodical UE measurement reports towards all of the UEs need to be triggered by gNB in the measured New Radio cell (See in TS 38.331[20]).

b) CC.

c) This measurement is obtained by incrementing the appropriate measurement bin using measured quantity value (see Table 10.1.16.1-1 in TS 38.133 [35]) when a SINR value is reported by a UE when *sinr* is used for *MeasQuantityResults* IE that is in *resultsSSB-Cell* IE within the *measResult* IE as configured by *MeasurementReport* configurations as defined in TS 38.331 [20].

d) A set of integer.

e) MR.NRScSSSINR.BinX

where X represents the range of Measured quantity SS-SINR value (-23 to 40 dB)

NOTE: Number of bins and the range for each bin is left to implementation.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

#### 5.1.1.33 Timing Advance

##### 5.1.1.33.1 Timing Advance distribution for NR Cell

a) This measurement provides the distribution of the Absolute Timing Advance (*TA*) values transmitted by the gNB to UEs in the cell..

b) CC

c) This measurement is obtained by incrementing the appropriate measurement bin when an Absolute Timing Advance Command is sent to a UE in the NR cell, see TS 38.321 [32].

d) Each subcounter is an integer.

e) L1M. ATADist.*Bin*
where *Bin* represents the range of absolute *TA* value (0 to 4095).

NOTE: Number of bins and the range for each bin is left to implementation.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is to support MDA.

#### 5.1.1.34 Incoming GTP Data Packet Loss in gNB over N3

a) This measurement provides the number of GTP data packets which are not successfully received at gNB over N3 after being sent by UPF. It is a measure of the incoming GTP data packet loss per N3 interface. The measurement is split into subcounters per QoS level (5QI) and subcounters per supported S-NSSAI.

b) CC.

c) This measurement is obtained by a counter: Number of missing incoming GTP sequence numbers (TS 29.281 [42]) among all GTP packets delivered by a UPF to a gNB per N3 interface. The separate subcounter can be maintained for each 5QI or for each GTP tunnel identified by TEID or for each supported S-NSSAI

d) Each measurement is an integer value representing the lost GTP packets. If the QoS level measurement is perfomed, the measurements are equal to the number of 5QIs. If the optional S-NSSAI subcounter measurements are performed, the number of measurements is equal to the number of supported S-NSSAIs.

e) The measurement name has the form GTP.InDataPktPacketLossN3gNB or GTP.InDataPktPacketLossN3gNB.QoSwhere QoS identifies the target quality of service class or GTP.InDataPktPacketLossN3gNB.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI.

f) EP\_NgU (contained by GNBCUUPFunction)

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and for reliability KPI.

### 5.1.2 Performance measurements valid only for non-split gNB deployment scenario

#### 5.1.2.1 PDCP Data Volume

##### 5.1.2.1.1 DL PDCP SDU Data Volume Measurements

5.1.2.1.1.1 DL Cell PDCP SDU Data Volume

1. This measurement provides the Data Volume (amount of PDCP SDU bits) in the downlink delivered to PDCP layer. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.
The unit is Mbit.

b) CC.

c) This measurement is obtained by counting the number of bits entering the NG-RAN PDCP layers. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels multiplied by the number of S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduVolumeDL\_Filter.

Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where *PLMN ID* represents the PLMN ID, *QoS* representes the mapped 5QI or the QCI level, and *SNSSAI* represents S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS .

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

NRCellCU in non-split NG-RAN deployment scenarios represents NRCell.

5.1.2.1.1.2 DL Cell PDCP SDU Data Volume on X2 Interface

1. This measurement provides the Data Volume (amount of PDCP SDU bits) in the downlink delivered on X2 interface in DC-scenarios. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3).
The unit is Mbit.

b) CC.

c) This measurement is obtained by counting the number of bits transferred in the downlink through X2 interface. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3).

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduVolumeX2DL\_Filter.

Where filter is a combination of PLMN ID and QoS level.

Where *PLMN ID* represents the PLMN ID, *QoS* representes the mapped 5QI or the QCI level.

f) NRCellCU.

g) Valid for packet switched traffic..

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

NRCellCU in non-split NG-RAN deployment scenarios represents NRCell.

5.1.2.1.1.3 DL Cell PDCP SDU Data Volume on Xn Interface

1. This measurement provides the Data Volume (amount of PDCP SDU bits) in the downlink delivered on Xn interface . The measurement is calculated per PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.
The unit is Mbit.

b) CC.

c) This measurement is obtained by counting the number of bits transferred in the downlink through Xn interface. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels multiplied by the number of S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduVolumeXnDL\_Filter.
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where *PLMN ID* represents the PLMN ID, *QoS* representes the mapped 5QI or the QCI level, and *SNSSAI* represents S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

NRCellCU in non-split NG-RAN deployment scenarios represents NRCell.

##### 5.1.2.1.2 UL PDCP SDU Data Volume Measurements

5.1.2.1.2.1 UL Cell PDCP SDU Data Volume

1. This measurement provides the Data Volume (amount of PDCP SDU bits) in the uplink delivered from PDCP layer to higher layers. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.
The unit is Mbit.

b) CC.

c) This measurement is obtained by counting the number of bits delivered from PDCP layer to higher layers. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels multiplied by the number of S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduVolumeUL\_Filter.
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where *PLMN ID* represents the PLMN ID, *QoS* representes the mapped 5QI or the QCI level, and *SNSSAI* represents S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

NRCellCU in non-split NG-RAN deployment scenarios represents NRCell.

5.1.2.1.2.2 UL Cell PDCP SDU Data Volume on X2 Interface

1. This measurement provides the Data Volume (amount of PDCP SDU bits) in the uplink delivered on X2 interface in NSA scenarios. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3).
The unit is Mbit.

b) CC

c) This measurement is obtained by counting the number of bits transferred in the uplink through X2 interface. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3).

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduVolumeX2UL\_Filter.

Where filter is a combination of PLMN ID and QoS level.

Where *PLMN ID* represents the PLMN ID, *QoS* representes the mapped 5QI or the QCI level.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

NRCellCU in non-split NG-RAN deployment scenarios represents NRCell.

5.1.2.1.2.3 UL Cell PDCP SDU Data Volume on Xn Interface

a) This measurement provides the Data Volume (amount of PDCP SDU bits) in the uplink delivered on Xn interface in SA scenarios. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.
The unit is Mbit.

b) CC.

c) This measurement is obtained by counting the number of bits transferred in the uplink through Xn interface. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels multiplied by the number of S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduVolumeXnUL\_Filter.

Where filter is a combination of PLMN ID and QoS level and S-NSSAI.

Where *PLMN ID* represents the PLMN ID, *QoS* representes the mapped 5QI or the QCI level, and *SNSSAI* represents S-NSSAI.

f) NRCellCU.

g) Valid for packet switched traffic..

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

NRCellCU in non-split NG-RAN deployment scenarios represents NRCell.

#### 5.1.2.2 Packet Success Rate

##### 5.1.2.2.1 UL PDCP SDU Success Rate

a) This measurement provides the fraction of PDCP SDU packets which are successfully received at gNB. It is a measure of the UL packet delivery success including any packet success in the air interface and in the gNB. Only user-plane traffic (DTCH) and only PDCP SDUs that have entered PDCP (and given a PDCP sequence number) are considered. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.

b) SI.

c) This measurement is obtained as: Number of successfully received UL PDCP sequence numbers, representing packets that are successfully delivered to higher layers, of a data radio bearer, divided by Total number of UL PDCP sequence numbers of a bearer, starting from the sequence number of the first packet delivered by UE PDCP to gNB until the sequence number of the last packet. Separate counters are optionally maintained for mapped 5QI (or QCI for NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the success rate. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurements are performed, the measurements are equal to the number of mapped 5QIs or the number of supported S-NSSAIs.

e) The measurement name has the form DRB.PacketSuccessRateUlgNBUu and optionally DRB.PacketSuccessRateUlgNBUu.*QOS* where *QOS* identifies the target quality of service class, and DRB.PacketSuccessRateUlgNBUu.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and for reliability KPI.

Note : NRCellCU in non-split NG-RAN deployment scenarios represents NRCell.

### 5.1.3 Performance measurements valid for split gNB deployment scenario

#### 5.1.3.1 Packet Loss Rate

##### 5.1.3.1.1 UL PDCP SDU Loss Rate

a) This measurement provides the fraction of PDCP SDU packets which are not successfully received at gNB-CU-UP. It is a measure of the UL packet loss including any packet losses in the air interface, in the gNB-CU and on the F1-U interface. Only user-plane traffic (DTCH) and only PDCP SDUs that have entered PDCP (and given a PDCP sequence number) are considered. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.

b) SI.

c) This measurement is obtained as: 1000000\* Number of missing UL PDCP sequence numbers, representing packets that are not delivered to higher layers, of a data radio bearer, divided by Total number of UL PDCP sequence numbers (also including missing sequence numbers) of a bearer, starting from the sequence number of the first packet delivered by UE PDCP to gNB-CU-UP until the sequence number of the last packet. If transmission of a packet might continue in another cell, it shall not be included in this count. Separate counters are optionally maintained for mapped 5QI (or QCI for NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurements are perfomed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.PacketLossRateUl and optionally DRB.PacketLossRateUl.*QOS* where *QOS* identifies the target quality of service class, and DRB.PacketLossRateUl.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) GNBCUUPFunction.

NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality). NRCellCU measurement applies only for 2-split deployment.

##### 5.1.3.1.2 UL F1-U Packet Loss Rate

a) This measurement provides the fraction of PDCP SDU packets which are not successfully received at gNB-CU-UP. It is a measure of the UL packet loss on the F1-U interface. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per supported S-NSSAI.

b) SI

c) This measurement is obtained as: 1000000\* Number of missing UL GTP sequence numbers (TS 29.281), representing packets that are not delivered to higher layers, of a data radio bearer, divided by Total number of UL GTP sequence numbers (also including missing sequence numbers) of a bearer, starting from the GTP sequence number of the first packet delivered by gNB-DU to gNB-CU-UP until the GTP sequence number of the last packet. Separate counters are optionally maintained for mapped 5QI (or QCI for option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurement are perfomed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.F1UpacketLossRateUl and optionally DRB.F1UPacketLossRateUl.*QOS* where *QOS* identifies the target quality of service class, and DRB.F1UPacketLossRateUl.S*NSSAI* where *SNSSAI* identifies the S-NSSAI.

f) GNBCUUPFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.3.1.3 DL F1-U Packet Loss Rate

a) This measurement provides the fraction of PDCP SDU packets which are not successfully received at the gNB-DU). It is a measure of the DL packet loss on the F1-U interface. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.

b) SI

c) This measurement is obtained as: 1000000\* Number of missing DL GTP sequence numbers (TS 29.281), representing packets that are not delivered to lower layers, of a data radio bearer, divided by Total number of UL GTP sequence numbers (also including missing sequence numbers) of a bearer, starting from the sequence number of the first packet delivered by gNB-CU-UP to gNB-DU until the GTP sequence number of the last packet. Separate counters are optionally maintained for mapped 5QI (or QCI for NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurement are perfomed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.F1UpacketLossRateDl .and optionally DRB.F1UPacketLossRateDl.*QOS* where *QOS* identifies the target quality of service class, and DRB.F1UPacketLossRateDl.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

#### 5.1.3.2 Packet Drop Rate

##### 5.1.3.2.1 DL PDCP SDU Drop rate in gNB-CU-UP

a) This measurement provides the fraction of PDCP SDU packets which are dropped on the downlink, due to high traffic load, traffic management etc in the gNB-CU-UP. Only user-plane traffic (DTCH) is considered. A dropped packet is one whose context is removed from the gNB-CU-UP without any part of it having been transmitted on the F1-U or Xn-U or X2-U interface. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.

NOTE: this measurement may include packets that were supposed to be sent via the eUtran air interface if using NR split bearer option 3, 4 or 7.

b) SI.

c) This measurement is obtained as: 1000000\*Number of DL packets, for which no part has been transmitted over the F1-U or Xn-U or X2-U interface, of a data radio bearer, that are discarded in the PDCP layer, divided by Number of DL packets for data radio bearers that has entered PDCP upper SAP. Separate counters are optionally maintained for mapped 5QI (or QCI for NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the drop rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurement are perfomed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.PdcpPacketDropRateDl and optionally DRB.PdcpPacketDropRateDl.*QOS*
where *QOS* identifies the target quality of service class, and DRB.PdcpPacketDropRateDl.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) GNBCUUPFunction.

NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality). NRCellCU measurement applies only for 2-split deployment.

##### 5.1.3.2.2 DL Packet Drop Rate in gNB-DU

a) This measurement provides the fraction of RLC SDU packets which are dropped on the downlink, due to high traffic load, traffic management etc in the gNB-DU. Only user-plane traffic (DTCH) is considered. A dropped packet is one whose context is removed from the gNB-DU without any part of it having been transmitted on the air interface. The measurement is optionally split into subcounters per QoS level (mapped 5QI or QCI in NR option 3), and subcounters per supported S-NSSAI.

b) SI.

c) This measurement is obtained as: 1000000\*Number of DL packets, for which no part has been transmitted over the air, of a data radio bearer, that are discarded in the gNB-DU divided by Number of DL packets for data radio bearers that were received from gNB-CU-UP. Separate counters are optionally maintained for mapped 5QI (or QCI for NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the drop rate multiplied by 1E6. The number of measurements is equal to one. If the optional QoS and S-NSSAI level measurement are perfomed, the measurements are equal to the number of mapped 5QIs and the number of supported S-NSSAIs.

e) The measurement name has the form DRB.RlcPacketDropRateDl and optionallyDRB.RlcPacketDropRateDl.*QOS*
where *QOS* identifies the target quality of service class, and DRB.RlcPacketDropRateDl.*SNSSAI* where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

#### 5.1.3.3 Packet delay

##### 5.1.3.3.1 Average delay DL in CU-UP

a) This measurement provides the average (arithmetic mean) PDCP SDU delay on the downlink within the gNB-CU-UP, for all PDCP packets. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained as: sum of (time when sending a PDCP SDU to the gNB-DU at the egress PDCP layer on F1-U/Xn-U, minus time of arrival of the same packet at NG-U ingress IP termination) divided by total number of PDCP SDUs arriving at NG-U ingress IP termination. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpSduDelayDl\_Filter,
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.
Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.3.3.2 Average delay DL on F1-U

a) This measurement provides the average (arithmetic mean) GTP packet delay DL on the F1-U interface. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained as: the time when receiving a GTP packet from the gNB-DU at the egress GTP termination, minus time when sending the same packet to gNB-DU at the GTP ingress termination, minus feedback delay time in gNB-DU, obtained result is divided by two.. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of S-NSSAIs.
 [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.PdcpF1DelayDl\_Filter,
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.
Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

NOTE : The NR RAN container (DL USER DATA/ DL DATA DELIVERY STATUS) carried in the GTP-U packet over the F1-U interface is used for the measurement.

##### 5.1.3.3.3 Average delay DL in gNB-DU

a) This measurement provides the average (arithmetic mean) RLC SDU delay on the downlink within the gNB-DU, for initial transmission of all RLC packets. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained as: sum of (time when the last part of an RLC SDU was scheduled and sent to the MAC layer for transmission over the air, minus time of arrival of the same packet at the RLC ingress F1-U termination) divided by total number of RLC SDUs arriving at the RLC ingress F1-U termination. If the RLC SDU needs retransmission (for Acknowledged Mode) the delay will still include only one contribution (the original one) to this measurement. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.

d) Each measurement is a real representing the mean delay in 0.1 millisecond. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form DRB.RlcSduDelayDl,
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.
Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.3.3.4 Distribution of delay DL in CU-UP

a) This measurement provides the distribution of PDCP SDU delay on the downlink within the gNB-CU-UP, for all PDCP packets. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained by 1) calculating the DL delay within the gNB-CU-UP for a PDCP SDU packet by: the time when sending a PDCP SDU to the gNB-DU at the egress PDCP layer on F1-U/Xn-U, minus time of arrival of the same packet at NG-U ingress IP termination; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the counters. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.

d) Each measurement is an integer representing the number of PDCP SDU packets measured with the delay within the range of the bin. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) DRB.PdcpSduDelayDlDist.Bin\_Filter, where Bin indicates a delay range which is vendor specific;
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.
Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.3.3.5 Distribution of delay DL on F1-U

a) This measurement provides the distribution of GTP packet delay DL on the F1-U interface. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained by 1) calculating the DL delay on F1-U for a GTP packet by: the time when receiving a GTP packet delivery status message from the gNB-DU at the egress GTP termination, minus time when sending the same packet to gNB-DU at the GTP ingress termination, minus feedback delay time in gNB-DU, obtained result is divided by two; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the counters. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI.

d) Each measurement is an integer representing the number of GTP packets measured with the delay within the range of the bin. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) DRB.GtpF1DelayDlDist.Bin\_Filter, where Bin indicates a delay range which is vendor specific;
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.
Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) GNBCUUPFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.3.3.6 Distribution of delay DL in gNB-DU

a) This measurement provides the distribution of RLC SDU delay on the downlink within the gNB-DU, for initial transmission of all RLC packets. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained by 1) calculating the delay on the downlink within the gNB-DU for a RLC SDU packet by: the time when the last part of an RLC SDU was scheduled and sent to the MAC layer for transmission over the air, minus time of arrival of the same packet at the RLC ingress F1-U termination; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the counters. The measurement is performed per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI. If the RLC SDU needs retransmission (for Acknowledged Mode) the delay will still include only one contribution (the original one) to this measurement.

d) Each measurement is an integer representing the number of RLC SDU packets measured with the delay within the range of the bin. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of S-NSSAIs.
[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) ≤ 100.

e) DRB.RlcSduDelayDlDist.Bin\_Filter, where Bin indicates a delay range which is vendor specific;
Where filter is a combination of PLMN ID and QoS level and S-NSSAI.
Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or QCI level, and SNSSAI represents S-NSSAI.

f) NRCellDU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

#### 5.1.3.4 IP Latency measurements

##### 5.1.3.4.1 General information

This clause defines the DL latency in gNB-DU. DL latency measurements for CU-UP and F1-U are not defined.

##### 5.1.3.4.2 Average IP Latency DL in gNB-DU

a) This measurement provides the average IP Latency in DL (arithmetic mean) within the gNB-DU, when there is no other prior data to be transmitted to the same UE in the gNB-DU. The measurement is optionally split into subcounters per QoS level and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained as: sum of (time when the first piece of an RLC SDU transmitted on the air interface, minus time of arrival of the same packet at the RLC ingress F1-U termination, for IP packets arriving when there is no other prior data to be transmitted to the same UE in the gNB-DU) divided by total number of RLC SDUs arriving at the RLC ingress F1-U termination when there is no other prior data to be transmitted to the same UE in the gNB-DU. Separate counters are optionally maintained for each mapped 5QI (or QCI for option 3) and for each S-NSSAI.

d) Each measurement is a real representing the average latency in 0.1 millisecond. The number of measurements is equal to one. If the optional QoS level subcounters and S-NSSAI subcounters are measurement is performed, the number of measurements is equal to the sum of number of supported mapped 5QIs and the number of S-NSSAIs.

e) The measurement name has the form DRB.RlcSduLatencyDl,
optionally DRB.RlcSduLatencyDl.*QOS* where *QOS* identifies the target quality of service class, and
optionally DRB.RlcSduLatencyDl.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

##### 5.1.3.4.3 Distribution of IP Latency DL in gNB-DU

a) This measurement provides the distribution of IP Latency in DL within the gNB-DU, when there is no other prior data to be transmitted to the same UE in the gNB-DU. The measurement is split into subcounters per QoS level and subcounters per S-NSSAI.

b) DER (n=1)

c) This measurement is obtained by 1) calculating the latency on the downlink within the gNB-DU for a RLC SDU packet by: time when the first piece of an RLC SDU transmitted on the air interface, minus time of arrival of the same packet at the RLC ingress F1-U termination, for IP packets arriving when there is no other prior data to be transmitted to the same UE in the gNB-DU; and 2) incrementing the corresponding bin with the latency range where the result of 1) falls into by 1 for the subcounters per QoS level (mapped 5QI or QCI in NR option 3) and subcunters per S-NSSAI.

d) Each measurement is an integer representing the number of RLC SDU packets measured with the latency within the range of the bin.

e) DRB.RlcSduLatencyDlDist.*bin*.*QOS,* where *QOS* identifies the target quality of service class, and *Bin* indicates a latency range which is vendor specific;
DRB.RlcSduLatencyDlDist.*bin*.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI, and *Bin* indicates a latency range which is vendor specifics.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality).

#### 5.1.3.5 UE Context Release

##### 5.1.3.5.1 UE Context Release Request (gNB-DU initiated)

a) This measurement provides the number of UE CONTEXT Release initiated by gNB-DU for each release cause.

b) SI

c) Transmission of an UE CONTEXT RELEASE REQUEST message initiated by gNB-DU. Each release request is to be added to the relevant cause measurement. The possible causes are defined in 38.473 [6]. The sum of all supported per causes measurements shall equal the total number of UE CONTEXT Release initiated by gNB-DU. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the .sum suffix.

e) The measurement name has the form UECNTX.RelReq.*Cause*
 where *Cause* identifies the release cause.

f) NRCellDU

g) Valid for packet switched traffic

h) 5GS

##### 5.1.3.5.2 Number of UE Context Release Requests (gNB-CU initiated)

a) This measurement provides the number of UE CONTEXT RELEASE initiated by gNB-CU for each release cause.

b) SI

c) Transmission of an UE CONTEXT RELEASE COMMAND message initiated by gNB-CU. Each release request is to be added to the relevant cause measurement. The possible causes are defined in 38.473 [6]. The sum of all supported per causes measurements shall equal the total number of UE CONTEXT Release initiated by gNB-CU. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value. The number of measurements is equal to the number of causes plus a possible sum value identified by the .sum suffix.

e) The measurement name has the form UECNTX.RelCmd.Cause where Cause identifies the release cause.

f) NRCellCU

g) Valid for packet switched traffic

h) 5GS

#### 5.1.3.6 PDCP data volume measurements

##### 5.1.3.6.1 PDCP PDU data volume Measurement

5.1.3.6.1.1 DL PDCP PDU Data Volume

1. This measurement provides the Data Volume (amount of PDCP PDU bits) in the downlink delivered from GNB-CU to GNB-DU. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

b) CC.

c) This measurement is obtained by counting the number of DL PDCP PDU bits sent to GNB-DU. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

The measurements of DL Cell PDCP PDU Data Volume in Dual-Connectivity scenarios is not included.

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form QosFlow.PdcpPduVolumeDL\_Filter.

f) GNBCUUPFunction.

NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality). NRCellCU measurement applies only for 2-split deployment.

5.1.3.6.1.2 UL PDCP PDU Data Volume

a) This measurement provides the Data Volume (amount of PDCP PDU bits) in the uplink delievered from GNB-DU to GNB-CU. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI. The unit is Mbit (1MBits=1000\*1000 bits).

b) CC

c) This measurement is obtained by counting the number of bits entering the GNB-CU. The measurement is performed at the PDCP PDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

The measurements of UL Cell PDCP PDU Data Volume in Dual-Connectivity scenarios is not included.

d) Each measurement is an integer value representing the number of bits measured in Mbits. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form QosFlow.PdcpPduVolumeUl\_Filter.

f) GNBCUUPFunction.

NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality). NRCellCU measurement applies only for 2-split deployment.

##### 5.1.3.6.2 PDCP SDU data volume Measurement

5.1.3.6.2.1 DL PDCP SDU Data Volume

This measurement provides the Data Volume (amount of PDCP SDU bits) in the downlink delivered to PDCP layer. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

The unit is Mbit.

b) CC

c) This measurement is obtained by counting the number of bits entering the NG-RAN PDCP layer. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the number of bits measured in Mbits. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form QosFlow.PdcpSduVolumeDl\_Filter.

f) GNBCUUPFunction.

NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality). NRCellCU measurement applies only for 2-split deployment.

5.1.3.6.2.2 UL PDCP SDU Data Volume

a) This measurement provides the Data Volume (amount of PDCP SDU bits) in the uplink delivered from PDCP layer to SDAP layer or UPF. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.
The unit is Mbit.

b) CC.

c) This measurement is obtained by counting the number of bits leaving the NG-RAN PDCP layer. The measurement is performed at the PDCP SDU level. The measurement is performed per configured PLMN ID and per QoS level (mapped 5QI or QCI in NR option 3) and per supported S-NSSAI.

d) Each measurement is an integer value representing the number of bits measured in Mbits. The number of measurements is equal to the number of PLMNs multiplied by the number of QoS levels or multiplied by the number of supported S-NSSAIs.
[Total no. of measurement instances] x [no. of filter values for all measurements] (DL and UL) ≤ 100.

e) The measurement name has the form QosFlow.PdcpSduVolumeUL\_Filter.

f) GNBCUUPFunction.

NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality). NRCellCU measurement applies only for 2-split deployment.

5.1.3.6.2.3 DL PDCP SDU Data Volume per interface

a) This measurement provides the Data Volume (amount of PDCP SDU bits) in the downlink delivered from GNB-CU-UP to GNB-DU (F1-U interface), to external gNB-CU-UP (Xn-U interface) and to external eNB (X2-U interface). The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI and per PLMN ID, and reported per Interface (F1-U, Xn-U, X2-U).

b) CC

c) This measurement is obtained by counting the number of DL PDCP SDU bits sent to GNB-DU (F1-U interface), sent to external gNB-CU-UP (Xn-U interface) and sent to external eNB (X2-U interface). The measurement is performed in GNB-CU-UP per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI and per PLMN ID, and reported per interface (F1-U, Xn-U, X2-U).

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of QoS levels per interface plus the number of S-NSSAIs per interface plus the number of PLMN ID.

e) The measurement names have the form DRB.F1uPdcpSduVolumeDL\_Filter.

Where filter is a combination of PLMN ID and QoS level and S-NSSAI. (F1-U interface measurements) (Xn-U interface measurements)

Where filter is a combination of PLMN ID and QoS level. (X2-U interface measurements)

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or the QCI level, and SNSSAI represents S-NSSAI.:

f) EP\_F1U (F1-U interface), EP\_XnU (Xn-U interface), EP\_X2U (X2-U interface).

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

#### 5.1.3.6.2.4 UL PDCP SDU Data Volume per interface

a) This measurement provides the Data Volume (amount of PDCP SDU bits) in the uplink delivered to GNB-CU-UP from GNB-DU (F1-U interface), from external gNB-CU-UP (Xn-U interface) and from external eNB (X2-U interface). The measurement is calculated per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI and per PLMN ID, and reported per Interface (F1-U, Xn-U, X2-U).

b) CC.

c) This measurement is obtained by counting the number of UL PDCP SDU bits entering the GNB-CU-UP from GNB-DU (F1-U interface), from external gNB-CU-UP (Xn-U interface) and from external eNB (X2-U interface). The measurement is performed in GNB-CU-UP per QoS level (mapped 5QI or QCI in NR option 3) and per S-NSSAI and per PLMN ID, and reported per Interface (F1-U, Xn-U, X2-U).

d) Each measurement is an integer value representing the number of bits measured in Mbits (1MBits=1000\*1000 bits). The number of measurements is equal to the number of QoS levels per interface plus the number of S-NSSAIs per interface plus the number of PLMN ID.

e) The measurement names have the form DRB.F1uPdcpSduVolumeUL\_Filter.

Where filter is a combination of PLMN ID and QoS level and S-NSSAI. (F1-U interface measurements) (Xn-U interface measurements)

Where filter is a combination of PLMN ID and QoS level. (X2-U interface measurements)

Where PLMN ID represents the PLMN ID, QoS representes the mapped 5QI or the QCI level, and SNSSAI represents S-NSSAI.:

f) EP\_F1U (F1-U interface), EP\_XnU (Xn-U interface), EP\_X2U (X2-U interface).

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and in the energy efficency (EE) area.

##### 5.1.3.7 Handovers measurements

##### 5.1.3.7.1 Intra-gNB handovers

###### 5.1.3.7.1.1 Number of requested legacy handover preparations

a) This measurement provides the number of outgoing intra-gNB legacy handover preparations requested by the source NRCellCU for split gNB deployment.

b) CC.

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP is sending UE CONTEXT MODIFICATION REQUEST message (see TS 38.473 [6]) to gNB-DU to initiate an intra-gNB legacy handover.

d) A single integer value.

e) MM.HoPrepIntraReq.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.3.7.1.2 Number of successful legacy handover preparations

a) This measurement provides the number of successful intra-gNB legacy handover preparations received by the source NRCellCU, for split gNB deployment.

b) CC

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP receives UE CONTEXT MODIFICATION RESPONSE message (see TS 38.473 [6]) from gNB-DU to initiate a successful intra-gNB legacy handover.

d) A single integer value.

e) MM.HoPrepIntraSucc.

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this performance measurement is for performance assurance.

###### 5.1.3.7.1.3 Number of requested conditional handover preparations

a) This measurement provides the number of outgoing intra-gNB conditional handover preparations requested by the source NRCellCU for a split gNB deployment.

b) CC.

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP is sending a UE CONTEXT MODIFICATION REQUEST message (see TS 38.473 [6] clause 8.3.4) to gNB-DU to request resources for an intra-gNB conditional handover.

d) A single integer value.

e) MM.ChoPrepIntraReq

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurement is for performance assurance.

###### 5.1.3.7.1.4 Number of successful conditional handover preparations

a) This measurement provides the number of successful intra-gNB conditional handover preparations received by the source NRCellCU, for a split gNB deployment.

b) CC

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP receives a UE CONTEXT MODIFICATION RESPONSE message (see TS 38.473 [6] clause 8.3.4) from gNB-DU to initiate a successful intra-gNB conditional handover.

d) A single integer value.

e) MM.ChoPrepIntraSucc

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurement is for performance assurance.

###### 5.1.3.7.1.5 Number of requested DAPS handover preparations

a) This measurement provides the number of outgoing intra-gNB DAPS handover preparations requested by the source NRCellCU for a split gNB deployment.

b) CC.

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP is sending a UE CONTEXT MODIFICATION REQUEST message (see TS 38.473 [6] clause 8.3.4) to gNB-DU to request resources for an intra-gNB DAPS handover.

d) A single integer value.

e) MM.DapsHoPrepIntraReq

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurement is for performance assurance.

###### 5.1.3.7.1.6 Number of successful DAPS handover preparations

a) This measurement provides the number of successful intra-gNB DAPS handover preparations received by the source NRCellCU, for a split gNB deployment.

b) CC

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP receives a UE CONTEXT MODIFICATION RESPONSE message (see TS 38.473 [6] clause 8.3.4) from gNB-DU to initiate a successful intra-gNB DAPS handover.

d) A single integer value.

e) MM.DapsHoPrepIntraSucc

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurement is for performance assurance.

###### 5.1.3.7.1.7 Number of UEs for which conditional handover preparations are requested

a) This measurement provides the number of UEs for which outgoing intra-gNB conditional handover preparations are requested by the source NRCellCU for a split gNB deployment.

b) CC.

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP is sending a UE CONTEXT MODIFICATION REQUEST message (see TS 38.473 [6] clause 8.3.4) to gNB-DU to request resources for an intra-gNB conditional handover. The counter is incremented by 1 for each UE, even if UE CONTEXT MODIFICATION REQUEST messages were sent for several cells.

d) A single integer value.

e) MM.ChoPrepIntraReqUes

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurement is for performance assurance.

###### 5.1.3.7.1.8 Number of UEs for which conditional handover preparations are successful

a) This measurement provides the number of UEs for which intra-gNB conditional handover preparations received by the source NRCellCU are successful, for a split gNB deployment.

b) CC

c) For split gNB deployment the measurement is triggered and stepped by 1 when gNB-CUCP receives a UE CONTEXT MODIFICATION RESPONSE message (see TS 38.473 [6] clause 8.3.4) from gNB-DU to initiate a successful intra-gNB conditional handover. The counter is incremented by 1 for each UE, even if UE CONTEXT MODIFICATION RESPONSE messages were received for several cells.

d) A single integer value.

e) MM.ChoPrepIntraSuccUes

f) NRCellCU

g) Valid for packet switched traffic.

h) 5GS

i) One usage of this performance measurement is for performance assurance.

#### 5.1.3.8 Void

#### 5.1.3.9 Void

## 5.2 Performance measurements for AMF

### 5.2.1 Registered subscribers measurement

#### 5.2.1.1 Mean number of registered subscribers

a) This measurement provides the mean number of registered state subscribers per AMF

b) SI

c) This measurement is obtained by sampling at a pre-defined interval the number of registered subscribers in an AMF and then taking the arithmetic mean. The measurement can be split into subcounters per S-NSSAI.

d) A single integer value

e) RM.RegisteredSubNbrMean.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI

f) AMFFunction

g) Valid for packet switching

h) 5GS

#### 5.2.1.2 Maximum number of registered subscribers

a) This measurement provides the maximum number of registered state subscribers per AMF

b) SI

c) This measurement is obtained by sampling at a pre-defined interval the number of registered subscribers in an AMF and then taking the maximum. The measurement can be split into subcounters per S-NSSAI.

d) A single integer value

e) RM.RegisteredSubNbrMax.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI

f) AMFFunction

g) Valid for packet switching

h) 5GS

### 5.2.2 Registration procedure related measurements

#### 5.2.2.1 Number of initial registration requests

a) This measurement provides the number of initial registration requests received by the AMF.

b) CC

c) On receipt by the AMF from the UE of Registration Request with the registration type indicating an initial registration (see clause 4.2.2.2.2 of TS 23.502 [7]). Each initial registration request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegInitReq.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.2 Number of successful initial registrations

a) This measurement provides the number of successful initial registrations at the AMF.

b) CC

c) On transmission of Registration Accept by the AMF to the UE that sent the initial registration request (see TS 23.502 [7]). Each accepted initial registration is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegInitSucc.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.3 Number of mobility registration update requests

a) This measurement provides the number of mobility registration update requests received by the AMF.

b) CC

c) On receipt by the AMF from the UE of Registration Request with the registration type indicating a Mobility Registration Update (see clause 4.2.2.2.2 of TS 23.502 [7]). Each mobility registration update request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegMobReq.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.4 Number of successful mobility registration updates

a) This measurement provides the number of successful mobility registration updates at the AMF.

b) CC

c) On transmission of Registration Accept by the AMF to the UE that sent the mobility registration update request (see TS 23.502 [7]). Each accepted mobility registration update is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegMobSucc.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.5 Number of periodic registration update requests

a) This measurement provides the number of periodic registration update requests received by the AMF.

b) CC

c) On receipt by the AMF from the UE of Registration Request with the registration type indicating a Periodic Registration Update (see clause 4.2.2.2.2 of TS 23.502 [7]). Each periodic registration update request is added to the relevant subcounter S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegPeriodReq.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.6 Number of successful periodic registration updates

a) This measurement provides the number of successful mobility registration updates at the AMF.

b) CC

c) On transmission of Registration Accept by the AMF to the UE that sent the periodic registration update request (see TS 23.502 [7]). Each accepted periodic registration update is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegPeriodSucc.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.7 Number of emergency registration requests

a) This measurement provides the number of emergency registration requests received by the AMF.

b) CC

c) On receipt by the AMF from the UE of Registration Request with the registration type indicating an Emergency Registration (see clause 4.2.2.2.2 of TS 23.502 [7]). Each emergency registration request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegEmergReq.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.8 Number of successful emergency registrations

a) This measurement provides the number of successful emergency registrations at the AMF.

b) CC

c) On transmission Registration Accept by the AMF to the UE that sent the emergency registration request (see TS 23.502 [7]). Each accepted emergency registration is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) RM.RegEmergSucc.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.2.9 Mean time of Registration procedure

a) This measurement provides the mean time of registration procedure during each granularity period. The measurement is split into subcounters per S-NSSAI per registration type.

b) DER(n=1)

c) This measurement is obtained by accumulating the time interval for every successful registration procedure per S-NSSAI per registration type between the receipt by the AMF from the UE of a " REGISTRATION REQUEST " and the sending of a " REGISTRATION ACCEPT " message to the UE over a granularity period using DER. The end value of this time will then be divided by the number of successful registration procedures observed in the granularity period to give the arithmetic mean, the accumulator shall be reinitialised at the beginning of each granularity period. The measurement is split into subcounters per registration type, see TS 24.501 [24].

d) Each measurement is an integer value.(in milliseconds)

e) RM.RegTimeMean.*SNSSAI.* InitialReg
RM.RegTimeMean.*SNSSAI.* MobilityRegUpdate
RM.RegTimeMean.*SNSSAI.* PeriodicRegUpdate
RM.RegTimeMean.*SNSSAI.* EmergencyReg

Where SNSSAI identifies the S-NSSAI, InitialReg identifies the registration type "Initial Registration ", MobilityRegUpdate identifies the registration type "Mobility Registration Update", PeriodicRegUpdate identifies the registration type "Periodic Registration Update", EmergencyReg identifies the registration type "Emergency Registration".

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the mean time of registration procedure during the granularity period.

#### 5.2.2.10 Max time of Registration procedure

a) This measurement provides the max time of registration procedure during each granularity period. The measurement is split into subcounters per S-NSSAI per registration type.

b) DER(n=1)

c) This measurement is obtained by monitoring the time interval for every successful registration procedure per S-NSSAI per registration type between the receipt by the AMF from the UE of a " REGISTRATION REQUEST " and the sending of a " REGISTRATION ACCEPT " message to the UE over a granularity period using DER. The high tide mark of this time will be stored in a gauge, the gauge shall be reinitialised at the beginning of each granularity period. The measurement is split into subcounters per registration type, see TS 24.501 [24].

d) Each measurement is an integer value.(in milliseconds)

e) RM.RegTimeMax.*SNSSAI.* InitialReg
RM.RegTimeMax.*SNSSAI.* MobilityRegUpdateRM.RegTimeMax.*SNSSAI.* PeriodicRegUpdateRM.RegTimeMax.*SNSSAI.* EmergencyReg

f) Where SNSSAI identifies the S-NSSAI, InitialRegidentifies the registration type "Initial Registration ", MobilityRegUpdate identifies the registration type "Mobility Registration Update", PeriodicRegUpdate identifies the registration type "Periodic Registration Update", EmergencyReg identifies the registration type "Emergency Registration".

g) AMFFunction

h) Valid for packet switched traffic

i) 5GS

j) One usage of this measurement is for monitoring the max time of registration procedure during the granularity period.

### 5.2.3 Service Request procedure related measurements

#### 5.2.3.1 Number of attempted network initiated service requests

a) This measurement provides the number of attempted network initiated service requests.

b) CC.

c) Receipt of Namf\_Communication\_N1N2MessageTransfer indicating a network initiated service request from SMF or another NF by the AMF (see TS 23.502 [7]).

d) An integer value.

e) MM.ServiceReqNetInitAtt.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.3.2 Number of successful network initiated service requests

a) This measurement provides the number of successful network initiated service requests.

b) CC.

c) Transmission of N2 request that contains "MM NAS Service Accept" by the AMF to (R)AN (see TS 23.502 [7]), corresponding to the received Namf\_Communication\_N1N2MessageTransfer that indicated a network initiated service request.

d) An integer value.

e) MM.ServiceReqNetInitSucc.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.3.3 Total number of attempted service requests (including both network initiated and UE initiated)

a) This measurement provides the total number of the attempted service requests, including both network initiated and UE initiated service requests.

b) CC.

c) Receipt of Service Request by the AMF from (R)AN (see TS 23.502 [7]).

d) An integer value.

e) MM.ServiceReqTotalAtt.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.3.4 Total number of successful service requests (including both network initiated and UE initiated)

a) This measurement provides the total number of the successful service requests, including both network initiated and UE initiated service requests.

b) CC.

c) Transmission of N2 request that contains "MM NAS Service Accept" by the AMF to (R)AN (see TS 23.502 [7]).

d) An integer value.

e) MM.ServiceReqTotalSucc.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.2.4 Measurements related to registration via untrusted non-3GPP access

#### 5.2.4.1 Number of initial registration requests via untrusted non-3GPP access

a) This measurement provides the number of initial registration requests via untrusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from N3IWF of an N2 message that contains Registration Request with the registration type indicating an initial registration (see clause 4.12.2.2 of TS 23.502 [7]). Each initial registration request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegInitReqNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.4.2 Number of successful initial registrations via untrusted non-3GPP access

a) This measurement provides the number of successful initial registrations via untrusted non-3GPP access at the AMF.

b) CC.

c) Transmission by the AMF to N3IWF of an N2 message that contains Registration Accept corresponding to an initial registration request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted initial registration is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegInitSuccNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.4.3 Number of mobility registration update requests via untrusted non-3GPP access

a) This measurement provides the number of mobility registration update requests via untrusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from N3IWF of an N2 message that contains Registration Request with the registration type indicating a Mobility Registration Update (see clause 4.12.2.2 of TS 23.502 [7]). Each mobility registration update request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegMobReqNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.4.4 Number of successful mobility registration updates via untrusted non-3GPP access

a) This measurement provides the number of successful mobility registration updates via untrusted non-3GPP access at the AMF.

b) CC.

c) Transmission by the AMF to N3IWF of an N2 message that contains Registration Accept corresponding to a mobility registration update request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted mobility registration update is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegMobSuccNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.4.5 Number of periodic registration update requests via untrusted non-3GPP access

a) This measurement provides the number of periodic registration update requests via untrusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from N3IWF of an N2 message that contains Registration Request with the registration type indicating a Periodic Registration Update (see clause 4.12.2.2 of TS 23.502 [7]). Each periodic registration update request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegPeriodReqNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.4.6 Number of successful periodic registration updates via untrusted non-3GPP access

a) This measurement provides the number of successful mobility registration updates via untrusted non-3GPP access at the AMF.

b) CC.

c) Transmission by the AMF to N3IWF of an N2 message that contains Registration Accept corresponding to a periodic registration update request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted periodic registration update is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegPeriodSuccNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.4.7 Number of emergency registration requests via untrusted non-3GPP access

a) This measurement provides the number of emergency registration requests via untrusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from N3IWF of an N2 message that contains Registration Request with the registration type indicating an Emergency Registration (see clause 4.2.2.2.2 of TS 23.502 [7]). Each emergency registration request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegEmergReqNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.4.8 Number of successful emergency registrations via untrusted non-3GPP access

a) This measurement provides the number of successful emergency registrations via untrusted non-3GPP access Transmission by the AMF to N3IWF of an N2 message that contains Registration Accept corresponding to at the AMF.

b) CC.

c) Transmission by the AMF to N3IWF of an N2 message that contains Registration Accept corresponding to an emergency registration request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted emergency registration is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value.

e) RM.RegEmergSuccNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.2.5 Mobility related measurements

#### 5.2.5.1 Inter-AMF handovers

##### 5.2.5.1.1 Number of PDU sessions requested for inter-AMF incoming handovers

a) This measurement provides the number of PDU sessions requested for the inter-AMF incoming handovers received by target AMF. This measurement is split into subcounters per S-NSSAI.

b) CC.

c) Receipt by the target AMF from source AMF of Namf\_Communication\_CreateUEContext Request (see clause 4.9.1.3 of TS 23.502 [7]). Each PDU session requested in the Namf\_Communication\_CreateUEContext Request (see TS 29.518 [21]) increments the relevant subcounter per S-NSSAI by 1.

d) Each measurement is an integer value.

e) MM.NbrPDUReqInterAMFHOInc.*SNSSAI.*

 Where the *SNSSAI* identifies theS-NSSAI.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.2.5.1.2 Number of PDU sessions failed to setup for inter-AMF incoming handovers

a) This measurement provides the number of PDU sessions failed to setup for inter-AMF incoming handover requests by target AMF. This measurement is split into subcounters per S-NSSAI and subcounters per failure cause.

b) CC.

c) Transmission by the target AMF to the source AMF of Namf\_Communication\_CreateUEContext Response (see clause 4.9.1.3 of TS 23.502 [7]) that contains the PDU Sessions failed to be setup list (including List Of PDU Sessions failed to be setup received from target RAN and the Non-accepted PDU session List generated by the T-AMF). Each PDU session failed to setup increments the relevant subcounter per S-NSSAI and the relevant subcounter per failure cause by 1 respectively.

d) Each measurement is an integer value.

e) MM.NbrPDUFailInterAMFHOInc.*SNSSAI,*MM.NbrPDUFailInterAMFHOInc.*cause,*

 Where the *SNSSAI* identifies theS-NSSAI, and *cause* identifies thefailure cause (Encoding of the Cause is defined in clause 9.3.1.2 of TS 38.413 [11]).

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.2.5.1.3 Number of QoS flows requested for inter-AMF incoming handovers

a) This measurement provides the number of QoS flows requested for inter-AMF incoming handover requests by target AMF. This measurement is split into subcounters per S-NSSAI and subcounters per 5QI.

b) CC.

c) Receipt by the target AMF from source AMF of Namf\_Communication\_CreateUEContext Request (see clause 4.9.1.3 of TS 23.502 [7]). Each QoS flow requested in the Namf\_Communication\_CreateUEContext Request (see TS 29.518 [21]) increments the relevant subcounter per S-NSSAI and the relevant subcounter per 5QI by 1 respectively.

d) Each measurement is an integer value.

e) MM.NbrQoSFlowReqInterAMFHOInc.*SNSSAI,* MM.NbrQoSFlowReqInterAMFHOInc.*5QI,*

 Where the *SNSSAI* identifies theS-NSSAI, and *5QI* identifies the5QI.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.2.5.1.4 Number of QoS flows failed to setup for inter-AMF incoming handovers

a) This measurement provides the number of PDU sessions failed to setup for inter-AMF incoming handover requests by target AMF. This measurement is split into subcounters per S-NSSAI, subcounters per 5QI, and subcounters per failure cause.

b) CC.

c) Transmission by the target AMF to the source AMF of Namf\_Communication\_CreateUEContext Response (see clause 4.9.1.3 of TS 23.502 [7]) that includes 1) the PDU Sessions failed to be setup list (including List Of PDU Sessions failed to be setup received from target RAN and the Non-accepted PDU session List generated by the T-AMF) and/or 2) the PDU sessions successfully setup but with the QoS flow failed to setup List. Each QoS flow corresponding to the PDU Session failed to be setup, or in the QoS flow failed to setup List of the PDU sessions successfully setup increments the relevant subcounter per S-NSSAI, the subcounter per 5QI and the subcounter per failure cause by 1 respectively.

d) Each measurement is an integer value.

e) MM.NbrQoSFlowFailInterAMFHOInc.*SNSSAI,*MM.NbrQoSFlowFailInterAMFHOInc.*5QI,*MM.NbrQoSFlowFailInterAMFHOInc.*cause,*

 Where the *SNSSAI* identifies theS-NSSAI, *5QI* identifies the5QI and *cause* identifies thefailure cause (Encoding of the Cause is defined in clause 9.3.1.2 of TS 38.413 [11]).

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.5.2 Measurements for 5G paging

##### 5.2.5.2.1 Number of 5G paging procedures

a) This measurement provides the number of 5G paging procedures initiated at the AMF. The initial paging procedures as well as the repeated paging procedures are counted.

b) CC.

c) Incremented when a 5G paging request is sent i.e. at the transmission of the first paging request (TS 23.502 [16] and TS 24.501 [24]).

d) A single integer value.

e) MM.Paging5GReq

f) AMFFunction

g) Valid for packet switching.

h) 5GS.

##### 5.2.5.2.2 Number of successful 5G paging procedures

a) This measurement provides the number of successful 5G paging procedures initiated at the AMF. The initial paging procedures as well as the repeated paging procedures are counted.

b) CC.

c) When a service request from UE that with service type value equal "mobile terminated service" is received at the AMF (see TS 23.502 [7] and TS 24.501 [24]), the AMF increments the count by 1.

d) A single integer value.

e) MM.Paging5GSucc

f) AMFFunction

g) Valid for packet switching.

h) 5GS.

#### 5.2.5.3 Handovers from 5GS to EPS

##### 5.2.5.3.1 Number of attempted handovers from 5GS to EPS via N26 interface

a) This measurement provides the number of attempted handovers from 5GS to EPS via N26 interface.

b) CC.

c) Transmission by the AMF to the MME of a Forward Relocation Request message (see clause 4.11.1.2.1 of TS 23.502 [7]) indicating the handover request from 5GS to EPS.

d) Each measurement is an integer value.

e) MM.HoOut5gsToEpsN26Att*.*

f) EP\_N26 (contained by AMFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.2.5.3.2 Number of successful handovers from 5GS to EPS via N26 interface

a) This measurement provides the number of successful handovers from 5GS to EPS via N26 interface.

b) CC.

c) Transmission by the AMF to the MME of a Forward Relocation Complete Notification message (see TS 29.274 [27]) indicating a successful handover from 5GS to EPS.

d) Each measurement is an integer value.

e) MM.HoOut5gsToEpsN26Succ*.*

f) EP\_N26 (contained by AMFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.2.5.3.3 Number of failed handovers from 5GS to EPS via N26 interface

a) This measurement provides the number of failed handovers from 5GS to EPS via N26 interface. This measurement is split into subcounters per failure cause.

b) CC.

c) Receipt by the AMF from the MME of a Forward Relocation Response message (see TS 29.274 [27]) indicating a failed handover from 5GS to EPS. Each received Forward Relocation Response message increments the relevant subcounter per failure cause by 1, and failure cases are specified in TS 29.274 [27].

d) Each measurement is an integer value.

e) MM.HoOut5gsToEpsN26Fail*.cause*where *cause* identifies the failure cause (see TS 29.274 [27])

f) EP\_N26 (contained by AMFFunction).

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.5.4 Handovers from EPS to 5GS

##### 5.2.5.4.1 Number of attempted handovers from EPS to 5GS via N26 interface

a) This measurement provides the number of attempted handovers from EPS to 5GS via N26 interface.

b) CC.

c) Receipt by the AMF from the MME of a Forward Relocation Request message (see clause 4.11.1.2.1 of TS 23.502 [7]) indicating the handover request from EPS to 5GS.

d) Each measurement is an integer value.

e) MM.HoIncEpsTo5gsN26Att*.*

f) EP\_N26 (contained by AMFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.2.5.4.2 Number of successful handovers from EPS to 5GS via N26 interface

a) This measurement provides the number of successful handovers from EPS to 5GS via N26 interface.

b) CC.

c) Receipt by the AMF from the MME of Forward Relocation Complete Notification message (see TS 29.274 [27]) indicating a successful handover from EPS to 5GS.

d) Each measurement is an integer value.

e) MM.HoIncEpsTo5gsN26Succ*.*

f) EP\_N26 (contained by AMFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.2.5.4.3 Number of failed handovers from EPS to 5GS via N26 interface

a) This measurement provides the number of failed handovers from EPS to 5GS via N26 interface. This measurement is split into subcounters per failure cause.

b) CC.

c) Transmission by the AMF to the MME of a Forward Relocation Response message (see TS 29.274 [27]) indicating a failed handover from EPS to 5GS. Each transmitted Forward Relocation Response message increments the relevant subcounter per failure cause by 1, and failure cases are specified in TS 29.274 [27].

d) Each measurement is an integer value.

e) MM.HoIncEpsTo5gsN26Fail*.cause*where *cause* identifies the failure cause (see TS 29.274 [27])

f) EP\_N26 (contained by AMFFunction).

g) Valid for packet switched traffic.

h) 5GS.

### 5.2.6 Measurements related to Service Requests via Untrusted non-3GPP Access

#### 5.2.6.1 Number of attempted service requests via Untrusted non-3GPP Access

a) This measurement provides the number of attempted service requests via Untrusted non-3GPP Access.

b) CC.

c) Receipt of an N2 Message indicating the Service Request by the AMF from N3IWF (see TS 23.502 [7]).

d) An integer value.

e) MM.ServiceReqNon3GPPAtt.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.6.2 Number of successful service requests via Untrusted non-3GPP Access

a) This measurement provides the number of successful service requests via Untrusted non-3GPP Access.

b) CC

c) Transmission of N2 request that contains "MM NAS Service Accept" by the AMF to N3IWF (see TS 23.502 [7]).

d) An integer value.

e) MM.ServiceReqNon3GPPSucc.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.2.7 Measurements related to SMS over NAS

#### 5.2.7.1 Registration of SMS over NAS

##### 5.2.7.1.1 Number of registration requests for SMS over NAS via 3GPP access

a) This measurement provides the number of registration requests for SMS over NAS received by the AF from UEs via 3GPP access.

b) CC

c) Receipt of a Registration Request message containing the "SMS supported" indication indicating that the UE supports SMS delivery over NAS by the AMF from UE via 3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasReg3GPPReq

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.1.2 Number of successful registrations allowed for SMS over NAS via 3GPP access

a) This measurement provides the number of successful registrations allowed for SMS over NAS sent by the AF to UEs via 3GPP access.

b) CC

c) Transmission of a Registration Accept message containing the "SMS allowed" indication by the AMF to UE via 3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasReg3GPPSucc

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.1.3 Number of registration requests for SMS over NAS via non-3GPP access

a) This measurement provides the number of registration requests for SMS over NAS received by the AF from UEs via non-3GPP access.

b) CC

c) Receipt of a Registration Request message containing the "SMS supported" indication indicating that the UE supports SMS delivery over NAS by the AMF from UE via non-3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasRegNon3GPPReq

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.1.4 Number of successful registrations allowed for SMS over NAS via non-3GPP access

a) This measurement provides the number of successful registrations allowed for SMS over NAS sent by the AF to UEs via non-3GPP access.

b) CC

c) Transmission of a Registration Accept message containing the "SMS allowed" indication by the AMF to UE via non-3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasRegNon3GPPSucc

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.2.7.2 MO SMS over NAS

##### 5.2.7.2.1 Number of attempted MO SMS messages over NAS via 3GPP access

a) This measurement provides the number of NAS messages encapsulating the SMS messages received by the AF from UEs via 3GPP access.

b) CC

c) Receipt of an NAS message with an indication of SMS transportation by the AMF from UE via 3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMo3GPPReq

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.2.2 Number of MO SMS messages successfully transported over NAS via 3GPP access

a) This measurement provides the number of MO SMS messages successfully transported over NAS via 3GPP access.

b) CC

c) Transmission, by the AMF to UE via 3GPP access, of an NAS message that contains the "submit report" indicating the MO SMS message has been successfully delivered (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMo3GPPSucc

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.2.3 Number of attempted MO SMS messages over NAS via non-3GPP access

a) This measurement provides the number of NAS messages encapsulating the SMS messages received by the AF from UEs via non-3GPP access.

b) CC

c) Receipt of an NAS message with an indication of SMS transportation by the AMF from UE via non-3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMoNon3GPPReq

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.2.4 Number of MO SMS messages successfully transported over NAS via non-3GPP access

a) This measurement provides the number of MO SMS messages successfully transported over NAS via non-3GPP access.

b) CC

c) Transmission, by the AMF to UE via non-3GPP access, of an NAS message that contains the "submit report" indicating the MO SMS message has been successfully submitted (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMoNon3GPPSucc

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.2.7.3 MT SMS over NAS

##### 5.2.7.3.1 Number of attempted MT SMS messages over NAS via 3GPP access

a) This measurement provides the number of NAS messages encapsulating the SMS messages sent by the AF to UEs via 3GPP access.

b) CC

c) Transmission of an NAS message with an indication of SMS transportation by the AMF to UE via 3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMt3GPPReq

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.3.2 Number of MT SMS messages successfully transported over NAS via 3GPP access

a) This measurement provides the number of MT SMS messages successfully transported over NAS via 3GPP access.

b) CC

c) Receipt, by the AMF from UE via 3GPP access, of an NAS message that contains the "delivery report" indicating the MT SMS message has been successfully delivered (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMt3GPPSucc

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.3.3 Number of attempted MT SMS messages over NAS via non-3GPP access

a) This measurement provides the number of NAS messages encapsulating the SMS messages sent by the AF to UEs via non-3GPP access.

b) CC

c) Transmission of an NAS message with an indication of SMS transportation by the AMF to UE via non-3GPP access (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMtNon3GPPReq

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.2.7.3.4 Number of MT SMS messages successfully transported over NAS via non-3GPP access

a) This measurement provides the number of MT SMS messages successfully transported over NAS via non-3GPP access.

b) CC

c) Receipt, by the AMF from UE via non-3GPP access, of an NAS message that contains the "delivery report" indicating the MT SMS message has been successfully delivered (see TS 23.502 [7]).

d) An integer value

e) SMS.SmsOverNasMtNon3GPPSucc

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

### 5.2.8 UE Configuration Update procedure related measurements

#### 5.2.8.1 Number of UE Configuration Update

a) This measurement provides the number of UE Configuration Update requested by the AMF.

b) CC

c) On transmission of Configuration Update Command from the AMF to UE (see TS 23.502 [7]).

d) Each counter is an integer value

e) MM.ConfUpdate

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.2.8.2 Number of successful UE Configuration Update

a) This measurement provides the number of UE Configuration Update successfully completed by the UE.

b) CC

c) On receipt by the AMF from the UE of Configuration Update Complete (see TS 23.502 [7]).

NOTE: Configuration Update Complete shall be requested for all parameters included in Configuration Update Command except when only NITZ is included.

d) Each counter is an integer value

e) MM.ConfUpdateSucc

f) AMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

### 5.2.9 Measurements related to registration via trusted non-3GPP access

#### 5.2.9.1 Number of initial registration requests via trusted non-3GPP access

a) This measurement provides the number of initial registration requests via trusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from TNGF of an N2 message that contains Registration Request with the registration type indicating an initial registration (see clause 4.12.2.2 of TS 23.502 [7]). Each initial registration request is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegInitReqTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.9.2 Number of successful initial registrations via trusted non-3GPP access

a) This measurement provides the number of successful initial registrations via trusted non-3GPP access at the AMF.

b) CC.

c) Transmission by the AMF to TNGF of an N2 message that contains Registration Accept corresponding to an initial registration request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted initial registration is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegInitSuccTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.9.3 Number of mobility registration update requests via trusted non-3GPP access

a) This measurement provides the number of mobility registration update requests via trusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from TNGF of an N2 message that contains Registration Request with the registration type indicating a Mobility Registration Update (see clause 4.12.2.2 of TS 23.502 [7]). Each mobility registration update request is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegMobReqTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.9.4 Number of successful mobility registration updates via trusted non-3GPP access

a) This measurement provides the number of successful mobility registration updates via trusted non-3GPP access at the AMF.

b) CC.

c) Transmission by the AMF to TNGF of an N2 message that contains Registration Accept corresponding to a mobility registration update request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted mobility registration update is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegMobSuccTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.9.5 Number of periodic registration update requests via trusted non-3GPP access

a) This measurement provides the number of periodic registration update requests via trusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from TNGF of an N2 message that contains Registration Request with the registration type indicating a Periodic Registration Update (see clause 4.12.2.2 of TS 23.502 [7]). Each periodic registration update request is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegPeriodReqTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.9.6 Number of successful periodic registration updates via trusted non-3GPP access

a) This measurement provides the number of successful mobility registration updates via trusted non-3GPP access at the AMF.

b) CC.

c) Transmission by the AMF to TNGF of an N2 message that contains Registration Accept corresponding to a periodic registration update request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted periodic registration update is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegPeriodSuccTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.9.7 Number of emergency registration requests via trusted non-3GPP access

a) This measurement provides the number of emergency registration requests via trusted non-3GPP access received by the AMF.

b) CC.

c) Receipt by the AMF from TNGF of an N2 message that contains Registration Request with the registration type indicating an Emergency Registration (see clause 4.2.2.2.2 of TS 23.502 [7]). Each emergency registration request is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegEmergReqTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.9.8 Number of successful emergency registrations via trusted non-3GPP access

a) This measurement provides the number of successful emergency registrations via trusted non-3GPP access at the AMF.

b) CC.

c) Transmission by the AMF to TNGF of an N2 message that contains Registration Accept corresponding to an emergency registration request (see clause 4.12.2.2 of TS 23.502 [7]). Each accepted emergency registration is added to the relevant subcounter per network slice identifier (S-NSSAI).

d) Each subcounter is an integer value.

e) RM.RegEmergSuccTrustNon3GPP.*SNSSAI.*

 Where *SNSSAI* identifies the network slice;

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.2.10 Measurements related to Service Requests via trusted non-3GPP Access

#### 5.2.10.1 Number of attempted service requests via trusted non-3GPP Access

a) This measurement provides the number of attempted service requests via trusted non-3GPP Access.

b) CC.

c) Receipt of an N2 Message indicating the Service Request by the AMF from TNGF (see TS 23.502 [7]).

d) An integer value.

e) MM.ServiceReqTrustNon3GPPAtt.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.2.10.2 Number of successful service requests via trusted non-3GPP Access

a) This measurement provides the number of successful service requests via trusted non-3GPP Access.

b) CC

c) Transmission of N2 request that contains "MM NAS Service Accept" by the AMF to TNGF (see TS 23.502 [7]).

d) An integer value.

e) MM.ServiceReqTrustNon3GPPSucc.

f) AMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.2.11 Authentication procedure related measurements

#### 5.2.11.1 Number of authentication requests

a) This measurement provides the number of authentication requests.

b) SI

c) AMF sends a NAS message Authentication -Request to the UE (see clause 6.1.3.2 in TS 33.501 [36]) to UE.

d) A single integer value

e) AMF.AuthReq

f) AMFFunction

g) Valid for packet switching

h) 5GS

#### 5.2.11.2 Number of failed authentications due to parameter error

a) This measurement provides the number of UE sends the authentication failure message to AMF when detects error authentication parameter contained in the authentication request. b) SI

c) AMF receives a NAS message Authentication Response (see clause 6.1.3.2 in TS 33.501 [36]) sent by UE, indicating UE authentication failure. The measurement is optionally split into subcounters with a CAUSE value indicating the reason for failure. The CAUSE value may be 20, 21, 26.

d) A single integer value

e) AMF.AuthFail
AMF.AuthFail.20
AMF.AuthFail.21
AMF.AuthFail.26

f) AMFFunction

g) Valid for packet switching

h) 5GS

#### 5.2.11.3 Number of authentication rejection

a) This measurement provides the number of authentication rejection.

b) SI

c) AMF sends a NAS message Authentication Reject to the UE (see clause 6.1.3.2 in TS 33.501 [36]) to UE.

d) A single integer value

e) AMF.AuthReject

f) AMFFunction

g) Valid for packet switching

h) 5GS

## 5.3 Performance measurements for SMF

### 5.3.1 Session Management

#### 5.3.1.1 Number of PDU sessions (Mean)

1. a) This measurement provides the mean number of PDU sessions.
2. b) SI
3. c) The measurement is obtained by sampling at a pre-defined interval, the number of PDU sessions established by SMF, and then taking the arithmetic mean. The measurement is optionally split into subcounters per S-NSSAI.
4. d) A single integer value
5. e) SM.SessionNbrMean.*SNSSAI*Where *SNSSAI* identifies the S-NSSAI
6. f) SMFFunction
7. g) Valid for packet switched traffic
8. h) 5GS

#### 5.3.1.2 Number of PDU sessions (Maximum)

a) This measurement provides the max number of PDU sessions.

b) SI

c) The measurement is obtained by sampling at a pre-defined interval, the number of PDU sessions established by SMF, and then selecting the maximum value. The measurement is optionally split into subcounters per S-NSSAI.

d) A single integer value

e) SM.SessionNbrMax.*SNSSAI*
Where *SNSSAI* identifies the S-NSSAI

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.3.1.3 Number of PDU session creation requests

a) This measurement provides the number of PDU sessions requested to be created by the SMF.

b) CC

c) On receipt by the SMF from AMF of Nsmf\_PDUSession\_CreateSMContext Request (see TS 23.502 [7]). Each PDU session requested to be created is added to the relevant subcounter per S-NSSAI and the relevant subcounter per request type.

d) Each subcounter is an integer value

e) SM.PduSessionCreationReq.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

 SM.PduSessionCreationReq*ReqType*.

 Where*ReqType* indicates the request type (e.g., initial request, initial emergency request) cause for the PDU session.

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.3.1.4 Number of successful PDU session creations

a) This measurement provides the number of PDU sessions successfully created by the SMF.

b) CC

c) On transmission by the SMF to AMF of Nsmf\_PDUSession\_CreateSMContext Response that indicates a successful PDU session creation (see TS 23.502 [7]). Each PDU session successfully created is added to the relevant subcounter per S-NSSAI and the relevant subcounter per request type.

d) Each subcounter is an integer value

e) SM.PduSessionCreationSucc.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

 SM.PduSessionCreationSucc*ReqType*.

 Where*ReqType* indicates the request type (e.g., initial request, initial emergency request) cause for the PDU session.

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.3.1.5 Number of failed PDU session creations

a) This measurement provides the number of PDU sessions failed to be created by the SMF.

b) CC

c) On transmission by the SMF to AMF of Nsmf\_PDUSession\_CreateSMContext Response that indicates a rejected PDU session creation (see TS 23.502 [7]). Each PDU session rejected to be created is added to the relevant subcounter per rejection cause.

d) Each subcounter is an integer value

e) SM.PduSessionCreationFail.*cause*

 Where *cause* indicates the rejection cause for the PDU session.

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.3.1.6 PDU session modifications

##### 5.3.1.6.1 Number of requested PDU session modifications (UE initiated)

a) This measurement provides the number of PDU session modification requests (initiated by UE) received by the SMF.

b) CC.

c) On receipt of Nsmf\_PDUSession\_UpdateSMContext Request which includes the N1 SM container IE indicating the "PDU Session Modification Request" (see TS 23.502 [7]) by the SMF from AMF.

d) A single integer value.

e) SM.PduSessionModUeInitReq.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.1.6.2 Number of successful PDU session modifications (UE initiated)

a) This measurement provides the number of successful PDU session modifications (initiated by UE) acknowledged by the SMF.

b) CC.

c) On transmission of Nsmf\_PDUSession\_UpdateSMContext Response indicating a successful PDU session modification by the SMF to AMF as reply to a smf\_PDUSession\_UpdateSMContext Request that includes the N1 SM container IE indicating the "PDU Session Modification Complete" (see TS 23.502 [7]) for a PDU session modification request (initiated by the UE).

d) A single integer value.

e) SM.PduSessionModUeInitSucc.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.1.6.3 Number of failed PDU session modifications (UE initiated)

a) This measurement provides the number of failed PDU session modifications (initiated by UE) responded by the SMF. This measurement is split into subcounters per failure cause.

b) CC.

c) On transmission of Nsmf\_PDUSession\_UpdateSMContext Response indicating a failed PDU session modification by the SMF to AMF (see TS 23.502 [7]) for a PDU session modification request (initiated by the UE). Each transmitted Nsmf\_PDUSession\_UpdateSMContext Response indicating the failed PDU session modification triggers the relevant subcounter per failure cause (see the causes listed in table 6.1.3.3.4.2.2-2 of TS 29.502 [14]) to increment by 1.

d) A single integer value.

e) SM.PduSessionModUeInitFail.*Cause.*

 Where *Cause* identifies the cause of the PDU session modification failure. Encoding of the Cause is defined in in table 6.1.3.3.4.2.2-2 of TS 29.502 [14].

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.1.6.4 Number of requested PDU session modifications (SMF initiated)

a) This measurement provides the number of PDU session modification requests (initiated by SMF) sent by the SMF to AMF.

b) CC.

c) On transmission of Namf\_Communication\_N1N2MessageTransfer which includes the N2 SM information IE and N1 SM container IE indicating the "PDU Session Modification Command" (see TS 23.502 [7]) by the SMF to AMF.

d) A single integer value.

e) SM.PduSessionModSmfInitReq.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.1.6.5 Number of successful PDU session modifications (SMF initiated)

a) This measurement provides the number of successful PDU session modifications (initiated by SMF) acknowledged by the SMF.

b) CC.

c) On transmission of Nsmf\_PDUSession\_UpdateSMContext Response indicating a successful PDU session modification by the SMF to AMF as reply to a smf\_PDUSession\_UpdateSMContext Request that includes the N1 SM container IE indicating the "PDU Session Modification Complete" (see TS 23.502 [7]) for a PDU session modification request (initiated by the SMF).

d) A single integer value.

e) SM.PduSessionModSmfInitSucc.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.1.6.6 Number of failed PDU session modifications (SMF initiated)

a) This measurement provides the number of failed PDU session modifications (initiated by SMF) responded by the SMF. This measurement is split into subcounters per failure cause.

b) CC.

c) On transmission of Nsmf\_PDUSession\_UpdateSMContext Response indicating a failed PDU session modification by the SMF to AMF (see TS 23.502 [7]) for a PDU session modification request (initiated by the SMF). Each transmitted Nsmf\_PDUSession\_UpdateSMContext Response indicating the failed PDU session modification triggers the relevant subcounter per failure cause (see the causes listed in table 6.1.3.3.4.2.2-2 of TS 29.502 [14]) to increment by 1.

d) A single integer value.

e) SM.PduSessionModSmfInitFail.*Cause.*

 Where *Cause* identifies the cause of the PDU session modification failure. Encoding of the Cause is defined in in table 6.1.3.3.4.2.2-2 of TS 29.502 [14].

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.3.1.7 PDU session releases

##### 5.3.1.7.1 Number of released PDU sessions (AMF initiated)

a) This measurement provides the number of released PDU sessions (initiated by AMF) at the SMF. There could be several reasons for the AMF to request release of PDU sessions, for instance the mismatch of PDU Session status between UE and AMF. This step may also be invoked due to a change of the set of network slices for a UE where a network slice instance is no longer available, as described in TS 23.501 clause 5.15.5.2.2, or the PDU Session(s) is not accepted by the T-AMF (e.g. S-NSSAI associated with the PDU Session is not available in the T-AMF). This measurement is split into subcounters per S-NSSAI and subcounters per cause.

b) CC.

c) On transmission of Nsmf\_PDUSession\_ReleaseSMContext Response indicating a successful PDU session release from the SMF to AMF, as a reply to the received Nsmf\_PDUSession\_ReleaseSMContext Request from the AMF (see TS 23.502 [7]). Each transmitted Nsmf\_PDUSession\_ReleaseSMContext Response triggers the relevant subcounter per S-NSSAI and the relevant subcounter per cause (the cause, ngApCause or 5GMmCauseValue as indicated in the received Nsmf\_PDUSession\_ReleaseSMContext Request, see Table 6.1.6.2.6-1 of TS 29.502 [14]) to increment by 1 respectively.

d) A single integer value.

e) SM.PduSessionRelAmfInit.*SNSSAI* andSM.PduSessionRelAmfInit.*cause.*

 Where the *SNSSAI* identifies theS-NSSAI; and the *cause* identifies thecause, ngApCause or 5GMmCauseValue as indicated in the received Nsmf\_PDUSession\_ReleaseSMContext Request, see Table 6.1.6.2.6-1 of TS 29.502 [14]).

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance.

#### 5.3.1.8 Number of PDU session creation requests in HR roaming scenario

a) This measurement provides the number of PDU sessions requested to be created by the H-SMF in Home-Routed roaming scenario.

b) CC

c) On receipt by the H-SMF from V-SMF of Nsmf\_PDUSession\_Create Request (see TS 23.502 [7]). Each PDU session requested to be created is added to the relevant subcounter per S-NSSAI and the relevant subcounter per request type.

d) Each subcounter is an integer value

e) SM.PduSessionCreationHRroam.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI;

SM.PduSessionCreationHRroam.*ReqType*

Where *ReqType* indicates the request type (e.g., initial request, initial emergency request) for the PDU session.

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.3.1.9 Number of successful PDU session creations in HR roaming scenario

a) This measurement provides the number of PDU sessions successfully created by the H-SMF in Home-Routed roaming scenario.

b) CC

c) On transmission by the H-SMF to V-SMF of Nsmf\_PDUSession\_Create Response that indicates a successful PDU session creation (see TS 23.502 [7]). Each PDU session successfully created is added to the relevant subcounter per S-NSSAI and the relevant subcounter per request type.

d) Each subcounter is an integer value

e) SM.PduSessionCreationHRroamSucc.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI;

SM.PduSessionCreationHRroamSucc.*ReqType*

Where *ReqType* indicates the request type (e.g., initial request, initial emergency request) for the PDU session.

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.3.1.10 Number of failed PDU session creations in HR roaming scenario

a) This measurement provides the number of PDU sessions failed to be created by the H-SMF in Home-Routed roaming scenario.

b) CC

c) On transmission by the H-SMF to V-SMF of Nsmf\_PDUSession\_Create Response that indicates a rejected PDU session creation (see TS 23.502 [7]). Each PDU session rejected to be created is added to the relevant subcounter per rejection cause.

d) Each subcounter is an integer value

e) SM.PduSessionCreationHRroamFail.*cause*

 Where *cause* indicates the rejection cause for the PDU session.

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.3.1.11 Mean time of PDU session establishment

a) This measurement provides the mean time of PDU session establishment during each granularity period. The measurement is split into subcounters per S-NSSAI.

b) DER(n=1)

c) This measurement is obtained by measuring the time interval for every successful PDU session establishment procedure per S-NSSAI between the receipt by SMF from AMF of " Nsmf\_PDUSession\_UpdateSMContext Request ", which includes N2 SM information received from (R)AN to the SMF and the sending of a " Nsmf\_PDUSession\_CreateSMContext Request or Nsmf\_PDUSession\_UpdateSMContext Request " message from AMF to the SMF over a granularity period using DER. The end value of this time will then be divided by the number of successful PDU session establishment observed in the granularity period to give the arithmetic mean, the accumulator shall be reinitialised at the beginning of each granularity period.

d) Each measurement is an integer value.(in milliseconds)

e) SM.PduSessionTimeMean.*SNSSAI*

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the mean time of registration procedure during the granularity period.

#### 5.3.1.12 Max time of PDU session establishment

a) This measurement provides the max time of PDU session establishment during each granularity period. The measurement is split into subcounters per S-NSSAI.

b) DER(n=1)

c) This measurement is obtained by measuring the time interval for every successful registration procedure per S-NSSAI per registration type between the receipt by SMF from AMF of " Nsmf\_PDUSession\_UpdateSMContext Request", which includes N2 SM information received from (R)AN to the SMF and the sending of a " Nsmf\_PDUSession\_CreateSMContext Request or Nsmf\_PDUSession\_UpdateSMContext Request PDU Session Establishment Request " message from AMF to the SMF over a granularity period using DER. The high tide mark of this time will be stored in a gauge, the gauge shall be reinitialised at the beginning of each granularity period.

d) Each measurement is an integer value.(in milliseconds)

e) SM.PduSessionTimeMax.*SNSSAI*

f) SMFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this measurement is for monitoring the max time of registration procedure during the granularity period.

### 5.3.2 QoS flow monitoring

#### 5.3.2.1 QoS flow monitoring

##### 5.3.2.1.1 Number of QoS flows requested to create

a) This measurement provides the number of QoS flows requested to create. This measurement is split into subcounters per S-NSSAI and subcounters per 5QI.

b) CC.

c) Receipt of Nsmf\_PDUSession\_UpdateSMContext Request which includes the N1 SM container IE containing the QoS flows requested to create (see TS 23.502 [7]) from AMF by the SMF; or transmission of Namf\_Communication\_N1N2MessageTransfer which includes N1 SM container IE containing the QoS flows requested to create to AMF by the SMF (see TS 23.502 [7]). Each QoS flow requested to create in the message triggers the relevant subcounter per S-NSSAI and the relevant subcounter per 5QI to increment by 1 respectively (the S-NSSAI is the S-NSSAI that the PDU session belongs to, or the new S-NSSAI if the S-NSSAI for the serving PLMN derived from the S-NSSAI of the home PLMN differs from the S-NSSAI provided in the Create SM Context Request, see clause 6.1.6.2.4 in TS 29.502 [15]).

d) Each measurement is an integer value.

e) SM.QoSflowCreateReq.*SNSSAI* andSM.QoSflowCreateReq.*5QI.*

 Where the *SNSSAI* identifies theS-NSSAI, and the *5QI* identifies the5QI.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.2.1.2 Number of QoS flows successfully created

a) This measurement provides the number of QoS flows successfully created. This measurement is split into subcounters per S-NSSAI and subcounters per 5QI.

b) CC.

c) Receipt of Nsmf\_PDUSession\_UpdateSMContext Request that includes the N2 SM information IE containing the successfully created (set up or added) QoS flows from AMF by the SMF (see TS 23.502 [7]). Each successfully created QoS flow triggers the relevant subcounter per S-NSSAI and the relevant subcounter per 5QI to increment by 1 respectively (the S-NSSAI is the S-NSSAI that the PDU session belongs to, or the new S-NSSAI if the S-NSSAI for the serving PLMN derived from the S-NSSAI of the home PLMN differs from the S-NSSAI provided in the Create SM Context Request, see clause 6.1.6.2.4 in TS 29.502 [15]).

d) Each measurement is an integer value.

e) SM.QoSflowCreateSucc.*SNSSAI* andSM.QoSflowCreateSucc.*5QI.*

 Where the *SNSSAI* identifies theS-NSSAI, and the *5QI* identifies the5QI.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.2.1.3 Number of QoS flows failed to create

a) This measurement provides the number of QoS flows failed to create. This measurement is split into subcounters per cause.

b) CC.

c) Receipt of Nsmf\_PDUSession\_UpdateSMContext Request that includes the N2 SM information IE containing the QoS flows failed to create (set up or add) from AMF by the SMF (see TS 23.502 [7]). Each QoS flow failed to create triggers the relevant subcounter per cause (see clause 9.3.1.13 in TS 38.413 [11]).

d) Each measurement is an integer value..

e) SM.QoSflowCreateFail.*cause.*

 Where the *cause* identifies thecause that resulted in the QoS flow setup failure (see clause 9.3.1.2 in TS 38.413 [11]).

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.2.1.4 Number of QoS flows requested to modify

a) This measurement provides the number of QoS flows requested to modify. This measurement is split into subcounters per S-NSSAI and subcounters per 5QI.

b) CC.

c) Receipt of Nsmf\_PDUSession\_UpdateSMContext Request which includes the N1 SM container IE containing the QoS flows requested to modify (see TS 23.502 [7]) from AMF by the SMF; or transmission of Namf\_Communication\_N1N2MessageTransfer which includes N1 SM container IE containing the QoS flows requested to modify to AMF by the SMF (see TS 23.502 [7]). Each QoS flow requested to modify in the message triggers the relevant subcounter per S-NSSAI and the relevant subcounter per 5QI to increment by 1 respectively (the S-NSSAI is the S-NSSAI that the PDU session belongs to, or the new S-NSSAI if the S-NSSAI for the serving PLMN derived from the S-NSSAI of the home PLMN differs from the S-NSSAI provided in the Create SM Context Request, see clause 6.1.6.2.4 in TS 29.502 [15]).

d) Each measurement is an integer value.

e) SM.QoSflowModReq.*SNSSAI* andSM.QoSflowModReq.*5QI.*

 Where the *SNSSAI* identifies theS-NSSAI, and the *5QI* identifies the5QI.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.2.1.5 Number of QoS flows successfully modified

a) This measurement provides the number of QoS flows successfully modified. This measurement is split into subcounters per S-NSSAI and subcounters per 5QI.

b) CC.

c) Receipt of Nsmf\_PDUSession\_UpdateSMContext Request that includes the N2 SM information IE containing the successfully modified QoS flows from AMF by the SMF (see TS 23.502 [7]). Each successfully modified QoS flow triggers the relevant subcounter per S-NSSAI and the relevant subcounter per 5QI to increment by 1 respectively (the S-NSSAI is the S-NSSAI that the PDU session belongs to, or the new S-NSSAI if the S-NSSAI for the serving PLMN derived from the S-NSSAI of the home PLMN differs from the S-NSSAI provided in the Create SM Context Request, see clause 6.1.6.2.4 in TS 29.502 [15]).

d) Each measurement is an integer value.

e) SM.QoSflowModSucc.*SNSSAI* andSM.QoSflowModSucc.*5QI.*

 Where the *SNSSAI* identifies theS-NSSAI, and the *5QI* identifies the5QI.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.2.1.6 Number of QoS flows failed to modify

a) This measurement provides the number of QoS flows failed to modify. This measurement is split into subcounters per cause.

b) CC.

c) Receipt of Nsmf\_PDUSession\_UpdateSMContext Request that includes the N2 SM information IE containing the QoS flows failed to modify from AMF by the SMF (see TS 23.502 [7]). Each QoS flow failed to modify triggers the relevant subcounter per cause (see clause 9.3.1.13 in TS 38.413 [11]).

d) Each measurement is an integer value.

e) SM.QoSflowModFail.*cause.*

 Where the *cause* identifies thecause that resulted in the QoS flow modification failure (see clause 9.3.1.2 in TS 38.413 [11]).

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.2.1.7 Mean number of QoS flows

a) This measurement provides the mean number of QoS flows at the SMF. This measurement is split into subcounters per S-NSSAI and subcounters per 5QI.

b) SI

c) This measurement is obtained by sampling at a pre-defined interval, the number of QoS flows per S-NSSAI and per 5QI, and then taking the arithmetic mean.

d) Each measurement is a real value.

e) SM.QoSflowNbrMean.*SNSSAI* andSM.QoSflowNbrMean.*5QI.*

 Where the *SNSSAI* identifies theS-NSSAI, and the *5QI* identifies the5QI.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.3.2.1.8 Peak number of QoS flows

a) This measurement provides the peak number of QoS flows at the SMF. This measurement is split into subcounters per S-NSSAI and subcounters per 5QI.

b) SI

c) This measurement is obtained by sampling at a pre-defined interval, the number of QoS flows per S-NSSAI and per 5QI, and then taking the maximum.

d) Each measurement is a real value.

e) SM.QoSflowNbrPeak.*SNSSAI* andSM.QoSflowNbrPeak.*5QI.*

 Where the *SNSSAI* identifies theS-NSSAI, and the *5QI* identifies the5QI.

f) SMFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.3.3 Performance measurement for N4 interface

#### 5.3.3.1 Number of N4 session modifications

a) This measurement provides the number of attempted N4 session modifications.

b) CC

c) Transmission of "N4 Session Modification Request" message from SMF, this counter is cumulated by different N4 Session Modification Request messages sent by SMF as specified in TS 23.502 [7] and TS 29.244 [16].

d) A single integer value.

e) SM.N4SessionModify.

f) SMFFunction

g) Valid for packet switching

h) 5GS.

#### 5.3.3.2 Number of failed N4 session modifications

A This measurement provides the number of failed N4 session modifications.

b) CC

c) Receipt of "N4 Session Modification Response" message with appropriate error cause value from UPF, SMF identifies a failed N4 session modification as defined in TS 23.502 [7] and TS 29.244 [16]. Each rejected N4 Session Modification Request increments the relevant subcounter by 1.

d) A single integer value.

e) SM.N4SessionModifyFail.*Cause*.

Where Cause identifies the reject cause of N4 session modification request, per the encoding of the cause specified in TS 29.244 [16].

f) SMFFunction

g) Valid for packet switching

h) 5GS.

#### 5.3.3.3 Number of N4 session deletions

a) This measurement provides the number of attempted N4 session deletions.

b) CC

c) Transmission of "N4 Session Deletion Request" message from SMF, this counter is cumulated by different N4 Session Deletion Request messages sent by SMF as specified in TS 23.502 [7] and TS 29.244 [16].

d) A single integer value.

e) SM.N4SessionDelete.

f) SMFFunction

g) Valid for packet switching

h) 5GS.

#### 5.3.3.4 Number of failed N4 session deletions

a) This measurement provides the number of failed N4 session deletions.

b) CC

c) Receipt of "N4 Session Deletion Response" message with appropriate error cause value from UPF, SMF identifies a failed N4 session deletion as defined in TS 23.502 [7] and TS 29.244 [16]. Each rejected N4 Session Deletion Request increments the relevant subcounter by 1.

d) A single integer value.

e) SM.N4SessionDeleteFail.*Cause*.

Where Cause identifies the reject cause of N4 session deletion request, per the encoding of the cause specified in TS 29.244 [16].

f) SMFFunction

g) Valid for packet switching

h) 5GS.

## 5.4 Performance measurements for UPF

### 5.4.1 N3 interface related measurements

#### 5.4.1.1 Number of incoming GTP data packets on the N3 interface, from (R)AN to UPF

a) This measurement provides the number of GTP data PDUs on the N3 interface which have been accepted and processed by the GTP-U protocol entity in UPF on the N3 interface. .The measurement can optionally be split into subcounters per S-NSSAI.

b) CC

c) Reception by the UPF of a GTP-U data PDU on the N3 interface from the (R)AN. See TS 23.501 [4].

d) Each measurement is a single integer value, the number of measurements is equal to one. If the optional S-NSSAI subcounter measurements are perfomed, the number of measurements is equal to the number of supported S-NSSAIs.

e) GTP.InDataPktN3UPF and optionally GTP.InDataPktN3UPF.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction).

g) Valid for packet switching.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality), and for reliability KPI.

#### 5.4.1.2 Number of outgoing GTP data packets of on the N3 interface, from UPF to (R)AN

a) This measurement provides the number of GTP data PDUs on the N3 interface which have been generated by the GTP-U protocol entity on the N3 interface. The measurement can optionally be split into subcounters per S-NSSAI.

b) CC

c) Transmission by the UPF of a GTP-U data PDU of on the N3 interface to the (R)AN. See TS 23.501 [4].

d) Each measurement is a single integer value, the number of measurements is equal to one. If the optional S-NSSAI subcounter measurements are perfomed, the number of measurements is equal to the number of supported S-NSSAIs..

e) GTP.OutDataPktN3UPF and optionally GTP.OutDataPktN3UPF.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction).

g) Valid for packet switching.

h) 5GS

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and for reliability KPI.

#### 5.4.1.3 Number of octets of incoming GTP data packets on the N3 interface, from (R)AN to UPF

a) This measurement provides the number of octets of incoming GTP data packets on the N3 interface which have been generated by the GTP-U protocol entity on the N3 interface. The measurement can optionally be split into subcounters per S-NSSAI.

b) CC

c) Reception by the UPF of a GTP-U data PDU on the N3 interface from (R)AN. See TS 23.501 [4].

d) Each measurement is a single integer value, the number of measurements is equal to one. If the optional S-NSSAI subcounter measurements are perfomed, the number of measurements is equal to the number of supported S-NSSAIs.

e) GTP.InDataOctN3UPF and optionally GTP.OutDataOctN3UPF.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N3

g) Valid for packet switching

h) 5GS

#### 5.4.1.4 Number of octets of outgoing GTP data packets on the N3 interface, from UPF to (R)AN

a) This measurement provides the number of octets of outgoing GTP data packets on the N3 interface which have been generated by the GTP-U protocol entity on the N3 interface. The measurement can optionally be split into subcounters per S-NSSAI.

b) CC

c) Transmission by the UPF of a GTP-U data PDU on the N3 interface to the(R)AN, .See TS 23.501 [4].

d) Each measurement is a single integer value, the number of measurements is equal to one. If the optional S-NSSAI subcounter measurements are perfomed, the number of measurements is equal to the number of supported S-NSSAIs.

e) GTP.OutDataOctN3UPF and optionally GTP.OutDataOctN3UPF.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N3

g) Valid for packet switching

h) 5GS

#### 5.4.1.5 Data volume of incoming GTP data packets per QoS level on the N3 interface, from (R)AN to UPF

a) This measurement provides the data volume of the incoming GTP data packets per QoS level which have been accepted and processed by the GTP-U protocol entity on the N3 interface. The measurement is calculated and split into subcounters per QoS level (5QI).

b) CC.

c) This measurement is obtained by counting the number of GTP PDU bits sent from GNB to UPF on the N3 interface. The measurement is performed per configured QoS level (5QI).

d) Each measurement is an integer value representing the number of bits measured in kbit . The number of measurements is equal to the number of QoS levels.

e) GTP.InDataVolumeQoSLevelN3UPF.

f) EP\_N3.

g) Valid for packet switching.

h) 5GS.

#### 5.4.1.6 Data volume of outgoing GTP data packets per QoS level on the N3 interface, from UPF to (R)AN

a) This measurement provides the data volume of the outgoing GTP data packets per QoS level which have been generated by the GTP-U protocol entity on the N3 interface. The measurement is calculated and split into subcounters per QoS level (5QI).

b) CC.

c) This measurement is obtained by counting the number of GTP PDU bits sent from UPF to GNB on the N3 interface. The measurement is performed per configured QoS level (5QI).

d) Each measurement is an integer value representing the number of bits measured in kbitk . The number of measurements is equal to the number of QoS levels.

e) GTP.OutDataVolumeQoSLevelN3UPF

f) EP\_N3.

g) Valid for packet switching.

h) 5GS.

#### 5.4.1.7 Incoming GTP Data Packet Loss in UPF over N3

a) This measurement provides the number of GTP data packets which are not successfully received at UPF. It is a measure of the incoming GTP data packet loss per N3 on an UPF interface. The measurement is split into subcounters per QoS level (5QI) or subconters per GTP tunnel (TEID) or subcounters per QoS level per GTP tunnel (TEID) or subcounters per S-NSSAI.

b) CC.

c) This measurement is obtained by a counter: Number of missing incoming GTP sequence numbers (TS 29.281 [42]) among all GTP packets delivered by a gNB to an UPF per N3 interface.The separate subcounter can be maintained for each 5QI or for each GTP tunnel identified by TEID or for each supported S-NSSAI.

d) Each measurement is an integer value representing the number of the lost GTP pakets. If the QoS level measurement is perfomed, the measurements are equal to the number of 5QIs. If the optional S-NSSAI subcounter measurements are performed, the number of measurements is equal to the number of supported S-NSSAIs.

e) The measurement name has the form GTP.InDataPktPacketLossN3UPF or GTP.InDataPktPacketLossN3UPF.QoS or GTP.InDataPktPacketLossN3UPF.TEID or GTP.InDataPktPacketLossN3UPF.TEID.QoSwhere QoS identifies the target quality of service class or GTP.InDataPktPacketLossN3UPF.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

i) One usage of this measurement is for performance assurance within integrity area (user plane connection quality) and for reliability KPI.

#### 5.4.1.8 Outgoing GTP Data Packet Loss

a) This measurement provides the number of GTP data packets which are not successfully received at gNB over N3. It is a measure of the outgoing GTP data packet loss per N3 on an UPF interface. The measurement is split into subcounters per QoS level (5QI).

b) CC.

c) This measurement is obtained by a counter: Number of missing outgoing GTP sequence numbers (TS 29.281) among all GTP packets delivered by an UPF interface to a gNB. Separate counter is maintained for each 5QI.

d) Each measurement is an integer value representing the lost GTP packets.. If the QoS level measurement is perfomed, the measurements are equal to the number of 5QIs.

e) The measurement name has the form GTP.OutDataPktPacketLossN3UPF or GTP.OutDataPktPacketLossN3UPF.QoSwhere QoS identifies the target quality of service class.

f) EP\_N3.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.4.1.9 Round-trip GTP Data Packet Delay

##### 5.4.1.9.1 Average round-trip N3 delay on PSA UPF

a) This measurement provides the average round-trip delay on a N3 interface on PSA UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained as: the sum (the time when receiving a GTP echo reply message from the gNB-CU-UP at PSA UPF's ingress GTP termination, minus time when sending the associated echo request message to gNB-CU-UP at the PSA UPF's GTP egress termination) divided by total number of GTP echo reply message received at PSA UPF's ingress GTP termination. This measurement is calculated for each DSCP.

d) Each measurement is a real representing the average delay in microseconds.

e) The measurement name has the form GTP.RttDelayN3DlPsaUpfMean.*DSCP*
Where *DSCP* identifies the DSCP.

f) EP\_N3 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.1.9.2 Distribution of round-trip N3 delay on PSA UPF

a) This measurement provides the distribution of delay on a N3 interface on PSA UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained by 1) calculating the RTT N3 delay by: the time when receiving a GTP echo reply message from the gNB-CU-UP at PSA UPF's ingress GTP termination, minus time when sending the associated echo request message to gNB-CU-UP at the PSA UPF's GTP egress termination; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounters per DSCP.

d) Each measurement is an integer representing the number of GTP echo messages measured with the delay within the range of the bin.

e) The measurement name has the form GTP.RttDelayN3PsaUpfDist.*Bin*.*DSCP*
Where *Bin* indicates a delay range which is vendor specific, and *DSCP* identifies the DSCP.

f) EP\_N3 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.1.9.3 Average round-trip N3 delay on I-UPF

a) This measurement provides the average round-trip delay on a N3 interface on I-UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained as: the sum (the time when receiving a GTP echo reply message from the gNB-DU at I-UPF's ingress GTP termination, minus time when sending the associated echo request message to gNB-DU at the I-UPF's GTP egress termination) divided by total number of GTP echo reply message received at I-UPF's ingress GTP termination. This measurement is calculated for each DSCP.

d) Each measurement is a real representing the average delay in microseconds.

e) The measurement name has the form GTP.RttDelayN3IUpfMean.*DSCP*
Where DSCP identifies the DSCP.

f) EP\_N3 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.1.9.4 Distribution of round-trip N3 delay on I-UPF

a) This measurement provides the distribution of delay on a N3 interface on I-UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained by 1) calculating the RTT N3 delay by: the time when receiving a GTP echo reply message from the gNB-DU at I-UPF's ingress GTP termination, minus time when sending the associated echo request message to gNB-DU at the I-UPF's GTP egress termination; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounters per DSCP.

d) Each measurement is an integer representing the number of GTP echo messages measured with the delay within the range of the bin.

e) The measurement name has the form GTP.RttDelayN3IUpfsDist.*Bin*.*DSCP*
Where *Bin* indicates a delay range which is vendor specific, and *DSCP* identifies the DSCP.

f) EP\_N3 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

#### 5.4.1.10 Number of incoming GTP data packets out-of-order on the N3 interface, from (R)AN to UPF

a) This measurement provides the number of incoming GTP data packets out-of-order on the N3 interface. The measurement is calculated and split into sub-counters per QoS level (5QI).

b) CC

c) This measurement is obtained by counting the number of GTP data packets with sequence numbers less than the maximum GTP sequence number received by UPF. Separate counter is maintained for each 5QI.

d) Each measurement is an integer value representing the number of GTP packets out-of-order. If the QoS level measurement is performed, the measurements are equal to the number of 5QIs.

e) The measurement name has the form GTP.InDataPktDisorderN3UPF or GTP.InDataPktDisorderN3UPF.QoS where QoS identifies the target quality of service class.

f) EP\_N3

g) Valid for packet switching

h) 5GS

### 5.4.2 N6 related measurements

#### 5.4.2.1 N6 incoming link usage

a) This measurement provides the PDU-layer incoming link usage of N6 interface.

b) CC

c) See clause 2.3.4 for IP packet. Definition: IP-type-P (broad spectrum of packet types) Link Usage in IETF RFC 5136 [5].

 NOTE: How to measure the unstructured data type is not specified in the present document.

d) Each measurement is an integer value.

e) IP.N6IncLinkUsage.*N6RP*
where *N6RP* identifies the N6 reference point of this UPF, the format of *N6RP* is vendor specific.

f) EP\_N6

g) Valid for packet switched traffic.

h) 5GS

#### 5.4.2.2 N6 outgoing link usage

a) This measurement provides the PDU-layer outcoming link usage of N6 interface.

b) CC

c) See clause 2.3.4 for IP packet. Definition: IP-type-P (broad spectrum of packet types) Link Usage in IETF RFC 5136 [5].

 NOTE: How to measure the unstructured data type is not specified in the present document.

d) Each measurement is an integer value.

e) IP.N6OutLinkUsage.*N6RP*
where *N6RP* identifies the N6 reference point of this UPF, the format of *N6RP* is vendor specific.

f) EP\_N6

g) Valid for packet switched traffic.

h) 5GS

### 5.4.3 N4 interface related measurements

#### 5.4.3.1 Session establishments

##### 5.4.3.1.1 Number of requested N4 session establishments

a) This measurement provides the number of N4 session establishment requests received by the UPF.

b) CC.

c) On receipt of N4 session establishment request message (see TS 23.502 [7]) by the UPF from SMF.

d) A single integer value.

e) SM.N4SessionEstabReq.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.3.1.2 Number of failed N4 session establishments

a) This measurement provides the number of failed N4 session establishments at the UPF. This measurement is split into subcounters per rejection cause.

b) CC.

c) On transmission of N4 session establishment response message that contains the cause indicating the rejection of N4 session establishment request (see TS 23.502 [7]) by the UPF to SMF. Each N4 session establishment response message indicating the rejection of N4 session establishment request triggers the relevant subcounter per rejection cause to increment by 1.

d) A single integer value.

e) SM.N4SessionEstabFail.*cause*where the cause identities the cause of the rejection of N4 session establishment request, per the encoding of the cause defined in clause 8.2.1 of TS 29.224 [16].

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.4.3.2 N4 Session reports

##### 5.4.3.2.1 Number of requested N4 session reports

a) This measurement provides the number of N4 session reports sent by the UPF.

b) CC.

c) When UPF sends N4 session report message (see TS 23.502 [7]) to SMF.

d) A single integer value.

e) SM.N4SessionReport.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.3.2.2 Number of successful N4 session reports

a) This measurement provides the number of successful N4 session report at the UPF.

b) CC.

c) On receipt of N4 session report ACK message (see TS 23.502 [7] by the UPF. Each N4 session report ACK message indicating the successful N4 session report request triggers the counter to increment by 1.

d) A single integer value.

e) SM.N4SessionReportSucc

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.4.4 N9 interface related measurements

#### 5.4.4.1 Round-trip GTP Data Packet Delay on N9 interface

##### 5.4.4.1.1 Average round-trip N9 delay on PSA UPF

a) This measurement provides the average round-trip delay on a N9 interface on PSA UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained as: the sum (the time when receiving a GTP echo reply message from the I-UPF at PSA UPF's ingress GTP termination, minus time when sending the associated echo request message to I-UPF at the PSA UPF's GTP egress termination) divided by total number of GTP echo reply message received at PSA UPF's ingress GTP termination. This measurement is calculated for each DSCP.

d) Each measurement is a real representing the average delay in microseconds.

e) The measurement name has the form GTP.RttDelayN9PsaUpfMean.*DSCP*
Where *DSCP* identifies the DSCP.

f) EP\_N9.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.4.1.2 Distribution of round-trip N9 delay on PSA UPF

a) This measurement provides the distribution of delay on a N9 interface on PSA UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained by 1) calculating the RTT N9 delay by: the time when receiving a GTP echo reply message from the I-UPF at PSA UPF's ingress GTP termination, minus time when sending the associated echo request message to I-UPF at the PSA UPF's GTP egress termination; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounters per DSCP.

d) Each measurement is an integer representing the number of GTP echo messages measured with the delay within the range of the bin.

e) The measurement name has the form GTP.RttDelayN9PsaUpfDist.*Bin*.*DSCP*
Where *Bin* indicates a delay range which is vendor specific, and *DSCP* identifies the DSCP.

f) EP\_N9.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.4.1.3 Average round-trip N9 delay on I-UPF

a) This measurement provides the average round-trip delay on a N9 interface on I-UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained as: the sum (the time when receiving a GTP echo reply message from the PSA UPF at I-UPF's ingress GTP termination, minus time when sending the associated echo request message to PSA UPF at the I-UPF's GTP egress termination) divided by total number of GTP echo reply message received at I-UPF's ingress GTP termination. This measurement is calculated for each DSCP.

d) Each measurement is a real representing the average delay in microseconds.

e) The measurement name has the form GTP.RttDelayN9IUpfMean.*DSCP*
Where DSCP identifies the DSCP.

f) EP\_N9.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.4.1.4 Distribution of round-trip N9 delay on I-UPF

a) This measurement provides the distribution of delay on a N9 interface on I-UPF. This measurement is split into subcounters per DSCP (Differentiated Services Code Point).

b) DER (n=1).

c) This measurement is obtained by 1) calculating the RTT N9 delay by: the time when receiving a GTP echo reply message from the PSA UPF at I-UPF's ingress GTP termination, minus time when sending the associated echo request message to PSA UPF at the I-UPF's GTP egress termination; and 2) incrementing the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounters per DSCP.

d) Each measurement is an integer representing the number of GTP echo messages measured with the delay within the range of the bin.

e) The measurement name has the form GTP.RttDelayN9IUpfDist.*Bin*.*DSCP*
Where *Bin* indicates a delay range which is vendor specific, and *DSCP* identifies the DSCP.

f) EP\_N9.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.4.4.2 GTP Data Packets and volume on N9 interface

##### 5.4.4.2.1 Number of incoming GTP data packets on the N9 interface for PSA UPF

a) This measurement provides the number of GTP data PDUs received on the N9 interface by the PSA UPF. This measurement is optionally split into subcounters per S-NSSAI.

b) CC

c) Reception by the PSA UPF of a GTP-U data PDU on the N9 interface from the I-UPF, see TS 23.501 [4].

d) Each measurement is an integer value.

e) GTP.InDataPktN9PsaUpf, and optionally
GTP.InDataPktN9PsaUpf.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N9

g) Valid for packet switching.

h) 5GS

##### 5.4.4.2.2 Number of outgoing GTP data packets of on the N9 interface for PSA UPF

a) This measurement provides the number of GTP data PDUs sent on the N9 interface by the PSA UPF. This measurement is optionally split into subcounters per S-NSSAI.

b) CC

c) Transmission by the PSA UPF of a GTP-U data PDU of on the N9 interface to the I-UPF, see TS 23.501 [4].

d) Each measurement is an integer value.

e) GTP.OutDataPktN9PsaUpf, and optionally
GTP.OutDataPktN9PsaUpf.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI

f) EP\_N9

g) Valid for packet switching.

h) 5GS

##### 5.4.4.2.3 Number of octets of incoming GTP data packets on the N9 interface for PSA UPF

a) This measurement provides the number of octets of GTP data PDUs received on the N9 interface by the PSA UPF. This measurement is optionally split into subcounters per S-NSSAI.

b) CC

c) Reception by the PSA UPF of a GTP-U data PDU on the N9 interface from the I-UPF, see TS 23.501 [4].

d) Each measurement is an integer value.

e) GTP.InDataOctN9PsaUpf, and optionally
GTP.InDataOctN9PsaUpf.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N9

g) Valid for packet switching

h) 5GS

##### 5.4.4.2.4 Number of octets of outgoing GTP data packets on the N9 interface for PSA UPF

a) This measurement provides the number of octets of outgoing GTP data PDUs sent on the N9 interface by the PSA UPF. This measurement is optionally split into subcounters per S-NSSAI.

b) CC

c) Transmission by the PSA UPF of a GTP-U data PDU of on the N9 interface to the I-UPF, see TS 23.501 [4].

d) Each measurement is an integer value.

e) GTP.OutDataOctN9PsaUpf and optionally
GTP.OutDataOctN9PsaUpf.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N9

g) Valid for packet switching

h) 5GS

### 5.4.5 GTP packets delay in UPF

#### 5.4.5.1 DL GTP packets delay in UPF

##### 5.4.5.1.1 Average DL GTP packets delay in PSA UPF

a) This measurement provides the average (arithmetic mean) DL GTP packets delay within the PSA UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained as: 1) sampling the DL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) sum of (time when sending the sampled DL GTP PDU to the gNB-CU-UP or I-UPF at the PSA UPF's egress GTP termination, minus time of arrival of the same packet at PSA UPF's ingress IP termination for N6 interface) divided by total number of sampled DL GTP PDUs sent to the gNB-CU-UP or I-UPF. The measurement is calculated per 5QI and per S-NSSAI.

d) Each measurement is an integer representing the mean delay in microseconds.

e) GTP.DelayDlInPsaUpfMean.*5QI*, where *5QI* identifies the 5QI;
GTP.DelayDlInPsaUpfMean.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.5.1.2 Distribution of DL GTP packets delay in PSA UPF

a) This measurement provides the distribution of DL GTP packets delay within the PSA UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained by 1) sampling the DL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) calculating the DL delay for the sampled GTP PDU in I-UPF by: time when sending the sampled DL GTP PDU to the gNB-CU-UP or I-UPF at the PSA UPF's egress GTP termination, minus time of arrival of the same packet at PSA UPF's ingress IP termination for N6 interface; and 3) incrementing the corresponding bin with the delay range where the result of 2) falls into by 1 for the subcounters per 5QI and subcounters per S-NSSAI.

d) Each measurement is an integer representing the number of sampled DL GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayDlInPsaUpfDist.*Bin*.*5QI*, where *Bin* indicates a delay range which is vendor specific, and *5QI* identifies the 5QI;
GTP.DelayDlInPsaUpfDist.*Bin*.*SNSSAI*, where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.5.1.3 Average DL GTP packets delay in I-UPF

a) This measurement provides the average (arithmetic mean) DL GTP packets delay within the I-UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained as: 1) sampling the DL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) sum of (time when sending the sampled DL GTP PDU to the gNB-CU-UP at the I-UPF's egress GTP termination, minus time of arrival of the same packet at I-UPF's ingress GTP termination for N9 interface) divided by total number of sampled DL GTP PDUs sent to the gNB-CU-UP. The measurement is calculated per 5QI and per S-NSSAI.

d) Each measurement is an integer representing the mean delay in microseconds.

e) GTP.DelayDlInIUpfMean.*5QI*, where *5QI* identifies the 5QI;
GTP.DelayDlInIUpfMean.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.5.1.4 Distribution of DL GTP packets delay in I-UPF

a) This measurement provides the distribution of DL GTP packets delay within the I-UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained by 1) sampling the DL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) calculating the DL delay for the sampled GTP PDU in I-UPF by: time when sending the DL GTP PDU to the gNB-CU-UP at the I-UPF's egress GTP termination, minus time of arrival of the same packet at I-UPF's ingress GTP termination for N9 interface; and 3) incrementing the corresponding bin with the delay range where the result of 2) falls into by 1 for the subcounters per 5QI and subcounters per S-NSSAI.

d) Each measurement is an integer representing the number of sampled DL GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayDlInIUpfDist. *Bin*.*5QI*, where *Bin* indicates a delay range which is vendor specific, and *5QI* identifies the 5QI;
GTP.DelayDlInIUpfDist. *Bin*.*SNSSAI*, where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.4.5.2 UL GTP packets delay in UPF

##### 5.4.5.2.1 Average UL GTP packets delay in PSA UPF

a) This measurement provides the average (arithmetic mean) UL GTP packets delay within the PSA UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained as: 1) sampling the UL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) sum of (time when sending the sampled UL data packet at the PSA UPF's egress IP termination for N6 interface, minus time of arrival of the corresponding GTP SDU from N3 or N9 interface at PSA UPF's ingress GTP termination) divided by total number of sampled UL data packets sent to N6 interface. The measurement is calculated per 5QI and per S-NSSAI.

d) Each measurement is an integer representing the mean delay in microseconds.

e) GTP.DelayUlInPsaUpfMean.*5QI*, where *5QI* identifies the 5QI;
GTP.DelayUlInPsaUpfMean.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.5.2.2 Distribution of UL GTP packets delay in PSA UPF

a) This measurement provides the distribution of UL GTP packets delay within the PSA UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained by 1) sampling the UL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) calculating the UL delay for a GTP PDU in I-UPF by: time when sending the sampled UL data packet at the PSA UPF's egress IP termination for N6 interface, minus time of arrival of the corresponding GTP SDU from N3 or N9 interface at PSA UPF's ingress GTP termination; and 3) incrementing the corresponding bin with the delay range where the result of 2) falls into by 1 for the subcounters per 5QI and subcounters per S-NSSAI.

d) Each measurement is an integer representing the number of sampled UL GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayUlInPsaUpfDist.*Bin*.*5QI*, where *Bin* indicates a delay range which is vendor specific, and *5QI* identifies the 5QI;
GTP.DelayUlInPsaUpfDist.*Bin*.*SNSSAI*, where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.5.2.3 Average UL GTP packets delay in I-UPF

a) This measurement provides the average (arithmetic mean) UL GTP packets delay within the I-UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained as: 1) sampling the UL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) sum of (time when sending the sampled UL GTP PDU to the PSA UPF at the I-UPF's egress GTP termination, minus time of arrival of the same packet from N3 interface at I-UPF's ingress GTP termination) divided by total number of sampled UL GTP PDUs sent to the PSA UPF. The measurement is calculated per 5QI and per S-NSSAI.

d) Each measurement is an integer representing the mean delay in microseconds.

e) GTP.DelayUlInIUpfMean.*5QI*, where *5QI* identifies the 5QI;
GTP.DelayUlInIUpfMean.*SNSSAI*, where *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.5.2.4 Distribution of UL GTP packets delay in I-UPF

a) This measurement provides the distribution of UL GTP packets delay within the I-UPF. The measurement is split into subcounters per 5QI and subcounters per S-NSSAI.

b) DER (n=1).

c) This measurement is obtained by 1) sampling the UL GTP PDUs (sampling rate is vendor specific) for this measurement, 2) calculating the UL delay for a GTP PDU in I-UPF by: time when sending the sampled UL GTP PDU to the PSA UPF at the I-UPF's egress GTP termination, minus time of arrival of the same packet from N3 interface at I-UPF's ingress GTP termination; and 3) incrementing the corresponding bin with the delay range where the result of2) falls into by 1 for the subcounters per 5QI and subcounters per S-NSSAI.

d) Each measurement is an integer representing the number of sampled UL GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayUlInIUpfDist.*Bin*.*5QI*, where *Bin* indicates a delay range which is vendor specific, and *5QI* identifies the 5QI;
GTP.DelayUlInIUpfDist.*Bin*.*SNSSAI*, where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) UPFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.4.6 Void

### 5.4.7 One way packet delay between NG-RAN and PSA UPF

#### 5.4.7.1 UL packet delay between NG-RAN and PSA UPF

##### 5.4.7.1.1 Average UL GTP packet delay between PSA UPF and NG-RAN

a) This measurement provides the average UL GTP packet delay between PSA UPF and NG-RAN. This measurement is split into subcounters per 5QI and subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF samples the GTP packets for QoS monitoring based on the policy provided by OAM or SMF.

NOTE: The sampling rate may vary for different S-NSSAI and different 5QIs, and the specific sampling rate is up to implementation unless given by the QoS monitoring policy.

 For each GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF;

- The 5QI and S-NSSAI associated to the GTP PDU.

 The PSA UPF counts the number (N) of GTP PDU monitoring response packets for each 5QI and each S-NSSAI respectively, and takes the following calculation for each 5QI and each S-NSSAI:

d) Each measurement is a real representing the average delay in microseconds.

e) GTP.DelayUlPsaUpfNgranMean.*5QI, where 5QI* identifies the 5QI;
GTP.DelayUlPsaUpfNgranMean.*SNSSAI, where SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.7.1.2 Distribution of UL GTP packet delay between PSA UPF and NG-RAN

a) This measurement provides the distribution of UL GTP packet delay between PSA UPF and NG-RAN. This measurement is split into subcounters per 5QI and subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF samples the GTP packets for QoS monitoring based on the policy provided by OAM or SMF.

NOTE: The sampling rate may vary for different S-NSSAI and different 5QIs, and the specific sampling rate is up to implementation unless given by the QoS monitoring policy.

 For each GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T3 received in the GTP-U header indicating the local time that the NG-RAN sent out the monitoring response packet to the UPF;

- T4 that the monitoring response packet received by the PSA UPF;

- The 5QI and S-NSSAI associated to the DL GTP PDU.

 The PSA UPF 1) takes the following calculation for each GTP PDU monitoring response packets for each 5QI and each S-NSSAI respectively, and 2) increment the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounters per 5QI and subcounters per S-NSSAI.

d) Each measurement is an integer representing the number of GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayUlPsaUpfNgranDist.*5QI*.*Bin,* Where *Bin* indicates a delay range which is vendor specific, and *5QI* identifies the 5QI;
GTP.DelayUlPsaUpfNgranDist.*SNSSAI.bin,* Where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

### 5.4.8 Round-trip packet delay between PSA UPF and NG-RAN

#### 5.4.8.1 Average round-trip packet delay between PSA UPF and NG-RAN

a) This measurement provides the average round-trip GTP packet delay between PSA UPF and NG-RAN. This measurement is split into subcounters per 5QI and subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are not time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF samples the GTP packets for QoS monitoring based on the policy provided by OAM or SMF.

NOTE: The sampling rate may vary for different S-NSSAI and different 5QIs, and the specific sampling rate is up to implementation unless given by the QoS monitoring policy.

 For each received GTP PDU monitoring response packet (packet i) encapsulated with QFI, TEID, and QMP indicator for QoS monitoring, the PSA UPF records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T1 received in the GTP-U header of the monitoring response packet indicating the local time that the DL GTP PDU was sent by the PSA UPF;

- T2 received in the GTP-U header of the monitoring response packet indicating the local time that the DL GTP PDU was received by NG-RAN;

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF;

- The 5QI and S-NSSAI associated to the DL GTP PDU.

 The PSA UPF counts the number (N) of received GTP PDU monitoring response packets for each 5QI and each S-NSSAI respectively, and takes the following calculation for each 5QI and each S-NSSAI:

d) Each measurement is a real representing the average delay in microseconds.

e) GTP.RttDelayPsaUpfNgranMean.*5QI, where 5QI* identifies the 5QI;
GTP.RttDelayPsaUpfNgranMean.*SNSSAI, where SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

#### 5.4.8.2 Distribution of round-trip packet delay between PSA UPF and NG-RAN

a) This measurement provides the distribution of round-trip GTP packet delay between PSA UPF and NG-RAN. This measurement is split into subcounters per 5QI and subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are not time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF samples the GTP packets for QoS monitoring based on the policy provided by OAM or SMF.

NOTE: The sampling rate may vary for different S-NSSAI and different 5QIs, and the specific sampling rate is up to implementation unless given by the QoS monitoring policy.

 For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T1 received in the GTP-U header of the monitoring response packet indicating the local time that the DL GTP PDU was sent by the PSA UPF;

- T2 received in the GTP-U header of the monitoring response packet indicating the local time that the DL GTP PDU was received by NG-RAN;

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF;

- The 5QI and S-NSSAI associated to the DL GTP PDU.

 The PSA UPF 1) takes the following calculation for each received GTP PDU monitoring response packet (packet i) for each 5QI and each S-NSSAI respectively, and 2) increment the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounters per 5QI and subcounters per S-NSSAI.

d) Each measurement is an integer representing the number of DL GTP PDUs measured with the delay within the range of the bin.

e) GTP.RttDelayPsaUpfNgranDist.*5QI*.*Bin,* Where *Bin* indicates a delay range which is vendor specific, and *5QI* identifies the 5QI;
GTP.RttDelayPsaUpfNgranDist.*SNSSAI.bin,* Where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

### 5.4.9 One way packet delay between PSA UPF and UE

#### 5.4.9.1 DL packet delay between PSA UPF and UE

##### 5.4.9.1.1 Average DL packet delay between PSA UPF and UE

a) This measurement provides the average DL packet delay between PSA UPF and UE. This measurement is split into subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF performs QoS monitoring per the request received from SMF during PDU Session Establishment or Modification procedure.

NOTE: The UPF may sample the GTP packets for QoS monitoring, the specific sampling rate is up to implementation

 For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information included in the GTP-U header (see 23.501 [4] and 38.415 [31]):

- T1 indicating the local time the DL GTP PDU monitoring packet was sent by the PSA UPF;

- T2 indicating the local time that the DL GTP PDU monitoring packet was received by NG-RAN;

- The DL Delay Result from NG-RAN to UE indicating the downlink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (see 38.415 [31],and the DL Delay Result is denoted by in the present document);

- The S-NSSAI associated to the DL GTP PDU monitoring response packet.

 The PSA UPF counts the number (N) of GTP PDU monitoring response packets for each S-NSSAI, and takes the following calculation for each S-NSSAI:

d) Each measurement is a real representing the average delay in 0.1ms.

e) GTP.DelayDlPsaUpfUeMean.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.9.1.2 Distribution of DL packet delay between PSA UPF and UE

a) This measurement provides the distribution of DL packet delay between PSA UPF and UE. This measurement is split into subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

The UPF performs QoS monitoring per the request received from SMF during PDU Session Establishment or Modification procedure.

NOTE: The UPF may sample the GTP packets for QoS monitoring the specific sampling rate is up to implementation.

For each received DL GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information included in the GTP-U header (see 23.501 [4] and 38.415 [31]):

- T1 indicating the local time the DL GTP PDU monitoring packet was sent by the PSA UPF;

- T2 indicating the local time that the DL GTP PDU monitoring packet was received by NG-RAN;

- The DL Delay Result from NG-RAN to UE indicating the downlink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (see 38.415 [31],and the DL Delay Result is denoted by in the present document);

- The S-NSSAI associated to the DL GTP PDU monitoring response packet.

 The PSA UPF 1) takes the following calculation for each GTP PDU monitoring response packet for each S-NSSAI, and 2) increment the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounter per S-NSSAI.

d) Each measurement is an integer representing the number of GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayDlPsaUpfUeDist.*SNSSAI.bin,* where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

#### 5.4.9.2 UL packet delay between PSA UPF and UE

##### 5.4.9.2.1 Average UL packet delay between PSA UPF and UE

a) This measurement provides the average UL packet delay between PSA UPF and UE. This measurement is split into subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

 The UPF performs QoS monitoring per the request received from SMF during PDU Session Establishment or Modification procedure.

NOTE: The UPF may sample the GTP packets for QoS monitoring, the specific sampling rate is up to implementation.

For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF;

- The UL Delay Result from UE to NG-RAN indicating the uplink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (see 38.415 [31], and the UL Delay Result is denoted by in the present document);

- The S-NSSAI associated to the GTP PDU monitoring response packet.

 The PSA UPF counts the number (N) of GTP PDU monitoring response packets for each S-NSSAI, and takes the following calculation for each S-NSSAI:

d) Each measurement is a real representing the average delay in 0.1ms.

e) GTP.DelayUlPsaUpfUeMean.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI;

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

##### 5.4.9.2.2 Distribution of UL packet delay between PSA UPF and UE

a) This measurement provides the distribution of UL packet delay between PSA UPF and UE. This measurement is split into subcounters per S-NSSAI. This measurement is only applicable to the case the PSA UPF and NG-RAN are time synchronised.

b) DER (n=1).

c) The measurement is obtained by the following method:

 The UPF performs QoS monitoring per the request received from SMF during PDU Session Establishment or Modification procedure.

NOTE: The UPF may sample the GTP packets for QoS monitoring, the specific sampling rate is up to implementation.

 For each received GTP PDU monitoring response packet (packet i) for QoS monitoring, the PSA UPF records the following time stamps and information (see 23.501 [4] and 38.415 [31]):

- T3 received in the GTP-U header of the monitoring response packet indicating the local time that the monitoring response packet was sent by the NG-RAN;

- T4 that the monitoring response packet was received by the PSA UPF;

- The UL Delay Result from UE to NG-RAN indicating the uplink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface (see 38.415 [31], and the UL Delay Result is denoted by in the present document);

- The S-NSSAI associated to the GTP PDU monitoring response packet.

 The PSA UPF 1) takes the following calculation for each GTP PDU monitoring response packet (packet i) for each S-NSSAI, and 2) increment the corresponding bin with the delay range where the result of 1) falls into by 1 for the subcounter per S-NSSAI.

d) Each measurement is an integer representing the number of GTP PDUs measured with the delay within the range of the bin.

e) GTP.DelayUlPsaUpfUeDist.*SNSSAI.bin,* where *Bin* indicates a delay range which is vendor specific, and *SNSSAI* identifies the S-NSSAI.

f) EP\_N3 (contained by UPFFunction);
EP\_N9 (contained by UPFFunction).

g) Valid for packet switched traffic.

h) 5GS.

### 5.4.10 QoS flow related measurements

#### 5.4.10.1 Mean number of QoS flows

a) This measurement provides the mean number of QoS flows of UPF.

b) SI

c) This measurement is obtained by sampling at a pre-defined interval, the number of QoS flows and then taking the arithmetic mean.The measurement is optionally split into subcounters per S-NSSAI and per DNN.

d) A single integer value

e) UPF.MeanQosFlows
UPF.MeanQosFlows.*SNSSAI ,*where *SNSSAI* identifies the S-NSSAI.
UPF.MeanQosFlows.*Dnn ,*where *Dnn* identifies the Data Network Name.

f) UPFFunction

g) Valid for packet switching

h) 5GS

#### 5.4.10.2 Maximum number of QoS flows

a) This measurement provides the max number of QoS flows of UPF.

b) SI

c) This measurement is obtained by sampling at a pre-defined interval, the number of QoS flows and then selecting the maximum value. The measurement is optionally split into subcounters per S-NSSAI and per DNN.

d) A single integer value

e) UPF.MaxQosFlows
UPF.MaxQosFlows.*SNSSAI ,*where *SNSSAI* identifies the S-NSSAI.
UPF.MaxQosFlows.*Dnn ,*where *Dnn* identifies the Data Network Name.

f) UPFFunction

g) Valid for packet switching

h) 5GS

## 5.5 Performance measurements for PCF

### 5.5.1 AM policy association related measurements

#### 5.5.1.1 Number of AM policy association requests

a) This measurement provides the number of AM policy association requests received by the visiting PCF ((V-)PCF).

b) CC

c) On receipt by the PCF from the AMF of Npcf\_AMPolicyControl\_Create (see TS 23.502 [7]). Each AM policy association request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) PA.PolicyAMAssoReq.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.5.1.2 Number of successful AM policy associations

a) This measurement provides the number of successful AM policy associations at the visiting PCF ((V-)PCF).

b) CC

c) On transmission by the PCF to the AMF of Npcf\_AMPolicyControl\_Create response (see TS 23.502 [7]). Each successful AM policy association is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) PA.PolicyAMAssoSucc.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.5.1.3 Number of AM policy association update requests

a) This measurement provides the number of AM policy association update requests PCF received from AMF.

b) CC

c) PCF receives the update (post) operation sent by AMF for the "policies / {polassoid} / update" resource URL.

d) A single integer value

e) PCF.PolicyAmAssocUpdateReq

f) PCFFunction

g) Valid for packet switching

h) 5GS

#### 5.5.1.4 Number of successful AM policy association updates

a) This measurement provides the number of successful update of AM policy association on PCF.

b) CC

c) PCF returns "200 OK" response message

d) A single integer value

e) PCF.PolicyAmAssocUpdateSucc

f) PCFFunction

g) Valid for packet switching

h) 5GS

#### 5.5.1.5 Number of AM policy association update notify requests

a) This measurement provides the number of SM policy association update notify requests PCF sends to SMF.

b) CC

c) PCF sends update (post) operation to AMF for "{notification URI} / update" or "{notification URI} / terminate" resource URL (see clause 4.2 in TS 29.507[39]). Each association update request is added to the relevant subcounter per S-NSSAI.

d) A single integer value

e) PCF.PolicyAmAssocNotifReq.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI

f) PCFFunction

g) Valid for packet switching

h) 5GS

#### 5.5.1.6 Number of successful AM policy association update notifies

a) This measurement provides the number of successful update notifies of AM policy association on PCF.

b) CC

c) PCF receives "204 No Content" response message sent by AMF (see clause 4.2 in TS 29.507[39]). Each successful association is added to the relevant subcounter per S-NSSAI.

d) A single integer value

e) PCF.PolicyAmAssocNotifSucc.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI

f) PCFFunction

g) Valid for packet switching

h) 5GS

### 5.5.2 SM policy association related measurements

#### 5.5.2.1 Number of SM policy association requests

a) This measurement provides the number of SM policy association requests received by the PCF.

b) CC

c) On receipt by the PCF from the SMF of Npcf\_SMPolicyControl\_Create (see TS 23.502 [7]). Each SM policy association request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) PA.PolicySMAssoReq.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.5.2.2 Number of successful SM policy associations

a) This measurement provides the number of successful SM policy associations at the PCF.

b) CC

c) On transmission by the PCF to the SMF of Npcf\_SMPolicyControl\_Create response (see TS 23.502 [7]). Each successful SM policy association is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) PA.PolicySMAssoSucc.*SNSSAI*

 Where *SNSSAI* identifies the S-NSSAI;

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is for performance assurance.

#### 5.5.2.3 Number of SM policy association update requests

a) This measurement provides the number of SM policy association update requests PCF received from SMF.

b) CC

c) PCF receives the update (post) operation sent by SMF for the " sm-policies/{smPolicyId}/update " resource URL (see clause 4.2 in TS 29.512[40]). Each association update request is added to the relevant subcounter per S-NSSAI.

d) A single integer value

e) PCF.PolicySmAssocUpdateReq.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI

f) PCFFunction

g) Valid for packet switching

h) 5GS

#### 5.5.2.4 Number of successful SM policy association updates

a) This measurement provides the number of successful update of SM policy association on PCF.

b) CC

c) PCF returns "200 OK" response message (see clause 4.2 in TS 29.512[40]). Each successful association is added to the relevant subcounter per S-NSSAI.

d) A single integer value

e) PCF.PolicySmAssocUpdateSucc.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI

f) PCFFunction

g) Valid for packet switching

h) 5GS

#### 5.5.2.5 Number of SM policy association update notify requests

a) This measurement provides the number of SM policy association update notify requests PCF sends to SMF.

b) CC

c) PCF sends update (post) operation to SMF for the " {NotificationUri}/update " resource URL (see clause 4.2 in TS 29.512[40]). Each association update request is added to the relevant subcounter per S-NSSAI.

d) A single integer value

e) PCF.PolicySmAssocNotifReq.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI

f) PCFFunction

g) Valid for packet switching

h) 5GS

#### 5.5.2.6 Number of successful SM policy association update notifies

a) This measurement provides the number of successful update notifies of SM policy association on PCF.

b) CC

c) PCF receives "200 OK" or "204 No Content" response message sent by SMF (see clause 4.2 in TS 29.512[40]). Each successful association is added to the relevant subcounter per S-NSSAI.

d) A single integer value

e) PCF.PolicySmAssocNotifSucc.*SNSSAI*

Where *SNSSAI* identifies the S-NSSAI

f) PCFFunction

g) Valid for packet switching

h) 5GS

### 5.5.3 UE policy association related measurements

#### 5.5.3.1 Number of UE policy association requests

a) This measurement provides the number of UE policy association requests received by the PCF.

b) CC

c) On receipt by the PCF from the AMF of Npcf\_UEPolicyControl Create Request (see TS 23.502 [7]).

d) A single integer value

e) PA.PolicyUeAssoReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.5.3.2 Number of successful UE policy associations

a) This measurement provides the number of successful UE policy associations at the PCF.

b) CC

c) On transmission by the PCF to the AMF of Npcf\_UEPolicyControl Create Response (see TS 23.502 [7]) indicating a successful UE policy association.

d) A single integer value

e) PA.PolicyUeAssoSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

### 5.5.4 Background data transfer policy control related measurements

#### 5.5.4.1 Background data transfer policy creation

##### 5.5.4.1.1 Number of background data transfer policy creation requests

a) This measurement provides the number of background data transfer policy creation requests received by the PCF.

b) CC

c) Receipt of an Npcf\_BDTPolicyControl\_Create request by the PCF from an NEF (see TS 23.502 [7]).

d) An integer value

e) BDTP.CreateReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.4.1.2 Number of successful background data transfer policy creations

a) This measurement provides the number of successful background data transfer policy creations at the PCF.

b) CC

c) Transmission of an Npcf\_BDTPolicyControl\_Create response by the PCF to an NEF indicating a successful background data transfer policy creation (see TS 29.554 [a]).

d) An integer value

e) BDTP.CreateSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.4.1.3 Number of failed background data transfer policy creations

a) This measurement provides the number of failed background data transfer policy creations at the PCF.

b) CC

c) Transmission of an Npcf\_BDTPolicyControl\_Create response by the PCF to an NEF indicating a failed background data transfer policy creation (see TS 29.554 [a]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) BDTP.CreateFail.*cause*
Where *cause* indicates the failure cause of background data transfer policy creation.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

### 5.5.5 AM policy authorization related measurements

#### 5.5.5.1 Creation of AM policy authorization

##### 5.5.5.1.1 Number of AM policy authorization creation requests

a) This measurement provides the number of AM policy authorization creation requests received by the PCF.

b) CC

c) Receipt of an Npcf\_AMPolicyAuthorization\_Create request by the PCF from an NF consumer (e.g., AF) (see 3GPP TS 23.502 [7]).

d) An integer value

e) PAU.AmCreateReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.5.1.2 Number of successful AM policy authorization creations

a) This measurement provides the number of successful AM policy authorization creations at the PCF.

b) CC

c) Transmission of an Npcf\_AMPolicyAuthorization\_Create response by the PCF to an NF consumer indicating a successful AM policy authorization creation (see TS 29.507 [39]).

d) An integer value

e) PAU.AmCreateSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.5.1.3 Number of failed AM policy authorization creations

a) This measurement provides the number of failed AM policy authorization creations at the PCF.

b) CC

c) Transmission of an Npcf\_AMPolicyAuthorization\_Create response by the PCF to an NF consumer indicating a failed AM policy authorization creation (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) PAU.AmCreateFail.*cause*
Where *cause* indicates the failure cause of the AM policy authorization creation.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.5.5.2 Update of AM policy authorization

##### 5.5.5.2.1 Number of AM policy authorization update requests

a) This measurement provides the number of AM policy authorization update requests received by the PCF.

b) CC

c) Receipt of an Npcf\_AMPolicyAuthorization\_Update request by the PCF from an NF consumer (e.g., AF) (see 3GPP TS 23.502 [7]).

d) An integer value

e) PAU.AmUpdateReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.5.2.2 Number of successful AM policy authorization updates

a) This measurement provides the number of successful AM policy authorization updates at the PCF.

b) CC

c) Transmission of an Npcf\_AMPolicyAuthorization\_Update response by the PCF to an NF consumer indicating a successful AM policy authorization update (see TS 29.507 [39]).

d) An integer value

e) PAU.AmUpdateSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.5.2.3 Number of failed AM policy authorization updates

a) This measurement provides the number of failed AM policy authorization updates at the PCF.

b) CC

c) Transmission of an Npcf\_AMPolicyAuthorization\_Update response by the PCF to an NF consumer indicating a failed AM policy authorization update (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) PAU.AmUpdateFail.*cause*
Where *cause* indicates the failure cause of the AM policy authorization update.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.5.5.3 Deletion of AM policy authorization

##### 5.5.5.3.1 Number of AM policy authorization deletion requests

a) This measurement provides the number of AM policy authorization deletion requests received by the PCF.

b) CC

c) Receipt of an Npcf\_AMPolicyAuthorization\_Delete request by the PCF from an NF consumer (e.g., AF) (see 3GPP TS 23.502 [7]).

d) An integer value

e) PAU.AmDeleteReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.5.3.2 Number of successful AM policy authorization deletions

a) This measurement provides the number of successful AM policy authorization deletions at the PCF.

b) CC

c) Transmission of an Npcf\_AMPolicyAuthorization\_Delete response by the PCF to an NF consumer indicating a successful AM policy authorization deletion (see TS 29.507 [39]).

d) An integer value

e) PAU.AmDeleteSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.5.3.3 Number of failed AM policy authorization deletions

a) This measurement provides the number of failed AM policy authorization deletions at the PCF.

b) CC

c) Transmission of an Npcf\_AMPolicyAuthorization\_Delete response by the PCF to an NF consumer indicating a failed AM policy authorization deletion (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) PAU.AmDeleteFail.*cause*
Where *cause* indicates the failure cause of the AM policy authorization deletion.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

### 5.5.6 SM policy authorization related measurements

#### 5.5.6.1 Creation of SM policy authorization

##### 5.5.6.1.1 Number of SM policy authorization creation requests

a) This measurement provides the number of SM policy authorization creation requests received by the PCF.

b) CC

c) Receipt of an Npcf\_PolicyAuthorization\_Create request by the PCF from an NF consumer (e.g., AF) (see TS 23.502 [7]).

d) An integer value

e) PAU.SmCreateReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.6.1.2 Number of successful SM policy authorization creations

a) This measurement provides the number of successful SM policy authorization creations at the PCF.

b) CC

c) Transmission of an Npcf\_PolicyAuthorization\_Create response by the PCF to an NF consumer indicating a successful SM policy authorization creation (see TS 29.507 [39]).

d) An integer value

e) PAU.SmCreateSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.6.1.3 Number of failed SM policy authorization creations

a) This measurement provides the number of failed SM policy authorization creations at the PCF.

b) CC

c) Transmission of an Npcf\_PolicyAuthorization\_Create response by the PCF to an NF consumer indicating a failed SM policy authorization creation (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) PAU.SmCreateFail.*cause*
Where *cause* indicates the failure cause of the SM policy authorization creation.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.5.6.2 Update of SM policy authorization

##### 5.5.6.2.1 Number of SM policy authorization update requests

a) This measurement provides the number of SM policy authorization update requests received by the PCF.

b) CC

c) Receipt of an Npcf\_PolicyAuthorization\_Update request by the PCF from an NF consumer (e.g., AF) (see 3GPP TS 23.502 [7]).

d) An integer value

e) PAU.SmUpdateReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.6.2.2 Number of successful SM policy authorization updates

a) This measurement provides the number of successful SM policy authorization updates at the PCF.

b) CC

c) Transmission of an Npcf\_PolicyAuthorization\_Update response by the PCF to an NF consumer indicating a successful SM policy authorization update (see TS 29.507 [39]).

d) An integer value

e) PAU.SmUpdateSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.6.2.3 Number of failed SM policy authorization updates

a) This measurement provides the number of failed SM policy authorization updates at the PCF.

b) CC

c) Transmission of an Npcf\_PolicyAuthorization\_Update response by the PCF to an NF consumer indicating a failed SM policy authorization update (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) PAU.SmUpdateFail.*cause*
Where *cause* indicates the failure cause of the SM policy authorization update.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.5.6.3 Deletion of SM policy authorization

##### 5.5.6.3.1 Number of SM policy authorization deletion requests

a) This measurement provides the number of SM policy authorization deletion requests received by the PCF.

b) CC

c) Receipt of an Npcf\_PolicyAuthorization\_Delete request by the PCF from an NF consumer (e.g., AF) (see 3GPP TS 23.502 [7]).

d) An integer value

e) PAU.SmDeleteReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.6.3.2 Number of successful SM policy authorization deletions

a) This measurement provides the number of successful SM policy authorization deletions at the PCF.

b) CC

c) Transmission of an Npcf\_PolicyAuthorization\_Delete response by the PCF to an NF consumer indicating a successful SM policy authorization deletion (see TS 29.507 [39]).

d) An integer value

e) PAU.SmDeleteSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.6.3.3 Number of failed SM policy authorization deletions

a) This measurement provides the number of failed SM policy authorization deletions at the PCF.

b) CC

c) Transmission of an Npcf\_PolicyAuthorization\_Delete response by the PCF to an NF consumer indicating a failed SM policy authorization deletion (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) PAU.SmDeleteFail.*cause*
Where *cause* indicates the failure cause of the SM policy authorization deletion.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

### 5.5.7 Event exposure related measurements

#### 5.5.7.1 Event exposure subscribe

##### 5.5.7.1.1 Number of event exposure subscribe requests

a) This measurement provides the number of event exposure subscribe requests received by the PCF.

b) CC

c) Receipt of an Npcf\_EventExposure\_Subscribe request by the PCF from an NF consumer (e.g., NEF) (see TS 23.502 [7]).

d) An integer value

e) EEX.SubscribeReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.7.1.2 Number of successful event exposure subscribe

a) This measurement provides the number of successful event exposure subscribe at the PCF.

b) CC

c) Transmission of an Npcf\_EventExposure\_Subscribe response by the PCF to an NF consumer (e.g., NEF) indicating a successful event exposure subscribe (see TS 29.507 [39]).

d) An integer value

e) EEX.SubscribeSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.7.1.3 Number of failed event exposure subscribe

a) This measurement provides the number of failed event exposure subscribe at the PCF.

b) CC

c) Transmission of an Npcf\_EventExposure\_Subscribe response by the PCF to an NF consumer (e.g., NEF) indicating a failed event exposure subscribe (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) EEX.SubscribeFail.*cause*
Where *cause* indicates the failure cause of the event exposure subscribe.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.5.7.2 Event exposure unsubscription

##### 5.5.7.2.1 Number of event exposure unsubscribe requests

a) This measurement provides the number of event exposure unsubscribe requests received by the PCF.

b) CC

c) Receipt of an Npcf\_EventExposure\_Unsubscribe request by the PCF from an NF consumer (e.g., NEF) (see 3GPP TS 23.502 [7]).

d) An integer value

e) EEX.UnsubscribeReq

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.7.2.2 Number of successful event exposure unsubscribe

a) This measurement provides the number of successful event exposure unsubscribe at the PCF.

b) CC

c) Transmission of an Npcf\_EventExposure\_Unsubscribe response by the PCF to an NF consumer (e.g., NEF) indicating a successful event exposure unsubscribe (see TS 29.507 [39]).

d) An integer value

e) EEX.UnsubscribeSucc

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.5.7.2.3 Number of failed event exposure unsubscribe

a) This measurement provides the number of failed event exposure unsubscribe at the PCF.

b) CC

c) Transmission of an Npcf\_EventExposure\_Unsubscribe response by the PCF to an NF consumer (e.g., NEF) indicating a failed event exposure unsubscribe (see TS 29.507 [39]), each message increments the relevant subcounter per failure cause by 1.

d) An integer value

e) EEX.UnsubscribeFail.*cause*
Where *cause* indicates the failure cause of the event exposure unsubscribe.

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.5.7.3 Event exposure notification

##### 5.5.7.3.1 Number of event exposure notifications

a) This measurement provides the number of event exposure notifications sent by the PCF.

b) CC

c) Transmission of an Npcf\_EventExposure\_Notify message by the PCF to an NF consumer (e.g., NEF) (see TS 29.502 [7]).

d) An integer value

e) EEX.NotifyNbr

f) PCFFunction

g) Valid for packet switched traffic

h) 5GS

## 5.6 Performance measurements for UDM

### 5.6.1 Mean number of registered subscribers through UDM

a) This measurement provides the mean number of registered subscribers to UDM .

b) SI

c) This measurement is obtained by sampling at a unified interval the number of registered subscribers in a UDM and then taking the arithmetic mean.

d) A single integer value

e) RM.RegisteredSubUDMNbrMean

f) UDMFunction

g) Valid for packet switching

h) 5GS

### 5.6.2 Maximum number of registered subscribers through UDM

a) This measurement provides the maximum number of registered subscribers to UDM .

b) SI

c) This measurement is obtained by sampling at a unified interval the number of registered subscribers in the UDM and then taking the maximum.

d) A single integer value

e) RM.RegisteredSubUDMNbrMax

f) UDMFunction

g) Valid for packet switching

h) 5GS

### 5.6.3 Mean number of unregistered subscribers through UDM

a) This measurement provides the mean number of unregistered subscribers to UDM .

b) SI

c) This measurement is obtained by sampling at a unified interval the number of unregistered subscribers in the UDM and then taking the arithmetic mean.

d) A single integer value

e) RM.UnregisteredSubUDMNbrMean

f) UDMFunction

g) Valid for packet switching

h) 5GS

### 5.6.4 Maximum number of unregistered subscribers through UDM

a) This measurement provides the maximum number of unregistered subscribers to UDM .

b) SI

c) This measurement is obtained by sampling at a unified interval the number of unregistered subscribers in the UDM and then taking the maximum.

d) A single integer value

e) RM.UnregisteredSubUDMNbrMax

f) UDMFunction

g) Valid for packet switching

h) 5GS

### 5.6.5 Distribution of subscriber profile sizes in UDM

a) This measurement provides the distribution of subscriber profile sizes in UDM.

b) CC

c) This measurement is obtained by the following method:

- for each observed subscriber profile its size is determined;

- the bin with the range corresponding to the observed service profile size is selected;

- the value of the counter for the selected bin is incremented by 1

E.g. for observed subscriber profile size of 3300 bytes, the counter corresponding to the bin "0-5000" is incremented by one.

d) Each measurement is an integer representing the count of service profiles with size within the range of the bin.

e) RM.SubscriberProfileSizesCount.Bin where Bin indicates the size range which is vendor specific.

f) UDMFunction

g) Valid for packet switching

h) 5GS

### 5.6.6 Mean size of subscriber profiles in UDM

a) This measurement provides the mean size of subscriber profiles in UDM.

b) SI

c) This measurement is obtained by inspecting the sizes ot subscriber profiles in UDM and then takin their arithmetic mean.

d) A single integer value.

e) RM.SubscriberProfileSizesMean.

f) UDMFunction

g) Valid for packet switching

h) 5GS

### 5.6.7 Distribution of UDM SubscriberDataManagement message sizes

a) This measurement provides the distribution of message sizes in UDM SubscriberDataManagement.

b) DER (n=1)

c) This measurement is obtained by the following method:

- for each observed UDM\_SubscriberDataManagement response or notification message ("SDM Get Response", "SDM Notification Notify", "SDM Info Response") its size is determined;

- the bin with the range corresponding to the observed message size is selected under sub-counter corresponding to the message type;

- the value of the counter for the selected bin is incremented by 1

E.g. for an observed "SDM Get Response" message with size of 4500 bytes, the counter corresponding to the bin "0-5000" is incremented by one.

d) Each measurement is an integer representing the count of service profiles with size within the range of the bin.

e) RM.UdmSdm.GetResponseSize.Bin where Bin indicates the size range which is vendor specific.

RM.UdmSdm.NotificationSize.Bin where Bin indicates the size range which is vendor specific.

RM.UdmSdm.InfoResponseSize.Bin where Bin indicates the size range which is vendor specific.

f) UDMFunction

g) Valid for packet switching

h) 5GS

### 5.6.8 Subscriber data management related measurements

#### 5.6.8.1 Subscription data getting

##### 5.6.8.1.1 Number of subscription data getting requests

a) This measurement provides the number of subscription data getting requests received by the UDM.

b) CC

c) Receipt of an Nudm\_SDM\_Get request by the UDM from a consumer NF (e.g., AMF), each message increments the relevant subcounter per subscriber data type by 1 (see 3GPP TS 23.502 [7]).

d) An integer value

e) SDM.GetReq.*Type,*Where *Type* indicates the subscription data type.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.8.1.2 Number of successful subscription data gettings

a) This measurement provides the number of successful subscription data gettings at UDM.

b) CC

c) Transmission of an Nudm\_SDM\_Get response by the UDM to a consumer NF (e.g., AMF) indicating a successful subscription data getting, each message increments the relevant subcounter per subscriber data type by 1 (see 3GPP TS 29.503 [51]).

d) An integer value

e) SDM.GetSucc.*Type,*Where *Type* indicates the subscription data type.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.8.1.3 Number of failed subscription data gettings

a) This measurement provides the number of failed subscription data gettings at UDM.

b) CC

c) Transmission of an Nudm\_SDM\_Get response by the UDM to a consumer NF (e.g., AMF) indicating a failed subscription data getting, each message increments the relevant subcounter per failure case by 1 (see TS 29.503 [51]).

d) An integer value

e) SDM.GetFail.*Cause,*Where *Cause* indicates the failure cause of the subscription data getting.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.6.8.2 SDM subscription

##### 5.6.8.2.1 Number of SDM subscribing requests

a) This measurement provides the number of SDM subscribing requests received by the UDM.

b) CC

c) Receipt of an Nudm\_SDM\_Subscribe request by the UDM from a consumer NF (e.g., AMF), each message increments the relevant subcounter per subscriber data type by 1 (see 3GPP TS 23.502 [7]).

d) An integer value

e) SDM.SubscribeReq.*Type,*Where *Type* indicates the subscription data type.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.8.2.2 Number of successful SDM subscribings

a) This measurement provides the number of successful SDM subscribings at UDM.

b) CC

c) Transmission of an Nudm\_SDM\_Subscribe by the UDM to a consumer NF (e.g., AMF) indicating a successful SDM subscribings, each message increments the relevant subcounter per subscriber data type by 1 (see 3GPP TS 29.503 [51[x]]).

d) An integer value

e) SDM.SubscribeSucc.*Type,*Where *Type* indicates the subscription data type.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.8.2.3 Number of failed SDM subscribings

a) This measurement provides the number of failed SDM subscribings at UDM.

b) CC

c) Transmission of an Nudm\_SDM\_Subscribe response by the UDM to a consumer NF (e.g., AMF) indicating a failed SDM subscribings, each message increments the relevant subcounter per failure case by 1 (see TS 29.503 [51]).

d) An integer value

e) SDM.SubscribeFail.*Cause,*Where *Cause* indicates the failure cause of the SDM subscribing.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.6.8.3 Subscription data notification

##### 5.6.8.3.1 Number of subscription data notifications

a) This measurement provides the number of subscription data notifications sent by the UDM.

b) CC

c) Transmission of an Nudm\_SDM\_Notification by the UDM from a consumer NF (e.g., AMF), each message increments the relevant subcounter per subscriber data type by 1 (see TS 23.502 [7]).

d) An integer value

e) SDM.SubDataNotif.*Type,*Where *Type* indicates the subscription data type.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

### 5.6.9 Parameter provisioning related measurements

#### 5.6.9.1 Parameter creations

##### 5.6.9.1.1 Number of parameter creation requests

a) This measurement provides the number of parameter creation requests received by the UDM.

b) CC

c) Receipt of an Nnef\_ParameterProvision\_Create request by the UDM from a consumer NF (e.g., NEF) (see TS 23.502 [7]).

d) An integer value

e) PPV.CreateReq.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.1.2 Number of successful parameter creations

a) This measurement provides the number of successful parameter creations at UDM.

b) CC

c) Transmission of an Nnef\_ParameterProvision\_Create response by the UDM to a consumer NF (e.g., AMF) indicating a successful parameter creation (see TS 29.503 [51]).

d) An integer value

e) PPV.CreateSucc.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.1.3 Number of failed parameter creations

a) This measurement provides the number of failed parameter creations at UDM.

b) CC

c) Transmission of an Nnef\_ParameterProvision\_Create response by the UDM to a consumer NF (e.g., AMF) indicating a failed parameter creation, each message increments the relevant subcounter per failure case by 1 (see TS 29.503 [51]).

d) An integer value

e) PPV.CreateFail.*Cause,*Where *Cause* indicates the failure cause of the parameter creation.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.6.9.2 Parameter update

##### 5.6.9.2.1 Number of parameter update requests

a) This measurement provides the number of parameter update requests received by the UDM.

b) CC

c) Receipt of an Nudm\_ParameterProvision\_Update request by the UDM from a consumer NF (e.g., NEF) (see TS 23.502 [7]).

d) An integer value

e) PPV.UpdateReq.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.2.2 Number of successful parameter updates

a) This measurement provides the number of successful parameter updates at UDM.

b) CC

c) Transmission of an Nudm\_ParameterProvision\_Update response by the UDM to a consumer NF (e.g., AMF) indicating a successful parameter update (see TS 29.503 [51]).

d) An integer value

e) PPV.UpdateSucc.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.2.3 Number of failed parameter updates

a) This measurement provides the number of failed parameter updates at UDM.

b) CC

c) Transmission of an Nudm\_ParameterProvision\_Update response by the UDM to a consumer NF (e.g., AMF) indicating a failed parameter update, each message increments the relevant subcounter per failure case by 1 (see TS 29.503 [51]).

d) An integer value

e) PPV.UpdateFail.*Cause,*Where *Cause* indicates the failure cause of the parameter update.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.6.9.3 Parameter deletion

##### 5.6.9.3.1 Number of parameter deletion requests

a) This measurement provides the number of parameter deletion requests received by the UDM.

b) CC

c) Receipt of an Nudm\_ParameterProvision\_Delete request by the UDM from a consumer NF (e.g., NEF) (see TS 23.502 [7]).

d) An integer value

e) PPV.DeleteReq.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.3.2 Number of successful parameter deletions

a) This measurement provides the number of successful parameter deletions at UDM.

b) CC

c) Transmission of an Nudm\_ParameterProvision\_Delete response by the UDM to a consumer NF (e.g., AMF) indicating a successful parameter deletion (see TS 29.503 [51]).

d) An integer value

e) PPV.DeleteSucc.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.3.3 Number of failed parameter deletions

a) This measurement provides the number of failed parameter deletions at UDM.

b) CC

c) Transmission of an Nudm\_ParameterProvision\_Delete response by the UDM to a consumer NF (e.g., AMF) indicating a failed parameter deletion, each message increments the relevant subcounter per failure case by 1 (see TS 29.503 [51]).

d) An integer value

e) PPV.DeleteFail.*Cause,*Where *Cause* indicates the failure cause of the parameter deletion.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

#### 5.6.9.4 Parameter getting

##### 5.6.9.4.1 Number of parameter getting requests

a) This measurement provides the number of parameter getting requests received by the UDM.

b) CC

c) Receipt of an Nudm\_ParameterProvision\_Get request by the UDM from a consumer NF (e.g., NEF) (see TS 23.502 [7]).

d) An integer value

e) PPV.GetReq.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.4.2 Number of successful parameter gettings

a) This measurement provides the number of successful parameter gettings at UDM.

b) CC

c) Transmission of an Nudm\_ParameterProvision\_Get response by the UDM to a consumer NF (e.g., AMF) indicating a successful parameter getting (see TS 29.503 [51]).

d) An integer value

e) PPV.GetSucc.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

##### 5.6.9.4.3 Number of failed parameter gettings

a) This measurement provides the number of failed parameter gettings at UDM.

b) CC

c) Transmission of an Nudm\_ParameterProvision\_Get response by the UDM to a consumer NF (e.g., AMF) indicating a failed parameter getting, each message increments the relevant subcounter per failure case by 1 (see TS 29.503 [51]).

d) An integer value

e) PPV.GetFail.*Cause,*Where *Cause* indicates the failure cause of the parameter getting.

f) UDMFunction

g) Valid for packet switched traffic

h) 5GS

## 5.7 Common performance measurements for NFs

### 5.7.1 VR usage of NF

#### 5.7.1.1 Virtual CPU usage

##### 5.7.1.1.1 Mean virtual CPU usage

a) This measurement provides the mean usage of the underlying virtualized CPUs for a virtualized 3GPP NF. This measurement is not applicable to the scenario that one VNFC instance supports more than 1 NFs.

b) OM.

c) The measurement job control service producer for NF(s) receives the VcpuUsageMeanVnf.*vComputeId* measurement(s) (see ETSI GS IFA 027 [17]) for the VNFC instances(s) from VNFM, and maps the measured object of each received measurement from VNFC instance to the MOI(s) of NF(s). The measurement is generated by taking the weighted average of the values of the VcpuUsageMeanVnf.*vComputeId* measurement(s) whose measured object(s) are mapped to the MOI of the measured NF. The algorithm of the weighted average is vendor specific.

d) A single integer value (Unit: %).

e) VR.VCpuUsageMean

f) GNBCUCPFunction (for 3 split scenario)
GNBCUUPFunction (for 3 split scenario)
GNBCUFunction (for 2 split scenario)
AMFFunction
SMFFunction
UPFFunction
N3IWFFunction
PCFFunction
AUSFFunction
UDMFunction
UDRFunction
UDSFFunction
NRFFunction
NSSFFunction
SMSFFunction
LMFFunction
NWDAFFunction
NGEIRFunction
SEPPFunction

 EASFunction

 EESFunction

 ECSFunction

g) Valid for packet switched traffic.

h) 5GS.

#### 5.7.1.2 Virtual memory usage

##### 5.7.1.2.1 Mean virtual memory usage

a) This measurement provides the mean usage of the underlying virtualized memories for a virtualized 3GPP NF. This measurement is not applicable to the scenario that one VNFC instance supports more than 1 NFs.

b) OM.

c) The measurement job control service producer for NF(s) receives the VmemoryUsageMeanVnf.*vComputeId* measurement(s) (see ETSI GS IFA 027 [17]) for the VNFC instances(s) from VNFM, and maps the measured object of each received measurement from VNFC instance to the MOI(s) of NF(s). The measurement is generated by taking the weighted average of the values of the VmemoryUsageMeanVnf.*vComputeId* measurement(s) whose measured object(s) are mapped to the MOI of the measured NF. The algorithm of the weighted average is vendor specific.

d) A single integer value (Unit: %).

e) VR.VMemoryUsageMean

f) GNBCUCPFunction (for 3 split scenario)
GNBCUUPFunction (for 3 split scenario)
GNBCUFunction (for 2 split scenario)
AMFFunction
SMFFunction
UPFFunction
N3IWFFunction
PCFFunction
AUSFFunction
UDMFunction
UDRFunction
UDSFFunction
NRFFunction
NSSFFunction
SMSFFunction
LMFFunction
NWDAFFunction
NGEIRFunction
SEPPFunction

 EASFunction

 EESFunction

 ECSFunction

g) Valid for packet switched traffic.

h) 5GS.

#### 5.7.1.3 Virtual disk usage

##### 5.7.1.3.1 Mean virtual disk usage

a) This measurement provides the mean usage of the underlying virtualized disks for a virtualized 3GPP NF. This measurement is not applicable to the scenario that one VNFC instance supports more than 1 NFs.

b) OM.

c) The measurement job control service producer for NF(s) receives the VdiskUsageMeanVnf.*vComputeId* measurement(s) (see ETSI GS IFA 027 [17]) for the VNFC instances(s) from VNFM, and maps the measured object of each received measurement from VNFC instance to the MOI(s) of NF(s). The measurement is generated by taking the weighted average of the values of the VdiskUsageMeanVnf.*vComputeId* measurement(s) whose measured object(s) are mapped to the MOI of the measured NF. The algorithm of the weighted average is vendor specific.

d) A single integer value (Unit: %).

e) VR.VDiskUsageMean

f) GNBCUCPFunction (for 3 split scenario)
GNBCUUPFunction (for 3 split scenario)
GNBCUFunction (for 2 split scenario)
AMFFunction
SMFFunction
UPFFunction
N3IWFFunction
PCFFunction
AUSFFunction
UDMFunction
UDRFunction
UDSFFunction
NRFFunction
NSSFFunction
SMSFFunction
LMFFunction
NWDAFFunction
NGEIRFunction
SEPPFunction

 EASFunction

 EESFunction

 ECSFunction

g) Valid for packet switched traffic.

h) 5GS.

### 5.7.2 Connection data volumes of NF

#### 5.7.2.1 Data volume of incoming bytes to EAS

a) This measurement provides the number of incoming bytes received by the EAS (Edge Application Server) [50] in edge data networks.

b) OM.

c) The measurement job control service producer for NF(s) receives the *ByteIncomingVnfExtCp* measurement(s) (see ETSI GS IFA 027 [17]) for the VNFC instances(s) supporting the EAS VNF from VNFM, and maps the measured object of received measurement(s) from VNFC instance to the EASFunction MOI [50]. The measurement is generated by aggregating the values of the *ByteIncomingVnfExtCp* measurement(s).

d) A single integer value.

e) DataVolum.InBytesEAS

f) EASFunction

g) Valid for packet switched traffic.

h) 5GS.

#### 5.7.2.2 Data volume of outgoing bytes from EAS

a) This measurement provides the number of outgoing bytes transmitted from the EAS in edge data networks.

b) OM.

c) The measurement job control service producer for NF(s) receives the *ByteOutgoingVnfExtCp* measurement(s) (see ETSI GS IFA 027 [17]) for the VNFC instances(s) supporting the EAS VNF from VNFM, and maps the measured object of received measurement(s) from VNFC instance to the EASFunction MOI. The measurement is generated by aggregating the values of the *ByteOutgoingVnfExtCp* measurement(s).

d) A single integer value.

e) DataVolum.OutBytesEAS

f) EASFunction

g) Valid for packet switched traffic.

h) 5GS.

#### 5.7.2.3 Data volume of incoming packets to EAS

a) This measurement provides the number of incoming packets received by the EAS in edge data networks.

b) OM.

c) The measurement job control service producer for NF(s) receives the *PacketIncomingVnfExtCp* measurement(s) (see ETSI GS IFA 027 [17]) for the VNFC instances(s) supporting the EAS VNF from VNFM, and maps the measured object of received measurement(s) from VNFC instance to the EASFunction MOI. The measurement is generated by aggregating the values of the *PacketIncomingVnfExtCp* measurement(s).

d) A single integer value.

e) DataVolum.InPacketsEAS

f) EASFunction

g) Valid for packet switched traffic.

h) 5GS.

#### 5.7.2.3 Data volume of Outgoing packets to EAS

a) This measurement provides the number of outgoing packets received by the EAS in edge data networks.

b) OM.

c) The measurement job control service producer for NF(s) receives the *PacketOutgoingVnfExtCp* measurement(s) (see ETSI GS IFA 027 [17]) for the VNFC instances(s) supporting the EAS VNF from VNFM, and maps the measured object of received measurement(s) from VNFC instance to the EASFunction MOI. The measurement is generated by aggregating the values of the *PacketOutgoingVnfExtCp* measurement(s).

d) A single integer value.

e) DataVolum.OutPacketsEAS

f) EASFunction

g) Valid for packet switched traffic.

h) 5GS.

## 5.8 Performance measurements for N3IWF

### 5.8.1 PDU Session Resource management

#### 5.8.1.1 PDU Session Resource setup

##### 5.8.1.1.1 Number of PDU Sessions requested to setup

a) This measurement provides the number of PDU Sessions in the PDU SESSION RESOURCE SETUP REQUESTs received by the N3IWF from AMF. This measurement is split into subcounters per S-NSSAI.

b) CC.

c) Receipt of PDU SESSION RESOURCE SETUP REQUEST message (see TS 29.413 [22]) by the N3IWF from the AMF. Each PDU Session requested to setup increments the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionSetupNon3GPPReq.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.1.1.2 Number of PDU Sessions successfully setup

a) This measurement provides the number of PDU Sessions successfully setup by the N3IWF for the PDU SESSION RESOURCE SETUP REQUESTs received from AMF. This measurement is split into subcounters per S-NSSAI.

b) CC.

c) Transmission of PDU SESSION RESOURCE SETUP RESPONSE message containing the "PDU Session Resource Setup Response List" IE (see TS 38.413 [11]) by the N3IWF to the AMF. Each PDU Session listed in the "PDU Session Resource Setup Response List" IE increments the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionSetupNon3GPPSucc.*SNSSAI.*

 Where *SNSSAI* identifies the *S-NSSAI*.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.1.1.3 Number of PDU Sessions failed to setup

a) This measurement provides the number of PDU Sessions failed to setup by the N3IWF for the PDU SESSION RESOURCE SETUP REQUESTs received from AMF. This measurement is split into subcounters per failure cause.

b) CC.

c) Transmission of PDU SESSION RESOURCE SETUP RESPONSE message containing the "PDU Session Resource Failed to Setup List" IE (see TS 38.413 [11]) by the N3IWF to the AMF. Each PDU Session listed in the "PDU Session Resource Failed to Setup List" IE increments the relevant subcounter per failure cause (see clause 9.3.1.2 of TS 38.413 [11]) by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionSetupNon3GPPFail.*Cause.*

 Where *Cause* identifies the cause of the PDU Sessions Resource Setup failure, per the "PDU Session Resource Setup Unsuccessful Transfer" IE. Encoding of the Cause is defined in clause 9.3.1.2 of TS 38.413 [11].

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.8.1.2 PDU Session Resource modification

##### 5.8.1.2.1 Number of PDU Sessions requested to modify

a) This measurement provides the number of PDU Sessions in the PDU SESSION RESOURCE MODIFY REQUESTs received by the N3IWF from AMF. This measurement is split into subcounters per S-NSSAI.

b) CC.

c) Receipt of PDU SESSION RESOURCE MODIFY REQUEST message (see TS 29.413 [22]) by the N3IWF from the AMF. Each PDU Session requested to modify increments the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionModifyNon3GPPReq.*SNSSAI.*

 Where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.1.2.2 Number of PDU Sessions successfully modified

a) This measurement provides the number of PDU Sessions successfully modified by the N3IWF for the PDU SESSION RESOURCE MODIFY REQUESTs received from AMF. This measurement is split into subcounters per S-NSSAI.

b) CC.

c) Transmission of PDU SESSION RESOURCE MODIFY RESPONSE message containing the "PDU Session Resource Modify Response Item" IE (see TS 38.413 [11]) by the N3IWF to the AMF. Each PDU Session listed in the "PDU Session Resource Modify Response Item" IE increments the relevant subcounter per S-NSSAI by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionModifyNon3GPPSucc.*SNSSAI.*

 Where *SNSSAI* identifies the *S-NSSAI*.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.1.2.3 Number of PDU Sessions failed to modify

a) This measurement provides the number of PDU Sessions failed to modify by the N3IWF for the PDU SESSION RESOURCE MODIFY REQUESTs received from AMF. This measurement is split into subcounters per failure cause.

b) CC.

c) Transmission of PDU SESSION RESOURCE MODIFY RESPONSE message containing the "PDU Session Resource Failed to Modify List" IE (see TS 38.413 [11]) by the N3IWF to the AMF. Each PDU Session listed in the "PDU Session Resource Failed to Modify List" IE increments the relevant subcounter per failure cause (see clause 9.3.1.2 of TS 38.413 [11]) by 1.

d) Each subcounter is an integer value.

e) SM.PDUSessionModifyNon3GPPFail.*Cause.*

 Where *Cause* identifies the cause of the PDU Sessions Resource modification failure, per the "PDU Session Resource Modify Unsuccessful Transfer" IE. Encoding of the Cause is defined in clause 9.3.1.2 of TS 38.413 [11].

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.8.2 QoS flow management

#### 5.8.2.1 QoS flow setup via untrusted non-3GPP access

##### 5.8.2.1.1 Number of initial QoS flows attempted to setup via untrusted non-3GPP access

a) This measurement provides the number of QoS flows attempted to setup via untrusted non-3GPP access during initial UE context setup. The measurement is split into subcounters per 5QI and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) Receipt by the N3IWF of an INITIAL CONTEXT SETUP REQUEST message (see TS 29.413 [22]). Each QoS flow requested to setup in the message is added to the relevant measurement per 5QI and relevant subcounter per per S-NSSAI.

d) Each measurement is an integer value.

e) QF.EstabNbrInitUntrustNon3gppAtt.*5QI,* where *5QI* identifies the 5QI, and

 QF.EstabNbrInitUntrustNon3gppAtt.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.1.2 Number of initial QoS flows successfully setup via untrusted non-3GPP access

a) This measurement provides the number of QoS flows successfully setup via untrusted non-3GPP access during initial UE context setup. The measurement is split into subcounters per 5QI and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) Transmission by the N3IWF of an INITIAL CONTEXT SETUP RESPONSE message (see TS 29.413 [22]). Each QoS flow successfully setup in the message is added to the relevant measurement per 5QI and per S-NSSAI.

d) Each measurement is an integer value.

e) The measurement name has the form:

e) QF.EstabNbrInitUntrustNon3gppSucc.*5QI,* where *5QI* identifies the 5QI, and

 QF.EstabNbrInitUntrustNon3gppSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.1.3 Number of initial QoS flows failed to setup via untrusted non-3GPP access

a) This measurement provides the number of QoS flows failed to setup via untrusted non-3GPP access during initial UE context setup. The measurement is split into subcounters per failure cause.

b) CC.

c) Transmission by the N3IWF of an INITIAL CONTEXT SETUP RESPONSE message (see TS 29.413 [22]). Each QoS flow failed to setup in the message is added to the relevant measurement per cause, the possible causes are specified in TS 38.413 [11].

d) Each measurement is an integer value.

e) QF.EstabNbrInitUntrustNon3gppFail.*cause,* where *cause* identifies the cause (see TS 38.413 [11]).

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.1.4 Number of additional QoS flows attempted to setup via untrusted non-3GPP access

a) This measurement provides the number of additional QoS flows attempted to setup via untrusted non-3GPP access. The measurement is split into subcounters per 5QI and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) Receipt by the N3IWF of a PDU SESSION RESOURCE SETUP REQUEST message or a PDU SESSION RESOURCE MODIFY REQUEST message (see TS 29.413 [22]). Each QoS flow requested to setup in the message is added to the relevant measurement per 5QI and relevant subcounter per per S-NSSAI.

d) Each measurement is an integer value.

e) QF.EstabNbrAddUntrustNon3gppAtt.*5QI,* where *5QI* identifies the 5QI, and

 QF.EstabNbrAddUntrustNon3gppAtt.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.1.5 Number of additional QoS flows successfully setup via untrusted non-3GPP access

a) This measurement provides the number of additional QoS flows successfully setup via untrusted non-3GPP access. The measurement is split into subcounters per 5QI and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) Transmission by the N3IWF of a PDU SESSION RESOURCE SETUP RESPONSE message or a PDU SESSION RESOURCE MODIFY RESPONSE message (see TS 29.413 [22]). Each QoS flow successfully setup in the message is added to the relevant measurement per 5QI and per S-NSSAI.

d) Each measurement is an integer value.

e) The measurement name has the form:

e) QF.EstabNbrAddUntrustNon3gppSucc.*5QI,* where *5QI* identifies the 5QI, and

 QF.EstabNbrAddUntrustNon3gppSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.1.6 Number of additional QoS flows failed to setup via untrusted non-3GPP access

a) This measurement provides the number of additional QoS flows failed to setup via untrusted non-3GPP access. The measurement is split into subcounters per failure cause.

b) CC.

c) Transmission by the N3IWF of a PDU SESSION RESOURCE SETUP RESPONSE message or a PDU SESSION RESOURCE MODIFY RESPONSE message (see TS 29.413 [22]). Each QoS flow failed to setup in the message is added to the relevant measurement per cause, the possible causes are specified in TS 38.413 [11].

d) Each measurement is an integer value.

e) QF.EstabNbrAddUntrustNon3gppFail.*cause,* where *cause* identifies the cause (see TS 38.413 [11]).

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.8.2.2 QoS flow modification via untrusted non-3GPP access

##### 5.8.2.2.1 Number of QoS flows attempted to modify via untrusted non-3GPP access

a) This measurement provides the number of QoS flows attempted to modify via untrusted non-3GPP access. The measurement is split into subcounters per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) On receipt by the N3IWF of a PDU SESSION RESOURCE MODIFY REQUEST message (see TS 38.413 [11]), each QoS flow requested to modify in this message is added to the relevant subcounter per QoS level (5QI) and relevant subcounter per S-NSSAI. In case the 5QI of the QoS flow is modified, the QoS flow is counted to the subcounter for the target 5QI.

d) Each measurement is an integer value.

e) QF.ModNbrUntrustNon3gppAtt.*5QI,* where *5QI* identifies the 5QI, and

 QF.ModNbrUntrustNon3gppAtt.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.2.2 Number of QoS flows successfully modified via untrusted non-3GPP access

a) This measurement provides the number of QoS flows successfully modified via untrusted non-3GPP access. The measurement is split into subcounters per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) On transmission by the N3IWF of a PDU SESSION RESOURCE MODIFY RESPONSE message (see TS 38.413 [11]), each QoS flow successfully modified is added to the relevant subcounter per QoS level (5QI) and relevant subcounter per S-NSSAI. In case the 5QI of the QoS flow is modified, the QoS flow is counted to the subcounter for the target 5QI.

d) Each measurement is an integer value.

e) QF.ModNbrUntrustNon3gppSucc.*5QI,* where *5QI* identifies the 5QI, and

 QF.ModNbrUntrustNon3gppSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.2.3 Number of QoS flows failed to modify via untrusted non-3GPP access

a) This measurement provides the number of QoS flows failed to modify via untrusted non-3GPP access. The measurement is split into subcounters per failure cause.

b) CC.

c) On transmission by the N3IWF of a PDU SESSION RESOURCE MODIFY RESPONSE message (see TS 38.413 [11]), each QoS flow failed to modify is added to the relevant subcounter per cause.

d) Each measurement is an integer value.

e) QF.ModNbrUntrustNon3gppFail.*cause,* where *cause* identifies the cause (see TS 38.413 [11]).

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.8.2.3 QoS flow release via untrusted non-3GPP access

##### 5.8.2.3.1 Number of QoS flows attempted to release

a) This measurement provides the number of QoS flows attempted to release via untrusted non-3GPP access. The measurement is split into subcounters per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) Receipt by the N3IWF of a PDU SESSION RESOURCE RELEASE COMMAND, PDU SESSION RESOURCE MODIFY REQUEST or UE CONTEXT RELEASE COMMAND message from AMF. Each QoS flow requested to release increments the relevant subcounter per 5QI and the relevant subcounter per S-NSSAI by 1 respectively.

d) Each measurement is an integer value.

e) QF.RelNbrUntrustNon3gppAtt.*5QI,* where *5QI* identifies the 5QI, and

 QF.RelNbrUntrustNon3gppAtt.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.3.2 Number of QoS flows successfully released

a) This measurement provides the number of QoS flows successfully released via untrusted non-3GPP access. The measurement is split into subcounters per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) Transmission by the N3IWF of a PDU SESSION RESOURCE RELEASE RESPONSE, PDU SESSION RESOURCE MODIFY RESPONSE or UE CONTEXT RELEASE COMPLETE message. Each QoS flow requested to release increments the relevant subcounter per 5QI and the relevant subcounter per S-NSSAI by 1 respectively.

d) Each measurement is an integer value.

e) QF.RelNbrUntrustNon3gppSucc.*5QI,* where *5QI* identifies the 5QI, and

 QF.RelNbrUntrustNon3gppSucc.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

##### 5.8.2.3.3 Number of released active QoS flows

a) This measurement provides the number of released QoS flows that were active at the time of release via untrusted non-3GPP access. QoS flows with bursty flow are seen as being active when there is user data in the queue in any of the directions. QoS flows with continuous flow are always seen as active QoS flows in the context of this measurement. This measurement is split into subcounters per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI).

b) CC.

c) Transmission by the N3IWF of a PDU SESSION RESOURCE RELEASE RESPONSE message for the PDU session resource release initiated by the AMF with the exception of corresponding PDU SESSION RESOURCE RELEASE COMMAND message with "Cause" equal to "Normal Release" or "User inactivity", "Load balancing TAU required", "Release due to CN-detected mobility", "O&M intervention", or transmission by the PDU SESSION RESOURCE MODIFY RESPONSE message for the PDU session resource modification initiated by the AMF with the exception of corresponding PDU SESSION RESOURCE MODIFY REQUEST message with the "Cause" equal to "Normal Release", or transmission by the N3IWF of UE CONTEXT RELEASE COMPLETE for the UE context release initiated by the N3IWF with the exception of the corresponding UE CONTEXT RELEASE REQUEST message with the cause equal to "Normal Release" or "User inactivity", "Partial handover", "Successful handover", or transmission by the N3IWF of UE CONTEXT RELEASE COMPLETE message for the UE context release initiated by the AMF with the exception of the corresponding UE CONTEXT RELEASE COMMAND message with "Cause" equal to "Normal Release", "Handover Cancelled" or a successful mobility activity (e.g., cause "Successful Handover", or "NG Intra system Handover triggered"), or receipt by the N3IWF of a PATH SWITCH REQUEST ACKNOWLEDGE or PATH SWITCH REQUEST FAILED message by which some or all QoS flows in the corresponding PATH SWITCH REQUEST need to be released , or transmission by the N3IWF of a NG RESET ACKNOWLEDGE message to AMF; or receipt by the N3IWF of a NG RESET ACKNOWLEDGE message from AMF; if any of the UL or DL of the QoS flow is considered active in TS 38.413 [11].

QoS flows with bursty flow are considered active when there is still data transmission in the DL or UL. QoS flows with continuous flow are always seen as active QoS flows in the context of this measurement. Each released active QoS flow increments the relevant subcounter per QoS level (5QI) and subcounters per network slice identifier (S-NSSAI) by 1 respectively.

How to define for a particular 5QI if the QoS flow is of type bursty flow or continuous flow is outside the scope of this document.

d) Each measurement is an integer value.

e) QF.RelActNbrUntrustNon3gpp.*5QI,* where *5QI* identifies the 5QI, and

 QF.RelActNbrUntrustNon3gpp.*SNSSAI,* where *SNSSAI* identifies the S-NSSAI.

f) N3IWFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.8.3 Void

### 5.8.4 Void

#### End of changes