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Contents

Foreword

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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".

[55]   3GPP TS 23.558: "Architecture for enabling Edge Applications".

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).

- 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).

- SP (measurement related to service provisioning).

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 is in the following form:

<Performance measurement>_<*Filter*>

For appending *Filter,* the separator '_' is used to append the filter to a given Performance measurement name. Vendor may also define any other separator.

If appending multiple *Filters*, the name is in the following form:

<Performance measurement>_<*Filter1*>_<*Filter2*>

The separator '_' or vendor specific separator is used between filters. The order is not important.

If no *Filter* is used, the name is in the form:

<Performance measurement>

The *Filter* is in the form: NameValue(s) where the name could be any of the possible *Filter* name defined for the performance measurement. When multiple values are provided for a given *Filter* name, values are separated by '|'. Value ranges are defined as 'x-y'. Combination of using '|' and ranges for the values of a given *Filter* name is possible. The order of the values is not important. Any other vendor specific multiple value form is allowed for the combination.

Examples:

- single *Filter* name with single value: DRB.PdcpF1DelayDl_*5QI22*

- single *Filter* name with multiple values: DRB.PdcpF1DelayDl_*5QI32|35-40*

- multiple (two) *Filter* names with single value per *Filter* name: DRB.PdcpF1DelayDl_*PLMN12_5QI20*

- multiple (two) *Filter* names and multiple values per *Filter* name: DRB.PdcpF1DelayDl_*PLMN2|5_5QI20-25*

- without any *Filter*: DRB.PdcpF1DelayDl

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) $\leq$ 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 $DRdl$ 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 $DRdl$ 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 $DRul$ 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 $DRul$ 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:

$$\frac{\sum_{i=1}^{N}(T2_i - T1_i)}{N}$$

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.

$$T2_i - T1_i$$

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: $M(T) = \left\lfloor \dfrac{M1(T)}{P(T)} * 100 \right\rfloor$, where $M(T)$ is the DL total PRB usage, which is percentage of PRBs used, averaged during time period T with value range: 0-100%; $M1(T)$ is a count of full physical resource blocks and all PRBs used for DL traffic transmission shall be included; $P(T)$ is total number of PRBs available for DL traffic transmission during time period T; and T 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: $M(T) = \left\lfloor \dfrac{M1(T)}{P(T)} * 100 \right\rfloor$, where $M(T)$ is the UL total PRB usage, which

is percentage of PRBs used, averaged during time period T with value range: 0-100%; $M1(T)$ is a count of full physical resource blocks and all PRBs used for UL traffic transmission shall be included; $P(T)$ is total number of PRBs available for UL traffic transmission during time period T; and T 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: $M[n] = \left\lfloor \dfrac{M1[n]}{P[n]} * 100 \right\rfloor$, where $M[n]$ is total PRB usage at sample

n for DL, which is a percentage of PRBs used, averaged during time period t_n (e.g. a millisecond) with value range: 0-100%; $M1[n]$ is a count of full physical resource blocks and all PRBs used for DL traffic transmission shall be included; $P(n)$ is the total number of PRBs available for DL traffic transmission during time period t_n and n is the sample with time period t_n 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 t_n.

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 defined by the vendor.

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: $M[n] = \left\lfloor \frac{M1[n]}{P[n]} * 100 \right\rfloor$, where $M[n]$ is total PRB usage at sample n for UL, which is a percentage of PRBs used, averaged during time period t_n (e.g. a millisecond) with value range: 0-100%; $M1[n]$ is a count of full physical resource blocks and all PRBs used for UL traffic transmission shall be included; $P(n)$ is the total number of PRBs available for UL traffic transmission during time period t_n and n is the sample with time period t_n 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 t_n.

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

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 performed, 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 performed, 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 performed, 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 performed, 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:

$$M_E(T) = \left\lfloor \frac{\sum_{\forall i} i * \sum_{\forall j} R_{ij}(T)}{\sum_{\forall j} P_j(T) * LM(T)} * 100 \right\rfloor$$

Where

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

$R_{ij}(T)$ denotes the number of PDSCH PRBs multiplexed by i MIMO layers at sampling occasion j.

$P_j(T)$ 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:

$$M_E(T) = \left\lfloor \frac{\sum_{\forall i} i * \sum_{\forall j} R_{ij}(T)}{\sum_{\forall j} P_j(T) * LM(T)} * 100 \right\rfloor,$$

Where

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

$R_{ij}(T)$ denotes the number of PUSCH PRBs multiplexed by i MIMO layers at sampling occasion j.

$P_j(T)$ 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:

$$M(T1) = \left\lfloor \frac{\sum_{\forall i} \sum_{\forall j} \{M1_{ij}(T1) * L_{ij}(T1)\}}{\sum_{\forall j} \{P_j(T1)\} * \beta} * 100 \right\rfloor$$

$$\beta = \max_{T2} Lave DL(T)$$

Where

$M(T1)$ denotes total PDSCH PRB usage per cell which is percentage of PRBs used, averaged during time period T1 with integer value.

$M1_{ij}(T1)$ denotes a count of PDSCH PRBs used for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carriers).

$L_{ij}(T1)$ denotes the number of MIMO layers scheduled for UE i at sampling occasion j.

i denotes a UE i that is scheduled during time period T1.

j denotes sampling occasion during time period T1 . A sampling occasion is 1 symbol.

$P_j(T1)$ denotes total number of PDSCH PRBs available for sampling occasion j on single MIMO layer per cell.

T1 denotes the time period during which the measurement is performed to calculate $M(T1)$, e.g. 15min, 1 hour, etc.

β is a variable factor for MIMO layers assigned with the maximum LaveDL during time period T2 with float value 1.00-100.00. For this measurement, the same β value is used for the entire duration of T1.

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

T denotes time period during which the measurement is performed to calculate $LaveDL(T)$, as defined in 5.1.1.30.

T2 is the time period during which the measurement is performed to calculate β, 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:

$$M(T1) = \left| \frac{\sum_{\forall i} \sum_{\forall j}\{M1_{ij}(T1) * L_{ij}(T1)\}}{\sum_{\forall j}\{P_j(T1)\} * \beta} * 100 \right|$$

$$\beta = \max_{T2} LaveUL(T)$$

Where

$M(T1)$ denotes total PUSCH PRB usage per cell which is percentage of PRBs used, averaged during time period T1 with integer value.

$M1_{ij}(T1)$ denotes a count of PUSCH PRBs used for traffic transmission for UE i on single MIMO layer per cell at sampling occasion j. Counting unit for PRB is 1 Resource Block x 1 symbol. (1 Resource Block = 12 sub-carriers).

$L_{ij}(T1)$ denotes the number of MIMO layers scheduled for UE i at sampling occasion j.

i denotes a UE i that is scheduled during time period T1.

j denotes sampling occasion during time period T1 . A sampling occasion is 1 symbol.

$P_j(T1)$ denotes total number of PUSCH PRB available for sampling occasion j on single MIMO layer per cell.

T1 denotes the time period during which the measurement is performed to calculate $M(T1)$, e.g. 15min, 1 hour, etc.

β is a variable factor for MIMO layers assigned with the maximum LaveUL during time period T2 with float value 1.00-100.00. For this measurement, the same β value is used for the entire duration of T1.

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

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

T2 is the time period during which the measurement is performed to calculate β, 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 $\sum_{UEs} \sum ThpTimeDl > 0$, $\frac{\sum_{UEs} \sum ThpVolDl}{\sum_{UEs} \sum ThpTimeDl} \times 1000$ [kbit/s]

If $\sum_{UEs} \sum ThpTimeDl = 0$, 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission, $ThpTimeDl = 0$, otherwise $ThpTimeDl = T1 - T2 \, [ms]$

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.
$T1$	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.
$T2$	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.
$ThpVolDl$	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 ID.

b) DER(N=1)

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 $\sum_{UEs} \sum ThpTimeDl > 0$, $\frac{\sum_{UEs} \sum ThpVolDl}{\sum_{UEs} \sum ThpTimeDl} \times 1000$ [kbit/s]

If $\sum_{UEs} \sum ThpTimeDl = 0$, 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission, $ThpTimeDl = 0$, otherwise $ThpTimeDl = T1 - T2$ $[ms]$

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.
$T1$	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.
$T2$	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.
$ThpVolDl$	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 ($ThpTimeDL$) may be counted and obtained by the formula:

$$ThpTimeDl = slot \times \frac{(TBVol - PaddingVol)}{TBVol} \, [ms]$$

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.

$$\text{If } \sum_{UEs} \sum ThpTimeUl > 0, \frac{\sum_{UEs} \sum ThpVolUl}{\sum_{UEs} \sum ThpTimeUl} \times 1000 \text{ [kbit/s]}$$

$$\text{If } \sum_{UEs} \sum ThpTimeUl = 0, 0 \text{ [kbit/s]}$$

For small data bursts, where all buffered data is included in one initial HARQ transmission $ThpTimeUl = 0$ otherwise:

$$ThpTimeUl = T1 - T2 \ [ms]$$

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).

    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) DER(N=1)

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 $\sum_{UEs} \sum ThpTimeUl > 0$, $\frac{\sum_{UEs} \sum ThpVolUl}{\sum_{UEs} \sum ThpTimeUl} \times 1000$ [kbit/s]

If $\sum_{UEs} \sum ThpTimeUl = 0$, 0 [kbit/s]

For small data bursts, where all buffered data is included in one initial HARQ transmission $ThpTimeUl = 0$ otherwise:

$$ThpTimeUl = T1 - T2 \ [ms]$$

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).

a)

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 ($ThpTimeUL$) may be counted and obtained by the formula:

$$ThpTimeUl = slot \times \frac{(TBVol - PaddingVol)}{TBVol} \ [ms]$$

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:

$$Percentage\ Unrestricted\ Volume\ DL = \frac{\sum_{UE} ThpUnresVolDl}{\sum_{UE}(ThpUnresVolDl + ThpVolDl)} * 100$$

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 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.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:

$$Percentage\ Unrestricted\ Volume\ UL\ = \frac{\sum_{UE} ThpUnresVolUl}{\sum_{UE}(ThpUnresVolUl + ThpVolUl)} * 100$$

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.

a)

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 performed, 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 performed, 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 performed, 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 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.

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 UE CONTEXT RELEASE [13] over Xn, or, if handover is performed via NG, the receipt of UE CONTEXT RELEASE COMMAND [11] from AMF and the sending of a RRCReconfiguration message triggering the Uu handover from the source NG-RAN to the UE 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 UE CONTEXT RELEASE [13] over Xn, or, if handover is performed via NG, the receipt of UE CONTEXT RELEASE COMMAND [11] from AMF and the sending of a RRCReconfiguration message triggering the Uu handover from the source NG-RAN to the UE 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 for source gNB per beam pair.

    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 at the source 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 NGAP UE CONTEXT RELEASE COMMAND are listed in [11]. An event increments the relevant subcounter by 1. For MM.HoExeInterSSBFail.UeCtxtRelCmd, 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.

Editor's note: FFS how the beam pair is identified

d) Each subcounter is an integer value.

e) MM.HoExeInterSSBFail.UeCtxtRelCmd.*cause*;
   MM.HoExeInterSSBFail.RrcReestabReq;
   MM.HoExeInterSSBFail.HoExeSupTimer;
   MM.HoExeInterSSBFail.RetrUeCtxtReq;

   Where *cause* identifies the failure cause of the NGAP 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   Intra-gNB handovers

5.1.1.6.2.1   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.

5.1.1.6.2.2   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.

5.1.1.6.3   Handovers between 5GS and EPS

5.1.1.6.3.1   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.

5.1.1.6.3.2   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.

5.1.1.6.3.3 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.

5.1.1.6.3.4 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.

5.1.1.6.3.5 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.

5.1.1.6.3.6   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

5.1.1.6.3.7   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.

5.1.1.6.3.8   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.

5.1.1.6.3.9 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.

5.1.1.6.3.10 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.

5.1.1.6.3.11 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.

5.1.1.6.3.12 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.

5.1.1.6.3.13 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.

5.1.1.6.3.14 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.

5.1.1.6.3.15 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.

5.1.1.6.3.16 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.

5.1.1.6.4 RRC redirection measurement

5.1.1.6.4.1 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

5.1.1.6.5 Intra/Inter-frequency Handover related measurements

5.1.1.6.5.1 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.

5.1.1.6.5.2 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.

5.1.1.6.5.3   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.

5.1.1.6.5.4   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.

5.1.1.6.6   Inter-gNB conditional handovers

5.1.1.6.6.1   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.

5.1.1.6.6.2 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.

5.1.1.6.6.3 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

5.1.1.6.6.4 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.

5.1.1.6.6.5 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.

5.1.1.6.6.6 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.

5.1.1.6.6.7 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.

5.1.1.6.6.8 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 if several *RRCReconfiguration* messages 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.

5.1.1.6.6.9 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.

5.1.1.6.6.10 Void

5.1.1.6.6.11 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 UE CONTEXT RELEASE (TS 38.423 [13] clause 8.2.7) over Xn and the receipt by the source NG-RAN from the target NG-RAN of a "HANDOVER SUCCESS" 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.

5.1.1.6.6.12 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 UE CONTEXT RELEASE (TS 38.423 [13] clause 8.2.7) over Xn and the receipt by the source NG-RAN from the target NG-RAN of a "HANDOVER SUCCESS" 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 max time of Inter-gNB handovers during the granularity period.

5.1.1.6.6.13 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.

5.1.1.6.6.14 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.

5.1.1.6.6.15 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

5.1.1.6.7 Intra-gNB conditional handovers

5.1.1.6.7.1 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.

5.1.1.6.7.2 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 if several *RRCReconfiguration* messages 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.

5.1.1.6.7.3 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.

5.1.1.6.8 Inter-gNB DAPS handovers

5.1.1.6.8.1 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.

5.1.1.6.8.2 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.

5.1.1.6.8.3 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.

5.1.1.6.8.4 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.

5.1.1.6.8.5 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.

5.1.1.6.8.6 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.

5.1.1.6.8.7 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.

5.1.1.6.8.8 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.

5.1.1.6.8.9 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.

5.1.1.6.9 Intra-gNB DAPS handovers

5.1.1.6.9.1 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.

5.1.1.6.9.2 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.

5.1.1.7 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. Any DRBs attempted to setup to support all requested QoS flows in the PDU SESSION RESOURCE SETUP REQUEST messages with same PDU Session IDs as an existing PDU Session are excluded.

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 PDU SESSION RESOURCE NOTIFY message with the exception of "Cause" equal to "Normal Release", "Handover Cancelled" or a successful mobility activity (e.g., cause "Successful Handover), 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 5QI and DRB.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 5QI and DRB.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 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.

5.1.1.10.6 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 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.

5.1.1.10.7 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]).

5.1.1.10.11 Mean number of DRBs undergoing from User Plane Path Failures

a) This measurement provides the number of DRB's prone to GTP-U Error Indication, the 5G CU-UP shall return a GTP-U Error Indication if it does not have a corresponding GTP-U context (see clause 5.2 of TS 23.527 [x]).

b) CC.

c) The 5G CU-UP should also notify the GTP-U user plane path failure via the Operation and Maintenance system. All DRB's of this UE are counted for this measurement to the target 5GS cell. Each DRB attempted to establish is added to the relevant measurement per QCI, the possible QCIs are included in TS 23.501 [4]. The sum of all supported per QCI measurements shall equal the total number of DRB's attempted to setup. In case only a subset of per QCI or per supported S-NSSAI measurements are 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 supported plus a possible sum value identified by the .sum suffix.

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

f) NRCellCU.

g) Valid for packet switched traffic.

h) 5GS.

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 4).

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 4), 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 resuming is 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 resuming is 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:

$$\sum_{k=1}^{n} numOfPreamblesPerSSB(k), \text{ where}$$

   "*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 RSRP as configured by reporting configurations as defined in TS 38.214 [33], in case the 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 UEs in the DL 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 multiplied by the number of supported S-NSSAIs.

[Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) $\leq$ 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 represents the mapped 5QI or/and QCI level, and *S-NSSAI* 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 UEs in the DL 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 multiplied by the number of supported S-NSSAIs.

   [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) $\leq$ 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 represents the mapped 5QI or/and QCI level, and *S-NSSAI* 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 UEs in the UL 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 multiplied by the number of supported S-NSSAIs.

   [Total No. of measurement instances] x [No. of filter values for all measurements] (DL and UL) $\leq$ 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 represents the mapped 5QI or/and QCI level, and *S-NSSAI* 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 UEs in the UL 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 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]). 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 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.MaxActiveUeUl_Filter,
where filter is a combination of *PLMN ID* and *QoS* level and *S-NSSAI,*
where *PLMN ID* represents the PLMN ID, *QoS* represents the mapped 5QI or/and QCI level, and *S-NSSAI* 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).

5.1.1.24 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 t_{x-1} to t_x.

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 t_{x-1} to t_x.

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
   HO.IntraSys.TooLate
   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 between NG-RAN and E-UTRAN, limited to the scenarios defined in TS 38.300 [49] clause 15.5.2.2.3. The measurement includes separate counters for various handover failure types, classified as "Inter-system too early handover"(inter-system mobility from E-UTRAN to NG-RAN) and "Inter-system too late handover" (inter-system mobility from NG-RAN to E-UTRAN).

b) CC.

c) The measurements of too early inter-systemhandover events are obtained by accumulating the number of failure events detected during the inter-system mobility from E-UTRAN to NG-RAN. The measurements of too late inter-system handover events are obtained by accumulating the number of failure events detected during the inter-system mobility from NG-RAN to E-UTRAN.

d) Each measurement is an integer value.

e) HO.InterSys.TooEarly
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 NG-RAN to E-UTRAN, see TS 38.300 [49] clause 15.5.2.3. 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 inter-systemhandovers is obtained by accumulating the number of inter-system unnecessary handover events detected during the inter-system mobility from NG-RAN to E-UTRAN.

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 between NG-RAN and E-UTRAN, see TS 38.300 [49] clause 15.5.2.4. 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 during the inter-system mobility between NG-RAN and E-UTRAN.

d) Each measurement is an integer value.

e) HO.InterSys.PingPong

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.

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:

$$LM(T) = \frac{\sum_j Lmax_j(T)}{K(T)}, \ \ K(T) = \sum_{j, Lmax_{j(T)} \neq 0} 1$$

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. $Lmax_j(T)$ denotes the maximum number of scheduled layer of PDSCH at sampling occasion j; *K(T)* denotes the number of sampling occasions at which $Lmax_j(T)$ 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:

$$LM(T) = \frac{\sum_j Lmax_j(T)}{K(T)}, \quad K(T) = \sum_{j,Lmax_{j(T)} \neq 0} 1$$

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. $Lmax_j(T)$ denotes the maximum number of scheduled layer of PUSCH at sampling occasion j; *K(T)* denotes the number of sampling occasions at which $Lmax_j(T)$ 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:

$$L_{aveDL} = \frac{\sum_{\forall j} \sum_{\forall k} \{M1_{kj}(T) * L_{kj}(T)\}}{\sum_{\forall j} \sum_{\forall k} \{M1_{kj}(T)\}},$$

where L_{aveDL} denotes the average value of scheduled MIMO layers per PRB per cell on the DL. *T* denotes the measurement period (e.g. 1 hour). And *j* denotes the sampling occasion *j* (e.g. 1 symbol). And *k* denotes the number of kinds of MIMO layers (e.g. 2 kinds). $L_{kj}(T)$ denotes the number of MIMO layers (e.g. 1 layers, 4layers, etc.) scheduled for traffic transmission at sampling occasion *j*. $M1_{kj}(T)$ denotes the number of PDSCH

PRBs used for transmission corresponding to $L_{kj}(T)$, at sampling occasion j. For example, a cell has 10 PRBs in total for one sampling occasion (j=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 L_{aveDL} 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:

$$L_{aveUL} = \frac{\sum_{\forall j}\sum_{\forall k}\{M1_{kj}(T)*L_{kj}(T)\}}{\sum_{\forall j}\sum_{\forall k}\{M1_{kj}(T)\}},$$

where L_{aveUL} denotes the average value of scheduled MIMO layers per PRB per cell on the UL. T denotes the measurement period (e.g. 1 hour). And j denotes the sampling occasion j (e.g. 1 symbol). And k denotes the number of kinds of MIMO layers (e.g. 2 kinds). $L_{kj}(T)$ denotes the number of MIMO layers (e.g. 1 layers, 4layers, etc.) scheduled for traffic transmission at sampling occasion j. $M1_{kj}$(T) denotes the number of PUSCH PRBs used for transmission corresponding to $L_{kj}(T)$, at sampling occasion j. For example, a cell has 10 PRBs in total for one sampling occasion (j=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 L_{aveUL} 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 (T_A) 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 T_A 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 performed, 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.QoS where 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

a) 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) $\leq$ 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

a) 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

a) 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* represetes 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

a) 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* represetes 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

a) 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 performed, 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 performed, 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 DL 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 performed, 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 dropped DL PDCP SDU packets whose contexts are 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, of a data radio bearer, divided by Number of DL PDCP SDU packets for data radio bearers that have entered PDCP-SAP after being decoded from GTP-U packets. 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 performed, 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 RLC SDU 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 dropped DL RLC SDU packets whose contexts are removed from the gNB-DU without any part of it having been transmitted on the air interface, of a data radio bearer, divided by Number of DL RLC SDU packets (as decoded from PDCP-PDUs received via GTP-U 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 performed, 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 optionally
DRB.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) $\leq$ 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 ingress GTP termination of GNBCUUPFunction, minus time when the same packet was sent to gNB-DU from the GTP egress termination of GNBCUUPFunction, minus feedback delay time (including queuing delay) 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.
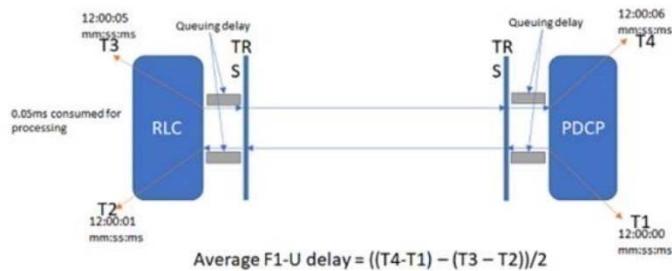
Figure 5.1.3.3.2-1 Average delay DL on F1U

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) $\leq$ 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) CC

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. This measurement is also counted to the SSB beam which the UE connects to when the UE CONTEXT RELEASE REQUEST message is transmitted. 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
   Beam

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is to support MDA.

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) CC

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. This measurement is also counted to the SSB beam which the UE connected to when the UE CONTEXT RELEASE COMMAND message is transmitted. 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
   Beam

g) Valid for packet switched traffic

h) 5GS

i) One usage of this performance measurements is to support MDA.

5.1.3.6 PDCP data volume measurements

5.1.3.6.1 PDCP PDU data volume Measurement

5.1.3.6.1 DL PDCP PDU Data Volume

a) 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.* MobilityRegUpdate
    RM.RegTimeMax.*SNSSAI.* PeriodicRegUpdate
    RM.RegTimeMax.*SNSSAI.* EmergencyReg

  f) 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".

  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 the S-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 the S-NSSAI, and *cause* identifies the failure 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 the S-NSSAI, and *5QI* identifies the 5QI.

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 the S-NSSAI, *5QI* identifies the 5QI and *cause* identifies the failure 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

a)

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)

a) This measurement provides the mean 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 taking the arithmetic mean. The measurement is optionally split into subcounters per S-NSSAI.

d) A single integer value

e) SM.SessionNbrMean.*SNSSAI*
   Where *SNSSAI* identifies the S-NSSAI

f) SMFFunction

g) Valid for packet switched traffic

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) 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 Nsmf_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 Nsmf_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* and SM.PduSessionRelAmfInit.*cause.*

Where the *SNSSAI* identifies the S-NSSAI; and the *cause* identifies 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]).

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* and SM.QoSflowCreateReq.*5QI*.

   Where the *SNSSAI* identifies the S-NSSAI, and the *5QI* identifies the 5QI.

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* and SM.QoSflowCreateSucc.*5QI*.

   Where the *SNSSAI* identifies the S-NSSAI, and the *5QI* identifies the 5QI.

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 the cause 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* and SM.QoSflowModReq.*5QI*.

   Where the *SNSSAI* identifies the S-NSSAI, and the *5QI* identifies the 5QI.

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* and SM.QoSflowModSucc.*5QI*.

   Where the *SNSSAI* identifies the S-NSSAI, and the *5QI* identifies the 5QI.

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 the cause 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* and SM.QoSflowNbrMean.*5QI*.

   Where the *SNSSAI* identifies the S-NSSAI, and the *5QI* identifies the 5QI.

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* and SM.QoSflowNbrPeak.*5QI*.

   Where the *SNSSAI* identifies the S-NSSAI, and the *5QI* identifies the 5QI.

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 performed, 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 performed, 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 performed, the number of measurements is equal to the number of supported S-NSSAIs.

e) GTP.InDataOctN3UPF and optionally GTP.InDataOctN3UPF.*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 performed, 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 kbit. 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 performed, 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.QoS where 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 performed, the measurements are equal to the number of 5QIs.

e) The measurement name has the form GTP.OutDataPktPacketLossN3UPF or GTP.OutDataPktPacketLossN3UPF.QoS where 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 PDU 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 PDU 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:

$$\frac{\sum_{i=1}^{N}(T4_i - T3_i)}{N}$$

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.

$$T4_i - T3_i$$

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:

$$\frac{\sum_{i=1}^{N}((T4_i - T1_i) - (T3_i - T2_i))}{N}$$

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.

$$(T4_i - T1_i) - (T3_i - T2_i)$$

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 $DRdl$ 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:

$$\frac{\sum_{i=1}^{N}(T2_i - T1_i + DRdl_i)}{N}$$

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 $DRdl$ 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.

$$T2_i - T1_i + DRdl_i$$

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 $DRul$ 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:

$$\frac{\sum_{i=1}^{N}(T4_i - T3_i + DRul_i)}{N}$$

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 $DRul$ 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.

$$T4_i - T3_i + DRul_i$$

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.X.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

5.9   Performance measurements for NEF

5.9.1   Measurements related to application triggering

5.9.1.1   Number of application trigger requests

a) This measurement provides the number of application trigger requests received by the NEF from AF.

b) CC

c) Receipt of an Nnef_Trigger_Delivery request by the NEF from AF (see TS 23.502 [7]).

d) An integer value

e) AT.AppTriggerReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.1.2   Number of application trigger requests accepted for delivery

a) This measurement provides the number of application trigger requests accepted for delivery to the UE.

b) CC

c) Transmission of Nnef_Trigger_Delivery response by the NEF to AF indicating the application trigger request has been accepted for delivery to the UE (see TS 23.502 [7]).

d) An integer value

e) AT.AppTriggerAcc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.1.3   Number of application trigger requests rejected for delivery

a) This measurement provides the number of application trigger requests rejected for delivery to the UE. This measurement is split into subcounters per error code (i.e., the response code as specified in clause 5.2.6 of TS 29.122 [23]).

b) CC

c) Transmission of an Nnef_Trigger_Delivery response by the NEF to AF indicating the application trigger request has been rejected for delivery to the UE (see TS 23.502 [7]). Each said Nnef_Trigger_Delivery response increments the relevant subcounter per error code (i.e., the response code as specified in clause 5.2.6 of TS 29.122 [23]) by 1.

d) Each subcounter is an integer value

e) AT.AppTriggerRej.*ErrorCode*
Where the *ErrorCode* identifies the error code (i.e., response code as specified in clause 5.2.6 of TS 29.122 [23]) causing the rejection.

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.1.4 Number of application trigger delivery reports

a) This measurement provides the number of application trigger delivery reports indicating the delivery results (e.g., success or failure) sent by the NEF to AF. This measurement is split into subcounters per delivery result (see the DeliveryResult specified in clause 5.7.2.2.3 of TS 29.122 [23]).

b) CC

c) Transmission of an Nnef_Trigger_DeliveryNotify message by the NEF to AF indicating the delivery result of the application trigger (see TS 23.502 [7]). Each said Nnef_Trigger_DeliveryNotify message increments the relevant subcounter per delivery result by 1 (see the DeliveryResult specified in clause 5.7.2.2.3 of TS 29.122 [23]).

d) Each subcounter is an integer value

e) AT.AppTriggerRej.*DeliveryResult*
Where the *DeliveryResult* identifies the delivery result (i.e., the DeliveryResult specified in clause 5.7.2.2.3 of TS 29.122 [23]).

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2 Measurements related to PFD management

5.9.2.1 PFD creation

5.9.2.1.1 Number of PFD creation requests

a) This measurement provides the number of PFD creation requests received by the NEF from AF.

b) CC

c) Receipt of an Nnef_PFDManagement_Create Request by the NEF from AF (see TS 23.502 [7]).

d) An integer value

e) PFD.CreateReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.1.2 Number of successful PFD creations

a) This measurement provides the number of successful PFD creations at NEF.

b) CC

c) Transmission of an Nnef_PFDManagement_Create Response by the NEF to AF indicating a successful PFD creation (see TS 23.502 [7]).

d) An integer value

e) PFD.CreateSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.2 PFD update

5.9.2.2.1 Number of PFD update requests

a) This measurement provides the number of PFD update requests received by the NEF from AF.

b) CC

c) Receipt of an Nnef_PFDManagement_Update Request by the NEF from AF (see TS 23.502 [7]).

d) An integer value

e) PFD.UpdateReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.2.2 Number of successful PFD updates

a) This measurement provides the number of successful PFD updates at NEF.

b) CC

c) Transmission of an Nnef_PFDManagement_Update Response by the NEF to AF indicating a successful PFD update (see TS 23.502 [7]).

d) An integer value

e) PFD.UpdateSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.3 PFD deletion

5.9.2.3.1 Number of PFD deletion requests

a) This measurement provides the number of PFD deletion requests received by the NEF from AF.

b) CC

c) Receipt of an Nnef_PFDManagement_Delete Request by the NEF from AF (see TS 23.502 [7]).

d) An integer value

e) PFD.DeleteReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.3.2 Number of successful PFD deletions

a) This measurement provides the number of successful PFD updates at NEF.

b) CC

c) Transmission of an Nnef_PFDManagement_Delete Response by the NEF to AF indicating a successful PFD deletion (see TS 23.502 [7]).

d) An integer value

e) PFD.DeleteSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.4 PFD fetch

5.9.2.4.1 Number of PFD fetch requests

a) This measurement provides the number of PFD fetch requests received by the NEF from SMF.

b) CC

c) Receipt of an Nnef_PFDManagement_Fetch Request by the NEF from SMF (see TS 23.502 [7]).

d) An integer value

e) PFD.FetchReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.4.2 Number of successful PFD fetch

a) This measurement provides the number of successful PFD fetch at NEF.

b) CC

c) Transmission of an Nnef_PFDManagement_Fetch Response by the NEF to SMF indicating a successful PFD fetch (see TS 23.502 [7]).

d) An integer value

e) PFD.FetchSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.5   PFD subscription

5.9.2.5.1   Number of PFD subscribing requests

a) This measurement provides the number of PFD subscribing requests received by the NEF from SMF.

b) CC

c) Receipt of an Nnef_PFDmanagement_Subscribe Request by the NEF from SMF (see TS 23.502 [7]).

d) An integer value

e) PFD.SubscribeReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.2.5.2   Number of successful PFD subscribings

a) This measurement provides the number of successful PFD subscribings at NEF.

b) CC

c) Transmission of an Nnef_PFDmanagement_Subscribe Response by the NEF to SMF indicating a successful PFD subscribe (see TS 23.502 [7]).

d) An integer value

e) PFD.SubscribeSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.3   NIDD configuration related measurements

5.9.3.1   NIDD configuration creation and update

5.9.3.1.1   Number of NIDD configuration creation requests

a) This measurement provides the number of NIDD configuration creation requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_NIDDConfiguration_Create request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) NIDD.NbrConfigCreatReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.3.1.2   Number of successful NIDD configuration creations

a) This measurement provides the number of successful NIDD configuration creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDDConfiguration_Create response message to AF indicating a successful NIDD configuration creation (see TS 29.522 [44].

d) A single integer value.

e) NIDD.NbrConfigCreatSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.3.1.3 Number of failed NIDD configuration creations

a) This measurement provides the number of failed NIDD configuration creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDDConfiguration_Create response message to AF indicating a failed NIDD configuration creation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) NIDD.NbrConfigCreatFail.*cause*
Where *cause* indicates the failure cause of the NIDD configuration creation.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.3.1.4 Number of NIDD configuration trigger requests

a) This measurement provides the number of requests sent by the NEF to ask AF to create NIDD configuration.

b) CC.

c) Transmission by the NEF of an Nnef_NIDDConfiguration_TriggerNotify message to AF (see TS 23.502 [7]).

d) Each measurement is an integer value.

e) NIDD.NbrConfigCreatTriggerNotify.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.3.1.5 Number of NIDD configuration update notifications

a) This measurement provides the number of NIDD configuration update notifications sent by the NEF to AF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDDConfiguration_UpdateNotify message to AF (see TS 23.502 [7]).

d) Each measurement is an integer value.

e) NIDD.NbrConfigUpdateNotify.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.3.2 NIDD configuration deletion

5.9.3.2.1 Number of NIDD configuration deletion requests

a) This measurement provides the number of NIDD configuration deletion requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_NIDDConfiguration_Delete request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) NIDD.NbrConfigDelReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.3.2.2 Number of successful NIDD configuration deletions

a) This measurement provides the number of NIDD configuration deletions by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDDConfiguration_Delete response message to AF indicating a successful NIDD configuration deletion (see TS 29.522 [44]).

d) A single integer value.

e) NIDD.NbrConfigDelSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.3.2.3 Number of failed NIDD configuration deletions

a) This measurement provides the number of failed NIDD configuration deletions by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDDConfiguration_Delete response message to AF indicating a failed NIDD configuration deletion (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) NIDD.NbrConfigDelFail.*cause*
Where *cause* indicates the failure cause of the NIDD configuration deletion.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.4 NIDD service related measurements

5.9.4.1 Mobile originated NIDD delivery

5.9.4.1.1 Number of mobile originated NIDD delivery requests

a) This measurement provides the number of mobile originated NIDD delivery requests received by the NEF from SMF.

b) CC.

c) Receipt by the NEF of an Nnef_NIDD_Delivery request message from SMF (see TS 23.502 [7]).

d) A single integer value.

e) NIDD.NbrMODeliveryReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.4.1.2 Number of successful mobile originated NIDD deliveries

a) This measurement provides the number of successful mobile originated NIDD deliveries by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDD_Delivery response message to SMF indicating a successful mobile originated NIDD delivery (see TS 29.541 [45]).

d) A single integer value.

e) NIDD.NbrMODeliverySucc.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.4.1.3 Number of failed mobile originated NIDD deliveries

a) This measurement provides the number of failed mobile originated NIDD deliveries by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDD_Delivery response message to SMF indicating a indicating a failed mobile originated NIDD delivery (see TS 29.541 [45]), each message increments the relevant subcounter per failure cause by 1.

d) A single integer value.

e) NIDD.NbrMODeliveryFail.*cause*
Where *cause* indicates the failure cause of the NIDD delivery.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.4.2   Mobile terminated NIDD delivery

5.9.4.2.1   Number of mobile terminated NIDD delivery requests

a) This measurement provides the number of mobile terminated NIDD delivery requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_NIDD_Delivery request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) NIDD.NbrMTDeliveryReq.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.4.2.2   Number of successful mobile terminated NIDD deliveries

a) This measurement provides the number of successful mobile terminated NIDD deliveries by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDD_Delivery response message to AF indicating a successful mobile terminated NIDD delivery (see TS 29.522 [44]).

d) A single integer value.

e) NIDD.NbrMTDeliverySucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.4.2.3   Number of failed mobile terminated NIDD deliveries

a) This measurement provides the number of failed mobile terminated NIDD deliveries by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_NIDD_Delivery response message to AF indicating a indicating a failed mobile terminated NIDD delivery (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) A single integer value.

e) NIDD.NbrMTDeliveryFail.*cause*
Where *cause* indicates the failure cause of the NIDD delivery.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.5 AF traffic influence related measurements

5.9.5.1 AF traffic influence creation

5.9.5.1.1 Number of AF traffic influence creation requests

a) This measurement provides the number of traffic influence creation requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_TrafficInfluence_Create request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) TI.NbrAfCreatReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.5.1.2 Number of successful AF traffic influence creations

a) This measurement provides the number of successful AF traffic influence creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_TrafficInfluence_Create response message to AF indicating a successful AF traffic influence creation (see TS 29.522 [44]).

d) A single integer value.

e) TI.NbrAfCreatSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.5.1.3 Number of failed AF traffic influence creations

a) This measurement provides the number of failed AF traffic influence creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_TrafficInfluence_Create response message to AF indicating a failed AF traffic influence creation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) TI.NbrAfCreatFail.*cause*
Where *cause* indicates the failure cause of the AF traffic influence creation.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.5.2 AF traffic influence update

5.9.5.2.1 Number of AF traffic influence update requests

a) This measurement provides the number of traffic influence update requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_TrafficInfluence_Update request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) TI.NbrAfUpdateReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.5.2.2 Number of successful AF traffic influence updates

a) This measurement provides the number of successful AF traffic influence updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_TrafficInfluence_Update response message to AF indicating a successful AF traffic influence update (see TS 29.522 [44]).

d) A single integer value.

e) TI.NbrAfUpdateSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.5.2.3 Number of failed AF traffic influence updates

a) This measurement provides the number of failed AF traffic influence updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_TrafficInfluence_Update response message to AF indicating a failed AF traffic influence update (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) TI.NbrAfUpdateFail.*cause*
Where *cause* indicates the failure cause of the AF traffic influence update.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.5.3 AF traffic influence deletion

5.9.5.3.1 Number of AF traffic influence deletion requests

a) This measurement provides the number of traffic influence deletion requests received by the NEF from AF.

    b) CC.

    c) Receipt by the NEF of an Nnef_TrafficInfluence_Delete request message from AF (see TS 23.502 [7]).

    d) A single integer value.

    e) TI.NbrAfDelReq

    f) NEFFunction.

    g) Valid for packet switched traffic.

    h) 5GS.

5.9.5.3.2 Number of successful AF traffic influence deletions

    a) This measurement provides the number of successful AF traffic influence deletions by the NEF.

    b) CC.

    c) Transmission by the NEF of an Nnef_TrafficInfluence_Delete response message to AF indicating a successful AF traffic influence deletion (see TS 29.522 [44]).

    d) A single integer value.

    e) TI.NbrAfDelSucc

    f) NEFFunction.

    g) Valid for packet switched traffic.

    h) 5GS.

5.9.5.3.3 Number of failed AF traffic influence deletions

    a) This measurement provides the number of failed AF traffic influence deletions by the NEF.

    b) CC.

    c) Transmission by the NEF of an Nnef_TrafficInfluence_Delete response message to AF indicating a failed AF traffic influence deletion (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

    d) Each measurement is an integer value.

    e) TI.NbrAfDelFail.*cause*
       Where *cause* indicates the failure cause of the AF traffic influence deletion.

    f) NEFFunction.

    g) Valid for packet switched traffic.

    h) 5GS.

5.9.6 External parameter provisioning related measurements

5.9.6.1 External parameter creation

5.9.6.1.1 Number of external parameter creation requests

    a) This measurement provides the number of external parameter creation requests received by the NEF from AF.

    b) CC.

    c) Receipt by the NEF of an Nnef_ParameterProvision_Create request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) EPP.NbrCreatReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.1.2 Number of successful external parameter creations

a) This measurement provides the number of successful external parameter creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ParameterProvision_Create response message to AF indicating a successful external parameter creation (see TS 29.522 [44]).

d) A single integer value.

e) EPP.NbrCreatSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.1.3 Number of failed external parameter creations

a) This measurement provides the number of failed external parameter creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ParameterProvision_Create response message to AF indicating a failed AF external parameter creation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) EPP.NbrCreatFail.*cause*
Where *cause* indicates the failure cause of the external parameter creation.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.2 External parameter update

5.9.6.2.1 Number of external parameter update requests

a) This measurement provides the number of external parameter update requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_ParameterProvision_Update request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) EPP.NbrUpdateReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.2.2 Number of successful external parameter updates

a) This measurement provides the number of successful external parameter updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ParameterProvision_Update response message to AF indicating a successful external parameter update (see TS 29.522 [44]).

d) A single integer value.

e) EPP.NbrUpdateSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.2.3 Number of failed external parameter updates

a) This measurement provides the number of failed external parameter updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ParameterProvision_Update response message to AF indicating a failed external parameter update (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) EPP.NbrUpdateFail.*cause*
Where *cause* indicates the failure cause of the external parameter update.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.3 External parameter deletion

5.9.6.3.1 Number of external parameter deletion requests

a) This measurement provides the number of external parameter deletion requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_ParameterProvision_Delete request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) EPP.NbrDelReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.3.2 Number of successful external parameter deletions

a) This measurement provides the number of external parameter deletions by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ParameterProvision_Delete response message to AF indicating a successful external parameter deletion (see TS 29.522 [44]).

d) A single integer value.

e) EPP.NbrDelSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.6.3.3 Number of failed external parameter deletions

a) This measurement provides the number of failed external parameter deletions by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ParameterProvision_Delete response message to AF indicating a failed external parameter deletion (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) EPP.NbrDelFail.*cause*
Where *cause* indicates the failure cause of the external parameter deletion.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.7 Connection establishment related measurements

5.9.7.1 SMF-NEF connection creation

5.9.7.1.1 Number of SMF-NEF connection creation requests

a) This measurement provides the number of SMF-NEF connection creation requests received by the NEF from SMF.

b) CC.

c) Receipt by the NEF of an Nnef_SMContext_Create request message from SMF (see TS 23.502 [7]).

d) A single integer value.

e) CE.NbrSmfNefCreatReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.7.1.2 Number of successful SMF-NEF connection creations

a) This measurement provides the number of successful SMF-NEF connection creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_SMContext_Create response message to SMF indicating a successful SMF-NEF connection creation (see TS 29.541 [45]).

d) A single integer value.

e) CE.NbrSmfNefCreatSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.7.1.3 Number of failed SMF-NEF connection creations

a) This measurement provides the number of failed SMF-NEF connection creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_SMContext_Create response message to SMF indicating a failed SMF-NEF connection creation (see TS 29.541 [45]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) CE.NbrSmfNefCreatFail.*cause*
Where *cause* indicates the failure cause of the SMF-NEF connection creation.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.7.2 SMF-NEF Connection release

5.9.7.2.1 Number of SMF-NEF Connection release requests

a) This measurement provides the number of SMF-NEF Connection release requests received by the NEF from SMF.

b) CC.

c) Receipt by the NEF of an Nnef_SMContext_Delete request message from SMF (see TS 23.502 [7]).

d) A single integer value.

e) CE.NbrSmfNefRelReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.7.2.2 Number of successful SMF-NEF Connection releases

a) This measurement provides the number of successful SMF-NEF Connection releases by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_SMContext_Delete response message to AF indicating a successful SMF-NEF Connection release (see TS 29.541 [45]).

d) A single integer value.

e) CE.NbrSmfNefRelSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.7.2.3 Number of failed SMF-NEF Connection releases

a) This measurement provides the number of failed SMF-NEF Connection releases by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_SMContext_Delete response message to AF indicating a failed SMF-NEF Connection release (see TS 29.541 [45]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) CE.NbrSmfNefRelFail.*cause*
   Where *cause* indicates the failure cause of the SMF-NEF Connection release.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.8 Service specific parameters provisioning related measurements

5.9.8.1 Service specific parameters creation

5.9.8.1.1 Number of service specific parameters creation requests

a) This measurement provides the number of service specific parameters creation requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_ServiceParameter_Create request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) SPP.NbrCreatReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.8.1.2 Number of successful service specific parameters creations

a) This measurement provides the number of successful service specific parameters creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ServiceParameter_Create response message to SMF indicating a successful service specific parameters creation (see TS 29.522 [44]).

d) A single integer value.

e) SPP.NbrCreatSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.8.1.3   Number of failed service specific parameters creations

a) This measurement provides the number of failed service specific parameters creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ServiceParameter_Create response message to AF indicating a failed service specific parameters creation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) SPP.NbrCreatFail.*cause*
Where *cause* indicates the failure cause of the service specific parameters creation.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.8.2   Service specific parameters update

5.9.f.2.1   Number of service specific parameters update requests

a) This measurement provides the number of service specific parameters update requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_ServiceParameter_Update request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) SPP.NbrUpdateReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.8.2.2   Number of successful service specific parameters updates

a) This measurement provides the number of successful service specific parameters updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ServiceParameter_Update response message to AF indicating a successful service specific parameters update (see TS 29.522 [44]).

d) A single integer value.

    e) SPP.NbrUpdateSucc

    f) NEFFunction.

    g) Valid for packet switched traffic.

    h) 5GS.

5.9.8.2.3   Number of failed service specific parameters updates

    a) This measurement provides the number of failed service specific parameters updates by the NEF.

    b) CC.

    c) Transmission by the NEF of an Nnef_ServiceParameter_Update response message to AF indicating a failed service specific parameters update (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

    d) Each measurement is an integer value.

    e) SPP.NbrUpdateFail.*cause*
       Where *cause* indicates the failure cause of the service specific parameters update.

    f) NEFFunction.

    g) Valid for packet switched traffic.

    h) 5GS.

5.9.8.3   Service specific parameters deletion

5.9.8.3.1   Number of service specific parameters deletion requests

    a) This measurement provides the number of service specific parameters deletion requests received by the NEF from AF.

    b) CC.

    c) Receipt by the NEF of an Nnef_ServiceParameter_Delete request message from AF (see TS 23.502 [7]).

    d) A single integer value.

    e) SPP.NbrDelReq

    f) NEFFunction.

    g) Valid for packet switched traffic.

    h) 5GS.

5.9.8.3.2   Number of successful service specific parameters deletions

    a) This measurement provides the number of successful service specific parameters deletions by the NEF.

    b) CC.

    c) Transmission by the NEF of an Nnef_ServiceParameter_Delete response message to AF indicating a successful service specific parameters deletion (see TS 29.522 [44]).

    d) A single integer value.

    e) SPP.NbrDelSucc

    f) NEFFunction.

    g) Valid for packet switched traffic.

h) 5GS.

5.9.8.3.3 Number of failed service specific parameters deletions

a) This measurement provides the number of failed service specific parameters deletions by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ServiceParameter_Delete response message to AF indicating a failed service specific parameters deletion (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) SPP.NbrDelFail.*cause*
Where *cause* indicates the failure cause of the service specific parameters deletion.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9 Background data transfer policy related measurements

5.9.9.1 Background data transfer policy negotiation

5.9.9.1.1 Number of background data transfer policy negotiation creation requests

a) This measurement provides the number of background data transfer policy negotiation creation requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_BDTPNegotiation_Create request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) BDTP.NbrNegCreatReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.1.2 Number of successful background data transfer policy negotiation creations

a) This measurement provides the number of successful background data transfer policy negotiation creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_BDTPNegotiation_Create response message to SMF indicating a successful background data transfer policy negotiation creation (see TS 29.522 [44]).

d) A single integer value.

e) BDTP.NbrNegCreatSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.1.3 Number of failed background data transfer policy negotiation creations

a) This measurement provides the number of failed background data transfer policy negotiation creations by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_BDTPNegotiation_Create response message to AF indicating a failed background data transfer policy negotiation creation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) BDTP.NbrNegCreatFail.*cause*
Where *cause* indicates the failure cause of the background data transfer policy negotiation creation.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.1.4 Number of background data transfer policy negotiation update requests

a) This measurement provides the number of background data transfer policy negotiation update requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_BDTPNegotiation Update request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) BDTP.NbrNegUpdateReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.1.5 Number of successful background data transfer policy negotiation updates

a) This measurement provides the number of successful background data transfer policy negotiation updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_BDTPNegotiation Update response message to AF indicating a successful background data transfer policy negotiation update (see TS 29.522 [44]).

d) A single integer value.

e) BDTP.NbrNegUpdateSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.1.6 Number of failed background data transfer policy negotiation updates

a) This measurement provides the number of failed background data transfer policy negotiation updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_BDTPNegotiation Update response message to AF indicating a failed background data transfer policy negotiation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) BDTP.NbrNegUpdateFail.*cause*
Where *cause* indicates the failure cause of the failed background data transfer policy negotiation update.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2 Background data transfer policy application

5.9.9.2.1 Number of background data transfer policy application requests

a) This measurement provides the number of background data transfer policy application requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_ApplyPolicy_Create request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) BDTP.NbrApplyCreatReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.2 Number of successful background data transfer policy applications

a) This measurement provides the number of successful background data transfer policy applications by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ApplyPolicy_Create response message to SMF indicating a successful background data transfer policy application (see TS 29.522 [44]).

d) A single integer value.

e) BDTP.NbrApplyCreatSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.3 Number of failed background data transfer policy applications

a) This measurement provides the number of failed background data transfer policy applications by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ApplyPolicy_Create response message to AF indicating a failed background data transfer policy application (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) BDTP.NbrApplyCreatFail.*cause*
Where *cause* indicates the failure cause of the background data transfer policy application.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.4 Number of background data transfer policy update requests

a) This measurement provides the number of background data transfer policy update requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_ApplyPolicy_Update request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) BDTP.NbrApplyUpdateReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.5 Number of successful background data transfer policy updates

a) This measurement provides the number of successful background data transfer policy updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ApplyPolicy_Update response message to AF indicating a successful background data transfer policy update (see TS 29.522 [44]).

d) A single integer value.

e) BDTP.NbrApplyUpdateSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.6 Number of failed background data transfer policy updates

a) This measurement provides the number of failed background data transfer policy updates by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ApplyPolicy_Update response message to AF indicating a failed background data transfer policy update (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) BDTP.NbrApplyUpdateFail.*cause*
Where *cause* indicates the failure cause of the failed background data transfer policy update.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.7 Number of background data transfer policy deletion requests

a) This measurement provides the number of background data transfer policy deletion requests received by the NEF from AF.

b) CC.

c) Receipt by the NEF of an Nnef_ApplyPolicy_Delete request message from AF (see TS 23.502 [7]).

d) A single integer value.

e) BDTP.NbrApplyDelReq

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.8 Number of successful background data transfer policy deletions

a) This measurement provides the number of successful background data transfer policy deletions by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ApplyPolicy_Delete response message to AF indicating a successful background data transfer policy deletion (see TS 29.522 [44]).

d) A single integer value.

e) BDTP.NbrApplyDelSucc

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.9.2.9 Number of failed background data transfer policy deletions

a) This measurement provides the number of failed background data transfer policy deletions by the NEF.

b) CC.

c) Transmission by the NEF of an Nnef_ApplyPolicy_Delete response message to AF indicating a failed background data transfer policy deletion (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) BDTP.NbrApplyDelFail.*cause*
Where *cause* indicates the failure cause of the failed background data transfer policy deletion.

f) NEFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.9.10 AF session with QoS

5.9.10.1 Creation of AF session with QoS

5.9.10.1.1 Number of AF session with QoS creation requests

a) This measurement provides the number of AF session with QoS creation requests received by the NEF.

b) CC

c) Receipt of an Nnef_AFsessionWithQoS_Create request by the NEF from an AF (see TS 23.502 [7]).

d) An integer value

e) AFQ.CreateReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.1.2 Number of successful AF session with QoS creations

a) This measurement provides the number of successful AF session with QoS creations at the NEF.

b) CC

c) Transmission of an Nnef_AFsessionWithQoS_Create response by the NEF to an AF indicating a successful AF session with QoS creation (see TS 29.522 [44]).

d) An integer value

e) AFQ.CreateSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.1.3 Number of failed AF session with QoS creations

a) This measurement provides the number of failed AF session with QoS creations at the NEF.

b) CC

c) Transmission of an Nnef_AFsessionWithQoS_Create response by the NEF to an AF indicating a failed AF session with QoS creation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) AFQ.CreateFail.*cause*
Where *cause* indicates the failure cause of the AF session with QoS creation.

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.2 Update of AF session with QoS

5.9.10.2.1 Number of AF session with QoS update requests

a) This measurement provides the number of AF session with QoS update requests received by the NEF.

b) CC

c) Receipt of an Nnef_AFsessionWithQoS_Update request by the NEF from an AF (see TS 23.502 [7]).

d) An integer value

e) AFQ.UpdateReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.2.2 Number of successful AF session with QoS updates

a) This measurement provides the number of successful AF session with QoS updates at the NEF.

b) CC

c) Transmission of an Nnef_AFsessionWithQoS_Update response by the NEF to an AF indicating a successful AF session with QoS update (see TS 29.522 [44]).

d) An integer value

e) AFQ.UpdateSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.2.3 Number of failed AF session with QoS updates

a) This measurement provides the number of failed AF session with QoS updates at the NEF.

b) CC

c) Transmission of an Nnef_AFsessionWithQoS_Update response by the NEF to an AF indicating a failed AF session with QoS update (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) AFQ.UpdateFail.*cause*
   Where *cause* indicates the failure cause of the AF session with QoS update.

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.3 Revocation of AF session with QoS

5.9.10.3.1 Number of AF session with QoS revocation requests

a) This measurement provides the number of AF session with QoS revocationrequests received by the NEF.

b) CC

c) Receipt of an Nnef_AFsessionWithQoS_Revoke request by the NEF from an AF (see TS 23.502 [7]).

d) An integer value

e) AFQ.RevokeReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.3.2 Number of successful AF session with QoS revocations

a) This measurement provides the number of successful AF session with QoS revocations at the NEF.

b) CC

c) Transmission of an Nnef_AFsessionWithQoS_Revoke response by the NEF to an AF indicating a successful AF session with QoS revocation (see TS 29.522 [44]).

d) An integer value

e) AFQ.RevokeSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.3.3 Number of failed AF session with QoS revocations

a) This measurement provides the number of failed AF session with QoS revocations at the NEF.

b) CC

c) Transmission of an Nnef_AFsessionWithQoS_Revoke response by the NEF to an AF indicating a failed AF session with QoS revocation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) AFQ.RevokeFail.*cause*
Where *cause* indicates the failure cause of the AF session with QoS revocation.

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.10.4 Notification of AF session with QoS

5.9.10.4.1 Number of AF session with QoS notifications

a) This measurement provides the number of AF session with QoS notifications sent by the NEF to AF.

b) CC

c) Transmission of an Nnef_AFsessionWithQoS_Notify message by the NEF to an AF (see TS 23.502 [7]).

d) An integer value

e) AFQ.NbrNotify

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11 UCMF provisioning

5.9.11.1 UCMF dictionary entry creation

5.9.11.1.1 Number of UCMF dictionary entry creation requests

a) This measurement provides the number of UCMF dictionary entry creation requests received by the NEF.

b) CC

c) Receipt of an Nnef_UCMFProvisioning_Create request by the NEF from an AF (see TS 23.502 [7]).

d) An integer value

e) UCM.EntryCreateReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.1.2 Number of successful UCMF dictionary entry creations

a) This measurement provides the number of successful UCMF dictionary entry creations at the NEF.

b) CC

c) Transmission of an Nnef_UCMFProvisioning_Create response by the NEF to an AF indicating a successful UCMF dictionary entry creation (see TS 29.522 [44]).

d) An integer value

e) UCM.EntryCreateSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.1.3 Number of failed UCMF dictionary entry creations

a) This measurement provides the number of failed UCMF dictionary entry creations at the NEF.

b) CC

c) Transmission of an Nnef_UCMFProvisioning_Create response by the NEF to an AF indicating a failed UCMF dictionary entry creation (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) UCM.EntryCreateFail.*cause*
   Where *cause* indicates the failure cause of the UCMF dictionary entry creation.

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.2   UCMF dictionary entry update

5.9.11.2.1   Number of UCMF dictionary entry update requests

a) This measurement provides the number of UCMF dictionary entry update requests received by the NEF.

b) CC

c) Receipt of an Nnef_UCMFProvisioning_Update request by the NEF from an AF (see TS 23.502 [7]).

d) An integer value

e) UCM.EntryUpdateReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.2.2   Number of successful UCMF dictionary entry updates

a) This measurement provides the number of successful UCMF dictionary entry updates at the NEF.

b) CC

c) Transmission of an Nnef_UCMFProvisioning_Update response by the NEF to an AF indicating a successful UCMF dictionary entry update (see TS 29.522 [44]).

d) An integer value

e) UCM.EntryUpdateSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.2.3   Number of failed UCMF dictionary entry updates

a) This measurement provides the number of failed UCMF dictionary entry updates at the NEF.

b) CC

c) Transmission of an Nnef_UCMFProvisioning_Update response by the NEF to an AF indicating a failed UCMF dictionary entry update (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) UCM.EntryUpdateFail.*cause*
Where *cause* indicates the failure cause of the UCMF dictionary entry update.

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.3 UCMF dictionary entry deletion

5.9.11.3.1 Number of UCMF dictionary entry deletion requests

a) This measurement provides the number of UCMF dictionary entry deletion requests received by the NEF.

b) CC

c) Receipt of an Nnef_UCMFProvisioning_Delete request by the NEF from an AF (see TS 23.502 [7]).

d) An integer value

e) UCM.EntryDelReq

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.3.2 Number of successful UCMF dictionary entry deletions

a) This measurement provides the number of successful UCMF dictionary entry deletions at the NEF.

b) CC

c) Transmission of an Nnef_UCMFProvisioning_Delete response by the NEF to an AF indicating a successful UCMF dictionary entry deletion (see TS 29.522 [44]).

d) An integer value

e) UCM.EntryDelSucc

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.9.11.3.3 Number of failed UCMF dictionary entry deletions

a) This measurement provides the number of failed UCMF dictionary entry deletions at the NEF.

b) CC

c) Transmission of an Nnef_UCMFProvisioning_Delete response by the NEF to an AF indicating a failed UCMF dictionary entry deletion (see TS 29.522 [44]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) UCM.EntryDelFail.*cause*
Where *cause* indicates the failure cause of the UCMF dictionary entry deletion.

f) NEFFunction

g) Valid for packet switched traffic

h) 5GS

5.10 Performance measurements for NRF

5.10.1 NF service registration related measurements

5.10.1.1 Number of NF service registration requests

a) This measurement provides the number of NF service registration requests received at the NRF.

b) CC.

c) Receipt by the NRF of an Nnrf_NFManagement_NFRegister Request message (see TS 23.502 [7]).

d) A single integer value.

e) NFS.RegReq

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.1.2 Number of successful NF service registrations

a) This measurement provides the number of successful NF service registrations at the NRF.

b) CC.

c) Transmission by the NRF of an Nnrf_NFManagement_NFRegister Response message (see TS 23.502 [7]) indicating a successful NF service registration.

d) A single integer value.

e) NFS.RegSucc

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.1.3 Number of failed NF service registrations due to encoding error of NF profile

a) This measurement provides the number of failed NF service registrations at the NRF due to encoding error of the received NF profile.

b) CC.

c) Transmission by the NRF of an Nnrf_NFManagement_NFRegister Response message (see TS 23.502 [7]) indicating a failed NF service registration due to encoding error of NF profile (see TS 29.510 [28]).

d) A single integer value.

e) NFS.RegFailEncodeErr

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.1.4 Number of failed NF service registrations due to NRF internal error

a) This measurement provides the number of failed NF service registrations at the NRF due to NRF internal error.

b) CC.

c) Transmission by the NRF of an Nnrf_NFManagement_NFRegister Response message (see TS 23.502 [7]) indicating a failed NF service registration due to NRF internal error (see TS 29.510 [28]).

d) A single integer value.

e) NFS.RegFailNrfErr

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.2 NF service update related measurements

5.10.2.1 Number of NF service update requests

a) This measurement provides the number of NF service update requests received at the NRF.

b) CC.

c) Receipt by the NRF of an Nnrf_NFManagement_NFUpdate Request message (see TS 23.502 [7]).

d) A single integer value.

e) NFS.UpdateReq

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.2.2 Number of successful NF service updates

a) This measurement provides the number of successful NF service updates at the NRF.

b) CC.

c) Transmission by the NRF of an Nnrf_NFManagement_NFUpdate Response message (see TS 23.502 [7]) indicating a successful NF service update.

d) A single integer value.

e) NFS.UpdateSucc

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.2.3 Number of failed NF service updates due to encoding error of NF profile

a) This measurement provides the number of failed NF service updates at the NRF due to encoding error of the received NF profile.

b) CC.

c) Transmission by the NRF of an Nnrf_NFManagement_NFUpdate Response message (see TS 23.502 [7]) indicating a failed NF service update due to encoding error of NF profile (see TS 29.510 [28]).

d) A single integer value.

e) NFS.UpdateFailEncodeErr

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.2.4 Number of failed NF service updates due to NRF internal error

a) This measurement provides the number of failed NF service updates at the NRF due to NRF internal error.

b) CC.

c) Transmission by the NRF of an Nnrf_NFManagement_NFUpdate Response message (see TS 23.502 [7]) indicating a failed NF service update due to NRF internal error (see TS 29.510 [28]).

d) A single integer value.

e) NFS.UpdateFailNrfErr

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.3 NF service discovery related measurements

5.10.3.1 Number of NF service discovery requests

a) This measurement provides the number of NF service discovery requests received at the NRF.

b) CC.

c) Receipt by the NRF of an Nnrf_NFDiscovery_Request message (see TS 23.502 [7]).

d) A single integer value.

e) NFS.DiscReq

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.3.2 Number of successful NF service discoveries

a) This measurement provides the number of successful NF service discoveries at the NRF.

b) CC.

c) Transmission by the NRF of an Nnrf_NFDiscovery_Request Response message (see TS 23.502 [7]) indicating a successful NF service discovery.

d) A single integer value.

e) NFS.DiscSucc

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.3.3 Number of failed NF service discoveries due to unauthorized NF Service consumer

a) This measurement provides the number of failed NF service discoveries due to the NF consumer is not allowed to discover the NF service(s).

b) CC.

c) Transmission by the NRF of an Nnrf_NFDiscovery_Request Response message (see TS 23.502 [7]) indicating a failed NF service registration due to the NF consumer is not allowed to discover the NF service(s) (see TS 29.510 [28]).

d) A single integer value.

e) NFS.DiscFailUnauth

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.3.4 Number of failed NF service discoveries due to input errors

a) This measurement provides the number of failed NF service discoveries at the NRF due to errors in the input data in the URI query parameters.

b) CC.

c) Transmission by the NRF of an Nnrf_NFDiscovery_Request Response message (see TS 23.502 [7]) indicating a failed NF service registration due to errors in the input data in the URI query parameters (see TS 29.510 [28]).

d) A single integer value.

e) NFS.DiscFailInputErr

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.10.3.5 Number of failed NF service discoveries due to NRF internal error

a) This measurement provides the number of failed NF service discoveries at the NRF due to NRF internal error.

b) CC.

c) Transmission by the NRF of an Nnrf_NFDiscovery_Request Response message (see TS 23.502 [7]) indicating a failed NF service discoveries due to NRF internal error (see TS 29.510 [28]).

d) A single integer value.

e) NFS.DiscFailNrfErr

f) NRFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.11 Performance measurements for NSSF

5.11.1 Network slice selection related measurements

5.11.1.1 Number of network slice selection requests

a) This measurement provides the number of network slice selection requests received by the NSSF.

b) CC.

c) Receipt by the NSSF of an Nnssf_NSSelection_Get request message from AMF (see TS 23.502 [7]).

d) A single integer value.

e) NSS.NbrGetReq

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.11.1.2 Number of successful network slice selections

a) This measurement provides the number of successful network slice selections made by the NSSF.

b) CC.

c) Transmission by the NSSF of an Nnssf_NSSelection_Get response message indicating a successful network slice selection to AMF (see TS 29.531 [41]).

d) A single integer value.

e) NSS.NbrGetSucc

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.11.1.3 Number of failed network slice selections

a) This measurement provides the number of failed network slice selections made by the NSSF. This measurement is split into subcounter per failure cause.

b) CC.

c) Transmission by the NSSF of an Nnssf_NSSelection_Get response message indicating a failed network slice selection to AMF (see TS 29.531 [41]), each message increments the relevant subcounter per failure cause by 1.

d) Each measurement is an integer value.

e) NSS.NbrGetFail.*cause*
Where *cause* indicates the failure cause of the network slice selection.

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.11.2   S-NSSAI availability related measurements

5.11.2.1   S-NSSAI availability update

5.11.2.1.1   Number of S-NSSAI availability update requests

a) This measurement provides the number of S-NSSAI availability update requests received by the NSSF.

b) CC.

c) Receipt by the NSSF of an Nnssf_NSSAIAvailability_Update request message from AMF (see TS 23.502 [7]).

d) A single integer value.

e) NSS.NbrNSSAIAvailUpdateReq

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.11.2.1.2   Number of successful S-NSSAI availability updates

a) This measurement provides the number of successful S-NSSAI availability updates made by the NSSF.

b) CC.

c) Transmission by the NSSF of an Nnssf_NSSAIAvailability_Update response message indicating a successful S-NSSAI availability update to AMF (see TS 29.531 [41]).

d) A single integer value.

e) NSS.NbrNSSAIAvailUpdateSucc

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.11.2.1.3   Number of failed S-NSSAI availability updates

a) This measurement provides the number of failed S-NSSAI availability updates made by the NSSF.

b) CC.

c) Transmission by the NSSF of an Nnssf_NSSAIAvailability_Update response message indicating a failed S-NSSAI availability update to AMF (see TS 29.531 [41]), each message increments the relevant subcounter per failure cause by 1.

d) A single integer value.

e) NSS.NbrNSSAIAvailUpdateFail.*cause*
    Where *cause* indicates the failure cause of S-NSSAI availability update.

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

### 5.11.2.2	S-NSSAI availability notification

#### 5.11.2.2.1	Number of S-NSSAI availability notification subscription requests

a) This measurement provides the number of S-NSSAI availability notification subscription requests received by the NSSF.

b) CC.

c) Receipt by the NSSF of an Nnssf_NSSAIAvailability_Subscribe request message from AMF (see TS 23.502 [7]).

d) A single integer value.

e) NSS.NbrNSSAIAvailSubscribeReq

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.11.2.2.2	Number of successful S-NSSAI availability notification subscriptions

a) This measurement provides the number of successful S-NSSAI availability notification subscriptions made by the NSSF.

b) CC.

c) Transmission by the NSSF of an Nnssf_NSSAIAvailability_Subscribe response message indicating a successful S-NSSAI availability notification subscription to AMF (see TS 29.531 [41]).

d) A single integer value.

e) NSS.NbrNSSAIAvailSubscribeSucc

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

#### 5.11.2.2.3	Number of failed S-NSSAI availability notification subscriptions

a) This measurement provides the number of failed S-NSSAI availability notification subscriptions made by the NSSF.

b) CC.

c) Transmission by the NSSF of an Nnssf_NSSAIAvailability_Subscribe response message indicating a S-NSSAI availability notification subscription to AMF (see TS 29.531 [41]), each message increments the relevant subcounter per failure cause by 1.

d) A single integer value.

e) NSS.NbrNSSAIAvailSubscribeFail.*cause*
Where *cause* indicates the failure cause of S-NSSAI availability notification subscription.

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.11.2.2.4 Number of S-NSSAI availability notifications

a) This measurement provides the number of S-NSSAI availability notifications sent by the NSSF.

b) CC.

c) Transmission by the NSSF of an Nnssf_NSSAIAvailability_Notify message to AMF (see TS 23.502 [7]).

d) A single integer value.

e) NSS.NbrNSSAIAvailNotify

f) NSSFFunction.

g) Valid for packet switched traffic.

h) 5GS.

5.12 Performance measurements for SMSF

5.12.1 MO SMS message delivery related measurements

5.12.1.1 Number of MO SMS delivery procedure requests

a) This measurement provides the number of MO SMS delivery procedure requests received by the SMSF from AMF.

b) CC

c) SMSF receives the MO SMS delivery procedure (POST) operation request sent by AMF for the " /ue-contexts/{supi}/sendsms" resource URL (see clause 5.2.2.4 of TS 29.540 [43]). Each request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.MoReq.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.12.1.2 Number of successful MO SMS delivery procedures

a) This measurement provides the number of successful MO SMS delivery procedures at the SMSF.

b) CC

c) SMSF returns "200 OK" response message (see clause 5.2.2.4 of TS 29.540 [43]). Each successful delivery procedure is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.MoSucc.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.12.2 MT SMS message delivery related measurements

5.12.2.1 Number of MT SMS delivery procedure requests

a) This measurement provides the number of MT SMS delivery procedure requests received by the SMSF from SC/SMS-GMSC.

b) CC

c) SMSF receives "Forward MT SM" (see 4.13.3.6-4.13.3.8 of TS 23.502 [7]) from SC/SMS-GMSC. Each request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.MtReq.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.12.2.2 Number of successful MT SMS delivery procedures

a) This measurement provides the number of successful MT SMS delivery procedures at the SMSF.

b) CC

c) SMSF returns " Delivery Rpt " message (see clause 4.13.3.6-4.13.3.8 of TS 23.502 [7]) to SC/SMS-GMSC. Each successful delivery procedure is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.MtSucc.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.12.3 Registration procedure related measurements

5.12.3.1 Number of registration requests

a) This measurement provides the number of registration requests received by the SMSF from AMF.

b) CC

c) SMSF receives the registration (PUT) operation request sent by AMF for the " /ue-contexts/{supi}" resource URL (see clause 5.2.2.2 of TS 29.540 [43]). Each registration request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.ActivateReq.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.12.3.2   Number of successful registrations

a) This measurement provides the number of successful registrations at the SMSF.

b) CC

c) SMSF returns "201 Created" or "204 No Content" response message (see clause 5.2.2.2 of TS 29.540 [43]). Each successful registration is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.ActivateSucc.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.12.3.3   Number of de-registration requests

a) This measurement provides the number of de-registration requests received by the SMSF from AMF.

b) CC

c) SMSF receives the de-registration (DELETE) operation request sent by AMF for the " /ue-contexts/{supi}" resource URL (see clause 5.2.2.3 of TS 29.540 [43]). Each de-registration request is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.DeactivateReq.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.12.3.4   Number of successful de-registrations

a) This measurement provides the number of successful de-registrations at the SMSF.

b) CC

c) SMSF returns "204 No Content" response message (see clause 5.2.2.3 of TS 29.540 [43]). Each successful de-registration is added to the relevant subcounter per S-NSSAI.

d) Each subcounter is an integer value

e) SMSF.DeactivateSucc.*SNSSAI*

   Where *SNSSAI* identifies the S-NSSAI;

f) SMSFFunction

g) Valid for packet switched traffic

h) 5GS

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

5.13   Performance measurements for UDR

5.13.1   Data management related measurements

5.13.1.1   Data set query

5.13.1.1.1   Number of data set query requests

a) This measurement provides the number of data set query requests received by the UDR.

b) CC

c) Receipt of an Nudr_DM_Query request by the UDR from an NF service consumer (see TS 23.502 [7]).

d) An integer value

e) DM.QueryReq

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.1.2   Number of successful data set queries

a) This measurement provides the number of succeful data set queries at the UDR.

b) CC

c) Transmission of an Nudr_DM_Query response by the UDR to an NF service consumer indicating a successful data set query (see TS 29.504 [47]).

d) An integer value

e) DM.QuerySucc

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.1.3   Number of failed data set queries

a) This measurement provides the number of failed data set queries at the UDR.

b) CC

c) Transmission of an Nudr_DM_Query response by the UDR to an NF service consumer indicating a failed data set query (see TS 29.504 [47]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) DM.QueryFail.*cause*
Where *cause* indicates the failure cause of the data set query.

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.2   Data record creation

5.13.1.2.1   Number of data record creation requests

a) This measurement provides the number of data record creation requests received by the UDR.

b) CC

c) Receipt of an Nudr_DM_Create request by the UDR from an NF service consumer (see TS 23.502 [7]).

d) An integer value

e) DM.CreateReq

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.2.2   Number of successful data record creations

a) This measurement provides the number of succesful data record creations at the UDR.

b) CC

c) Transmission of an Nudr_DM_Create response by the UDR to an NF service consumer indicating a successful data record creation (see TS 29.504 [47]).

d) An integer value

e) DM.CreateSucc

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.2.3   Number of failed data record creations

a) This measurement provides the number of failed data record creations at the UDR.

b) CC

c) Transmission of an Nudr_DM_Create response by the UDR to an NF service consumer indicating a failed data record creation (see TS 29.504 [47]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) DM.CreateFail.*cause*
Where *cause* indicates the failure cause of the data record creation.

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.3   Data record deletion

5.13.1.3.1   Number of data record deletion requests

a) This measurement provides the number of data record deletion requests received by the UDR.

b) CC

c) Receipt of an Nudr_DM_Delete request by the UDR from an NF service consumer (see TS 23.502 [7]).

d) An integer value

e) DM.DeleteReq

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.3.2   Number of successful data record deletions

a) This measurement provides the number of succesful data record deletions at the UDR.

b) CC

c) Transmission of an Nudr_DM_Delete response by the UDR to an NF service consumer indicating a successful data record deletion (see TS 29.504 [47].

d) An integer value

e) DM.DeleteSucc

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.3.3   Number of failed data record deletions

a) This measurement provides the number of failed data record deletions at the UDR.

b) CC

c) Transmission of an Nudr_DM_Delete response by the UDR to an NF service consumer indicating a failed data record deletion (see TS 29.504 [47]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) DM.DeleteFail.*cause*
Where *cause* indicates the failure cause of the data record deletion.

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.4 Data record update

5.13.1.4.1 Number of data record update requests

a) This measurement provides the number of data record update requests received by the UDR.

b) CC

c) Receipt of an Nudr_DM_Update request by the UDR from an NF service consumer (see TS 23.502 [7]).

d) An integer value

e) DM.UpdateReq

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.4.2 Number of successful data record updates

a) This measurement provides the number of succeful data record updates at the UDR.

b) CC

c) Transmission of an Nudr_DM_Update response by the UDR to an NF service consumer indicating a successful data record update (see TS 29.504 [47]).

d) An integer value

e) DM.UpdateSucc

f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.13.1.4.3 Number of failed data record updates

a) This measurement provides the number of failed data record updates at the UDR.

b) CC

c) Transmission of an Nudr_DM_Update response by the UDR to an NF service consumer indicating a failed data record update (see TS 29.504 [47]), each message increments the relevant subcounter per failure cause by 1.

d) Each subcounter is an integer value

e) DM.UpdateFail.*cause*
Where *cause* indicates the failure cause of the data record update.

    f) UDRFunction

    g) Valid for packet switched traffic

    h) 5GS

5.13.1.5 Data modification notification subscription

5.13.1.5.1 Number of data modification notification subscribing requests

    a) This measurement provides the number of data modification (including change on existing data record and addition of data record) notification subscribing requests received by the UDR.

    b) CC

    c) Receipt of an Nudr_DM_Subscribe request by the UDR from an NF service consumer (see TS 23.502 [7]).

    d) An integer value

    e) DM.SubscribeReq

    f) UDRFunction

    g) Valid for packet switched traffic

    h) 5GS

5.13.1.5.2 Number of successful data modification notification subscribings

    a) This measurement provides the number of succeful data modification (including change on existing data record and addition of data record) notification subscribings at the UDR.

    b) CC

    c) Transmission of an Nudr_DM_Subscribe response by the UDR to an NF service consumer indicating a successful data modification notification subscribing (see TS 29.504 [47]).

    d) An integer value

    e) DM.SubscribeSucc

    f) UDRFunction

    g) Valid for packet switched traffic

    h) 5GS

5.13.1.5.3 Number of failed data modification notification subscribings

    a) This measurement provides the number of failed data modification (including change on existing data record and addition of data record) notification subscribings at the UDR.

    b) CC

    c) Transmission of an Nudr_DM_Subscribe response by the UDR to an NF service consumer indicating a failed data modification notification subscribing (see TS 29.504 [47]), each message increments the relevant subcounter per failure cause by 1.

    d) Each subcounter is an integer value

    e) DM.SubscribeFail.*cause*
       Where *cause* indicates the failure cause of the data modification notification subscribing.

    f) UDRFunction

g) Valid for packet switched traffic

h) 5GS

5.14   Performance measurements for ECS

5.14.1   EES Registration procedure related measurements

5.14.1.1   Number of registration requests

a) This measurement provides the number of EES registration requests (see clause 8.4.4 of TS 23.558 [52]) received by the ECS.

b) CC

c) On receipt by the ECS from the EES of EES Registration Request. Each initial registration request is added.

d) Each subcounter is an integer value

e) RM.EesRegReq

f) ECSFunction

g) Valid for packet switched traffic

h) 5GS

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

5.14.1.2   Number of successful registrations

a) This measurement provides the number of successful EES registration request at the ECS.

b) CC

c) On transmission of EES Registration Response (see clause 8.4.4 of TS 23.558 [52]) by the ECS to the EES that sent the registration request. Each accepted initial registration is added.

d) Each subcounter is an integer value

e) RM.EesRegSucc

f) ECSFunction

g) Valid for packet switched traffic

h) 5GS

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

5.14.2   Service provisioning procedure related measurements

5.14.2.1   Number of service provisionig requests

a) This measurement provides the number of Service provisioning requests (see clause 8.3.3 of TS 23.558 [55]) received by the ECS.

b) CC

c) On receipt by the ECS from the EEC of Service provisioning request. Each provisioning request is added.

d) Each subcounter is an integer value

e) SP.SerProvReq

f) ECSFunction

g) Valid for packet switched traffic

h) 5GS

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

5.14.2.2 Number of successful discovery

a) This measurement provides the number of successful Service provisioning request at the ECS.

b) CC

c) On transmission of Service provisioning response (see clause 8.3.3 of TS 23.558 [55]) by the ECS to the EEC that sent the provisioning request. Each accepted request is added.

d) Each subcounter is an integer value

e) SP.SerProvSucc

f) ECSFunction

g) Valid for packet switched traffic

h) 5GS

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

5.15 Performance measurements for EES

5.15.1 EAS Discovery procedure related measurements

5.15.1.1 Number of discovery requests

a) This measurement provides the number of EAS discovery requests (see clause 8.5.2 of TS 23.558 [52]) received by the EES.

b) CC

c) On receipt by the EES from the EEC of EAS Discovery Request. Each discovery request is added.

d) Each subcounter is an integer value

e) DIS.EasDisReq

f) EESFunction

g) Valid for packet switched traffic

h) 5GS

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

5.15.1.2 Number of successful discovery

a) This measurement provides the number of successful EAS discovery request at the EES.

b) CC

c) On transmission of EAS Discovery Response (see clause 8.5.2 of TS 23.558 [52]) by the EES to the EEC that sent the registration request. Each accepted request is added.

d) Each subcounter is an integer value

e) DIS.EasDisSucc

f) EESFunction

g) Valid for packet switched traffic

h) 5GS

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

5.15.2 EEC Registration procedure related measurements

5.15.2.1 Number of registration requests

a) This measurement provides the number of EEC registration requests (see clause 8.4.2 of TS 23.558 [52]) received by the EES.

b) CC

c) On receipt by the EES from the EEC of EEC Registration Request. Each initial registration request is added.

d) Each subcounter is an integer value

e) RM.EecRegReq

f) EESFunction

g) Valid for packet switched traffic

h) 5GS

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

5.15.2.2 Number of successful registrations

a) This measurement provides the number of successful EEC registration request at the EES.

b) CC

c) On transmission of EEC Registration Response (see clause 8.4.2 of TS 23.558 [52]) by the EES to the EEC that sent the registration request. Each accepted initial registration is added.

d) Each subcounter is an integer value

e) RM.EecRegSucc

f) EESFunction

g) Valid for packet switched traffic

h) 5GS

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

5.15.3 EAS Registration procedure related measurements

5.15.3.1 Number of registration requests

a) This measurement provides the number of EAS registration requests (see clause 8.4.3 of TS 23.558 [52]) received by the EES.

b) CC

c) On receipt by the EES from the EAS of EAS Registration Request. Each initial registration request is added.

d) Each subcounter is an integer value

e) RM.EasRegReq

f) EESFunction

g) Valid for packet switched traffic

h) 5GS

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

5.15.3.2 Number of successful registrations

a) This measurement provides the number of successful EAS registration request at the EES.

b) CC

c) On transmission of EAS Registration Response (see clause 8.4.3 of TS 23.558 [52]) by the EES to the EAS that sent the registration request. Each accepted initial registration is added.

d) Each subcounter is an integer value

e) RM.EasRegSucc

f) EESFunction

g) Valid for packet switched traffic

h) 5GS

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

5.16 Performance measurements for LMF

5.16.1 Location determination related measurements

5.16.1.1 Number of location determination requests

a) This measurement provides the number of location determination requests received by the LMF.

b) CC

c) Receipt of an Nlmf_Location_DetermineLocation request by the LMF from an NF service consumer (see TS 23.273 [53]).

d) An integer value

e) LM.LocationDeterReq

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.16.1.2 Number of successful location determinations

a) This measurement provides the number of successful location determinations provided by the LMF.

b) CC

c) Transmission of an Nlmf_Location_DetermineLocation response by the LMF to an NF service consumer indicating a successful location determination (see TS 29.572 [54]).

d) An integer value

e) LM.LocationDeterSucc

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.16.1.3 Number of failed location determinations

a) This measurement provides the number of failed location determinations provided by the LMF.

b) CC

c) Transmission of an Nlmf_Location_DetermineLocation response by the LMF to an NF service consumer indicating a failed location determination, each message increments the relevant subcounter per failure case by 1 (see TS 29.572 [54]).

d) An integer value

e) LM.LocationDeterFail.*Cause,*
Where *Cause* indicates the failure cause of the location determination.

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.16.2 Location notification related measurements

5.16.2.1 Number of location notifications for successful activation

a) This measurement provides the number of location notifications for successful activation provided by the LMF.

b) CC

c) Transmission from the LMF to an NF service consumer of an Nlmf_Location_EventNotify message indicating the (periodic or triggered) location was successfully activated in the target UE (see TS 29.572 [54]).

d) An integer value

e) LM.LocationNotifSucc

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.16.2.2 Number of location notifications for failed activation

a) This measurement provides the number of location notifications for failed activation provided by the LMF.

b) CC

c) Transmission from the LMF to an NF service consumer of an Nlmf_Location_EventNotify message indicating the (periodic or triggered) location was failed to be activated in the target UE (see TS 29.572 [54]).

d) An integer value

e) LM.LocationNotifFail.*Cause,*
Where *Cause* indicates the failure cause of failed location activation in the target UE.

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.16.3 Location context transfer related measurements

5.16.3.1 Number of location context transfer requests

a) This measurement provides the number of location context transfer requests received by the LMF.

b) CC

c) Receipt of an Nlmf_Location_LocationContextTransfer request by the LMF from an NF service consumer (see TS 23.273 [53]).

d) An integer value

e) LM.LocationContextTranReq

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.16.3.2 Number of successful context transfers

a) This measurement provides the number of successful context transfers provided by the LMF.

b) CC

c) Transmission of an Nlmf_Location_LocationContextTransfer response by the LMF to an NF service consumer indicating a successful location context transfer (see TS 29.572 [54]).

d) An integer value

e) LM.LocationContextTranSucc

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.16.3.3 Number of failed location context transfers

a) This measurement provides the number of failed location context transfers provided by the LMF.

b) CC

c) Transmission of an Nlmf_Location_LocationContextTransfer response by the LMF to an NF service consumer indicating a failed location context transfer, each message increments the relevant subcounter per failure case by 1 (see TS 29.572 [54]).

d) An integer value

e) LM.LocationContextTranFail.*Cause,*
Where *Cause* indicates the failure cause of the location context transfer.

f) LMFFunction

g) Valid for packet switched traffic

h) 5GS

5.17 Void

6 Measurements related to end-to-end 5G network and network slicing

6.1 Void

6.2 Virtualised resource usage measurement

a) This measurement provides the mean usage of virtualised resource (e.g. processor, memory, disk) in single network slice instance during the granularity period.

b) OM

c) This measurement is generated with .sum suffix for the usage of each virtualised NF (see TS 32.426 [1]) related to single network slice instance by taking the weighted average. The algorithm of the weighted average is vendor specific.

d) Each measurement is an real value (Unit:%).

e) MeanProcessorUsage

MeanMemoryUsage

MeanDiskUsage

f) Performance measurement service.

g) Packet Switched.

h) 5GS

NOTE: The name of service in f) needs to align with the TS (e.g., 28.550) defining the management service.

Annex A (informative):
Use cases for performance measurements

A.1   Monitoring of UL and DL user plane latency in NG-RAN

Satisfying low latency expectations for 5G services, such as URLLC, is one of the key tasks for the operator to meet service performance expectations. As the performance in UL and DL differs, it is important for operators to be able to monitor the UL and DL user plane latencies separately. With performance measurements allowing the operator to obtain or derive the UL and DL user plane latency information separately, the operators can pinpoint the services performance problems to specific problems in UL or DL.

The DL IP latency monitoring in NG-RAN refers to the transmission within gNB of IP packets arriving when there is no other prior data to be transmitted to the same UE in the gNB.

The average DL latency needs to be measured to give an general indication of the latency performance; further more the latency distributions (into bins with latency ranges) need to be measured, to tell the occurrences about the packets with each certain range of latency and better reflect the user experience.

Different network slices may have different requirements on the delay, so the delay needs to be measured for each S-NSSAI.

To further pinpoint performance problem detected, separate counters may be provided per mapped 5QI (which are particularly useful when the mapped 5QI is used by few services and users and the packet size does not vary much).

A.2   Monitoring of UL and DL packet loss in NG-RAN

Keeping track of UL and DL packet loss in the NG-RAN is essential, since for certain services packets that are lost along the way through the system may have a noticeable impact on the end user. UL and DL packet loss measurements can be useful for evaluation, optimization and for performance assurance within the integrity area (user plane connection quality). Subcounters per QoS Level as well as per supported S-NSSAI is helpful for operator to pinpoint the reason for high packet loss rate.

UL packet loss is a measure of packets dropped in the UE and the packets lost on the interfaces (air interface and F1-U interface). If parts of the gNB are deployed in a virtualized environment, it is important to measure also the F1-U UL interface packet loss in a separate measurement, to be able to pinpoint the reason for high packet loss.

A.3   Monitoring of DL packet drop in NG-RAN

Keeping track of DL packet drops in the NG-RAN is essential, since for certain services packets that are dropped along the way through the system may have a noticeable impact on the end user. DL packet drop measurements can be useful for evaluation, optimization and for performance assurance of the network. Subcounters per QoS Level as well as per supported S-NSSAI is helpful for operator to pinpoint the reason for high packet drop rate.

For gNBs that are deployed in a split architecture, e.g. when parts of a gNB are deployed in a virtualized environment, the DL packet drops may occur in two parts; the gNB CU-UP and the gNB DU. Therefore, it is important to measure this separately.

A.4   Monitoring of UL and DL user plane delay in NG-RAN

Satisfying low packet delay is of prime concern for some services, particularly conversational services like speech and instant messaging. As the performance in UL and DL differs, it is important for operators to be able to monitor the UL

and DL user plane delay separately. With performance measurements allowing the operator to obtain or derive the UL and DL user plane delay information separately, the operators can pinpoint the services performance problems to specific problems in UL or DL.

The DL delay monitoring in gNB refers to the delay of any packet within NG-RAN, including air interface delay until the UE receives the packet. A gNB deployed in a split architecture, the user plane delay will occur in gNB-CU-UP, on the F1 interface, in gNB-DU and on the air interface. Therefore, the delay measurements related to the four segments needs to be monitored for the DL delay to pinpoint where end user impact from packet delay occurs.

The average DL delay needs to be measured to give a general indication of the delay performance; further more the delay distributions (into bins with delay ranges) need to be measured, to tell the occurrences about the packets with each certain range of delay and better reflect the user experience.

The UL delay monitoring in gNB refers to the delay of any packet within NG-RAN, including air interface delay until the packet leaves gNB-CU-UP. There are 4 components associated to UL delay (UL over-the-air interface delay, gNB-DU delay, F1-U delay, CU-UP delay). Therefore, the delay measurements related to these four segments needs to be monitored for the UL delay to pinpoint where end user impact from packet delay occurs. The beamforming capabilities of the NRCellDU and of the UE can be different. This might create a difference in the successful reception probability of the DL data transmitted by the gNB-DU, versus the UL data transmitted by the UE as the later might involve more retransmission than the former one. This will increase the UL over-the-air delay compared to the DL over-the-air delay.

For multi-operator RAN sharing scenario, different operators may have different requirements on the packet delay. It is of great importance to enable each operator to monitor the packet delay within its PLMN, also it helps the operators to pinpoint the network and service performance problems in a specific PLMN.

Different network slices may have different requirements on the delay, so the delay needs to be measured for each S-NSSAI.

To further pinpoint a detected delay performance problem, the packet delay measurement separation may be based on mapped 5QI (or for QCI in case of NR option 3).

NOTE: It is an asumtion that the DL/UL delay on the F1 interface is equal, only DL measurement is defined.

A.5 Monitoring of UE Context Release Request (gNB-DU initiated)

In order to monitor the stability of the network and detect the service/connection interruption caused by NGRAN, monitoring the UE Context Release Request initiated by gNB-DU is an effective method. Collecting the measurements for these events and analysing the releasing cause conveyed in the message, operators could detect the stability of NG-RAN, and could decide a specific means to improve the NG-RAN performance. Moreover, measuring the UE Context Releases on the SSB beam from where the UE CONTEXT is released is useful for analyzing the coverage problem.

A.6 Monitoring of physical radio resource utilization

The physical radio resource utilization measurements could provide operators the load information of the radio network during the measurement time period. The physical radio resource utilization measurements should reflect the average usage and the usage distribution of the radio resource of the physical layer. The measurements can make the operator to be aware of whether a cell has ever experienced high load or not in the monitoring period, and is a key input to network capacity planning and load balancing.

Network slicing is an important feature in 5GS, monitoring physical radio resource utilization per S-NSSAI is helpful for opeators to be aware of the load.

A.7 Monitoring of RRC connection number

The number of the users in RRC connected and inactive mode need to be monitored as it reflects the load of the radio network, the operators can use this information for dynamic frequency resource allocation or load balance purpose. Moreover, it is an important factor to be evaluated in the radio network capacity enhancement decision-making.

A.8 Monitoring of UE Context Release (gNB-CU initiated)

In order to monitor the stability of the network and detect the service/connection interruption caused by NG-RAN, monitoring the UE Context Release Command initiated by gNB-CU is an effective method. Collecting the measurements for these events and analysing the releasing cause conveyed in the message, operators could detect the stability of NG-RAN, and could decide a specific means to improve the NG-RAN performance. Moreover, measuring the UE Context Releases on the SSB beam from where the UE CONTEXT is released is useful for analyzing the coverage problem.

A.9 Monitoring of UE Throughput in NG-RAN

Keeping track of UL and DL UE throughput in the NG-RAN is essential, to ensure end user satisfaction and well-functioning and well configured cells and scheduling features.

The restricted UE throughput per mapped 5QI will show the scheduling efficiency and QoS priority handling in the gNB and the ratio between unrestricted and restricted volume will show the gNB ability to handle small data transfers efficiently.

To be able to monitor the spread of throughput within the cell, and estimate the ratio of satisfied users, the throughput distribution measurement can be used.

When network slicing is supported by the NG-RAN, multiple s S-NSSAIs may be supported. The UL and DL UE throughput for each S-NSSAI is then of importance to the operator to pinpoint a specific performance problem.

For RAN sharing scenarios, the UL and DL UE throughput in each PLMN is of importance to pinpoint performance problem in a specific PLMN.

A.10 Monitoring of Unrestricted volume in NG-RAN

Measuring the share of unrestricted user data volume in the NG-RAN is important, to show the gNB ability to handle small data transfers efficiently and to see how large share of the volume that is part of the UE throughput measurement. It is not meaningful to measure throughput for data transfers so small that they fit in one single slot but it is still important to know how much such transfers can be handled by the gNB.

When network slicing is supported by the NG-RAN, multiple s S-NSSAIs may be supported. The share of unrestricted volume for each S-NSSAI is then of importance to the operator to pinpoint a specific performance problem.

A.11 N3 data volume related measurements

N3 related measurements are used to measure data volume on N3 interface including incoming and outgoing of GTP data packets in total and per QoS level without counting the mandatory part of the GTP-U header

It is useful to analyse transport bandwidth usage of N3 interface in total and QoS level granularity. If the transport bandwidth usage is too high, more bandwidth should be deployed, or load balance should be considered according to core network dimension if there are multiple UPFs connected to multiple gNodeBs. Decision on the additional bandwidth provisioning or load balancing can be made in more fine grained level due to the QoS level measurement.

So it is necessary to define N3 related measurements.

A.12 N6 related measurements

N6 related measurements are used to measure data volume on N6 interface including incoming and outgoing of IP data packets.

It is useful to analyse transport bandwidth usage of N6 interface. If the transport bandwidth usage is too high, more bandwidth should be deployed.

So it is necessary to define N6 related measurements.

A.13 Registration related measurements

A UE needs to register with the 5GS to get authorization to receive services, to enable mobility tracking and to enable reachability. The following registration types are defined:

- Initial Registration to the 5GS;

- Mobility Registration Update (upon changing to a new Tracking Area (TA) outside the UE's Registration Area in both CM-CONNECTED and CM-IDLE state, or when the UE needs to update its capabilities or protocol parameters that are negotiated in Registration procedure with or without changing to a new TA);

- Periodic Registration Update (due to a predefined time period of inactivity); and

- Emergency Registration (i.e. the UE is in limited service state).

The registration may be via 3GPP access, or via untrusted or trusted non-3GPP access.

The performance of registration for each registration type needs to be monitored by the operator since it is relevant to whether the end user can use the service of 5GS or a specific network slice. The performance of registration via 3GPP access and non-3GPP access (including untrusted and trusted non-3GPP access) needs to be monitored respectively.

A.14 PDU session establishment related measurements

The PDU session establishment is one of essential procedures for 5G network. The performance of PDU session establishment directly impacts the QoS of the network and the QoE of the end users. Therefore, the performance measurements are needed to reflect the performance of the PDU session establishment.

The PDU sessions are created in two scerarios; Non-roaming/LBO-roaming and HR-roaming, and are created by (V-)SMF and H-SMF respectively.

On receipt by the (V-)SMF from AMF of Nsmf_PDUSession_CreateSMContex Request, the PDU session is created in non-roaming/LBO-roaming scenario and HR-roaming scenario.

On receipt by the H-SMF from V-SMF of Nsmf_PDUSession_Create Request, the PDU session is created in HR-roaming scenario.

The number and success rate of PDU session creations, the number of PDU sessions running on the SMF are some of the basic performance measurements to monitor the performance of the PDU session establishment. And the performance measurements of failed PDU session creations are helpful to solve the network issues in case the performance is below the expectation.

A.15 Policy association related measurements

To ensure the UE properly use the services provided by 5GS, the UE needs to be associated with a set of policies. The policies are categorized into AM policy, SM policy and UE policy and these kinds of policies are provisioned by PCF.

The AM policy association needs to be established in case the UE initially registers to the network or the UE needs the AMF re-allocation. The AM policy association needs to be updated when the policy control request trigger is met or the AMF is relocated due to the UE mobility and the old PCF is selected (see clause 4.2 in TS 29.507[39]).

The SM policy association needs to be established when the UE requests a PDU Session Establishment. The SM policy association needs to be updated when Policy Control Request Trigger condition is met (see clause 4.2 in TS 29.512[40]).

The UE policy association needs to be established in the following scenarios:

1. UE initial registration with the network when a UE Policy Container is received.

2. The AMF relocation with PCF change in handover procedure and registration procedure.

3. UE registration with 5GS when the UE moves from EPS to 5GS and there is no existing UE Policy Association between AMF and PCF for this UE.

The policy association establishment is the essential steps allowing the UE to be served by the 5GS under the designed policies, therefore it needs to be monitored.

A.16   Monitoring of PDU session resource setup in NG-RAN

The PDU Session Resource Setup procedure in NG-RAN is to assign resources on Uu and NG-U for one or several PDU session resources and the corresponding QoS flows, and to setup corresponding Data Radio Bearers for a given UE.

The PDU Session Resource Setup is one of the most key procedure to allocate resources in the NG-RAN to the UE per the QoS requirements for the NSSAI(s). Whether or not the PDU Session Resource is successfully setup for the NSSAI(s) has direct impact to the user experience. The failed PDU Session Resource Setup may directly cause the service failure for an end user. So, the performance related to the PDU Session Resource Setup for the gNB needs to be monitored.

A.17   Monitoring of handovers

Mobility is one of the most significant feature of the mobile networks, and handover is one typical action of the mobility. The handover failure would cause service discontinuation, thus the performance of the handover has direct impact to the user experience.The handover procedure includes handover preparation, handover resource allocation and handover execution, and the performance related to handover needs to be monitored for each phase. The resources (e.g., PDU Session Resource) need to be prepared and allocated for a handover according to the QoS requirements for each S-NSSAI.

The handover could occur intra-gNB and inter-gNB for 5G networks, and for inter-gNB case the handover could happen via NG or Xn interface. The handover could occur Intra-frequency and Inter-frequency for 5G networks. The handover could also occur between 5GS and EPS.

It is also important to have information about the used beams in the source and target cells in order to optimize the handover performance taking beam ids into account.

For the handover failures, the measurements with specific causes are required for trouble shooting.

The handover parameters setting could be specific for each NCR, and the handover performance could vary significantly for different NCRs, therefore the performance needs to be measured per NCR to support handover parameters optimization when necessary.

A.18   Monitor of BLER performance

The TB Error Rate in UL/DL can directly reflect the BLER, and has an influence on MCS selection and user throughput. It can be helpful to estimate the performance of radio resource management like radio resource schedulein transport layer and be helpful in trouble shooting. Furthermore, they should be taken into account to optimize the system performance. To obtain TB Error Rate by calculating, the number of total and error TBs transmitted in a cell should be monitored.

A.19   Monitor of ARQ and HARQ performance

Reliable Packet Delivery is one of the important Performance factor for a better User experience. HARQ re-transmissions at the MAC layer ensure reliable packet delivery

In addition, RLC can be configured to operate in acknowledged mode for those applications that need very low packet drops and can tolerate a slightly higher delay from RLC re-transmissions.

If a MAC PDU is not delivered, HARQ takes care of re-transmitting (up to a maximum configurable number). If all the re-transmissions fail at MAC layer, and if RLC is configured to operate in acknowledged mode, RLC's ARQ mechanism will take care of any residual packet errors.

It is important to:

a) Maintain the block error rate or packet error rate within tolerable limits.

b) Ensure that HARQ re-transmissions take care of most packet errors, instead of relying on RLC layer re-transmissions (which would increase the delay).

So, it is important to monitor the performance of these schemes.

HARQ Performance if viewed at MCS (Modulation Coded Scheme) can help in monitoring the MCS Performance also.

A.20   Monitoring of PDU session modifications

The PDU session may need to be modified by various causes (see TS 29.502 [14]), whether a PDU session can be successful modified may impact the communication services supported by the PDU session. Therefore the performance of PDU session modification procedures need to be monitored. Besides PDU session modification requests and successes, the PDU session modification failures with specific causes need to be monitored for trouble shooting.

A.21   Monitoring of PDU session releases

The PDU session release may be released by the UE, SMF or AMF. When a PDU session is released by an unexpected reason, the user service would be impacted. The PDU session releases initiated by the UE and SMF are usually triggered by normal reason (e.g., UE deregistration, under request from DN, etc.). The PDU session releases initiated by AMF may be due to an abnormal reason (e.g., mismatch of PDU Session status between UE and AMF). Therefore the PDU session releases initiated by AMF need to be monitored.

A.22   Monitoring of N4 session management

UPF handles the user plane path of PDU Sessions. UPF selection is performed by SMF, and deployments where a UPF is controlled either by a single SMF or multiple SMFs (for different PDU Sessions) are supported.

The SMF uses N4 session management procedures to control the traffic detection, traffic reporting, QoS enforcement and traffic routing of the UPF.

The N4 session management procedures include N4 Session Establishment procedure, N4 session Modification procedure and N4 session release procedure.

If PDF fails to handle the user plane path for a PDU session, the user service will be impacted. So the performance about N4 session management needs to be monitored.

A.23 Use case of VR measurements for NF

In case the NF is virtualized, the performance of an NF may be impacted by the underlying VRs (i.e., virtual CPUs, virtual memories, virtual storages, and connection data volumes). To enable the operator to analyze the impact of the VRs to the performance of the NF, the performance of the virtual compute, virtual memory and virtual disk also needs to be monitored. The usage is the key measurement for the performance of the VR, it can tell whether the VR is overloaded and whether the VR is efficiently utilized. By correlating the VR related measurements with the performance measurement of the NF, the operator can know whether the NF performance issue is caused by the VRs or not. When necessary, the operator may take appropriate action to solve the performance issue of the NF, for example, to scale in/out the VNF instance(s) that realizes the NF, or switch on/off the auto-scaling for the VNF instance(s).

A.24 Monitoring of DRB Setup in NG-RAN

The DRB setup procedure in NG-RAN is to assign resources in gNB and on the air interface (Uu) for one or several DRBs that will handle the QoS flows requested to setup by the core network. The gNB may map several QoS flows to the same DRB so there is no one-to-one mapping between the flows and DRBs.

At DRB setup, the gNB will handle all QoS flows mapped to one DRB the same (mapped 5QI). A QoS flow that is at a later stage mapped to an already setup existing DRB will not increment the DRB setup counters.

The DRB setup is one of the most key procedures to allocate resources in the NG-RAN to the UE per the QoS requirements. Whether or not the DRB is successfully setup has direct impact to the user experience. A failed DRB setup may directly cause service failure or degradation for an end user. So, the performance related to the DRB setup for the gNB needs to be monitored per supported mapped 5QI and per S-NSSAI.

A.25 Monitoring of PDCP data volume measurements

In 5GS, Cell PDCP data volume is a useful measurement which represents the real data traffic for each cell. The monitor of the Cell PDCP data volume could provide operators the traffic information and is useful for operators to do cell load evaluation, load balancing and cell capacity planning.

In addition, in scenarios of dual connectivity, for split bearers, PDCP data is transferred between the MN and the SN via the MN-SN user plane interface. To monitor the real PDCP data volume transmitted in MN and SN in MR-DC scenarios, the data volume transferred between MN and SN should be counted.

A.26 Monitoring of RF performance

RF Performance includes performance of Power Resource Utilization, RF signal, TA, interference and etc. Monitoring of the performance measurements can help to reflect the cell loading information and abnormal conditions.

Monitoring of the quality of RF signal in the cell is useful for the purpose of network planning and overall service quality assessment. Measurements of Channel Quality Indicator (CQI) reported by UEs is a useful metric reflecting RF signal quality and service quality.

A.27 Monitoring of RF measurements

MCS represents the modulation and coding schemes scheduled for the physical resources by NG-RAN. The measurements of MCS distribution is a useful metric reflecting the efficiency for PDSCH and PUSCH RBs. It is helpful

for operator to optimize the scheduling of physical resources to improve the network efficiency and overall service quality.

The MCS scheduling strategies of MU-MIMO and SU-MIMO are different due to factors such as user pairing and interference. So it is necessary to distinguish statistics and measurements of MCS distribution for MU-MIMO and SU-MIMO.

A.28   Monitor of QoS flow release

QoS flow is the key and limited resource for 5G RAN (including NG-RAN and non-3GPP access) to deliver services. The release of the QoS flow needs to be monitored as:

-   an abnormal release of the QoS flow will cause the call(/session) drop, which directly impacts the QoS delivered by the networks, and the satisfaction degree of the end user;

-   a successfully released QoS flow can be used to setup other requested calls(/sessions). The QoS flow failed to be released will still occupy the limited resource and hence it can not be used to admit other requested calls(/sessions).

From a retainability measurement aspect, QoS flows do not need to be released because they are inactive, they can be kept to give fast access when new data arrives.

To define (from a QoS flow release measurement point of view) if a QoS flow is considered active or not, the QoS flow can be divided into two groups:

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 flow (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}.

The specific reason causing the abnormal and failed release of the QoS flow is required in order to find out the problem and ascertain the solutions. And due to different priority and tolerance for different service type with different QoS level in the networks, the monitor needs to be opened on each service type with QoS level.

The QoS flow can be released by PDU Session Resource Release procedure, UE Context Release procedure, Reset procedure either initiated by 5G RAN (including NG-RAN and non-3GPP access) or AMF and NG Path Switch procedure (see TS 38.413 [11]).

So performance measurements related to QoS flow Release (see TS 38.413 [11]) and UE Context Release (see TS 38.413 [11]) procedure for each service type with QoS level are necessary to support the monitor of QoS flow release.

The abnormal release of the QoS flow has potential scenario where, regardless of receiving the UE Context Release Command with the cause related to abnormal release, the end user does not perceive it as abnormal. This scenario is explicitly related to 5QI 1 calls, for other services it is not possible to determine the reason behind the cause code. It is typical to encounter such scenario, a so called "double UE Context", when Radio Link Failure occurs during an ongoing 5QI 1 call and RRC Connection Re-establishment attempt fails on target or other cell. If then the UE does a new RRC Connection the 5QI 1 QoS flow is set-up during Initial Context Setup in the target or other cell. However, when AMF receives that service request with the Initial UE message through the target or other cell, it realizes that it already has the same UE Context but from the source cell (it has not been released yet). In such case, AMF sends UE Context Release Command to the source cell. As the 5QI 1 QoS flow has been successfully setup in the target or other cell, the 5QI 1 QoS flow release in the source cell may not be perceived as a drop (abnormal release) by the end user, as the service has been sustained with some interruption time, and can't be considered as a drop in the 5QI 1 QoS flow Drop Ratio. This interruption time may be monitored in order to evaluate how it can impact the QoS of the 5QI 1 Flows due to double NG (double UE context)". Moreover, the 5QI 1 QoS Flows that can be immediately released due to radio reasons with UE connectivity lost (when T-RLF timer was not started) may be delayed by time interval based on this average interruption time to possibly transform them to double NG scenario to keep the calls active and reduce further the 5QI 1 QoS flow Drop Ratio.

From QoS perspective it is important to focus also on call duration as in some cases wrong quality perceived by the end user is not fully reflected by drop ratio nor retainability KPI. Typical case is when due to poor radio conditions the end user redials (the call was terminated normally) to the same party to secure the quality. But in this case the drop ratio KPI will not show any degradation. Secondly, although the call is dropped the end user may or may not redial depending on dropped call duration compared to the case when the call would be normally released. It is therefore highly recommended to monitor average and distribution of duration of normally and abnormally released calls.

A.29   Monitor of call (/session) setup performance

Call(/session) setup is one of most important step to start delivering services by the networks to users.

The success or failure of a call(/session) setup directly impacts the quality level for delivering the service by the networks, and also the feeling of the end user. So the success or failure of call(/session) setup needs be monitored, this can be achieved by the calculation of call setup success rate which gives a direct view to evaluate the call setup performance, and the analysis of the specific reason causing the failure to find out the problem and ascertain the solutions.

In addition, the time duration of the call(/session) setup need to be monitored as it impacts the end user experience, and by comparison with operator's benchmark requirements, the optimization may be required according the performance.

To support the monitor of success or failure of the call(/session) setup, the performance measurements related toPDU Session Resource Setup/modify (See TS 38.413[11]) in NG-RAN or via trusted/untrusted non-3GPP access and Initial Context Setup (See TS 38.413[11]) procedures for each QoS level and each S-NSSAI are needed.

A.30   Void

A.31   Monitoring of QoS flows for SMF

To support a service for a UE, the QoS flow supporting the specific QoS needs to be added or modified. If the QoS flow fails to be added or modified, the user service cannot be conducted or the QoS cannot be met. So the QoS flow addition and modification need to be monitored.

Furthermore, in order to know the UE traffic pattern at SMF, it is necessary to monitor the peak and mean number of ongoing QoS flows for each granularity period.

A.32   Monitoring of service requests

The Service Request procedure is initiated via 3GPP access:

> by the UE in CM-IDLE state in order to send uplink signalling messages, user data, or as a response to a network paging request; or

> by the network when the network needs to signal (e.g. N1 signalling to UE, Mobile-terminated SMS, User Plane connection activation for PDU Session(s) to deliver mobile terminating user data) with a UE.

The Service Request procedure via non-3GPP Access (including untrusted and trusted non-3GPP access) is used by a UE:

- in CM-IDLE state over non-3GPP access to request the re-establishment of the NAS signalling connection and the re-establishment of the user plane for all or some of the PDU Sessions which are associated to non-3GPP access; and

- in CM-CONNECTED state over non-3GPP access to request the re-establishment of the user plane for one or more PDU Sessions which are associated to non-3GPP access.

The Service Request procedures via 3GPP access and via untrusted/trusted non-3GPP Access need to be monitored respectively in order to know the performance of the 5G network in terms of providing services to the UEs.

A.33 Monitoring of DL PDCP UE buffered throughput

To monitor DL PDCP buffered throughput per UE and bearer is essential, to ensure end user satisfaction and well functioning and well configured cells. If an end user often experiences low quality during use of a service, the end-user might change wireless subscription provider, i.e. loss of income for the network operator.

A.34 Monitoring of RRC connection setup in NG-RAN

RRC connection setup is one of most important step to start delivering services by the networks to users, (see TS 38.331 [20]).

Whether or not the RRC connection is successfully setup has direct impact to the user experience. A failed RRC connection setup may cause service failure or failure in updating tracking area information for an end user. So, the performance related to the RRC connection setup for the gNB needs to be monitored. This can be achieved by the calculation of RRC connection setup success (or failure) rate (number of successful (or failed) / number of attempt) which gives a direct view to evaluate the RRC connection setup performance, and the analysis of the specific reason causing the failure to find out the problem and ascertain the solutions.

Since the intended service is not yet know when establishing the RRC connection, it is not possible to do separation between QoS classes or S-NSSAIs.

A.35 Monitoring of UE associated NG signalling connection setup in NG-RAN

The NG signalling connection setup procedure in NG-RAN is to establish signalling connection between gNB and AMF for a given UE.

Whether or not the NG signalling connection is successfully setup has direct impact on the user experience. A failed NG signalling connection setup may directly cause service failure or failure in updating tracking area information for an end user. So, the performance related to the NG signalling connection setup for the gNB needs to be monitored. This can be achieved by the calculation of success rate for UE associated NG signalling connection (number of successful / number of attempted) which gives a direct view to evaluate the setup performance.

Since the intended service is not yet know when establishing the UE associated NG signalling connection, it is not possible to do separation between QoS classes or S-NSSAI.

A.36 Monitoring of PDCP data volume per interface

In 5GS, PDCP data volume is a useful measurement which represents the real data traffic towards each GNBDUFunction (F1-U interface), each external gNB-CU-UP (Xn-U interface) and each external eNB (X2-U interface). The monitoring of the PDCP data volume could provide operators with traffic information and is a useful measure in performance assurance within integrity area (user plane connection quality) and in energy efficiency evaluation.

A.37 Monitoring of RRC connection re-establishment

The failed RRC connection re-establishment will cause the call (/session) drop, which directly impacts the QoS delivered by the networks.

A.38   Monitoring of RRC connection resuming

RRC connection resuming is one of important step to start delivering services by the networks to users or for RNA update.

The success or failure of a RRC connection resuming directly impacts the quality level for delivering the service by the networks, and also the feeling of the end user. So the success or failure of RRC connection resuming needs be monitored, this can be achieved by the calculation of RRC connection resuming success rate which gives a direct view to evaluate the resume performance, and the analysis of the specific reason causing the failure to find out the problem and ascertain the solutions.

A.39   Monitoring of inter-AMF handovers

The handover could occur from a source NG-RAN to the target NG-RAN that are served by different AMFs. During the handover, the PDU sessions and QoS flows need to be setup in the target side. The failure of the PDU session setup or QoS flow setup during the inter-AMF handover has direct impact to the user's experience. Therefore, it is necessary to monitor the performance related to PDU session setup or QoS flow setup for the Inter-AMF handover.

A.40   Monitoring of incoming/outgoing GTP packet loss on N3

Keeping track of GTP data packet loss over N3 is essential, since for certain services packets that are lost along the way through the system may have a noticeable impact on the end user. Incoming/outgoing GTP data packet loss measurements can be useful for evaluation, optimization, and performance assurance between gNB and UPF in the core. It is also important for the performance measurement of end-to-end point of view from UE to UPF. Performance degradation can happen any point although the focus is centered more at UE and RAN. When the monitoring incoming/outgoing GTP packet loss on N3 requires specific measurements per GTP tunnel, the monitoring of incoming/outgoing GTP packet loss on N3 can use subcounters per TEID to provide the measurements within a GTP tunnel.

A.41   Monitoring of round-trip GTP packet delay on N3

Keeping track of GTP data packet delay over N3 is essential, since for certain services packet delay along the way through the system may have a noticeable impact on the end user. Incoming/outgoing GTP data packet delay measurements can be useful for evaluation, optimization, and performance assurance between gNB and UPF in the core. It is also important for the performance measurement of end-to-end point of view from UE to UPF. Performance degradation can happen any point although the focus is centered more at UE and RAN.

A.42   Monitoring of PDU session resource management for untrusted non-3GPP access

The PDU Session Resource management procedure for Untrusted non-3GPP Access is to manage resources in Untrusted non-3GPP Access for the PDU sessions.

The PDU Session Resource needs to be setup or modified via the Untrusted non-3GPP Access for the UE per the QoS requirements for the NSSAI(s).

The PDU Session Resource setup and modification via the Untrusted non-3GPP Access have direct impact to the user experience. So, the performance related to the PDU Session Resource setup and modification via the Untrusted non-3GPP Access needs to be monitored.

A.43 Monitor of DRB release

DRB is the key and limited resource for NG-RAN to deliver services. Once a QoS flow reaches a gNB it will trigger setup of a new DRB or it will be mapped to an existing DRB. The decision on how to map QoS flows into new or existing DRBs is taken at the CU-CP. CU-CP also defines one set of QoS parameters (one 5QI) for the DRB. If a QoS flow is mapped to an existing DRB, the packets belonging to that QoS flow are not treated with the 5QI of the QoS flow, but they are treated with the mapped 5QI of the DRB.

The release of the DRB needs to be monitored as:

- an abnormal release of the DRB will cause the call(/session) drop, which directly impacts the QoS and slice delivered by the network, and the satisfaction degree of the end user;

- a successfully released DRB can be used to setup other requested calls(/sessions). The DRB failed to be released will still occupy the limited resource and hence it can not be used to admit other requested calls(/sessions).

From a retainability measurement aspect, DRBs do not need to be released because they are inactive, they can be kept to give fast access when new data arrives.

To define (from a DRB release measurement point of view) if a DRB is considered active or not, the DRB can be divided into two groups:

- For DRBs with bursty flow, a DRB is said to be 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.

- For DRBs with continuous flow, the DRB is seen as being active 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}.

Due to different priority and tolerance for different service type with different QoS level in the DRB, the measurement needs to be performed per mapped 5QI, to be able to judge the result.

Similarly, the abnormal and failed DRB releases will affect different Service Level Agreements in the networks. Therefore, each S-NSSAI needs to be monitored.

The DRB can be released by PDU Session Resource Release procedure, PDU Session Resource Modify procedure, PDU Session Resource Notify procedure, UE Context Release procedure, Reset procedure either initiated by NG-RAN or AMF and NG Path Switch procedure (see TS 38.413 [11]).

Therefore, performance measurements related to DRB Release (see TS 38.413 [11]) and UE Context Release (see TS 38.413 [11]) procedure for each QoS level (mapped 5QI) and each S-NSSAI are necessary to support the monitor of DRB release.

A.44 Monitoring of application triggering

When the AF needs to trigger the UE for some actions, the AF requests the NEF to send an application trigger to the UE.

The application in the UE may perform actions as indicated by the Trigger payload when the Triggered payload is received at the UE. For example initiation of immediate or later communication with the application server based on the information contained in the Trigger payload, which includes the PDU Session Establishment procedure if the related PDU Session is not already established.

Therefore, to ensure the application run normally, the network needs to successfully deliver the application trigger to the UE.

A.45 Monitoring of SMS over NAS

The SMS can be transferred over NAS in 5G networks. To enable SMS over NAS transporting, the UE includes an "SMS supported" indication in Registration Request indicating the UE's capability for SMS over NAS transport, and in the Registration Accept the networks indicates to the UE whether the network allows the SMS message delivery over NAS. If the SMS over NAS is allowed by the network, the SMS messages can be originated or terminated by the UE, via 3GPP or non-3GPP access.

The performance of SMS over NAS, as a service provided to the end users, has direct impact to user experience and user satisfaction, and thus needs to be monitored. For this purpose, the measurements for the following aspects are needed:

- registration procedure for SMS over NAS to reflect whether the UEs are allowed or disallowed to send or receive SMS messages over NAS;

- the number of SMS messages requested to be sent or received over NAS and the number of SMS messages successfully delivered over NAS, which can directly reflect whether the services can be successfully delivered to the users.

A.46 Monitoring of round-trip GTP packet delay on N9

When I-UPF exists, the delay over N9 interface for DL/UL data packets is essential as part of the e2e packet delay, since for certain services packet delay along the way through the system may have a noticeable impact on the end user. RTT GTP data packet delay measurements for DL/UL data packets can be useful for evaluation, optimization, and performance assurance for the N9 interface between PSA UPF and I-UPF. It is also important for the performance measurement of end-to-end point of view from UE to PSA UPF. Performance degradation can happen any point, so the RTT N9 delay needs to be measured at PSA UPF and I-UPF respectively. The GTP packets are prioritized for transmitting using DSCPs, so it is necessary to measure the round-trip GTP packet delay per DSCP.

A.47 Monitoring of GTP packets delay in UPF

The GTP packets may be delayed on the interfaces and in the NFs. For some services (such as URLLC sevices), the end to end packet delay in the network has clear impact to users' experience. The GTP packets delay in the UPF, as one segment of the end to end delay in the network, needs to be measured in order to indicate where the performance degradation happens. The GTP packets are prioritized for transmitting for different 5QIs and S-NSSAIs, so the measurements per 5QI and S-NSSAI are needed.

A.48 Monitoring of round-trip delay between PSA UPF and UE

The end to end delay in 5G networks between UE and PSA UPF has direct impact to users' experience for some types of services (e.g., URLLC). In case the PSA UPF and NG-RAN are not time synchronised, the round-trip delay between PSA UPF and UE can be measured at PSA UPF.

The measurements on the round-trip delay between PSA UPF and NE can be used to evaluate the user plane delay performance in 5G networks and users' experience.

A.49 Monitoring of Power, Energy and Environmental (PEE) parameters

Power, Energy and Environmental (PEE) parameters, combined with data volume measurements, are valuable information for operators to measure the energy efficiency of their 5G network. Hence it is necessary to define PEE parameters related to 5G network such as power, energy, temperature, voltage, current and humidity.

A.50 Monitoring of UE configuration update

To ensure the UE properly use the services provided by 5GS, the UE needs to update access and mobility management related parameters decided and provided by the AMF.

The UE configuration update is the essential steps allowing the UE to be served by the 5GS under the changed configuration, therefore it needs to be monitored.

A.51 Monitoring of subscriber's number for UDM

The number of subscribers including registered and unregistered subscribers for UDM need to be monitored as it reflects the service load of the UDM, the operators can use this information for resource allocation or load balance purpose.

A.52 Monitoring of QoS flow modification

The QoS flow may need to be modified to fulfil the updated QoS requirements for the UE. The QoS modification success or failure has direct impact to the users about the QoS that the network can provide. The performance measurements related to QoS flow modification are needed to evaluate the performance that whether or not the UE's updated QoS requirements are fulfilled by the network, and to support finding the causes of the failures for troubleshooting.

The QoS flows, within the PDU session, may be established in NG-RAN or untrusted/trusted non-3GPP access, so separate performance measurements are needed to monitor the QoS flow modifications respectively in NG-RAN and untrusted or trusted non-3GPP access.

A.53 Monitoring of handovers between 5GS and EPS

The handover could occur between 5GS and EPS with or without N26 interface. The success or failure of the handover between 5GS and EPS directly impacts the users' experience, especially for the service of voice over IMS. When the handover occurs via the N26 interface, the handover may succeed or fail on the N26 interface. The performance of handover between 5GS and EPS needs to be monitored, and for failure cases the measurements with specific causes are needed for trouble shooting.

A.54 Monitoring of NF service registration and update

The NRF maintains the information of available NF instances and their supported services, and each NF instance informs the NRF of the list of NF services that it supports.

The NF instance may make this information available to NRF when the NF instance becomes operative for the first time (registration) or upon individual NF service instance activation/de-activation within the NF instance (update operation) e.g. triggered after a scaling operation. The NF instance while registering the list of NF services it supports, for each NF service, may provide a notification endpoint information for each type of notification service that the NF service is prepared to consume, to the NRF during the NF instance registration. The NF instance could also update or delete the NF service related parameters (e.g. to delete the notification endpoint information). Registration with the NRF includes capacity and configuration information of the NF instances and at time of instantiation.

The failed NF service registration or update would result in that 1) the NF service cannot be discovered or consumed by the consumer, and 2) the NF service may not be able to receive the notifications for the other NF services it needs to consume, such failures would impact many users who need to be supported by the NF services. Therefore, the performance of the NF service registration or update need to be monitored, especially for the failure cases which need to trigger trouble shooting.

A.55 Monitoring of NF service discovery

An NF service is one type of capability exposed by an NF (NF Service Producer) to other authorized NF (NF Service Consumer) through a service-based interface. A Network Function could expose one or more NF services.

The NF discovery and NF service discovery enable Core Network entities (NFs or Service Communication Proxy (SCP)) to discover a set of NF instance(s) and NF service instance(s) for a specific NF service or an NF type. Unless the expected NF and NF service information is locally configured on the requester NF, e.g. when the expected NF service or NF is in the same PLMN as the requester NF, the NF and NF service discovery is implemented via the Network Repository Function (NRF).

If the NF service instance(s) cannot be discovered by the NF consumer, the network feature may not be fully supported thus the uses may suffer from service failures. Therefore, the performance of the NF service discovery needs to be monitored.

A.56 Monitoring of PFD management

The Packet Flow Description (PFD) describes the packet flow for the UL/DL application traffic by a tuple of protocol, server-side IP and port number.

Management of Packet Flow Descriptions (PFDs) refers to the capability to create, update or delete PFDs in the NEF (PFDF) for the applications under the request of AF, and the distribution from the NEF (PFDF) to the SMF and finally to the UPF.

The 5G network needs to have the up-to-date PFDs in order to deliver the user data to the destination for the applications, and the applications cannot be fulfilled without PFDs or with wrong or obsolete PFDs. Therefore, the performance of PFD management, including PFD creation, update, deletion, fetch and subscription, needs to be monitored.

A.57 Monitoring of incoming GTP packet out-of-order on N3 interface

If the sequence is out-of-order during the link transmission between gNB and UPF, especially for the TCP-type service, fast retransmission and even the exponential back-off process of the TCP occur, it will have a great impact on the terminal service rate. Adding the out-of-order packet measurement metrics on the N3 interface is helpful to better observe and evaluate the transmission quality of the data link between the gNB and the UPF. It is of significance to the high-rate and high-reliability services.

A.58 Monitoring of PCI to detect PCI collision or confusion

Each NR cell is assigned a PCI that enables UE to uniquely identify the cell. PCI values need to be reused, as there are only 1008 PCI values. Typically, operators use network planning tool to assign PCIs to cells when the network is deployed to insure all neighbouring cells have different PCIs. However, due to the addition of new cells or changes of neighbour relations from ANR functions, issues can arise, such as PCI collision, PCI confusion.

The measurement of PCI values for candidate cells can be used by C-SON to detect potential PCI issues. The example in Fig A.x.-1 show the PCI values assigned to neighboring cells, where

- Cell #6: PCI = 7

- Cell #10: PCI = 9

- Cell #7: PCI = 1

- Cell #8: PCI = 7

C-SON PCI configuration function can collect and anaylze the measurements to detecet the PCI issue between cell #6 and cell #8.
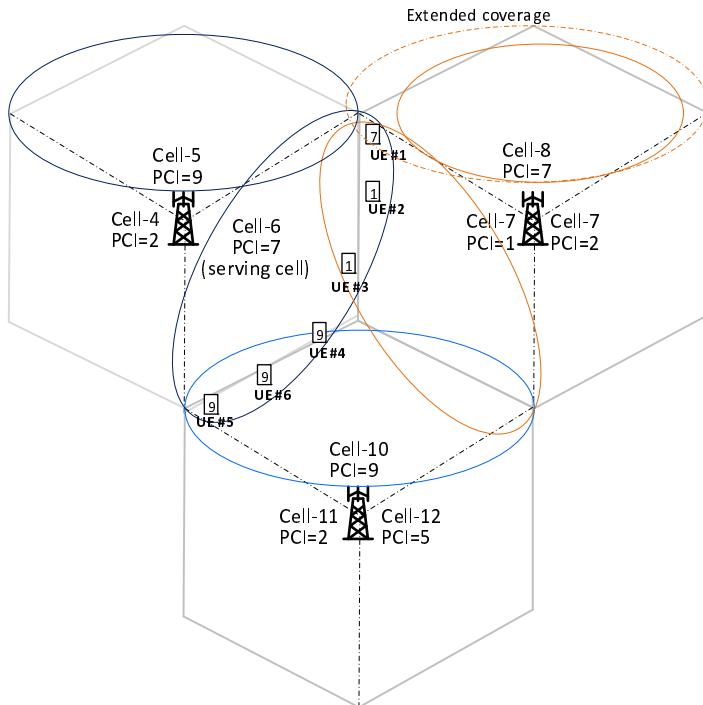
Figure A.58-1: PCI configuration example

A.59 Monitoring of RACH usage

The RACH plays a vital role in the following procedures:

- Initial access from RRC_IDLE;

- Initial access after radio link failure;

- Handover requiring random access procedure;

- DL data arrival during RRC_CONNECTED requiring random access procedure;

- UL data arrival during RRC_CONNECTED requiring random access procedure;

Furthermore, the random access procedure takes two distinct forms:

- Contention based using a randomly selected preamble (applicable to all five events);

- Non-contention based using a dedicated preamble (applicable to only handover and DL data arrival).

In the use-case of RACH configuration optimization, received Random Access Preambles and a contention indicator are signalled across an OAM interface.

Monitoring of the preamble usage in a cell allows the operator to determine if the resources allocated to the RACH by the gNodeB are appropriate for the number of random access attempts. If the resources are underutilised, then the operator may reconfigure the gNodeB (via CM) to allocate less resource to RACH thereby freeing up resource for other uplink transmissions. Alternatively, if the resources are heavily utilised then this is indicative of RACH congestion leading to increased latency for the procedures listed above. To this effect, measurements directly reflecting RACH congestion experienced by the gNodeB and by the UEs are useful.

The gNodeB can partition the RACH resource between dedicated preambles, randomly selected preambles in group A and randomly selected preambles in group B. This partitioning can be evaluated when usage measurements are made on each set separately. In a cell configured with multiple SSBs, it is important to get the measurements per SSB.

A.60   Monitoring of the number of active UEs in NG-RAN

The number of the active UEs per direction in each cell is a valuable measurement for operators to know how many DRBs are running with buffered data per cell and QoS or S-NSSAI basis. For multi-operator RAN sharing scenario, PLMN basis is needed, too. This kind of information can help operators to tune the admission control parameters for the cell and to estimate load in neighbour cells, to ensure that the UEs admitted achieve the target QoS and that capacity is not over-estimated when distributing load between cells and gNBs.

A.61   Monitoring of one way delay between PSA UPF and NG-RAN

The DL and UL one way delay has direct impact to users' experience for some types of services (e.g., URLLC). The one way delay between PSA UPF and NG-RAN is part of the end to end one-way delay and is not expected very long comparing to the delay in between NG-RAN and UE.

In case the PSA UPF and NG-RAN are time synchronised, the UL one way delay can be measured by PSA UPF and the DL one way delay can be measured by NG-RAN.

The measurements on the one way DL and UL delay between PSA UPF and NG-RAN can be used to evaluate and optimize the DL and UL user plane delay performance between 5GC and NG-RAN.

A.62   Monitoring of round-trip delay between PSA UPF and NG-RAN

The end to end delay in 5G networks between UE and PSA UPF has direct impact to users' experience for some types of services (e.g., URLLC). The delay between PSA UPF and NG-RAN is part of the end to end one-way delay and is not expected very long comparing to the delay in between NG-RAN and UE.

In case the PSA UPF and NG-RAN are not time synchronised, the round-trip delay can be measured at PSA UPF.

The measurements on the round-trip delay between PSA UPF and NG-RAN can be used to evaluate and optimize the DL and UL user plane delay performance between 5GC and NG-RAN.

A.63   Monitoring of beam switches

Beam is an important feature in 5G networks. In case the intra-beam switch function is enabled (see TS 38.331 [20]), due to the complexity of the radio environment, especially when UE moves quickly and frequently, it is possible to have problems such as pointing deviation, which can lead to switch failure. The success rate of beam switch can help to reflect whether there is a problem in beam related parameter configuration. Furthermore, low beam switch success rate will impact user experience. Therefore, it is essential in network operations to monitor the success rate of beam switch and to define the related measurements.

A.64   Monitoring of RF performance

Monitoring of the quality of RF signal in the cell is useful for the purpose of network planning and network optimization.

In case the L1-RSRP report function is enabled, measurements of RSRP per beam reported by UEs is a useful metric reflecting RF signal strength. In 5G NR, gNB cells transmit many narrow beams targeting UEs in the cell that result in better link budget and lower interference. However, some areas between beams of neighbouring NR cells , or between the NR cell and the neighbor E-UTRA cell may experience poor coverage or coverage holes. Therefore, it is necessary to optimize the beam coverage by coordinating the beam management function across multiple neighboring NR cells.

The Absolute Timing Advance reflects the distance of the UE from the cell antenna. The distribution of Absolute Timing Advance reflects UE distribution in the NR cell, thus it is helpful for analyzing the coverage and the capacity.

A.65 Monitoring of one way delay between PSA UPF and UE

The end to end DL/UL delay in 5G networks between UE and PSA UPF has direct impact to users' experience for some types of services (e.g., URLLC). In case the PSA UPF and NG-RAN are time synchronised, the DL/UL delay between PSA UPF and UE can be measured at PSA UPF.

The measurements on the DL/UL delay between PSA UPF and NE can be used to evaluate the user plane delay performance in 5G networks and users' experience.

A.66 Monitoring of MRO performance

5G NR cells may experience issues, such as too early or too late handover, handover to wrong cell, ping-pong handover, that not only impact user experience, but also waste network resources, if handover parameters are not set properly. MRO is intended to automatically detect the handover issues, and determine actions to configure the handover parameters in cells in order to improve the handover performance.

It is also important to have information about the used beams in the source in order to optimize the handover performance taking beam IDs into account.

The MRO related measurements are used to support the mobility roburstness optimization SON function.

A.67 Monitoring of distribution of integrated delay in NG-RAN

The integrated DL/UL packet delay in NG-RAN, i.e., the delay between NG-RAN and UE (including the delay at gNB-CU-UP, on F1-U and on gNB-DU for split scenario and the delay over Uu interface) is one significant part of the e2e delay that has direct impact to users' experience for some types of services (e.g., URLLC).

Besides the average integrated delay in NG-RAN which can reflect whether or not the users experience can be met on average, it is very useful for operator to know how many (percents of) data packets are with satfistfied delay perfomance, and how many are not with satisfied performance and how far they are from the satisfied performance. Therefore, the distribution of integrated delay in NG-RAN needs to be monitored.

As each S-NSSAI or 5QI has different requirements on the delay, so the distribution of integrated delay in NG-RAN needs to be monitored per S-NSSAI and per 5QI.

For multi-operator RAN sharing scenario, different operators may have different S-NSSAI or 5QI requirements on the packet delay, so the distribution of integrated delay in NG-RAN per S-NSSAI and per 5QI for each PLMN needs to be monitored, too.

A.68 Monitoring of GTP data packets and volume on N9 interface

In 5GC, the user plane data traffic is transmitted on N9 interface between PSA UPF and I-UPF. The data volume of GTP data packets on N9 interface is helpful for operators to understand the traffic distribution of the 5GC, and evaluate and optimize the bandwidth of the N9 interface. The number of GTP packets on the N9 interface is relevant to the packets processing that may result in larger or smaller packet delay on the interface.

Therefore, the data volume and number of GTP data packets on the N9 interface need to be monitored.

To support the resource allocation and optimization on N9 interface for the network slicing, the data volume and GTP data packets need to be monitored for each S-NSSAI.

A.69   Use case of UE power headroom

UE power headroom measurement is important for analyzing UE power distribution, to learn whether the uplink signal strength can be increased or not. So it is very useful to do trouble shooting of coverage hole and coverage balance for uplink. It is also used to evaluate the power control performance and increase UE power headroom as possible with QoS is guaranteed for the purpose of energy saving. These questions are determined by the ratio of the number of larger or less than threshold to the total number of it and the threshold is configurable.

A.70   Monitor of paging performance

In NR, Paging is under the control of the 5GC or NG-RAN (aka RAN initiated paging and CN initiated paging). When the 5GC wants to page (CN initiated paging) a UE, it has to page it in all cells that belong to the TA(s) to which the UE is registered.

The paging load per cell and gNB is an important measure for the operator as it allows the operator to properly dimension the resources for paging in the NR Cell and gNB.

At an NR Cell and gNB it makes sense to measure the number of discarded paging messages if this is due to some problem in the gNB, such as paging occasion overflow. In that scenario the periodicity of paging occasions can be reconfigured in order to ensure that all paging messages are transmitted by the gNB in the first available paging occasion, thereby avoiding paging delays and extended call setup delay.

Operators need to know when such an event occurs, in order to identify if the problem is at the NR cell or gNB level or not.

In addition to discarded paging records measurement, it is important to know total paging records received so that discarded paging records ratio can be derived.

Total number of paging records received is important in the sense that, it may be fine if the discarded paging records are high if discarded paging records ratio is small. On the other hand, it may be problematic if discarded paging records are low, if discarded paging records ratio turn out to be high.

A.71   UE and traffic per SSB beam related measurements

UE and traffic per SSB beam related measurements is helpful for analyzing users and services under different SSB beam coverage, and for network optimization and adjustment of SSB beam coverage or balancing of users and traffic under different SSB BEAM beams. Through the statistics, operator can learn about user distribution and service distribution which is the important information for network planning.

A.72   Monitoring of network slice selection

The network slice selection service enables the network to select the network slice to serve the UE, and enables the NSSF to provide the AMF the Allowed NSSAI and the Configured NSSAI for the Serving PLMN.

The network slice selection service may be consumed during Registration procedure, during inter-PLMN mobility procedure, PDU session establishment and UE configuration update, etc.

The network slice selection is the primary step enabling the 5G networks to support network slicing, therefore the performance of network slice selection needs to be monitored.

A.73 Use case of EPS fallback monitor

Under the constraints of UE and network coverage, EPS fallback is an important means to guarantee voice continuity. Restricted by the UE capability and network configuration, the EPS fallback supports the modes of handover and redirection.The measurement related to EPS fallback is helpful for evaluating voice continuity and for the operator's network planning and optimization.

A.74 Use case of EPS fallback handover time monitor

The measurement statistics of EPS fallback handover time include the total time consumed by the whole handover time or the time in the execution phase. The EPS fallback handover time directly affects user perception, and the time in the execution phase helps to optimize the performance of different systems.

A.75 Use case of MU-MIMO measurements

The application of MU-MIMO greatly improves the network capacity. Whether MU-MIMO getting the most out of itself will impact the improvement of network capacity and performance. MU-MIMO related statistics can reflect the disparity between the actual effect of MU-MIMO and the maximum layers supported by the network, and help to fix and improve the MU-MIMO algorithm.

A.76 Monitoring of subscriber profile sizes in UDM

The subscriber profiles maintained by UDM have two parts - static and dynamic data. Dynamic part of the subscriber profile grows over time (e.g. due to roaming conditions, dynamic dereferencing of provisioning data, addition/enabling of new features). The uncontrolled and unnoticed growth of subscriber profiles may result in degraded system performance and lead to service impacts.

Various corrective actions varying from subscriber profile optimization (clean-up/compression/re-structuring) to applying configuration changes and scaling may be applied to resolve/mitigate the issue.

Operators need to be aware of the subscriber profile size dynamics in order to be able to mitigate potential network-wide problems before they occur.

A.77 Monitoring of SS-RSRQ

SS-RSRQ is used in 5G NR networks to determine the quality of the radio channel. RSRQ, unlike RSRP (wanted signal strength), also includes interference level due to the inclusion of RSSI in calculation. This measurement is usefule to eveluate the qulity of cell coverage through the SS-RSRQ distribution,especially to optimize cell selection and handover related parameters configration, mainly in border parts of cell.

A.78 Monitoring of SS-SINR

SS-SINR is the ratio of the received signal level and the sum of interference and noise, which is used in 5G NR networks to determine the quality of the radio channel. This measurement is useful to eveluate the QoS of Synchronization Signal through the SS-SINR distribution for each cell. It is helpful to troubleshooting weak coverage cell or low NR access rate cell according to the ratio of SS-SINR bins that is below predefined threshold and all of the SS-SINR bins.

A.79   Monitoring of S-NSSAI availability update and notification

The S-NSSAI(s) supported by the AMF on a per TS basis may be changed and the change needs be updated to NSSF. The AMF may subscribe to the notification of any changes to the NSSAI availability information updated by another AMF on a per TA basis.

The up-to-date and effective S-NSSAI availability information are fundamental to support network slicing for 5G, therefore the performance of S-NSSAI availability service needs to be monitored.

A.80   Monitoring of SMS delivery procedures

SMS delivery is one of the essential procedures for SMS service. The performance of SMS delivery procedures reflect the quality of SMS service for users. The monitoring of SMS delivery request and success is needed for SMS service evaluation.

A.81   Monitoring of registration and de-registration procedure for SMS

In order to activate SMS service for a given service user, a registration procedure for SMS over NAS is needed. Registration procedure related measurements can reflect the success ratio for access to 5GS of SMS users.

De-registration procedure is invoked to deactivate SMS service for a given service user, which results in deleting an individual UE Context for SMS in the SMSF. De-registration procedure related measurements can reflect the success ratio for deactivating SMS service.

A.82   Monitoring of NIDD (Non-IP Data Delivery)

NIDD service may be used to handle Mobile Originated (MO) and Mobile Terminated (MT) communication with UEs to AF, where the data used for the communication is considered unstructured (a.k.a., Non-IP).

NIDD is handled using an Unstructured PDU session to the NEF, and NIDD API may be used for a PDU session based on the configuration in the subscription.

The NIDD configuration service can be used for AF to update the NEF ID for the NIDD service, and to indicate which serialization formats it supports for mobile originated and mobile terminated traffic in the Reliable Data Server Configuration.

Therefore, for evaluation of NIDD performance, the NIDD configuration and NIDD service need to be monitored with the relevant performance measurements.

A.83   Monitoring of AF traffic influence

As described in TS 23.501 [4], an Application Function may send requests to influence SMF routeing decisions for User Plane traffic of PDU Sessions. The AF requests may influence UPF (re)selection and allow routeing of user traffic to a local access (identified by a DNAI) to a Data Network. The AF may request the traffic influence via NEF.

The fulfilment of traffic influence per the request from AF means that the user data traffic is routed according to the requirements from the application, therefore performance measurements are needed to indicate whether the AF traffic influence requests are fulfilled.

A.84 Monitoring of external parameter provisioning

The NEF allows an external party (AF) to provision the information, such as expected UE behaviour (regarding UE movement or communication characteristics) and service specific parameters, or the 5G VN (Virtual Network) group information to 5G network functions, see TS 23.501 [4].

The failed external parameter provisioning would impact the UE behaviour or service fulfilment; therefore, the performance of external parameter provisioning needs to be monitored.

A.85 Monitoring of SMF-NEF connection establishment

For delivering the NIDD service, the SMF-NEF connection needs to be established for a PDU Session for a UE. NEF provides the capabilities to create, update and release the SMF-NEF connection.

The SMF-NEF connection is used for transferring the NIDD data, therefore the performance of the SMF-NEF connection establishment impacts users' experience about the NIDD service.

A.86 Monitoring of service specific parameters provisioning

AF may need to provide service specific parameters to 5G system via NEF in order to support the service not provided by the PLMN. The 5GS, after receiving via NEF, delivers the service specific parameters to the target UEs.

The service specific parameter provisioning service provided by NEF is critical for the 5GS (including the UEs) to support these services. Therefore, it would be necessary for the operators to monitor the performance of the service specific parameter provisioning.

A.87 Monitoring of background data transfer policy negotiation and application

AF may need to negotiate the policies for future background data transfer with 5GS via NEF, before the UE's PDU Session establishment. Per the request from AF, the NEF negotiates with H-PCF about the transfer policies for the future background data transfer. The transfer policies may contain a desired time window for the background data transfer, a reference to a charging rate for the time window, network area information, and optionally a maximum aggregated bitrate, as described in clause 6.1.2.4 of TS 23.503 [46].

The AF may apply the negotiated policies for a future PDU Session at some point.

The policies for the background data transfer have strong relevance to users' experience, therefore the measurements are needed to monitor the performance of policy negotiation and application for background data transfer.

A.88 Monitoring of data management for UDR

UDR provides data management services for the subscriber and application related data, including:

- Subscription Data,

- Policy Data,

- Structured Data for exposure,

- Application data: Packet Flow Descriptions (PFDs) for application detection and AF request information for multiple UEs;

- NF Group ID corresponding to subscriber identifier (e.g. IMPI, IMPU, SUPI).

The data management services provided by UDR allow to its consumer (e.g., UDM, PCF and NEF) to read, create, update, delete a particular set of data and subscribe/unsubscribe to notification of relevant data changes.

Users' service may not be fulfilled due to a poorly performing (e.g. overloaded) data management service, therefore it is indispensable that the performance of data management services can be monitored.

A.89   Monitoring of background data transfer policy control

For background data transfer, AF may need to negotiate the policies for with 5GS via NEF, and apply the negotiated policies for a future PDU Session.

PCF provides the services for NEF to control the background data transfer polices, including creation and update of the background data transfer policies.

The fulfilment of background data transfer related services for the users rely on background data transfer policy. Therefore it is necessary to monitor the performance of background data transfer policy control.

A.90   Monitoring of AF session with QoS

To support a specific QoS requirements for an application, the AF may provide the required QoS information when setting up the connection with the UE. NEF offers the "AF session with QoS" service allowing the AF to send the QoS information for the session, and then interacts with 5GC NFs to apply the QoS requirements to the session.

If the 5GC fails to meet required QoS for an application for the UE, the user's experience is directly impacted. Therefore, the performance of "AF session with QoS" needs to be monitored.

A.91   Monitoring of UCMF provisioning

The UCMF is used for storage of dictionary entries corresponding to either PLMN-assigned or Manufacturer-assigned UE Radio Capability IDs.

Provisioning of Manufacturer-assigned UE Radio Capability ID entries in the UCMF is performed from an AF that interacts with the UCMF either directly or via the NEF.

Knowing the UE radio capabilities is critical for the 5G system to provide the appropriate control for the UE, missing the UE radio capabilities may cause discretional control for the UEs thus result in failures or performance degradation. Therefore, the performance measurements are needed to assess the performance of UCMF provisioning.

A.92   Monitoring of Time-domain average Maximum Scheduled Layer Number for MIMO scenario

The Time-domain average maximum scheduled layer number for MIMO scenario measurement could provide operators the scheduled layer number, the actural spatial capability of a cell under MIMO scenario and can help operators to calculate the radio resource untilization rate.

A.93   Monitoring of Average value of scheduled MIMO layers per PRB

The average value of scheduled MIMO layers per PRB should be monitored, as it reflects the capacity improvement brought by MIMO in the 5G business network, quantitatively. The operators can use this information to compare cell

capacity among different areas and support capacity enhancement decision-making. Besides, the information can be used to optimize the MIMO equipment performance and other OAM works.

A.94 Monitoring of policy authorization

To ensure the 5GS has proper AM and SM polices supporting an external application, the AF may need to query, create, or change the AM and SM policies for a UE in the 5GS.

The PCF may authorize the AF to, directly or indirectly via NEF, query, create or change the AM and SM policies.

The performance of AM and SM policy management authorization to AF may directly impact the user's experience when using the subject applications, therefore the policy authorization needs to be monitored.

A.95 Monitoring of event exposure

An NF (e.g., NEF or NWDAF) may need to subscribe and get notified about PCF events for a group of UE(s) or any UE accessing a combination of (DNN, S-NSSAI).

The events can be subscribed by a NF consumer from PCF are described in clause 6.1.3.18 of TS 23.503 [46].

The NF consumer may use the events exposed by PCF for controlling the UE, hence the performance of event exposure needs to be monitored.

A.96 Monitoring of PRB Usage for MIMO in NG-RAN

The PRB Usage for MIMO with dynamic factor measurement could provide operators the load information of radio network in MIMO scenario taking spatial resource into consideration. In the early stage of network development, the measurements with a dynamic spatial factor can reflect the actual frequency and space resource utilization of a cell after MU-MIMO is activated. In the late stage of network development, the measurements can help operators be aware of whether a cell has experienced high load.

The SDM PDSCH/PUSCH PRB Usage considers all subscribers' MIMO layers in a cell. Correspondingly, it is based on the average value of all scheduled MIMO layers. When subscribers in a cell spread over (e.g. distribute randomly), operators can use SDM PDSCH/PUSCH PRB Usage to evaluate the usage of cell capacity in this scenario.

A.97 Monitoring of subscriber data management at UDM

The subscribe data are managed in UDM, and provided to other consumer NFs (e.g., AMF, SMF, SMSF, NEF, and 5G DDNMF, etc) in 5GS to provide the network services to the users. The subscriber data management in UDM allows some consumer NFs to get the subscriber data, and some consumer NFs to subscribe to the notifications of the updates of the subscriber data. It is important to monitor the performance of the subscriber data management.

A.98 Monitoring of parameter provisioning at UDM

The UDM allows provision, by the consumer NF (e.g., NEF), of information which can be used for the UE in 5GS, such as expected UE behaviour (regarding UE movement or communication characteristics) and service specific parameters, or the 5G VN (Virtual Network) group information to 5G network functions, see TS 23.501 [4].

The failed parameter provisioning would impact the UE behaviour or service fulfilment; therefore, it is needed to monitor the performance of parameter provisioning.

A.99   Use case of measurements for ECS.

ECS related measurements are used to measure the performance of an ECS on each of the supported functionality.

The EES Registration procedure allows an EES to provide its information to an ECS to be used during service provisioning. It is useful to analyse the EES registration success rate in order to assess ECS performance. If the failure rate increases beyond a defined threshold, corrective actions can be taken by the OAM systems. Hence, it is necessary to collect measurement related with EES Registration procedures.

A.100   Use case of measurements for EES.

EES related measurements are used to measure the performance of an EES on each of the supported functionality.

Discovery procedures enable entities in an edge deployment to obtain information about EAS and their available services, based on specified criteria of interest. It is useful to analyse the EAS discovery success rate in order to assess EES performance. The discovery procedure may fail due to the unavailability of the relavant EAS. If the failure rate increases beyond a defined threshold, corrective actions (e.g instantiating the required EAS) can be taken by the OAM systems. Hence, it is necessary to collect measurement realted with EEC Registration procedures.

An EEC performs registration with an EES in order to provide information that can be used by the EES in Edge Computing services. It is useful to analyse the EEC registration success rate in order to assess EES performance. If the failure rate increases beyond a defined threshold, corrective actions can be taken by the OAM systems. Hence, it is necessary to collect measurement related with EEC Registration procedures.

The EAS Registration procedure allows an EAS to provide its information to an EES in order to enable its discovery. It is useful to analyse the EAS registration success rate in order to assess EES performance. If the failure rate increases beyond a defined threshold, corrective actions can be taken by the OAM systems. Hence, it is necessary to collect measurement related with EAS Registration procedures.

A.101   Monitoring of location management

The UE location is required for various purposes, e.g., location-based applications, lawful interception, emergency calls, as well as the positioning services, etc.

The LMF manages the overall co-ordination and scheduling of resources required for the location of a UE for 5G. It also calculates or verifies a final location and any velocity estimate and may estimate the achieved accuracy. The LMF determine the result of the positioning in geographical co-ordinates.

The LMF provides location management related NF services (such as location determination, location notification, and location context transfer) in order for the consumer to get the location of the UEs. Therefore, the performance of location management related NF services need to be monitored in order to evaluate whether it can fulfil the consumer's requirements, and to figure out the causes for the failures to derive the remedy solutions.

A.102   Monitoring of DRBs undergoing GTP User Plane Path failures

The DRB setup procedure in NG-RAN is to assign resources in gNB and on the air interface (Uu) for one or several DRBs that will handle the QoS flows requested to setup by the core network. The gNB may map several QoS flows to the same DRB so there is no one-to-one mapping between the flows and DRBs.

At DRB setup, the gNB will handle all QoS flows mapped to one DRB the same (mapped 5QI). A QoS flow that is at a later stage mapped to an already setup existing DRB will not increment the DRB setup counters.

The DRB setup is one of the most key procedures to allocate resources in the NG-RAN to the UE per the QoS requirements. Whether or not the DRB is successfully setup has direct impact to the user experience. A failed DRB setup

may directly cause service failure or degradation for an end user. So, the performance related to the DRB setup for the gNB needs to be monitored per supported mapped 5QI and per S-NSSAI.

During transient path failures (e.g. path failures not exceeding few minutes at most), maintaining the PDU session contexts associated with the peer's IP address enables the delivery of end user services (when the path is re-established again) and this also avoids unnecessary signalling in the network for restoring those PDU sessions. It is not intended to maintain PDU session contexts during long path failures (e.g. exceeding few minutes at most) as this would imply undesirable effects like undue charging.

The total number of active transient path failures irrespective of whether this path restores into PDU session or not is measured with this use case.

A.103 Use case of measurements for ECS.

ECS related measurements are used to measure the performance of an ECS on each of the supported functionality.

Service provisioning procedures enable EEC to discover the available edge service. It is useful to analyse the service provisioning success rate in order to assess ECS performance. The provisionig procedure may fail due to the unavailability of the relavant EES. If the failure rate increases beyond a defined threshold, corrective actions (e.g instantiating the required EES) can be taken by the OAM systems. Hence, it is necessary to collect measurement related with service provisioning procedures.

Annex B (informative): Change history

**Change history**
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
---	---	---	---	---	---	---	---
2018-09	SA#81					Upgrade to change control version	15.0.0
2018-12	SA#82	SP-181047	0002	1	F	Remove the redundant measurement of end-to-end latency KPI	15.1.0
2018-12	SA#82	SP-181047	0024	1	F	Correction of the Packet loss measurements	15.1.0
2018-12	SA#82	SP-181048	0004	2	B	Add PDU Session Resource setup related measurements for gNB	16.0.0
2018-12	SA#82	SP-181048	0005	2	B	Add inter-gNB handover related measurements	16.0.0
2018-12	SA#82	SP-181048	0011	1	B	Add use case and definitions of TB related measurements	16.0.0
2018-12	SA#82	SP-181048	0016	1	F	PM terms for NSI and NSSI	16.0.0
2018-12	SA#82	SP-181048	0017	1	B	Add PDU session modification related measurements for SMF	16.0.0
2018-12	SA#82	SP-181048	0018	1	B	Add PDU session release related measurements for SMF	16.0.0
2018-12	SA#82	SP-181048	0019	-	B	Add N4 Session Establishment related measurements for UPF	16.0.0
2018-12	SA#82	SP-181048	0020	1	B	Add NF performance measurements related to VR	16.0.0
2018-12	SA#82	SP-181048	0034	1	B	Add DRB setup related measurements and UC for gNB	16.0.0
2018-12	SA#82	SP-181048	0036	-	B	Add use case and definitions of PDCP data volume measurements	16.0.0
2019-03	SA#83	SP-190111	0043	1	B	Add measurements of CQI distribution	16.1.0
2019-03	SA#83	SP-190111	0044	1	B	Add measurements of MCS distribution	16.1.0
2019-03	SA#83	SP-190111	0045	1	B	Add measurements related to QoS flow retainability	16.1.0
2019-03	SA#83	SP-190111	0046	1	B	Add measurements of PDCP data volume in DC-scenarios	16.1.0
2019-03	SA#83	SP-190111	0047	1	B	Add QoS flow related performance measurements	16.1.0
2019-03	SA#83	SP-190111	0049	1	F	Clean-up	16.1.0
2019-03	SA#83	SP-190111	0050	1	B	Add QoS flow related measurements for SMF	16.1.0
2019-03	SA#83	SP-190111	0051	1	B	Add service requests related measurements for AMF	16.1.0
2019-03	SA#83	SP-190111	0052	1	B	Add use case for PDCP end user throughput measurements	16.1.0
2019-03	SA#83	SP-190111	0053	1	B	Add measurements and UC related to RRC connection establishment	16.1.0
2019-03	SA#83	SP-190111	0054	-	B	Add measurements and UC related to setup of UE associated NG signalling connection	16.1.0
2019-03	SA#83	SP-190119	0055	1	B	Add PDCP data volume measurements for EE	16.1.0
2019-03	SA#83	SP-190111	0060	1	B	Add measurements of RRC connection re-establishment	16.1.0
2019-03	SA#83	SP-190111	0061	1	B	Add measurements of RRC connection resuming	16.1.0
2019-03	SA#83	SP-190111	0065	-	B	Add use case and definitions of QoS level measurement over N3	16.1.0
2019-03	SA#83	SP-190111	0067	-	B	Add measurements related to registration via untrusted non-3GPP Access for AMF	16.1.0
2019-03	SA#83	SP-190111	0068	1	B	Add measurements related to inter-AMF handover	16.1.0
2019-03	SA#83	SP-190111	0070	2	B	Add radio resource utilization of network slice instance measurements	16.1.0
2019-03	SA#83	SP-190122	0072	1	A	Correction of percentage unrestricted volume measurements	16.1.0
2019-06	SA#84	SP-190371	0074	1	B	Add use case and definitions of packet loss measurement over N3	16.2.0
2019-06	SA#84	SP-190371	0075	1	B	Add use case and definitions of packet delay measurement over N3	16.2.0
2019-06	SA#84	SP-190371	0076	1	B	Add measurements related to Service Requests via Untrusted non-3GPP Access	16.2.0
2019-06	SA#84	SP-190371	0077	-	B	Add measurements related to PDU session resource management via Untrusted non-3GPP Access	16.2.0
2019-06	SA#84	SP-190371	0079	1	B	Add measurements related to inter gNB Handover	16.2.0
2019-06	SA#84	SP-190371	0080	1	B	Add measurements related to intra gNB Handover	16.2.0
2019-06	SA#84	SP-190371	0082	-	F	Correct DRBs successfully setup measurement	16.2.0
2019-06	SA#84	SP-190375	0084	-	A	Correction of F1 measurements	16.2.0
2019-06	SA#84	SP-190371	0085	1	F	Correction of monitoring of PDCP data volume measurements	16.2.0

2019-06	SA#84	SP-190371	0086	2	F	Correction of PRB measurements	16.2.0
2019-09	SA#85	SP-190746	0081	3	B	Add measurements related to DRB retainability	16.3.0
2019-09	SA#85	SP-190746	0088	-	B	Add measurements related to application triggering	16.3.0
2019-09	SA#85	SP-190746	0089	1	B	Add measurements related to SMS over NAS	16.3.0
2019-09	SA#85	SP-190746	0090	-	F	Correction of clause titles	16.3.0
2019-09	SA#85	SP-190748	0092	-	A	Correct the definition of Average delay DL air-interface measurement	16.3.0
2019-09	SA#85	SP-190751	0094	1	A	Correction on kbits abbreviation	16.3.0
2019-09	SA#85	SP-190746	0095	1	B	Add measurement of SMF for N4 interface	16.3.0
2019-09	SA#85	SP-190746	0096	-	B	Add measurement of UPF for N4 interface	16.3.0
2019-09	SA#85	SP-190746	0097	1	B	Add measurement of paging	16.3.0
2019-09	SA#85	SP-190746	0098	1	F	Update performance measurements for UDM	16.3.0
2019-09	SA#85	SP-190746	0101	2	B	Update and add delay related measurements for NG-RAN	16.3.0
2019-09	SA#85	SP-190746	0102	2	B	Update and add latency related measurements for NG-RAN	16.3.0
2019-09	SA#85	SP-190746	0104	1	B	Update and add measurements related to RTT N3 delay for DL data packets on UPF	16.3.0
2019-09	SA#85	SP-190746	0105	2	B	Add measurements related to RTT N9 delay for DL and UL data packets	16.3.0
2019-09	SA#85	SP-190746	0106	2	B	Add measurements related to GTP packet delay within UPF	16.3.0
2019-09	SA#85	SP-190746	0109	1	B	Add measurements related to round-trip delay between PSA UPF and UE	16.3.0
2019-09	SA#85	SP-190755	0111	2	B	Add Power, Energy and Environmental (PEE) measurements and related use case description	16.3.0
2019-09	SA#85	SP-190747	0112	1	B	Add Number of PDU session creation in HR roaming scenario	16.3.0
2019-09	SA#85	SP-190747	0113	1	F	Update the measurement related to Number of PDU session creation	16.3.0
2019-09	SA#85	SP-190747	0114	1	B	Add UE Configuration Update procedure related measurements	16.3.0
2019-09	SA#85	SP-190748	0117	-	F	Correction of QoS flow monitoring for SMF	16.3.0
2019-09	SA#85	SP-190747	0122	1	F	Modify PM definition for non-split NG-RAN scenario	16.3.0
2019-09	SA#85	SP-190747	0123	1	F	Modify DRB setup management related measurements	16.3.0
2019-09	SA#85	SP-190747	0124	1	F	Modify PDU Sessions setup related measurements	16.3.0
2019-09	SA#85	SP-190747	0127	2	B	Add a description of Inter-gNB handover Execution time measurement	16.3.0
2019-09	SA#85	SP-190747	0128	2	B	Add a description of PDU session establishment time measurement	16.3.0
2019-09	SA#85	SP-190747	0129	2	B	Add measurements related to extended monitoring of the retainability for the 5QI 1 QoS Flow services	16.3.0
2019-09	SA#85	SP-190747	0131	-	B	Add new definition of measurements related to AMF registration procedure set-up time measurement	16.3.0
2019-12	SA#86	SP-191149	0131 A	1	B	Add new Use case related to extended 5QI 1 QoS Flow Retainability monitoring into A30→ not implemented due to CR clash (MCC)	16.4.0
2019-12	SA#86	SP-191149	0132	2	B	Add new measurements related to QoS Flow Setup via Initial Context Setup	16.4.0
2019-12	SA#86	SP-191149	0133	2	B	Add new Use case related to extended 5QI 1 QoS Flow establishment via Initial Context Setup into A30	16.4.0
2019-12	SA#86	SP-191174	0135	-	A	Correction of Registered subscribers measurement for AMF	16.4.0
2019-12	SA#86	SP-191149	0139	1	B	Add Unregistered subscribers measurements for UDM	16.4.0
2019-12	SA#86	SP-191171	0140	1	B	Add performance measurements extension to support multiple tenants environment	16.4.0
2019-12	SA#86	SP-191149	0142	1	B	Add measurements related to handover between 5GS and EPS	16.4.0
2019-12	SA#86	SP-191149	0143	-	B	Add measurements related to registration via trusted non-3GPP access	16.4.0
2019-12	SA#86	SP-191149	0144	-	B	Add measurements related to service requests via trusted non-3GPP access	16.4.0
2019-12	SA#86	SP-191149	0145	2	B	Add measurements related to QoS flow modification in NG-RAN	16.4.0
2019-12	SA#86	SP-191149	0146	1	B	Add measurements related to QoS flow setup via untrusted non-3GPP access	16.4.0

2019-12	SA#86	SP-191149	0147	1	B	Add measurements related to QoS flow modification via untrusted non-3GPP access	16.4.0
2019-12	SA#86	SP-191149	0148	1	B	Add measurements related to handover between 5GS and EPS via N26 interface	16.4.0
2019-12	SA#86	SP-191149	0151	-	B	Add measurements related to NF service registration and update	16.4.0
2019-12	SA#86	SP-191149	0152	-	B	Add measurements related to NF service discovery	16.4.0
2019-12	SA#86	SP-191149	0153	-	B	Add measurements related to UE policy association	16.4.0
2019-12	SA#86	SP-191149	0154	-	B	Add measurements related to PFD management	16.4.0
2019-12	SA#86	SP-191149	0155	-	B	Add measurements related to QoS flow release via untrusted non-3GPP access	16.4.0
2019-12	SA#86	SP-191149	0156	1	C	Add measured object NRCellRelation to the handover related measurements.	16.4.0
2019-12	SA#86	SP-191149	0157	3	B	Add measurements of packets out-of-order	16.4.0
2019-12	SA#86	SP-191149	0158	1	B	Packet Drop Rate measurements update	16.4.0
2019-12	SA#86	SP-191149	0159	1	B	Packet Loss Rate measurements update	16.4.0
2019-12	SA#86	SP-191149	0160	1	B	PDCP Data Volume measurements update	16.4.0
2019-12	SA#86	SP-191149	0161	1	B	UE Throughput measurements update	16.4.0
2019-12	SA#86	SP-191180	0163	-	B	Add use case of monitoring of PCI to detect PCI collision or confusion	16.4.0
2020-03	SA#87E	SP-200162	0173	-	F	Correction of PDCP Data Volume measurement name	16.5.0
2020-03	SA#87E	SP-200162	0174	-	F	Correction of text color	16.5.0
2020-03	SA#87E	SP-200162	0175	1	F	Correction of UE throughput measurements	16.5.0
2020-03	SA#87E	SP-200162	0176	1	F	Correction of Packet Drop Rate measurements	16.5.0
2020-03	SA#87E	SP-200162	0177	1	F	Correction of Packet Loss Rate measurements	16.5.0
2020-03	SA#87E	SP-200162	0181	1	B	Add new measurements related to DRB Setup via Initial Context Setup	16.5.0
2020-03	SA#87E	SP-200162	0182	1	F	Correct measurements related to QoS flows	16.5.0
2020-03	SA#87E	SP-200162	0184	1	B	Add reference to RAN L2 measurement specification	16.5.0
2020-03	SA#87E	SP-200162	0185	1	B	Add Random Access Preambles measurements	16.5.0
2020-03	SA#87E	SP-200162	0186	1	B	Add measurement Average delay UL on over-the-air interface	16.5.0
2020-03	SA#87E	SP-200162	0187	1	B	Add Number of Active UEs measurements	16.5.0
2020-03	SA#87E	SP-200162	0188	1	B	Add measurements related to DL delay between PSA UPF and NG-RAN	16.5.0
2020-03	SA#87E	SP-200162	0189	1	B	Add measurements related to UL delay between PSA UPF and NG-RAN	16.5.0
2020-03	SA#87E	SP-200162	0190	1	B	Add measurements related to round-trip delay between PSA UPF and NG-RAN	16.5.0
2020-03	SA#87E	SP-200162	0194	1	B	Add measurements for SSB beam switch	16.5.0
2020-03	SA#87E	SP-200162	0197	1	B	Add use case and definitions of RSRP measurements	16.5.0
2020-03	SA#87E	SP-200162	0200	-	B	Add new Use cases into A.28 according to agreed CRs:	16.5.0
2020-07	SA#88-E	SP-200502	0191	3	B	Add measurements related to DL delay between PSA UPF and UE	16.6.0
2020-07	SA#88-E	SP-200502	0192	3	B	Add measurements related to DL delay between PSA UPF and UE	16.6.0
2020-07	SA#88-E	SP-200502	0201	1	B	Add new measurements for Average Normally Released Call (5QI 1 QoS Flow) Duration and Average Abnormally Released Call (5QI 1 QoS Flow) Duration.	16.6.0
2020-07	SA#88-E	SP-200502	0203	-	A	Adding Per Slice N3 measurements	16.6.0
2020-07	SA#88-E	SP-200502	0204	-	F	Corrections of Number of Active UEs measurements	16.6.0
2020-07	SA#88-E	SP-200502	0206	1	B	Add measurement Average RLC packet delay in the UL	16.6.0
2020-07	SA#88-E	SP-200502	0207	1	B	Add measurement Average PDCP re-ordering delay in the UL	16.6.0
2020-07	SA#88-E	SP-200502	0208	-	B	Add Number of stored inactive UE contexts measurements	16.6.0
2020-07	SA#88-E	SP-200493	0210	-	B	Add handover measurements related to MRO	16.6.0
2020-07	SA#88-E	SP-200493	0211	1	F	Update the measurements related to the delay of DL air-interface	16.6.0
2020-07	SA#88-E	SP-200493	0212	1	F	Update the precision of packet delay	16.6.0
2020-07	SA#88-E	SP-200503	0215	2	B	Add measurements related to DL packet delay between NG-RAN and UE	16.6.0
2020-07	SA#88-E	SP-200503	0216	2	B	Add measurements related to UL packet delay between NG-RAN and UE	16.6.0
2020-07	SA#88-E	SP-200497	0220	1	B	Clarify performance indicators exposed to a tenant	16.6.0

2020-07	SA#88-E	SP-200502	0223	1	B	Modify PRB usage measurements	16.6.0
2020-07	SA#88-E	SP-200502	0226	2	F	Editorial correction	16.6.0
2020-07	SA#88-E	SP-200502	0227	1	F	Update the definition of UE throughput related measurements	16.6.0
2020-07	SA#88-E	SP-200503	0229	1	B	Add measurements on N9 interface for UPF	16.6.0
2020-07	SA#88-E	SP-200503	0231	1	B	Addition of authentication measurements for AMF	16.6.0
2020-07	SA#88-E	SP-200503	0234	1	B	Add UE power headroom measurement	16.6.0
2020-07	SA#88-E	SP-200503	0235	1	B	Addition of QoS flow measurements for UPF	16.6.0
2020-07	SA#88-E	SP-200503	0236	-	F	Modify DL Cell PDCP SDU Data Volume on Xn Interface measurement	16.6.0
2020-07	SA#88-E	SP-200503	0237	1	B	Add Paging measurement	16.6.0
2020-07	SA#88-E	SP-200503	0238	1	B	Addition of AM policy association update measurements for PCF	16.6.0
2020-07	SA#88-E	SP-200503	0239	1	B	Add Number of UE related SSB beam index Measurement	16.6.0
2020-07	SA#88-E	SP-200503	0240	1	B	Add Power utilization measurements	16.6.0
2020-07	SA#88-E	SP-200503	0241	1	F	Update the descriptions of PRB related measurements	16.6.0
2020-07	SA#88-E	SP-200485	0242	1	F	Cleanup based on refined slice definitions	16.6.0
2020-09	SA#89E	SP-200738	0251	1	F	Addition of AM policy association update notify measurements for PCF	16.7.0
2020-09	SA#89E	SP-200738	0252	-	F	Addition of SM policy association update measurements for PCF	16.7.0
2020-09	SA#89E	SP-200738	0253	1	F	Update the description of RRC connection re-establishment related measurements	16.7.0
2020-09	SA#89E	SP-200738	0254	1	F	Modify MCS related Measurements	16.7.0
2020-09	SA#89E	SP-200732	0262	3	B	Add measurements for RACH optimization management for NR	16.7.0
2020-09	SA#89E	SP-200751	0265	1	F	Deleting Round-trip packet delay between PSA UPF and UE	16.7.0
2020-09	SA#89E	SP-200747	0243	1	B	Movement of "Distribution of Normally Released Call (5QI 1 QoS Flow) Duration" and "Distribution of Abnormally Released Call (5QI 1 QoS Flow) Duration" measurements to chapter 5.1.1.24.	17.0.0
2020-09	SA#89E	SP-200747	0244	1	B	Add PLMN granularity for UE throughput measurements	17.0.0
2020-09	SA#89E	SP-200747	0245	1	B	Add RRC establishment failure measurements	17.0.0
2020-09	SA#89E	SP-200747	0249	-	B	Add measurements on network slice selection	17.0.0
2020-09	SA#89E	SP-200747	0250	-	B	Add measurements on NSSAI availability service	17.0.0
2020-09	SA#89E	SP-200747	0255	1	B	ADD EPS fallback handover related Measurement	17.0.0
2020-09	SA#89E	SP-200747	0256	1	B	Add incoming and outgoing GTP data packet loss TEID	17.0.0
2020-09	SA#89E	SP-200747	0257	1	B	ADD EPS fallback redirection related Measurement	17.0.0
2020-09	SA#89E	SP-200747	0258	1	B	Add EPS fallback handover mean time measurement	17.0.0
2020-09	SA#89E	SP-200747	0259	1	B	Add measurements for RB distribution per layer of MU-MIMO	17.0.0
2020-09	SA#89E	SP-200747	0260	-	B	Add UDM subscriber profile measurements	17.0.0
2020-09	SA#89E	SP-200747	0261	1	B	Add MCS distribution measurement of MU-MIMO	17.0.0
2020-09	SA#89E	SP-200747	0263	1	B	Addition of RSRQ measurement	17.0.0
2020-09	SA#89E	SP-200747	0264	-	B	Addition of SINR measurement	17.0.0
2020-12	SA#90e	SP-201058	0266	1	F	Add to A.28 new part related to interruption time interval for 5QI 1 QoS Flow released due to double NG (double UE context) monitoring	17.1.0
2020-12	SA#90e	SP-201054	0278	1	A	Correction of paging measurements	17.1.0
2020-12	SA#90e	SP-201054	0279	-	A	Add missing paging discard measurements	17.1.0
2020-12	SA#90e	SP-201054	0281	-	A	Correct measurements related to QoS Flow release and DRB release	17.1.0
2021-03	SA#91e	SP-210156	0282	-	B	Addition of SMS message delivery related measurements for SMSF	17.2.0
2021-03	SA#91e	SP-210156	0283	-	B	Addition of Registration measurements for SMSF	17.2.0
2021-03	SA#91e	SP-210141	0284	1	B	Add PLMN granularity for number of active UEs measurements	17.2.0
2021-03	SA#91e	SP-210141	0285	1	B	Add PLMN granularity for packet delay measurements	17.2.0
2021-03	SA#91e	SP-210141	0286	1	B	Add PLMN granularity for Radio resource utilization measurements	17.2.0
2021-03	SA#91e	SP-210156	0288	1	B	CR for WI ePM_KPI_5G converted from draftCR S5-211355	17.2.0

2021-03	SA#91e	SP-210156	0289	1	B	Add measurements related data management for UDR	17.2.0
2021-03	SA#91e	SP-210156	0290	-	B	Add measurements related to background data transfer policy control for PCF	17.2.0
2021-03	SA#91e	SP-210156	0291		B	Add measurements to cover all accessibility types	17.2.0
2021-03	SA#91e	SP-210150	0293	-	A	Update measurements to consider abnormal releases in RRC connected state	17.2.0
2021-03	SA#91e	SP-210141	0294	1	B	Add PLMN granularity for RRC connection number measurements	17.2.0
2021-03	SA#91e	SP-210141	0295	-	B	Add PLMN granularity for packet delay measurements in split gNB scenario	17.2.0
2021-03	SA#91e	SP-210141	0296	-	B	Add Filter and Filter naming description	17.2.0
2021-03	SA#91e	SP-210150	0298	-	A	Message names correction	17.2.0
2021-04	SA#91e					Removing revision marks	17.2.1
2021-06	SA#92e	SP-210404	0287	3	B	CHO measurements	17.3.0
2021-06	SA#92e	SP-210412	0299	-	B	Add measurements related to data record creation for UDR	17.3.0
2021-06	SA#92e	SP-210412	0300	-	B	Add measurements related to data record deletion for UDR	17.3.0
2021-06	SA#92e	SP-210412	0301	-	B	Add measurements related to data record update for UDR	17.3.0
2021-06	SA#92e	SP-210412	0302	-	B	Add measurements related to data modification notification subscription for UDR	17.3.0
2021-06	SA#92e	SP-210412	0303	1	B	New measurements for the number of attempted and successfully resumed DRBs	17.3.0
2021-06	SA#92e	SP-210406	0305	-	A	Fix definition of measurement Average delay DL on F1-U	17.3.0
2021-06	SA#92e	SP-210412	0306	1	B	Add PMs on inter-gNB successful and failed handover execution per beam pair	17.3.0
2021-06	SA#92e					Removing revision marks (MCC)	17.3.1
2021-09	SA#93e	SP-210874	0308	1	B	Add RRM related measurements	17.4.0
2021-09	SA#93e	SP-210874	0309	-	F	Correction for the Number of Active Ues measurements	17.4.0
2021-09	SA#93e	SP-210872	0311	1	B	Add measurements related to AF session with QoS for NEF	17.4.0
2021-09	SA#93e	SP-210872	0312	-	B	Add measurements related to applying policy for NEF	17.4.0
2021-09	SA#93e	SP-210872	0313	1	B	Add measurements related to UCMF provisioning for NEF	17.4.0
2021-09	SA#93e	SP-210872	0315	-	F	Add PLMN granularity to PDCP SDU data volume measurement per interface for split gNB deployment scenario	17.4.0
2021-09	SA#93e	SP-210862	0316	1	A	Revise the calculation for average round-trip packet delay between PSA UPF and NG-RAN	17.4.0
2021-09	SA#93e	SP-210884	0318	-	A	Replace Editor's notes with references	17.4.0
2021-12	SA#94e	SP-211476	0321	-	F	Correction of the typo within the update field of the 5.1.1.24.2 Average Abnormally Released Call (5QI 1 QoS Flow) Duration measurement.	17.5.0
2021-12	SA#94e	SP-211476	0322	1	B	Add Time-domain average Maximum Scheduled Layer Number for MIMO scenario	17.5.0
2021-12	SA#94e	SP-211476	0324	-	B	Introduction of average value of scheduled MIMO layers per PRB	17.5.0
2021-12	SA#94e	SP-211477	0326	1	A	Correct handover execution failure measurement	17.5.0
2021-12	SA#94e	SP-211477	0328	1	A	Update handover measurements	17.5.0
2021-12	SA#94e	SP-211476	0329	-	B	Add measurements related to AM policy authorization for PCF	17.5.0
2021-12	SA#94e	SP-211476	0330	-	B	Add measurements related to SM policy authorization for PCF	17.5.0
2021-12	SA#94e	SP-211476	0331	-	B	Add measurements related to event exposure for PCF	17.5.0
2021-12	SA#94e	SP-211457	0332	1	B	Add EAS data volume measurements	17.5.0
2021-12	SA#94e	SP-211476	0333	1	B	Add enhanced MIMO PRB Usage for cell	17.5.0
2021-12	SA#94e	SP-211477	0335	-	A	Correct definition of Distribution of UL UE throughput in gNB.	17.5.0
2021-12	SA#94e	SP-211474	0336	-	B	DAPS handover Performance Measurements	17.5.0
3021-12	SA#94e	SP-211476	0338	-	B	Add measurements related to subscriber data management for UDM	17.5.0
2021-12	SA#94e	SP-211476	0339	-	B	Add measurements related to parameter provision for UDM	17.5.0

2021-12	SA#94e	SP-211452	0340	1	B	Add PM on Handover failures per beam related to MRO for intra-system mobility	17.5.0
2022-03	SA#95e	SP-220180	0341	1	B	Add Space Division Multiplexing PRB Usage for MIMO cell	17.6.0
2022-03	SA#95e	SP-220180	0342	-	F	Remove the number of failed conditional handover executions which is not implementable	17.6.0
2022-03	SA#95e	SP-220180	0343	-	F	Add one more trigger point to the number of failed DAPS handover preparations performance measurement	17.6.0
2022-03	SA#95e	SP-220180	0344	1	F	Modify Description of MIMO PRB Usage for Cell	17.6.0
2022-03	SA#95e	SP-220180	0345	1	F	Modify description of sampling occasion of scheduled layers	17.6.0
2022-03	SA#95e	SP-220173	0348	1	B	Performance measurements for ECS - EES Registration	17.6.0
2022-03	SA#95e	SP-220173	0349	1	B	Performance measurements for EES - EAS Discovery	17.6.0
2022-03	SA#95e	SP-220173	0350	1	B	Performance measurements for EES - EEC Registration	17.6.0
2022-03	SA#95e	SP-220173	0351	1	B	Performance measurements for EES - EAS Registration	17.6.0
2022-03	SA#95e	SP-220177	0352	1	B	Add beam and TA related measurements to support coverage problem analysis	17.6.0
2022-03	SA#95e	SP-220180	0353	1	B	Add location context transfer related measurements for LMF	17.6.0
2022-03	SA#95e	SP-220180	0354	1	B	Add location determination and notification related measurements for LMF	17.6.0
2022-03	SA#95e	SP-220161	0356	-	A	Correct wording and header	17.6.0
2022-03	SA#95e	SP-220172	0357	1	B	Conditional handover measurements	17.6.0
2022-03	SA#95e	SP-220180	0358	-	B	Enhance PM on Handover failures per beam related to MRO for intra-system mobility	17.6.0
2022-03	SA#95e	SP-220180	0360	1	B	Adding new packets based performance measurements	17.6.0
2022-03	SA#95e	SP-220180	0361	1	B	Updating packets based performance measurements	17.6.0
2022-06	SA#96	SP-220512	0363	-	F	Correct implementation mistakes	17.7.0
2022-06	SA#96	SP-220513	0364	-	F	Correct the definition of DRB setup related counters	17.7.0
2022-06	SA#96	SP-220496	0365	1	F	EditorialCorrections	17.7.0
2022-06	SA#96	SP-220513	0366	-	F	Correct handover execution failure per beam pair measurement	17.7.0
2022-06	SA#96	SP-220513	0368	-	A	Clean up of PM related to MRO	17.7.0
2022-06	SA#96	SP-220514	0369	-	B	Mean number of DRBs undergoing from User Plane Path Failures	17.7.0
2022-06	SA#96	SP-220514	0373	-	B	Enhance UE Context Release measurements for MDA	17.7.0
2022-06	SA#96	SP-220506	0374	-	B	Performance measurements for ECS - Service Provisioning	17.7.0
2022-06	SA#96					Editorials	17.7.1
2022-09	SA#97e	SP-220853	0378	1	A	Clarification of inter-system too early and too late handover failures and unnecessary handovers for inter-system mobility	17.8.0
2022-12	SA#98e	SP-221185	0390	1	F	Correct Mean and Max Time of requested conditional handover executions	17.9.0
2022-12	SA#98e	SP-221185	0391	1	F	Correct Mean and Max Time of requested legacy handover executions	17.9.0
2022-12	SA#98e	SP-221185	0392	2	F	Correction of Wideband CQI distribution	17.9.0
2023-03	SA#99	SP-230244	0405	1	F	Correct conditions of Number of UEs configured with conditional handover	17.10.0
2023-09	SA#101	SP-230941	0443	1	A	Rel-17 CR TS 28.552 Clarification of Average delay over F1U measurement	17.11.0
2023-12	SA#102	SP-231471	0477	1	F	Rel-17 CR 28.552 Correction of PDSCH MCS distribution measurement	17.12.0
2023-12	SA#102	SP-231487	0483	1	A	Rel-17 CR TS28.552 Fix Packet Drop Rate	17.12.0
2023-12	SA#102	SP-231464	0491	-	F	remove duplicated clause for ECS measurement	17.12.0
2023-12	SA#102	SP-231487	0495	-	A	Fix error related to number of PDU session creation measurement	17.12.0
2024-03	SA#103	SP-240166	0511	1	F	Rel-17 28.552 Correct measurement definition SS-RSRP distribution per SSB of neighbour cell	17.13.0

2024-03	SA#103	SP-240185	0519	-	F	Rel-17 CR TS28.552 Fix collecting method for UE Context Release	17.13.0
2024-06	SA#104	SP-240807	0529	1	F	Rel-17 CR TS 28.552 Include the sub_counter value when reporting Performance Measurements	17.14.0
2024-06	SA#104	SP-240812	0532	1	A	Rel-17 CR TS 28.552 Rectify the incorrect condition for DL F1U PL measurement	17.14.0
2024-06	SA#104	SP-240822	0542	-	A	Rel-17 CR 28.552 Correct measurement definitions for number of samples	17.14.0
2024-06	SA#104	SP-240841	0542	-	F	Rel-17 CR TS 28.552 Correction to Number of Active UEs measurements	17.14.0
2024-06	SA#104	SP-240807	0561	-	F	Rel-17 CR TS28.552 Fix collecting method and subcounter for Distribution of UE throughput in gNB	17.14.0
2024-06	SA#104	SP-240812	0571	-	A	Rel-17 CR TS 28.552 Correcting the measurement name to indicate the correct direction of the traffic	17.14.0
2024-09	SA#105	SP-241163	0582	-	F	Rel-17 CR TS 28.552 Correction on Number of released active DRBs	17.15.0
2024-09	SA#105	SP-241163	0595	-	F	Rel-17 CR TS 28.552 Correct location notification related measurement	17.15.0
2024-12	SA#106	SP-241636	0617	-	A	Rel-17 CR TS28.552 Fix message for Number of successful PDU session modifications	17.16.0
2025-03	SA#107	SP-250154	0664		A	Rel-17 CR TS28.552 Correct unit and description of some measurements	17.17.0

History

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