Company / organisation	**UIC ERTMS/GSM-R OFG** **UNITEL**

ERTMS/GSM-R Quality of Service Test Specification

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	NAME	**DATE**	**VISA**
Author	EECT Radio Working Group	March 2022	
Review	ERTMS/GSM-R OFG UTG	March 2022	Boris Gombač Alexander Ende
Approval	ERTMS/GSM-R ERIG Chairman	March 2022	Robert Sarfati

EVOLUTION SHEET

Version	Date	Author	Modification
0.1	3 June 2003	QoS Working Group	First draft version, based on a QoS Working document created by GSM-R/UNISIG.
0.2	13 June 2003	QoS Working Group	Updated after GSM-R internal review.
0.3	21 July 2003	QoS Working Group	Update after comments from UNISIG.
0.4	25 July 2003	QoS Working Group	Update after comments of UNISIG and GSM-R internal review.
1.0	11 September 2003	QoS Working Group	Final approved version.
1.1	16th September 2005	GSM-R QoS Working Group	Update after new release of Subset-093 and new definition of transmission interference metric.
1.2	7th July 2006	GSM-R QoS Working Group	Update after terrain feedback about the transmission interference and the network registration metrics. Addition of an appendix proposing a sample size for KPI validation.
2.0	30th October 2006	GSM-R QoS Working Group	Generic improvement of QoS parameter definitions, prerequisites, algorithms and statistics through interim document versions 1.2a to 1.2i.
2.01	22nd November 2006	OG meeting #26	Comments of OG meeting included.
3.0	19th February 2007	ERIG/IG/UNISIG/EEIG	Specification update approved issue
3.0.1	24th May 2016	GSM-R QoS Working Group	CS mode changes drafted
3.0.2	27th May 2016	GSM-R QoS Working Group	Additional CS mode changes incorporated
3.0.3	30th May 2016	GSM-R QoS Working Group	Definition of requirement and performance indicator incorporated, consistency through the entire document incorporated
3.0.4	29th September 2016	IG / GSM-R QoS Working Group	Required changes of IG review incorporated, Recommendation in table 6-3 incorporated
3.0.5	15 March 2017	GSM-R QoS Working Group	PS mode requirements incorporated and inputs from EIM

3.0.6	15 May 2017	EECT	Include review point agreed at EECT 5th April.
3.0.7	15 July 2017	EECT	Include review point agreed at EECT 7th June & alignment with SS093.
3.0.8	04 Sept. 2017	UIC	Include revisions agreed at EECT-GSMR#8 and EECT-GSMR#9
3.0.9.1	13 Oct. 2017	UIC	Include revisions agreed at EECT-GSMR#10 (22 Sept.2017) up to clause 5
3.0.10	16 Feb. 2018	UIC	Include revisions agreed at EECT-GSMR up to 24012018 till clause 5 excluding clause 3.5 and TTI/TREC aspects.
3.0.11	1 Oct 2018	UIC	Acceptance of changes as agreed up to EECT#7 + addition of new clause 3.5.1
3.0.11a	17 Oct 2018	UIC	Version updated to reflect all EECT agreed modifications. Clause 3.5.1 amended.
3.0.11b	24 Oct 2018	EECT	Version updated to reflect the EECT agreed modifications that were not included in 3.0.11a
3.0.11c	5 Mar 2019	EECT	Version updated to reflect the EECT agreed modifications that were made to 3.0.11b, excluding the review of clauses 3.5.1, 6.2.x and 6.4.4.
3.0.11h	7 Apr 2020	EECT	Version updated to reflect the EECT agreed modifications that were made to all the sections, between internal versions 3.0.11c and 3.0.11g
3.0.11h_plus	14 May 2020	EECT	Version generated to distribute to the testing companies, with the proposals discussed in the EECT meetings up to 14 May 2020 on acceptance criteria, with all tracked changes accepted
3.0.11i	29 May 2020	EECT	Version including the previous changes, and the modifications agreed in EECT meetings up to 27 May 2020 (moving summary table from clause 6 to 4), with all tracked changes accepted

3.0.11j	March 2021	EECT	Including the previous changes, modifications agreed in EECT meetings up to 11 Feb 2021, with all tracked changes accepted. Including ERA decision on MATVR acceptance value (not agreed by all EECT members).
3.0.12	July 2021	EECT	Including the internal revisions and agreements reached during EECT meetings up to July 2021.
3.0.13	March 2022	EECT	Including the sector revision and formatting
4.0.0.0	March 2022	EECT	Final draft
4.0.0.1	March 2022	EECT	Document footer updated
4.0.0.2	March 2022	EECT	Final draft after review
4.0.0	March 2022	EECT	Final approved issue

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1 INTRODUCTION

1.1 *Purpose*

ETCS requires transport services of the GSM-R network. The applicable GSM-R system requirements are summarised in [EIRENE SRS]. This document defines the test conditions and test cases necessary to validate the Quality of Service requirements as defined in [Subset-093]. While GSM-R CS-mode shall be supported for the operation of ETCS, the use of PS mode is optional for the network.

Optional features for the trackside (GSM-R and ETCS RBCs), if not implemented in the network, such as PS mode, shall not be considered for testing purposes described in the corresponding part of the document.

The present document describes the measurement setup including the test conditions, applicable measurement reference points, sample volume and the corresponding test cases to verify the bearer service performance of the particular GSM-R deployment that is envisaged for the operation of ETCS level 2/3. It takes into account [Subset-093] requirements.

It includes:

- Detailed conditions for the QoS performance indicators.
- The interfaces on which the bearer service and the QoS performance indicators are applicable.
- The methods of measuring and verification of QoS performance indicators' values.

1.2 *References*

[Subset-093]	UNISIG Subset-093, v 4.0.0,
[ER FFFIS]	Radio Transmission FFFIS for EuroRadio, A 11 T 6001,
[Subset-037]	UNISIG Subset-037,
[EIRENE FRS]	EIRENE Functional Requirement Specification,
[EIRENE SRS]	EIRENE System Requirement Specification,
[FFFIS SIM]	FFFIS for GSM-R SIM Cards. MORANE P 38 T 9001,
[TS 103 368]	ETSI TS 103 368 v1.2.1 Railway Telecommunications; Commands necessary for mobile radio equipment operation on railways,
[TS 145 005]	Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005 version 4.19.0 Release 4).

Note: For documents indexed in CCS TSI, the listed versions are applicable.

1.3   Abbreviations and definitions

1.3.1   Abbreviations

APN	Access Point Name
ASCII	American Standard Code for Information Interchange. ASCII code is the numerical representation of a character such as 'a' or '@' etc.
AT	ATtention Command (refer to [TS 103 368] for description of the commands)
ATD	AT Dial
BSS	Base Station Sub-System
CED	Connection Establishment Delay
CLR	Connection Loss Rate
CRC	Cellular Result Code
CS	Circuit Switched
DL	Downlink
DNS	Domain Name Service
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
EDLD	ETCS-DNS Lookup Delay (RBC FQDN-to-IP Resolution Delay)
EF	Error-Free
GBR	Guaranteed Bit Rate
GPS	Global Positioning System
GPRS-AD	GPRS Attach Delay
HDLC	High-Level Data Link Control
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
ISDN	Integrated Services Digital Network
KPI	Key Performance Indicator
MAC	Medium Access Control
MATVR	MA Transmission Violation Rate
MSISDN	Mobile Station ISDN Number
MT	Mobile Termination
NRD	Network Registration Delay
NT	Network Termination
OBU	On-Board Unit
PDP-CAD	PDP Context Activation Delay
PFC	Packet Flow Context
PPP	Point to Point Protocol
PS	Packet Switched
PS-SS	PS Service Setup
QoS	Quality of Service
RBC	Radio Block Centre
RLC	Radio Link Control
RF	Radio Frequency
SS	Service Setup
TD	Transfer Delay

TE	**T**erminal **E**quipment
TI	**T**ransmission **I**nterference
TTD	**T**ransaction **T**ransfer **D**elay
UL	**U**plink

1.3.2 Definitions

Call	Refers to circuit switched (CS) connection that can be used for voice or data communication
Connection	Refers to end-to-end data communication using CS communication
Confidence	Confidence level is the confidence in the measurement result, please see Appendix A, Clarification on Statistics
Data frame	A frame is defined as 30 consecutive octets.
I$_{FIX-CS}$	The interface between ETCS communication entity and GSM-R on the fixed side for CS mode, according to [ER FFFIS]. Measurement reference point applicable for Circuit Switched bearer service at the fixed network
I$_{FIX-PS}$	The interface between the ETCS communication entity and GSM-R on the fixed side for PS mode according to [ER FFFIS]. Measurement reference point applicable for Packet Switched bearer service at the fixed network
I$_{GPRS}$	The interface between ETCS-Onboard and the GSM-R mobile termination for PS mode, according to [ER FFFIS]. Measurement reference point applicable for Packet Switched bearer service at the trainborne equipment
I$_{GSM-R}$	The interface between ETCS-Onboard and the GSM-R mobile termination for CS mode, according to [ER FFFIS]. Measurement reference point applicable for Circuit Switched bearer service at the trainborne equipment
Octet	8 data bits
Percentile	The percentage of values of a distribution to rank a particular value
Rate	Value per time unit, e.g. per hour
Ratio	Quotient of two quantities in percent, e.g. error quantity to the total amount of events;
Um	The GSM-R radio interface
User	In this document, User means test operator

2 INTERFACES AND OTHER ASPECTS

2.1 System and Measurement Architecture

In order to define and clarify the different QoS aspects, a reference system architecture is needed. Both the operational system architecture and the measurement architecture are shown below[1].
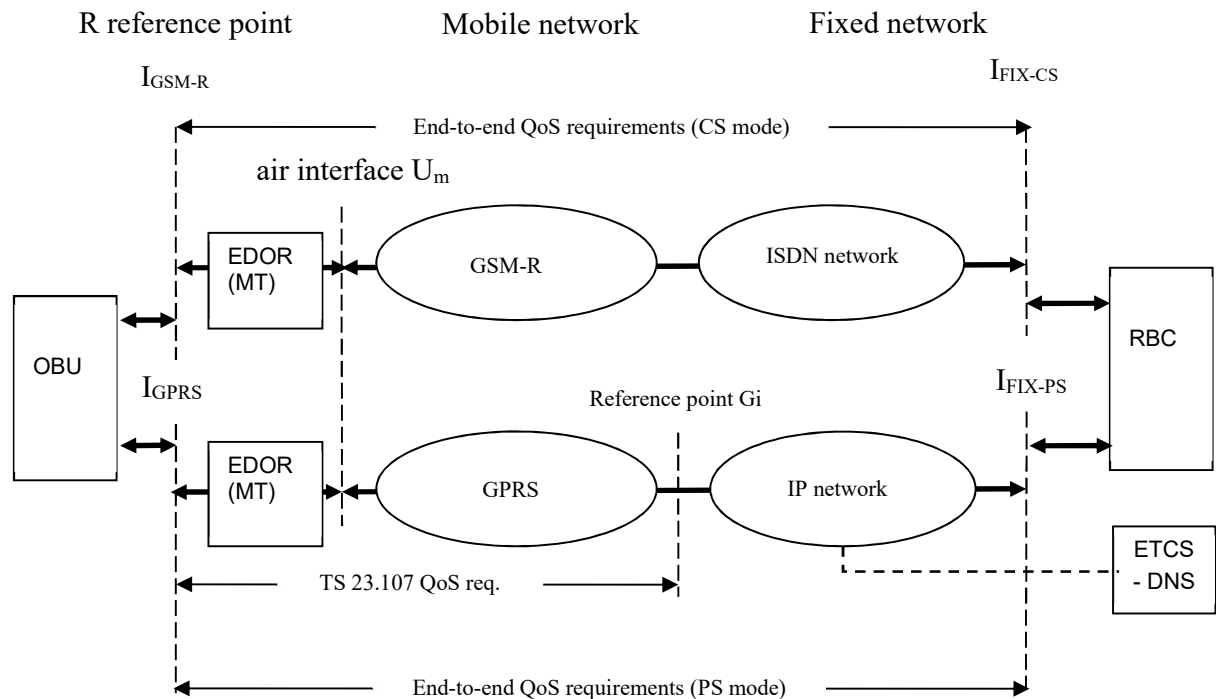
Figure 1: 2.1-1 - CS&PS mode - Operational System Architecture

Figure1: 2.1-1 shows the Operational System Architecture including the essential communication network elements consisting of:

- The GSM-R mobile termination, MT.
- The GSM-R network for CS mode.
- The GPRS network for PS mode.
- The fixed network between the GSM-R network and the RBC I_{FIX-CS} for the CS mode and I_{FIX-PS} for PS mode.

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[1] Note that TTD (in PS) involves either the OBU or the RBC for the end to end measurement.

Napaka! Vira sklicevanja ni bilo mogoče najti. gives the Measurement Architecture.

R reference point   Mobile network   Fixed network

I_{GSM-R} I_{FIX-CS}

End-to-end QoS requirements (CS mode)

air interface U_m

Test (MT)   GSM-R   ISDN network   Test App.

Test App. I_{GPRS} Reference point Gi I_{FIX-PS}

Test (MT)   GPRS   IP network

ETCS - DNS

End-to-end QoS requirements (PS mode)
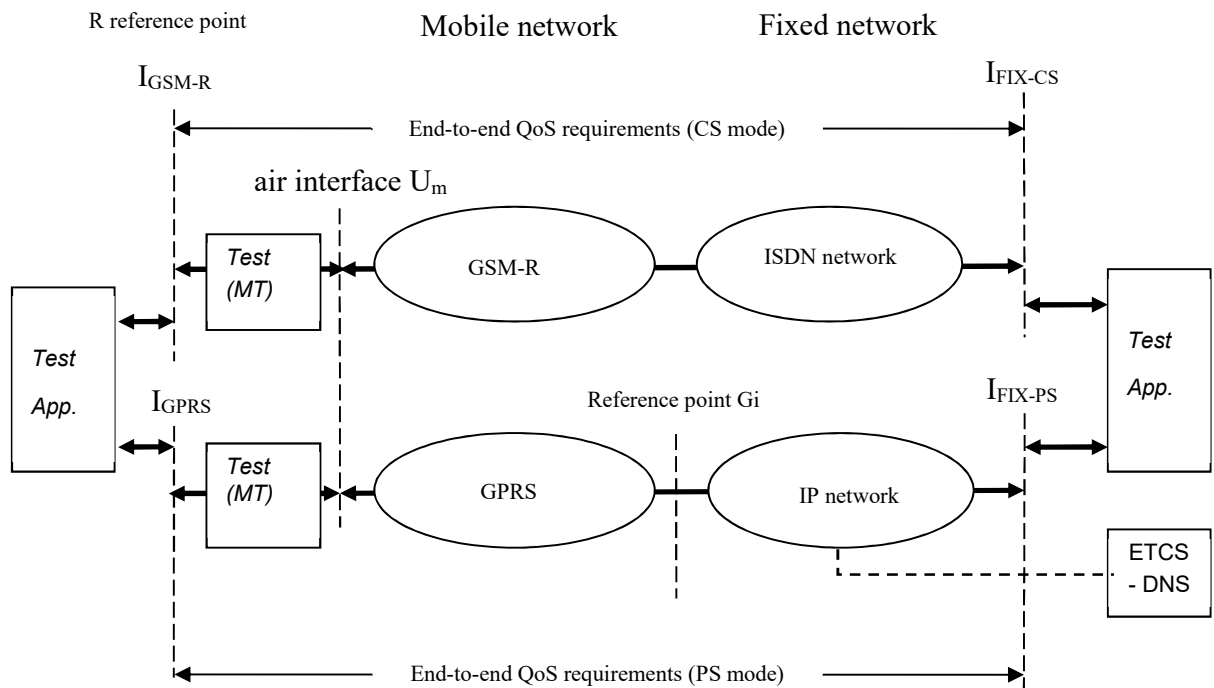
Figure 2: 2.1-2 - CS&PS mode - Measurement Architecture

2.2 Prerequisites and clarifications

2.2.1 General Conditions

The purpose of these tests is to verify and validate the GSM-R subsystem as a transport system for ETCS according to the values in Table **1**: 4.3-1 and Table **2**: 4.3-2.

User Plane related EuroRadio protocol stacks applicable for CS mode or PS mode are not used during testing.

The architecture of the EDOR is specified by [EIRENE SRS]. An EDOR consists of at least two Mobile Terminations. If one Mobile Termination is compliant to the QoS requirements based on this O-2475 Test Specification and the EDOR consists of multiple Mobile Terminations of the same type having the same software version, compliance is automatically extended to the EDOR.

Measurement applications are used to collect the QoS result(s).

The tests shall be performed using the same bearer service(s) as used for ETCS operation, according to [EIRENE SRS]. The network configuration for testing has to be according to the one intended to be used in operation. Measuring in the test area shall be done using the appropriate data rate (the values in this document correspond to 4,8 kbps for CS).

For PS mode, test packets are used that represent the ETCS application message length and the headers which are needed for end-to-end communication between the OBU and

the RBC including network layer overhead (i.e. Internet Protocol based on IP version 4 addressing).

The test area is defined as the area where ETCS is planned to be in operation. ETCS operation boundaries are usually marked by an ETCS "announcement" balise.

The tests shall be performed under nominal operational conditions. Non-availabilities due to technical defects or disturbances due to other radio operators are excluded. Tests shall be done at a speed not lower than 80% of the maximum permitted operational speed unless otherwise stated in the test plan.

> Note: Any restrictions applicable during the testing are expected to be included in the test plan.

The equipment to be used has a behaviour as defined in the relevant specifications (for example, regarding interferences immunity and intermodulation).

The network configuration and the relevant parameters are described within the test cases and shall be recorded.

2.2.2 Statistics

QoS requirements are validated with a specified Confidence Level in O-2475. This allows calculation of the minimum number of samples needed for statistical significance before a test can be considered as completed. See Appendix D, Statistical approach for ETCS QoS requirements validation and Appendix A, Clarification on Statistics (informative).

Additional testing to increase the confidence level beyond the one defined by O-2475 could be agreed on a national or operator basis.

2.2.3 Mobile Termination

The Mobile Termination is registered to the GSM-R network under test, if not stated otherwise in testing conditions.

ETCS data communication in CS mode considers only Power Class 2 (8Watt) Mobile Terminations. In PS mode using EGPRS higher modulation and coding schemes, 2W is applicable, and for lower coding schemes, 8 W is applicable, according to [TS 145 005].

The Mobile Termination is compliant with [EIRENE SRS] and [ER FFFIS] specifications.

The GSM-R MT uses a SIM card with the corresponding ETCS profile compliant to [FFFIS SIM].

The multiplexing function should not add delays for ETCS that influence the results.

2.2.4 GSM-R Network

The configuration of network specific parameters is a national matter.

2.2.5 ISDN network interface

For CS mode, the ISDN interface to be used shall be compliant with [ER FFFIS].

The ISDN network may consist of other transit network/transmission elements. It is assumed, that, resource establishment delay (i.e. Call Setup) caused by the ISDN network shall not exceed the time as defined in [EIRENE SRS] clause 3.4.3.

For the acceptance of the GSM-R network, if the delay exceeds the defined time, this additional delay shall not be taken into account. For the ETCS operation, the delay has to be kept within the defined limit.

2.2.6 IP Packet Data Network (PDN)

PS mode, the external IP-PDN shall not exceed the delay value stated in [Subset-093] (i.e. the delay exceeding the value stated in [Subset-093] shall not be taken into account).

For the acceptance of the GSM-R network, if the delay exceeds the defined time, this additional delay shall not be taken into account. For the ETCS operation, the delay has to be kept within the defined limit.

To ensure low ETCS packet latency inside the external IP-PDN, the GGSN may utilise QoS attributes to configure the differentiated edge functionality which provides the interworking between the GPRS/EGPRS and the external IP based data network. ETCS DNS shall be included, and it may be part of the IP network.

2.3   Tests

2.3.1 Testing phases

ETCS integration may consider the following phases:

- Phase 0 – Radio Network optimisation, ensuring that the air interface is performing well considering mainly radio performance indicators (not covered by this document). It is recommended to perform this phase prior to start the end-to-end QoS tests specified by this document.
- Phase 1 – End-to-end testing and further optimisation of the radio network if necessary. The end-to-end QoS tests are those specified in this document.
- Phase 2 – ETCS integration tests using operational components like RBC, OBU and EuroRadio protocol stack (not covered by this document).
- Phase 3 – ETCS operation encompassing in-service monitoring, using components in service (not covered by this document).
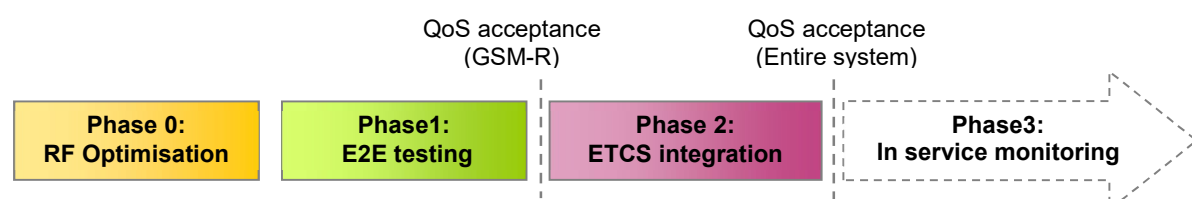
Figure 3: 2.3.1-1 - Testing phases

During **Phase 0**, testing and optimisation of the GSM-R network is usually part of national project efforts.

In **Phase 1**, basic testing of QoS for ETCS will be necessary or helpful for optimising the GSM-R network that will support the operation of ETCS. QoS test equipment shall be used as "test application" that may detect possible network deficiencies. Fundamental configuration as well as local problems can be identified.

In **Phase 2**, the objective is to integrate the real ETCS application consisting of EURORADIO equipment, RBC and OBU into the GSM-R transport system. Nevertheless, it can be necessary to further optimize the network to ensure proper ETCS functionality. It can be necessary under some conditions to perform additional testing in this phase, e.g. in view of forthcoming railway operation.

Phase 3 is related to a deployed ERTMS solution in which both GSM-R and ETCS L2/L3 are operational.

Therefore, the extent of each testing phase and its purpose is a decision of the national projects. As already indicated, Phases 2 and 3 are not covered in this document, but some guidelines can be found in clause 5.1

2.3.2 Phase 1 Test Plan

The combination of test scenarios/measurements is a matter of the test plan. It is recommended to use the same conditions for testing as expected for ETCS operation.

The test plan should cover items such as, for example:

- Length of track;
- Direction of test trips;
- Speed;
- Location/drive test requirements for specific tests (such as network registration, PS Service Setup);
- Sample size, taking into account the length of track;
- The split of the track in the corresponding "acceptance sections" of 20 and/or 100 km.
- The size of the packets for PS mode testing, (either 560 or 320 octets): if the RBC will be using packets larger than 320 octets (MA), tests are performed with 560 octets packets; otherwise, tests are performed with 320 octets packets;
- SIM card used (including its configuration regarding access to visited networks);
- Use of multiple MTs and associated antennas to perform testing (to ensure the efficiency of testing, respecting the traffic capabilities of the transport system);
- Combination of measurements when appropriate such as PS mode – service setup in a PS network together with GSM-R network registration.
- Identification of the location where a test has to be performed.

- Verification of the GPRS Attach Delay or PDP context activation when the PS Service Setup is considered.
- If simultaneous operation of ETCS application and non-ETCS application is used (in which case, the feature Packet Flow Context (PFC) shall be activated according to [EIRENE SRS]).
- GPRS/E-GPRS coding scheme(s) (static or dynamic, according to [EIRENE SRS]).
- The test reporting may consider the following items:
  - The number of samples taken or measurement duration of test runs.
  - The number of timeouts or invalid outcomes during measurements.
  - A representation of the measured data, such as: percentiles, mean, standard deviation, minimum, maximum, etc.

The compliance to RBC FQDN-to-IP Resolution Delay requirements [Subset-093] applicable to PS mode can be provided by the ETCS-DNS provider or along with the GSM-R bearer service compliance measurements.

There is a dependency between the PS traffic capabilities of the transport system of a track and the measurements in accordance to 3.10. It is assumed that adequate traffic engineering of the transport system is in place. As such, the verification of the traffic capabilities of the network is not part of this document.

In Phase 1, conditional acceptance may be envisaged for KPI measurements that do not meet the requirements. A deviation of the required KPI values for conditional acceptance (e.g. less than 10%), is to be agreed between parties. Confirmation of the conditional acceptance will be provided if during in-service monitoring (Phase 3) the expected operational performance is achieved.

2.3.3   Test Tools

Required tools are indicated in the corresponding sub-clause of clause 3.1.1 In order to obtain additional information during the test cases execution, the following complementary tools might be useful:

- Test terminal for tracking possible failure in automated test.
- Protocol analyser for tracking possible failure at the Abis interface.
- Protocol analyser for error detection at the Gb interface and for monitoring RLC/MAC sequences.
- Measurement MT for tracking possible failure of the lower protocol layers in automated measurement.
- For the reason of simultaneous operation of ETCS and non-ETCS application in the network, the measurement tool could be used to generate TCP traffic (e.g. continuous TCP stream) applicable to non-ETCS application users.

3 ACCEPTANCE TEST SPECIFICATION FOR PHASE 1

3.1 CS mode - Connection Establishment Delay

3.1.1 Definition

Connection Establishment Delay (CED) is defined as the value of the elapsed time between the connection establishment request and the indication of successful connection establishment (see Table **1**: 4.3-1).

3.1.2 Pre-conditions for measurement

- Measurement reference points are I_{GSM-R} and I_{FIX-CS}. I_{GSM-R} is the reference point to gather measurement data.
- Only MSISDN numbers shall be used when performing this test.
- The Mobile Termination is registered to the GSM-R network under test and is in idle mode.
- The measurement can be done stationary since there is no significant expected impact on the KPI due to the train movement.

3.1.3 For measurement

- At I_{GSM-R}, the elapsed time between the delivery of the corresponding ATD command to the MT and the successful connection establishment by CONNECT indication shall be captured at I_{GSM-R}.
- Transmission of data in both directions.
- The recovery time between consecutive call attempts (from the release of the last call to the next call attempt) shall be at least 6 seconds to ensure successful measurement.

The CED is calculated as the time difference between the delivery of the corresponding ATD command to the MT and the corresponding CONNECT indication.

If data communication is not possible in one or both directions after receiving connection establishment indication CONNECT, the attempt shall be evaluated as not successful (logged as a value of CED>10 s).

3.1.4 Required tools

- Test application(s) for answering the incoming call and for the control of Mobile Termination, measurement of elapsed time and automation (scripting).
- Positioning information (e.g. GPS).

3.2   Deleted

3.3   CS mode - Connection Loss Rate

3.3.1   Definition

Connection Loss Rate (CLR) is defined as the number of connections released unintentionally per total accumulated connection time (see Table **1**: 4.3-1).

3.3.2   Pre-conditions for measurement

- Measurement reference points are I_{GSM-R} and I_{FIX-CS}. I_{GSM-R} is the reference point to gather measurement data.
- The cumulated time of a CS mode connection refers to the end-to-end data transmission phase excluding the successful connection establishment time. The Connection Establishment Delay (see clause 3.1) shall be deducted from the entire time (delay to be deducted is between the message ATD and the message CONNECT, coming both from the MT).
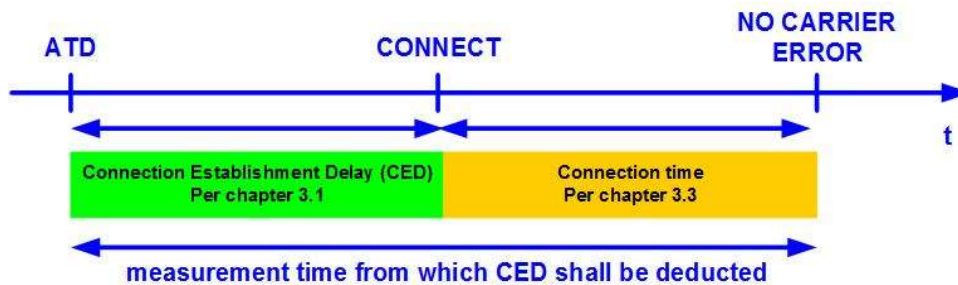
Figure 4: 3.3.2-1 - Cumulated time for a CS mode connection

- The minimum duration of a CS mode connection shall be at least 15 seconds.
- The test results are only concerning number of losses over the total observation time.
- The number of established calls and the resulting connection duration are aggregated to the total observation time to reach the required confidence level.

3.3.3   For measurement

At $I_{GSM-R,}$ if one of the following events is unexpectedly detected, a connection loss is assumed and counted:

- Indication of ERROR. (Note1)
- Indication of NO CARRIER. (Note2)
- When the receiving side on either end (I_{GSM-R} or I_{FIX-CS}) is not receiving data for more than 10 seconds. (Note3)

Note 1: The first occurrence of such event whichever comes first is sufficient to assume a connection loss.

Note 2: A combination of these events occurring in sequence before starting connection re-establishment is counted as only one connection loss.

Note 3: This condition is related to HDLC behaviour for which the connection is terminated if no data transmission is possible for more than 10 seconds.

The single connection duration for this connection established shall be accumulated to the total connection duration. The confidence level of CLR measurements may be further increased by obtaining network statistics on connection losses during operation. See clause 5.1

The CLR is calculated as the ratio between the number of connections released unintentionally and the total accumulated connection time.

3.3.4 Required tools

- Test application(s) for answering the incoming call and for control of terminal, measurement of number of connections unexpectedly released, connection time and automation (scripting).
- Positioning information (e.g. GPS).

3.4 CS mode - Transfer Delay of user data frame

3.4.1 Definition

Transfer Delay (TD) is defined as the elapsed time between the request for transfer of a test data frame until the indication of the successful test data frame reception (see Table **1**: 4.3-1).

3.4.2 Pre-conditions for measurement

- Measurement reference points are I_{GSM-R} and I_{FIX-CS}. I_{GSM-R} is the reference point to gather measurement data.
- The length of a test data frame shall be in accordance with 3.5.3.
- The fixed side application is responsible for replying back to all incoming data frames to the sender.
- The response time of the test application shall be considered as negligible or measured and subtracted from the round-trip transfer delay.
- The measurement can be done stationary since there is no significant expected impact on the KPI due to the train movement.

3.4.3 For measurement

- The round-trip delay including the processing delay of the answering station is measured.
- Only test data frames received with a correct CRC check sum shall be evaluated.

The TD is calculated as the round-trip delay to which the processing delay of the answering station is subtracted (if not negligible) divided by 2.

3.4.4 Required tools

- Test application(s) for answering the incoming call and for control of terminal, measurement of elapsed time and automation (scripting).
- Positioning information (e.g. GPS).

3.5 CS mode – MA Transmission Violation Rate

3.5.1 Definition

The MA Transmission Violation Rate is defined as the number of MA Transmission Violations during the measurement time (See Table **1**: 4.3-1).

An MA Transmission Violation occurs when a sent MA message is not received within 12 s.

3.5.2 Pre-conditions for measurement

- Measurement reference points are I_{GSM-R} and I_{FIX-CS} to gather measurement data. The connection is successfully established.
- The measurement shall be done without use of HDLC.

3.5.3 For measurement

The reference is based on an MA message consisting of 250 octets, which is transmitted every 20 seconds.

The purpose of this KPI is to test the bearer service performance by exchanging test frames independent for both directions of transmission, UL and DL, across the GSM-R subsystem. For this reason, some auxiliary parameters are used to compute the fulfillment of this KPI that are described as follows.

Test Frame: A test frame as per definition consists of 28 octets encompassing following sub-parts:

- [Start flag] octet to indicate the start of the frame (1 octet).
- [Data Payload] of 24 octets encompassing:
  - [**sequence number**] having a length of 2 octets to mark the frame.
  - [**User Payload**] content is an implementation choice.
- [CRC-16] checksum having a length of 2 octets to detect valid data frames on the receiving application.
- [End flag] octet to indicate the end of the frame (1 octet).

Note 1: The User Payload can contain same characters as used for the start/end flag. For uniqueness reasons such repetition in the frame content requires a specific designation by a quotation mark, i.e. ESC character, which is appended in front of the repeated character. Once the quotation mark is used its repetition needs to be detected and marked again, e.g. by negation. At the time, one quotation mark is required for the start/end flag and for the ESC character (reserved characters). After quoting, the user payload gets reduced, if necessary, to 24 octets by deleting the super numerous octet(s).

Note 2: The CRC-16 checksum can contain reserved characters. To avoid different length of frames, the reserved characters in the checksum gets negated. Furthermore, it is assumed that the lower detection rate of bit errors is acceptable.

A **TI (Transmission Interference)** starts with an erroneous test frame and it ends with the last erroneous test frame within an observation period of 15 test frames which corresponds to 1 second (*Note 3*).

Note 3: Considering the start bit and the stop bit of each octet, an entire test frame will result to 280 bits having test frame duration of 58.3 ms with a data bearer of 4800 bits/s. Considering this, it results in a rate of 1 frame every 66.7 ms, including an average guard time of about 8 ms.

A **Transmission Recovery (TR)** starts after each **TI** and ends just before the next erroneous test frame.

Every **TR** monitoring period, starting after each **TI**, consists of 165 frames (11*15 test frames or approximately 11 s) and is defined as **Transmission Recovery Extended Time (T_{REC_ext})** (examples are in § 6.2.3).

TR monitoring ends if at least 105 continuous non-erroneous frames (7*15 test frames or approximately 7s) are found. This time is defined as **Transmission Recovery Time (T_{REC})** (examples are in § 6.2.3).

A **Movement Authority Transmission Violation** is assumed if more than one TI occurs during T_{REC_ext} and T_{REC} is not respected (examples are in § 6.2.4).
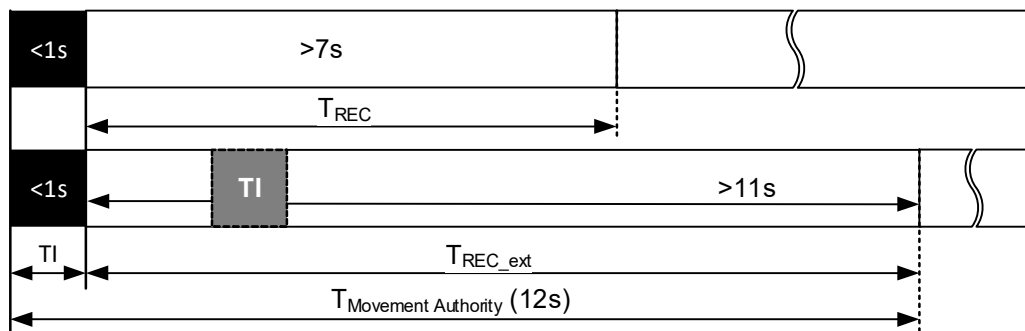
Figure 5: 3.5.3-1 - Relation between T_{REC} and $T_{REC\ extended}$

At least the frame numbers of the error-free received test frames (having a valid CRC) shall be captured during the measurement because the frame number has a direct relation with the transmission time.

TI, T_{REC} and T_{REC_ext} are necessary in order to derive the rate and are obtained from the analysis of the measured data.

Detailed examples and figures of TI, T_{REC} and T_{REC_ext} can be obtained from clause 6.2.

For the acceptance of the GSM-R transport system applicable for the successful transport of ETCS message, i.e. Movement Authority, the following relationship applies in accordance with [Subset-093]:

$$\text{MA Transmission Violation Rate} = \frac{n}{t_{meas}}$$

"n" is the number of Movement Authority transmission violations during the measurement period t_{meas}

3.5.4 Required tools

- Test application(s) for answering the incoming call and for control of Mobile Termination, measurement of transmission interferences and automation (scripting).
- Test application capable of transmitting and receiving a data stream.
- Positioning information (e.g. GPS).

3.6 GSM-R Network Registration Delay

3.6.1 Definition

GSM-R Network Registration Delay (NRD) is the elapsed time between the registration request +COPS=1,2,"<network2select>" and the indication of successful registration onto GSM-R network CS-domain "+CREG: 1" or "+CREG: 5" (see Table **1**: 4.3-1).

3.6.2 Pre-conditions for measurement

- Measurement reference point is I_{GSM-R} to gather measurement data.
- The measurement can be done stationary since there is no significant expected impact on the KPI due to the train movement.

3.6.3 For measurement

- The test sequence starts with a registration using manual mode on a forbidden Mobile network (e.g. GSM Public) followed by registration in manual mode to the GSM-R network under test.
- At I_{GSM-R}, the elapsed time between the delivery of the command +COPS=1,2,"<network2select>" and the result "+CREG: 1" or "+CREG: 5".

  Note: The result +CREG:1 is only applicable on home GSM-R network and +CREG:5 for a visited (roaming) network, if included in the test plan.

The NRD is calculated as the time difference between the command +COPS=1,2, "<network2select>" and its result.

  Note: An example of command script sequence is proposed in Appendix C,Command scripts for testing purposes (informative)

3.6.4 Required tools

- Test application for control of Mobile Termination, measurement of elapsed time and automation (scripting).
- Positioning information (e.g. GPS).

3.7 PS mode – PS Service Setup

3.7.1 Definition

PS Service Setup (PS-SS) is defined as the elapsed time between the registration request "+COPS=1,2, network2select" and the indication of the reception of the result code "OK" as the response to PDP context activation order +CGACT? →CGACT: <cid>,<state>; state=activated (see Table **1**: 4.3-1).

The PS Service Setup test reflects several operational scenarios, e.g. "Start of Mission". Hence, the following test sequence provides the information about the time required between GSM-R network registration and the PS bearer availability of the packet data network associated to ETCS entities. Following sub test-sequences constitutes the entire test scenario in the following order:

1. Network registration according to clause 3.6.
2. GPRS Attach according to clause3.8.
3. PDP Context activation according to clause 3.9.

Each sub-sequence test has to be succeeded before the next sub-sequence test starts.

3.7.2 Pre-conditions for measurement

- Measurement reference points are I$_{GPRS}$ and I$_{FIX-PS}$. I$_{GPRS}$ is the reference point to gather measurement data.
- The ETCS APN has been provisioned to the applicable test subscriber profile taking into account the QoS profile as specified by [ER FFFIS].
- "Automatic attachment according to [TS 103 368] shall be disabled. The command "+RCGATT=0" shall be applied."
- This test is applicable to locations where the ETCS mission starts or will be continued by another ETCS controlling entity e.g. when crossing the border.
- GSM-R network deregistration is required prior the execution of each PS Service Setup (PDP context deactivation and GPRS Detach are implicit).
- The measurement can be done stationary since there is no significant expected impact on the KPI due to the train movement.

3.7.3 For measurement

- The test sequence shall always begin using a manual registration to a forbidden Mobile network (e.g. GSM Public) Mobile network that prevents roaming access.
- The result to the GPRS attach is: "+CGREG: 1" / "+CGREG: 5". *(Note 1).*
- GPRS Attach, PDP context activation, QoS and APN settings shall be ordered by the Terminal Equipment.
- For the QoS settings, traffic class "Streaming" shall be applied while the other settings e.g. GBR DL remains as subscribed. The following command and settings are applicable: "+CGEQREQ=1,1".

- For the APN, the following command and settings are applicable: "+CGDCONT=1,"IP","ETCS",,, ".
- To activate the PDP context, the following command and settings are applicable: "+CGACT=1,1".
- To establish the communication between the TE and the GSM-R network, the command "+CGDATA="PPP",1" shall be used. The communication is established when the TE receives the indication "CONNECT".
- Necessary underlying TE-MT protocol establishment and control settings i.e. PPP shall be applied according to [ER FFFIS].

Note 1: The result +CREG:1 is only applicable on home GSM-R network and +CREG:5 for a visited (roaming) network, if included in the test plan.

The PS-SS is calculated as the time difference between the registration request +COPS=1,2,"<network2select>" and the indication of the successful establishment of the PDP context.

After PDP context activation, the access to the ETCS network elements shall be verified by using a short bidirectional data sequence (< 10 sec) (e.g. DNS query).

If data communication is not possible in one or both directions, the corresponding measurement sample has to be evaluated as not successful (logged as a value of PS-SS >40 s).

Note: An example of command script sequence is proposed in Appendix C,Command scripts for testing purposes (informative).

3.7.4 Required tools

- Test application for control of Mobile Termination, measurement of elapsed time and automation (scripting).
- Positioning information (e.g. GPS).

3.8 PS mode - GPRS Attach Delay

3.8.1 Definition

GPRS Attach Delay (GPRS-AD) is the elapsed time between the GPRS Attach request "+CGATT=1" and the indication of successful registration onto the GSM-R network PS-domain "+CGREG: 1" (see Table **2**: 4.3-2).

3.8.2 Pre-conditions for measurement

- Measurement reference point is I$_{GPRS}$ to gather measurement data.
- The ETCS APN has been provisioned to the applicable test subscriber profile taking into account the QoS profile as specified by [ER FFFIS].
- Automatic attachment according to [TS 103 368] shall be disabled. The command "+RCGATT=0" shall be applied.
- The Mobile Termination is already registered to the GSM-R CS-domain of the network under test.

- This test is applicable to locations where the ETCS mission starts or will be continued by another ETCS controlling entity supporting PS.
- The measurement can be done stationary since there is no significant expected impact on the KPI due to the train movement.

3.8.3 For measurement

- The measurement is done at I_{GPRS}.

The GPRS-AD is calculated as the time difference between the order of the command "+CGATT=1" and the result " +CGREG:1".

Note: An example of command script sequence is proposed in Appendix C, Command scripts for testing purposes (informative).

3.8.4 Required tools

- Test application for control of Mobile Termination, measurement of elapsed time and automation (scripting).
- Positioning information (e.g. GPS).

3.9 PS mode – PDP Context Activation Delay

3.9.1 Definition

PDP Context Activation Delay (PDP-CAD) is the elapsed time between PDP Context Activation request "+CGACT=1" and the reception of the result code "OK" as the response to PDP context activation order +CGACT? →CGACT: <cid>,<state>; state=activated (see Table **2**: 4.3-2).

3.9.2 Pre-conditions for measurement

- Measurement reference points are I_{GPRS} and I_{FIX-PS}. I_{GPRS} is the reference point to gather measurement data.
- The Mobile Termination is already registered to the GSM-R CS-domain and PS-domain (i.e. is attached to GPRS) of the network under test.
- The ETCS APN has been provisioned to the applicable test subscriber profile taking into account the QoS profile as specified by [ER FFFIS].
- For the QoS settings, traffic class "Streaming" shall be applied while the other settings e.g. GBR DL remain as subscribed. The following command is used: "+CGEQREQ=1,1".
- For the APN, the following command and settings are applicable: "+CGDCONT=1,"IP","ETCS",,, ".
- The measurement can be done stationary since there is no significant expected impact on the KPI due to the train movement.

3.9.3 For measurement

- At I_{GPRS}, the elapsed time between the order of the command "+CGACT=1" and the reception of the result code "OK" as the response to PDP context activation order.

- Optionally, to establish the communication between the TE and the network, the command "+CGDATA="PPP",1" shall be used. The communication is established when the TE receives the response "Connect". *(Note 1)*
- Necessary underlying TE-MT protocol establishment and control settings i.e. PPP shall be applied according to [ER FFFIS].

The PDP-CAD is calculated as the time difference between the PDP Context Activation request and the successful establishment of the PDP context.

After PDP context activation, the access to the ETCS network elements shall be verified by using a short bidirectional data sequence (< 10 sec) (e.g. DNS query).

If data communication is not possible in one or both directions, the corresponding measurement sample has to be evaluated as not successful (logged as a value of PDP-CAD >3s).

Note 1: An example of command script sequence is proposed in Appendix C,Command scripts for testing purposes (informative).

3.9.4 Required tools

- Test application for control of Mobile Termination, measurement of elapsed time and automation (scripting).
- Positioning information (e.g. GPS).

3.10 PS mode – Transaction Transfer Delay

3.10.1 Definition

The IP based Transaction Transfer Delay is defined as:

Value of elapsed time from the request to send an IP packet that comprises all the header information at the reference point I_{GPRS}/I_{FIX_PS} of the transmitting entity to the indication of the acknowledging IP packet at the same reference point (see Figure 6: 3.10.1-1).The measurement always takes into account train borne (OBU) as well as trackside (RBC) initiated IP data transfer as indicated in Figure 6: 3.10.1-1 (see Table **2**: 4.3-2).
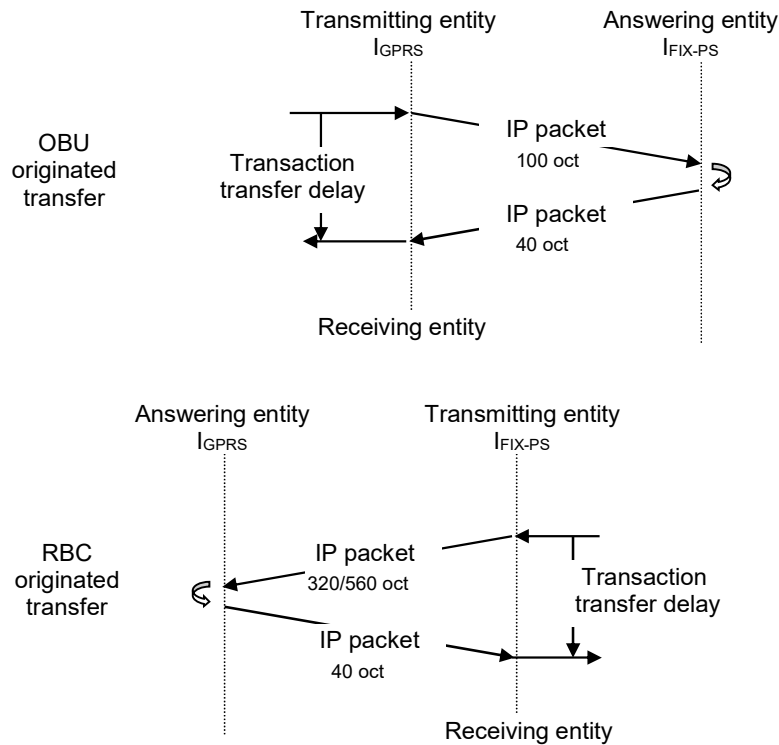
Figure 6: 3.10.1-1 - Transaction Transfer Delay

The transport protocol UDP shall be used for testing. Other transport protocols are excluded.

A test IP packet consists of an IP header, a transport protocol UDP header and the resulting amount of user data to constitute the desired IP packet size according to [Subset-093]. The number of transport protocol octets and the number of IP protocol octets are the following (see Figure 7: 3.10.1-2):

UDP: 8 octets

IPv4 protocol without options: 20 octets
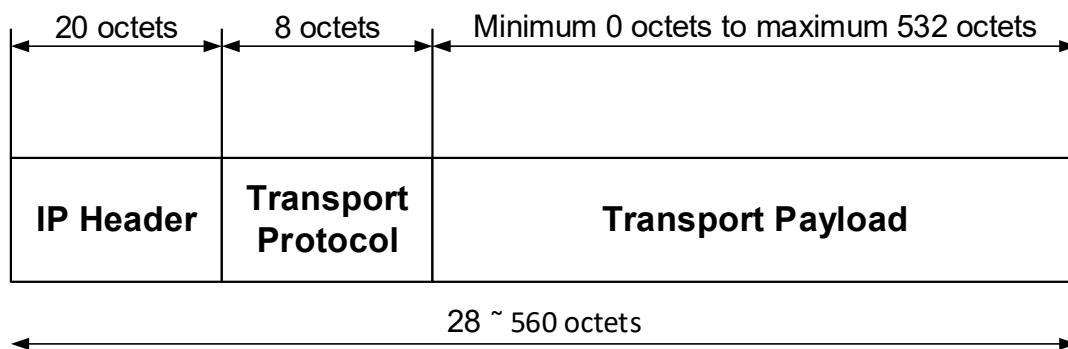
Figure 7: 3.10.1-2 - Test IP packet composition

The response test data packet has the following format:

- UDP: IP header (20 octets) + UDP header (8 octets) + payload (0 to 532 octets).

According to [Subset-093], the following test sequences and the corresponding test data packet sizes are applicable:

OBU originated transaction transfer: 100 octets originating test data packet, 40 octets response test data packet.

RBC originating transaction transfer: 320 octets originating test data packet, 40 octets response test data packet.

If larger packets than 320 octets are used by the ETCS application *(Note)*:

560 octets originating test data packet,

40 octets response test data packet.

Note: To be captured in the test plan.

3.10.2 Pre-conditions for measurement

- Measurement reference points are I_{GPRS} and I_{FIX-PS} to gather measurement data.
- The ETCS APN has been provisioned to the applicable test subscriber profile taking into account the QoS profile as specified by [ER FFFIS].
- The Mobile Termination is already registered to the GSM-R CS-domain and PS-domain (i.e. GPRS attached and PDP context activated) of the network under test.
- Necessary underlying TE-MT protocol establishment and control settings i.e. PPP shall be applied according to [ER FFFIS].
- The speed of the serial baud rate shall be according to the [ER FFFIS].
- To establish the communication between the TE and the GSM-R network, the command "+CGDATA="PPP",1" shall be used. The communication is established when the TE receives the indication "Connect".
- Connection between track and train side application is established.
- Prior to the measurement, QoS and APN settings for ETCS shall be ordered by the Terminal Equipment(s).
  - o The ETCS APN has been provisioned to the applicable ETCS test subscriber profile taking into account the QoS profile as specified by [ER FFFIS].
  - o For ETCS test application, the QoS settings traffic class "Streaming" shall be applied while the other settings e.g. GBR DL remains as subscribed. Following command and settings are applicable: "+CGEQREQ=1,1".
  - o For the APN following command and the corresponding settings are applicable: "+CGDCONT=1,"IP","ETCS",,, ".
- If simultaneous operation of ETCS application and non-ETCS application is applicable, the feature Packet Flow Context (PFC) shall be applied according to [EIRENE SRS].

- o If the operation of non-ETCS application is applicable, a dedicated APN shall be provided for these kind of applications concatenated to a QoS profile which is according to [EIRENE SRS].
- o For non-ETCS test application, the subscribed QoS settings remains unchanged – no modification by using the command "+CGEQREQ" is required.
- o For the APN following command and the corresponding settings are applicable: "+CGDCONT=1,"IP","<applicable APN>",,, ".
- o The PDP context for the non-ETCS test application shall be established prior transaction transfer delay measurements starts. The command +CGACT=1 applies.

- The Transaction Transfer Delay test needs to be performed according to the coding scheme(s) defined in the test plan.

- A response time (i.e. <100ms) of the test application shall be considered as negligible or measured and afterwards subtracted from the round trip transfer delay.

- A dedicated MT shall be used for the non-ETCS test application.

- The answering entity shall allow the processing of the incoming packets of a particular test user e.g. IP address etc.

3.10.3 For measurement

- A relation between the messages between the two test entities (OBU and RBC emulators) has to be established to allow the measurement.

- OBU originated and RBC originated transaction transfer sequences can be tested standalone or in a joint approach, but each transaction transfer sequence shall be analysed autonomously.

- If the reception of the originating test IP packet is erroneous, it shall be considered as not successful.

- A transaction is considered as completed if the response test IP packet indicates the successful transmission of the originating test IP data packet.

- The test application originating entity at the measurement reference point I_{GPRS} / I_{FIX-PS} sends the test IP packet to the answering entity.

- After successful reception of the test data packet, the answering entity will send back a response test IP packet indicating the error free or erroneous transmission of the originating IP data packet. A transaction always comprises a single originating test data packet and corresponding response IP data packet.

- The resulting Transaction Transfer Delay time comprises the transfer delay of the originating and response test IP data packet.

- It is recommended that the time gap between consecutive test sequences (time between two transactions) is set to 4 seconds.

- It is recommended to perform the measurements of the UL and DL transactions independently.

The TTD is calculated as the time difference between the request to send an IP packet (comprising all the header information) at the reference point I_{GPRS}/I_{FIX_PS} of the

transmitting entity and the indication of the acknowledging IP packet at the same reference point.

3.10.4 Required tools

- End to End measurement application for control of terminal, measurement of elapsed time and automation (scripting).
- The measurement tool shall emulate the transaction sequences encompassing the applicable test IP data packets as specified by [Subset-093]. In addition, the measurement tool shall automatically encapsulate the test IP data packets by following additional layers in the listed order as follows:
  o Transport Protocol (UDP).
  o Internet Protocol version 4.
- Positioning information (e.g. GPS).

3.11 PS mode – ETCS-DNS Lookup Delay

3.11.1 Definition

The ETCS-DNS Lookup Delay (EDLD, RBC FQDN-to-IP Resolution Delay) is the value of elapsed time from the request to query a Domain Name System resolution including one RBC-FQDN until the response of the applicable RBC IP-address (See Table **2**: 4.3-2).
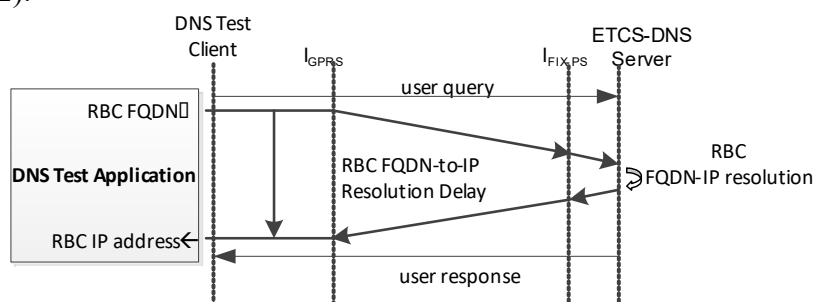
Figure 8: 3.11.1-1RBC FQDN-to-IP resolution flow

A Domain Name System (DNS) is used to provide the mapping between RBC-FQDN and the applicable RBC-IP address. The ETCS-DNS server is the repository of information that makes up the ETCS domain name database.

The DNS test application entity at the measurement reference point I_{GPRS} forwards the DNS user query including the applicable RBC FQDN. The ETCS-DNS server will resolve the RBC-FQDN into the applicable RBC-IP address which is part of the user response back to the DNS test application.

A transaction always comprises a single DNS user query and its corresponding response. The resulting DNS Transaction Transfer Delay time comprises the transfer delay of the DNS user query, the processing delay of the ETCS-DNS server to resolve the RBC-FQDN to RBC-IP address and the DNS user response.

A DNS transaction is completed if the DNS user response contains the applicable RBC IP address.

3.11.2 Pre-conditions for measurement

- Measurement reference points are I_{GPRS} and I_{FIX-PS}. I_{GPRS} is the reference point to gather measurement data.
- The ETCS APN has been provisioned to the applicable test subscriber profile taking into account the QoS profile as specified by [ER FFFIS].
- A PS connection between track and train side application is established.
- For the composition of an RBC - Full Qualified Domain Name (FQDN) [Subset-037] shall be applied.
- Necessary DNS system definitions for ETCS purposes shall be applied according to [Subset-037] and [ER FFFIS].
- The definition of the applicable local "ETCS-DNS zone data" is not a subject of this test instruction.
- The Mobile Termination under test shall have an active PDP context to the ETCS APN. The PDP context activation response message includes the applicable ETCS-DNS server IP address to be used for the DNS test application.
- The communication between the TE and the GSM-R network "+CGDATA="PPP",1" has been established.
- The measurement can be done stationary since there is no significant expected impact on the KPI due to the train movement.

3.11.3 For measurement

- During measurement execution, the DNS Server caching should be turned off.
- The elapsed time between DNS user query and response messages shall be measured.

The EDLD is calculated as the time difference between the request to query the ETCS-DNS on a Domain Name System resolution including one RBC-FQDN and the response of the applicable RBC IP-address

3.11.4 Required tools

- End-to-End DNS measurement application for control of the terminal, measurement of elapsed time and automation (scripting).
- Positioning information (e.g. GPS).

4 PHASE 1: SUMMARY OF ETCS QOS REQUIREMENTS FOR ACCEPTANCE

4.1 General

This clause recommends sample sizes for ETCS QoS requirements acceptance in Phase 1.

[Subset-093] requirements specify the quality of the communication system to be fulfilled.

The validation procedures for the requirements and the statistical approach are described in *Appendix D*, Statistical approach for ETCS QoS requirements validation.

4.2 Background

ETCS QoS performance indicators differ on statistical characteristics and their corresponding target values and related sample sizes. The choice for a particular sample size is, to a large extent, arbitrary and is a compromise between costs (time and effort to perform validation tests) and precision (reproducibility and confidence level).

ETCS QoS performance indicators parameters can be subdivided into two categories. Each category requires a specific statistical approach to determine the minimum necessary sample size for each performance indicator.

These categories are:

Delay sensitive KPIs:
Connection Establishment Delay (**CED**),
Transfer Delay (**TD**),
Network Registration Delay (**NRD**),
PS mode Service Setup (**PS-SS**),
GPRS Attach Delay (GPRS-**AD**),
PDP Context Activation Delay (PDP-**CAD**),
ETCS-DNS Lookup Delay (EDLD),
Transaction Transfer Delay (**TTD**)

Note: A timeout limit for the measurements needs to be at least 2 times higher than the required value under measurement.

Rate sensitive KPIs:
Connection Loss Rate (**CLR**),
MA Transmission Violation Rate (**MATVR**),

4.3 Summary of KPI validation in Phase 1

Table **1**: 4.3-1 provides the overview of the ETCS QoS performance indicators applicable for CS mode. It lists the values stated in [Subset 093], the category of the indicator and the validation procedure at Phase 1, taking into account the length of the track, the speed of the vehicle used for testing and the distance between contiguous samples. Based on different calculations (*Appendix D*, Statistical approach for ETCS QoS requirements validation), for the rate sensitive indicators, a sample size based on measurement time (dependent on the track length) is indicated as recommendation for the validation process in order to ensure a determined confidence level.

ETCS QoS Performance indicator parameter	Requirement (Subset-093)	Category	Track length dependency (Yes/No)	Validation procedure at Phase 1 Minimum recommended sample size (Note 6)
Connection Establishment Delay (CED) of Mobile Originated Calls (Note 1)	≤10s (99%)	Delay sensitive	No	Criteria: Requirement successfully validated if the 99th-percentile of the samples values are less than 10s. Measurement can be done stationary, at relevant locations (according to the test plan). 100 samples
Connection Loss Rate (CLR) (Note 4)	$\leq 10^{-2}$/h	Rate sensitive	Yes	Criteria: Requirement successfully validated if no connection loss occurs within the test duration to validate the MATVR.. (Note 7) (Note 8) Measurement to be done in a non-stationary environment (during drive test).
Transfer Delay (TD) (Note 2)	≤0.5s (99%)	Delay sensitive	No	Criteria: Requirement successfully validated if the 99th-percentile of the samples values are equal or less than 0.5s Measurement can be done stationary. 100 samples
MA Transmission Violation Rate (Note 5)	$\leq 10^{-2}$/h	Rate sensitive	Yes	[Refer to 6.4.4.4.2 for MA factor description, clause.6.2: 300h*MA factor With MA factor = 1/20, 15h]; Criteria: With a minimum distance between samples of 10 meters, considering a probability of 99,9% for reception of MA : the number of tolerated violations and the recommended duration of the test for validation is: For a section length of 100 km: 15 hours test duration (with 54 tolerated violations in total as a maximum); For a section length of 20 km: 5 hours test duration (with 18 tolerated violations in total as a maximum) (Note 5) (Note 7) (Note 9) Measurement to be done in a non-stationary environment (during drive test).
Network Registration Delay (NRD) (Note 3)	≤35s (99%)	Delay sensitive	No	Criteria: Requirement successfully validated if the 99th-percentile of the samples values are equal or less than 35 s. Measurement can be done stationary at relevant locations (according to the test plan). 100 samples

Table 1: 4.3-1 - Recommended sample size for CS mode measurement with the objective of network - acceptance (Phase 1)

Note 1: For CED a sample or event is defined as a call set up (attempt).

Note 2: For TD a sample or event is defined as the transmission/reception of a data frame.

Note 3: For NRD a sample or event is defined as a network registration session as described in clause 6.3 (Appendix C,Command scripts for testing purposes (informative).

Note 4: For CLR, the sample size is expressed as the duration of the measurement.

Note 5: A decision has been taken by the EU Agency for Railways to set the recommended acceptance value to 99.9% as explained in 6.4.2.3 Considerations for validation of MATVR.

Note 6: In this table, sample sizes are calculated for a specific confidence level. Decreasing the confidence level typically results in a smaller sample size (and hence in a reduction of measurement time and costs).

Note 7: The values in the table correspond to a confidence level recommended for Phase 1. To increase the confidence level, additional number of samples need to be collected; this is recommended for Phase 3 (during ETCS operation).

Note 8: According to clause 6.4.2.3   Considerations for validation of MATVR.

Note 9: definition according to clause 6.4.3.3   Line length consideration for acceptance in Phase 1

Table **2**: 4.3-2 provides the overview of ETCS QoS performance indicators applicable for PS mode. It lists requirements and the recommended minimum required sample sizes.

ETCS QoS Performance Indicator parameter	Requirement [Subset-093]	Category	Track length dependency (Yes/No)	Validation procedure at Phase 1 Minimum recommended sample size (Note 4)
PS Service Setup (PS-SS)	≤ 35s (99%),	Delay sensitive	No	Criteria: Requirement successfully validated if the 99th-percentile of the samples values are equal or less than 35 s. Measurement can be done stationary at relevant locations (according to the test plan). 100 samples
GPRS Attach Delay (GPRS-AD) [Note 1]	≤ 5s (99%)	Delay sensitive	No	Criteria: Requirement successfully validated if the 99th-percentile of the samples values are equal or less than 5 s. Measurement can be done stationary at relevant locations (according to the test plan). 100 samples
PDP-Context Activation Delay (PDP-CAD) [Note 1]	≤ 3s (99%)	Delay sensitive	No	Criteria: Requirement successfully validated if the 99th-percentile of the samples values are equal or less than 3 s. Measurement can be done stationary at relevant locations (according to the test plan). 100 samples
Transaction Transfer Delay (TTD)	a) Mobile originated (OBU), 100 octets: ≤ 2.6s (99%) b) Mobile terminated (RBC), 320 octets: ≤ 3.0s (99%), OR Mobile terminated (RBC), 560 octets: ≤ 3.5s (99%)	Delay sensitive	Yes	Criteria: Requirement successfully validated if the 99th-percentile of the samples values are -for mobile originated (100 octets), equal or less than 2.6s; - for mobile terminated: (320octets), equal or less than 3.0s; or (560 octets) is equal or less than 3.5 s. Minimum of 1 sample per 40 meters for each type of transaction. (Note 3). It is recommended to measure TTD with the same number of runs/test duration as those applicable for MATVR, starting a transaction every 4 seconds This means for the number of samples and duration of the test: - For a section length of 100 km: 15 hours test duration (resulting into 1 sample per 7,4 meters); - For a section length of 20 km: 5 hours test duration (resulting into 1 sample per 4,4 meters). Measurement has to be done in a non-stationary environment (during drive test). (Note 5)
ETCS-DNS Lookup Delay (EDLD) (Note 2)	≤ 3s (99%)	Delay sensitive	No	Criteria: Requirement is successfully validated if the 99th-percentile of the samples values are equal or less than 3s; Measurement can be done stationary; 100 samples

Table 2: 4.3-2 - Recommended sample size for PS mode measurement with the objective of network acceptance (Phase 1

Note 1: The dedicated verification of this performance indicator should not be necessary if the PS Service Setup has been considered (refer to the test plan).

Note 2: The verification of this performance indicator may be the responsibility of the ETCS DNS provider.

Note 3: For the measurement, a transaction starts every 4 seconds, to be done for each type (mobile originated / mobile terminated). This is a delay sensitive KPI, and there is a relation with the length of the track: therefore, it should be understood that the recommendation is to take 1 sample every 40 m, since the parameter will be measured as non-stationary.

Note 4: In this annex, sample sizes are calculated for a specific confidence level. Decreasing the confidence level typically results in a smaller sample size (and hence in a reduction of measurement time and costs).

Note 5: definition according to clause 6.4.3.3   Line length consideration for acceptance in Phase 1

5 PHASE 2 AND 3 - MONITORING OF QUALITY OF SERVICE DURING OPERATION

5.1 General

This section is dedicated to Phase 2 and 3 as already mentioned in clause 2.3.1 and includes the recommended measures to increase the confidence levels as well as the continuous monitoring of the ETCS quality parameters to detect possible GSM-R transport service error conditions or transport service quality degradation.

5.2 Methodology

With the acceptance of Phase 1 resulting from the testing done using the procedures in clause 3.1, the GSM-R transport system's quality assessment is a time limited snapshot with a given confidence statement that varies with the measurement effort.

During Phase 2, the ETCS application, with the specific engineering for the track, will follow the integration testing, and it will be stabilised, correcting issues also in the communication system, if any, resulting in an ETCS application ready for service.

For the measurement methodology in Phase 3, two possible approaches can be pursued:

1.) Continuation of the snapshot method based on dedicated test drives at regular time windows. The quality of the GSM-R transport system is recorded according to the measuring method described in clause 3.1 The statement on quality remains as a time limited snapshot and could provide an improved confidence level of the individual KPIs with respects to the overall operational ETCS/GSM-R performance.

2.) Continuous quality monitoring by means of protocol interception (e.g. enabled by interface probing) in the ETCS/GSM-R network. This approach allows a targeted monitoring of the corresponding messages or transactions (e.g. the resulting global number of erroneous and non-erroneous messages/transactions) that can provide statements to the operational performance without the need of measuring the individual KPIs. This method allows the use of real ETCS user plane messages which eliminates the inclusion of the specific auxiliary parameters defined in clause 3.1 The continuous monitoring also allows an improved statement about the operational ERTMS performance.

Note: if the operational ETCS performance is as expected in Phase 3, only monitoring is required.

6   APPENDIXES

6.1   Appendix A, Clarification on Statistics (informative)

6.1.1   General

The QoS requirements may be verified up to a certain confidence level as agreed on a national or operator basis. The term confidence level is further explained below.
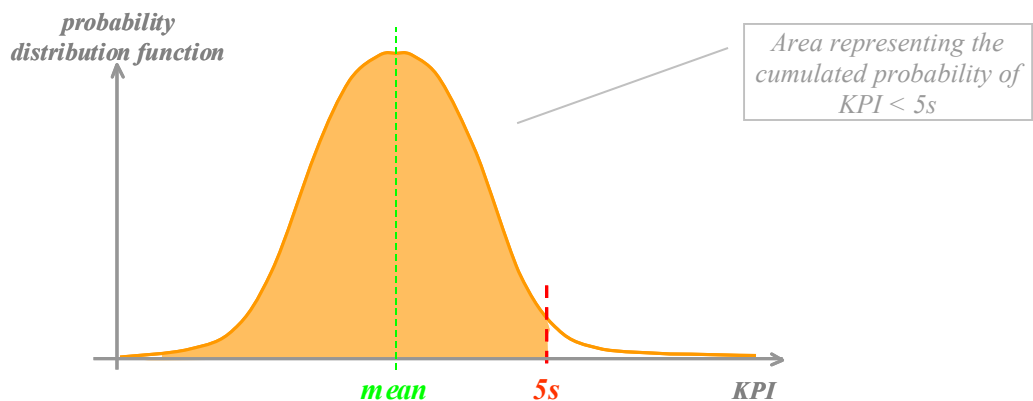
For ease of understanding, illustrations and explanations are based on the following assumption:

"t<5sec (95%) with a confidence level of 90%"

This assumption is based on a continuous set of values. Similar illustrations can be drawn on discrete set of values.

6.1.2   Quantiles

A statement t<5sec (95%) means that for the KPI to evaluate, 95% of all values are smaller than 5s.

Figure 9: 6.1.2-1- Normal Distribution - Density Function

Equivalent to the above statement is that the area under the distribution function (Figure 10: 6.1.2-2) is enclosed in the interval [0s; 5s].

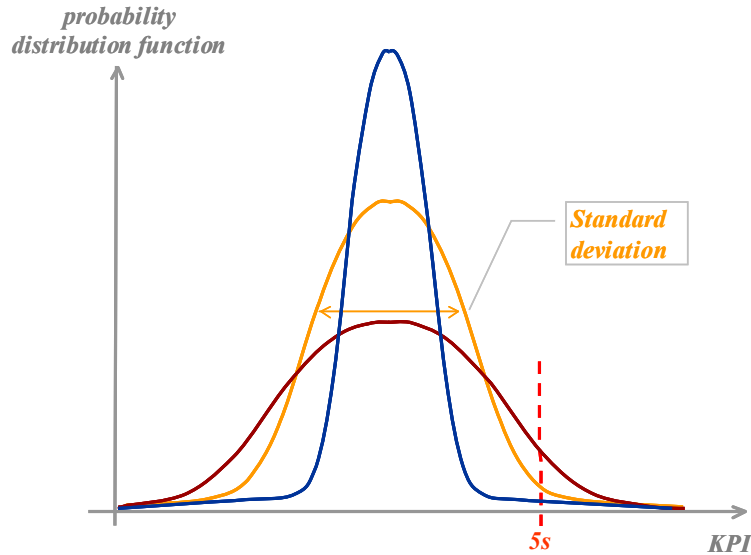The cumulated statistic is often used to visualise whether the KPI target is met.
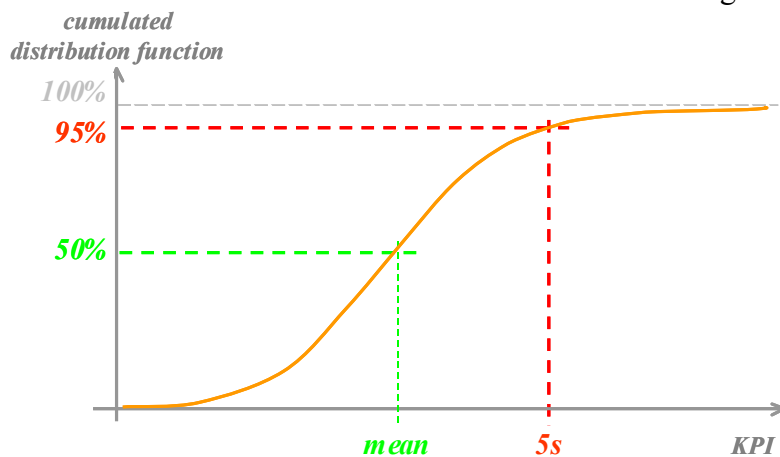
Figure 10: 6.1.2-2 - Normal Distribution – Distribution Function

Note: The mean value of the KPI can be different from the KPI target.

6.1.3 Standard deviation

The standard deviation shows the spreading of a statistical law.

Figure 11: 6.1.3-1 - Normal Distribution - Standard Deviation

Note: There is no relationship between the standard deviation, samples which are counted as "errors" and confidence intervals. The standard deviation is a property of the statistical law, whereas the confidence interval is related to measured estimations.

6.1.4 Confidence Intervals

The true probability law represents the statistical properties of the entire set of sample values that corresponds to the KPI. For practical reasons, it is only possible to collect a limited set of measurement samples. Hence, the subset's properties may differ from the true probability law.
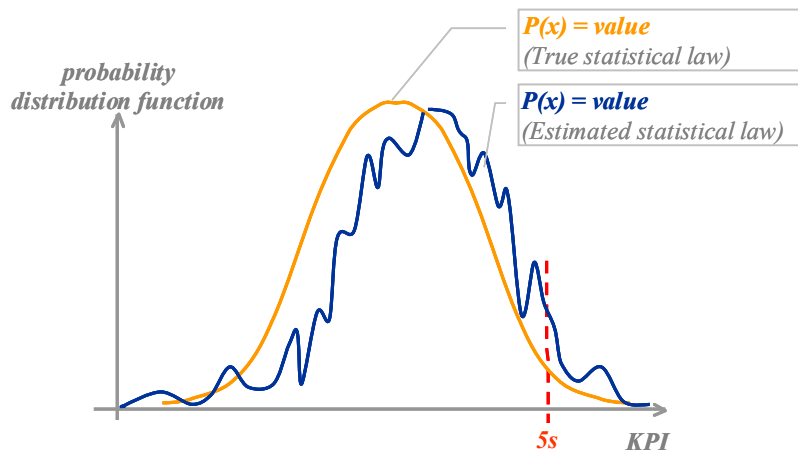
Figure 12: 6.1.4-1 - Density Function - True Probability
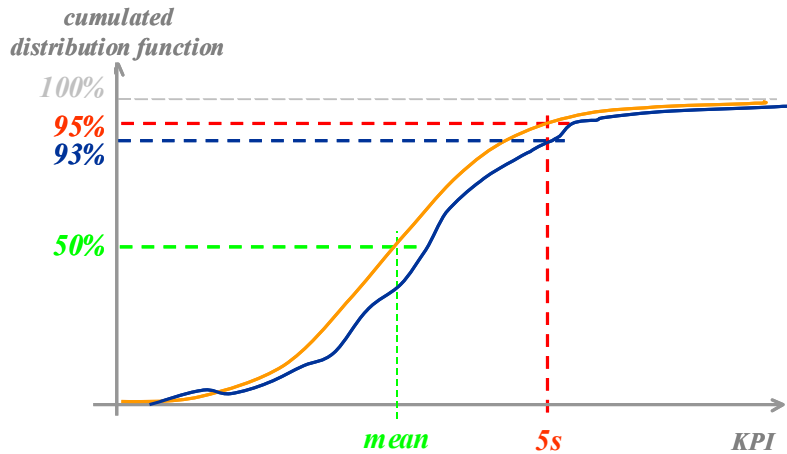
Figure 13: 6.1.4-2 - Distribution Function - True Probability

Although it is impossible to determine precisely this difference*, estimation of the probability that the subset is within x% of the true statistical can be made: it is called the confidence interval.

**) If it would be known, the true statistical law could be computed!*

Note: The larger the number of samples within the subset, the smaller the confidence interval. For the Gaussian law, as an approximation, the size of the confidence interval

decreases with $\dfrac{1}{\sqrt{number\_of\_samples}}$ *.*

This means to increase the confidence level from 90% to 99% keeping the same interval, 100 times more samples are needed! The knowledge of the confidence interval and the type of statistical law allow computing the number of samples needed. A confidence level of 90% means that there is probability of 10% to fall out of the interval [0, measured KPI for t<5s]. It does NOT mean that the "error" of the measurement sample portion is 10%.

6.1.5 One sided interval

A one-sided interval is used when it is considered that the parameter of a distribution either does not go below a lower bound value or, does not exceed an upper- bound value. In a one-sided test, the range of acceptance constitutes the area under the probability density function that is determined by either the lower or the upper tail area. This is illustrated in the following figure:
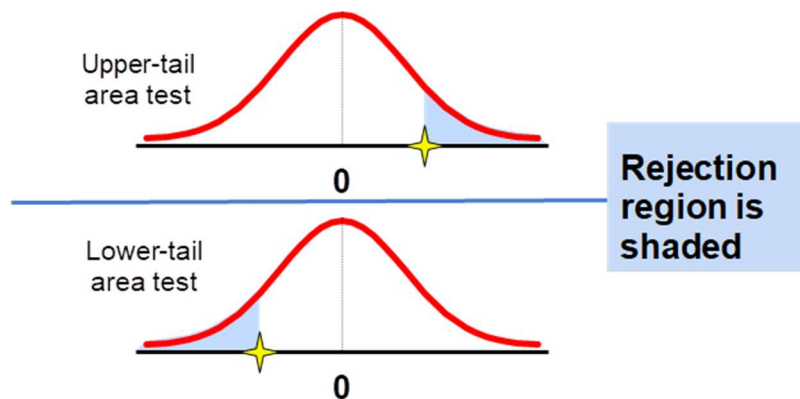

Figure 14: 6.1.5-1 - One sided interval

6.2 Appendix B, MA Transmission Violation Rate (MATVR) KPI evaluation in CS mode (informative)

6.2.1 General

This Appendix describes the different violations that can occur during the reception of test frames in accordance to clause 3.5. The violation events are valuable input variables for the acceptance criteria. The definitions of the different events in clause 3.5.3 are applicable.In order to comply with transmission quality, each test frame is examined in terms of transmission interference and transmission recovery. Therefore, a test frame is included in multiple observation periods (see Figure 15: 6.2.1-1) to comply with Transmission Interference and Transmission Recovery simultaneously.
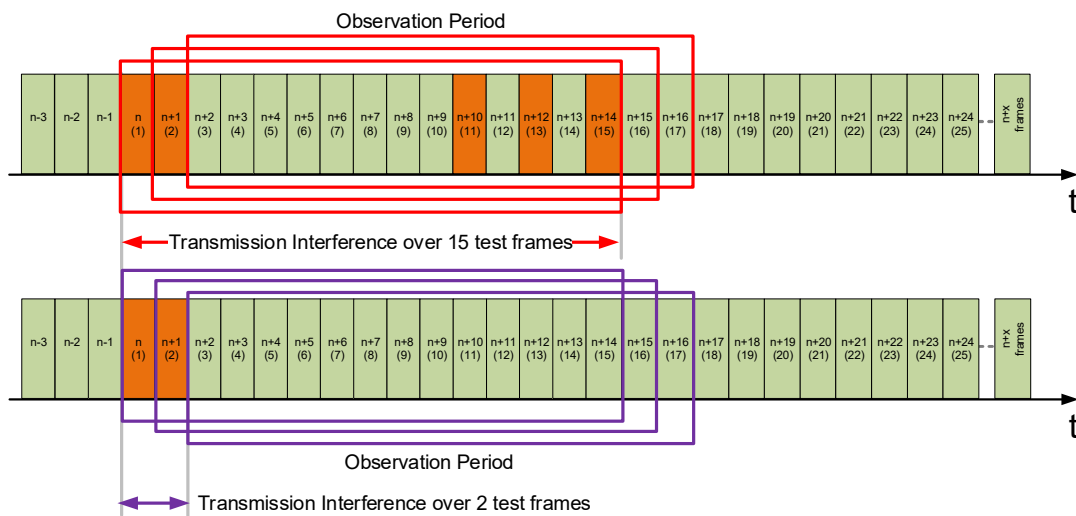
Figure 15: 6.2.1-1 - Observation period for TI processing

6.2.2 TI Events

The information given below contains some examples of Transmission Interference (TI) states and subsequent TR monitoring for the evaluation of the KPI. The TI event cases highlight different specific events (see Figure 15: 6.2.1-1):

- **Case 1:** A TI consists of 15 contiguous invalid test frames having 0 valid test frames.
- **Case 2a:** A TI consists of 2 invalid test frames with a distance of 13 valid test frames.
- Case 2b: A TI consists of 2 invalid test frames with a distance of 0 valid test frames.
- **Case 3:** A TI consists of 1 invalid test frame followed by multiple number of valid test frames ≥14.
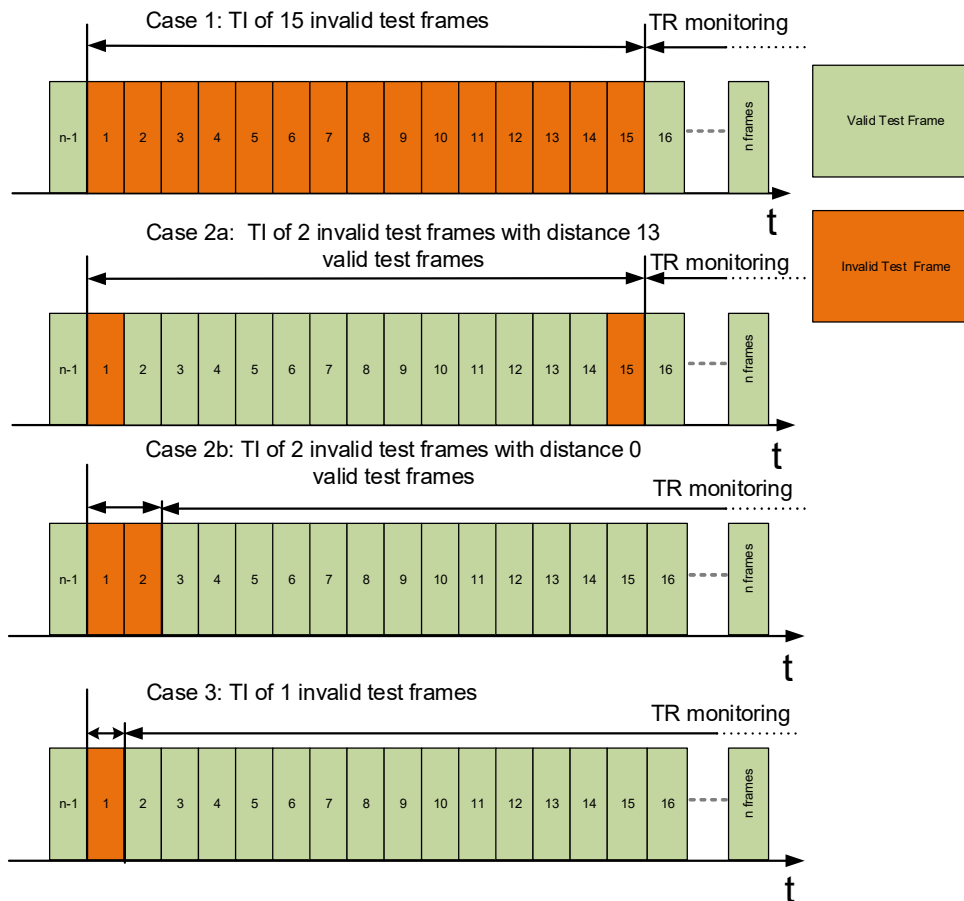
Figure 16: 6.2.2-1 - Examples TI event

6.2.3 T_{REC} and T_{REC_ext} events

Transmission recovery (TR), Transmission Recovery Time (T_{REC}) and Transmission Recovery Extended Time (T_{REC_ext}) are defined in clause 3.5.3.

The following examples give T_{REC} and T_{REC_ext} valid events at limits (Figure 17: 6.2.3.-1) that need to be considered for the evaluation of the KPI:

- Case 1: One TI starts the monitoring of TR that is followed by T_{REC} (7x [15] valid test frames).

- Cases 2a and 2b: A second (contiguous in case 2a) TI occurs during TR monitoring period T_{REC_ext}. Even with the occurrence of the second TI (TI 2), T_{REC} is still fulfilled within T_{REC_ext}.

- Case 3: The occurrence of a few contiguous TIs is assumed. TR monitoring starts after the first TI (TI 1) to observe the T_{REC_ext} fulfilment. Four additional contiguous TIs (TI 2 till TI 5) follow TI 1 that violate T_{REC}_ext. The remaining number of test frames within T_{REC}_ext after TI 5, if those frames are received non-erroneous, fulfil T_{REC}.

- Case 4: A second TI occurs during TR monitoring. The occurrence of this TI violates the first T_{REC} but T_{REC}_ext is fulfilled.
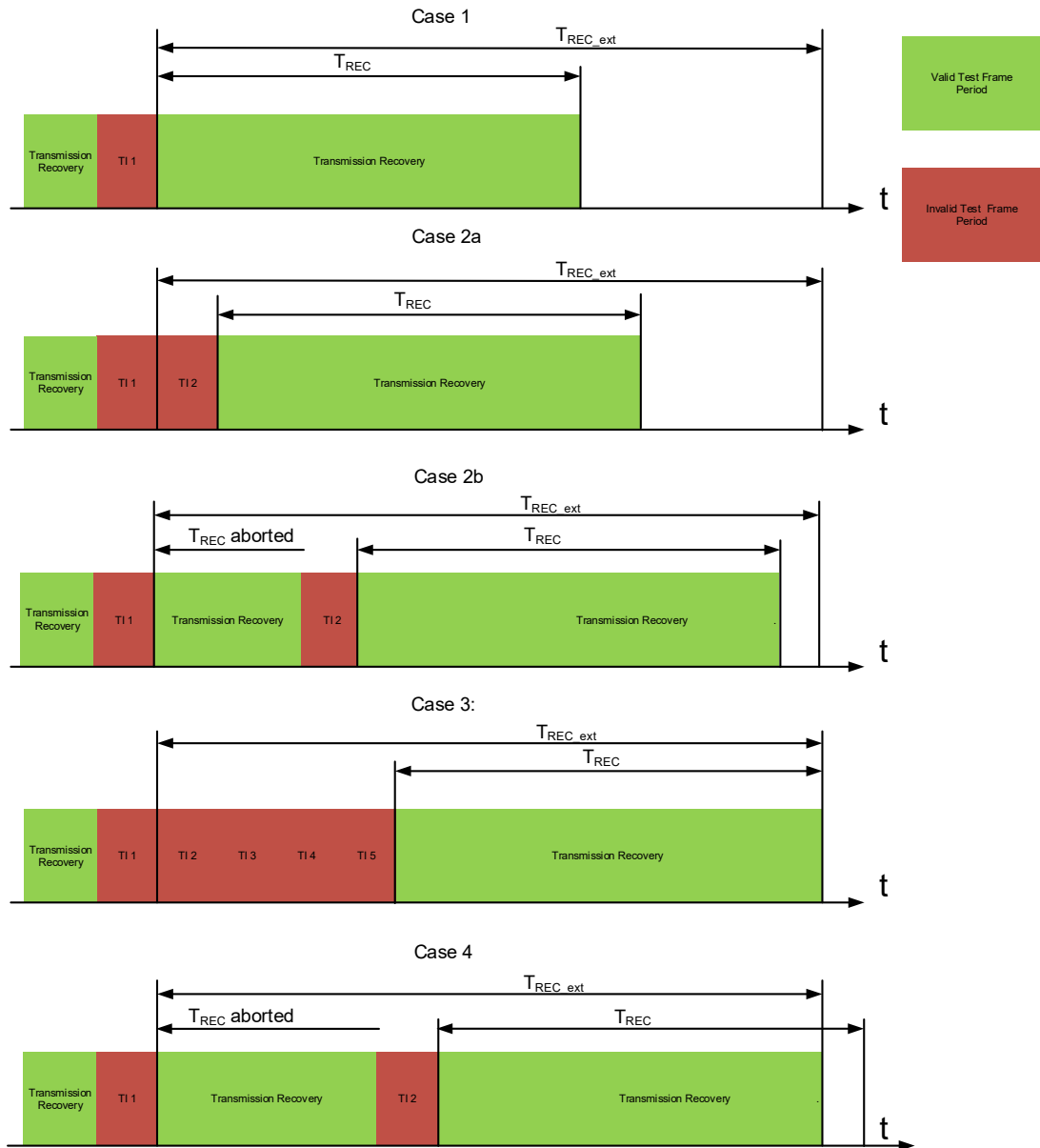
Figure 17: 6.2.3-1 - Examples valid T_{REC} and $T_{REC\ ext}$ events

6.2.4   Movement Authority Transmission Violation

A Movement Authority Transmission violation is present when T_{REC} and T_{REC_ext} are not fulfilled. A few cases illustrate if a violation (Figure 18: 6.2.4-1) is present:

- Case 1a**:** Two (contiguous) TIs (TI 1 and TI 2) start TR monitoring of T_{REC_ext}. An additional TI (TI 3) occurs violating T_{REC} and T_{REC_ext}.

- Case 1b**:** A second TI (TI 2) occurs during TR monitoring of T_{REC_ext} which violates T_{REC} a first time. A third TI (TI 3) occurs during T_{REC_ext} which violates T_{REC} a second time and in this context T_{REC_ext} is violated too.

- Case 2: The occurrence of a few contiguous TIs is assumed. TR monitoring starts after the first TI (TI 1) to observe T_{REC_ext} fulfilment. Five additional contiguous TIs (TI 2 till TI 6) follow TI 1, which violate T_{REC_ext}. The remaining number of test frames within T_{REC_ext} after TI 6, if those frames are received non-erroneously, violates T_{REC} too.
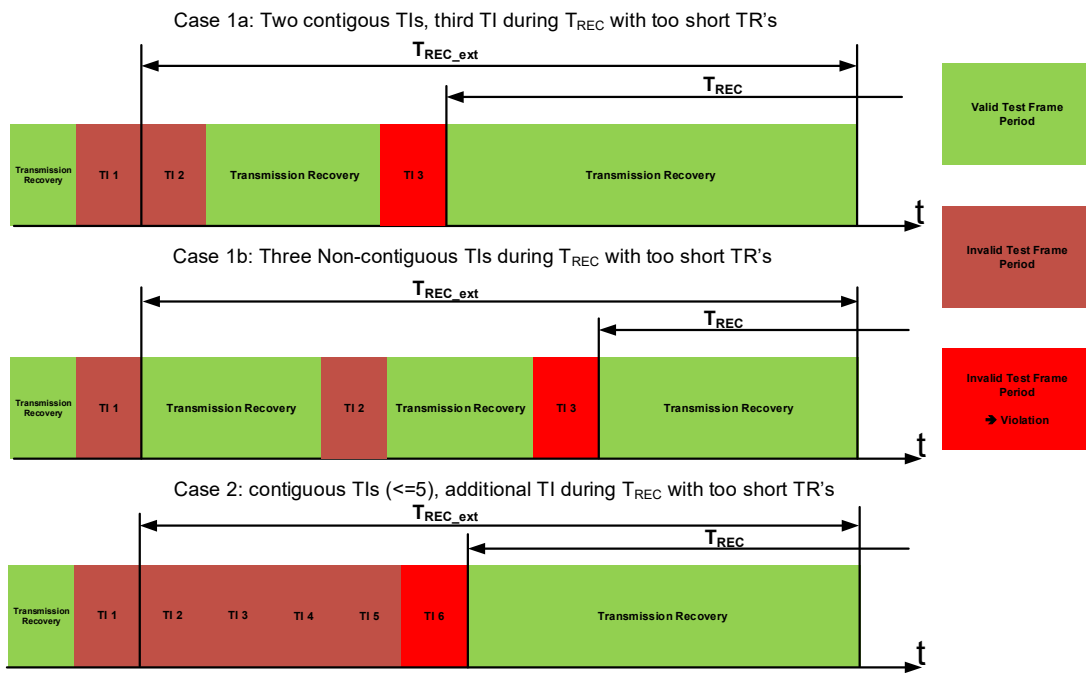
Figure 18: 6.2.4-1 - Examples $T_{REC\ ext}$ violation

6.3 Appendix C,Command scripts for testing purposes (informative)

6.3.1 General

This clause contains suggestions for command script processing arranged according to the respective test scenarios. The command scripts contain the corresponding AT Commands according to [TS 103 368].

6.3.2 Command script for the use in the Home PLMN (CS-domain Network Registration Delay)

```
// select a forbidden network
AT+COPS=1,2,"ForbiddenNetwork"
// wait for +CREG: 3

// select "network2select" = Home PLMN
AT+COPS=1,2," network2select"
// measurement [1] begins
// wait for +CREG: 1
// measurement [1] ends.
```

6.3.3 Command script for the use in the Visited PLMN (CS-domain Network Registration Delay)

Note : This is optional, in case it is agreed in the test plan to verify the behavior of foreign SIM cards.

```
// select a forbidden network
AT+COPS=1,2,"ForbiddenNetwork"
// wait for +CREG: 3

// select "network2select" = Visited PLMN
AT+COPS=1,2," network2select"
// measurement [2] begins
// wait for +CREG: 5
// measurement [2] ends.
```

6.3.4 Command script for the use in the Home PLMN (PS-domain Service Setup)

```
// select a forbidden network
AT+COPS=1,2,"ForbiddenNetwork"
// wait for +CREG: 3
// select "network2select" = Home PLMN
AT+COPS=1,2," network2select"
// measurement [1] begins
// wait for +CREG: 1
AT+CGATT=1
// wait for +CGREG: 1
AT+CGACT=1,1
// wait for "OK" as response to PDP Context Activation

// time measurement [1] ends
// OPTIONAL: verify that user data can be exchanged
AT+CGDATA="PPP",1
// wait for "CONNECT"  to start the PPP establishment
request
```

6.3.5 Command script for the use in the Visited PLMN (PS-domain Service Setup)

```
// select a forbidden network
AT+COPS=1,2,"ForbiddenNetwork"
// wait for +CREG: 3
// select "network2select" = Visited PLMN
AT+COPS=1,2," network2select"
// measurement [1] begins
// wait for +CREG: 5
AT+CGATT=1
// wait for +CGREG: 5
AT+CGACT=1,1
// wait for "OK" as response to PDP Context Activation
// time measurement [1] ends
// OPTIONAL: verify that user data can be exchanged
AT+CGDATA="PPP",1
// wait for "CONNECT"  to start the PPP establishment
request
```

6.3.6 Command script for PS-domain GPRS Attach

```
// select "network2select" = Home PLMN
AT+COPS=1,2," network2select"
// wait for +CREG: 1
// measurement [1] begins
AT+CGATT=1
// wait for +CGREG: 1
// time measurement [1] ends
```

6.3.7 Command script for PS-domain PDP Context Activation

```
// select "network2select" = Home PLMN
AT+COPS=1,2," network2select"
// wait for +CREG: 1
AT+CGATT=1
// wait for +CGREG: 1
// measurement [1] begins
AT+CGACT=1,1
// wait for "OK" as response to PDP Context Activation
// time measurement [1] ends
// OPTIONAL: verify that user data can be exchanged
AT+CGDATA="PPP",1
// wait for "CONNECT" to start the PPP establishment
request
```

6.4 Appendix D, Statistical approach for ETCS QoS requirements validation

6.4.1 Delay sensitive performance indicators

6.4.1.1 General

From a statistical perspective, the delay sensitive performance indicators can be described by some kind of statistical distribution, which has a mean delay μ and the corresponding standard deviation σ.

This sub-clause describes the mathematical context for determining the required test sample size to achieve a certain reliability in its validity.

6.4.1.2 Theoretical background

The *t*-test (and also the *t*-distribution) will be used where the test size would be normally distributed if the scaling parameter (the parameter defining the dispersion - the standard deviation for a normally distributed random variable) would be known. However, this parameter is unknown as a scaling parameter when determining the necessary number of test samples and is therefore replaced by an estimate.

The shape of the *t*-distribution is very similar to the standard normal distribution, at least for larger samples. However, if the size of the sample size is small, the *t*-distribution is flatter than the standard normal distribution. Therefore, the *t*-distribution needs another parameter that changes its variance (and thus its shape). These are the degrees of freedom (df).
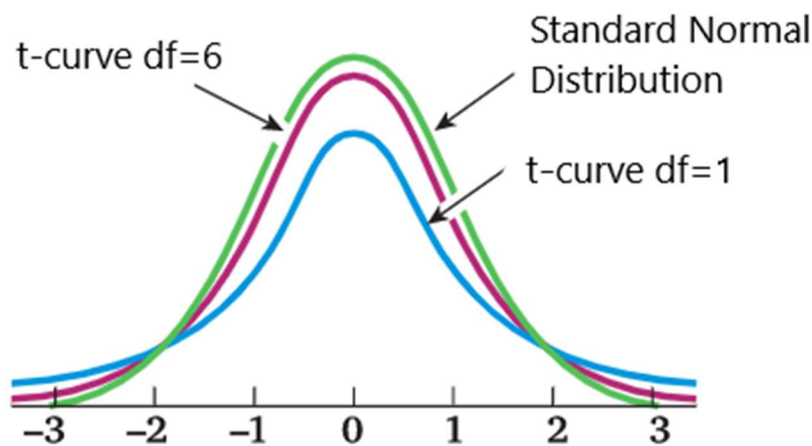
Figure 19: 6.4.1.2-1 - Context between normal and Student-t distribution

The degrees of freedom can be thought of as the number of ways that a system, with a fixed value, can vary independently. The degree of freedom corresponds with the sample size (i.e. $df = n - 1$).

The standard deviation σ is then replaced by the standard deviation of the samples *s*.

The *t*-distribution approaches the standard normal distribution with increasing df.

The confidence interval is denoted as:

$$\bar{x} \pm t^* \cdot \frac{s}{\sqrt{n}}$$ (Eq.-6.4.1.2-1)

Where:

$\bar{x} =$ is the sample mean (best estimate of the population mean μ)
$s =$ standard deviation of the sample
$n =$ sample size
$t^* =$ t-parameter (df = n – 1)

Note: "**t***" depends on the sample size **n**.

For a one-sided interval with a confidence level of 95%, **t*** = 1.67 (**n**=60), for a one-sided interval with a confidence level of 90% **t*** = 1.29 (**n**=60).

Rather good reproducibility is achieved if **n** is chosen in a way that $\bar{x}$ does not deviate more than a small percentage from one measurement campaign to another with a high confidence level. Using (Eq.6.4.1.2-1) and making a choice for a deviation of $\bar{x}$ of 10% results in:

$$0.1\bar{x} = t^* \cdot \frac{s}{\sqrt{n}}$$ (Eq.-6.4.1.2-2)

Solving for n yields: $n = \left(\frac{s t^*}{0.1\bar{x}} \right)^2$ (Eq.-6.4.1.2-3)

Measurements have outlined that the ratio $s/\bar{x}$ is much smaller than 0.5 for all performance indicators.

Taking the worst-case value of **s/$\bar{x}$ = 0.5**, a confidence level of 95% (one-sided confidence interval) and applying equation (Eq.6.4.1.2-3) results in n = 70.

6.4.1.3 Considerations for validation of delay sensitive indicators

Compliancy with the requirements is demonstrated by taking the 99th-percentile from the measurement data set.

The k-percentile is defined as that value of the measurement data set which corresponds to a cumulative frequency of (**n** of **k**)/**100**.

With **n**=100, the 99th-percentile is simply the 99th value of the measurement data set (when sorted in ascending order). If the value corresponding to the 99th percentile of the delay sensitive indicator is less than the value specified, the requirement is successfully validated.

6.4.2 Rate sensitive performance indicators

6.4.2.1 General

From a statistical perspective, the rate sensitive performance indicators can be described by the Poisson statistical distribution.

This sub-clause describes the mathematical context for determining the required test duration to achieve a certain confidence level.

6.4.2.2 Theoretical background

Assuming that a rate is characterized by:

- The number of losses/violations is proportional to the measurement time.
- The probability of any kind of loss/violation is almost zero over a short period of time.
- The losses/violations are independent events.

Then the rate sensitive performance indicators are reasonably modelled by the Poisson distribution.

Note that it is not sensible to speak about a sample size here, but rather of a certain measurement time interval in which a rate sensitive performance indicator may or may not appear.

For a Poisson distribution the following formula applies:

$$P(k) = (Rt)^k . \frac{e^{-Rt}}{k!}$$ (Eq.-6.4.2.2-1)

Where:
$P(k) =$ The probability that k failures occur within a measurement time interval t if the (Loss/Violation) Rate is R;
$k =$ Number of losses/violations in a measurement time interval t;
$R =$ Loss Rate (losses/violations per hour);
$t =$ Measurement time interval (hours);

Note: For a Poisson distribution the mean and the variance are equal to" R∗t".

If a confidence level is selected and the probability that 1 or more losses/violations occur in a measurement time interval t under the pre-condition that the Loss Rate or Violation Rate is truly R=0.01/hour, the measurement time t can be calculated. The probability of having 1 or more losses or violations in a measurement time t (in hours) is:

$$P(k >= 1) = 1 - P(k = 0) = 1 - e^{-0.01} = Confidence\ Level$$ (Eq.-6.4.2.2-2)

For example, if a confidence level of 50% is chosen, solving (Eq.-6.4.2.2-2) results into measurement time t_{meas} of 70 h.

Alternatively stated: if the Loss Rate/Violation Rate is truly R=0.01/hour and is measured over a period of 70 hours, then the probability of experiencing no loss/violation at all is 50%.

6.4.2.3 Considerations for validation of MATVR

According to the theoretical context in this clause, the requirement of ≤10E-2/h for the MATVR and the assumption of a confidence level of 95%, this results in a T_{meas} of 300h (see Table **1**: 4.3-1) .

The requirement according to [Subset-093] is based on the exchange of an MA message every 20 seconds (f_{MA}). Accordingly, the quality rating of the GSM-R transmission channel is subject to a 20-fold oversampling with reference to a single Transmission Interference (TI) time window of one second or less.

With the assumed operative approach of a MA frequency (f_{ma}) of 20 seconds, T_{meas} is reduced by the factor (180 MA*h^{-1}/3600 test MA*h^{-1}) to 15 hours.

> *Note 1: The relationship between measurement oversampling (MA frequency) and operational MA frequency is linear. Accordingly, the factor between operational MA frequency and test MA frequency needs to be considered for the calculation of total time required for measurement (180 MA*h-1/3600 test MA*h-1).*

> *Note 2: The change in the confidence level according to clause 6.4.4 and/or the change in MA frequency (fma) inevitably leads to changes in expenses of t_{meas}.*

According to the requirement in [Subset-093] of (P) 99.995% of the cases, the MATVR 1/(1-P) corresponds to 1 out of 20000 contiguous test samples being erroneous.

At the moment of issuing the current version of the document, sufficient evidence on the acceptance criteria for this indicator which has been newly introduced could not be gathered for concluding at which MATVR the ETCS operation would be disrupted.

In order to get this evidence, further information from measurements in operational networks is required. Therefore, different P values (probability of not receiving an MA) have been considered in this clause.

A decision was taken by the EU Agency for Railways to set a criteria which corresponds to the (P) value of 99.9%, which can be reviewed (and increased) if proven not to be sufficient. Further information is provided in clause 6.4.4.

6.4.2.4 Considerations for validation of CLR

According to the requirement in [Subset-093], one connection loss is allowed per 100 hours.

Based on the theoretical background, a confidence level of 50% corresponds to 70 hours measurement time t_{meas}.

Based on the return of experience, where very few issues have been seen related to the Connection Loss Rate in those networks where the other performance indicators measured in non-static conditions are validated, it is considered that the measurement time used for acceptance of the network in Phase 1 can be lined up with the measurement time of MATVR.

6.4.3 Dependency on location for non-stationary performance indicators

6.4.3.1 General

This clause describes the dependency of the determination of the performance indicators on its position. At this point, a distinction is made between performance indicators that depend on the train speed and length of the line to be measured and those that are more likely to be recorded stationary.

6.4.3.2 Theoretical Background

Basic variables

To determine the number of necessary test samples, define the following variables:

The resolution to be achieved in [meter], between two contiguous test samples referred to as "D_{sample}".

- The total length of the line "L_{track}" in [km] to be examined.
- The applicable train speed profiles in [km/h] are referred to as "v" which are used for the line during operation.
- The time duration of a Test Interval according to 3.5.3 in [seconds] denoted to Tsample_CS having the value of 1 second applicable for CS mode.
- The time duration of a Test Interval according to 3.10.3 in [seconds] denoted to T_{sample}_PS having the value of 4 seconds applicable for PS mode
- The assumption of sub-clause 6.4.2.2   Theoretical   background) applies.
- The Movement Authority interval "Ima" that determines the time interval between contiguous Movement Authorities.

Determination of test runs

- The train speed "v" determines how many test frames can be exchanged during a test run considering a certain track length (Ltrack). The product of T_{sample} and v yields into the real distance between adjacent MA test samples Dmeas in [m].

$$D_{meas} = T_{sample} * v \qquad\qquad\qquad \text{(Eq.-6.4.3.2-1)}$$

- The measurement time that result to the minimum number of test runs depends on Ltrack:

$$T_{meas} = T_{sample} * L_{track} / D_{sample} \qquad\qquad \text{(Eq.-6.4.3.2-2)}$$

- The number of minimum number of runs contains the ratio of Tmeas*v/Ltrack.

Substituting equation 2 in this ratio it results to:

$$Number\ of\ test\ runs = T_{sample} * v / D_{sample} \qquad \text{(Eq.-6.4.3.2-3)}$$

Note: Equation 6.4.3.2-3 may result in fractional numbers which might be not applicable for a test run, therefore, they should be rounded up to the next integer.

6.4.3.3 Line length consideration for acceptance in Phase 1

For the acceptance tests in phase 1, different line lengths may be considered for acceptance. These can vary between a few kilometers and a few hundred kilometers.

In order to adequate the testing effort to the length of the line, the total line length will be considered as a multiple of an "acceptance section length". The use of such "acceptance section length" allows to execute the corresponding tests in one section at a time or in a combination of sections, which eases the organization of the testing campaign.

The length of the "acceptance section" is set to two values: 20 km and to 100 km.

Lines shorter than 20 km are considered to be composed of 1 "acceptance section of 20 km".

Lines longer than 20 km are composed of a number of individual sections of "20 km" and "100 km".

The multiples are understood as «integer numbers»: i.e. a line of 50 km is composed of 3 sections of 20 km, (two of 20 km length and another one of 10 km).

For lengths lower than 5 km, it is suggested to consider them inside the last "acceptance section": i.e. a line of 105 km is composed of 1 section of 100 km; a line of 43 km is composed of 2 sections of 20 km.

The acceptance criteria is to be met in each of the acceptance sections.

6.4.4 MATVR considerations for acceptance in Phase 1

6.4.4.1 General

This clause includes the result of the discussions held to understand the possible acceptance criteria for the MATVR indicator.

A set of values of P have been studied (probability of not receiving an MA) and their correspondence to the measurement time and MATVR value.

All the measurements proposed consider both the uplink and downlink traffic: at the ETCS application level, in order to receive an MA, the previous message received in the train has to be acknowledged by the train, and this acknowledgement has to be received in the RBC; otherwise, no MA will be sent, and the connection will be considered as lost; at the HDLC level, both uplink and downlink have to be correctly established.

The variables and values appearing in the summary Table **1**: 4.3-1 correspond to those in the following section:

Pre-assumptions:
- l_{ma} is the MA interval (operational set up, set to 20 s).
- T_{sample} is the sample time, set to 1 second (1 sample per second).

For the statistical approach:
- P is the probability of receiving an MA [Subset-093] (input value).
- Confidence level, set to 95% (input value).
- N_{viol} is the number of violations tolerated in the proposed time. (N_{viol} is >=1) (output value).

- T_{meas_t} is the time required for the measurement (output value).

For the location based approach:

- $D_{\_sample}$ is the distance between contiguous samples (input value).
- L_{track} is the length of the track under measurement (input value).
- T_{meas_L} is the measurement time in order to perform the minimum number of trips for L_{track} (output value).

$T_{\_meas}$ is the resulting time required for the measurement itself, which is the maximum of the times from the statistical and the location based approach.

6.4.4.2 Calculations for different probabilities of receiving an MA

The two L_{track} of 20 km and 100 km have been used, corresponding to the "acceptance section length types" defined in 6.4.3.3 Line length consideration for acceptance in Phase 1.

With l_{ma}=20 s (MA interval, time between two consecutive MAs), the criteria would be:

- As a maximum, 1 error every 20000 samples, which means 1 error in 111,1 h of measurement; considering P= 99,995%.
- As a maximum, 1 error every 10000 samples, which means 1 error in 55,5 h of measurement; considering P= 99,99%.
- As a maximum, 1 error every 5000 samples, which means 1 error in 27 h of measurement; considering P= 99,98%.
- As a maximum, 1 error every 2000 samples, which means 1 error in 11,1 h of measurement; considering P= 99,95%.
- As a maximum, 1 error every 1000 samples, which means 1 error in 5 h of measurement; considering P= 99,90%.

6.5 For guidance only

Calculations have been performed with the set of parameters for the case where the section length is 20 km and 100 km, with l_{ma}=20 s, D_{sample}=10m (distance between samples), and a confidence level of 95%:

6.5.1 SUMMARY TABLE for a section of 20 km

P	[%]	99,995	99,99	99,98	99,97	99,96	99,95	**99,9**	99,5	99
Measurement duration (T_meas)	[h]	16,7	8,3	4,2	2,8	2,1	1,7	**0,8**	0,6	0,6
MATVR validation criterion		3 in 16,7 hours	3 in 8,3 hours	3 in 4,2 hours	3 in 2,8 hours	3 in 2,1 hours	3 in 1,7 hours	**3 in 0,8 hours**	10 in 0,6 hours	20 in 0,6 hours
For information, this corresponds to the following trips evaluation versus speed:										
# trips at 80 km/h		67	34	17	12	9	7	**4**	3	3
# trips at 200 km/h		167	84	42	28	21	17	**9**	6	6
# trips at 300 km/h		251	126	63	42	32	26	**13**	9	9

6.5.2 SUMMARY TABLE for a section of 100 km

P	[%]	99,995	99,99	99,98	99,97	99,96	99,95	**99,9**	99,5	99
Measurement duration (T_meas)	[h]	16,7	8,3	4,2	2,8	2,8	2,8	**2,8**	2,8	2,8
MATVR validation criterion		3 in 16,7 hours	3 in 8,3 hours	3 in 4,2 hours	3 in 2,8 hours	4 in 2,8 hours	5 in 2,8 hours	**10 in 2,8 hours**	50 in 2,8 hours	100 in 2,8 hours
For information, this corresponds to the following trips evaluation versus speed:										
# trips at 80 km/h		14	7	4	3	3	3	**3**	3	3
# trips at 200 km/h		34	17	9	6	6	6	**6**	6	6
# trips at 300 km/h		51	26	13	9	9	9	**9**	9	9

To increase the confidence level, a measurement time of 15 hours for the section length of 100 km and of 5 hours for the section length of 20 km is considered.

When taking P=99,9% (decision taken by EU Agency for Railways), and considering the measurement time for the section lengths of 100 km and 20 km, the criteria in Table **1**: 4.3-1 for MATVR acceptance in Phase 1 would read:

- *For acceptance section lengths of 100 km, with a minimum distance between samples of 10 meters, considering 99,9% probability for reception of MA: the number of violations shall not exceed 54 per 15 hours test duration (confidence level higher than 95%).*

- *For acceptance section lengths of 20 km, with a minimum distance between samples of 10 meters, considering 99,9% probability for reception of MA: the number of violations shall not exceed 18 per 5 hours test duration (confidence level higher than 95%).*

END OF DOCUMENT.