ETSI TS 132 425 V9.5.0 (2011-01)

Technical Specification

LTE;
Telecommunication management;
Performance Management (PM);
Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)
(3GPP TS 32.425 version 9.5.0 Release 9)

Reference
RTS/TSGS-0532425v950

Keywords
LTE

ETSI

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Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

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Contents

Foreword

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

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

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Introduction

The present document is part of a TS-family covering the 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; as identified below:

32.401	Performance Management (PM); Concept and requirements
52.402	Performance Management (PM); Performance measurements – GSM
32.404	Performance Management (PM); Performance measurements - Definitions and template
32.405	Performance Management (PM); Performance measurements Universal Terrestrial Radio Access Network (UTRAN)
32.406	Performance Management (PM); Performance measurements Core Network (CN) Packet Switched (PS) domain
32.407	Performance Management (PM); Performance measurements Core Network (CN) Circuit Switched (CS) domain
32.408	Performance Management (PM); Performance measurements Teleservice
32.409	Performance Management (PM); Performance measurements IP Multimedia Subsystem (IMS)
32.425	**Performance Management (PM); Evolved Performance measurements Universal Terrestrial Radio Access Network (E-UTRAN)**
32.426	Performance Management (PM); Evolved Packet Core (EPC)

The present document is part of a set of specifications, which describe the requirements and information model necessary for the standardised Operation, Administration and Maintenance (OA&M) of a multi-vendor E-UTRAN and EPC system.

During the lifetime of an E-UTRAN, its logical and physical configuration will undergo changes of varying degrees and frequencies in order to optimise the utilisation of the network resources. These changes will be executed through network configuration management activities and/or network engineering, see TS 32.600 [3].

Many of the activities involved in the daily operation and future network planning of an E-UTRAN require data on which to base decisions. This data refers to the load carried by the network and the grade of service offered. In order to produce this data performance measurements are executed in the NEs, which comprise the network. The data can then be transferred to an external system, e.g. an Operations System (OS) in TMN terminology, for further evaluation. The purpose of the present document is to describe the mechanisms involved in the collection of the data and the definition of the data itself.

Annex B of TS 32.404 helps in the definition of new performance measurements that can be submitted to 3GPP for potential adoption and inclusion in the present document. Annex B of TS 32.404 discusses a top-down performance measurement definition methodology that focuses on how the end-user of performance measurements can use the measurements.

1 Scope

The present document describes the measurements for E-UTRAN.

TS 32.401 [5] describes Performance Management concepts and requirements.

The present document is valid for all measurement types provided by an implementation of an E-UTRAN.

Only measurement types that are specific to E-UTRAN are defined within the present documents. Vendor specific measurement types used in E-UTRAN are not covered. Instead, these could be applied according to manufacturer's documentation.

Measurements related to "external" technologies (such as ATM or IP) as described by "external" standards bodies (e.g. ITU-T or IETF) shall only be referenced within this specification, wherever there is a need identified for the existence of such a reference.

The definition of the standard measurements is intended to result in comparability of measurement data produced in a multi-vendor network, for those measurement types that can be standardised across all vendors' implementations.

The structure of the present document is as follows:

- Header 1: Network Element (e.g. measurements related to eNodeB);
- Header 2: Measurement function (e.g. RRC connection setup related measurements);
- Header 3: Measurements.

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 and/or edition number or version number) 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 TS 32.101: "Telecommunication management; Principles and high level requirements".

[2] 3GPP TS 32.102: "Telecommunication management; Architecture".

[3] 3GPP TS 32.600: "Telecommunication management; Configuration Management (CM); Concept and high-level requirements".

[4] Void.

[5] 3GPP TS 32.401: "Telecommunication management; Performance Management (PM); Concept and requirements".

[6] 3GPP TS 32.404: "Performance Management (PM); Performance measurements - Definitions and template".

[7] 3GPP TS 32.762: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP): Information Service (IS)".

[8] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".

[9] 3GPP TS 36.413: "Evolved Universal Terrestrial Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

[10] 3GPP TS 36.423: "Evolved Universal Terrestrial Radio Access Network (EUTRAN); X2 application protocol (X2AP)".

[11] TS 36.314, "Evolved Universal Terrestrial Radio Access (E-UTRA); Layer 2 – Measurements (Release 8)"

[12] TS 36.300, "Evolved Universal Terrestrial Radio Access (E-UTRA); and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8)".

[13] 3GPP TS 32.450 "Telecommunication management; Key Performance Indicators (KPI) for E-UTRAN: Definitions (Release 8)".

[14] 3GPP TS 36.304, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode".

[15] 3GPP TS 32.552, "Technical Specification Group Services and SystemAspects; Telecommunication management; Self-Optimization OAM; Stage 2 descriptions".

[16] 3GPP TS 23.272, "Technical Specification Group Services and System Aspects; Circuit Switched (CS) fallback in Evolved Packet System (EPS); Stage 2".

3 Measurement family and abbreviations

3.1 Measurement family

The measurement names defined in the present document are all beginning with a prefix containing the measurement family name (e.g. RRC.AttConnEstab.*Cause*). This family name identifies all measurements which relate to a given functionality and it may be used for measurement administration (see TS 32.401 [5]).

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)
- RRU (measurements related to Radio Resource Utilization)
- ERAB (measurements related to E-RAB)
- HO (measurements related to Handover)
- S1SIG (measurements related to S1 Signalling)
- SRB (measurements related to Signalling Radio Bearer)
- PAG (measurements related to Paging)
- EQPT(measurements related to Equipment)
- UECNTX(measurements related to UE CONTEXT)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3G	3rd Generation
3GPP	3G Partnership Project
EPS	Evolved Packet System
EQPT	Equipment
E-UTRAN	Evolved UTRAN
E-RAB	E-UTRAN Radio Access Bearer
HO	Handover
QoS	Quality of Service
UTRAN	Universal Terrestrial Radio Access Network

You can find below a list of abbreviations used within the measurement types for field E of the measurement template (see 3GPP TS 32.404 [6]).

Alloc	Allocation
Att	Attempt(s,ed)
Conn	Connection
Ded	Dedicated
DL	Downlink
ENB	eNodeB
Estab	Establish (ed,ment)
Fail	Fail(ed, ure)
Freq	Frequency
Inc	Incoming
Out	Outgoing
Pkt	Packet(s)
Prep	Prepare(/Preparation)
Late	Latency
Mod	Modify(/Modification)
Nbr	Number
Rel	Release(s,d)
Res	Resource
Succ	Success(es,ful)
UL	Uplink

4 Measurements related to eNodeB

4.1 RRC connection related measurements

4.1.1 RRC connection establishment

The three measurement types defined in the subclauses 4.1.1.1, 4.1.1.2 and 4.1.1.3 are subject to the "2 out of 3 approach".

4.1.1.1 Attempted RRC connection establishments

a) This measurement provides the number of RRC connection establishment attempts for each establishment cause.

b) CC

c) Receipt of a RRCConnectionRequest message by the eNodeB from the UE. Each RRCConnectionRequest message received is added to the relevant per establishment cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of RRCConnectionRequest. 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 RRC.ConnEstabAtt.*Cause*
where *Cause* identifies the establishment cause.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.1.1.2 Successful RRC connection establishments

a) This measurement provides the number of successful RRC establishments for each establishment cause.

b) CC

c) Receipt by the eNodeB of a RRCConnectionSetupComplete message following a RRC connection establishment request. Each RRCConnectionSetupComplete message received is added to the relevant per establishment cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of successful RRC Connection Establishments. 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 RRC.ConnEstabSucc.*Cause*
where *Cause* identifies the establishment cause.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.1.1.3 Failed RRC connection establishments

a) This measurement provides the number of RRC establishment failures for each establishment cause.

b) CC

c) Transmission of an RRCConnectionReject message by the eNodeB to the UE or an expected RRCConnectionSetupComplete message not received by the eNodeB. Each failed RRC connection establishment is added to the relevant per establishment cause measurement. The possible causes are included in TS 36.331 [8].
The sum of all supported per cause measurements shall equal the total number of RRC connection establishment failures. 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 RRC.ConnEstabFail.*Cause*
where *Cause* identifies the establishment cause.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.1.1.4 Failed RRC connection establishment per failure cause

a) This measurement provides the number of failed RRC establishment per failure cause. This measurement is to support LBO target setting and evaluation, see [15]

b) CC

c) Transmission of an RRCConnectionReject message by the eNodeB to the UE.
Each transmitted RRCConnectionReject message caused by "congestion" is added to the measurement cause "*Congestion*", and each transmitted RRCConnectionReject message caused by the other reasons is added to measurement cause "*Unspecified*".

d) Each measurement is an integer value.

e) RRC.ConnEstabFaileNBCause.*Congestion*
RRC.ConnEstabFaileNBCause.*Unspecified*

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) The measurement is use to count "Failed RRC connection establishment related to load" for LBO target setting and evaluation, see [15].

4.1.2 RRC connection re-establishment

The three measurement types defined in the subclause 4.1.2.n are subject to the "2 out of 3 approach".

4.1.2.1 Attempted RRC connection re-establishments

a) This measurement provides the number of RRC connection re-establishment attempts for each re-establishment cause.

b) CC.

c) Receipt of a RRCConnectionReestablishmentRequest message by the eNodeB from the UE. Each RRCConnectionReestablishmentRequest received is added to the relevant per reestablishment cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of RRC connection re-stablishment attempts. 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 RRC.ConnReEstabAtt.*Cause*
where *Cause* identifies the reestablishment cause.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.1.2.2 Successful RRC connection re-establishments

a) This measurement provides the number of successful RRC connection re-establishments for each re-establishment cause.

b) CC.

c) Receipt by the eNodeB of a RRCConnectionReestablishmentComplete message following a RRC connection reestablishment request. Each RRCConnectionReestablishmentComplete message received is added to the relevant per reestablishment cause measurement. The possible causes are included in TS 36.331 [8]. The sum of all supported per cause measurements shall equal the total number of successful RRC connection re-establishments. 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 RRC.ConnReEstabSucc.*Cause*
where *Cause* identifies the establishment cause.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.1.2.3 Failed RRC connection re-establishments

a) This measurement provides the number of RRC re-establishment failures for each re-establishment cause.

b) CC.

c) Transmission of an RRCConnectionReestablishmentReject message by the eNodeB to the UE or an expected RRCConnectionReestablishmentComplete message not received by the eNodeB.
Each failed RRC connection re-establishment is added to the relevant per re-establishment.cause measurement. The possible causes are included in TS 36.331 [8].
The sum of all supported per cause measurements shall equal the total number of RRC connection re-establishment failures. 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 RRC.ConnReEstabFail.*Cause*
where *Cause* identifies the re-establishment.cause.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.1.3 RRC connection number

4.1.3.1 Mean number of RRC Connections

a) This measurement provides the mean number of RRC Connections during each granularity period.

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval, the number of RRC connections for each E-UTRAN Cell and then taking the arithmetic mean

d) A single integer value.

e) RRC.ConnMean

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.1.3.2 Maximum number of RRC Connections

a) This measurement provides the maximum number of RRC Connections during each granularity period.

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval, the number of RRC connections for each E-UTRAN cell and then taking the maximum.

d) A single integer value.

e) RRC.ConnMax

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.1.4 RRC connection setup time

4.1.4.1 Mean RRC connection setup time

a) This measurement provides the mean time per establishment cause it takes to establish an RRC connection.

b) DER (n=1).

c) This measurement is obtained by accumulating the time intervals for every successful RRC connection establishment between the receipt of a RRCConnectionRequest and the corresponding RRCConnectionSetupComplete message by the eNodeB over the granularity period. The end value of this time will then be divided by the number of successful RRC connections 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 establishment cause, and the possible causes are included in TS 36.331 [8].

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

e) The measurement name has the form RRC.ConnEstabTimeMean.*Cause*
where *Cause* identifies the establishment cause

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.1.4.2 Maximum RRC connection setup time

a) This measurement provides the maximum time per establishment cause it takes to establish an RRC connection.

b) GAUGE.

c) This measurement is obtained by monitoring the time intervals for each successful RRC connection establishment between the receipt of a RRCConnectionRequest and the corresponding RRCConnectionSetupComplete message by the eNodeB over the granularity period. 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 establishment cause, and the possible causes are included in TS 36.331 [8].

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

e) The measurement name has the form RRC.ConnEstabTimeMax.*Cause*
where *Cause* identifies the establishment cause

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.1.5 UE CONTEXT Release

4.1.5.1 Number of UE CONTEXT Release Request initiated by eNodeB

a) This measurement provides the number of UE CONTEXT Release initiated by eNB for each release cause.

b) CC.

c) Transmission of an UE CONTEXT RELEASE REQUEST message initiated by eNodeB. Each release request is to be added to the relevant cause measurement. The possible causes are defined in 36.413 [9]. The sum of all supported per causes measurements shall equal the total number of UE CONTEXT Release initiated by eNodeB. 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) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

i) By differenciate the causes, this measurement is used to count "The number of abnormal RRC connection release related to load", which can be used for LBO target calculation..

4.1.5.2 Successful UE CONTEXT Release

a) This measurement provides the number of successful UE Context Release.

b) CC.

c) Sending of UE CONTEXT RELEASE COMPLETE from eNB to MME.

d) A single integer value.

e) UEContext.RelSuccNbr

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

i) This measurement can be used to count "the total number of RRC connection release", which can be used for LBO target calculation.

4.2 E-RAB related measurements

4.2.1 E-RAB setup

4.2.1.1 Number of initial E-RABs attempted to setup

a) This measurement provides the number of initial E-RABs attempted to setup. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On receipt by the eNodeB of an INITIAL CONTEXT SETUP REQUEST message, each requested E-RAB in the message is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to setup. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.EstabInitAttNbr.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.1.2 Number of initial E-RABs successfully established

a) This measurement provides the number of initial E-RABs successfully established. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On transmission by the eNodeB of an INITIAL CONTEXT SETUP RESPONSE message, each E-RAB successfully established is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs successfully setup. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.EstabInitSuccNbr.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.1.3 Number of initial E-RABs failed to setup

a) This measurement provides the number of initial E-RABs failed to setup. The measurement is split into subcounters per failure cause.

b) CC

c) On transmission by the eNodeB of an INITIAL CONTEXT SETUP RESPONSE, or INITIAL CONTEXT SETUP FAILURE message, each E-RAB failed to establish is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of E-RABs 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 ERAB.EstabInitFailNbr.*Cause*
where *Cause* identifies the cause resulting in the initial E-RAB setup failure.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.1.4 Number of additional E-RABs attempted to setup

a) This measurement provides the number of additional E-RABs attempted to setup. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On receipt by the eNodeB of an E-RAB SETUP REQUEST message, each requested E-RAB in the message is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of additional E-RABs attempted to setup. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB. EstabAddAttNbr.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Accessibility KPI "E-RAB Accessibility" defined in [13].

4.2.1.5 Number of additional E-RABs successfully established

a) This measurement provides the number of additional E-RABs successfully established. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On transmission by the eNodeB of an E-RAB SETUP RESPONSE message, each E-RAB successfully established is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of additional E-RABs successfully setup. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.EstabAddSuccNbr.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Accessibility KPI "E-RAB Accessibility" defined [13].

4.2.1.6 Number of additional E-RABs failed to setup

a) This measurement provides the number of additional E-RABs failed to setup. The measurement is split into subcounters per failure cause.

b) CC

c) On transmission by the eNodeB of an E-RAB SETUP RESPONSE message, each E-RAB failed to establish is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of additional E-RABs 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 ERAB. EstabAddFailNbr.*Cause*
where *Cause* identifies the cause resulting in the additional E-RAB setup failure.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.1.7 Mean E-RAB Setup time

a) This measurement provides the mean time per QCI it takes to establish an E-RAB.

b) DER (n=1)

c) This measurement is obtained by accumulating the time intervals for every successfully established E-RAB between the receipt of an E-RAB SETUP REQUEST or INITIAL CONTEXT SETUP REQUEST message and the transmission of the corresponding E-RAB SETUP RESPONSE or INITIAL CONTEXT SETUP RESPONSE message by the eNodeB over the granularity period. The end value of this time will then be divided by the number of successfully established E-RABs 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 QCI, and the possible QCIs are included in TS 36.413 [9].

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

e) The measurement name has the form ERAB.EstabTimeMean.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.2.1.8 Maximum E-RAB Setup time

a) This measurement provides the maximum time per QCI it takes to establish an E-RAB.

b) GAUGE

c) This measurement is obtained by monitoring the time intervals for every successfully established E-RAB between the receipt of an E-RAB SETUP REQUEST or INITIAL CONTEXT SETUP REQUEST message and the transmission of the corresponding E-RAB SETUP RESPONSE or INITIAL CONTEXT SETUP RESPONSE message by the eNodeB over the granularity period. 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 QCI, and the possible QCIs are included in TS 36.413 [9].

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

e) The measurement name has the form ERAB.EstabTimeMax.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.2.2 E-RAB release

4.2.2.1 Number of E-RABs requested to release initiated by eNodeB per QCI

a) This measurement provides the number of E-RABs requested to release initiated by eNodeB. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On transmission by the eNodeB of an E-RAB RELEASE INDICATION or UE CONTEXT RELEASE REQUEST message, each corresponding E-RAB requested to release is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs requested to release initiated by eNodeB. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.RelEnbNbr.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.2.2 Number of E-RABs requested to release initiated by eNodeB per cause

a) This measurement provides the number of E-RABs requested to release initiated by eNodeB. The measurement is split into subcounters per cause.

b) CC

c) On transmission by the eNodeB of an E-RAB RELEASE INDICATION or UE CONTEXT RELEASE REQUEST message, each corresponding E-RAB requested to release is added to the relevant measurement per cause. Possible causes are included in TS 36.413 [9].

d) Each measurement is an integer value. The number of measurements is equal to the number of supported causes.

e) The measurement names have the form ERAB.RelEnbNbr.*cause*
where *cause* identifies the reason for the E-RABs release request initiated by eNodeB.

f) EUtranCellFDD
   EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.2.3 Number of E-RABs attempted to release

a) This measurement provides the number of E-RABs attempted to release. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On receipt by the eNodeB of an E-RAB RELEASE COMMAND or UE CONTEXT RELEASE COMMAND or UE CONTEXT RELEASE message, each corresponding E-RAB to release is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to release. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.RelAttNbr.*QCI*
   where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
   EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.2.4 Number of E-RABs successfully released

a) This measurement provides the number of E-RABs successfully released. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On transmission by the eNodeB of an E-RAB RELEASE RESPONSE or UE CONTEXT RELEASE COMPLETE message, or the E-RAB released successfully by source eNB after receiving UE CONTEXT RELEASE, each corresponding E-RAB successfully released is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs successfully released. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.RelSuccNbr.*QCI*
   where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
   EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.2.5 Number of E-RABs failed to release

a) This measurement provides the number of E-RABs failed to release. The measurement is split into subcounters per failure cause.

b) CC

c) On transmission by the eNodeB of an E-RAB RELEASE RESPONSE message, each E-RAB failed to release is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of E-RABs failed to release. 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 ERAB.RelFailNbr.*Cause*
where *Cause* identifies the cause resulting in the E-RAB release failure.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.2.6 Number of released active E-RABs

a) This measurement provides the number of released E-RABs that were active at the time of release (i.e.when there was user data in the queue in any of the directions). The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On transmission by the eNodeB of an E-RAB RELEASE RESPONSE or UE CONTEXT RELEASE COMPLETE message with the exception of those succeeding the message UE CONTEXT RELEASE COMMAND with 'Cause' indicating that the release was performed due to a successful Mobility activity, if any of the UL or DL are considered active (according to the definition used for "Number of active UEs in TS 36.314 when there is still data in the DL or UL buffer, each corresponding E-RAB to release is added to the relevant measurement per QCI. The possible QCIs are described in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to release with data in the DL or UL buffer. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.RelActNbr.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Retainability KPI "E-RAB Retainability" defined in [13]

4.2.3 E-RAB modification

4.2.3.1 Number of E-RABs attempted to modify the QoS parameter

a) This measurement provides the number of E-RABs attempted to modify the QoS parameter. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On receipt by the eNodeB of an E-RAB MODIFY REQUEST message, each E-RAB attempted to modify the QoS parameter is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs attempted to modify the QoS parameter. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.ModQoSAttNbr.*QCI*
where *QCI* identifies the target E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.3.2 Number of E-RABs successfully modified the QoS parameter

a) This measurement provides the number of E-RABs successfully modified the QoS parameter. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) On transmission by the eNodeB of an E-RAB MODIFY RESPONSE message, each E-RAB successfully modified the QoS parameter is added to the relevant measurement per QCI, the possible QCIs are included in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total number of E-RABs successfully modified the QoS parameter. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.ModQoSSuccNbr.*QCI*
where *QCI* identifies the target E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.3.3 Number of E-RABs failed to modify the QoS parameter

a) This measurement provides the number of E-RABs failed to be modified the QoS parameter. The measurement is split into subcounters per failure cause.

b) CC

c) On transmission by the eNodeB of an E-RAB MODIFY RESPONSE message, each E-RAB failed to modify the QoS parameter is added to the relevant measurement per cause, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of E-RABs failed to modify the QoS parameter. 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 ERAB.ModQoSFailNbr.*Cause*
where *Cause* identifies the cause resulting in the E-RAB Modify failure.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.2.4 E-RAB activity

4.2.4.1 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. A UE is said to be "in session" if any E-RAB data on a Data Radio Bearer (UL or DL) has been transferred during the last 100 ms.

d) Each measurement is an integer value.

e) ERAB.SessionTimeUE

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Retainability KPI "E-RAB Retainability" defined in [13].

4.2.4.2 In-session activity time for E-RABs

a) This measurement provides the aggregated active session time for E-RABs in a cell. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) Number of session seconds aggregated for E-RABs with a certain QCI. The E-RABs for a UE is said to be "in session" if any E-RAB data on any Data Radio Bearer (UL or DL) has been transferred during the last 100 ms for that QCI. The possible QCIs are described in TS 36.413 [9]. The sum of all supported per QCI measurements shall equal the total session seconds. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.SessionTimeQCI.*QCI*

where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Retainability KPI "E-RAB Retainability" defined in [13].

4.2.5 E-RAB number

4.2.5.1 Average Number of simultaneous E-RABs.

a) This measurement provides the average number of simultaneous E-RABs. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval, the number of simultaneous E-RABs and then taking the arithmetic mean. The measurement is split into subcounters per QCI, and the possible QCIs are included in TS 36.413 [9]. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.UsageNbrMean.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.2.5.2 Maximum Number of simultaneous E-RABs.

a) This measurement provides the maximum number of simultaneous E-RABs. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval, the number of simultaneous E-RABs and then taking the maximum. The measurement is split into subcounters per QCI, and the possible QCIs are included in TS 36.413 [9]. In case only a subset of per QCI 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 QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form ERAB.UsageNbrMax.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.3 Handover related measurements

4.3.1 Intra-RAT Handovers

4.3.1.1 Intra-eNB Handover related measurements

4.3.1.1.1 Attempted outgoing intra-eNB handovers per handover cause

a) This measurement provides the number of attempted outgoing intra-eNB handovers per handover cause.

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to the UE triggering the intra-eNB handover (see TS 36.331 [8]). Each *RRCConnectionReconfiguration* message transimtted is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9].
The sum of all supported per cause measurements shall equal the total number of outgoing intra-eNB handover events. 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 supported plus a possible sum value identified by the .sum suffix.

e) HO.IntraEnbOutAtt.*Cause*
where *Cause* identifies the cause for handover.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.1.2 Successful outgoing intra-eNB handovers per handover cause

a) This measurement provides the number of successful outgoing intra-eNB handovers per handover cause.

b) CC.

c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB handover (see TS 36.331 [8]). Each *RRCConnectionReconfigurationComplete* message transimtted is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9].
The sum of all supported per cause measurements shall equal the total number of outgoing intra-eNB handover events. 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 supported plus a possible sum value identified by the .sum suffix

e) HO.IntraEnbOutSucc.*Cause*
where *Cause* identifies the cause for handover.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.2 Inter-eNB Handover related measurements

4.3.1.2.1 Attempted outgoing inter-eNB handover preparations

a) This measurement provides the number of attempted outgoing inter-eNB handover preparations.

b) CC.

c) Transmission of the X2AP message HANDOVER REQUEST from the source eNB to the target eNB (see TS 36.423[10]), indicating the attempt of an outgoing inter-eNB handover preparation or on transmission of S1AP message HANDOVER REQUIRED to the MME (see TS 36.413 [9]).

d) A single integer value.

e) HO.InterEnbOutPrepAtt

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.2.2 Attempted outgoing inter-eNB handover executions per handover cause

a) This measurement provides the number of attempted outgoing inter-eNB handovers per handover cause.

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover from the source eNB to the target eNB, indicating the attempt of an outgoing inter-eNB handover (see TS 36.331 [8]). Each *RRCConnectionReconfiguration* message transimtted is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9].
The sum of all supported per cause measurements shall equal the total number of outgoing inter-eNB handover events. 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 supported plus a possible sum value identified by the .sum suffix.

e) HO.InterEnbOutAtt.*Cause*
*w*here *Cause* identifies the cause for handover

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.2.3 Successful outgoing inter-eNB handover executions per handover cause

a) This measurement provides the number of successful outgoing inter-eNB handovers per handover cause.

b) CC.

c) Receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover. Each UE CONTEXT RELEASE message or UE CONTEXT RELEASE COMMAND message received is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9].
The sum of all supported per cause measurements shall equal the total number of outgoing inter-eNB handover events. 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 supported plus a possible sum value identified by the .sum suffix.

e) HO.InterEnbOutSucc.*Cause*
where *Cause* identifies the cause for handover.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.3 Handover measurements on neighbour cell basis

4.3.1.3.1 Attempted outgoing handovers per handover cause

a) This measurement provides the number of attempted outgoing handovers per handover cause and LTE target cell specific.

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the intra-RAT handover to the target eNB (see TS 36.331 [8]). Each *RRCConnectionReconfiguration* message transimtted is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9].
The sum of all supported per cause measurements shall equal the total number of outgoing handover events. 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 supported plus a possible sum value identified by the .sum suffix.

e) HO.OutAttTarget.*Cause*
*w*here *Cause* identifies the cause for handover

f) EUtranRelation

g) Valid for packet switched traffic

h) EPS

4.3.1.3.2 Successful outgoing handovers per handover cause

a) This measurement provides the number of successful outgoing handovers per handover cause and LTE target cell specific.

b) CC.

c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB handover (see TS 36.331 [8]), or receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful inter-eNB handover, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful inter-eNB handover. Each *RRCConnectionReconfigurationComplete*, UE CONTEXT RELEASE message or UE CONTEXT RELEASE COMMAND message received is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of outgoing intra-RAT handover events. 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 supported plus a possible sum value identified by the .sum suffix.

e) HO.OutSuccTarget.*Cause*
where *Cause* identifies the cause for handover.

f) EUtranRelation

g) Valid for packet switched traffic

h) EPS

4.3.1.3.3 Number of handover failures related with MRO

a) This measurement provides the number of outgoing handover related events that fail related with MRO. Handover related events include normal successful handovers and all failure events by which a UE in RRC connected state changes its serving cell without following a normal handover. Different MRO failure cases are found in [12]. The measurement includes separate counters for the number of handover failures classified as "too early", "too late" and "to wrong cell".

b) CC

c) The measurement is obtained by accumulating the number of failure events related to handover which are identified by the eNB according to the definitions in TS 36.300 [12].

d) Each measurement is an integer value.

e) The measurements are named

HO.IntraFreqOutFail.TooEarly

HO.IntraFreqOutFail.TooLate

HO.IntraFreqOutFail.ToWrongCell

f) EUtranRelation

g) Valid for packet switched traffic

h) EPS

4.3.1.4 Intra- / Inter-frequency Handover related measurements

4.3.1.4.1 Attempted outgoing intra-frequency handovers

a) This measurement provides the number of attempted outgoing intra-frequency handovers.

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover, indicating the attempt of an outgoing intra-frequency handover (see TS 36.331 [8]).

d) A single integer value.

e) HO.IntraFreqOutAtt.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.4.2 Successful outgoing intra-frequency handovers

a) This measurement provides the number of successful outgoing intra-frequency handovers.

b) CC.

c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB intra-frequency handover (see TS 36.331 [8]), or receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful inter-eNB intra-frequency handover, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover.

d) A single integer value.

e) HO.IntraFreqOutSucc

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.4.3 Attempted outgoing inter-frequency handovers – gap-assisted measurement

a) This measurement provides the number of attempted outgoing inter-frequency handovers, when measurement gaps are used [12].

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover, indicating the attempt of an outgoing inter-frequency handover when measurement gaps are used (see TS 36.331 [8]).

d) A single integer value.

e) HO.InterFreqMeasGapOutAtt

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.4.4 Successful outgoing inter-frequency handovers – gap-assisted measurement

a) This measurement provides the number of successful outgoing inter-frequency handovers, when measurement gaps are used [12].

b) CC.

c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB inter-frequency handover when measurement gaps are used (see TS 36.331 [8]), or receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful inter-frequency handover when measurement gaps are used, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful inter-frequency handover when measurement gaps are used.

d) A single integer value.

e) HO.InterFreqMeasGapOutSucc

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.4.5 Attempted outgoing inter-frequency handovers – non gap-assisted measurement

a) This measurement provides the number of attempted outgoing inter-frequency handovers, when measurement gaps are not used [12].

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover, indicating the attempt of an outgoing inter-frequency handover when measurement gaps are not used (see TS 36.331 [8]).

d) A single integer value.

e) HO.InterFreqNoMeasGapOutAtt

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.4.6 Successful outgoing inter-frequency handovers – non gap-assisted measurement

a) This measurement provides the number of successful outgoing inter-frequency handovers, when measurement gaps are not used [12].

b) CC.

c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB inter-frequency handover when measurement gaps are not used (see TS 36.331 [8]), or receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful inter-frequency handover when measurement gaps are not used, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful inter-frequency handover when measurement gaps are not used.

d) A single integer value.

e) HO.InterFreqNoMeasGapOutSucc

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.5 Handover related measurements for DRX / non-DRX

4.3.1.5.1 Attempted outgoing handovers with DRX

a) This measurement provides the number of attempted outgoing handovers, when DRX is used (for DRX see [12]).

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover, indicating the attempt of an outgoing handover when DRX is used (see TS 36.331 [8]).

d) A single integer value.

e) HO.DrxOutAtt

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.5.2 Successful outgoing handovers with DRX

a) This measurement provides the number of successful outgoing handovers, when DRX is used (for DRX see [12]).

b) CC.

c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB handover when DRX is used (see TS 36.331 [8]), or receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover when DRX is used, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handover when DRX is used.

d) A single integer value.

e) HO.DrxOutSucc

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.5.3 Attempted outgoing handovers non-DRX

a) This measurement provides the number of attempted outgoing handovers, when DRX is not used (for DRX see [12]).

b) CC.

c) Transmission of the *RRCConnectionReconfiguration* message to UE triggering the handover, indicating the attempt of an outgoing handover when DRX is not used (see TS 36.331 [8]).

d) A single integer value.

e) HO.NoDrxOutAtt.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.1.5.4 Successful outgoing handovers non-DRX

a) This measurement provides the number of successful outgoing handovers, when DRX is not used (for DRX see [12]).

b) CC.

c) Receipt of a RRC message *RRCConnectionReconfigurationComplete* sent from the UE to the target (=source) eNB, indicating a successful outgoing intra-eNB handover when DRX is not used (see TS 36.331 [8]) when DRX is not used, or receipt at the source eNB of UE CONTEXT RELEASE [10] over the X2 from the target eNB following a successful handover when DRX is not used, or if handover is performed via S1, receipt of UE CONTEXT RELEASE COMMAND[9] at the source eNB following a successful handoverwhen DRX is not used.

d) A single integer value.

e) HO.NoDrxOutSucc

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.3.2 Inter-RAT Handovers

4.3.2.1 Measurements related to inter-RAT Handovers – target cell of 3GPP and non-3GPP network technology

4.3.2.1.1 Attempted outgoing inter-RAT handovers per handover cause

a) This measurement provides the number of attempted outgoing inter-RAT handovers per cause and target cell specific.

b) CC.

c) Transmission of the *MobilityFromEUTRACommand* message or the *HandoverFromEUTRAPreparationRequest* message from the serving eNB to the UE indicating the attempt of an outgoing handover from EUTRAN to UTRAN or to GERAN or to CDMA2000 (see TS 36.331 [8]). Each *MobilityFromEUTRACommand* message or

HandoverFromEUTRAPreparationRequest message transmitted is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9]. The sum of all supported per cause measurements shall equal the total number of outgoing inter-RAT handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
All IRAT handovers to the neighbouring cells in non-eUTRAN networks are measured.

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) HO.IartOutAtt.*Cause*
*w*here *Cause* identifies the cause for handover

f) EUtranCellFDD
EUtranCellTDD
GSMRelation
UTRANRelation
CDMA2000Relation

g) Valid for packet switched traffic

h) EPS

4.3.2.1.2 Successful outgoing inter-RAT handovers per handover cause

a) This measurement provides the number of successful outgoing inter-RAT handovers per cause target cell specific.

b) CC.

c) Receipt of a S1AP message UE CONTEXT RELEASE COMMAND sent from the MME to the source eNB, indicating a successful IRAT handover (see TS 36.413 [9]). Each UE CONTEXT RELEASE COMMAND message received is added to the relevant per handover cause measurement, the possible causes are included in TS 36.413 [9].
The sum of all supported per cause measurements shall equal the total number of outgoing inter-RAT handover events. In case only a subset of per cause measurements is supported, a sum subcounter will be provided first.
All IRAT handovers to the neighbouring cells in non-eUTRAN are measured.

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) HO.IartOutSucc.*Cause*
*w*here *Cause* indicating the cause for handover.

f) EUtranCellFDD
EUtranCellTDD
GSMRelation
UTRANRelation
CDMA2000Relation

g) Valid for packet switched traffic

h) EPS

4.4 Cell level radio bearer QoS related measurements

4.4.1 Cell PDCP SDU bit-rate

4.4.1.1 Average DL cell PDCP SDU bit-rate

a) This measurement provides the average cell bit-rate of PDCP SDUs on the downlink. This represents the ingress rate of user plane traffic to the eNodeB (via X2 or S1). The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) This measurement is obtained by accumulating the number of bits entering the eNodeB, and then dividing the sum by the measurement period . The measurement is performed at the PDCP SDU level. PDCP SDUs that are forwarded over the X2/S1 to another eNodeB during handover shall be deducted from the bit count – if this results in a negative bit count the bit count shall be set to zero. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total DL cell PDCP SDU bit-rate. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value representing the bit-rate measured in kb/s. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB.PdcpSduBitrateDl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.1.2 Average UL cell PDCP SDU bit-rate

a) This measurement provides the average cell bit-rate of PDCP SDUs on the uplink. This represents successful transmissions of user plane traffic; control signalling and retransmissions are excluded from this measure. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) CC

c) This measurement is obtained by accumulating the number of bits leaving the eNodeB on the X2 or S1 interface, and then dividing the sum by the measurement period. The measurement is performed at the PDCP SDU level. PDCP SDUs that were not received over the air interface in the cell (but were forwarded from another eNodeB during handover) are excluded from the count. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total UL cell PDCP SDU bit-rate. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value representing the bit-rate measured in kb/s. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB. PdcpSduBitrateUl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.1.3 Maximum DL cell PDCP SDU bit-rate

a) This measurement provides the maximum cell bit-rate of PDCP SDUs on the downlink. This represents the maximum ingress rate of user plane traffic to the eNodeB (via X2 or S1). This is a sum counter measured across all QCIs.

b) SI

c) This measurement is obtained by sampling at pre-defined intervals the DL cell PDCP SDU bit-rate summed across all QCIs (see clause 4.4.1.1), and then taking the arithmetic maximum of these samples.

d) A single integer value representing the maximum bit-rate measured in kb/s.

e) DRB.PdcpSduBitrateDlMax

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.1.4 Maximum UL cell PDCP SDU bit-rate

a) This measurement provides the maximum cell bit-rate of PDCP SDUs measured on the uplink. This represents successful transmissions of user plane traffic; control signalling and retransmissions are excluded from this measure. This is a sum counter measured across all QCIs.

b) SI

c) The measurement is obtained by sampling at pre-defined intervals the UL cell PDCP SDU bit-rate summed across all QCIs (see clause 4.4.1.2), and then taking the arithmetic maximum of these samples.

d) A single integer value representing the maximum bit-rate measured in kb/s.

e) DRB.PdcpSduBitrateUlMax

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.1.5 Average DL cell control plane PDCP SDU bit-rate

a) This measurement provides the average cell bit-rate of control plane PDCP SDUs on the downlink.

b) CC.

c) This measurement is obtained by accumulating the number of received control plane PDCP SDU bits by the eNodeB, including the control plane PDCP SDU bits received from S1 and RRC SAP, and then dividing the sum by the measurement period.

d) An single integer value in kb/s.

e) SRB.PdcpSduBitrateDl

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.4.1.6 Average UL cell control plane PDCP SDU bit-rate

a) This measurement provides the average cell bit-rate of control plane PDCP SDUs on the uplink.
This represents successful transmissions of control plane traffic;

b) CC.

c) This measurement is obtained by accumulating the number of transmitted uplink control plane PDCP SDU bits by the eNodeB, and then dividing the sum by the measurement period.

d) An single integer value in kb/s.

e) SRB.PdcpSduBitrateUl

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switching.

h) EPS

4.4.2 Active UEs

4.4.2.1 Average number of active UEs on the DL

a) This measurement provides the average number of UEs that have DTCH data queued on the downlink. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI.

d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB.UEActiveDl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.2.2 Average number of active UEs on the UL

a) This measurement provides the average number of UEs that have DTCH data queued on the uplink. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI.

d) Each measurement is an integer value. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB.UEActiveUl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.3 Packet Delay and Drop Rate

4.4.3.1 Average DL PDCP SDU delay

a) This measurement provides the average (arithmetic mean) PDCP SDU delay on the downlink. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) DER (n=1)

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11].

d) Each measurement is an integer value representing the mean delay in ms. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB.PdcpSduDelayDl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.3.2 DL PDCP SDU drop rate

a) This measurement provides the fraction of IP packets (PDCP SDUs) which are dropped on the downlink. Only user-plane traffic (DTCH) is considered. A dropped packet is one whose context is removed from the eNodeB without any part of it having been transmitted on the air interface. Packets discarded during handover are excluded from the count. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. In case only a subset of per QCI measurements is supported, a drop rate subcounter calculated across all QCIs will be provided first.

d) Each measurement is an integer value representing the drop rate multiplied by 1E6. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB.PdcpSduDropRateDl.*QCI*
where *QCI* identifies the target E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.4 Packet loss rate

4.4.4.1 DL PDCP SDU air interface loss rate

a) This measurement provides the fraction of IP packets (PDCP SDUs) which are lost (not successfully transmitted) on the downlink air interface. Only user-plane traffic (DTCH) is considered. A lost packet is one whose context is removed from the eNodeB after an attempt has been made to transmit part or all of the packet on the air interface but the whole packet has not been successfully transmitted. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. In case only a subset of per QCI measurements is supported, a loss rate subcounter calculated across all QCIs will be provided first.

d) Each measurement is an integer value representing the air interface loss rate multiplied by 1E6. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB. PdcpSduAirLossRateDl.*QCI*
where *QCI* identifies the target E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.4.2 UL PDCP SDU loss rate

a) This measurement provides the fraction of IP packets (PDCP SDUs) which are lost (not successfully received) on the uplink. Only user-plane traffic (DTCH) and only PDCP SDUs that have entered PDCP (and given a PDCP sequence number) are considered. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. In case only a subset of per QCI measurements is supported, a loss rate subcounter calculated across all QCIs will be provided first.

d) Each measurement is an integer value representing the loss rate multiplied by 1E6. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form DRB.PdcpSduLossRateUl.*QCI*
where *QCI* identifies the target E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.4.5 IP Latency measurements

4.4.5.1 IP Latency in DL, E-RAB level

a) This measurement provides IP Latency in DL on E-RAB level.

b) CC

c) This measurement is obtained by the following formula for E-RABs

$$\frac{\text{LatTime}}{\text{LatSample}}$$

LatTime is obtained by accumulating the time T for E-RABs

$$T = t_{first\ part\ of\ data\ volume\ transmitted} - t_{data\ received} \quad [ms]$$

The sample of "T" is made for the new arrived IP data block (PDCP SDU) when there is no other prior data to be transmitted to the same UE in the eNodeB .

LatSample is obtained by accumulating the number of Latency samples taken on the E-RAB level

The measurement is split into subcounters per E-RAB QoS level (QCI).

d) Each measurement is an integer value representing the time in ms. The number of measurements is equal to the number of QCIs.

e) The measurement name has the form DRB.IpLateDl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Integrity KPI "E-UTRAN IP Latency" defined in [13]

4.4.6 IP Throughput measurements

4.4.6.1 IP Throughput in DL

a) This measurement provides IP throughput in downlink.

b) DER(N=1)

c) This measurement is obtained according to the definition "Scheduled IP Throughput" in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI.

d) Each measurement is a real value representing the throughput in kbits/s. The number of measurements is equal to the number of QCIs.

e) The measurement name has the form DRB.IPThpDl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Integrity KPI "E-UTRAN IP Throughput" defined in [13]

4.4.6.2 IP Throughput in UL

a) This measurement provides IP throughput in uplink.

b) DER(N=1)

c) This measurement is obtained according to the definition "Scheduled IP Throughput" in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI.

d) Each measurement is a real value representing the volume in kbits. The number of measurements is equal to the number of QCIs.

e) The measurement name has the form DRB.IPThpUl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Integrity KPI "E-UTRAN IP Throughput" defined in [13]

4.5 Radio resource utilization related measurements

4.5.1 DL PRB Usage for traffic

a) This measurement provides the usage (in percentage) of physical resource blocks (PRBs) on the downlink for DTCH traffic. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total PRB usage for DTCH. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value from 0 to 100. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form RRU.PrbDl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.5.2 UL PRB Usage for traffic

a) This measurement provides the usage (in percentage) of physical resource blocks (PRBs) on the uplink for DTCH traffic. The measurement is split into subcounters per E-RAB QoS level (QCI).

b) SI

c) This measurement is obtained according to the definition in 3GPP TS 36.314 [11]. Separate counters are maintained for each QCI. The sum of all supported per QCI measurements shall equal the total PRB usage for DTCH. In case only a subset of per QCI measurements is supported, a sum subcounter will be provided first.

d) Each measurement is an integer value from 0 to 100. The number of measurements is equal to the number of QCIs plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form RRU.PrbUl.*QCI*
where *QCI* identifies the E-RAB level quality of service class.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.5.3 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 according to the definition in 3GPP TS 36.314 [11].

d) A single integer value from 0 to 100.

e) RRU.PrbTotDl

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.5.4 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 according to the definition in 3GPP TS 36.314 [11].

d) A single integer value from 0 to 100.

e) RRU.PrbTotUl

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.5.5 RACH Usage

a) This measurement provides the mean number of RACH preambles received in a cell in one second. 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) CC

c) This measurement is obtained according to the definition in 36.314 [11].

d) Each measurement is an integer value.

e) RRU.RachPreambleDedMean

RRU.RachPreambleAMean

RRU.RachPreambleBMean

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

4.5.6 Cell Unavailable Time

a) This measurement provides the length of time the cell has been unavailable for each cause.

b) DER (n=1)

c) This measurement is obtained by accumulating the time periods when the cell is unavailable per cause. The possible cause could be "manual intervention" and "fault". The sum of all supported per cause measurements shall equal the total time periods of cell unavailability. 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 (in seconds). The number of measurements is equal to the number of supported causes plus a possible sum value identified by the *.sum* suffix.

e) The measurement name has the form RRU.CellUnavailableTime.cause.

   Where *cause* identifies the cause resuling in cell unavailable.

f) EUtranCellFDD
   EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support KPI "E-UTRAN Cell Availability" defined in [13].

4.6 UE-associated logical S1-connection related measurements

4.6.1 UE-associated logical S1-connection establishment

4.6.1.1 Attempted UE-associated logical S1-connection establishment from eNB to MME

a) This measurement provides the number of attempted UE-associated logical S1-connection establishments from eNB to MME.

b) CC

c) Transmission of an INITIAL UE MESSAGE by the eNodeB to the MME (See 36.413 [9]).

d) A single integer value.

e) S1SIG.ConnEstabAtt

f) EUtranCellFDD
   EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Accessibility KPI "E-RAB Accessibility" defined in [13].

4.6.1.2 Succesful UE-associated logical S1-connection establishment from eNB to MME

a) This measurement provides the number of successful UE-associated logical S1-connection establishments from eNB to MME.

b) CC

c) On receipt by the eNB of first message from MME which succeeds INITIAL UE MESSAGE message on an UE-associated logical S1-connection (See 36.413 [9]).

d) A single integer value.

e) S1SIG.ConnEstabSucc

f) EUtranCellFDD
   EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

i) This measurement is to support the Accessibility KPI "E-RAB Accessibility" defined in [13]

4.7 Paging related measurements

4.7.1 Paging Performance

4.7.1.1 Number of paging records discarded at the eNodeB.

a) This measurement provides the number of paging records that are discarded at the eNB for paging occasions in each cell.

b) CC

c) Reception of a S1AP PAGING message from MME, see TS 36.413[9], with UE identity which satisfies the following formulae from TS 36.304 [14].

X = (T div N)*(UE_ID mod N)

Y = floor(UE_ID/N) mod Ns

AND the maximum number of paging records that can be queued for each paging occasion has been reached.

d) A single integer value.

e) PAG. DiscardedNbr

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic.

h) EPS

4.8 Measurements related to equipment resources

4.8.1 eNodeB processor usage

4.8.1.1 Mean processor usage

a) This measurement provides the mean usage of each key processor during the granularity period. Each equipment may have more than one key processor, how to indentify key processor is vendor specific.

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval the usage of the processor and then taking the arithmetic mean for each key processor.

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

e) EQPT.MeanProcessorUsage.*ProcessorID*
where *ProcessorID* identifies the key processor of this equipment, the format of *ProcessorID* is vendor specific.

f) ManagedElement.

g) Valid for packet switched traffic.

h) EPS.

4.8.1.2 Peak processor usage

a) This measurement provides the peak usage of each key processor during the granularity period. Each equipment may have more than one key processor, how to indentify key processor is vendor specific.

b) SI.

c) This measurement is obtained by sampling at a pre-defined interval the usage of the processor and then taking the maximum for each key processor.

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

e) EQPT.PeakProcessorUsage.*ProcessorID*
where *ProcessorID* identifies the key processor of this equipment, the format of *ProcessorID* is vendor specific.

f) ManagedElement.

g) Valid for packet switched traffic.

h) EPS.

4.9 Common LAs of overlapping RAT"s coverage

4.9.1 Number of incoming IRAT mobility events per LA

a) This measurement provides the number of incoming IRAT mobility events per E-UTRAN cell. This measurement is split into subcounters per LA.

b) CC.

c) On receipt by the eNB from UE of an RRCConnectionSetupComplete message in which the most significant bit of the "mmegi" in "RegisteredMME" IE is "0" (see TS 36.331 [8]). Each RRCConnectionSetupComplete message received is added to the relevant per LAI measurement.

d) Each measurement is an integer value.

e) RRC.IratIncMobility.*LAI*
where *LAI* identifies the LAI of the RAT"s coverage the UE comes from.

f) EUtranCellFDD
EUtranCellTDD

g) Valid for packet switched traffic

h) EPS

Annex A (informative): Use cases for performance measurements defintion

This annex provides the concrete use cases for the E-UTRAN performance measurements defined in clause 4.

A.1 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.

And due to different priority and tolerance for different service type with different OoS level in the networks, the monitor needs to be opened on each service type and OoS level.

To complete the call(/session) setup procedure, E-UTRAN is mainly responsible for the establishment of radio and S1 signaling connection and service bearer by the RRC connection establishment (See 3GPP TS 36.331[8]), RRC connection reestablishment after RRC connection dropped due to some reasons like radio link failure or handover failure etc (See 3GPP TS 36.331[8]) E-RAB setup (See 3GPP TS 36.413[9]) and Initial UE Context Setup (See 3GPP TS 36.413[9]) procedure.

To support the monitor of success or failure of the call(/session) setup, the performance measurements related to RRC connection establishment (See 3GPP TS 36.331[8]), RRC connection reestablishment (See 3GPP TS 36.331[8]) procedure, and the performance measurements related to E-RAB setup (See 3GPP TS 36.413[9]) and Initial UE Context Setup (See 3GPP TS 36.413[9]) procedure for each QoS level are required To support the monitor of time duration of setup call(/session) setup, the performance measurements related to RRC connection setup time and E-RAB setup time are required.

A.2 Monitor of E-RAB release

E-RAB is the key and limited resource for E-UTRAN to deliver services. The release of the E-RAB needs to be monitored as:

- an abnormal release of the E-RAB 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 E-RAB can be used to setup other requested calls(/sessions). The E-RAB failed to be released will still occupy the limited resource and hence it can not be used to admit other requested calls(/sessions).

The specific reason causing the abnormal and failed release of the E-RAB 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 OoS level in the networks, the monitor needs to be opened on each service type with OoS level.

The E-RAB can be released by E-RAB Release (See 3GPP TS 36.413[9]) and UE Context Release (See 3GPP TS 36.413[9] and 3GPP TS 36.423[10]) procedure, either initiated by eNodeB or MME.

So performance measurements related to E-RAB Release (See 3GPP TS 36.413[9]) and UE Context Release (See 3GPP TS 36.413[9]) procedure for each service type with QoS level are necessary to support the monitor of E-RAB release.

A.3 Monitor of E-RAB level QoS modification

When an E-RAB has been established, the QoS it experiences in the E-UTRAN is dependent upon the E-RAB level QoS parameters established for the bearer, together with settings of other bearers established in the same cell. If the QoS experienced by a bearer does not meet the expected performance, or the resource need be reassigned for other bearers, the E-RAB level QoS may be adjusted (typically with a knock-on effect onto other bearers).

So the modification of E-RAB level QoS parameters needs to be monitored, and due to different priority and tolerance for different service type with different OoS level in the networks, the monitor needs to be opened on each target service type with OoS level.

The E-RAB level QoS can be modified by E-RAB Modify procedure (see 3GPP TS 36.413[9]), in which the MME entity instructs the eNodeB to change one or more QoS parameters on an E-RAB using the E-RAB MODIFY REQUEST message. The eNodeB typically makes the adjustments as instructed (and adjusts the RRM applied to the bearer appropriately) but in some circumstances the bearer modification can fail. The eNodeB returns an E-RAB MODIFY RESPONSE message that tells the MME whether the modification was successful or not – for an unsuccessful modification a cause value is included. It is important for OAM to measure the failure rate of the bearer modifications, this information can be used, for example, to make adjustments to OAM CM settings.

A.4 Overview handover related Use Cases

Use Case	PM KPI / elementary object
Continuous Network Supervision: Supervision of overall handover performance. It is essential in network operations to follow the success rate of various handover. Low handover success rate will impact user experience, therefore it is important to define measurements to follow handover success rate.	- outgoing Intra RAT HO Success Rate (cell) *1 - outgoing Inter RAT HO Success Rate (cell) *1 - outgoing Inter System HO Success Rate (cell) *1 *3 - outgoing Intra Frequency HO Success Rate (cell) *1 - outgoing Inter Frequency HO Success Rate (cell) *1 - outgoing Intra eNB HO Success Rate (cell) *2 - outgoing Inter eNB HO Success Rate (cell) *2 *1: It is expected that the HO success rate may vary depending on the respective scenarios : intra-RAT, inter-RAT, inter System, intra frequency, inter frequency *2: it is expected that the HO success rate may vary depending on the used external interfaces *3: inter system : LTE- non 3GPP HO
Troubleshooting: Detection of bad handover relation. The first use case provides the overall performance of handover success rate on E-UTRAN cell level, but it is essential to get a knowledge between which cell pairs the handover success rate is low. Therefore it is important to know the success rate on neighbor cell relation basis.	- HO Success Rate (neighbourcell)
Troubleshooting: Reason for started handover To go for further analysis of handover failures, it is essential to know what causes the handovers. For this we need to know	- outgoing HO Success Rate per HO reason (neighbor cell) *4

the success rate of handovers per HO reason.	*4 different results expected e.g. emergency or normal HO
Troubleshooting: Reason for failed handover. To go for further detailed analysis for handover failure it is important to know what the reason for handover failure was, or whether the handover was assisted by measurement gaps or was with DRX. It is also important to know if measurement gaps and DRX are helping in handover procedure or not. (i.e. what is the handover failure rate if measurement gaps are switched on. Measurement gaps and DRX can cause more load and battery consumption to the UE, therefore if these are not causing any changes in handover failure rate, operators may not use them)	- outgoing HO Failure Distribution Rate (cell+neighbourcell) - HO Path Switching Failure Distribution Rate (cell or Interface) - HO Failure Rate DRX / Non DRX (cell) *5 - Inter frequency HO Failure Rate Meas gap assisted / not assisted (cell) *5 *5: measurement only on cell basis and not per neighbourcell due to amount of counters as mentioned above.
Network Planning: Traffic flow analysis or Network Planning: Handover traffic optimization	- outgoing Intra RAT HO Success Rate (neighbour cell) - outgoing Inter RAT HO Success Rate (cell) - outgoing Inter System HO Success Rate (cell)

A.5 Monitor of cell level QoS and radio resource utilisation

In an E-UTRAN cell the quality of service achieved is directly influenced by a number of factors, including:

- Loading of users on the cell
- Traffic loading and characteristics
- UE locations and mobility
- RRM policies
    - Scheduling
    - congestion control
    - admission control
    - layer 2 protocol configuration
- Mapping of traffic to QCI
- Setting of QoS parameters other than the QCI.

It is very important to be able to monitor the QoS to determine whether the combined effect of these policies, algorithms and external factors is satisfactory. Unsatisfactory QoS may rectified by adjusting policies and RRM settings, for instance.

Cell bit-rate

A fundamental measure of QoS is the throughput (data rate) of the cell. The total cell throughput measured across all radio bearers gives an indication of the loading and activity in the cell. Adding a per QCI counter allows the loading on the different QCIs to be measured. For example, if QCI 1 is used exclusively for VoIP then the loading of conversational speech can be directly determined. Finally, the maximum throughput can indicate to the operator whether there is enough capacity in the network; for example, is the backhaul sufficient. Separate counters should be configured on the downlink and uplink. Complexity may be reduced by performing the counters at layer 3, giving the ingress bit-rate to the eNB on the downlink and the egress bit-rate from the eNB on the uplink.

Cell throughput includes both User Plane data and Control Plane data. To support the User Plane data, necessary Control Plane data also need to be transmitted. This Control Plane data although required, will not be perceived (felt) by the User. The total cell throughput helps to evaluate the usage of bandwidth and radio resource.

Operators ideally want to see the Control Plane data as small as possible when compared to the User Plane data without compromising on the service.

Hence it is important to monitor the total cell throughput as well as how much is occupied by Control Plane Data.

Number of actives UEs

It is also of interest to determine how many users are enjoying the throughput numbers determined for each QCI. Therefore, we may count the number of users that are active for each QCI – here active users have data queued pending transmission. A simple division of the throughput (data rate) of a QCI by the number of active users on the QCI indicates the throughput per user on the QCI. For example, taking QCI 1 this metric could indicate the typical codec rate being employed in the cell. Alternatively, for QCI 9 supporting low priority TCP-based traffic it can indicate the typical bandwidth pipe size for a user when he has data to send / receive.

DL packet delay

Latency is of prime concern for some services, particularly conversational services like speech and instant messaging. A counter is added to measure the mean delay for IP packets incurred within the eNodeB. Separate counters are provided per QCI which are particularly useful when the QCI is used by very few services and the packet sizes vary little. It is only practical to measure packet delays on the downlink.

DL packet drop rate

When a cell is heavily loaded congestion can take place. When congestion is not severe the impact is typically the incurrence of additional delay for non-GBR radio bearers. However, when congestion is severe the eNodeB may be forced to discard packets. It is important for the operator to have visibility of packet discard so that corrective action can be instigated (for example, by adjusting admission control settings in the network). It is only practical to measure packet discards on the downlink. Packet discards on handover should not be included in the count.

PRB Usage

The resource utilisation, measured in terms of physical resource blocks (PRBs), is a useful measure of whether a cell is lightly loaded or not. Loading is a key input to network capacity planning and load balancing. Furthermore, when resource utilisation per QCI is reported the distribution of resources between different services can be estimated.

Downlink Air interface packet loss rate

The downlink air interface packet loss can be directly compared with the PELR value of a QCI to see if the packet loss (over the air interface) aspect of quality of service is being met within the cell (see [12] for more details on PELR). On the downlink this measurement can be added to the congestion losses (see DL packet drop rate) to determine the total packet loss rate at the eNodeB. Consequently, the downlink useful bit-rate can be estimated by scaling the measurement of the downlink PDCP ingress bit-rate by (1 – DL packet drop rate) (1 – air interface packet loss rate).

Uplink packet loss rate

The uplink air interface packet loss rate (per QCI) can be compared directly with the PELR defined for that QCI. An estimate of the uplink air interface packet loss may be provided by the "Uplink PDCP SDU loss rate". This uplink measurement is based on PDCP sequence numbers and cannot precisely measure the air interface losses. Any packets discarded by the UE within the protocol stack (i.e. at layer 2) are also counted since they will have been given a PDCP sequence number. Discards at layer 3 are not counted.

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 are signaled 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 eNodeB are appropriate for the number of random access attempts. If the resources are underutilised then the operator may reconfigure the eNodeB (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.

The eNodeB 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.

A.6 Monitor of the number of connected users

The number of the connected users in each cell is valuable information for operators to know how many uses are connecting to E-UTRAN per cell basis. This kind of information can help operator to tune the admission control parameters for the cell and to do load balancing between cells to ensure that the target percentage or number the of users admitted achieve the target QoS.

A.7 Monitoring of interference situation

In the LTE radio technology interference has to be coordinated on the basis uplink and downlink i.e. in a coordinated usage of the UL resources (Physical Resource Blocks, PRBs) and DL Transmitted Power, which lead to improve SIR and corresponding throughput. These are achieved by means of mechanisms employing channel quality indicators in support of scheduling/radio resource allocation functions.

These RRM functions in the eNB require the setting of frequency / power restrictions and preferences for the resource usage in the different cells. Setting and updating these parameters is the task of a network optimisation (done by operator or automatically by SON).

Use cases for the related interference measurements are e.g. optimisation of ICIC related RRM functionality, the detection of long distance interferer and the interference due to spurious emissions of neighbour cells. The later case is assumed only in high load scenarios or unsufficent ICIC functionality due to the the fact that ICIC functionality would minimise interference autonomously if sufficient bandwidth is available.

The necessary measurements to identify and anylse the interference situation as input for optimisation tasks has to be defined.

A.8 Monitor of ARQ and HARQ performance

Reliable Packet Delivery is one of the important Performance factor for a better User experience. HARQ retransmissions 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 retransmissions.

If a MAC PDU is not delivered, HARQ takes care of retransmitting (upto a maximum configurable number). If all the retransmissions 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 retransmissions take care of most packet errors, instead of relying on RLC layer retransmissions (which would increase the delay).

So, it is important to monitor the performance of these schemes.
ARQ Performance if viewed at QCI level can help in monitoring the distribution for each of the services.

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

A.9 Monitor of RF performance

RF Performance reflects the cell loading levels and abnormal conditions.

In the Downlink, Power Resources are managed by the EUTRAN Cell(RAN).
More Power Resources may help in increasing the Capacity of the System. Hence, there the power resources could be effectively used to optimize the Capacity of the System.

Hence there is a need to keep monitoring the Power Resource Utilization in % and also in absolute terms.

A.10 Monitor of paging performance

In EUTRAN, Paging is under the control of the MME. When the MME wants to page 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 is an important measure for the operator as it allows the operator to properly dimension the resources for paging in the E-UTRAN Cell .

At an E-UTRAN Cell it makes sense to measure the number of discarded paging messages if this is due to some problem in the eNodeB, 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 eNodeB 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 E-UTRAN cell level or not.

A.11 Use case of eNodeB processor usage

When network is very busy, for example on important holiday or emergency events happened, the traffic of one eNodeB is very heavy. So eNodeB processor usage measurements are very important to indicate eNodeB processor load capability. If eNodeB processor usage is too high, operator must take action to avoid network paralysis.

A.12 Monitor of simultaneous E-RABs

E-RAB is one of the EUTRAN Cell resources which are limited in number.

Hence along with the E-RAB Setup Success Rate, there is a need to keep monitoring the simultaneous E-RABs and having them at QCI level can help in learning the service distribution in time periods.

Average / Maximum simultaneous E-RABs, can help to know the average / maximum utilization of the resources in time periods, thereby helping to do necessary resource capacity engineering.

A.13 Monitoring of MRO

The following measurement is defined specifically to monitor the performance of intra-frequency handover optimisation:

- Number of handover failures for MRO.

The measurement examines "handover related events" in which the serving cell of a RRC connected UE is changed. Handover related events are either normal successful handovers, or they are failures. Different failure modes are possible and the measurement provides counts for the occurrences of the failure modes related with MRO, "too early", "too late" and "to wrong cell". The detailed definitions of these modes are captured in [12]. The counters provide visibility of the mix of failure problems that the handover optimistion function is tackling.

A.14 Monitoring of common LAs of overlapping target RAT''s coverage

For CS fallback in EPS, as defined in section 5.1A of 3GPP TS 23.272[16], the fallback procedure is likely to be faster if the network can allocate a Location Area to the UE that is the LA of the overlapping target RAT's coverage. For this situation, the MME should avoid allocating TAI lists that span multiple Location Areas of the target RAT, this can be achieved by:

- configuring the E-UTRAN cell's TAI to align the LA boundary of the target RAT;
- the MME being configured to know which TAIs are within which LA; and
- the MME using the TAI of the current E-UTRAN cell to derive the LAI.

Also as specified in section 4.3.4 of 3GPP TS 23.272[16], to facilitate the alignment of TA boundaries with LA boundaries, the E-UTRAN can gather statistics (from the inbound inter-RAT mobility events of all UEs) of the most common LAs indicated in the RRC signalling.

From such measurements per E-UTRAN cell basis, operators 1) can know the common LA(s) of the overlapping target RAT''s coverage for each TA, which is useful to configure the TAI list within which LA boundary to MME, operators can also 2) detect the case that TA spans multiple LAs if different most common LA(s) is/are reported from the E-UTRAN cells in the same TA, operators may take actions to rectify it if needed.

Annex B (informative): Change history

Change history								
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Cat**	**Old**	**New**
Mar 2009	SP-43	SP-090143	--	--	Presentation to SA for information and approval	--	1.0.0	8.0.0
Jun 2009	SP-44	SP-090408	002	--	Add missing E-UTRAN measurement for paging discards at the eNodeB - Align with 36.304 and 32.426	F	8.0.0	8.1.0
Jun 2009	SP-44	SP-090290	001	--	Addition of eNodeB processor usage related measurements	B	8.1.0	9.0.0
Sep 2009	SP-45	SP-090542	004	--	Correction on the IP latency and additional SAE Bearers setup measurements	A	9.0.0	9.1.0
Sep 2009	SP-45	SP-090542	006	--	Alignment of PRB usage related measurements with 36.314	A	9.0.0	9.1.0
Sep 2009	SP-45	SP-090627	007	--	Add SAE Bearer number related measurements	B	9.0.0	9.1.0
Mar 2010	SP-47	SP-100035	010	--	Add RRC connection release as a PM counter	F	9.1.0	9.2.0
Mar 2010	SP-47	SP-100035	011	--	Introduction of handover failure PM counters for handover optimisation	F	9.1.0	9.2.0
Mar 2010	SP-47	SP-100035	012	--	Add a PM counter of RRC connection establishments per failure cause	F	9.1.0	9.2.0
Jun 2010	SP-48	SP-100259	021	--	Correct L3 messages in measurement definitions	A	9.2.0	9.3.0
Jun 2010	SP-48	SP-100412	017	--	Add IP Throughput measurements	F	9.2.0	9.3.0
Jun 2010	SP-48	SP-100262	014	--	Missing measurement related to common LAs to support faster CS fallback in EPS	F	9.2.0	9.3.0
Jun 2010	SP-48	SP-100262	016	--	Add the missing reference of causes in HO measurements	F	9.2.0	9.3.0
Sep 2010	SP-49	SP-100488	027	--	Correction of intra-RAT HO measurements	F	9.3.0	9.4.0
Dec 2010	SP-50	SP-100878	029	1	Correcting L3 messages and cleanup	A	9.4.0	9.5.0

History

Document history		
V9.1.0	January 2010	Publication
V9.2.0	April 2010	Publication
V9.3.0	July 2010	Publication
V9.4.0	October 2010	Publication
V9.5.0	January 2011	Publication