

ETSI TS 132 450 V15.2.0 (2019-10)



**Universal Mobile Telecommunications System (UMTS);
LTE;
Telecommunication management;
Key Performance Indicators (KPI) for Evolved Universal
Terrestrial Radio Access Network (E-UTRAN): Definitions
(3GPP TS 32.450 version 15.2.0 Release 15)**



Reference

RTS/TSGS-0532450vf20

Keywords

LTE,UMTS

ETSI

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Foreword

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

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

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

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

- 32.451: Key Performance Indicators (KPI) for E-UTRAN; Requirements;
- 32.450: Key Performance Indicators (KPI) for E-UTRAN; Definitions. Key Performance Indicators (KPI).

1 Scope

The present document specifies definitions of Key Performance Indicators (KPIs) for E-UTRAN.

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] ITU-T Recommendation E.800: "Terms and Definitions related to Quality of Service and Network Performance including Dependability".
- [2] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [3] 3GPP TS 32.404: "Telecommunication management; Performance Management (PM); Performance measurements - Definitions and template".
- [4] 3GPP TS 32.405: "Telecommunication management; Performance Management (PM); Performance measurements Universal Terrestrial Radio Access Network (UTRAN) ".
- [5] 3GPP TS 32.406: "Telecommunication management; Performance Management (PM); Performance measurements Core Network (CN) Packet Switched (PS) domain".
- [6] 3GPP TS 32.407: "Telecommunication management; Performance Management (PM); Performance measurements Core Network (CN) Circuit Switched (CS) domain".
- [7] 3GPP TS 32.408: "Telecommunication management; Performance Management (PM); Performance measurements Teleservice".
- [8] 3GPP TS 32.409: "Telecommunication management; Performance Management (PM); Performance measurements IP Multimedia Subsystem (IMS)".
- [9] 3GPP TS 52.402: "Telecommunication management; Performance Management (PM); Performance measurements - GSM".
- [10] 3GPP TS 32.425: "Telecommunication management; Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [2] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [2].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [2] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [2].

eNB	E-UTRAN Node B
EE	Energy Efficiency
EPS	Evolved Packet System
E-RAB	E-UTRAN Radio Access Bearer
E-UTRAN	Evolved UTRAN
kbit	kilobit (1000 bits)
KPI	Key Performance Indicator
KQI	Key Quality Indicator
LTE	Long Term Evolution
QoS	Quality of Service
RAT	Radio Access Technology
TTI	Transmission Time Interval
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Radio Access Network

4 KPI Overview

The following KPI categories are covered by the present document:

- Accessibility (see the definition in [1]).
- Retainability (see the definition in [1]).
- Integrity (see the definition in [1]).
- Availability
- Mobility
- Energy Efficiency

5 KPI Definitions Template

- a) Long name (Mandatory): This field shall contain the long and descriptive name of the KPI.
- b) Description (Mandatory): This field shall contain the description of the KPI. Within this field it should be given if the KPI is focusing on network or user view.
- c) Logical formula definition (Mandatory):
The logical formula should describe what the KPI formula is in logical way. The description of the formula is given in a written textual format without any measurement or counter names. E.g. a success rate KPI's logical formula is the successful event divided by all event.

- d) Physical formula definition (Optional):
This field should contain the KPI formula description using the 3GPP defined counter names.
This field can be used only if the counters needed for the KPI formula is defined in any of the 3GPP TS for performance measurements (TS 32.404 [3], TS 32.405 [4], TS 32.406 [5], TS 32.407 [6], TS 32.408 [7], TS 32.409 [8], TS 52.402 [9], TS 32.425 [10])
- e) Measurement names used for the KPI (Optional):
This section should list the measurement names used for the KPI.
This section can be filled out only when the underlying measurements for the KPI formula can be defined, i.e. physical formula definition is available.

- f) KPI Object (mandatory)
This section shall describe the object of the KPI. The object of the KPI is one or some of the following:

- UTRAN;
- GERAN;
- CS core;
- PS core;
- IMS;
- E-UTRAN.

The field can have multiple selection, e.g. for a network level end to end KPI the selection can be UTRAN+PS core network.

- g) KPI category (mandatory)
This section contains the classification of the KPI into one of the KPI categories listed in section 4

- h) Unit of the KPI (mandatory)
This section describes the unit of the KPI. The unit can be one of the following:

- percentage;
- time interval (second or millisecond);
- Erlang;
- bit/J;
- kbit/s.

- i) Type of the KPI (Mandatory)
This section describes the type of the KPI. The KPI type can be one of the following:

- MEAN: This KPI is produced to reflect a mean measurement value based on a number of sample results.
- RATIO: KPI is produced to reflect the percentage of a specific case occurrence to all the cases.
- CUM: This KPI is produced to reflect a cumulative measurement which is always increasing.

- j) Remark: (Optional)
This field is for any further information that is needed for the KPI definition.
Here it is proposed to define any additional information that would be needed for the KPI definition; e.g. the definition of a call in UTRAN.

6 E-UTRAN KPI Definitions

6.1 KPI Category "Accessibility"

6.1.1 E-RAB Accessibility

6.1.1.1 Definition

- a) E-RAB Accessibility.
- b) A KPI that shows probability for an end-user to be provided with an E-RAB at request.
- c) Probability success rate for E-RABs establishment. Successful attempts compared with total number of attempts for the different parts of the E-RAB establishment.

$$A1 = \text{InitialEPSBEstabSR} = \frac{\sum_{\text{cause}} \text{RRC.ConnEstabSucc.[Cause]}}{\sum_{\text{cause}} \text{RRC.ConnEstabAtt.[Cause]}} \times \frac{\sum \text{S1SIG.ConnEstabSucc}}{\sum \text{S1SIG.ConnEstabAtt}} \times \frac{\sum_{\text{QCI}} \text{ERAB.EstabInitSuccNbr.[QCI]}}{\sum_{\text{QCI}} \text{ERAB.EstabInitAttNbr.[QCI]}} \times 100$$

$$A2 = \text{AddedEPSBEstabSR} = \frac{\sum_{\text{QCI}} \text{ERAB.EstabAddSuccNbr[QCI]}}{\sum_{\text{QCI}} \text{ERAB.EstabAddAttNbr[QCI]}} \times 100$$

- e) RRC.ConnEstabAtt.Cause
RRC.ConnEstabSucc.Cause
S1SIG.ConnEstabAtt
S1SIG.ConnEstabSucc
ERAB.EstabInitAttNbr.QCI
ERAB.EstabInitSuccNbr.QCI
ERAB.EstabAddAttNbr.QCI
ERAB.EstabAddSuccNbr.QCI
- f) E-UTRAN
- g) Accessibility
- h) Percentage
- i) RATIO
- j) The definition of the service provided by E-UTRAN is E-RABs.

6.1.1.2 Extended definition

Mapping of end-user applications towards E-RABs can be different depending on operator strategy; hence the measurement shall be adjustable depending on operator E-RAB mapping strategy.

Table 1 Example of service mapping towards E-RABs

<i>Operator</i>	<i>Service</i>	<i>E-RAB mapping</i>
A	X	Initial E-RAB

A	Y	Initial E-RAB
B	X	Initial E-RAB
B	Y	Added E-RAB

To provide Accessibility measurement from E-UTRAN that can be mapped to a service for the operator the following measurements are defined:

A1: Initial E-RAB establishment success rate

A2: Added E-RAB establishment success rate

The establishment success rate is defined as:

Number of successful E-RAB establishments

Number of received E-RAB establishment attempts

Services can be mapped towards either Initial or Added E-RABs depending on operator strategy. If a different QoS characteristic is required compared with the QoS characteristic provided by an existing Initial E-RAB, an Added E-RAB can be requested. QoS characteristics can be defined on an E-RAB basis; hence both Initial E-RAB establishment success rate (A1) and Added E-RAB establishment success rate (A2) shall be available per QoS group.

With these two measures the operator can calculate the service accessibility depending on E-RAB mapping as follows:

Service mapped on Initial E-RAB = $A1 * 100$ [%]

Service mapped on Added E-RAB = $A1 * A2 * 100$ [%]

6.2 KPI Category "Retainability"

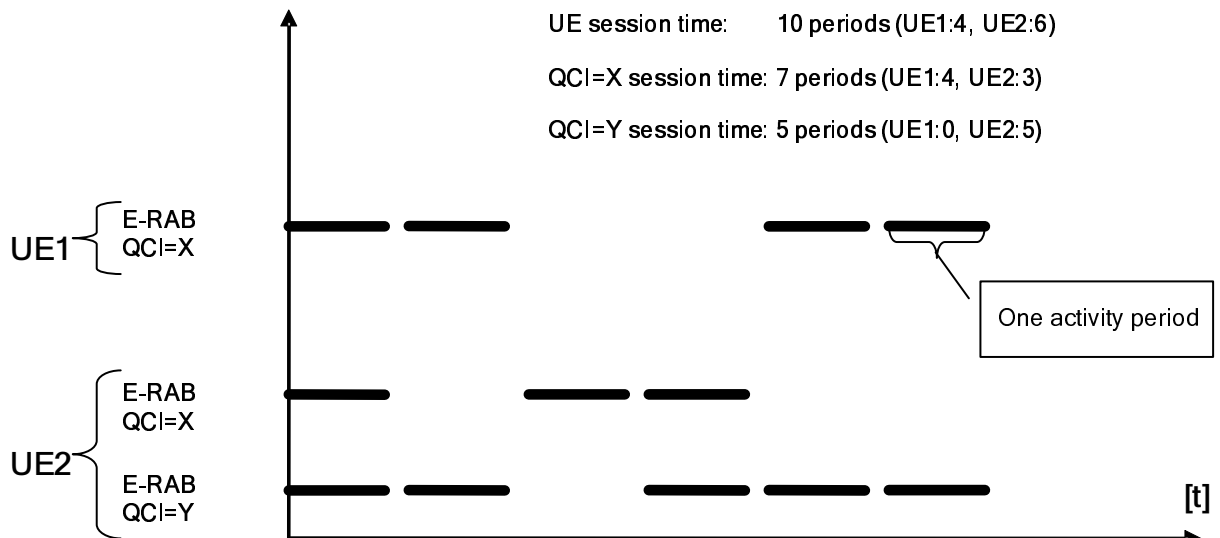
6.2.1 E-RAB Retainability

6.2.1.1 Definition

- a) E-RAB Retainability.
- b) A measurement that shows how often an end-user abnormally loses an E-RAB during the time the E-RAB is used.
- c) Number of E-RABs with data in a buffer that was abnormally released, normalized with number of data session time units.
- d) To measure E-RAB Retainability for a single QCI (R1) is fairly straight forward.

$$R1_{QCI=x} = \frac{ERAB.RelActNbr.QCI_{QCI=x}}{ERAB.SessionTimeQCI.QCI_{QCI=x}}$$

However to measure the E-RAB Retainability for UEs is not as straight forward. The measurement R1 is defined to look at the activity level of just one QCI at the time, so to use this formula and measurements in an aggregated way to get E-RAB Retainability on UE level will not be accurate (e.g. for an UE with multiple E-RABs, there might be E-RABs that are active at the same time, hence aggregating the QCI measurements for session time will give a larger session time than the total UE session time. See picture below).



Hence a measurement E-RAB Retainability on UE level is defined (R2) to provide a measurement for the overall E-RAB Retainability.

$$R2 = \frac{\sum_{QCI} ERAB.RelActNbr.[QCI]}{ERAB.SessionTimeUE}$$

- e) ERAB.RelActNbr.QCI
- ERAB.SessionTimeUE
- ERAB.SessionTimeQCI.QCI
- f) E-UTRAN.
- g) Retainability.
- h) Active release/second.
- i) MEAN.
- j) The definition of the service provided by E-UTRAN is E-RABs.

6.2.1.2 Extended definition

The retainability rate is defined as:

$$\frac{\text{Number of abnormally released E-RAB with data in any of the buffers}}{\text{Active E-RAB Time}} \quad [\text{Releases/Session time}]$$

As for defining an abnormal E-RAB release with end-user impact, it shall only be considered an abnormal release of the E-RABs if the eNodeB considers there to be data waiting for transfer in any of the buffers.

As for defining an E-RAB as active, an E-RAB shall be considered active if there recently has been any data transmission in any direction.

6.3 KPI Category "Integrity"

6.3.1 E-UTRAN IP Throughput

6.3.1.1 Definition

- a) E-UTRAN IP Throughput.
- b) A KPI that shows how E-UTRAN impacts the service quality provided to an end-user.
- c) Payload data volume on IP level per elapsed time unit on the Uu interface.
- d) IP Throughput for a single QCI:

$$\text{Downlink } Thp_{QCI=x} = DRB.IPThpDl_{QCI=x}$$

$$\text{Uplink } Thp_{QCI=x} = DRB.IPThpUl_{QCI=x}$$

- e) DRB.IPThpDl.QCI

DRB.IPThpUl.QCI

- f) E-UTRAN

- g) Integrity

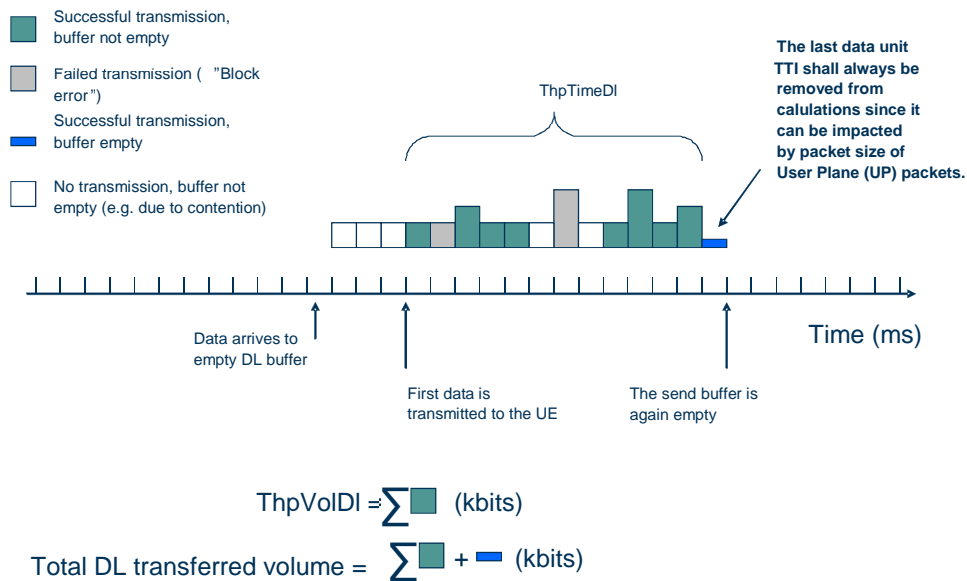
- h) kbit/s

- i) MEAN

- j) To make sure that only impacts from the RAN is included in this measurement, time units to be included in "elapsed time unit on the Uu interface" shall only be the ones where there is data in the buffer to be transmitted. E.g. in application data flows such as a web session, there are times when there is no data to transmit by the eNodeB due to bursty traffic pattern, then this "eNodeB idle time" shall not be included in "elapsed time unit on the Uu interface".

6.3.1.2 Extended definition

To achieve a Throughput measurement (below examples are given for DL) that is independent of file size it is important to remove the samples where one TTI on the radio interface is not utilized. (Successful transmission, buffer empty in figure below).



IP Throughput in DL = ThpVolDI / ThpTimeDI (kbits/s)

Figure 1

To achieve a throughput measurement that is independent of bursty traffic pattern, it is important to make sure that idle gaps between incoming data is not included in the measurements. That shall be done as considering each burst of data as one sample.

ThpVolDI is the volume on IP level and the ThpTimeDI is the time elapsed on Uu for transmission of the volume included in ThpVolDI.

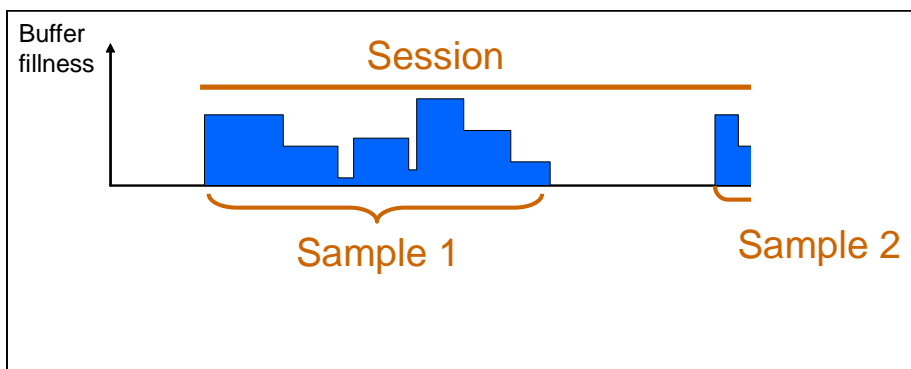


Figure 2

$$IP \text{ Throughput } DL = \frac{\sum_{Samples} ThpVolDI}{\sum_{Samples} ThpTimeDI}$$

Since services can be mapped towards different kind of E-RABs, the IP Throughput measurement shall be available per QoS group.

6.3.2 E-UTRAN IP Latency

6.3.2.1 Definition

- a) E-UTRAN IP Latency.

- b) A measurement that shows how E-UTRAN impacts on the delay experienced by an end-user.
- c) Time from reception of IP packet to transmission of first packet over the Uu.
- d) *Downlink* $Lat_{QCI=x} = DRB.IPLatDI_{QCI=x}$
- e) DRB.IPLatDI.QCI
- f) E-UTRAN.
- g) Integrity.
- h) Milliseconds.
- i) MEAN.
- j) To make sure only contribution from the RAN is included in this measurement, only delay of the first block to the Uu is counted.

6.3.2.2 Extended definition

To achieve a delay measurement that is independent of IP data block size only the first packet sent to Uu is measured.

To find the delay for a certain packet size the IP Throughput measure can be used together with IP Latency (after the first block on the Uu, the remaining time of the packet can be calculated with the IP Throughput measure).

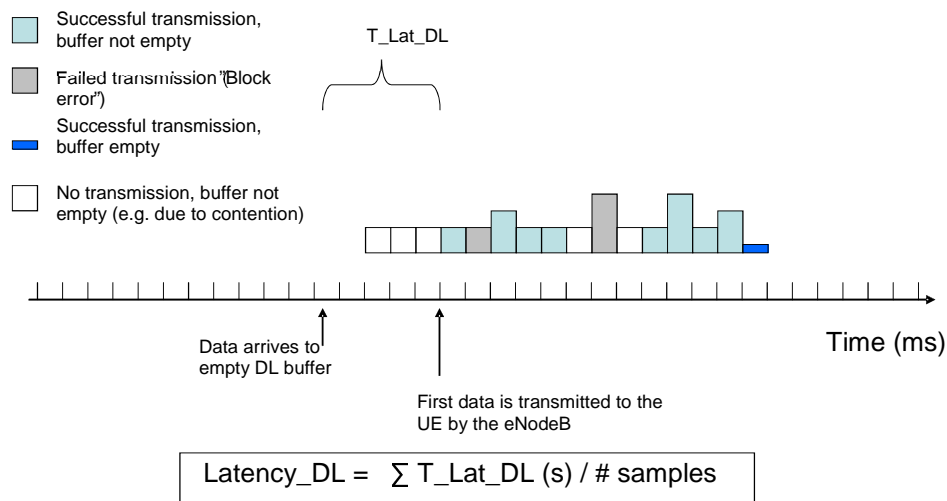


Figure 3

T_Lat is defined as the time between reception of IP packet and the time when the eNodeB transmits the first block to Uu.

Since services can be mapped towards different kind of E-RABs, the Latency measure shall be available per QoS group.

6.4 KPI Category "Availability"

6.4.1 E-UTRAN Cell Availability

6.4.1.1 Definition

- a) E-UTRAN Cell Availability.
- b) A KPI that shows Availability of E-UTRAN Cell.
- c) Percentage of time that the cell is considered available.

$$d) \text{ CellAvailability} = \frac{\text{measurement_period} - \sum_{\text{cause}} \text{RRU.CellUnavailableTime.[cause]}}{\text{measurement_period}} \times 100$$

- e) RRU.CellUnavailableTime.cause
- f) E-UTRAN
- g) Availability
- h) Percentage
- i) RATIO
- j) -

6.4.1.2 Extended Definition

$$\text{Availability} = \frac{\text{Time that cell is available}}{\text{Measurement Time}} * 100 [\%]$$

As for defining the cell as available, it shall be considered available when the eNodeB can provide E-RAB service in the cell.

6.5 KPI Category "Mobility"

6.5.1 E-UTRAN Mobility

6.5.1.1 Definition

- a) E-UTRAN Mobility.
- b) A KPI that shows how E-UTRAN Mobility functionality is working.
- c) Success rate of E-UTRAN Mobility.

$$d) \text{ Mobility Success Rate}_{\text{QCI=x}} = \frac{\text{HO.ExeSucc}}{\text{HO.ExeAtt}} \times \frac{\text{HO.PrepSucc.QCI}_{\text{QCI=x}}}{\text{HO.PrepAtt.QCI}_{\text{QCI=x}}} \times 100 [\%]$$

- e) HO.ExeAtt
- HO.ExeSucc

HO.PrepAtt.*QCI*

HO.PrepSucc.*QCI*

f) E-UTRAN

g) Mobility

h) Percentage

i) RATIO

j) -

6.5.1.2 Extended Definition

The measurement shall include both Intra E-UTRAN and Inter RAT handovers.

The measurement shall include both the preparation and execution phase of the handover.

"Entering preparation phase" is defined as the point of time when the source eNB attempts to prepare resources for an UE in a neighboring cell.

"Success of execution phase" is defined as the point of time when the source eNB receives information that the UE successfully is connected to the target cell.

6.6 KPI Category "Energy Efficiency"

6.6.1 E-UTRAN data Energy Efficiency

6.6.1.1 Definition

a) E-UTRAN data Energy Efficiency.

b) A KPI that shows data energy efficiency in operational E-UTRAN.

c) Data Volume (DV) divided by Energy Consumption (EC) of the considered network elements.

d)
$$EE_{MN,DV} = \frac{\sum_{Samples} (DRB.PdcpSduBitrateUL.QCI + DRB.PdcpSduBitrateDL.QCI) \times MeasurementPeriodTime}{\sum_{Samples} PEE.Energy}$$

e) DRB.PdcpSduBitrateUL.*QCI*

DRB.PdcpSduBitrateDL.*QCI*

PEE.Energy

f) E-UTRAN

g) Energy Efficiency

h) bit/J

i) MEAN

j) The Data Volume (in kbit) is obtained by multiplying average DL/UL cell PDCP SDU bit-rate values (in kbit/s) of the considered network elements by the measurement period value (in sec). The Energy Consumption (kWh) is obtained by measuring the PEE.Energy of the considered network elements over the same period of time. The samples are aggregated at the eNodeB/RN level.

Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
Dec 2008	SP-42	SP-080719			Presentation to SA for information		1.0.0
Mar 2009	SP-43	SP-090065	--	--	Presentation to SA for approval	2.0.0	8.0.0
Jun 2009	SP-44	SP-090289	001	--	Correction of extended definition for Mobility KPI	8.0.0	8.1.0
Sep 2009	SP-45	SP-090542	002	--	Correction on the IP latency KPI	8.1.0	8.2.0
Dec 2009	-	-	-	-	Update to Rel-9 version	8.2.0	9.0.0
Jun 2010	SP-48	SP-100412	003	-	Add formulas for IP Throughput KPI	9.0.0	9.1.0
Mar 2011	-	-	-	-	Update to Rel-10 version (MCC)	9.1.0	10.0.0
May 2011	SP-52	SP-110285	007	-	Correction of the measurement names in the KPI definition of E-RAB Accessibility	10.0.0	10.1.0
May 2011	SP-52	SP-110287	008	1	Correction of the measurement names in the KPI definition of E-RAB Retainability to align with 32.425	10.0.0	10.1.0
2012-09	-	-	-	-	Update to Rel-11 version (MCC)	10.1.0	11.0.0
2014-10	-	-	-	-	Update to Rel-12 version (MCC)	11.0.0	12.0.0
2016-01	-	-	-	-	Update to Rel-13 version (MCC)	12.0.0	13.0.0
2017-04	SA#75	-	-	-	Promotion to Release 14 without technical change	13.0.0	14.0.0
2018-06	-	-	-	-	Update to Rel-15 version (MCC)	14.0.0	15.0.0
2018-12	SA#82	SP-181039	0018	1	Add missing energy efficiency KPI for E-UTRAN	15.0.0	15.1.0

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2019-09	SA#85	SP-190749	0021	-	A	Correction on kbits abbreviation	15.2.0

History

Document history		
V15.0.0	July 2018	Publication
V15.1.0	April 2019	Publication
V15.2.0	October 2019	Publication