



EEIG ERTMS Users Group
123-133 Rue Froissart, 1040 Brussels, Belgium
Tel: +32 (0)2 673.99.33 - TVA BE0455.935.830
Website: www.ertms.be E-mail: info@ertms.be

ERTMS USERS GROUP - ENGINEERING GUIDELINE

74. RBC/RBC handovers

Ref: EUG_17E112
Version: 1.0
Date: 10/10/2017

Modification history

Version	Date	Modification / Description	Editor
0.1	27/01/2017	First draft based on ESG Topic - Border Crossing_V0 12 (Version 2)	A. Meijer
0.2	10/03/2017	Based on Review comments RO, JA, ESG57	A. Meijer
0.3	18/07/2017	Based on review comments SW, RG, WL and information from RO and workshop Border Crossings. Added general track layout and sequence diagram.	A. Meijer
0.4	01/09/2017	Based on review comments KKH, SMc, Adif Added new issue about revocation of emergency stop	A. Meijer
0.5	18/09/2017	Based on review comments GR, ESG61	A. Meijer
1.0	10/10/2017	Final version	A. Meijer

Table of Contents

1.	Introduction.....	5
1.1	Introduction.....	5
1.2	Scope and Field of Application	5
1.3	Applicable system versions.....	5
1.3.2	Definitions.....	6
1.4	Document structure	6
2.	References and Abbreviations.....	7
2.1	Abbreviations.....	7
2.2	References	7
3.	RBC/RBC Handover	9
3.1	Introduction.....	9
3.2	Functional steps	9
3.3	General track layout.....	9
3.4	General Sequence Diagram	11
4.	Issues to be addressed.....	13
4.1	Introduction.....	13
4.2	Issues RBC/RBC handovers.....	13
4.2.1	RBC/RBC border mapping.....	13
4.2.2	Defining RBC/RBC border location	13
4.2.3	Operational processes.....	14
4.2.4	Performance	15
4.2.5	Location of NID_C change in relation to RBC/RBC border.....	15
4.2.6	Supervision gap in RBC/RBC handover.....	15
4.2.7	Onboards handling only one communications session.....	16
4.2.8	Radio network identity and RBC contact details.....	16
4.2.9	Train data changed during RBC/RBC handover	17
4.2.10	Faulty definition of Q_RRIMACHANGE and Q_TDCHANGE	17
4.2.11	Session establishment leads to supervision gap for vehicles with one mobile during RBC/RBC handover.....	17
4.2.12	RBC/RBC transition not to be combined with session management	17
4.2.13	Supervision change by position report	18
4.2.14	TSRs in the RBC/RBC handover area	18
4.2.15	Trackside degraded situations	18
4.2.16	RBC/RBC Handover coincides with level transition Level 2 – Level 3.....	18
4.3	Functional constraints RBC/RBC handover	19
4.3.2	Conditional Emergency Stop function	19
4.3.3	Revocation of emergency stop function	19

4.3.4	Text message function.....	20
4.3.5	Movement authority request and position report parameters	20
4.3.6	List of balises for SH area or and List of balises in SR authority	20
4.3.7	Data used by applications outside the ERTMS/ETCS system.....	20
4.3.8	Geographical position function.....	20
4.3.9	Reversing function.....	21
4.3.10	Train running number from RBC.....	21
4.3.11	Radio hole function.....	21
4.3.12	TSR revocation function	21
4.3.13	Message acknowledgement function	22
4.3.14	RRI confirmation.....	22
4.3.15	Constraints for packets and messages	22
4.3.16	Unnecessary functions	22
5.	Recommended solution RBC/RBC handover.....	24
5.1	Basic considerations.....	24
5.2	Recommended solution	24
5.2.1	General solution	24
5.3	Specific recommendations.....	25
5.3.1	Solution for onboards with only one communication session	25
5.3.2	Solution for Supervision gap	25
5.3.3	Solution for issues radio hole function	25
5.3.4	Solution for NID_C change	26
5.3.5	Solution for TSRs in the RBC/RBC handover area	26
5.3.6	Solution for radio network Identity and RBC contact details.....	26
5.4	Onboard recommendations	27

1. Introduction

1.1 Introduction

- 1.1.1.1 The requirements of the RBC/RBC handover are defined in chapter 3 and 5 of the SRS (see [SS026]) and in the FIS for the RBC/RBC handover (see [SS039]).
- 1.1.1.2 RBC/RBC handovers are however not fully transparent between RBCs (e.g. no CES functionality, see CR1183) and not always easy to implement with complex track layouts.
- 1.1.1.3 The aim of this document is to provide a recommended trackside solution for the engineering of RBC/RBC handover. The objective is to support an efficient and safe implementation of ERTMS, from a technical and operational point, simplifying and harmonising future system implementations taking advantage of the experience obtained from projects already in operation.
- 1.1.1.4 Authors of the document consider that the issues identified and tackled represent the status of the present knowledge and implementations concerning RBC/RBC handovers.

1.2 Scope and Field of Application

- 1.2.1.1 This document is based on ERTMS/ETCS Baseline 2 and 3 and applicable for ETCS Levels 2 and 3.
- 1.2.1.2 It is strongly recommended that any entity using ERTMS/ETCS follows the recommendations defined in this document.

1.3 Applicable system versions

- 1.3.1.1 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	This guideline	Not applicable
2.Y	This guideline	This guideline

Table 1: System version management

- 1.3.1.2 This guideline is applicable for a trackside where system version is 1.Y or 2.Y.
- 1.3.1.3 This guideline takes into consideration the following onboard systems:
 - Onboard system with pure system version 1.Y (i.e.: they are not fitted with any other system version)

– Onboard system supporting version 1.Y and 2.Y, with active system version 1.Y or 2.Y

1.3.1.4 An RBC/RBC handover between a Baseline 3 RBC and a Baseline 2 RBC requires specific attention. Requirements will be described in [SS129] which is under development.

1.3.1.5 Note: Connections between Baseline 3 RBCs with at least one RBC that is operating with system version X=1 is covered by [SS039 3.1.0/3.2.0] chapter 6.

1.3.2 **Definitions**

1.3.2.1 Intentionally left empty.

1.4 **Document structure**

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 the RBC/RBC handover.

1.4.1.4 Chapter 4 provides a list of issues to be considered and for some issues a possible solution.

1.4.1.5 Chapter 5 provides the recommendations for engineering RBC/RBC handovers.

2. References and Abbreviations

2.1 Abbreviations

Abbreviation	Description
ACC RBC	Accepting RBC
AR	Announcement RBC transition
HOV RBC	Handing Over RBC
IXL	Interlocking
MT	Mobile Terminal
NR	Radio Network Registration
p	Packet, e.g. p131 is ETCS packet 131
RRI	Route Related Information
RTO	RBC transition order

2.2 References

2.2.1.1 The following documents and versions apply:

Ref. N°	Document Reference	Title	Version
[SS026]	SUBSET-026	System Requirements Specification	2.3.0 + [SS108] (B2) 3.4.0 (B3 MR1) 3.6.0 (B3 R2)
[SS037]	SUBSET-037	EuroRadio FIS	2.3.0(B2) 3.1.0 (BR MR1) 3.2.0 (B3 R2)
[SS039]	SUBSET-039	FIS for the RBC/RBC Handover	2.3.0(B2) 3.1.0 (BR MR1) 3.2.0 (B3 R2)
[SS040]	SUBSET-040	Dimensioning and Engineering rules	2.3.0 (B2) 3.3.0 (B3 MR1) 3.4.0 (B3 R2)
[SS093]	SUBSET-093	GSM-R Interfaces: Class 1 Requirements	2.3.0 (B2/B3 MR1)
[SS108]	SUBSET-108	Interoperability-related consolidation on TSI annex A documents	1.2.0

Ref. N°	Document Reference	Title	Version
[SS113]	SUBSET-113	Report from UNISIG Hazard Log	1.2.29 Under development
[SS129]	SUBSET-129	FIS for the RBC/RBC Handover involving a Baseline 2 RBC	Under development
[ATAF]	EUG_69	Automatic Track Ahead Free (B3) Guideline	1.5
[CRxxxx]	ERA CR Database	ERA CR Database	-

3. RBC/RBC Handover

3.1 Introduction

- 3.1.1.1 This chapter intends to give a general overview of how to perform an RBC transition from the HOV RBC to the ACC RBC 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.
- 3.1.1.2 The actual RBC/RBC handover procedures can be found in [SS026] 5.15 with more detailed information.

3.2 Functional steps

- 3.2.1.1 In order to facilitate the recommendations detailed in chapter 5, the RBC transition is divided into the following functional steps:
 - 1) Radio Network registration (if required)
 - 2) RBC transition announcement
 - 3) RBC transition
- 3.2.1.2 The successful transition from HOV RBC to ACC RBC requires that each of these steps is completed before the next is performed.
- 3.2.1.3 The Radio Network registration is only required if the two RBC areas use a different radio network.

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 RBC transition 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.

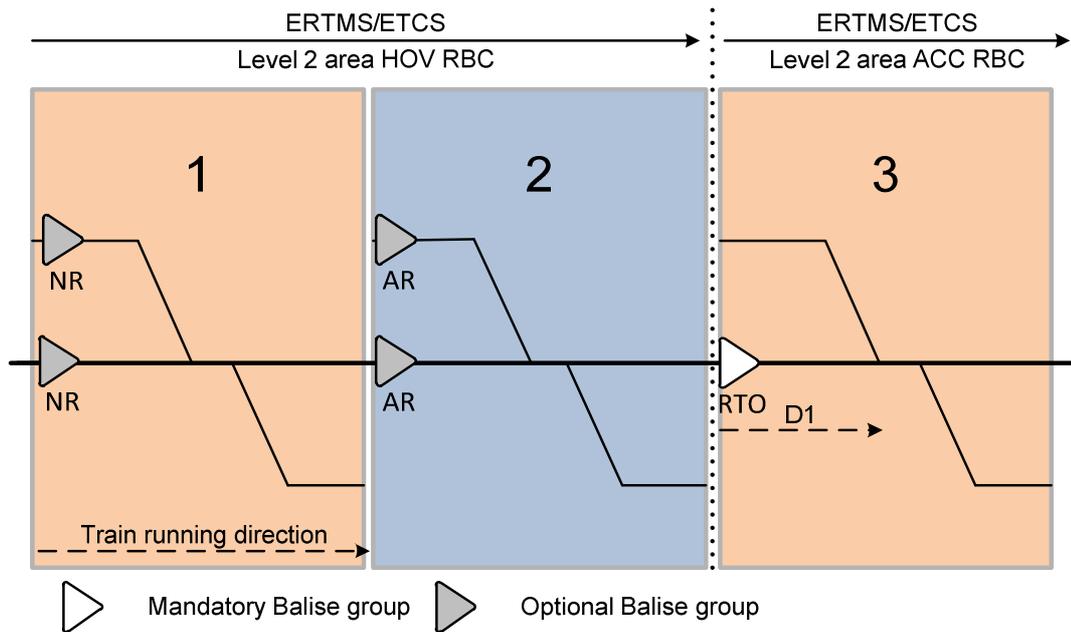


Figure 1: Generic track layout for RBC transition

3.3.1.2 The table below represents the balise groups and information (in ETCS packets) needed for each functional step to succeed with an RBC transition.

BG	BG DESCRIPTION	BG INFORMATION (ETCS PACKETS)
NR	Radio Network Registration	Packet 45: Radio Network Registration with the identity of the GSM-R network of the ACC RBC area
AR	Announcement RBC transition	Packet 131: RBC transition order announcing the coming RBC transition at the RBC/RBC border
RTO	RBC transition order	Packet 131: RBC transition order with immediate order Packet 45: Radio Network Registration with the identity of the GSM-R network of the ACC RBC area (optional)

Table 2: Balise groups for RBC transition

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. Network Registration information is necessary in case the radio network changes at the RBC/RBC border. This Balise group NR is optional required as this information could also be sent by the HOV RBC.

- 3.3.1.5 Balise group AR orders the train to establish communication session with the ACC RBC. The actual moment to establish communication session is dependent on the number of communication sessions the onboard is capable to use. This Balise group AR is optional as the announcement could also be sent by the HOV RBC.
- 3.3.1.6 Balise group RTO is located at the RBC/RBC border and orders the immediate RBC transition to the ACC RBC. This is required by [SS026] 5.15.1.3. This balise group will also be needed for degraded situations in case no RBC/RBC handover was announced and in case a not connected train will pass the border. The actual moment of transferring the train supervision is dependent on the number of communication sessions the onboard is capable to use.
- 3.3.1.7 In case the radio network changes at the RBC/RBC border and no balise group NR is used the balise group RTO should contain an order to register with the appropriate radio network for not connected trains, e.g. sleeping units.

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 3 functional steps listed in 3.2.1.1 above.

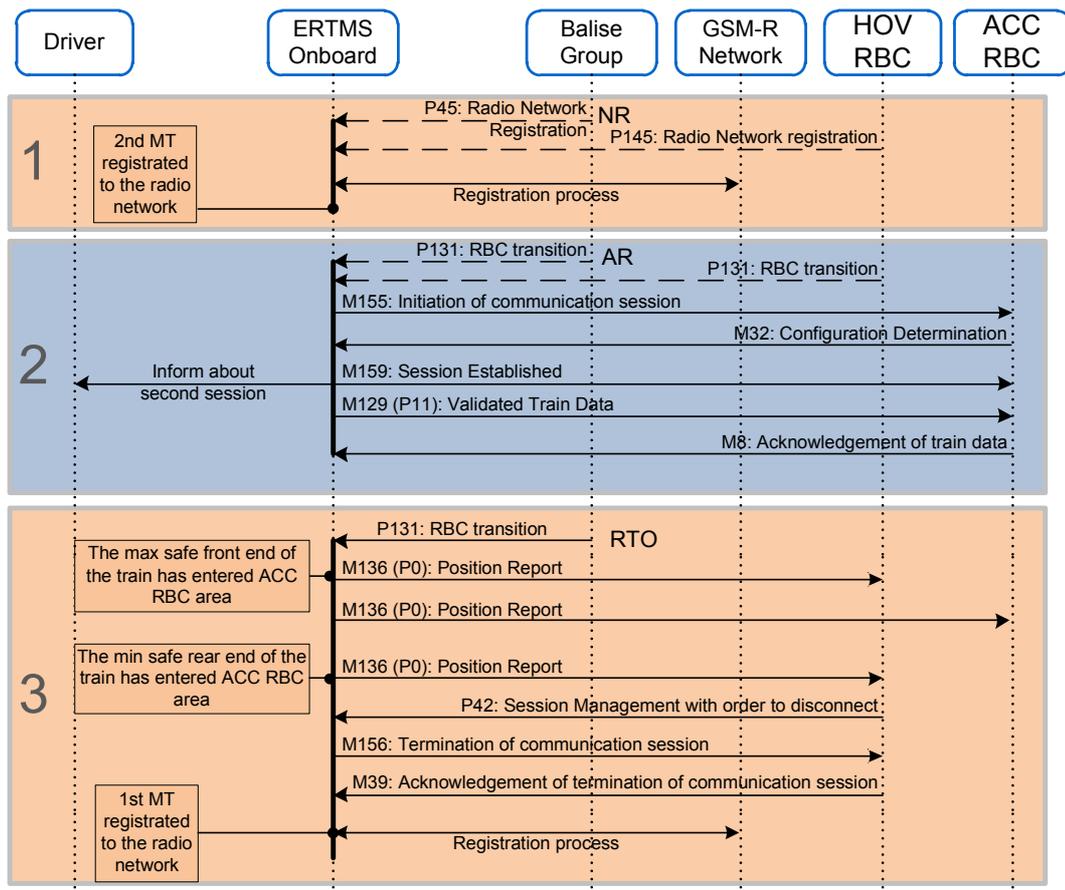


Figure 2: General sequence diagram for RBC transition

3.4.1.2 This sequence diagram is based on an onboard that is capable to use 2 communication sessions as this will be the nominal case.

- 3.4.1.3 In case of an onboard that is only capable to use 1 communication session the active Mobile Terminal will not register to the other radio network in step 1, but will postpone this registration till the connection is terminated with the HOV RBC in step 3. In step 2 there will be no session establishment with the ACC RBC, this session establishment will be postponed till the connection is terminated with the HOV RBC in step 3 and after any required radio network registration.
- 3.4.1.4 The information exchanged and the time required for that are further detailed for each functional step in chapter 5. The dashed arrows in step 1 define the Radio Network Registration by either balise group or HOV RBC. The dashed arrows in step 2 define the RBC transition order by either balise group or HOV RBC.
- 3.4.1.5 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.
- 3.4.1.6 The generation of movement authorities is not described in the general sequence diagram. When the HOV RBC generates a movement authority which reaches the RBC/RBC border, it informs the ACC RBC. This will nominally be before functional step 2.
- 3.4.1.7 The "first" Mobile Terminal (1st MT) refers to the one used for communication session with HOV RBC and "second" Mobile Terminal (2nd MT) to the one used for communication session with ACC RBC.

4. Issues to be addressed

4.1 Introduction

4.1.1.1 This chapter lists issues that need to be considered for the engineering of RBC/RBC handovers and most of them are further detailed in the recommended solutions given in chapter 5. The issues that are not part of the recommended solutions are mentioned here because projects may still need to consider them. For some of those issues a possible solution is described.

4.2 Issues RBC/RBC handovers

4.2.1 RBC/RBC border mapping

4.2.1.1 The number of RBCs and the RBC/RBC border locations should be carefully considered.

4.2.1.2 The following items are to be considered:

- Number of RBCs
- Area size per RBC
- RBC connection with interlockings (e.g. 1-to-n, n-to-1, n-to-n)
- Type of location of RBC/RBC borders (e.g. open line or stations area)
- Use of RBC telephone numbers (e.g. unique telephone number or a smart routing to the specific RBC's based on RBC Identity)
- Other borders that need to coincide with an RBC/RBC border (e.g. change of NID_C, national values, GSM-R/GPRS)

4.2.1.3 There is also no formal definition as to what constitutes an RBC and what constitutes an IXL, so the border is often blurred, in particular when it comes to where specific controls are implemented, at RBC or IXL level. This makes it difficult to determine an optimum RBC/RBC border location where different suppliers, interlockings and RBCs are involved.

4.2.1.4 This issue is further elaborated in the recommended solution.

4.2.2 Defining RBC/RBC border location

4.2.2.1 The following items are to be considered in relation to RBC/RBC border locations:

- Location of IXL borders i.e. should IXL and RBC/RBC borders be at the same or different locations?
- Location of GSM-R cell borders due to potential communications issues.
- Location of GSM-R network borders due to potential communications issues.
- Location of traction changeover areas, due to the higher risk of stranding in an area where no traction can be given. This is particularly relevant when an RBC/RBC Handover is performed with 1 Mobile Terminal where communications could be disturbed for too long and train could be braked.
- Location of track side objects, e.g. points covering border. This may introduce additional complexity to the handover design and may impact on the ERTMS

functions employed for emergency situations, for example the use of Conditional Emergency Stop for flank protection at point areas.

4.2.2.2 When defining an RBC/RBC border location also the following items are to be considered:

- Location when connection with the ACC RBC is initiated.
- Train traffic density and the required performance of the system and the interface between the RBCs.
- Roll-out steps of the ERTMS implementation, to avoid software/configuration updates.

4.2.2.3 This issue is further elaborated in the recommended solution.

4.2.3 Operational processes

4.2.3.1 The following items related to operational processes are to be considered in relation to RBC/RBC border locations:

- Data entry of RBC data at Start of Mission. It is possibly unclear for the driver which data to enter (see section 4.3.13).
- Start of Mission close to the RBC/RBC border when first MA is the one over RBC/RBC border (including ATAF – see [ATAF]).
- Turn back movements (possibly connected with wrong RBC).
- For system version X=1, RBC/RBC handover borders shall not be located where SH or RV mode movements could take place as RBC/RBC handovers are rejected by the onboard (See [SS040] 6.1.1.1.1).
- For system version X=2 the need for RV movements across the RBC/RBC border should be avoided as the RBC transition orders are not accepted in RV mode. If RV moves are required, the operational consequences need to be managed.
- It may not be possible to conduct the normal start of mission procedure within the 1st block before the border if utilising ATAF with CES (See [ATAF]) as a triggered CES in the ACC RBC area cannot be sent to the HOV RBC by which a train still could be supervised, e.g. during a single session handover(see section 4.2.7 and 4.3.2)
- No 2nd RBC/RBC handover within ($T_{NVCONTACT} * \text{maximum driving speed} + \text{train length} + \text{distance required for an MA ahead to avoid the driver starting to brake}$) due to the MA extension arriving late as there is insufficient time to connect with 2nd ACC RBC. The driver may start to brake due to the presentation/interpretation of TTI or Target Distance information, or the indication point on the planning area on Baseline 3 Release 2 onboard, or pre-indication on other onboards.
- The minimum MA length should preferably be ($T_{NVCONTACT} * \text{maximum driving speed} + \text{distance required for an MA ahead to avoid the driver starting to brake}$) in advance of the RBC/RBC border to avoid lack of MA in case an RBC/RBC handover will take place with an onboard handling only one

communication session. The driver may start to brake due to the presentation/interpretation of TTI or Target Distance information, or the indication point on the planning area on Baseline 3 Release 2 onboards, or pre-indication on other onboards.

4.2.3.2 This issue is further elaborated in the recommended solution.

4.2.4 **Performance**

4.2.4.1 The size of an RBC area and the amount of borders could be based on the RBC performance. The following items related to RBC performance are to be considered:

- Restrictions on the number of trains that an RBC can simultaneously manage (e.g. is there an upper limit driven by processing time, communications channels etc.).
- Availability issues when using large control areas (if small number of RBC's).
- Maintainability issues when using large control areas (if small number of RBC's).
- System down time for configuration updates, impact on ongoing train traffic.
- Hot swappable, hot configurable, short down time.
- Complexity of the track layout (number of objects managed by the RBC/IXL)

4.2.4.2 This issue is not elaborated in the recommended solution.

4.2.5 **Location of NID_C change in relation to RBC/RBC border**

4.2.5.1 Some RBCs can handle only one set of national values and only one NID_C identification to which the set of national values applies. This potential limitation needs to be taken into account at RBC/RBC handover in terms of the national values.

4.2.5.2 Some mitigations are described in chapter 5.

4.2.6 **Supervision gap in RBC/RBC handover**

4.2.6.1 The switch of RBC supervision in the onboard at the RBC/RBC handover is performed when the onboard reports the position passing the RBC/RBC border with the max safe front end ([SS026], 5.15.2.2.4.1 and 5.15.2.2.5.1).

4.2.6.2 If the confidence interval is large, and the train is stopped before it is actually at the RBC/RBC border (for example due to a service brake reaction on expiration of T_NVCONTACT) and the max safe front end has already passed the border, then the handover to the ACC RBC is performed, but the train is in contact with the ACC RBC that actually cannot authorize any movements before the actual border as it has no authority over the RBC area that the train is actually in.

4.2.6.3 This issue may also arise if a train stops at a normal stopping position in close proximity to the border and the max safe front end has already passed the border and the handover to the accepting RBC is performed. If the train subsequently performs an End of Mission followed by a new Start of Mission the last known RBC is the ACC RBC which again cannot authorize any train movements as it has no authority over the RBC area that the train is actually in.

4.2.6.4 For this risk hazard ETCS-H0022 was raised in [SS113].

4.2.6.5 Note: CR1228 was raised to propose a solution to this issue, but this has not been incorporated into the relevant specifications as part of release 2 for baseline 3, and as of the date of issue of this guideline document there is no agreed solution.

4.2.6.6 Some mitigations are described in chapter 5.

4.2.7 **Onboards handling only one communications session**

4.2.7.1 In clause [SS026] 3.15.1.1.3 it is described that performing an RBC/RBC handover with an onboard which can only handle one communication session may result in performance penalties since it will not be able to “prepare” the expected supervision.

4.2.7.2 This could also lead to safety issues as when switching from RBCs there is, for some time and distance, no supervision available from any RBC. Any safety or performance related controls dependent on information being transmitted between the RBC and the train in the period during which the supervision is not available will be ineffective, for example co-operative shortening movement authority, conditional or unconditional emergency stop, or position report etc. Resulting hazards and their mitigation must form part of the implementation design.

4.2.7.3 The consequences of lack of supervision could be compared to normal loss of radio communication inside an RBC area. The difference in this case is that all trains with one communication session available will suffer this at the same location and basic mitigations could not be sufficient enough in case of frequent occurrence of these trains.

4.2.7.4 In [SS026 3.6.0] an RBC/RBC handover with an onboard which can only handle one communication session is seen as degraded situation (see also section 5.4).

4.2.7.5 Some mitigations are described in chapter 5.

4.2.8 **Radio network identity and RBC contact details**

4.2.8.1 Radio data information (Radio network identity and RBC contact details i.e. RBC identity and telephone number) and changes to this information are managed by the onboard based on packets received from the trackside or via driver entered or revalidated data, and according to the mode of operation.

4.2.8.2 Transitions to No Power (NP) mode do not affect radio network identity, but cause the RBC contact details to be set to invalid. These contact details will need to be revalidated at Start of Mission in the following circumstances:

- Without cold movement detector any transition to NP will require revalidation of RBC contact details.
- With cold movement detector revalidation is only required if movement is detected.

4.2.8.3 Where trains are hauled in NP mode over a border and re-awakened in a different location, the Radio Network identity and/or RBC contact details stored by the onboard may not be suitable for the awakening location and the driver may be required to enter the correct contact details during start of mission. Also, following train maintenance where onboard components have been changed out, the data communication information may be unknown or incorrect for the maintenance location.

- 4.2.8.4 Note: The available National Values in the onboard could also not be suitable for the awakening location.
- 4.2.8.5 Some mitigations are described in chapter 5.
- 4.2.9 **Train data changed during RBC/RBC handover**
- 4.2.9.1 In the [SS039 2.3.0] there is only one possibility to send train data; namely in the pre-Announcement message. That means that in case train data has changed (e.g. due to input from external sources) during an ongoing handover transaction, it is not clear how to inform the Accepting RBC about this new train data without cancelling the handover process.
- 4.2.9.2 For this risk hazard ETCS-H0037 was raised in [SS113]. This risk is applicable if one or both RBCs involved in the RBC/RBC handover are based on ERTMS/ETCS Baseline 2. Mitigation can be found in [SS113].
- 4.2.9.3 This issue is not elaborated in the recommended solution.
- 4.2.10 **Faulty definition of Q_RRIMACHANGE and Q_TDCHANGE**
- 4.2.10.1 The definition of the variables Q_RRIMACHANGE and Q_TDCHANGE is incorrect in [SS039 2.3.0]. CR1088 was raised and has a solution for ERTMS/ETCS Baseline 3.
- 4.2.10.2 For this risk hazard ETCS-H0047 was raised in [SS113]. This risk is applicable if one or both RBCs involved in the RBC/RBC handover are based on ERTMS/ETCS Baseline 2. Mitigation can be found in [SS113].
- 4.2.10.3 This issue is not elaborated in the recommended solution.
- 4.2.11 **Session establishment leads to supervision gap for vehicles with one mobile during RBC/RBC handover**
- 4.2.11.1 Some system aspects have been missed in [SS026 3.4.0] in relation to combination of RBC/RBC transition order and session establishment order. This could lead to supervision by the ACC RBC while still in HOV RBC area.
- 4.2.11.2 For this risk hazard ETCS-H0070 was raised in [SS113]. Mitigation can be found in [SS113]. For ERTMS/ETCS Baseline 3 Release 2 onboards this is solved by CR933.
- 4.2.11.3 This issue is not elaborated in the recommended solution.
- 4.2.12 **RBC/RBC transition not to be combined with session management**
- 4.2.12.1 The onboard reaction to an RBC/RBC transition order received together with a session management order is not unambiguously defined. CR933 is implemented in ERTMS/ETCS Baseline 3 Release 2. A solution for other baselines could be to not combine the RBC/RBC transition order (p131) with the session management order (p42) in the same balise group, but in another balise group.
- 4.2.12.2 This issue is not elaborated in the recommended solution.

4.2.13 Supervision change by position report

- 4.2.13.1 Due to issues reading balise groups the RBC/RBC transition could be reported by a balise group in the RBC/RBC handover area instead of the balise group at the border. If this balise group is not known the RBC supervision may not be changed from HOV RBC to ACC RBC correctly.
- 4.2.13.2 The HOV RBC should also have knowledge about other BG after the RBC/RBC border.
- 4.2.13.3 This issue is not elaborated in the recommended solution.

4.2.14 TSRs in the RBC/RBC handover area

- 4.2.14.1 TSR information in the ACC RBC area can be transferred to the HOV RBC as part of RRI information. However there is no specified facility for the transfer of TSR information in the HOV RBC area to the ACC RBC. This means that for degraded moves through the RBC/RBC handover area, TSRs in the HOV area can only be included in a first MA from the ACC RBC if special arrangements are implemented to define that TSR information in the ACC RBC
- 4.2.14.2 The ACC RBC could be configured with track description information covering maximum train length prior to the RBC/RBC border to avoid the “Entering FS/OS” message being displayed to a driver when the ACC RBC provides an MA following a degraded move over the border. However where this information is configured in the ACC RBC, a lack of information on TSRs in the HOV RBC area will not result in the “Entering FS/OS” message because there is track description information for the entire length of the train and the train cannot know that TSR information is potentially missing.
- 4.2.14.3 If the ACC RBC is not configured with track description information covering maximum train length prior to the RBC/RBC border, the train in degraded situation passing the RBC/RBC border will not receive any track description from the HOV RBC. This will result in an “Entering FS/OS” message and the driver is responsible for any applicable temporary speed restriction.
- 4.2.14.4 Some mitigations are described in chapter 5.

4.2.15 Trackside degraded situations

- 4.2.15.1 In case of minor trackside failures, e.g. failure of one balise group, the RBC/RBC transition still should be performed. Redundancy concepts are to be considered for balise failures and communication issues.
- 4.2.15.2 This issue is not elaborated in the recommended solution.

4.2.16 RBC/RBC Handover coincides with level transition Level 2 – Level 3

- 4.2.16.1 At the RBC/RBC Handover a level transition between Level 2 and Level 3 can coincide as both Levels use RBC communication.
- 4.2.16.2 The location of the actual level transition is based on the estimated front end ([SS026] 5.10.1.5). The location of the actual RBC transition is based on the max safe front end ([SS026] 5.15.2.2.5).

4.2.16.3 Based on this behaviour it is possible that an onboard reports the "wrong" level to the supervising RBC until a new position report is provided with the estimated front end in advance of the border.

4.2.16.4 This issue is not elaborated in the recommended solution.

4.3 **Functional constraints RBC/RBC handover**

4.3.1.1 Some functions are not available on the RBC/RBC handover interface and cannot be used for trains passing the RBC/RBC border. In this paragraph those functions are described.

4.3.1.2 It should be kept in mind that if only one session could be established the train will be not connected and thus not supervised by ACC RBC for some distance in the ACC RBC area. In general all functions based on radio messages are for this distance not available.

4.3.1.3 The dynamic behaviour, e.g. train positioning based on dynamic confidence interval, and timing constraints, e.g. time for session establishment and termination, are also to be considered when designing an RBC/RBC transition. This is applicable for RBC/RBC handovers with one and two sessions.

4.3.2 **Conditional Emergency Stop function**

4.3.2.1 The Conditional Emergency Message (M15) cannot be sent on the RBC/RBC interface, nor is a specific RBC/RBC handover function available to fulfil this function. Note: For this issue CR1193 was raised.

4.3.2.2 The Conditional Emergency Stop function could be used for depart authorisation based on the guideline [ATAF].

4.3.2.3 The Conditional Emergency Stop function could be used as emergency stop under certain hazardous situations, e.g. flank protection.

4.3.2.4 Some mitigations are described in chapter 5.

4.3.3 **Revocation of emergency stop function**

4.3.3.1 The Revocation of Emergency Stop Message (M18) cannot be sent by the ACC RBC when a train received in rear of the RBC/RBC transition a Conditional Emergency Stop Message (M15) or Unconditional Emergency Stop Message (M16) from the HOV RBC and passed the RBC/RBC border before a Revocation of Emergency Stop Message (M18) is sent.

4.3.3.2 This is because the Emergency message identity (NID_EM) is not known by the ACC RBC.

4.3.3.3 A new movement authority will not be accepted until the emergency message has been revoked, a possible procedure is to use the Override procedure to revoke the emergency stop.

4.3.3.4 This issue is not elaborated in the recommended solution.

4.3.4 **Text message function**

4.3.4.1 Text messages (p72, 76) cannot be sent on the RBC/RBC interface nor is a specific RBC/RBC handover function available to fulfil this function.

4.3.4.2 If text messages are required while the ACC RBC is not yet supervising, a possible solution is that the information could be sent by balises provided that the information is static.

4.3.4.3 This issue is not elaborated in the recommended solution.

4.3.5 **Movement authority request and position report parameters**

4.3.5.1 Movement authority request (p57) and position report parameters (p58) cannot be sent on the RBC/RBC interface nor is a specific RBC/RBC handover function available to fulfil this function.

4.3.5.2 Changes in these parameters cannot be received by the onboard as long as the ACC RBC is not yet supervising. There is no specific solution available.

4.3.5.3 This issue is not elaborated in the recommended solution.

4.3.6 **List of balises for SH area or and List of balises in SR authority**

4.3.6.1 List of balises for SH area (p49) and List of balises in SR authority (p63) cannot be sent on the RBC/RBC interface nor is a specific RBC/RBC handover function available to fulfil this function.

4.3.6.2 If a List of balises for SH area (p49) is required while the ACC RBC is not yet supervising, the information could be sent by balises provided that the information is static.

4.3.6.3 List of balises in SR authority (p63) cannot be received by the onboard as long as the ACC RBC is not yet supervising. The solution described in CR494 is to send the information as soon as the ACC RBC is supervising neglecting the possible supervision gap if only one session available. There is no specific solution available.

4.3.6.4 This issue is not elaborated in the recommended solution.

4.3.7 **Data used by applications outside the ERTMS/ETCS system**

4.3.7.1 Data used by applications outside the ERTMS/ETCS system (p44) cannot be sent on the RBC/RBC interface nor is a specific RBC/RBC handover function available to fulfil this function.

4.3.7.2 Changes in this data cannot be received or sent by the onboard as long as the ACC RBC is not yet supervising. There is no specific solution available.

4.3.7.3 This issue is not elaborated in the recommended solution.

4.3.8 **Geographical position function**

4.3.8.1 Geographical position information (p79) cannot be sent on the RBC/RBC interface nor is a specific RBC/RBC handover function available to fulfil this function.

- 4.3.8.2 If geographical position information is required while the ACC RBC is not yet supervising, a possible solution is that the information could be sent by balises provided that the information is static.
- 4.3.8.3 This issue is not elaborated in the recommended solution.
- 4.3.9 **Reversing function**
- 4.3.9.1 Information about Reversing (p138, 139) cannot be sent on the RBC/RBC interface nor is a specific RBC/RBC handover function available to fulfil this function.
- 4.3.9.2 Reversing information could be sent by balises, but this information is normally dynamic and will require switchable balises. There is no specific solution available
- 4.3.9.3 This issue is not elaborated in the recommended solution.
- 4.3.10 **Train running number from RBC**
- 4.3.10.1 The Train running number from RBC (p140) cannot be sent on the RBC/RBC interface nor is a specific RBC/RBC handover function available to fulfil this function. There is no specific solution available.
- 4.3.10.2 This issue is not elaborated in the recommended solution.
- 4.3.11 **Radio hole function**
- 4.3.11.1 Radio hole function as track condition (p68) is specified for RBC/RBC handover. However using the radio hole functionality in the RBC/RBC handover area could lead to technical issues as radio communication is essential for the RBC/RBC handover.
- 4.3.11.2 For example the beginning of a real radio hole should only start in the ACC RBC area after the handing over has taken place as the actual RBC/RBC handover based on p131 should be reported to the HOV RBC.
- 4.3.11.3 Therefore this function cannot be used in RBC/RBC handover areas. Where radio hole functionality is used to manage GSM-R radio failures, for example base station failures, this will not be available near RBC/RBC borders.
- 4.3.11.4 Some mitigations are described in chapter 5.
- 4.3.12 **TSR revocation function**
- 4.3.12.1 TSR Revocation function (p66) is not mandatory on the RBC/RBC interface for Baseline 2 according to [SS039 230] 5.3.1.2. It is possible that TSR Revocation information cannot be passed from a handing-over RBC to the accepting RBC, or vice versa. This means that a TSR Revocation in the RBC/RBC handover area that impacts on operations (within train length of the RBC/RBC border) cannot be included in the MA issued by the accepting RBC. This could result in the situation where the speed of a train crossing the RBC/RBC border is not controlled correctly and this could lead to performance issues.
- 4.3.12.2 This issue is not elaborated in the recommended solution.

4.3.13 **Message acknowledgement function**

- 4.3.13.1 The acknowledgement message (M146) is not available on the RBC/RBC handover interface. Functions that need an acknowledgement are not possible to use.
- 4.3.13.2 An example is the need of knowing if a train in the HOV RBC area has accepted a level transition order to ensure the STM system is activated in hot standby in case the ACC RBC area uses an overlay with LNTC.
- 4.3.13.3 This issue is not elaborated in the recommended solution.

4.3.14 **RRI confirmation**

- 4.3.14.1 RRI confirmation is not mandatory on the RBC/RBC interface for Baseline 2 according to [SS039 v230] 5.3.1.2. It is possible that RRI confirmation information cannot be passed from a handing-over RBC to the accepting RBC, or vice versa. This means functions relying on the RRI confirmation cannot be used if one or both RBC's are based on ERTMS/ETCS Baseline 2. A function is for example request for shortening of MA.
- 4.3.14.2 This issue is not elaborated in the recommended solution.

4.3.15 **Constraints for packets and messages**

- 4.3.15.1 In [SS039 2.3.0] 6.3.1 and [SS039 3.1.0/3.2.0] 5.3.1 the following additional constraints are described for packet and messages (see [SS039] for more details):
- Q_TRACKINIT = 1 shall not be sent
 - Number of TSR shall not exceed limit set by N_REMAINTSR
 - LX identities are not duplicated
 - Track description may also be changed if Q_RRIMACHANGE <>0
 - Special value "Now" in the national values (p3) and level transition order (p41) shall not be used
 - The status of Q_TDCHANGE shall be maintained until an RRI message indicating this changed track data has been acknowledged by the HOV RBC.
- 4.3.15.2 In the messages on the RBC/RBC interface only the following modes (M_MODE) can be sent because in other modes either the Accepting RBC cannot forward any information to the on-board or the on-board cannot handle an RBC/RBC handover: FS, OS, SR, TR, PT, NL or LS(SV2.Y).
- 4.3.15.3 This issue is not elaborated in the recommended solution.
- #### 4.3.16 **Unnecessary functions**
- 4.3.16.1 Some packets and messages are not available on the RBC/RBC interface which will normally not be used at RBC/RBC handovers. For completeness these are described here together with the rationale.
- 4.3.16.2 Movement Authority with shifted reference (M33): as information from the ACC RBC area is always in advance of the current train location this function is not required.

- 4.3.16.3 Session Management (p42): a session management order will intervene with the session management for the RBC/RBC handover and this function is thus not necessary. For overlay situations Session Management can be sent by balises.
- 4.3.16.4 Radio Network registration (p45): a radio network change should be performed before session establishment with the ACC RBC and this function is thus not necessary.
- 4.3.16.5 RBC/RBC transition order (p131): as only one RBC/RBC handover can be handled at a time, it is not possible to announce a second RBC/RBC handover. This should be taken into account when engineering consecutive RBC/RBC handovers.
- 4.3.16.6 Train to track messages (p0, 1, 3, 4, 9): this information is normally sent directly to the ACC RBC. If only one session is available this information cannot be sent as long as the ACC RBC is not supervising.
- 4.3.16.7 This issue is not elaborated in the recommended solution.

5. Recommended solution RBC/RBC handover

5.1 Basic considerations

- 5.1.1.1 Ideally there should not be RBC/RBC handovers for a train. System limitations will lead however to the need for more than one physical RBC. The number of RBCs should be limited as far as is practicable.
- 5.1.1.2 There are system developments to make it possible to perform an RBC/RBC handover without interfering with the communication with the train, i.e. changing from one physical RBC to another without the need for a RBC/RBC handover based on the ERTMS specification and without the need for connecting and disconnecting the radio communication on ERTMS application level. This could make an efficient and safe implementation possible. The recommended solution is based on the situation such a solution is not available or not possible, e.g. at geographical borders.
- 5.1.1.3 It is recommended that both parties of each RBC check all applicable operational scenarios at the RBC/RBC handover location, e.g. Start of Mission, route revocation and turn back movements, in relation with their specific RBC behaviour.
- 5.1.1.4 It is recommended that both parties agree on the use of non-mandatory functions.
- 5.1.1.5 The expected benefit of the described solution is:
- an efficient and safe implementation of RBC/RBC handover
- 5.1.1.6 The following issues from chapter 4 must be considered in the solution:
- RBC/RBC border mapping
 - Defining RBC/RBC border location
 - Operational processes
 - Radio network identity and RBC contact details
 - TSRs in the RBC/RBC handover area
 - Conditional Emergency Stop function
 - Radio hole function

5.2 Recommended solution

5.2.1 General solution

- 5.2.1.1 To overcome most issues RBC/RBC borders should be situated:
- On plain line i.e. where there are no or limited infrastructure features (junctions, level crossings etc.) that the RBC/RBC handover would need to take into account.
 - Avoiding GSM-R cell borders as mixing RBC/RBC borders and GSM-R cell borders can impact on performance.
- 5.2.1.2 The distance D1 (see Figure 1) between an RBC/RBC border and the items as described in 4.2.2.1 should be based on driving time at line speed. The driving time should be based on the time to set up the communication session with the new RBC (~40s - see [SS037], 7.3.2.3.1) and (where necessary) the time to register to the 'new' network (40s – see [SS093], 6.3.7.3).

- 5.2.1.3 Within this distance D1 a normal start of mission scenario should be prevented as there could be not enough time to connect to the ACC RBC. The minimum time to depart and pass the RBC/RBC handover could be taken in to account.
- 5.2.1.4 Where an RBC/RBC border coincides with a (national) border, the RBC owners shall agree on the interface to avoid issues related to messages not described in the RBC interface which could be sent by the RBC, or optional functions that may or may not have been implemented.
- 5.2.1.5 If NID_C and/or National Values have to be changed at the RBC/RBC border the RBCs should be capable of handling multiple NID_C and National Values sets.

5.3 **Specific recommendations**

5.3.1 **Solution for onboards with only one communication session**

- 5.3.1.1 In general the impact on performance and safety when the RBC/RBC border is passed with a train with one communication session available must be considered as part of the implementation (see section 4.2.7).
- 5.3.1.2 Adding some distance to D1 (see section 5.2.1) could solve performance penalties and safety issues. This additional distance should be based on the system behaviour that the HOV RBC disconnects after the whole train has left the HOV RBC area and the time to connect to the ACC RBC after disconnection.
- 5.3.1.3 For all safety mitigation used, e.g. CES for flank protection, it should be prevented that trains with only one communication session have additional safety risks passing the distance D1 while the onboard could be not supervised.
- 5.3.1.4 A possible solution is to limit the authorisation given by the ACC RBC through the RBC/RBC interface by length and/or allowed speed until the onboard is connected to the ACC RBC.

5.3.2 **Solution for Supervision gap**

- 5.3.2.1 To solve the supervision gap the RBC could be configured to announce the RBC/RBC handover location beyond the actual RBC/RBC handover location and the RBC/RBC handover is performed on the balise group at the RBC/RBC border.
- 5.3.2.2 The size of the odometer confidence interval could be managed through the provision of additional balise groups on the approach to the RBC/RBC handover location.
- 5.3.2.3 If geographically possible, RBC/RBC handovers should be avoided where trains may normally stop, although this does not address those occasions where the train may be stopped abnormally e.g. in response to an expiry of T_NVCONTACT or on receipt of an emergency stop command.

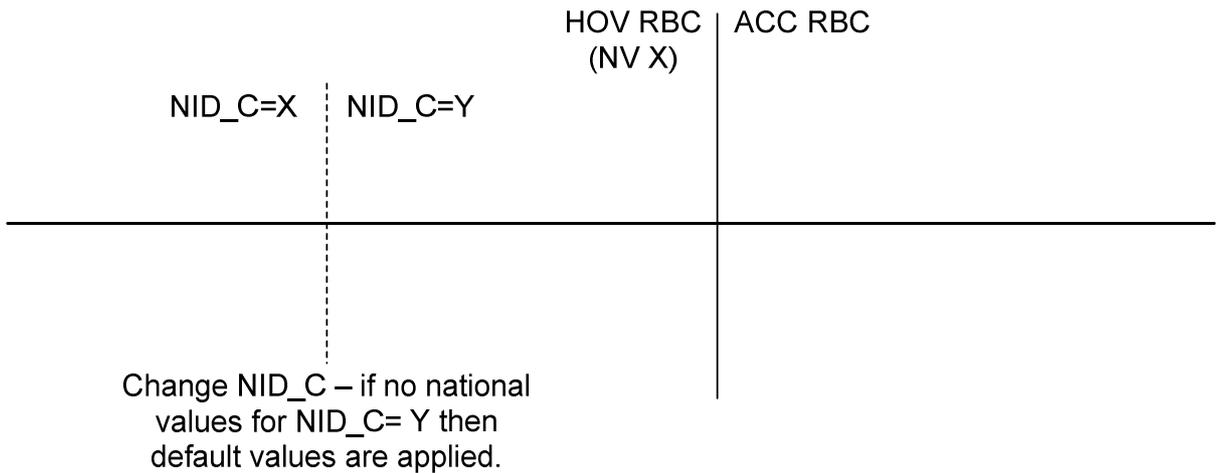
5.3.3 **Solution for issues radio hole function**

- 5.3.3.1 The issues of using the radio hole function during the RBC/RBC handover could be solved by provision of better GSM-R network capability, for example additional redundancy, in the RBC/RBC handover area (see section 4.3.11).

5.3.4 Solution for NID_C change

5.3.4.1 When changing NID_C and/or national values at a border in relation with an RBC/RBC handover it shall be checked that there are no undesired consequences when changing the values; especially if the borders (NID_C, national values, RBC) are not at the same location.

5.3.4.2 It should be prevented that the NID_C changes without the onboard has already received or is receiving at the same moment national values applicable for this new NID_C. Otherwise the default national values will be used.



5.3.5 Solution for TSRs in the RBC/RBC handover area

5.3.5.1 A solution for the fact that TSR information cannot always be passed (e.g. in SR) from the HOV RBC to the ACC RBC, is to enter the TSR separately into both RBCs, but this is not preferred as this will cost additional time and could lead to mistakes. It should be technically possible for a single TSR entry interface to pass information to different RBCs, but it is not known if any supplier currently provides this facility.

5.3.5.2 Another possible solution is for the ACC RBC to only give a first MA once the entire train is within its RBC area for degraded operation. This will avoid the situation where the “Entering FS/OS” message is not displayed where the track description information in the ACC RBC covering the area before the border cannot include any active TSR information.

5.3.6 Solution for radio network Identity and RBC contact details

5.3.6.1 Drivers will require a means to accurately determine the appropriate communication information for locations where they regularly perform start of mission and the communication information stored onboard could be invalid or unknown. Possible means of providing this information include provision of communication data by RBC area in the driver’s route book.

5.4 **Onboard recommendations**

- 5.4.1.1 The onboard should be able to handle at least two communications sessions simultaneously to facilitate communications setup with the handing over and accepting RBC. This will prevent performance penalties and safety issues.
- 5.4.1.2 Baseline 3 Release 2 onboards are already required to handle at least two communications sessions simultaneously, see [SS026 3.6.0] 3.5.2.4.
- 5.4.1.3 The optional onboard function Cold Movement Detector should be provided to minimize RBC data entry on trains performing start of mission in the RBC/RBC handover area.