ERTMS/ETCS

GSM-R
Bearer Service Requirements

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3.0.9 (20-Oct-2015)	6.4, 6.7, 11.2, 11.4	Modifications after EEIG meeting	LK
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3.024	4.1, 6.2, 6.6.5, 6.6.7	Changes for interference measurement and CR5036	EECT
	10.6.1, 10.6.2	rework integration UIC proposal for interference justification	FK
	all	formatting	FK
	Figure 1, 6.7.5, 6.7.6, 6.7.7, Figure 5, 11.3	changes after EECT agreements (29.08.2017&22.09.2017)	FK
	3	incl. CR5036 for EIRENE, FFFIS ER & Subset-37	FK
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	6.6.5.6	changes after EECT agreements 26.10.2017	FK
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	6.6.7, 6.7.3, 6.7.4, 6.7.5, 10.6.2	changes after EECT agreements 14.11.2017	FK

3.0.26	6.6.5, 6.6.7, 7, 10.6	Rework of Transmission Interference and Transmission Recovery	FK
	13 (Annex E)	"DB, Draft: Operational Requirements to GSM-R Quality of Service, v1.1, 3 August 2004" included	FK
	Full document	Harmonization of the KPI names	FK
3.0.27	4.1, 5.1, 6.5.1, 6.6, 10.2, 10.3, 10.5, 11.3, 11.4	Remove Connection Establishment Error Rate, include decisions of EECT Small error corrections Include timings of CR1146	FK
3.0.28	Full document	Conditions for each KPI added Modifications after EECT agreements Small error corrections	FK
3.0.29	Full document	Include the change remarks from the review	FK
3.0.30	3, 4.1, 6.1, 6.4.1, 6.5.1, 6.6, 6.7.1, 6.7.6, 10.2, 10.5	Modifications after Review	FK
3.0.31	6.5.1	Modification after Review	FK
3.0.32	3, 5.1, 6.5.1	Modifications after Review and EECT decisions	FK
	6.6.3, 6.6.4, 6.6.7, 6.7.5, 6.7.6, 6.7.7, 10.4, 10.5	Reordering chapter according to O-2475	FK
3.0.33	All	Modification after Review	FK
4.0.0		Clean version	FK

2. TABLE OF CONTENTS

3. REFERENCES

3.1.1.1 This document list incorporates by dated or undated references, provisions from other publications. These references are cited at the appropriate place in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this document only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to apply.

Reference	Description	Version
Subset-023	Glossary of Terms and Abbreviations	3.3.0
Subset-026	System Requirements Specification	In line with CCS TSI 2016 and amendments
Subset-037	EuroRadio FIS	3.2.0, incl. CR1319 and CR1146 in Opinion 2020-2
EIRENE FRS	EIRENE Functional Requirements Specification incl. CR1319 in Opinion 2020-2	8.0.0
EIRENE SRS	EIRENE System Requirements Specification incl. CR1319 in Opinion 2020-2	16.0.0
ER FFFIS	UIC; A11 T6001; Radio Transmission FFFIS for EURORADIO incl. CR1319 in Opinion 2020-2	13.0.0
GSM 04.21 ETSI TS 100 945	Rate Adaptation on the MS-BSS Interface	8.3.0
ETSI TS 103 368	Commands necessary for mobile radio equipment operation on railways	1.1.1
3GPP TS 23.107	Quality of Service; Concept and architecture	4.2.0
ITU-T V.24	List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)	02.00
ITU-T V.25ter	Serial asynchronous dialing and control	07/97
ITU-T V.110	Support by an ISDN of data terminal equipments with V-series type interfaces	02.00
O-2475	UIC O-2475; ERTMS/GSM-R Quality of Service Test Specification	4.0.0

Reference	Description	Version
EEIG 11E017	ETCS over GPRS principles and functional requirements	2C 27-July—2015
O-8664	UIC O-8664; ETCS in PS mode; GPRS/EGPRS Guideline	see [EIRENE SRS]
TS 103 328	ETSI TS 103 328; Railway Telecommunications: GPRS/EGPRS requirements for ETCS	see [EIRENE SRS]
EEIG 04E117	ETCS/GSM-R QoS user requirements – Operational analysis (https://ertms.be/workgroups/ETCS_requirements_on_radio_communication) Note: Relevant parts of this document can be found in Annex D	Version 1 14-Oct-2005
EEIG 09E033	GSM-R/ETCS Integration Review, Final Report and Conclusions (https://ertms.be/workgroups/ETCS_requirements_on_radio_communication)	Version 1 29-April-2009
ERQoS	GSM-R QoS Impact on EuroRadio and ETCS application, Unisig_ALS_ERQoS	v.010 08.04
O-8662	UIC O-8662; ETCS over GPRS Phase 1 report	1.0 28-Sep-2015

4. TERMS AND DEFINITIONS

4.1 Abbreviations

4.1.1.1 For general ERTMS/ETCS terms, definitions and abbreviations refer to [Subset-023]. New terms and abbreviations relevant and used in this specification are specified here.

AT	ATtention command set
ATD	AT command Dial
B channel	User channel of ISDN
B_m channel	User channel of GSM PLMN on the air interface
BG	Balise Group
BRI	Basic Rate Interface
BS25	Bearer Service 25: asynchronous data 4.8 kbit/s in 3GPP
CS	Circuit switched
D channel	Control channel of ISDN
DCE	Data Circuit Equipment
DCD	Data Carrier Detect
DL	Down Link
D_m channel	Control channel of GSM PLMN on the air interface
DTE	Data Terminal Equipment
EDOR	ETCS Data Only Radio
EGPRS	Enhanced GPRS
eMLPP	enhanced Multi-Level Precedence and Pre-emption
EoG	ETCS over GPRS
ER	EuroRadio
ETCS-DNS	ETCS-Domain Name Server
FQDN	Full Qualified Domain Name
GBR	Guaranteed Bit Rate
GGSN	Gateway GPRS Support Node
HDLC	High level Data Link Control
IMSI	International Mobile Subscriber Identity
ISDN	Integrated Services Digital Network
MOC	Mobile Originated Call
MS	Mobile Station (a GSM entity)
MT	Mobile Termination/Terminated
MTC	Mobile Terminated Call
MTBD	Mean Time Between Disturbance

PFC	Packet Flow Context
PLMN	Public Land Mobile Network
PS	Packet switched
PDP	Packet Data Protocol
PRI	Primary Rate Interface
QoS	Quality of Services
RBC	Radio Block Centre
SGSN	Serving GPRS Support Node
UDI	Unrestricted Digital
UL	Up Link

4.2 Definitions

4.2.1.1 Definitions for the purpose of this specification are inserted in the respective sections.

5. GENERAL

5.1 Scope of this document

5.1.1.1 The scope of this document is to specify the Radio Communication System End-to-End performance requirements for control command signalling including GSM-R network services, the fixed side access, interconnections (for authentication) and interfaces.

5.1.1.2 The data transmission part of the End-to-End communication protocols is fully described in the EuroRadio FIS [Subset-037].

5.1.1.3 The Radio Transmission FFFIS for EuroRadio [ER FFFIS] specifies the physical, electrical and functional details related to the interfaces.

5.1.1.4 All requirements are applicable to a GSM-R based mobile network.

5.1.1.5 This document covers performance requirements for circuit switched bearer services (CS mode) and packet switched bearer services (PS mode) needed for ETCS. It is valid for the line categories Dedicated HighSpeed Line, High-Capacity Line and Urban Railways as described in [EEIG 04E117, Table 1, see Annex D]. For Low-Capacity Lines another set of less stringent QoS parameters values could be used.

Note: The operational requirements are similar for all the line categories, except for the probability not to receive an MA extension in 12s.

5.1.1.6 Some lines may have operational requirements different from those listed above. In this case, an adapted set of the QoS parameter values, including the corresponding ETCS engineering rules, have to be used.

5.1.1.7 For measurement of the Quality of Service requirements, [O-2475] is applicable.

5.2 Introduction

5.2.1.1 The definition of the GSM services and associated physical and communication signalling protocols on the air interface are standardised in the specifications produced by the ETSI GSM Technical Committee for the public GSM implementation as well as for the GSM-R.

5.2.1.2 The following GSM services according to [EIRENE SRS] are required:

a) Transparent data bearer service (CS mode)
b) Enhanced multi-level precedence and pre-emption (eMLPP) (CS mode)
c) (Enhanced) General Packet Radio Service (PS mode) as referred in [TS 103 328]. Note: optional on the network side

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6. END-TO-END GSM-R NETWORKS SERVICE REQUIREMENTS

6.1 Service aspects

6.1.1.1 For the exchange of information between OBU and RBC, the EuroRadio protocol uses the bearer services of a GSM-R network. The service provider makes these data bearer services available at defined interfaces (see Figure 1).

6.1.1.2 The data bearer services are described as data access and transfer in the GSM-R network from the Terminal Equipment on the mobile side (i.e. OBU) via the Mobile Termination (MT), a network gateway and the interworking with Integrated Services Digital Network (ISDN) or IP networks to the Terminal equipment on the fixed side (i.e. RBC).

6.1.1.3 Figure 1 illustrates the End-to-End system architecture from a service point of view (ETCS-DNS may be part of the IP data network).

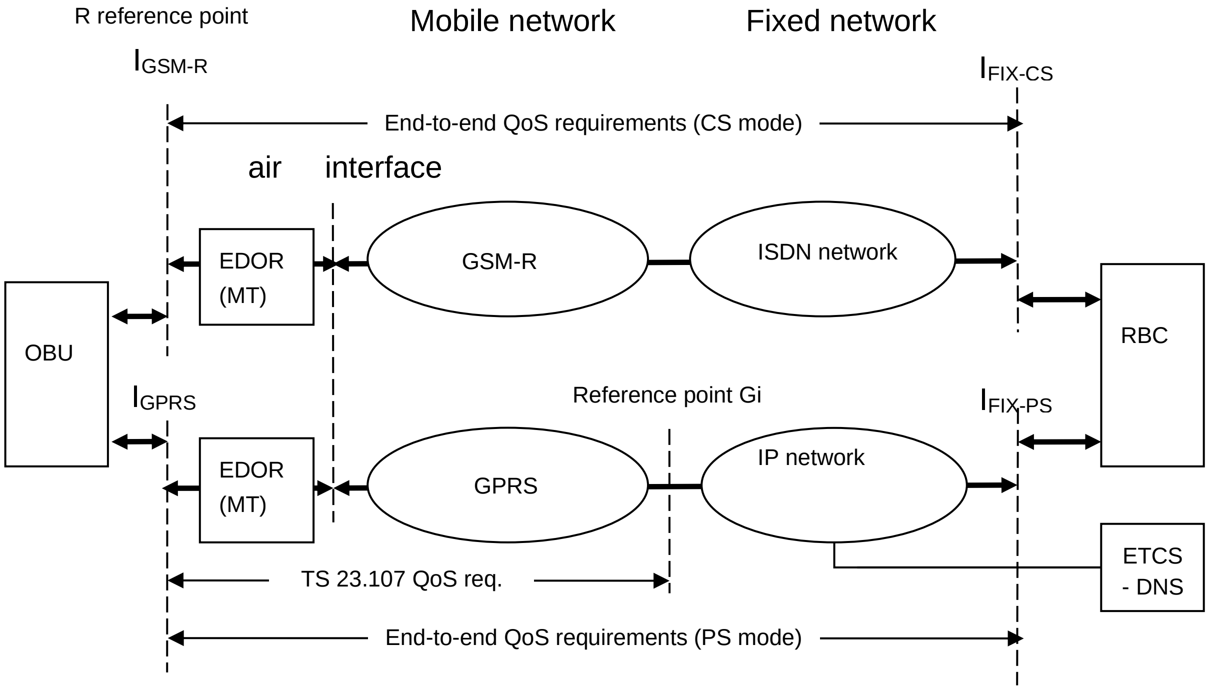

Figure 1: System architecture and interfaces

6.1.1.4 The service access points of the data bearer in CS mode at the OBU side are:

- the service access point to the signalling stack for the establishment or release of the physical connection,
- the service access point to the data channel I_{GSM-R}.

6.1.1.5 The service access point in CS mode at the RBC side is defined by the interface I_{FIX-CS}.

6.1.1.6 The service access points of data bearer services in PS mode at the OBU side are:

- the service access point to the signalling stack for the establishment or release of a service access (in principle the AT-commands to activate GPRS/EGPRS bearer service such as PDP context),
- the service access point to the data channel I_{GPRS}.

6.1.1.7 The service access point in PS mode at the RBC side is defined by interface $I_{FIX\text{-}PS}$.

6.2 Data bearer service in CS mode

6.2.1.1 The BS25 transparent bearer service shall be used.

6.2.1.2 It shall provide the following features and attributes:

a) Data transfer allowing multiple rate data streams which are rate-adapted [GSM 04.21] and [ITU-T V.110]

b) Unrestricted Digital Information (UDI) – only supported through ISDN interworking (no analogue modem in the transmission path)

c) Full rate radio channel

d) Transfer of data only (no alternate speech/data)

e) Operation in asynchronous transparent mode

6.3 Additional services (CS mode)

6.3.1.1 The supplementary service “Enhanced multi-level precedence and pre-emption” shall be provided.

6.3.1.2 The priority value for control-command (safety) shall be assigned according to [EIRENE FRS §10.2] and [EIRENE SRS §10.2].

6.4 Data bearer service in PS mode

6.4.1 General PS mode requirements

6.4.1.1 Transport connection establishment initiated from the OBU to one or more RBC(s) and user data exchange between OBU and RBC shall be supported for ETCS as specified in [Subset-037].

6.4.1.2 The QoS requirements are applicable to class B mobiles and GSM-R networks.

6.4.1.3 Incoming circuit switched mode communications to an EDOR will be prevented by the network according to [EIRENE SRS] and [ER FFFIS].

6.4.1.4 Detailed requirements of the GPRS/EGPRS bearer services and parameters necessary for ETCS operation over GSM-R are specified in [TS 103 328].

6.4.1.5 The communication between trainborne equipment i.e. OBU and trackside i.e. RBC is based on IP version 4 according to [EIRENE SRS]/[ER FFFIS].

6.5 Quality of Service requirements

6.5.1 Requirements on all applied data services

6.5.1.1 The Quality of Service (QoS) requirements are related to the applied end-to-end bearer service of GSM-R and the fixed communication networks.

6.5.1.2 End-to-end Quality of Service shall be considered at the service access points.

6.5.1.3 The end-to-end QoS requirements for CS mode are specified between the interface I_{GSM-R} at the service access point and the interface I_{FIX-CS} at the RBC side (Figure 1).

6.5.1.4 The end-to-end QoS requirements for PS mode are specified between the interface I_{GPRS} at the service access point and the interface I_{FIX-PS} at the RBC side. Other QoS requirements are applicable to the interface I_{GPRS} and the network interface at reference point G_i according to [3GPP TS 23.107] (see Figure 1).

6.5.1.5 The Mobile Termination and the network shall be able to support train-to-trackside data communications at a train speed up to 500 km/h according to [EIRENE FRS].

6.5.1.6 The QoS requirements are valid for one end-to-end connection for one train running under operational conditions.

6.5.1.7 These operational conditions notably include the following:

- The operational Permitted Speed of the track shall be used. The verification of requirements shall be performed in the operational network at the defined service access points.
- The QoS requirements need not be applied at all locations and times if this exception does not influence operation generally, e.g. at announced radio holes according to [Subset-026, section 3.5]).
- Subscriptions and SIM cards with the ETCS QoS profile shall be used.
- The available PS bandwidth can be shared between the ETCS application and other packet switched traffic (mixed ETCS/non-ETCS traffic as specified in [TS 103 328]). **Note**: How to generate non-ETCS traffic is defined in [O-2475] and takes into account the different operational cases (ETCS only operation or mixed mode operation).

6.5.1.8 The delay contribution of the fixed IP network e.g. caused by the network load (beyond the Gi reference point) shall not significantly affect the end-to-end Transfer Delay of ETCS message.

Note: The fixed IP network load condition does not need to be measured. It is a design rule and an assumption to simplify the measurement.

6.5.1.9 The QoS requirements in this document are based on conditions that depend on the trackside implementation of ETCS. Such conditions are described in the related QoS requirements' paragraphs. The following figure shows the basic timing relations.

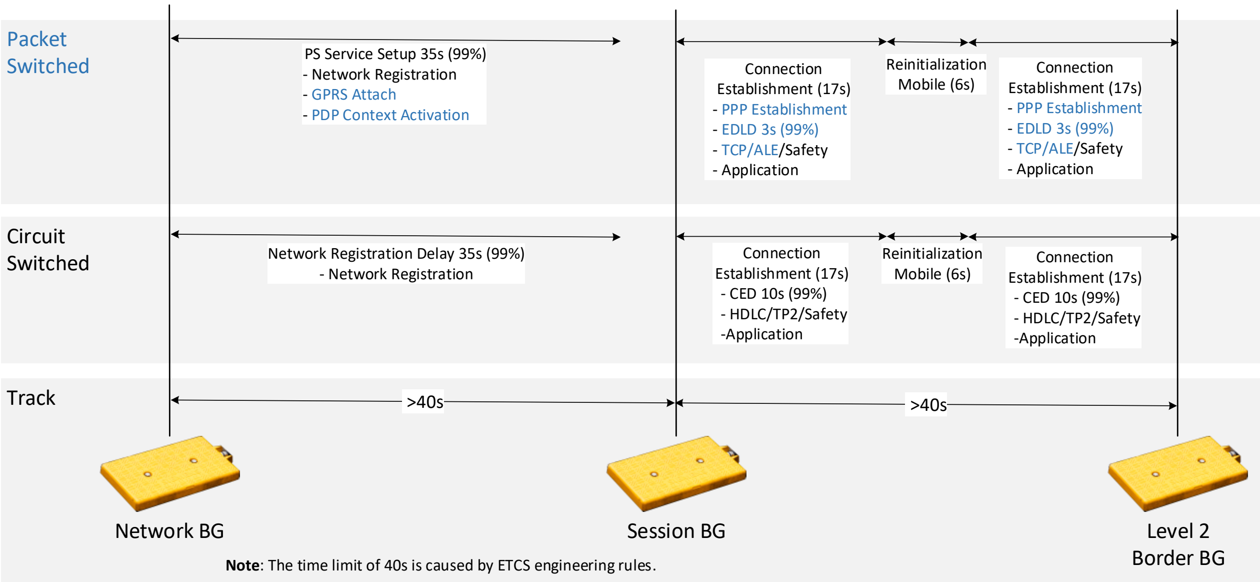

Figure 2: Relationship between trackside elements and QoS parameters

6.5.1.10 The QoS requirements reflect railway operational targets [EEIG 04E117]. If different operational targets are required, then other KPI values may be necessary (see for example [EEIG 09E033]). Such a case is not covered by this specification and this aspect of ETCS System Performance becomes the responsibility of whoever specifies different operational targets.

Note1: To ease the understanding, extracts of the document [EEIG 04E117] are made available in Annex D.

Note2: A justification of the QoS requirements is given in Annex B and C.

6.5.1.11 QoS requirements have no relation to the methodology of the measurement (refer to [O-2475] for specification of testing).

6.5.1.12 [EEIG 11E017] gives the principles for applying GPRS/EGPRS bearer services for ETCS.

Note: The QoS requirements are applicable for GPRS/EGPRS bearer service.

6.6 Data bearer service in CS mode - QoS requirements

6.6.1 Connection Establishment Delay (CED)

6.6.1.1 Connection Establishment Delay is defined as:

Value of elapsed time between the connection establishment request and the indication of successful connection establishment.

6.6.1.2 In case of mobile originated calls, the delay is defined between the request by command ATD and the response CONNECT.

6.6.1.3 The Connection Establishment Delay of mobile originated calls shall be ≤10 s (99 %), since CED >10 s is evaluated by the ETCS application as not successful (see justification in 10.2).

6.6.1.4 If the operational QoS targets of [EEIG 04E117, table 6 and following text] are required, then the ETCS infrastructure including the GSM-R network has to be designed in such a way that at least two consecutive connection establishment attempts will be possible (Recommended pre-condition for ETCS infrastructure).

6.6.1.5 If data cannot be exchanged in one or both directions after receiving connection establishment indication CONNECT, the attempt shall be evaluated as a CED >10 s.

6.6.2 Intentionally deleted

6.6.3 Connection Loss Rate (CLR)

6.6.3.1 The Connection Loss Rate is defined as:

Number of connections released unintentionally per accumulated connection time.

6.6.3.2 The Connection Loss Rate shall be ≤ 10^{-2}/h (see justification in 10.4).

6.6.3.3 If the operational QoS-targets of [EEIG 04E117, §11.4] are required, then the ETCS infrastructure has to be designed in such a way that at least the following conditions are fulfilled (Recommended pre-condition for ETCS infrastructure):

- T_NVCONTACT ≥ 38.5s **and**
- M_NVCONTACT different to train trip **and**
- A new MA reaches the OBU before standstill.

6.6.4 End-to-end Transfer Delay (TD)

6.6.4.1 The end-to-end Transfer Delay of a user data block is defined as:

The delay between the delivery of the first bit of the user data block at the service access point of the transmitting entity and the reception of the last bit of the same user data block at the service access point of the receiving entity.

6.6.4.2 The end-to-end Transfer Delay of user data block of 28 octets shall be ≤0.5s (99%) (see justification in 10.5).

6.6.5 MA Transmission Violation Rate (MATVR)

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

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

6.6.5.3 The MA Transmission Violation Rate is defined as:

Number of MA Transmission Violations during the measurement time.

6.6.5.4 The MA Transmission Violation Rate shall be ≤ 10^{-2}/h (see justification in 10.6), assuming that:

1: ETCS “Perturbation location mechanism” for MA extension, according to [Subset-026, §7.4.2.14], is used by trackside (i.e. the OBU initiates a request for MA extension)

and

2: The ETCS “Perturbation location mechanism” is configured to allow the RBC 12s for MA transmission. (i.e. the timer for MA Extension Request results in a 12s transmission window before braking).

6.6.6 GSM-R Network Registration Delay (NRD)

6.6.6.1 The GSM-R Network Registration Delay is defined as:

Value of elapsed time from the request of registration to the indication of a successful registration.

6.6.6.2 The Network Registration Delay shall be ≤35s (99%), since NRD >40s is evaluated by the ETCS application as not successful (see justification in 10.7), assuming that the ETCS Trackside configuration ensures that there are 40s between passing Network Balise Group and Session Balise Group.

Note: A NRD >40s will cause a not successful L2 border crossing. The NRD performance, in accordance with 10.7, will be confirmed during operation.

6.6.7 Summary of QoS requirements

6.6.7.1 Table 1 summarises the QoS requirements specific for the CS mode.

Note: The description of the requirements and the applicable preconditions are specified in the preceding sections 6.6.1 – 6.6.6.

Table 1 Summary of QoS requirements (CS mode)

QoS Parameter	**Value**
Connection Establishment Delay of mobile originated calls (CED) (refer to chapter 6.6.1)	≤ 10s (99%)
Connection Loss Rate (CLR) (refer to chapter 6.6.3)	≤ 10^{-2} /h
Maximum end-to-end Transfer Delay (TD) (of 30 octets data block) (refer to chapter 6.6.4)	≤ 0.5s (99%)
MA Transmission Violation Rate (MATVR) (refer to chapter6.6.5)	≤ 10^{-2} /h
Network Registration Delay (NRD) (refer to chapter 6.6.6)	≤35s (99%)

6.7 Data bearer service in PS mode - QoS requirements

6.7.1 General information

6.7.1.1 ETSI [TS 103 328] specifies the minimum GPRS/EGPRS bearer service requirements necessary for ETCS operation.

6.7.1.2 The GPRS/EGPRS Guideline [O-8664] provides recommendations for GPRS/EGPRS parameters and system settings.

6.7.2 PS Service Setup (PS-SS)

6.7.2.1 PS Service Setup is defined according to "EoG principles and functionalities" [EEIG 11E017] as a sequence of actions for network registration, GPRS attach, and PDP context activation.

6.7.2.2 The PS Service Setup delay is defined as:

Value of elapsed time from the request for network registration to the indication of successful PDP context activation.

6.7.2.3 The PS Service Setup delay shall be ≤35s (99%), since PS-SS >40s are evaluated by the ETCS application as not successful (see justification in 11.2), assuming that

the ETCS Trackside configuration ensures that there are 40s between passing Network Balise Group and Session Balise Group.

Note: A PS-SS >40s may cause a not successful L2 border crossing. The PS-SS performance, in accordance with 11.2, is to be confirmed during operation.

6.7.2.4 After PDP context activation, the access to the ETCS network elements shall be verified by using DNS query. If data communication is not possible, the attempt shall be evaluated as a PS-SS >40 s.

6.7.3 GPRS Attach Delay (GPRS-AD)

6.7.3.1 The GPRS Attach Delay is defined as:

Value of elapsed time from the request for GPRS attach to the indication of successful GPRS attach.

6.7.3.2 Precondition: The Mobile Termination shall be registered to the corresponding GSM-R network.

6.7.3.3 The GPRS Attach Delay shall be ≤ 5s (99%), since GPRS-AD >5s is evaluated by the ETCS application as not successful (see justification in 11.2).

6.7.4 PDP Context Activation Delay (PDP-CAD)

6.7.4.1 The PDP Context Activation Delay is defined as:

Value of elapsed time from the request for PDP context activation to the indication of successful PDP context activation.

6.7.4.2 Precondition: The Mobile Termination shall be registered to the corresponding GSM-R network and successfully GPRS attached.

6.7.4.3 The PDP Context Activation Delay shall be ≤ 3s (99%), since PDP-CAD >3s is evaluated by the ETCS application as not successful (see justification in 11.2).

6.7.4.4 After PDP context activation, the access to the ETCS network elements shall be verified by using DNS query. If data communication is not possible, the attempt shall be evaluated as a PDP-CAD >3 s.

6.7.5 Transaction Transfer Delay (TTD)

6.7.5.1 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 (refer to 11.3.1.4) at the reference point I_{GPRS} to the indication of the acknowledging IP packet at the same reference point (see Figure 3).

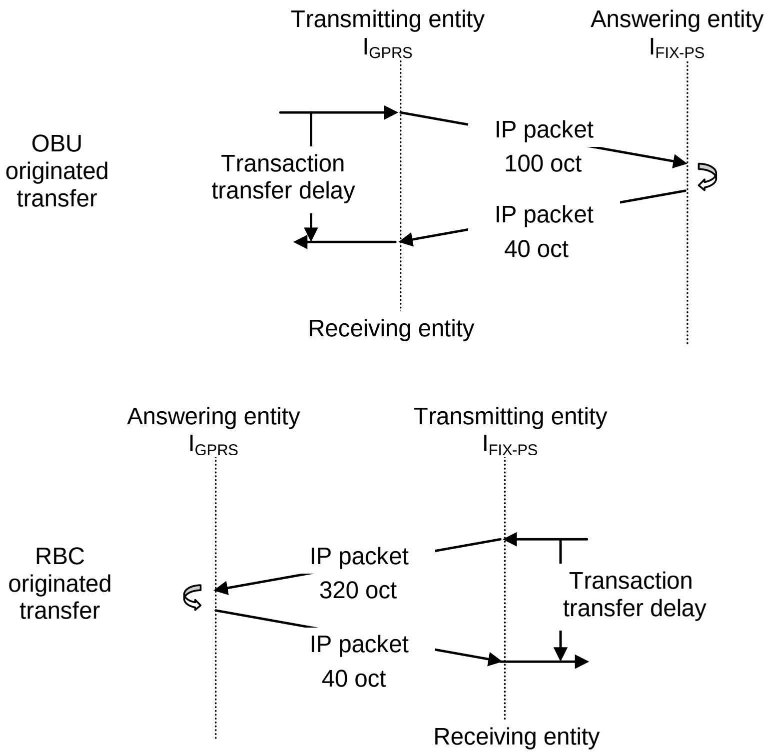

Figure 3: Transaction Transfer Delay

6.7.5.2 OBU originated data transfer according to Figure 3: The Transaction Transfer Delay including one 100 octet IP packet and one 40 octets IP packet shall be ≤ 2.6s (99%) (see justification in 11.3).

6.7.5.3 RBC originated data transfer according to Figure 3: The Transaction Transfer Delay including one 320 octet IP packet and one 40 octets IP packet shall be ≤ 3.0s (99%) (see justification in 11.3).

6.7.5.4 RBC originated data transfer according to Figure 3: The Transaction Transfer Delay including one 560 octet IP packet and one 40 octets IP packet shall be ≤ 3.5s (99%) (see justification in 11.3).

6.7.5.5 The processing delay of the answering entity shall not exceed 30 ms.

Note: These Transaction Transfer Delay figures include any delays e.g., associated with cell re-selection, or first-packet delay.

6.7.5.6 The maximum round-trip delay for a 560 octets IP packet within the fixed IP network shall not exceed 100 ms (see Figure 1: Gi to Gi via $I_{fix\text{-}ps}$ including the measurement equipment).

Note: The determination of these transactions can be combined in one measurement.

6.7.6 ETCS-DNS Lookup Delay (EDLD)

6.7.6.1 ETCS-DNS Lookup Delay is defined as:

Value of elapsed time from the resolution request (OBU) of RBC FQDN until the reception of the applicable RBC IP address.

6.7.6.2 Precondition: The Mobile Termination shall have an active PDP context.

6.7.6.3 The ETCS-DNS Lookup Delay shall be ≤ 3s (99%).

6.7.6.4 EDLD >5s is evaluated by the ETCS application as not successful (see justification in 11.4).

Note: This requirement includes the delay of the transmission network.

6.7.7 Summary of QoS requirements (PS mode)

6.7.7.1 Table 2 contains the summary of the end-to-end QoS requirements (PS mode).

Note: The description of requirements and the preconditions are specified in the preceding sections 6.7.2- 6.7.5

Table 2 Summary of QoS requirements (PS mode)

QoS Parameter	Value
PS Service Setup delay (PS-SS) (refer to chapter 6.7.2)	≤35s (99%) (see note to „Network Registration Delay”)
GPRS Attach Delay (GPRS-AD) (refer to chapter 6.7.3)	≤ 5s (99%)
PDP Context Activation Delay (PDP-CAD) (refer to chapter 6.7.4)	≤ 3s (99%)

Transaction Transfer Delay (TTD) OBU originated 100 octets RBC originated 320 octets RBC originated 560 octets (optional, if MAs in operation are smaller than or equal to 320 octets) (refer to chapter 6.7.5)	≤ 2.6s (99%) ≤ 3.0s (99%) ≤ 3.5s (99%)
ETCS-DNS Lookup Delay (EDLD) (refer to chapter 6.7.66.7.5)	≤ 3s (99%).

7. FIXED NETWORK INTERFACE REQUIREMENTS

7.1.1.1 The requirements are specified by [ER FFFIS].

8. MOBILE NETWORK INTERFACE REQUIREMENTS

8.1 Foreword

8.1.1.1 This part of the specification does not define mandatory requirements for interoperability. It is a preferred solution, in case interchangeability between OBU and Mobile Termination is required for a given implementation.

8.1.1.2 This section gives only limited information. [ER FFFIS] is to be used for full compliance.

8.2 Interface definition

8.2.1.1 If an MT interface is used at the Mobile Termination, the service access point at the Mobile Termination corresponds with the service access point of the MT; Interface $I_{GSM\text{-}R}$ (CS mode) or Interface I_{GPRS} (PS mode).

8.2.1.2 [ETSI TS 103 368] specifies a profile of AT commands and recommends that this profile is to be used for controlling Mobile Termination functions and GSM network services through a Terminal Adapter.

8.2.1.3 For the Mobile Termination type MT the signalling over the V-interface shall be in accordance with [ETSI TS 103 368], using the V.25ter command set.

8.2.1.4 State control using physical circuits is mandatory.

8.2.1.5 The V-interface shall conform to recommendation [ITU-T V.24]. The signals required are specified in [ER FFFIS].

8.2.1.6 Note that in the case of CS mode mobile originated calls, it is allowed to set the priority value “command control (safety)” at subscription time.

8.2.1.7 The call control AT commands applicable to CS mode, the AT commands to establish the PS mode service, the interface control AT commands and responses used on the V-interface at the service access point are specified in [ER FFFIS].

9. ANNEX A (INFORMATIVE) MA TRANSMISSION VIOLATION RATE (CS MODE ONLY)

9.1 General

9.1.1.1 The common principles of HDLC transmission are described in [Subset-037].

9.1.1.2 The usual QoS parameter used as measure of accuracy of data transmission via transparent B/B_m channels is the bit error rate.

9.1.1.3 The QoS parameter relevant for layer 2 accuracy is the HDLC frame error rate.

9.1.1.4 It is not possible to define relationships between the bit error rate and the HDLC frame error rate. The channel behaviour is not known: error bursts and interruptions of data transmission during radio cell handover can happen.

9.1.1.5 Additionally, statistical distributions of values such as error rates do not accurately map the requirements from the ETCS point of view. Transfer of user data is requested in bursts; the transfer delay can be critical for the application. It has to be guaranteed for some application messages that data can be transferred to the train within a defined time interval.

9.1.1.6 A model of service behaviour is necessary reflecting all relevant features of GSM-R networks.

9.1.1.7 This model can be used as a normative reference for acceptance tests and for network maintenance during ETCS operation. It enables the ETCS supplier to demonstrate the correct operation of ETCS constituents during conformance testing without the variations caused by GSM-R networks.

10. ANNEX B (INFORMATIVE) JUSTIFICATION OF QOS PARAMETER VALUES (CS MODE)

10.1 General

10.1.1.1 The railway operational targets have been analysed [EEIG 04E117]. From these current operational targets (to the ETCS application), QoS requirements to GSM-R networks have been derived.

10.1.1.2 The ETCS target values shall be further evaluated and confirmed by RAMS analysis.

10.1.1.3 [ERQoS] contains detailed calculations for the relevant ETCS scenarios.

10.1.1.4 In CS mode the data bearer service provides a transparent B_m channel. The QoS requirements are requirements to the bearer service.

10.2 Connection Establishment Delay (CED)

10.2.1.1 It is assumed that an unsuccessful connection establishment will cause train operation delays of less than 5 minutes.

10.2.1.2 The QoS target for operational train delays less than 5 minutes in the case of entry into ETCS L2/L3 is $2*10^{-5}$ /h [EEIG 04E117, table 6].

10.2.1.3 A complex derivation from [EEIG 04E117, table 6 and following text] suggests that a value $<10^{-4}$ is acceptable for entry into ETCS L2/L3.

10.2.1.4 If only one safe connection establishment attempt is possible, the Connection Establishment Delay shall be ≤10s (10^{-4}). In case of two attempts (as specified in 6.6.1.4) the probability of an unsuccessful entry into ETCS L2/L3 (caused by delayed connection establishment) is equal to the product of the probability to exceed the delay limit of both attempts. If the probability to exceed the delay limit is $<10^{-2}$, the probability of unsuccessful entry into ETCS L2/L3 is $10^{-4} = 10^{-2} * 10^{-2}$.

10.2.1.5 To trigger the second connection establishment delays >10 s will be evaluated as not successful and the connection process of the first attempt will be cancelled by the on-board communication system.

10.2.1.6 Balise groups must be placed on the approach to the ETCS L2/L3 area to ensure that GSM-R network registration takes place and an RBC session is established in reasonable time to allow the necessary ETCS messages to be passed when required. The positioning of these balise groups shall take into account the time needed to complete the registration and communication session establishment process at the applicable line speed.

10.2.1.7 Note: Specification of the overall delay for entry into ETCS L2/L3 is a matter of infrastructure engineering. A commonly used value is 40s in the case of existing GSM-R network registration (see [ERQoS]).

10.2.1.8 An RBC transition order must be sent by the handing-over RBC at the right time to ensure that a communication session is established with the accepting RBC to allow the necessary ETCS messages to be passed when required. The time needed to complete the communication session establishment process at the applicable line speed shall be taken into account.

10.3 Intentionally deleted

10.4 Connection Loss Rate (CLR)

10.4.1 QoS targets

10.4.1.1 The impact of the connection loss has been analysed by [EEIG 04E117 §11.4] for the case, that T_NVCONTACT does **not** expire.

10.4.1.2 The connection loss influences the MA propagation time. The ETCS message delay caused by connection loss indication and re-establishment of the ETCS safe connection (at least 22s according to [ERQoS] chapter 7) shall be added to the MA transfer delay (around 1s for a 200 octet MA). In case of a connection loss, the operational targets to MA extension <= 12s (99.9964% for Dedicated High-Speed lines [EEIG 04E117 §7.6.1]) can never be fulfilled.

10.4.1.3 If a connection loss happens, the probability increases that trains get delayed.

10.4.1.4 The QoS target for operational train delays of more than 5 minutes and less than 5 minutes in case of MA extension are described in [EEIG 04E117, table 6].

10.4.1.5 By eliminating the MA refreshment rate the value of $\leq 2.7 * 10^{-4}$ /h can be derived from [EEIG 04E117, table 6 and following text] for an operational delay of more than 5 minutes caused by an MA extension and $\leq 2.2 * 10^{-3}$/h for less than 5 minutes.

10.4.2 Conclusions

10.4.2.1 There is a direct influence of the QoS target for operational delays > 5 minutes on the Connection Loss Rate, if after connection loss and connection re-establishment the new MA does not reach the train before standstill, i.e. the requirement for Connection Loss Rate is $\leq 2.7 * 10^{-4}$ /h.

10.4.2.2 If after connection loss and connection re-establishment the new MA reaches the train before standstill, the train can be accelerated again. There is a direct influence of the QoS target operational delays <5 minutes on the Connection Loss Rate, i.e. the requirement for the Connection Loss Rate is $\leq 2.2*10^{-3}$/h.

10.4.2.3 In case of M_NVCONTACT = “Train trip”, it is irrelevant whether the MA reaches the train before standstill or not. An operational delay > 5 minutes will occur. In this case the requirement for Connection Loss Rate is $\leq 2.7 * 10^{-4}$ /h.

10.4.2.4 A Connection Loss Rate of $<10^{-2}$/h has been proven to be sufficient for the expected ETCS operation performance.

10.4.2.5 If after connection loss some delay for connection re-establishment is accepted, the calculations of [ERQoS] show:

a) The time without ETCS supervision caused by the re-establishment of the safe connection after connection loss is at least 22s. The Connection Loss Rate has a direct influence on the operational delay.

b) If 22s ≤ T_NVCONTACT < 38.5s, then one safe connection re-establishment attempt could be possible. The Connection Loss Rate has a direct influence on the operational delay.

c) If 38.5s ≤ T_NVCONTACT < 61s, then a second connection establishment attempt is possible. The probability of an operational delay (caused by connection loss) is equal to the product of the Connection Loss Rate and the probability to exceed the Connection Establishment Delay.

10.5 End-to-end Transfer Delay (TD)

10.5.1.1 For a robust behaviour of the HDLC protocol reliable transmission delays are necessary. The value is the base to determine the T1 timer value.

Note: Additional delay of 5s by connection loss indication has been taken into account.

10.6 MA Transmission Violation Rate (MATVR)

10.6.1.1 According to [EEIG 04E117, §7.6.1], there are three line categories (1-3) where the probability to receive an MA of 250 octets within 12 s is between 99.9967% and 99.9948%. In this context, the probability to receive an MA is considered to be 99.995% and the MA transmit interval is assumed to be 20 s.

10.6.1.2 The EuroRadio stack will generate one user data block (for one MA of 250 octets) of approximately 14 frames with 30 octets length each and will perform transmission error correction by using the HDLC protocol.

Note: An average MA has a length of 250 octets or 2000 bits. Including protocol overhead, approximately 4000 bits are transmitted. With the assumed HDLC frame length of 30 octets (300 bits including start and stop bit) this requires 14 frames.

10.6.1.3 Disruptions to the transmitted data will be assumed as not longer than 1.5 s (loop time 2*TD, shortest useful T1 timer).

10.6.1.4 If the entire MA message or parts of the MA message are erroneous, the retransmission of the necessary HDLC frames require up to 5.8 seconds. Considering a certain margin, the MA recovery time requires 7s without additional transmission disruptions.

10.6.1.5 The HDLC protocol tries to retransmit erroneous frames for an interval of several seconds. According to commonly used values, the retransmission interval is configured to be 6 seconds (using the combination of the HDLC parameters T1=1.5 s and N2=4). Multiple received erroneous frames up to 5 s will be covered if the subsequent contiguous 7 s transmission time is free of disruptions (MA expected to be received within 12 s).

10.6.1.6 Considering the timing of HDLC one additional retransmission can be tolerated within the MA transmission interval of 12 s.

10.6.1.7 In order to achieve a MA transmission probability of 99.995 %, one single MA transmission violation every 20.000 MAs is acceptable. Assuming that an MA is transmitted every 20 s, the transmission of 20.000 MAs takes about 100h. This implies that the MA Transmission Violation Rate is required to be equal or less than 10^{-2} /h.

10.7 Network Registration Delay (NRD)

10.7.1.1 The network registration has to be successful before reaching the announcement balise. If there is no registration passing this balise, the ETCS application will not try to connect the RBC. In this case the train will be stopped at the border to the L2/L3 area.

10.7.1.2 A commonly used value for this target value is 40s (see [ERQoS]), but could differ according to national definition [EEIG 04E117 §8.3].

10.7.1.3 The probability for unsuccessful connection attempt to the RBC is assumed with 10^{-4} (see 10.2). Because the unsuccessful registration at the announcement balise has the same effect, the probability for a network registration error has to be minor in relation to an unsuccessful connection attempt. Therefore, the probability for an NRD ≤ 40 s will be assumed with 99.999%.

10.7.1.4 Also, the probability for a network registration error can be redefined on national level [EEIG 04E117 §8.3].

11. ANNEX C (INFORMATIVE) JUSTIFICATION OF QOS PARAMETER VALUES (PS MODE)

11.1 General

11.1.1.1 ETCS L2/L3 requires mission critical data transfer. If a movement authority is not available at the right time, a train may brake - that is likely to cause an operational train delay. The operation of ETCS L2/L3 requires a guaranteed transmission transfer delay.

11.1.1.2 Burst errors can occur in radio networks. Such errors can induce additional delays because of retransmissions over the air interface.

11.1.1.3 In PS mode, the bearer service is connectionless and transmission resources are allocated on demand and released after no more data are to be transmitted. This aspect will be covered by the Transaction Transfer Delay requirements. Therefore section 6.7 does not contain explicit bearer service resource establishment QoS requirements.

11.2 PS Service Setup (PS-SS), GPRS Attach Delay (GPRS-AD), PDP Context Activation Delay (PDP-CAD)

11.2.1.1 The sequence of actions to establish the PS mode GPRS/EGPRS bearer services is:

- Network Registration (NRD)
- GPRS attach (GPRS-AD)
- PDP context activation (PDP-CAD)

Note: The GPRS attach may be part of the network registration (called “automatic GPRS Attach” -see [ER FFFIS]) or may be requested by a separate command to the MT.

11.2.1.2 If a MT is already registered in CS mode, then only GPRS attach and PDP context activation are necessary.

11.2.1.3 Note: Three use cases have been considered to establish the GPRS/EGPRS bearer service:

a) complete PS Service Setup (including network registration),
b) for GPRS/EGPRS islands (i.e. GPRS not enabled in adjacent cells): GPRS attach and PDP context activation without network registration, and
c) PDP context activation only.

A QoS requirement for use case b) is not specified. If necessary, the figure for use case b) can be calculated using the results of GPRS Attach Delay and PDP Context Activation Delay measurements.

11.2.1.4 There are only QoS requirements defined for case a). Because of the unchanged engineering rules the same value as for NRD - 40s (99.999%) - is assumed.

11.2.1.5 The GPRS-AD and PDP-CAD requirements are based on measurements on GSM-R networks and measurements performed by the Mobile Termination suppliers. They are used in the PS-SS sequence as timeout to limit the registration delay in case of networks not supporting PS services.

11.3 Transaction Transfer Delay (TTD)

11.3.1.1 Justification of the transaction transfer delay requirement: According to [EEIG 04E117 §7.6.1] the transfer delay requirement of a 250 octet MA at the interface between ETCS application layer and the safety layer is in the range of 4 - 5s on average and 12s (about 99.995%).

11.3.1.2 Measurements confirmed that a (MA request and MA extension) Transaction Transfer Delay at the service access point to the safety layer of a 200 octet message is about 1.56s on average, 1.67s (95%) and <=2s (99%). These values were gathered when four OBUs simultaneously used the same time slot of a GSM-R radio cell. Furthermore the values include upper layer processing times such as MAC computation and MAC check of the safety layer.

11.3.1.3 The lengths of the application messages are different depending on the transfer directions. Messages in an OBU-initiated transfer are generally smaller than in RBC-initiated transfer.

11.3.1.4 Additionally, the safety layer header and trailer (9 octets), the ALE header (10 octets), the TCP header (20 octets) and the IP header (20 octets) shall be added to the application message length to get the IP packet length.

11.3.1.5 The most commonly used application messages in OBU-initiated transfer are Position Report (33 octet) and MA request (51 octet). Hence, 100 octets are assumed as a typical IP packet length.

11.3.1.6 The most commonly used application message in RBC-initiated transfer is MA extension of about 250 octets. Hence, 320 octets are assumed as a typical IP packet length.

11.3.1.7 ETCS message length will not exceed 500 octets according to Subset-040. For the measurement, a maximum IP packet length of 560 octets is assumed.

11.3.1.8 The requirements are specified as transaction delay (round trip) having small acknowledgement IP packets to simplify the measurements. The length of the acknowledgement packet is assumed to be 40 octets (20 octets IP header and 20 octets content).

11.3.1.9 The QoS requirements are independent of the network load/radio access utilisation.

11.3.1.10 The different transactions i.e. RBC or OBU-originated can be combined in one measurement scenario but the transactions should be treated independently.

11.3.1.11 The average bandwidth during the measurement should not exceed the planned dedicated bandwidth requirement to one MT (up to 4000 bit/s according to [ER FFFIS, table 2-2]).

11.3.1.12 IP packet error ratio requirements are not specified. Erroneous radio blocks are detected and corrected on the lower layer air interface entities i.e. Radio Link Control protocol (see [ER FFFIS]).

11.3.1.13 De-sequenced or duplicated IP packets are not considered as errors for IP transmission. Therefore, the EuroRadio FIS [Subset-037] will manage these cases.

11.3.1.14 Compared to HDLC in CS-mode, the RLC/MAC layer in GPRS/EGPRS operated in acknowledged mode offers more advanced ARQ retransmission methods. These methods use pre-emptive transmission of radio blocks for pending acknowledgements and correct transmission errors locally over the air-interface by retransmitting erroneous radio blocks. Hence the RLC acknowledged mode operation in GPRS/EGPRS provides more reliable and faster data transmission over the radio interface than its HDLC counterpart (end-to-end transmission error correction) in CS-mode.

11.3.1.15 The requirements above are assuming, similar to what is explained for CS mode, that:

1: ETCS “Perturbation location mechanism” for MA extension, according to [Subset-026, §7.4.2.14], is used by trackside (i.e. the OBU initiates a request for MA extension); **and**

2: The ETCS “Perturbation location mechanism” is configured to allow the RBC 12s for MA transmission. (i.e. the timer for MA Extension Request results in a 12s transmission window before braking).

11.4 ETCS-DNS Lookup Delay (EDLD)

11.4.1.1 According to [Subset-037] the mobile foreseen for the ETCS communication will be started with active PDP context to be prepared for ETCS communication.

11.4.1.2 By an incoming communication request for an RBC supporting PS the following steps are necessary:

- Establishment of PPP protocol.
- ETCS-DNS lookup to provide the IP address of the specific RBC FQDN. Additionally, ETCS-DNS lookup is used to provide the information regarding whether a specific RBC supports data exchange in PS mode and possibly other information (e.g. values of parameter settings).
  - ⇨ 3s (99%) - based on measurements on GSM-R networks and measurements performed by the Mobile Termination suppliers

From the timing point of view this sequence corresponds with the connection establishment in CS case see CED – 10s (99%).

11.4.1.3 In order to reach the overall probability of 99% for both PPP establishment and EDLD (which are two sequential steps), the ETCS application processing timeout value for PPP establishment needs to be 3s and for EDLD 5s.

11.4.1.4 The lookup transaction includes the Transaction Transfer Delay of ETCS-DNS server request, DNS to OBU response and DNS processing time.

11.5 Reservation of radio resources

11.5.1 Packet flow context

11.5.1.1 The Packet Flow Context (PFC) is a feature in GPRS/EGPRS that manages the QoS characteristics of the traffic within the Base Station Subsystem domain. This feature is mandatory in case of “Mixed PS Traffic” mode operation in the network according to [TS 103 328].

11.5.1.2 PFC is requested for the operation of ETCS to allocate guaranteed bandwidth on demand compared to other ongoing non-ETCS packet data transfer(s) in the GSM-R/GPRS radio access network.

11.5.1.3 There are four traffic classes: conversational, streaming, interactive and background. Conversational and streaming traffic class support “Guaranteed Bit Rate” (GBR) resource type, and interactive plus background traffic class are part of the “non-Guaranteed Bit Rate” (non-GBR) resource type.

With GBR in mind, dedicated bandwidth will be allocated in the serving cell to the requesting user. The remaining bandwidth in the cell will be distributed to the non-guaranteed Bit Rate resource type according to a scheduling mechanism. The scheduling algorithm is implementation dependent.

Note: The total amount of requested GBR cannot exceed the maximum provided GPRS/EGPRS bandwidth of a GSM-R radio cell.

11.5.1.4 The use of GBR is required for ETCS data transfer. At PDP context activation, the ETCS application shall request the specific traffic class that supports GBR. The other QoS attributes are requested “as subscribed”, i.e. the QoS attributes defined in the HLR will be applicable (see [ER FFFIS].

11.5.2 Data transfer

11.5.2.1 If the number of ETCS users transferring data at a given time <u>exceeds the capacity</u> of the radio cell, the first accepted ETCS users with GBR will get the requested guaranteed bit rate, up to the possible GPRS/EGPRS capacity limit of the GSM-R radio cell. The remaining ETCS users will be downgraded to a profile without GBR and served by the remaining capacity in the cell according to their negotiated QoS profile.

Example: If five ETCS users are transferring data at the same time and the cell has a capacity to handle only three, the first three will receive the guaranteed bit rate and the remaining two will be temporarily assigned to QoS profile without GBR. The remaining two will be served by the bandwidth in the cell that remains after the GBR users are served. Within the remaining bandwidth, the usual traffic class and weighting mechanism applies to all users.

11.5.2.2 Cell re-selection during data exchange requires new negotiation of transport resources in the target radio cell, i.e. depending on the capacity and number of concurrent users in the target radio cell there is a risk for MS requesting GBR to be downgraded to a different QoS class with lower priority.

11.5.2.3 The assigned traffic class is kept until the release of the BSS context.

11.5.3 Guaranteed bit rate

11.5.3.1 The requirement for the guaranteed bitrate (GBR) is equivalent to the bitrate in CS mode. Current implementations confirm that the net bandwidth of BS25 of nearly 4000 bit/s will be sufficient for safe data traffic of ETCS.

11.5.3.2 The net bit rate for coding scheme CS2 is 12 kbit/s per GPRS time slot. If 4 kbit/s is selected as GBR, three simultaneous ETCS users may use one time slot. More users can share the time slot, but for those the bitrate is not guaranteed. Depending on the capacity of the cell, first ETCS users who request GBR will get the GBR.

11.5.3.3 To fulfil the requirements in section 6.7 proper traffic engineering is assumed.

12. ANNEX D (INFORMATIVE) USED PARTS OF [EEIG 04E117]

This annex contains sections of the document [EEIG 04E117] to give the reader of Subset-093 the access to these sections. The numbering in this annex corresponds with the original numbering. Not copied sections are signed by a "…"

…

Line Category	1	2	3	4	5
Typical profile	Dedicated High-Speed Line	High-Capacity Line	Low-Capacity Line	Urban Railways	Dedicated Freight
Line Speed (km/h)	160-350	120-230	120-160	Up to 140	120
Typical Speed (km/h)	300	200	160	120	100
Traffic	Passenger	Passenger and freight	Passenger and freight	Passenger	Freight
Traffic Density (trains per hour per direction)	15	8 (mixed traffic) 15 (passenger only)	Typically 2-10	30	Typically 12
Typical profile	Dedicated High-Speed Line	High-Capacity Line	Low-Capacity Line	Urban Railways	Dedicated Freight
Operational processes which determine track capacity	2 successive trains (same direction)	2 successive trains (same direction) Track branch to allow overtaking at certain locations	Crossing of 2 trains of opposite direction on a single track line Change of running direction	2 successive trains (same direction) Track branch to allow overtaking at certain locations	2 successive trains (same direction)

Table 1: Line Categories

…

Note: The analysis for the values used in the following section can be found in Annex E

7.3 Quality of Service Requirements

The QoS criterion T_{Total} for MA transfer and processing time for each track category requires the fulfilment of the average value of column (3) and the maximum values of columns (4) to (6):

Headway [min]	Trains/h and direction	Mean Value [s]	Δt smaller or equal 4s	Δt smaller or equal 7s	Δt smaller or equal 12s
(1)	(2)	(3)	(4)	(5)	(6)
2	30	4.02	49.7%	93.2%	99.9967%
4	15	4.07	48.7%	92.9%	99.9964%
7.5	8	4.24	45.3%	91.7%	99.9948%
30	2	7,83	2,8%	34.0%	98.1576%

Table 3. QoS criterion T_{Total} for MA transfer depending on track category.

Average value and distribution function can be illustrated as shown in Figure 8 for two of the defined line categories:

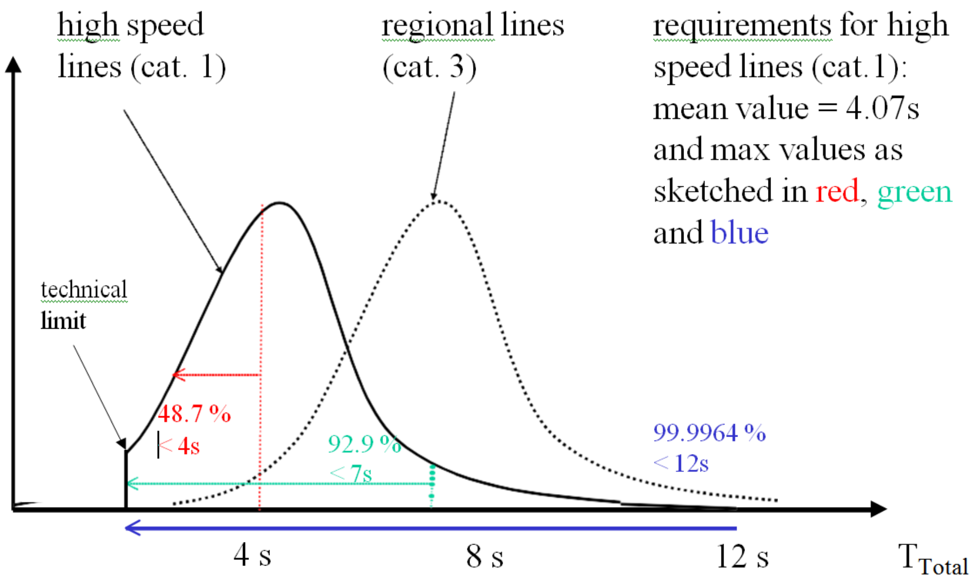

Figure 8. Statistical distribution of MA extension time.

Normally, ETCS Level 2 will be applied on lines without lineside signals. However, in certain circumstances, lineside signals will also be installed as described in the ETCS SRS (Chapter 2). Where lineside signals are also installed, these signals may be switched off or a special aspect used if a route is set for an ETCS equipped train. Some railways may not switch off the lineside signal aspects in which case the driver will receive information both from the lineside signals and the ETCS DMI. In these cases, the time difference between the aspect change and the corresponding DMI update should be reduced as much as possible for ergonomic reasons. A time difference of less than 5s should be achieved wherever possible.

7.4 Influences of MA Extension Scenario on ETCS/GSM-R QoS

From an operational point of view, late MA update results in a new MA only being received and displayed on the DMI after the Indication Point has been passed. Late update occurs when the MA update cycle exceeds the target value. The mean update time cannot be used as the performance target since this will result in delay in 50% of cases. A suitable target value must therefore be specified which will ensure that the top-level target is achieved, taking account of the apportionment of the top-level target between the relevant scenarios.

A bottom-up analysis can also be carried out based on a detailed study of the behaviour of the ETCS and GSM-R sub-systems. UNISIG documents UNISIG_ALS_ERQoS v.0.1.0 [5] and UNISIG_ALC_COM_SEL0452 v0.3.0 [6] provide such an analysis. The target value suggested by UNISIG in [6] covers the range 4.1s to 5.0s mean for a Baud rate of 4800 bit/s a BER of 10-4 and an MA length of 250 to 500 octets. This value does not allow for any perturbing effects such as HDLC frame repetition caused by interference or cell handover and can be taken as the perfect case value for this scenario. The equivalent mean value including effects of HDLC errors is quoted as 5.7s. The worst-case value is quoted as 12.5s (after the 6s position report time is deducted which is not relevant to this scenario). This worst-case value takes all normal perturbations into account (GSM-R cell handover) but excludes more serious effects such as burst errors due to electrical interference or a loss of communication. Hence, the normal case mean transmission time would be 4.5s for a 250 octet MA with a normal case maximum update time of 12.5s with a 750 octet MA. This leads to the conclusion that an MA update allowance of 12.5s maximum would ensure that all MA updates occur without operational delay (excluding effects of interference bursts and loss of communication). Note that this bottom-up analysis is included here for information purposes only. The QoS targets will be derived according to the top-down analysis described in Section 6.

A top-down analysis of the impact of QoS related delays is primarily concerned with operational delay, i.e. delayed arrival times. The relationship between delayed MA update and the consequential delay in terms of delayed arrival time needs to be determined. Transmission delays in excess of the normal case maximum transmission time will result in MA update taking place after the train has passed the Indication Point. The Indication Point represents the moment at which the driver becomes aware of the need to apply the brake. If we assume that the driver applies the brake manually on reaching the Indication Point, the train speed will have reduced by the time the updated MA is displayed on the DMI. The driver will then release the brake and apply power to return the train to the nominal line speed. This process is illustrated in Figure 9.

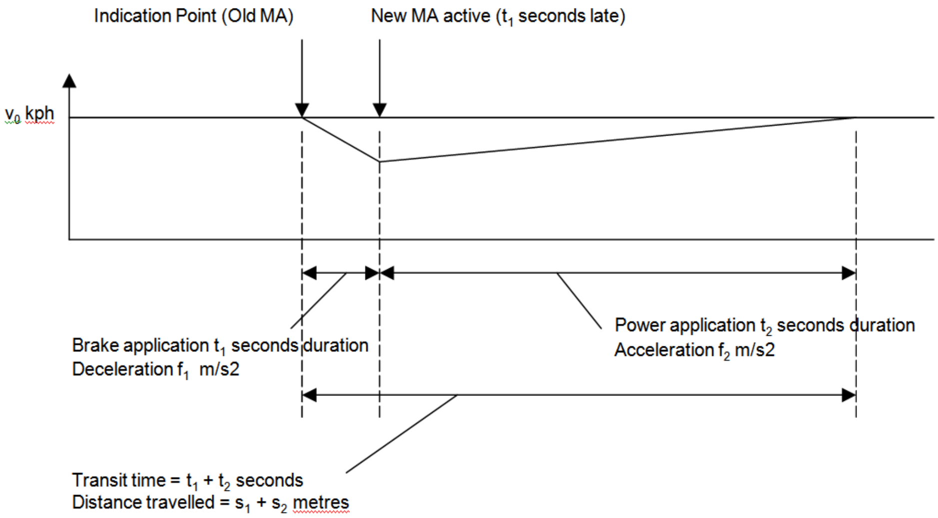

Figure 9: Late MA Update - Consequential delay

The magnitude of the operational delay is a function of the extent of the transmission delay and the train’s dynamic properties. This process is described in more detail in Appendix D.

For example, assuming driver initiated deceleration and acceleration characteristics of 0.5m/s2 and 0.3m/s2 respectively, a train travelling at 200km/h, will experience no delays for an MA update delay up to 10s. An operational delay of 9s would result from an MA update delay of 30s. These figures assume that the driver will make a partial service brake application within 1s of reaching the Indication Point. Hence, it can be seen that MA update delays in the range 0-10s are likely to have little impact in terms of overall journey times. Nevertheless, updates which occur after the train has reached the Indication Point are undesirable for ergonomic reasons and the potential passenger discomfort and energy wastage resulting from an unnecessary brake application. For this reason, the scenario success criterion that MA updates should be displayed before the train reaches the Indication Point remains valid.

Figure 10 shows the relationship between the MA update time distribution function and the resultant impact on journey time. It can be seen that the potential journey time delay is strongly influenced by the magnitude of the time margin between the mean MA update time and the target update time value adopted for ETCS/GSM-R QoS. The greater the QoS update time target, the smaller the impact on journey time. There is an upper limit associated with the MA update time, this is a function of the error recovery algorithms employed within Euroradio. Failure to deliver an MA update within this time limit results in a radio link failure being declared, refer to the Loss of Communication scenario.

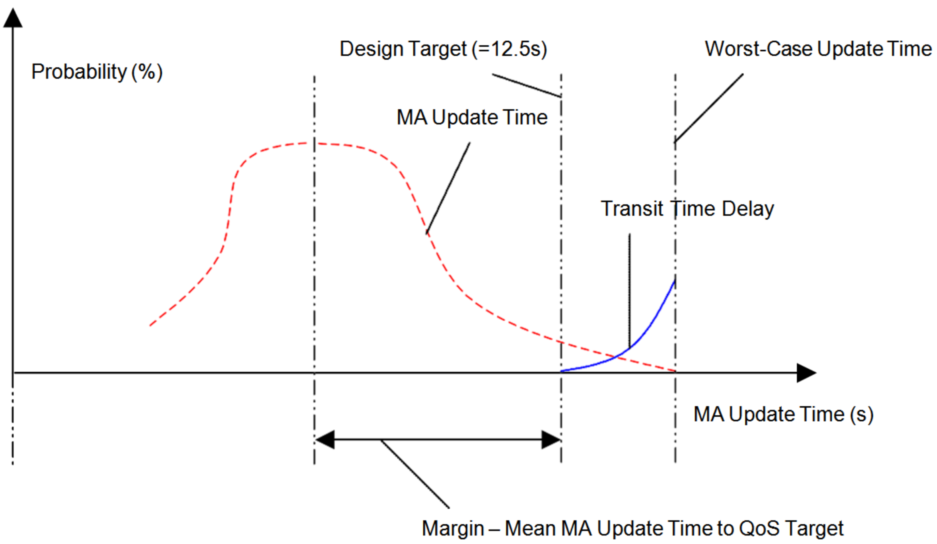

Figure 10: Relationship between MA update distribution and potential journey delay

As explained above, the resultant delay is dependent on the line speed and a particular train's dynamic characteristics at the same speed. Trains having a large deceleration to acceleration ratio will experience more delay in response to late MA update. Hence choice of an appropriate MA update allowance is dependent on the characteristics of the rolling stock using the line.

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7.6.1 Requirements Summary

The following operational requirements emerge from this analysis:

- The mean MA update response time (interlocking output to DMI update) shall lie in the range 4 to 5s for a 250 octet MA.
- The MA update time for a 250 octet MA shall not exceed 12s in 99.9967% of cases (Category 1 line), 99.9964% of cases (Category 2 line), 99.9948% of cases (Category 3 line) and 98.1576% of cases (Category 4 line).
- The signalling system shall be designed for an MA update time of 12.5s assuming a data transmission rate of 4800 Baud, BER of 10E-4 and a 750 octet MA. Where smaller values are required in time-critical locations, e.g. stations and junctions, this must be achieved by optimisation of MA size, data transmission rate and BER.

Note: the above requirements assume a GSM-R transmission with a BER of 10E-4 and a data transmission rate of 4800 Baud.

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8.3 Quality of Service Requirements

Section 8.2 concluded that there are two principal Quality of Service response time parameters applicable to the entry into Level 2 scenario, TGSMRREG and TANNOUNCEMENTL2/3. Appropriate target values for these parameters must now be considered. Note: the apportionment of the top level operational target to this scenario must be performed first as described in Section 13.

A prompt response to the manual registration order received from the trackside balise (see Section 8.1) is clearly preferable since this limit the extent of GSM-R coverage which must be provided in rear of the ETCS Level 2 area. The longer the time taken to complete the registration process, the greater the extent of GSM-R radio coverage that must be provided. Determination of the absolute value of TGSMRREG is largely an economic matter so far as the infrastructure elements are concerned. Appropriate values can therefore be determined at national level. In conclusion, the principal interoperability requirement so far as Quality of Service is concerned is the ability of a given network to complete the registration process within the nationally specified target value. The registration process will exceed this limit in a minority of cases leading to a failure to meet the fundamental objective of allowing a train to enter onto a Level 2 area without reduction of speed.

Hence, a defined confidence factor needs to be established for the probability of successfully completing the registration process within the nationally specified target value.

Likewise, the absolute value of the ETCS announcement parameter, TANNOUNCEMENTL2/3, is not significant in itself, provided the announcement balise is place sufficiently far in rear of the brake indication point (distant signal). As for the GSM-R registration process, the important consideration from the Quality of Service point of view is the confidence factor associated with achievement of the target value since values in excess of the target will result in failure to achieve the scenario’s fundamental performance objective. It is important to note that this parameter includes performance parameters related to ETCS, GSM-R (including associated fixed telecommunication links) and the national signalling system. The contribution of the wholly national elements, i.e. the GSM-R related fixed telecommunication links and the national signalling system should not be included within the derivation of the ETCS QoS parameters due to the wide variation in the performance attributes of individual national systems. These national systems have no impact on interoperability; nevertheless, an appropriate allowance must be made when formulating relevant national application engineering rules governing placement of the announcement balise.

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11.4 Analysis

A sequence of events is triggered when Euroradio detects of a loss of connection with the ultimate aim of re-establishing the connection between the Onboard and the RBC. This sequence is illustrated in Figure 19.

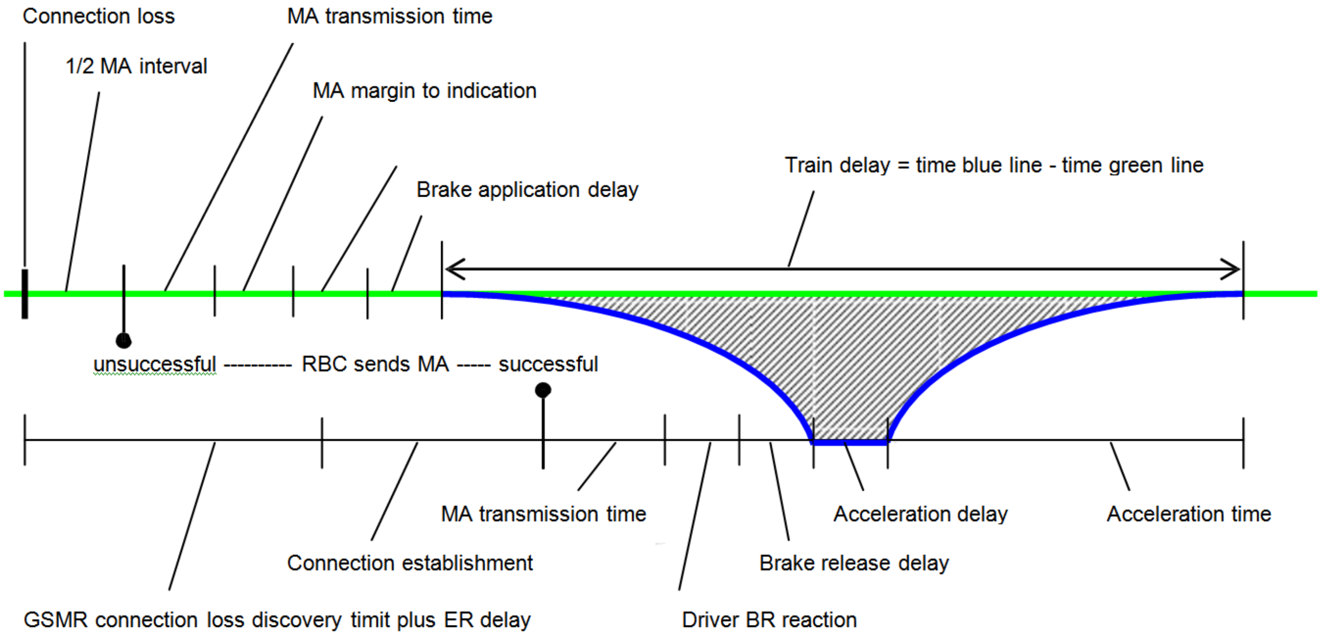

Figure 19: Loss of Connection

The scenario commences with a sudden break in communication between the Onboard and the RBC. Initially, neither party is aware that communication has been lost. Two independent processes are initiated following a break in the track to train communication link. These processes are described below:

Braking Process: Provided a valid MA is Onboard and no new MA is needed, the train will continue to run normally with the driver obeying the last transmitted MA. At some later point, a new MA would normally be received by the Onboard. Due to the fact that no communication session exists, the new MA will not be received when expected. The period of time between the break in communication occurring and the expected arrival time of a new MA could vary from zero (new MA required immediately) up to the normal MA refresh cycle (new MA just received). On average, this interval will be taken to be one-half of the normal MA refresh cycle. The new MA would normally be expected to be received and decoded with a small margin before it is actually needed, i.e. a small time prior to the Indication Point. The Indication Point represents the moment at which the driver becomes aware of the need to apply the brake to stop the train before the end of the current MA. As no new MA has been received, the driver will apply the brake in response to passing the Indication Point. The brakes will start to slow the train after a further delay corresponding to the brake system response time.

Re-establishment Process: In parallel with the braking process described above, the Euroradio layer will attempt to re-establish the connection with the RBC. A period of time is required by the GSM-R Mobile Station before the loss of connection is positively confirmed. Following detection of the loss of connection by the Mobile Station, the Euroradio layer is informed and the re-establishment process commences. The Euroradio layer will make a maximum of three reconnection attempts if necessary, however for the purpose of this analysis it is assumed that a successful reconnection is made on the first attempt. It is assumed that the new MA will be transmitted as soon as the communication link is restored. Following successful receipt of the new MA by the Onboard, the DMI will be updated and the driver will release the brake control after a short reaction time. The train speed will stop reducing after a further delay corresponding to the brake system response time. The driver will now apply power and after an acceleration delay the train speed will start to increase.

After some time, the train will regain its initial speed. The resultant operational delay is equal to the difference in transit times for the delayed train to cover the distance for which the train speed was travelling below the normal line speed compared with a train traversing the same route with no delay.

Taking the case of a Category 2 line with a nominal operational line speed of 200 kph, a delay of 28s will result, assuming the following typical train characteristics and ETCS parameter values:

Line speed	*200 km/h*
Block length	*1500 m*
Deceleration	*0.5 m/s2*
Acceleration	*0.3 m/s2*
MA to Indication margin	*3 s*
Driver reaction time (apply brake)	*1 s*
Driver reaction time (release brake)	*2 s*
Brake response time (apply and release)	*3 s*
MA Update time	*5 s*
Connection loss detection time	*10 s*
Euroradio delay (detection to re-establishment	*1 s*
Connection establishment delay	*40 s*

This result is typical of the delays which can be expected with high speed passenger trains operating on Category 2 lines. Other trains will be affected differently. For example, freight trains are likely to experience smaller delays due to their poorer braking capabilities.

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Category	Operational Delay, t [min]	Journey Duration [h]	ETCS QoS related MTBD (from Table 2) [h]	MA Extension MTBD/frequency [h] ([/h])	Awakening MTBD/frequency [h]/[/h]	Entry into L2 MTBD/frequency [h]/[/h]	QoS Target per MA extension [/h]	QoS Target per Awakening [/h]	QoS Target per Entry into L2 [/h]
Pure High Speed	>5	3	10000	11111 (100)	200000 (.33)	200000 (2)	9.0E-7	1.5E-5	2.5E-6
	0<t<5		1250	1389 (100)	25000 (.33)	25000 (2)	7.2E-6	1.2E-4	2.0E-5
High Capacity Line	>5	5	16667	18519 (100)	333333 (.2)	333333 (2)	5.4E-7	1.5E-5	1.5E-6
	0<t<5		2083	2315 (100)	41667 (.2)	41667 (2)	4.3E-6	1.2E-4	1.2E-5
Low Capacity Line	>5	4	13333	14815 (100)	266667 (.25)	266667 (2)	6.8E-7	1.5E-5	1.9E-6
	0<t<5		1667	1852 (100)	33333 (.25)	33333 (2)	5.4E-6	1.2E-4	1.5E-5
Urban Railways[8]	>2	1	5555	6173 (100)	111111 (1)	111111 (2)	1.6E-7	9.0E-6	4.5E-6
	0<t<2		926	1029 (100)	18519 (1)	18519 (2)	9.7E-6	5.4E-5	2.7E-5

Table 6: QoS Targets by Scenario

[8] Due to a different punctuality target for urban railways the QoS ETCS part is estimated to have a share of 30% of delays of more than 2 minutes and 90% for delays of less than 2 minutes.

The apportionment process described above represents one of a variety of methods by which appropriate QoS targets for ETCS can be derived. Nevertheless, the values given in Table 6 are intended to form a basis for the technical QoS requirements to be derived by ETCS and GSM-R supply industries.

Alternative apportionments can also be considered. For example, an apportionment based on the probability of a given operational delay per scenario could be proposed as follows:

- Entry into Level 2: operational delay >300s (Trip possible)
- Awakening: mean operational delay about 60s
- MA extension: typical delay as a maximum we assume 30s

Now we have to weigh the scenarios according to their influence on the top-level QoS targets:

- Entry into level 2: weighting factor: $\lambda_{L2} = 1$
- Awakening: weighting factor: $\lambda_{AW} = 1/5 = 5\ \lambda_{L2}$
- MA extension: weighting factor: $\lambda_{MA} = 1/10 = 10\ \lambda_{L2}$

So, the total probability of a disturbance due to ETCS, λ_{ETCS}, is given by

$$\lambda_{ETCS} = \lambda_{L2} + \lambda_{AW} + \lambda_{MA} = \lambda_{L2} + 5\ \lambda_{L2} + 10\ \lambda_{L2} = 16\ \lambda_{L2}$$

Taking the previous example of the Category 1 line and the >5 minute delay:

$$\lambda = \lambda_{ETCS} = 1 / MTBD = 10^{-4}\ [/h]$$

Hence:

$\boldsymbol{\lambda_{L2} = 1/16\ \lambda = 10^{-4} / 16 = 6.25 \times 10^{-6}}$ [/h] (one relevant event every 32 000h)

$\boldsymbol{\lambda_{AW} = 5/16\ \lambda = 10^{-4} * 5 / 16 = 31.25 \times 10^{-6}}$ [/h] (one relevant event every 160 000h)

$\boldsymbol{\lambda_{MA} = 10/16\ \lambda = 10^{-4} * 10 / 16 = 62.5 \times 10^{-6}}$ [/h] (one relevant event every 16 000h)

These targets are a little different to those given in Table 6. Values for the complete range of line categories and delay targets can be derived in the same way. Ultimately, any suitable apportionment can be used provided the top-level targets defined in Table 2 are respected.

13. ANNEX E (INFORMATIVE) DB, DRAFT: OPERATIONAL REQUIREMENTS TO GSM-R QUALITY OF SERVICE, V1.1, 3 AUGUST 2004

Draft: Operational Requirements to GSM-R Quality of Service

Because of the statistical character of the quality of service (QoS) parameters of GSM-R (e.g. a “maximum connection loss rate of x / hour”) it is necessary to define limits up to which regular railway operation under control of ETCS is possible or up to which a signal transmission delay caused by GSM-R is bearable for the railways, respectively.

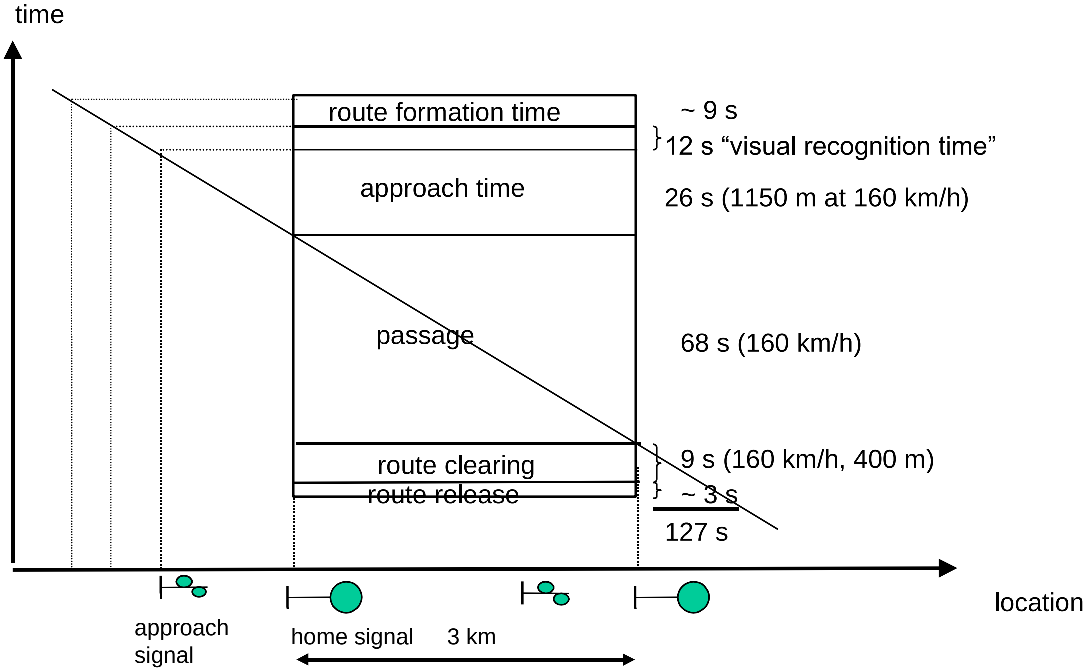
This Annex includes the information contained in a document taken as a basis for the calculations in [E117], which was a first draft provided by Deutsche Bahn AG at the time of writing [E117], concerning the maximum bearable transfer and processing time for a movement authority (MA) or MA extension from two points of view:

a) an acceptable value for the processing time for an MA which does not cause any train delay.
b) an acceptable value for the processing time for an MA which does not decrease the existing track capacity.

End to end delay of MA transfer and processing, $t_{MAdelay}$, means in this connection the total time delay from the entrance interface between interlocking and RBC to the interface between ETCS onboard unit and the train machinery.

Determination of occupancy time for a block section:

The following illustration shows all those processes which determine the total occupancy time of a 3 km block section of a line equipped with signals and a maximum permitted velocity of 160 km/h:



In case of an intermittent, signal based train control system, the "visual recognition time" requires that the trackside elements are set and the signal shows "green" 12 s before the train passes the approach signal to keep traffic fluent, because otherwise the driver would start to apply the service brake to stop the train as soon as he recognizes the approach signal indicating to stop ahead.

In case of a continuous train control system such as the German LZB or ETCS this "visual recognition time" represents the time at which an optical or acoustical signal informs the driver that a brake application point is ahead. Though this parameter is set to 8 s, in case of LZB the "visual recognition time" of 12 s has not been reduced in consideration of the required time to transmit the electric signal from the trackside to the train and for the processing time on board. This leaves up to $t_{MAdelay}$ = 4 s for signal transmission in case of LZB. Up to the same amount of time is acceptable for the transfer and processing of an MA from RBC to train in case that GSM-R works properly ("regular case")[1]:

$t_{MAdelay, ETCS} \leq$ 4 s as regular case

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[1] In case of running trains by an automatic train control system the information of a driver 8 s ahead of a signal is almost obsolete and the total visual recognition time of 12 s could be allocated to GSM-R / ETCS.

However, because of the statistical nature of the QoS of GSM-R and the technical processes of ETCS the amount of time to transfer and processing of an MA might rise in a worst case scenario up to 10 s and higher (this value needs to be confirmed / disproved by Unisig / GSM-R industry) which would cause delays or a reduction of track capacity. These two aspects will be illustrated in the following two examples:

Example a) Acceptable deviations from regular case – considering train delay

Assumption:

- 30 MA / hour will be transmitted to the train
- The DB includes a time reserve to the timetable of approximately 3.6 min / h (216 s). We assume that a train control system can consume a 10 % share[2] of this without any effect on punctuality. From these 10% we allocate another 1/3 share to ETCS / GSM-R.

Under these assumptions one MA transferred via GSM-R may be delayed by 216 s * 0,0333 = 7 s without any effect on punctuality. This means one out of all 30 MA (3.3%) may arrive 7 s late. In addition with the regular transfer and processing time of 4 s this would sum up to an overall transfer and processing time of 11 s.

The same calculation leads to an acceptable transfer delay for an MA of 19 s in only one out of 60 cases (1.7 %) or of 26 s in only one out of 90 cases (1.1 %).

Summary for transfer and process time of an MA $t_{MAdelay}$:

96.6 % $t_{MAdelay} \leq 4$ s
100 % $t_{MAdelay} \leq 11$ s

or:

98.3 % $t_{MAdelay} \leq 4$ s
100 % $t_{MAdelay} \leq 18$ s

or:

98.9 % $t_{MAdelay} \leq 4$ s
100 % $t_{MAdelay} \leq 25$ s

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[2] A recent analysis of delays gave the result that train control systems cause approximately a 10 % share of all delays.

A maximum limit for the delay is given by the parameter $T_{NVCONTACT}$ (40 – 60 s in Germany), because exceeding this time would result in several further problems. Besides, already values $t_{MAdelay}$ > 12 s (larger than the visual recognition time) can disturb operation because in case of tracks with traffic close to the limits of track capacity $t_{MAdelay}$ > 12 s would induce braking of a train.

Besides the influence of $T_{NVCONTACT}$ also safety aspects need to be considered: We are of the opinion that the only safety relevant cases in this connection are violations of routes. An investigation lead to the results that violations of routes are (1) very rare and (2) on routes with a permitted speed larger than 160 km/h route protecting points are required which reduce the possibility of a violation further. This leads us to the conclusion that the requirements derived from operational needs are tougher than those based on safety aspects. Therefore, safety aspects in connection with transfer delay will not be dealt with further in this paper.

Example b) Acceptable deviations from regular case – considering track capacity

The second approach considers track capacity. The time to transmit a movement authority from interlocking to driver's display is part of the occupancy time (see above), an increase beyond the present value of 4s means a reduction of track capacity. We therefore derive requirements for the QoS of data transfer under the restriction that no significant reduction in track capacity compared to LZB is acceptable. A criterion could be: *The calculated value for the track capacity is not reduced by more than 0.5 tracks every tenth day.* In reality, of course, this does not mean the loss of a track (which could not be sold then) but rather leads to a reduction of time reserves.

The following example shall illustrate this for a typical line with passenger and freight traffic and a nominal capacity of 144 trains per day and direction which means a mean headway of 10 min (1440 min / 144 trains). In fact, to reach a high operational quality this headway of 10 min follows the DB rule to keep round about one track free between two occupied tracks. This allows to insert a delayed train between two punctual trains without affecting them and means, the minimum mean headway in this case is 5 min (300 s). The mean headway of 5 min shall already include an MA transfer time of $t_{MAdelay}$ = 4 s.

(1440 * 60 seconds) / (2 * 300 seconds) = 144 trains per day and direction

In case that the value for the MA transfer time, $t_{MAdelay}$, increases from 4 s to 5 s the track capacity decreases to:

(1440 * 60 seconds) / (2 * (300 + 1) seconds) = 143.52 trains per day and direction

As a result we get for this typical track the following requirement concerning QoS of data transfer:

The value for the transfer time of an MA of $t_{MAdelay}$ = 4 s is allowed to reach up to 5 s on 10 % of days.

To derive a mathematical expression for this requirement for all track categories which were defined by the QoS working group, we proceed in the following way:

To take into account the statistical nature of data transmission we admit the following exception from the strict rule $t_{MAdelay} \leq 4$ s:

1. The 4 s are allowed to be an **average** value not a maximum value.
2. On 9 days the average value for $t_{MAdelay}$ = 4 s must be fulfilled, on the tenth day an increase depending on the track's capacity as calculated in column (3) of the table below can be accepted. The example of a headway of 5 min from above is also included.

We further assume that rules of statistics can be applied here. The distribution of the average values of $t_{MAdelay}$ per day (i) can be described by a distribution function $f_i(x)$ with a mean value μ_i. On 9 days μ_i = 4 s and on the tenth day as in column (3). If we further assume that the distributions are independent from each other, we can describe them by one distribution function with a mean value as in column (4). This mean value is the acceptable mean value for $t_{MAdelay}$.

headway [min]	trains / h and direction	average value μ on 10th day [s]	acceptable mean value for $t_{MAdelay}$ [s]
(1)	(2)	(3)	(4)
2	30	4,17	4,02
5	12	5,04	4,10
4	15	4,67	4,07
7,5	8	6,35	4,24
30	2	42,25	7,83

c) Table 1

The specification of a mean value is not sufficient for a complete definition of QoS for data transfer. To further derive upper limits for $t_{MAdelay}$ we have assumed $f_i(x)$ to be normal distributed with the acceptable mean value of the table above and $\sigma^2 = 2$ [3]. This definitely does not represent a correct image of the real distribution of $t_{MAdelay}$ but this is not necessary in this case anyway. The assumed distribution function is only a tool to derive values for a QoS criterion which considers track capacity. This finally leads to the following:

[3] The motivation to set σ^2 to 2 was to allow a very small amount of transfer times to be even larger than those 12s which cause only minor operational disturbances (column 6 in table 2).

- The track capacity sets the higher requirements concerning QoS.
- The requirements derived here are essential for those tracks which make use of the full theoretical track capacity, this is the case particularly in knots. Outside of knots larger transfer delays may have no effect on operational quality.
- The upper limit for $t_{MAdelay}$ is set to 12 s because a larger value can induce braking of a train.

These results are summarized in the table below:

The QoS criterion for MA transfer and processing time for each track category requires the fulfillment of the average value of column (3) and the maximum values of columns (4) to (6):

headway [min]	trains / h and direction	mean value [s]	Δt smaller or equal 4 s	Δt smaller or equal 7 s	Δt smaller or equal 12 s
(1)	(2)	(3)	(4)	(5)	(6)
2	30	4,02	49,7%	93,2%	99,9967%
4	15	4,07	48,7%	92,9%	99,9964%
7,5	8	4,24	45,3%	91,7%	99,9948%
30	2	7,83	2,8%	34,0%	98,1576%

Table 2

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