ERTMS USERS GROUP - ENGINEERING GUIDELINE

77. LEVEL TRANSITION FROM LEVEL NTC TO LEVEL 2

Ref:	19E129
Version:	3-
Date:	22/09/2021

Modification history

Version	Date	Modification / Description	Editor
0.1	04/03/2019	Format change from ERA_040039 document V2.0	DC
0.2	08/05/2019	Update for Baseline 3 trackside, feedback from ESG74	WL
0.3	14/06/2019	Update based on ESG75	WL
0.4	09/07/2019	Update according to ESG76	WL
1.0	10/10/2019	Version 1.0 release	ESG
1.0a	20/02/2020	Added issue of odometric error for max/min safe front end-based supervisions.	AB
1.0b	15/05/2020	Update based on ESG83	ATJ, GR
1.0c	26/05/2020	Error corrections	GR, WL, AJM
2.0	07/07/2020	Version 2.0 release	ESG
2a	25/06/2021	Opinion ERA-OPI-2020-2 incorporated	WL
2b	29/06/2021	Update after ESG92 Allocation of EUG document code 19E129	GR
3-	22/09/2021	Version 3 release	ESG

Table of Contents

1. Introduction

1.1 Foreword

1.1.1.1 The procedure for level transitions is defined technically in chapter 5 of the SRS (see [SS026]) and operationally the harmonised ETCS rules apply (see [OPE]) in addition to national rules. The procedures possible for transitions from level NTC to level 2 are very flexible and currently there are many different ERTMS implementations dealing with this issue.

1.1.1.2 The aim of this document is to define a set of recommended trackside solutions for the engineering of transitions from level NTC to an area only equipped for level 2 for the benefit of future ERTMS projects. The objective is to support an efficient and safe implementation of ERTMS, both from a technical and operational point, simplifying and harmonising future system implementations taking advantage of the experience obtained from projects already in operation.

1.2 Scope & field of application

1.2.1.1 This document is based on ERTMS/ETCS Baseline 3 Release 2 including [OPINION ERA 2020-2] and applicable for transitions from an area only equipped with level NTC to an area only equipped with ETCS Level 2.

1.2.1.2 Some ERTMS functions, controls or information are considered out of scope of this document because they are not directly related to the transition procedure:

- The route suitability check in rear of a level 2 area depends on many local issues such as national procedures, national rules, type of unsuitability, the geographical location of the unsuitability and places to stop trains if not suitable. Thus, the route suitability function is considered out of scope for this document.
- Track conditions information is considered as general information to be sent to the train not linked only to the transition and thus out of scope for this document.

1.2.1.3 Preventing trains that are not fitted with ERTMS/ETCS onboard equipment from entering the ETCS Level 2 area is out of the scope for this document.

1.2.1.4 It is strongly recommended that any entity using ERTMS/ETCS follows the recommendations defined in this document.

1.3 Applicable system versions

1.1.1.1 Table 1 describes which trackside and onboard system versions are managed by this guideline. It also describes in which guidelines other system version combinations are managed.

	Trackside System Version	
Onboard System Version	1.Y	2.Y
1.Y	ERA_ERTMS_040039	Not applicable
2.Y	ERA_ERTMS_040039	This guideline

1.1.1.2 This guideline is applicable for a Baseline 3 Release 2 including Art10SP(2017) trackside with system version 2.1.

1.1.1.3 However, this guideline takes into consideration the following onboard systems:

- onboard systems supporting version 1.Y and 2.Y, with active system version 2.Y when approaching the level transition, i.e.: B3 MR1, B3 R2 and B3 R2+Art10SP(2017) onboards.

1.4 Document description

1.4.1.1 Chapter 1 introduces the document and defines the scope.

1.4.1.2 Chapter 2 provides references, terms and abbreviations used in this document.

1.4.1.3 Chapter 3 provides the general functional steps for transition to level 2.

1.4.1.4 Chapter 4 provides the criteria assessed for the recommendations.

1.4.1.5 Chapter 5 provides the recommendations for each functional step.

1.4.1.6 Appendices provide details about radio issues.

2. References

2.1 Reference documents

Ref. N°	Document Reference	Title	Last Issue
[OPE]	TSI OPE Annex A	Annex A, TSI OPE, 2012/464/EC, ETCS rules and Principles	4
[SS026]	SUBSET-026	ERTMS/ETCS Class 1 System Requirements Specification	3.6.0
[SS037]	SUBSET-037	Euroradio FIS	3.2.0
[SS041]	SUBSET-041	Performance Requirements for Interoperability	3.2.0
[SS093]	SUBSET-093	GSM-R Interfaces: Class 1 Requirements	2.3.0
[EUG_69]	EUG_69	Automatic Track Ahead Free (B3)	2.0
[OPINION ERA 2020-2]	Opinion ERA-OPI-2020-2	OPINION OPI 2020-2 OF THE EUROPEAN UNION AGENCY FOR RAILWAYS for European Commission regarding Error Corrections to the CCS TSI	-

Table 1: Reference documents

2.2 Terms and abbreviations

2.2.1 Terminology

TERM	DEFINITION
ETCS approach area	The area in rear of the ETCS border where balise groups are located to facilitate the transition to ETCS Level 2
ETCS area	The area in between ETCS borders with infrastructure for trains running in ETCS levels 1, 2 or 3
ETCS border	The location where the ETCS level is changed
On-sight route	A locked route which is not unambiguously detected free

2.2.2 Abbreviations

ATP	Automatic Train Protection (national systems)
BG	Balise Group
DMI	Driver Machine Interface
EoA	End of Authority
FS	Full Supervision (ETCS mode)
LRBG	Last Relevant Balise Group
L2	ERTMS/ETCS Level 2
LNTC	ERTMS/ETCS Level NTC
LTA	Balise group for Level Transition Announcement
LTC	Balise group for Level Transition Cancellation
LTO	Balise group for Level Transition Order
M	Message, e.g., M3 is ERTMS message 3
MA	Movement Authority
NR	Balise group for Network Registration
OS	On-sight (ETCS mode)
P	Packet, e.g., P41 is ETCS packet 41
QoS	Quality of Service (radio network)
RBC	Radio Block Centre
REF	Balise group used as reference
SE	Balise group for Session Establishment
SoM	Start-of-Mission; procedure for start-up of an ERTMS/ETCS train
ST	Balise group for Session Termination

STM	Specific Transmission Module (for national ATP systems)
TAF	Track Ahead Free
TSR	Temporary Speed Restriction

3. Transition from level NTC to level 2

3.1 Introduction

3.1.1.1 This chapter intends to give a general overview of how to perform a transition from level NTC to level 2 and can be used as a reference for the issues discussed in chapter 4. The track layout and sequence diagram presented here are further detailed in chapter 5, e.g., with alternative solutions as applicable for each functional step.

3.2 Functional Steps

3.2.1.1 To facilitate the recommendations detailed in chapter 5, the transition to level 2 is divided into the following functional steps:

1) Radio Network registration
2) RBC connection establishment
3) Level 2 announcement and MA
4) Level 2 transition

3.2.1.2 The successful transition to level 2 requires that each of these steps are completed before the next is performed.

3.3 General Track Layout

3.3.1.1 The following drawing shows the general and relevant track design and balise groups needed to perform the different functional steps of the transition from level NTC to level 2 listed in paragraph 3.2.1.1. There are intentionally no signals shown in the figure as they are not relevant for the transition procedure as such from a technical point of view.

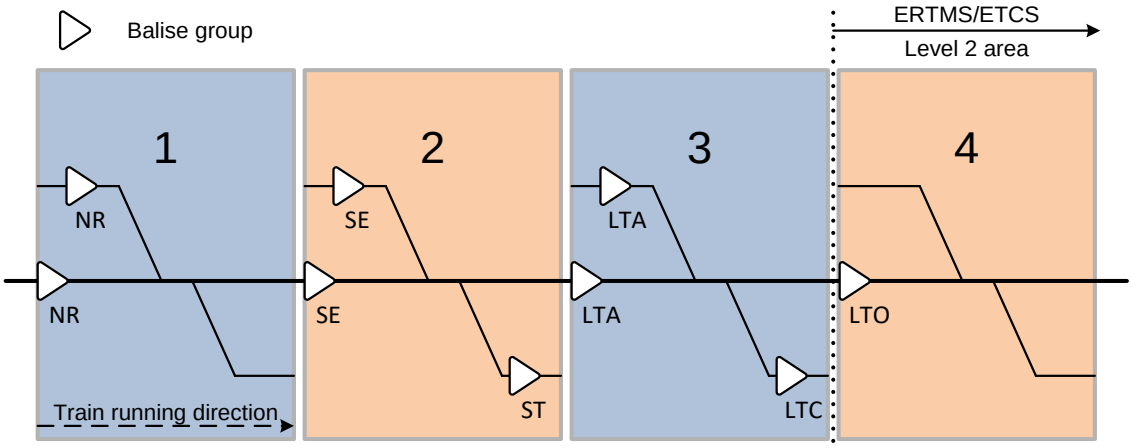


Figure 1: Generic track layout for transition from LNTC to L2

3.3.1.2 The table below represents the balise groups and information (in ETCS packets) needed for each functional step to succeed with a transition from level NTC to level 2. Alternative solutions will be suggested in chapter 5.

BG	BG DESCRIPTION	BG INFORMATION (ETCS PACKETS)
NR	Radio Network Registration	Packet 45: Radio Network Registration with the identity of the GSM-R network
SE	Session Establishment	Packet 42: Session Management with order to establish communication session with the RBC (including ETCS identity + telephone number)
ST	Session Termination	Packet 42: Session Management with order to terminate the session with the specified RBC
LTA	Level Transition Announcement	Packet 41: Level Transition Order announcing the coming transition to level 2 at the ETCS border In case of announcement by the RBC, the balise group doesn't contain packet 41, the LTA balise group is only used as unambiguous location reference for the RBC (REF).
LTC	Level Transition Cancellation	Packet 41: Level Transition Order with immediate transition to the level applicable in that area; this cancels the announced transition to level 2 Packet 42: Session Management with order to terminate the session with the specified RBC
LTO	Level Transition Order	Packet 41: Level Transition Order (with immediate transition to level 2)

Table 2: Balise groups for transition from LNTC to L2

3.3.1.3 The information in the balise groups in the figures is only valid in the indicated train running direction, unless defined otherwise.

3.3.1.4 Balise group NR orders the train to register with the appropriate radio network. This means that the network must be available at this location.

3.3.1.5 Balise group SE orders the train to establish communication session with the RBC. The RBC contact information is stored onboard the train.

3.3.1.6 Balise group ST orders the train to disconnect with the RBC if in a route diverting from the ETCS border. Alternatively, ST can be left out if SE has a switchable balise with information depending on route locking; this is elaborated in step 2 in section 5.2.4.

3.3.1.7 Balise group LTA can be used to announce the transition to level 2 and is also an important location reference for the RBC to be able to give MA to the train. If the RBC announces the level transition, the LTA is only used as location reference (REF). There must be one such balise group and if possible, the LTA is placed where there are no more tracks diverging from the border.

3.3.1.8 Balise group LTC is needed for cancelling a level transition order in case there are diverging tracks between LTA and the ETCS border. This balise group should also order the train to disconnect with the RBC.

3.3.1.9 Balise group LTO is located at the ETCS border and orders the immediate transition to ETCS Level 2.

3.3.1.10 Note: As mitigation for the issue described in CR1311 [OPINION ERA 2020-2] it is recommended to include the value "1" for Q_SLEEPSESSION for all session termination orders.

3.4 General Sequence Diagram

3.4.1.1 The following sequence diagram shows the relevant information that is exchanged between the main actors when performing the four functional steps listed in 3.2.1.1 above.

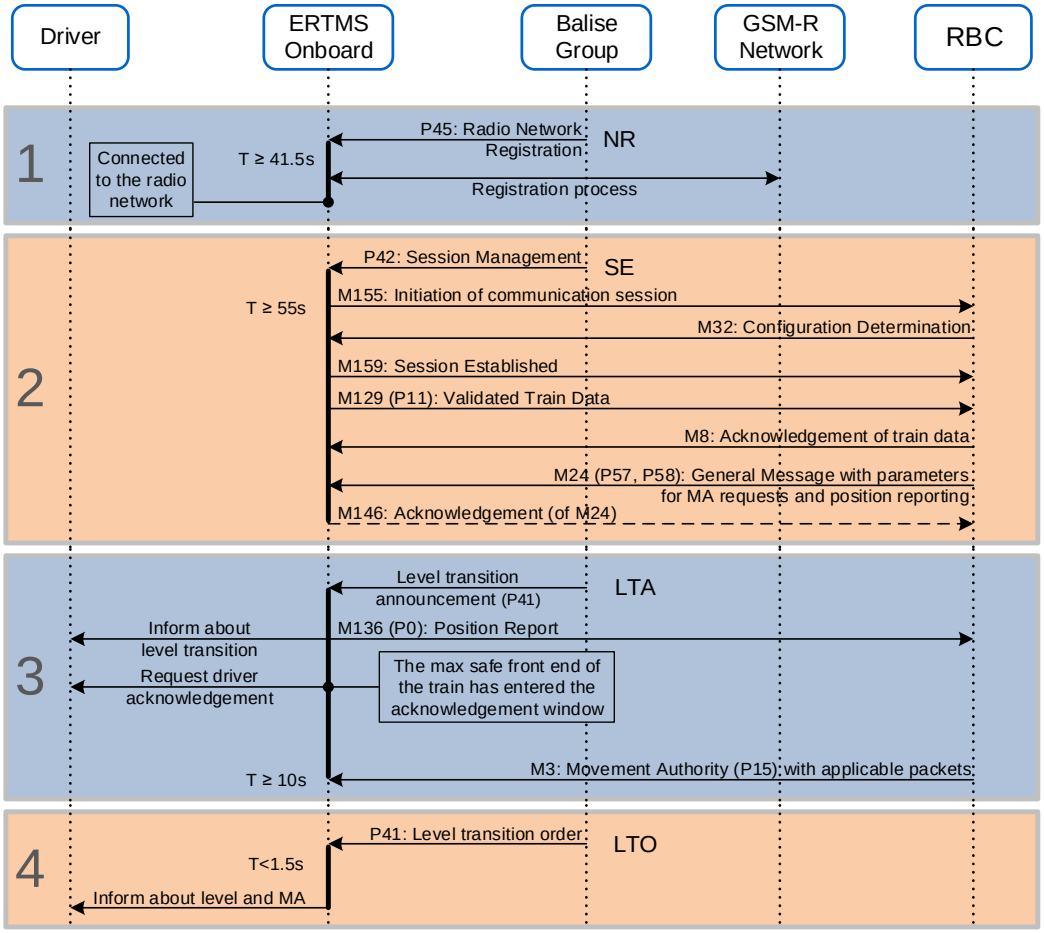


Figure 2: General sequence diagram for transition from LNTC to L2

3.4.1.2 The information exchange and the time required for that are further detailed for each functional step in chapter 5. The dashed arrow in step 2 is not absolutely needed because the level transition will take place also without it.

3.4.1.3 The information exchanged between the ERTMS/ETCS onboard and the RBC after the communication session has been established in step 2 is necessary for the correct functioning, as otherwise the train may not get or accept MA and will then be tripped if passing the ETCS border. This is further explained in 5.2.3.6 and 5.2.3.7 as a prerequisite for the events in step 3.

3.4.1.4 The diagram above does not represent all the mandatory information exchanged by the relevant actors but defines in general the different functional steps that are considered in this document for the recommendations given in chapter 5.

4. Issues to be addressed

4.1 Introduction

4.1.1.1 This chapter lists the issues that need to be considered for the transition from level NTC to level 2 and some of them are further detailed in the recommendations given in chapter 5. The issues that are not part of the recommendations are mentioned here because projects could still need to consider them.

4.1.1.2 After establishing a communication session between a train and the RBC, the two main issues are to determine where this train will enter the ETCS area and that it is this train that actually enters, i.e., to make sure that the RBC gives the correct Movement Authority to the correct train.

4.2 Issues

4.2.1 Entry location determination

4.2.1.1 For a successful transition to ETCS Level 2, it is essential that the trackside system is able to determine at which ETCS border location an approaching train will enter as otherwise the train will not have any Movement Authority and thus being tripped when making the transition to level 2 after passing the border.

4.2.1.2 The entry location is determined by having an unambiguous location reference for the RBC, i.e., the train must report a position by which the RBC is able to determine where the train will enter its area.

4.2.1.3 The possibility for the RBC to determine where the train will enter depends on the track layout in the area in rear of the ETCS border, i.e., on the presence of points.

4.2.1.4 The RBC can determine the entry location in the following ways:

- by a position report with LRBG in an unambiguous route to the border
- by a position report supported with route information from the Interlocking
- by an MA request with information identifying the border location (packet 9) initiated by the information “Track Ahead Free up to level 2/3 transition location” (packet 90) given by a switchable balise

4.2.1.5 Note that to be sure that a train reports its position on each balise group, the position report parameters should be sent to the trains after establishing a communication session as otherwise a train may use inappropriate parameters.

4.2.1.6 Note that the alternative of using packet 90 only works when the track from the balise location up to the ETCS border is free, but then it also solves the problem to determine the first entering train.

4.2.1.7 Considerations for the entry location determination are further detailed for functional step 3 in section 5.3.

4.2.2 First entering train determination

4.2.2.1 For a safe and successful transition to ETCS Level 2, it is essential that the ERTMS system is able to assure that there is no other train between a certain ETCS border location and the ERTMS/ETCS train the RBC expects to be entering at that border location. This must cover multiple track occupations by vehicles known or not known by the RBC on the approach to the ETCS border, e.g., when driving on-sight or splitting trains before the border.

4.2.2.2 This problem can be solved either before or after the border to the ETCS area by checking that the train is the correct one. The recommended solutions are described for functional step 4 in section 5.3.5.10.

4.2.3 Loss of route protection in the route from the ETCS border

4.2.3.1 There must be a safe reaction in case one or more conditions supervised to protect the route in advance of the ETCS border fail, e.g., due to unexpected track occupations or emergency stops initiated by staff or automatic systems.

4.2.3.2 The system that detects the loss of route protection is responsible to take action to resolve the hazardous situation, e.g., by informing the RBC and the adjacent national system to try to stop an affected train. The RBC can then withdraw the authorisation it has given for the ETCS area by a shortened MA or by an Unconditional or Conditional Emergency Stop message (the MA or Emergency Stop message will be evaluated as soon as the level transition has occurred). Note: An Unconditional or Conditional Emergency Stop message that is in the transition buffer cannot be revoked as long as the train is in level NTC.

4.2.3.3 Another possible mitigation, for example if the national system cannot provide a mitigation, is to install a switchable balise group at or in rear of the ETCS border which gives a transition order to ETCS Level 1 and a L1 stop order in case this route is not protected; in addition it requires a balise group at or in advance of the border with an immediate transition order to level 2. This is also proposed as an alternative solution for determining the first entering train in 5.4.8.

4.2.3.4 There is no direct impact on the transition procedure, only on the possibility to approach and pass the ETCS border. Thus, this issue is not further considered in chapter 5.

4.2.3.5 Note that erroneous track occupations that mimic normal passage are part of the problem to determine the first entering train; this can also be solved with the switchable balise proposed in 4.2.3.3 above.

4.2.4 Authorisation across the ETCS border

4.2.4.1 The authorisation for the train to pass the ETCS border is the responsibility of the national system; this is a project issue and therefore not considered in chapter 5.

4.2.5 Allow level transition at line speed

4.2.5.1 Trains approaching the ETCS area should not face speed restrictions caused by the transition procedure to ETCS Level 2, e.g., lowered speed to compensate for delays in processing or the radio network.

4.2.5.2 This operationally important goal is achieved by correct engineering of the ETCS approach area and the GSM-R network.

4.2.5.3 The recommendations in chapter 5 take into account that the level transition can be done at line speed for the nominal situation, but to cover also degraded situations there is need for additional considerations, e.g. extending the ETCS approach area and repeating information in balise groups, which could be in contradiction with other criteria in this chapter.

4.2.5.4 This is not further considered in chapter 5 as each project must decide for which situations the level transition should be possible at line speed and make the additional provisions for that, e.g., for start-of-mission near the ETCS border.

4.2.5.5 Note that this is partly an engineering issue for the first block in the ETCS area as the speed supervision in the ERTMS/ETCS onboard may be more restrictive than for the NTC area. Thus, it might not be possible to approach the ETCS border at the line speed allowed in that area unless the first block section in the ETCS area is long enough to avoid an immediate brake intervention after making the transition to level 2.

4.2.6 Avoid transition announcement for diverging trains

4.2.6.1 Vehicles moving in the ETCS approach area should not receive a level transition announcement (which has to be displayed to the driver) or be forced to make a level transition unless they are routed to the ETCS border.

4.2.6.2 If the announcement cannot be avoided, then it must be cancelled before the level transition is performed by the ERTMS/ETCS onboard.

4.2.6.3 This problem can be avoided if using a switchable balise to announce the level transition only if the train is routed towards the ETCS border or by announcing the level transition from the RBC.

4.2.6.4 This is considered for functional step 3 in sections 5.3.2 and 5.3.4.

4.2.7 Driver acknowledgement of level transition (only for trains without CR1166)

4.2.7.1 In trains not implementing CR1166 (Art10 2017 CR), the driver will be requested to acknowledge the transition to level 2.

4.2.7.2 When requested to acknowledge, the driver should do so at latest 5 seconds after making the transition (in step 4), as otherwise the train will be braked; see [SS026] 5.10.4.2.

4.2.7.3 This is considered in section 5.5.3.

4.2.8 Avoid contradiction between line side and cab signalling

4.2.8.1 Unclear or overlapping responsibilities of two signalling systems can give different and contradicting signalling information to the driver. This could be caused by different delays,

different signalling principles (e.g., speed signalling / distance to go), different track information, different odometers, etc.

4.2.8.2 This issue is avoided by synchronisations of the involved signalling systems or a clear split of responsibility at the ETCS border.

4.2.8.3 This issue has no impact on the transition procedure and is not further considered in chapter 5.

4.2.9 Manual cancellation of the route from the ETCS border

4.2.9.1 In case the route from the ETCS border is cancelled manually for operational purposes (e.g., for preferred vehicle movements, change of departure sequence, etc.), the authorisation must be revoked. This can be achieved by a changed (shortened) Movement Authority, but only if it can be sent to the affected train.

4.2.9.2 To cover for the case of a lost communication session, the Movement Authority sent to a train outside the ETCS area with EoA inside the ETCS area can be limited in time by specifying a section timeout for the MA. If the timeout expires the train will shorten the MA to the location of the border. The section timeout must be defined considering the operational needs. Depending on this, the MA can be repeated cyclically to reinitiate the section timeout.

4.2.9.3 This issue has no direct impact on the transition procedure and is not further considered in chapter 5.

4.2.10 Start of mission in rear of the ETCS border

4.2.10.1 ERTMS/ETCS trains always have the possibility to perform start-of-mission in the area before the ETCS border, but the selection of ETCS level(s) and national systems is limited by a table of priority of trackside supported levels, if available onboard the train.

4.2.10.2 Trains running into the ETCS area after start of mission at a signal protecting the ETCS border should not be unnecessarily restricted in speed when approaching the border or tripped at the border due to lack of Movement Authority. But this depends on where the train starts.

4.2.10.3 When a train starts in level NTC with the appropriate national system, then the possibility to approach the ETCS border and make the transition to level 2 without being tripped depends on where the train starts and if the following steps have been accomplished by reading information from balise groups before the train passes the border:

- Radio network registration (if needed)
- Establish a communication session with the RBC
- Receive Movement Authorisation from the RBC

4.2.10.4 Considerations for start-of-missions in level NTC are noted for functional steps 1, 2 and 3 in sections 5.1, 5.2 and 5.3, respectively, but for this to be successful it depends on where this will be done and the actual track layout from the location of the train towards the ETCS border.

4.2.10.5 Note that there could be operational benefits from being able to start in level 2 in rear of the pure level 2 area, due to the time needed for the onboard to connect with the RBC and especially if the train will not pass the LTA balise group on its way towards the ETCS border. For additional information see also section 4.2.17.

4.2.11 Allow transition with On-sight route to and/or from the ETCS border

4.2.11.1 The possibility for a train to approach the ETCS border in an On-sight route on a track which is not detected clear may cause problems for the issues of determining where the train will pass the ETCS border and if it is the correct train that enters.

4.2.11.2 For an On-sight route starting shortly in advance of the border, there is a risk that the train will be braked after the transition to level 2 due to the onboard supervising the start of the OS mode profile as EoA/SvL. As it may not be possible to move the start of the On-sight route/area further from the border, this can instead be solved by engineering the start of the OS profile at the ETCS border, but then the national system or national rules must consider this in the authorisation for passing the ETCS border.

4.2.11.3 Considerations for approaching the ETCS border in an On-sight route are further detailed for functional step 3 in section 5.3.

4.2.11.4 Considerations for an On-sight route from the ETCS border are further detailed for functional step 4 in section 5.3.5.10.

4.2.11.5 Note: the alternative solution noted in 4.2.3.3 solves the problem to determine the correct entering train in case of On-sight routes to or from the ETCS border where the track is not detected clear.

4.2.12 Minimise the use of switchable balises

4.2.12.1 Switchable balises should be avoided due to the extra costs compared with a fixed balise, but there are cases where they can be useful.

4.2.12.2 The transition to ETCS Level 2 can be achieved using only fixed balises and the balises in the recommendations in chapter 5 are fixed unless explicitly stated to be switchable for a well-defined purpose.

4.2.12.3 Note that the solution using ETCS packet 90, Track Ahead Free up to level 2/3 transition location, needs switchable balises as that information is sent depending on track statuses.

4.2.12.4 Note also that one switchable balise sending information on the basis of points positions could avoid unnecessary radio connections and several balise groups for disconnection and cancellation.

4.2.13 Minimise the size of the ETCS approach area

4.2.13.1 The engineering of the ETCS approach area depends on the actual situation like track geography and line speeds.

4.2.13.2 In case a project requests to have this as short as possible, it must be noted that then the risk of being tripped when passing the ETCS border is increased due to the fact that the train may not receive a Movement Authority in time or even fail to establish a communication session with the RBC.

4.2.13.3 For a successful transition to ETCS Level 2, the recommendations in chapter 5 for placement of the balise groups should be followed, as otherwise the risk of failure is increased.

4.2.14 Management of TSRs in the area in advance of the ETCS border

4.2.14.1 The systems on both sides of the ETCS border must be aware of speed restrictions having an impact on the train speeds. It is always possible to transmit TSRs from the RBC and/or balise groups. Note that braking curves may differ between ETCS and the national ATP.

4.2.14.2 This has no impact on the transition procedure and is not further considered in the recommendations in chapter 5.

4.2.15 Avoid displaying “Entry in FS/OS” to the drivers

4.2.15.1 This issue depends on the fact that the ERTMS/ETCS onboard does not have track description for the full length of the train. It can be solved by providing the track description from a location in rear of the border considering the longest train expected to enter at this border location.

4.2.15.2 This issue is considered in section 5.3, but there is no general solution as it depends on the actual track layout.

4.2.16 Management of National Values

4.2.16.1 The ERTMS/ETCS train that enters the ETCS area should have the correct National values stored onboard. This can be achieved by transmitting them from a balise group or from the RBC. This is further described in 5.5.2.

4.2.17 Manual level selection in rear of the ETCS border

4.2.17.1 The train driver may manually select level when the train is at standstill. In case level 2 is available for manual selection (in the table of trackside supported levels or with no table onboard), the driver could change to level 2 already in rear of the border and if there is an MA in the onboard transition buffer use this to move in the level NTC area. However, when choosing this solution, the possibility to have an MA starting in rear of the border and the risk associated to run the distance up to the border not protected by the NTC shall be evaluated.

4.2.17.2 Trains can be prevented or allowed to start in level 2 using ETCS Packet 46, Conditional Level Transition Order. This is considered in 5.3.2.3.

4.2.17.3 The misuse of an MA in the onboard transition buffer can be limited by giving the MA with a low-speed profile or a mode profile in on-sight to the transition location. This is considered in section 5.3.

4.2.18 Approaching the border after override to pass a signal

4.2.18.1 In case mitigation 4.2.3.3 is in place, for trains not implementing CR1306 (Art10 2017 CR) it is not clear what happens when a BG message containing “Stop if in SR” and a L1 MA with V_MAIN = 0 is received. This could cause a train to enter TR mode when passing a signal at danger (V_MAIN=0) with a main BG giving “Stop if in SR” or not included in the

list of expected balises in SR, although the override function is active. This is considered in 5.4.8.

4.2.19 Shunting and level transitions

4.2.19.1 Trains that are performing shunting movements in LNTC (without being in SH mode) such that the RBC cannot send a Movement Authority will be tripped when making the transition to level 2 after passing the border.

4.2.19.2 Note that trains that are in level NTC mode SH will only be tripped when passing a balise group with “Danger for SH” if the balise group also contains an immediate LTO to L2.

4.2.19.3 A possible solution is a procedure that the driver stops and requests level 2 SH mode before passing the border.

4.2.19.4 This topic is project specific and is not considered in chapter 5**Error! Reference source not found.**.

4.2.20 Location of ETCS border

4.2.20.1 The location of the border signal and the ETCS border could be strongly related. For example, when the signal at the ETCS border does not show a proceed aspect until the RBC has received acknowledgement for the MA sent to the approaching train. If the border is in the middle of a signal block the relation is less important.

4.2.20.2 When considering the location of the ETCS border the national system behaviour should be taken into account. E.g., is the national system a continuous or spot-based system, what kind of protection is used for signal passed at danger and what kind of operational procedures are needed for passing a signal at danger.

4.2.20.3 This topic is project specific and is not considered in chapter 5.

4.2.21 Supervision of location-based data in the L2 area when announced from NTC area

4.2.21.1 As no linking is used in NTC area, on a change of LRBG, the train will always subtract the estimated travelled distance between the reference balise group of the location-based data and the new LRBG to the supervised location-based data (see clause paragraph 3.6.4.3.b of [SS026]).

4.2.21.2 As a consequence, the supervision of location-based data with maximum safe front end (e.g., SvL, speed reduction) or minimum safe front end (EOA) could be overestimated or underestimated, leading to potential performance (early brake application) or safety impacts (late brake application).

4.2.21.3 This issue is addressed in paragraph 5.5.1.2 of this document.

5. Recommended solutions

5.1 Radio Network Registration

5.1.1 Basic considerations

5.1.1.1 Functional step 1 is about the process for the ERTMS/ETCS onboard to register with the relevant radio network.

5.1.1.2 The recommendations related to radio network registration apply if it is likely that ERTMS/ETCS trains can approach the ETCS Level 2 border without being registered or registered with the wrong network. In case it can be assured that the trains will always be registered with the relevant radio network, then this step may be left out.

5.1.1.3 It is essential for the success of this step that the GSM-R network covers the area where the train is ordered to register and that the quality of service (QoS) is sufficient from here towards the ETCS border.

5.1.2 Track layout

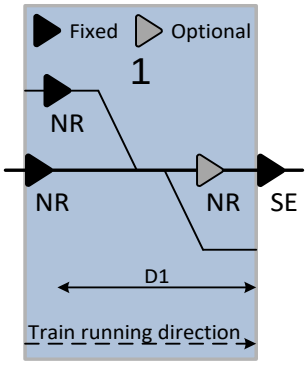
TRACK LAYOUT	BG	DESCRIPTION	BG INFORMATION
	NR	Radio Network Registration	Packet 45: Network Registration order with GSM-R network identity
	SE	Session Establishment	Packet 42: Session Management with order to connect to the RBC

Table 3: Balise groups used for functional step 1

5.1.2.1 Balise group NR orders the correct network registration and shall be installed so that the train is registered with the radio network before reaching balise group SE.

5.1.2.2 Balise group NR must be installed in all tracks leading to balise group SE unless it is assured that the approaching ERTMS/ETCS train is already registered with the relevant radio network.

5.1.2.3 D1 is the minimum distance between balise groups NR and SE, which should be calculated using the times T1+T2 from section 5.1.3 below and the applicable line speed. This assures that the level transition can be made when travelling at line speed.

5.1.2.4 NR is assumed to be a fixed balise group. There is no possibility to order disconnection from a radio network, thus there is no need to consider diverging tracks between NR and SE for trains routed away from the ETCS border.

5.1.2.5 Note that in case a diverging track leads into another radio network, it may be necessary to install a balise group for registration with this network instead.

5.1.2.6 The NR balise group after the points in the main track is optional (grey) depending on the possibility for trains to change direction and approach the ETCS border without passing any other NR, e.g., if arriving from the lower diverging track. This is also useful in case trains can perform start-of-mission closer to balise group SE than the distance D1.

5.1.2.7 Note that if installing the optional NR balise group, there is still needed to consider the distance to SE for a successful level transition, but the speed of the trains that start or turn in this area is initially lower.

5.1.3 Sequence diagram

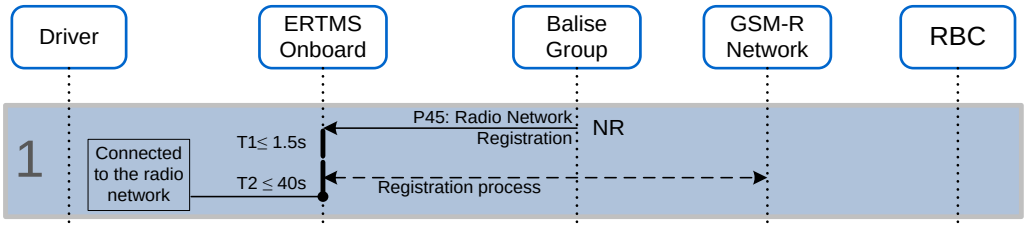


Figure 3: Sequence diagram for step 1

5.1.3.1 T1 is the processing time needed in the ERTMS/ETCS onboard equipment; this is assumed to be similar to the time specified in [SS041] 5.2.1.2.

5.1.3.2 T2 is the time needed to register with the radio network. According to [SS093] 6.3.7.3, this can take up to 40 seconds so for engineering it is recommended to use a minimum value of 40 seconds. Note that this time is only a parameter used for testing the quality of service (QoS) when commissioning the radio network and does not relate to normal operation.

5.1.3.3 The time T2 needs to be evaluated by each project taking into account their specific conditions. For this time, see also the further details given in Appendix A.1, Radio Network Registration.

5.1.4 Alternative solutions

5.1.4.1 Not applicable for this functional step

5.1.5 Degraded situations

5.1.5.1 This functional step has the following degraded situations:

- Failure to read the NR balise group
- Failure to register with the correct radio network (after reading NR)

5.1.5.2 The consequence is that the train cannot connect to the RBC; thus, it will not get any MA and trips if passing the ETCS border due to the lack of MA in level 2.

5.1.5.3 Both these situations can be mitigated by repeating the information in NR in other balises. This must still respect the distance to SE as otherwise the train may be connected to the radio network, but still without MA at the ETCS border.

5.2 RBC Connection Establishment

5.2.1 Basic considerations

5.2.1.1 Functional step 2 is about the process to connect the ERTMS/ETCS onboard with the RBC and establish a communication session.

5.2.1.2 Note that the ERTMS/ETCS onboard equipment only considers the order to establish a communication session when already registered with a radio network, so the previous step must have been completed successfully.

5.2.2 Track layout

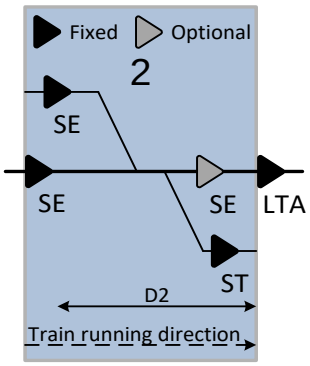
TRACK LAYOUT	BG	DESCRIPTION	BG INFORMATION
	SE	Session Establishment	Packet 42: Session Management with order to connect with the RBC including RBC contact information
	ST	Session Termination	Packet 42: Session Management; order to disconnect with the RBC
	LTA	Level Transition Announcement	See the next functional step for details about this balise group

Table 4: Balise groups used for functional step 2

5.2.2.1 Balise group SE orders the session establishment to the relevant RBC. It must be installed in all tracks leading to balise group LTA so that the train is able to establish a communication session with the RBC and receive a Movement Authority in rear of the ETCS border.

5.2.2.2 After a balise group SE (ordering to connect with an RBC), a balise group ST (ordering to disconnect with the same RBC) must be installed in all tracks leading away from the ETCS border.

5.2.2.3 All balise groups SE and ST are assumed to be fixed balise groups. Balise group SE should be marked as linked so that it can be used as LRBG in position reports.

5.2.2.4 D2 is the minimum distance between balise groups SE and LTA, which should be calculated using the times T1+T3+T4 in section 5.2.3 below and the applicable line speed. This is to make sure that the communication session is established when the message from the LTA is received onboard and that the level transition can be made when travelling at line speed.

5.2.2.5 The SE balise group after the points in the main track is optional (grey) depending on the possibility for trains to change direction and approach the ETCS border without passing any other SE balise, e.g., if arriving from the lower diverging track. This can also be used in case trains can perform start-of-mission closer to balise group LTA than the distance D2. Note that if having this optional SE balise group there is still needed to consider the

distance to balise group LTA for a successful level transition, but for trains starting in this area their relevant speed should be lower.

5.2.3 Sequence diagram

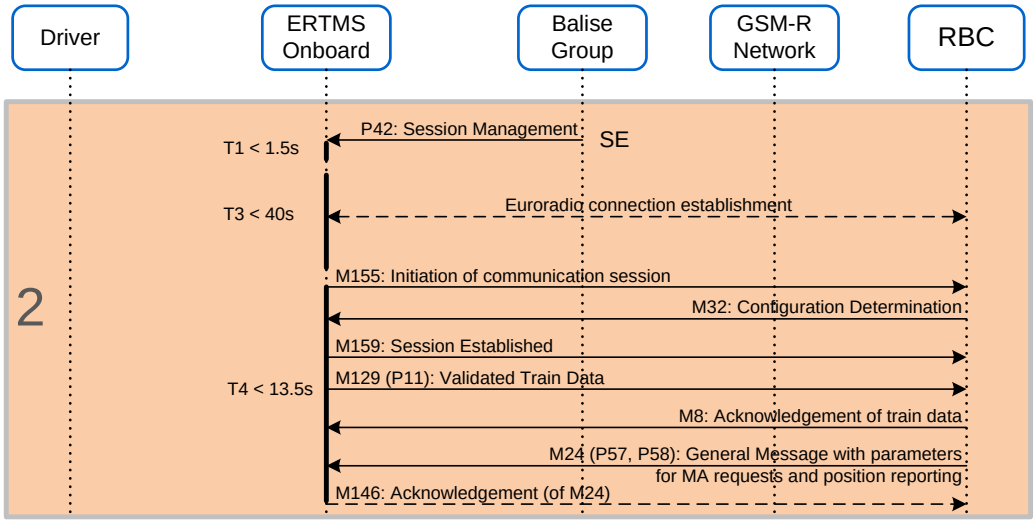


Figure 4: Sequence diagram for step 2

5.2.3.1 T1 is the processing time needed in the ERTMS/ETCS onboard equipment to initiate a communication session establishment according to [SS041] 5.2.1.2.

5.2.3.2 T3 is the time needed to establish the connection between the RBC and the ERTMS/ETCS onboard equipment; according to [SS037] 7.3.2.3.1, this time is a dimensioning parameter which could be up to 40 seconds depending on the network before being considered an unacceptable delay.

5.2.3.3 The time T3 needs to be evaluated by each project taking into account their specific conditions. For this time, see also the further details given in Appendix A.2, Connecting with the RBC.

5.2.3.4 T4 is the time needed to establish the communication session between the RBC and the ERTMS/ETCS onboard equipment, i.e., the exchange of application messages (M155, M32 and M159) after the connection has been established. In addition, T4 includes the time needed to send the validated train data (M129) and the parameters for MA-request and position reporting as described below.

5.2.3.5 T4 is estimated to take less than 13.5 seconds (6 messages; 2s for preparing and sending each of them and 1.5s for evaluation of the message with packet 58), but it depends on the quality of the radio network and on processing in the RBC and in the ERTMS/ETCS onboard. Note that this time is just a conservative estimate, and it must be checked for each project.

5.2.3.6 When the communication session has been established the train will send its Validated Train Data (M129) to the RBC, which the RBC must acknowledge (M8). If unacknowledged, the ERTMS/ETCS onboard will not accept any Movement Authority and consequently it will be tripped when making the transition to level 2 after passing the ETCS border.

5.2.3.7 After this or in parallel with the train data messages, it is recommended that the RBC sends information to the onboard about the relevant parameters for MA requests and position reporting (ETCS packets 57 and 58, respectively). This is necessary as otherwise the onboard may not report its position when reading the LTA balise group due to the currently used parameters. Therefore, this information must be received before passing the LTA. The acknowledgement of M24 is not part of T4 as this is only important for the RBC to know that it was received by the train.

5.2.3.8 The engineering of the distance D2 should consider the 40 seconds from [SS037] 7.3.2.3.1 and the additional time for handling the balise telegram and application messages. Thus, the total time required, T1+T3+T4, should be about 55 seconds, but note the recommendations above to evaluate this for the specific project conditions.

5.2.4 Alternative solution

5.2.4.1 Instead of using an ST balise group to order disconnection with the RBC, SE could use a switchable balise giving the connection order depending on route locking towards the ETCS border. This avoids unnecessary connections to the RBC in case the number of available connections is a limited resource.

5.2.5 Degraded situations

5.2.5.1 This functional step has the following degraded situations:

1. Failure to read the SE balise group
2. Failure to connect to the RBC (after reading the SE balise group)
3. Failure to read the ST balise group
4. Delayed connection with the RBC

5.2.5.2 The consequence of degraded situations 1 and 2 is that the train will not be connected to the RBC; thus, it will not get any MA and trips when passing the ETCS border due to the lack of MA after transition to level 2.

5.2.5.3 The degraded situations 1 and 2 can be mitigated by repeating the information in SE in other balises. This must also consider the distance to the LTA and the border as otherwise the train could be connected to the RBC, but still without MA at the border.

5.2.5.4 The consequence of degraded situation 3 is that the train will not disconnect from the RBC unless the RBC orders the train to disconnect. The need and measures to mitigate this is project specific; see also the alternative solution in 5.2.4.1.

5.2.5.5 For degraded situation 4 there is a risk that the train will not have an MA when passing the border and thus tripped when making the transition to level 2. This can be caused by disturbances in the GSM-R network or insufficient network quality. It can be mitigated by investigating the network QoS and the performance of the involved mobiles.

5.2.5.6 Another possible solution to degraded situation 4 is to have a signal at the ETCS border that does not clear until the RBC has received an acknowledgement from the approaching train for the MA from the ETCS border. This signal never clears for unfitted trains, nor in degraded situations related to the radio network or if the RBC cannot provide an MA. But

this solution requires some connection between the RBC and the trackside, and it may have impact on the operational performance approaching the ETCS border.

5.3 Level 2 Announcement and MA

5.3.1 Basic considerations

5.3.1.1 Functional step 3 is about the process to announce the transition to level 2 and receive a Movement Authority before passing the ETCS border.

5.3.1.2 For the RBC to be able to send MA a communication session must have been established in the previous functional step. For the ERTMS/ETCS onboard to accept the MA from the RBC, it must have received a level transition order announcing the transition to level 2 at a further location.

5.3.1.3 The following issues must be considered in this functional step:

- Entry location determination
- Avoid transition announcement for diverging trains
- Start of mission in rear of the ETCS border
- Allow transition with On-sight route to and/or from the ETCS border
- Avoid displaying “Entry in FS/OS” to the drivers
- Manual level selection in rear of the ETCS border

5.3.1.4 For a successful transition to level 2, the RBC must be able to determine at which border location an approaching train will enter as otherwise the RBC cannot send a Movement Authority to the train and without MA the train will be tripped when making the transition to level 2 after passing the border.

5.3.1.5 The possibility for the RBC to determine where the train will enter depends primarily on the track layout in the area in rear of the ETCS border, i.e., on the presence of points.

5.3.1.6 The RBC can determine the entry location in the following ways:

- by a position report with LRBG in an unambiguous route to the border
- by a position report supported with route information from the Interlocking
- by an MA request with information identifying the border location (packet 9) initiated by the information “Track Ahead Free up to level 2/3 transition location” (packet 90) in a switchable balise group

5.3.1.7 Note that the solution using packet 90 solves also the problem to determine the first entering train in the next functional step (see 5.4.1) as this depends on the track being free up to the ETCS border, but this also means that it does not work if the track detection fails and may not work with On-sight routes; see 5.3.5.5.

5.3.1.8 The MA given by the RBC should, if possible, provide track description from a location in rear of the border and for the full length of the train, as otherwise the onboard will display “Entry in Full Supervision” or “Entry in On-sight” to the driver after the level transition and until the track description covers the full length of the train. Considering the issue of manually selecting level 2 in rear of the ETCS border, the MA should be given with a low-

speed profile or a mode profile in On-sight up to the level transition location; the speed profile should be given without train length delay to avoid unnecessary performance loss.

5.3.1.9 There are two more things to consider as a prerequisite here; one is that the ERTMS/ETCS onboard must have received the acknowledgement of the train data from the RBC and the other is that the onboard should have received position report parameters (packet 58), as otherwise it may not report on balise passage if other parameters are in use onboard. These two actions are described in 5.2.3.6 and 5.2.3.7.

5.3.2 Track layout

5.3.2.1 The need for balises in this functional step depends on the track layout and the distance to the ETCS border. The level transition can be announced by balise or by the RBC (together with the MA). The level transition can be announced independent of the presence of diverging routes, but then the transition must be cancelled for trains routed away from the border. The task for the balise group announcing the level transition is also to provide an unambiguous reference for the RBC to know where the train will enter so that the RBC can give the correct MA.

5.3.2.2 Note that sending the announcement only by the RBC and together with the MA provides information to the driver that the connection is established, and the MA is received which can be helpful in degraded situations. On the other hand, in case of disturbances in the radio network the driver may get a shorter notice about the level transition.

5.3.2.3 It can also be considered having a packet 46 allowing level NTC in the balise group the RBC uses as reference for giving MA and level transition announcement as this then avoids the issue of manual selection of Level 2 in rear of the border in case only LNTC is allowed. If drivers are allowed to start in L2 in rear of the border, protection shall be provided by ETCS in rear of the border (an overlap between LNTC and L2 shall be envisaged) and level 2 could be added to packet 46.

5.3.2.4 In case of diverging tracks near the ETCS border, it is recommended to avoid announcing a level transition to trains that will not pass the ETCS border as this may be confusing to the train driver when seen on the DMI; in case of announcement by balise this can be achieved by using a switchable balise.

TRACK LAYOUT	BG	DESCRIPTION	BG INFORMATION
	LTA	Level Transition Announcement (for solution 1)	Packet 41: Level Transition Order announcing the transition to level 2 at the location of the ETCS border In case of announcement by the RBC, the balise group doesn't contain packet 41, the LTA balise group is only used as unambiguous location reference for the RBC (REF).

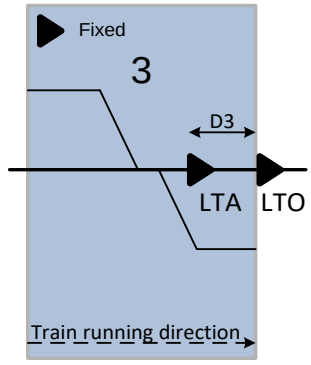
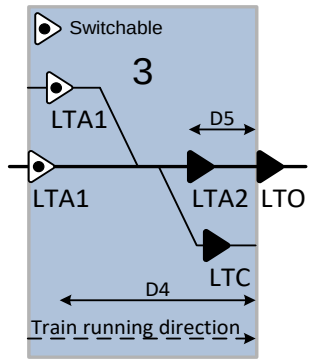
Solution 1:  Solution 2:  	LTA1	Level Transition Announcement (for solution 2)	Packet 41: Level Transition Order announcing the transition to level 2 at the location of the ETCS border Packet 90: Track Ahead Free up to level 2/3 transition location
	LTC	Level Transition Cancellation (if needed for solution 2)	Packet 41: Level Transition Order with immediate transition to the applicable level; this cancels the transition to level 2 Packet 42: Session Management with order to terminate the session with the specified RBC
	LTA2	Level Transition Announcement (for solution 2)	Packet 41: Level Transition Order announcing the transition to level 2 at the location of the ETCS border
	LTO	Level Transition Order	Packet 41: Level Transition Order (immediate transition to level 2)

Table 5: Balise groups used for functional step 3

5.3.2.5 For the RBC to be able to send MA it must know where the train will enter, and two solutions are recommended for this. In the first figure above, the LTA balise group at distance D3 is an unambiguous location reference for the RBC to determine where the train will enter because there are no more diverging points towards the border. In the second figure, none of the LTA1 balise groups is an unambiguous reference due to the presence of a diverging track which could lead away from the border or to another border location. But the LTA1 can be an unambiguous reference if switchable with the information depending on route locking towards the border.

5.3.2.6 The most important parameter for placing the balise group that is used for the level transition announcement or location reference is the distance to the ETCS border and the minimum distance should be calculated using the times T1+T5+T6+T7+T8 from section 5.3.3 below and the applicable line speed. This is to make sure that an MA is received by the ERTMS/ETCS onboard equipment and stored in its transition buffer before performing the transition to level 2.

5.3.2.7 In case the required distance is greater than to the LTA at distance D3 (i.e., to an unambiguous reference) then solution 2 with LTA1 at D4 must be used instead.

5.3.2.8 In case there are multiple tracks leading to the ETCS border then the distance should be calculated for each track based on its own specific speed profile.

5.3.2.9 Balise group LTA (or LTA1 and LTA2 depending on solution) announces the transition to level 2. In case the transition should be performed when reading the LTO, then the level transition order should announce the transition for a location in advance of the border and the LTO. This is because the ERTMS/ETCS onboard equipment will otherwise make the

transition according to the travelled distance of the estimated front end of the train and this depends on the actual accumulated odometer inaccuracy. In that case the announced location must consider the possible inaccuracy when making the transition based on the estimated train front end somewhere near the border.

5.3.2.10 Balise group LTC cancels the transition to level 2 and is put in tracks diverging from the ETCS border after having passed an LTA1 balise group. The LTC must be located within the distance D4 from the LTA1, as otherwise the train will perform the transition after having travelled the announced distance to the border. Note that this location must also consider the accumulated odometer inaccuracy onboard the train. Preferably, the LTC is read even before the driver is requested to acknowledge the transition. The LTC can be left out if the LTA1 has a switchable balise with also the announcement depending on route locking towards the border, but only if the route cannot be changed after passing LTA1.

5.3.2.11 Balise group LTA2 (for solution 2) announces the transition and can be installed after the last diverging track as an unambiguous location reference for degraded situations considering the same times for distance D5 to the border (but expected to be approaching at a lower speed).

5.3.3 Sequence diagrams

5.3.3.1 The recommended solutions are presented in separate diagrams as they involve different messages, but the sequences are very similar as seen below. Note that the dashed arrows are not necessary for the transition process as such.

5.3.3.2 **Solution 1** – a position report in an unambiguous route to the ETCS border

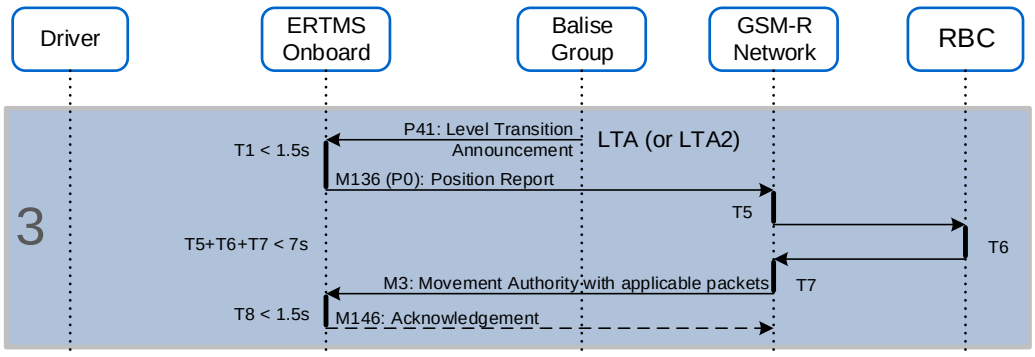


Figure 5: Sequence diagram for solution using position report

5.3.3.3 This solution uses a position report with an unambiguous balise group (LTA or LTA2) as LRBG for the RBC to send MA to the train. The times T_x are discussed further down, but note that the sum of T5, T6 and T7 is only an assumption which has to be evaluated for each project. Note that the LTA2 is for degraded situations in solution 2 and the sending of MA depends on how it is checked that it is the correct train to authorise.

5.3.3.4 Note that in case of announcement by the RBC, the RBC shall send the LTA together with the MA to the train in response to the position report that refers to the unambiguous positioned balise group.

5.3.3.5 **Solution 2** – MA request with information about the border location

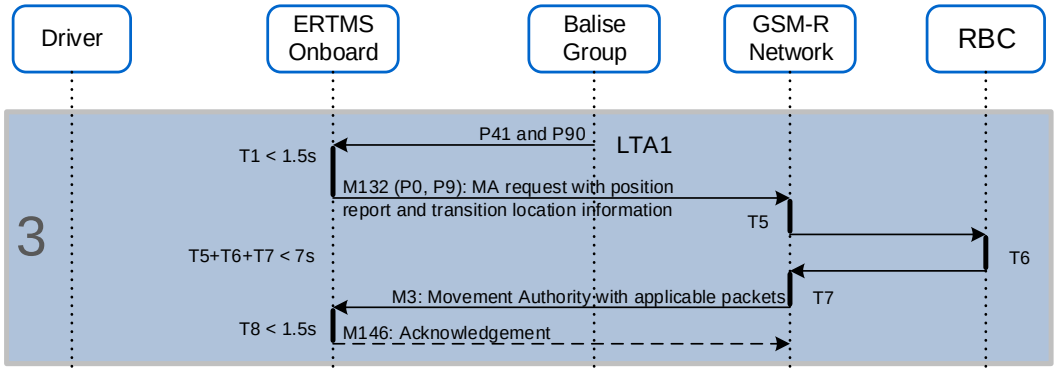


Figure 6: Sequence diagram for solution with MA-request

5.3.3.6 This solution uses ETCS packet 90, 'Track Ahead Free up to level 2/3 transition location' information. The ERTMS/ETCS onboard equipment only accepts this information if a transition to level 2 has already been announced or is announced in the same message as packet 90.

5.3.3.7 At the reception of packet 90, the ERTMS/ETCS onboard equipment sends an MA request only if it has a communication session established with the RBC, i.e., after a successful completion of functional step 2. This MA request informs the RBC about the identity of the balise group at the border where the train will enter.

5.3.3.8 The times T1, T5, T6, T7 and T8 are expected to be the same for both solutions. Note that the times for T5, T6 and T7 are only assumptions which must be evaluated for each project and its specific characteristics. In addition, if the time when the driver should be informed about the coming level transition is longer than T1+T5+T6+T7+T8, then that time must be considered instead.

5.3.3.9 T1 is the time needed by the ERTMS/ETCS onboard equipment to process the information received from the LTA balise group before sending a position report. This is assumed to be similar to the time specified in [SS041] 5.2.1.3.

5.3.3.10 T5 is the time needed to transmit a position report to the RBC (time between the sending of the first bit of the message (position report or MA request) by the ERTMS/ETCS onboard equipment and the reception of the last bit of this message by the RBC).

5.3.3.11 T6 is the processing time needed by the RBC to generate a Movement Authority with the associated track description. This time may be longer for solution 1 to be able to detect that this is the correct train; see section 5.4.5 about pre-check.

5.3.3.12 T7 is the time needed to transmit the MA from the RBC to the ERTMS/ETCS onboard equipment (time between the sending of the first bit of the MA by the RBC and the reception of the last bit of this MA by the ERTMS/ETCS onboard equipment).

5.3.3.13 T8 is the time needed by the ERTMS/ETCS onboard equipment to process the MA (for storage in the transition buffer). This is assumed to be equal to the time specified in [SS041] 5.2.1.4.

5.3.4 Alternative solution

5.3.4.1 Not applicable for this functional step.

5.3.5 Degraded situations

5.3.5.1 This functional step has the following degraded situations:

1. Failure to read the LTA balise group
2. Failure to read the LTC balise group
3. No packet 41 and/or 90 from a switchable LTA
4. MA-request not received by the RBC. Delayed MA from the RBC
5. Delayed level transition announcement and MA from the RBC

5.3.5.2 The consequence of degraded situation 1 is that there is no level transition announcement, thus the RBC may not know where the train is, and the train driver will not be informed about the upcoming level transition.

5.3.5.3 Degraded situation 1 can be mitigated by repeating the LTA information in other balises. Such additional balises must also consider the distance to the border as otherwise the train may still be without MA when making the level transition. Alternatively, the announcement can be given by the RBC if it can locate the train.

5.3.5.4 The consequence of degraded situation 2 is that the train will make the level transition after travelling the announced distance and trip as it has no MA. This failure can be mitigated by repeating the LTC information in other balises or by having the announcement in a switchable balise.

5.3.5.5 Degraded situation 3 can be caused by other occupations (e.g., in On-sight routes), failures in the system providing the data for the switchable balise or a failure in the switchable balise itself. The consequence is that the RBC may not be able to determine where the train will enter. This can be mitigated by having another LTA closer to the border, if this is feasible for the level transition.

5.3.5.6 Note that if the track cannot be detected free then the train is assumed to approach the ETCS border with reduced speed; thus, the distance needed to perform the activities in this step is shorter than when travelling at line speed. In case the track is occupied by another train then there could also be problems in the next functional step, see 5.4.1.

5.3.5.7 None of the degraded situations above occur if the announcement is given by the RBC, but the RBC still needs an unambiguous location reference from a position report to be able to give the announcement and MA.

5.3.5.8 The consequence of degraded situation 4 is that the RBC may not know where the train will enter and will therefore not send MA until it knows. Thus, the train will be tripped if making the transition to level 2 without an MA. The expected MA-request is not repeated by the onboard unless initiated by another packet 90. Thus, this degraded situation can be mitigated the same way as described in 5.3.5.3.

5.3.5.9 The consequence of degraded situation 5 is that without MA the train will be tripped when performing the transition to level 2. The mitigation for this problem is the same as described in 5.2.5.5, or alternatively as described in 5.2.5.6.

5.3.5.10 A possible solution to degraded situation 5 is to have a switchable balise group at or shortly in rear of the border which gives a conditional level transition order (packet 46) with level 1 first and level 2 second in the priority list, together with a L1 MA for the first block in the ETCS area. The switchable balise group has to be followed by another balise group shortly in advance of the first one to give a transition order (packet 41) to level 2. This solution allows trains that did not receive the LTA and MA from the RBC yet on time to enter the ETCS area without being tripped, while trains that received already the LTA/MA ignore the conditional level transition order (according to [SS026] 4.8.3 exception [11]).

5.3.5.11 Note that the switchable balise group shall give a transition order to level 1 and a L1 stop order in case the route from the border is not clear (for more details see also the alternative solution for the level transition in 5.4.8).

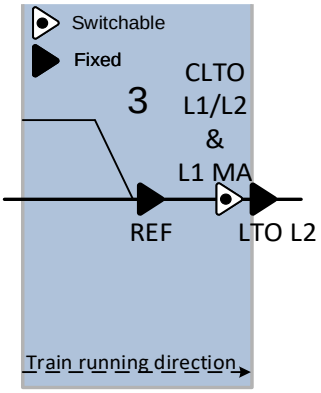


Figure 7: Solution for degraded situation 6

5.4 Level 2 Transition

5.4.1 Basic considerations

5.4.1.1 The following recommendations are related to functional step 4; i.e., the transition to level 2.

5.4.1.2 The following issues must be considered in this functional step:

- First entering train determination
- Allow transition with On-sight route to and/or from the ETCS border

5.4.1.3 The primary issue for this functional step is to determine if it is the correct train that enters, and it is linked to the issue about On-sight routes and to track occupations that mimic normal passage as they may make this task more difficult. The RBC can check this before or after the train has passed the ETCS border, i.e., as a pre-check or a post-check. Another option is that the train instead of the RBC checks whether it has passed the ETCS border.

5.4.1.4 Using a pre-check, the RBC can wait with giving MA until the check is ok, but with a post-check the RBC must give MA for the train to pass the border and instead revoke the MA if the check fails. As for the previous steps in the transition procedure, both of these methods depend on the quality of the radio network; the pre-check can fail to provide an

MA in time causing the train to trip at the border and the post-check can fail to revoke the MA, if the radio communication is disturbed or interrupted.

5.4.1.5 The following solutions are recommended to determine that it is the correct train that enters:

1. Post-check of the correct entering train
2. Pre-check of the correct entering train
3. Track Ahead Free to level 2/3 transition location (ETCS packet 90)
4. Post-check by train using a Conditional Emergency Stop message

5.4.1.6 The first two uses a position report in rear (pre) or in advance (post) of the ETCS border as basis for determining that there is no other train that could enter at the same border location.

5.4.1.7 The third uses the “TAF to level 2” information (packet 90) resulting in an MA-request (with packet 9) informing the RBC that the track was free up to the border. This is an unambiguous solution, but it only works if the track from the balise sending packet 90 to (the start of the route at) the ETCS border is detected free when the train passes that balise group (see section 5.3.2). Note that this solution is also a pre-check as it is done before sending MA.

5.4.1.8 The fourth solution is that the RBC sends a Conditional Emergency Stop message to the train as soon as the RBC is informed that the section in advance of the ETCS border becomes occupied. The train ignores the Conditional Emergency Stop message if it has already passed the ETCS border.

5.4.2 Track layout

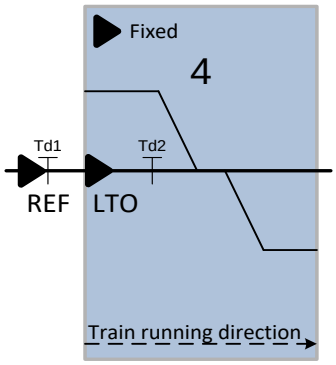
TRACK LAYOUT	BG	DESCRIPTION	BG INFORMATION
	LTO	Level Transition Order	Packet 41: Level Transition Order (immediate transition to level 2)
	REF	Reference balise group (if needed)	Packet 90: Track Ahead Free up to level 2/3 transition location (optional)

Table 6: Balise group used for functional step 4

5.4.2.1 The LTO is a fixed balise ordering the immediate transition to ETCS Level 2. The REF is used for specific position reporting while Td1 and Td2 are locations for division of the track for train detection purposes, for example track joints or axle counters. The locations are described further on for the solution using them.

5.4.3 Sequence diagram

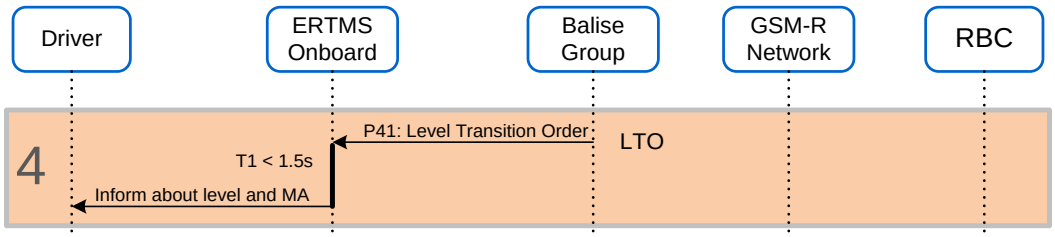


Figure 8: Sequence diagram for step 4

5.4.3.1 T1 is the time needed by the ERTMS/ETCS onboard equipment to process the information received from the LTO before presenting it on the driver DMI according to [SS041] 5.2.1.3.

5.4.3.2 Note that after the transition to ETCS Level 2, the STM may still have access to the brake system for some time until it is in state Cold Standby and may therefore need access to information from the national system. As the STM is not in the scope of the guideline, this is not further considered here.

5.4.4 Solution for train determination using post-check of position

5.4.4.1 This solution relies on a position report from the expected train for a location at or in advance of the ETCS border and on track detection for that area. As the train must have an MA to avoid being tripped at the border, this is provided according to 5.3.3.2 in step 3 and the RBC will revoke the MA in case the post-check fails.

5.4.4.2 When the track detection at or in advance of the ETCS border (i.e., Td2 in 5.4.2) informs the RBC about being occupied, the RBC starts a timer unless it has already received a position report indicating that the expected train has passed the border. In case the track detection (Td2) is located at some distance from the LTO then there could be need for another balise near Td2 or that the RBC requests the train to send a position report at this location.

5.4.4.3 If the post-check timer expires then the RBC will revoke the MA by sending a shortened MA or an Unconditional Emergency Stop Message to the train. This message will be put in the onboard transition buffer if the ERTMS/ETCS onboard is still in level NTC and if in level 2 it will be used immediately. If the train is still in level NTC, then the occupation was caused by some other vehicle.

5.4.4.4 The value of this post-check timeout is project specific, and it depends on the response times for the systems in use. If the timeout is too long, then there is an increased risk that another vehicle is moving in front of the expected train and if the timeout is too short there is a risk that the correct train will be stopped.

5.4.4.5 The post-check solution works with On-sight routes to the ETCS border, but it can only be used for an On-sight route from the border if the track in advance of Td2 was detected free when that route was locked.

5.4.4.6 Note that for On-sight routes from the border the MA will be given with an OS mode profile and the first entering train can be determined using the alternative solution proposed in 5.4.8.

5.4.5 Solution for train determination using Pre-check of position

5.4.5.1 This solution uses a position report from the expected train related to track detection in rear of the ETCS border. It requires information from the adjacent area about track occupancy from a specific location in the ETCS approach area up to the start of the route covered by the MA. It is assumed that the RBC gets this information from the Interlocking system it is connected to, but the related information may also appear on some other interface; this is an implementation matter for the specific project.

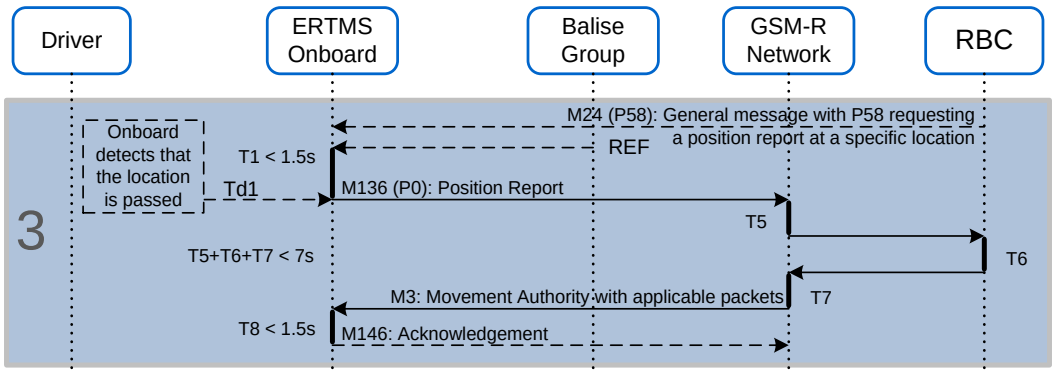


Figure 9: Sequence diagram for solution using pre-check of position

5.4.5.2 The RBC requests a position report (packet 58) for a location at or near a track division in rear of the ETCS border; see Td1 in 5.4.2. Alternatively, there is a specific reference balise group, REF, at this location as seen in the sequence diagram above. As the RBC does not give MA until the check is ok, the location of Td1 or the REF must consider the same times as detailed in 5.3.3 for step 3, except for T1 if not based on a balise; see 5.3.3.9 to 5.3.3.13 for details about the times T1, T5, T6, T7 and T8.

5.4.5.3 If the train reports a position relative to the specific location (e.g., with the REF balise group as LRBG) almost at the same time as the trackside equipment reports that the section following this location becomes occupied then the RBC can conclude that the train is the only vehicle in that section. If the remaining train detection sections to the ETCS border are detected free or there are no remaining sections, the RBC concludes this is the first train approaching the level 2 area and can send MA to the train.

5.4.5.4 In case the train does not report within a certain timeout, the RBC will not send MA to the train. The time difference allowed between the reported occupancy and the related position report is project specific depending on the systems in use, but it must be sufficiently short to assure that it was the correct train that caused the occupation and long enough to ensure that trains get MA.

5.4.5.5 The pre-check solution does not work with On-sight routes in rear of the ETCS border unless the track in advance of Td1 can be detected free when that route is locked. Therefore, for On-sight routes this solution can be combined with another pre-check location for a track division closer to the border or with the alternative solution proposed in 5.4.8.

5.4.5.6 If the pre-check fails and no alternative solutions are in place for determining the first entering train, the RBC could give MA with OS mode profile for the complete route. This

way the train can enter the ETCS area and possibly get MA without OS mode profile at a further location.

5.4.6 Solution for train determination using TAF with packet 90

5.4.6.1 This solution uses the same solution as for determining the entry location; see 5.3.3.5. As that is done before sending MA, this is in principle a pre-check. The packet 90 can also be used for solution 1; see 5.3.3.2, either given by a separate balise group or by the LTA (or LTA2) if it is a feasible location for this information.

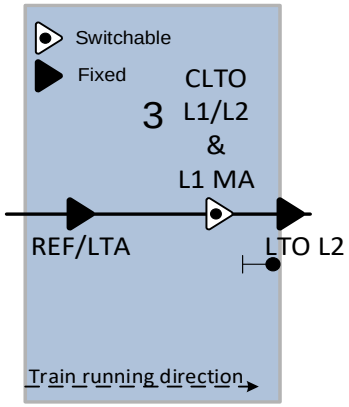
5.4.6.2 Note: this solution does not work with On-sight routes towards the ETCS border, unless the track to the border can be detected free; for mitigations see 5.3.5.5.

5.4.7 Solution for train determination using CES message

5.4.7.1 This solution uses the same solution as described in [EUG_69] for the ATAF using CES message. This is in principle a post-check and works with On-sight routes towards the border.

5.4.8 Alternative solution

5.4.8.1 The task to determine that it is the correct train that enters the ETCS area can also be solved by having a switchable balise group at or shortly in rear of the border which gives a transition order to ETCS Level 1 and a L1 stop order in case the route from the border is not clear. If this solution is applied, the balise group should not contain “Stop if in SR”. In addition, there must be another balise group shortly in advance of the first one to give a transition order to level 2. When using this switchable balise group it could be considered to implement the solution as described in 5.3.5.10.

TRACK LAYOUT	BG	DESCRIPTION	BG INFORMATION
Situation 1: if signal shows proceed 	LTA (REF)	Level Transition Announcement	Packet 41: Level Transition Order announcing the transition to level 2 at the location of the ETCS border In case of announcement by the RBC, the balise group does not contain packet 41, the LTA balise group is only used as unambiguous location reference for the RBC (REF).
	CLTO L1/L2 & L1 MA	Conditional Level Transition Order & Movement Authority	Packet 46: Conditional Level Transition Order (with level 1 first and level 2 second in the priority list) Packet 12 (together with 21 and 27): L1 MA for the first block in the ETCS area

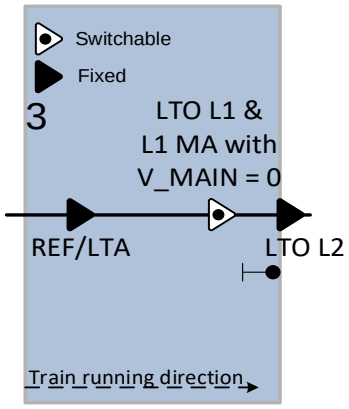
	LTO L2	Level Transition Order	Packet 41: Level Transition Order (immediate transition to level 2)
Situation 2: if signal at danger  	LTA (REF)	Level Transition Announcement	Packet 41: Level Transition Order announcing the transition to level 2 at the location of the ETCS border In case of announcement by the RBC, the balise group does not need to contain packet 41, the LTA balise group is only used as unambiguous location reference for the RBC (REF).
	LTO L1/L2 & L1 MA with V_MAIN = 0	Level Transition Order & Movement Authority	Packet 41: Level Transition Order (with level 1 first and level 2 second in the priority list) Packet 12 (together with 21 and 27): L1 MA with V_MAIN = 0
	LTO L2	Level Transition Order	Packet 41: Level Transition Order (immediate transition to level 2)

Figure 10: Example of alternative solution making use of L1

5.4.9 Degraded situations

5.4.9.1 This functional step has the following degraded situations:

1. Failure to read the LTO balise group
2. No MA request indicating that the track was free to the ETCS border
3. Other occupation that mimics normal passage at the ETCS border
4. Position report for pre-check not received by the RBC
5. Position report for post-check not received by the RBC

5.4.9.2 The consequence of degraded situation 1 is that the train will not change level at the ETCS border; instead, it will change level when the ERTMS/ETCS onboard detects that the estimated front end has passed the location in the level transition announcement.

5.4.9.3 This failure can be mitigated by repeating the information in the LTO in other balises, but the need for that is limited due the redundancy in the announcement and thus the train will anyway make the transition shortly after the border.

5.4.9.4 The consequence of degraded situation 2 is that the RBC will not send MA to the train and if the train passes the ETCS border it will be tripped when changing to level 2. This can be mitigated by

- another balise group initiating the MA request closer to the ETCS border, OR

- a signal at the ETCS border that does not show a proceed aspect until after the RBC has received acknowledgement for the MA sent to the approaching train, OR
- the MA is given with an OS mode profile starting at the ETCS border.

5.4.9.5 Degraded situation 3 should be covered by all the proposed solutions, but the pre- and post-checks based on a position report do depend on engineering which must also avoid that the correct train trips itself. Thus, a project using one of those solutions must analyse if it is possible for another (short) vehicle to move undetected in front of the correct train.

5.4.9.6 The consequence of degraded situation 4 is that the RBC will not send MA to the train and thus the train will be tripped when making the transition to level 2 after passing the ETCS border. This can be mitigated by the RBC requesting position reports for several nearby locations that could still fulfil the pre-check, if feasible.

5.4.9.7 The consequence of degraded situation 5 is that the RBC will try to revoke the MA after the supervised time has expired; see 5.4.4.3. The result depends on the availability of the safe connection, as this may be the reason why the position report was not received. The failure can be mitigated by the RBC requesting position reports for several nearby locations that still fulfil the post-check conditions, if feasible.

5.4.9.8 Note that for the solution using CES message, degraded situations 4 and 5 are not an issue, because the RBC will send a Conditional Emergency Stop message to the train as soon as the RBC is informed that the section in advance of the ETCS border becomes occupied.

5.5 General Recommendations for Transition to Level 2

5.5.1 Balises

5.5.1.1 The balise groups in the ETCS approach area must consist of at least two balises for the information in them to be valid in a defined direction. In addition, by having two (or more) balises in each balise group, the RBC does not need to assign a coordinate system for trains approaching the ETCS border.

5.5.1.2 All balise groups that are supposed to be used as reference (LRBG) in position reports sent to the RBC must be marked as linked as otherwise the train may report with an old LRBG from a different area with a balise identity not known by the RBC. Hence, all balise groups from the SE and onwards to the ETCS border should be marked as linked in the balise telegram header, see [SS026] 8.4.2.1.

5.5.1.3 These balise groups, including the balise groups which are installed between the SE and the LTO balise group to realise functions for the other running direction, if announced as linked in the header, should also be included in the linking transmitted with the MA from the RBC to:

- Reduce the odometric error when entering the L2 area;
- Allow the train to relocate the location related information received in the NTC area using accurate distances (see clause [SS026] 3.6.4.3 a), between the reference of location related information and the LTO BG, as the linking is the first information to be used when extracting data from the buffer (see [SS026] 4.8.1.6).

5.5.1.4 In case it is required to have a consistent sequence of actions on a train not implementing the solution of CR1312 issue 1, it is recommended not to combine packets 42 and 45 in one balise group.

5.5.2 National Values

5.5.2.1 The ERTMS/ETCS train entering the ETCS area should have the correct National Values stored onboard. This can be achieved by having the National Values (ETCS packet 3) in the LTO balise group at the ETCS border. The advantage of giving the National Values from a balise group is that all trains passing it will have the correct values.

5.5.2.2 For redundancy reasons, the National values can also be sent by the RBC, e.g., before sending any Movement Authority to the train. Note that this does not work for trains in Sleeping mode without a communication session, so the balise group should be the primary alternative.

5.5.2.3 Note that if giving National Values for the ETCS area in a balise group in rear of the ETCS border, then the National Values may need to be changed if the train moves away from the ETCS area.

5.5.3 Driver acknowledgement of level transition (only for trains without CR1166)

5.5.3.1 For trains not implementing CR1166 [OPINION ERA 2020-2], the level transition must be acknowledged.

5.5.3.2 The driver will be requested to acknowledge the transition to level 2, except if the onboard is in non-leading (NL) mode.

5.5.3.3 A level transition announcement gives the distance to the level border and the distance in rear of the border where the driver is requested to acknowledge the transition. The distance in rear of the border can be seen as a certain time before making the transition considering the applicable line speed and the announcement must be transmitted in rear of the required acknowledgement distance/time, including the required processing time of the level transition announcement. If the driver is not required to acknowledge in rear of the border, the distance is set to zero.

5.5.3.4 When requested to acknowledge, the driver should do so at latest 5 seconds after making the transition, as otherwise the train will be braked; see [SS026] 5.10.4.2.

5.5.3.5 For an On-sight route from the ETCS border, the driver could be requested to acknowledge both the OS mode and the level transition at the same time. This is avoided by announcing the level transition with a distance in rear of the border where the driver is requested to acknowledge the transition, i.e., by separating the requests in time.

5.5.3.6 It is recommended to request the driver to acknowledge the level transition in rear of the border, as this avoids simultaneous requests for acknowledgement when the level 2 MA is for a route with an on-sight profile starting at the border.

5.5.3.7 In case cancellation of a level transition cannot be avoided for diverging trains, the level transition should preferably be cancelled before the driver is requested to acknowledge the level transition.

APPENDICES

A.1 RADIO NETWORK REGISTRATION

A.1.1.1 When the ERTMS/ETCS onboard receives an order to register to a new network, this order is forwarded to the mobile within less than 1.5 sec which is assumed to be the same limit as for connection establishment in [SS041] 5.2.1.2. An order to register to the same network is ignored by the ERTMS/ETCS onboard.

A.1.1.2 When the mobile terminal is ordered to register to a network, it is assumed to start scanning the GSM-R frequencies for the requested network. There are different 'levels' of scanning:

1) same network, same location - a very short scan of last cell plus neighbours;

2) same network, different location - scans the operators' frequencies between remembered limits;

3) roaming allowed, registered network not available - scans all frequencies, in order GSM-R, then public GSM, then E-GSM at 900MHz, until finding a valid one.

A.1.1.3 Approximate times to scan the GSM frequency bands are:

only the GSM-R frequencies	6 sec
GSM-R + public 900MHz band	44 sec
GSM-R + public 900MHz + E-GSM	60 sec

A.1.1.4 Note that the order and these figures depend on the mobile manufacturer.

A.1.1.5 When the network has been found, the registration process occurs which should not take longer than a few seconds.

A.1.1.6 If the registration with the requested network cannot be achieved, no other registration attempt is done until another order is received.

A.1.1.7 Summarising these activities, normal scanning and registration times are shown in the table below.

Activities during registration	Time span	Typical time
Read and evaluate balise	<1.5 sec	<1.5 sec
Scan GSM-R/GSM network	(6-60 sec)	unknown
Register to network	<5 sec	2 sec
Total time	unknown	unknown

A.1.1.8 Note that 'total' or 'typical' times for network registration are only examples or cannot be given as it depends on the particular mobile in use and the radio coverage, frequency planning, etc.

A.1.1.9 Note that times for GPRS cannot be given, because these aren't specified in the current version of [SS093].

A.2 CONNECTING WITH THE RBC

A.2.1.1 When the ERTMS/ETCS onboard receives an order to establish a communication session, this is given to the mobile terminal within 1.5 sec as specified in [SS041] 5.2.1.2. An order to connect to the same RBC is ignored by the ERTMS/ETCS onboard; otherwise, the mobile will be ordered to establish a communication session with the indicated RBC.

A.2.1.2 The mobile tries to connect to the RBC which can take up to 10 sec (see [SS093] connection establishment delay). If this fails, the mobile will return an error and the ERTMS/ETCS onboard may then initiate another connection attempt; see [SS026] 3.5.3.7. Experiences from projects show that it often takes more than one attempt to establish the physical connection, so the engineering should account for that.

A.2.1.3 When connected to the RBC, the EuroRadio Communication and Safety Layers will be set up. The times needed for this are seen in the table below.

Activities during connection establishment	Time span	Typical time
Read and evaluate balise	<1.5 sec	<1.5 sec
Establish GSM physical connection[1]	<10 sec	8-15 sec[2]
Establish EuroRadio safe connection	<30 sec	15 sec
Total time	<41.5 sec	24-31 sec[2]

Note 1: can be re-initiated by the application in case of failure
Note 2: the longer time is with one connection failure

A.2.1.4 After the safe connection has been set up, a communication session on ETCS application level is established by exchanging application messages between the ERTMS/ETCS onboard and the RBC.

A.2.1.5 Note that times for GPRS cannot be given, because these aren't specified in the current version of [SS093].