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ERTMS USERS GROUP – ENGINEERING GUIDELINE

74. RBC/RBC handovers

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1. Introduction

1.1 Foreword

1.1.1.1 The requirements of the RBC/RBC handover are defined in chapter 3 and 5 of the SRS (see SUBSET-026 [1]) and in the FIS for the RBC/RBC handover (see SUBSET-039 [3]).

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.

1.1.1.5 This guideline is part of a bundle of guidelines with the Overall ETCS guideline [11] being the main guideline which will redirect the reader to the relevant guidelines. Be aware that the Overall ETCS guideline may also include recommendations which are related to the topics addressed in this guideline.

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 level 2 and 3.

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

1.2.1.3 This guideline considers the ERA/OPI/2020-2 [9]. CR1267 and CR1312 item 1 are also identified to have an impact on this guideline and the latter is adapted accordingly.

1.2.1.4 This guideline is applicable for a trackside where the System Version is 1.Y or 2.Y.

1.2.1.5 This guideline takes into consideration the following on-board systems:

- On-board system with pure System Version 1.Y (i.e. they are not fitted with any other System Version)
- On-board system supporting System Version 1.Y and 2.Y, with active System Version 1.Y or 2.Y

1.2.1.6 An RBC/RBC handover between a Baseline 3 RBC and a Baseline 2 RBC requires specific attention. Requirements will be described in SUBSET-129 [8].

1.2.1.6.1 Note: Connections between Baseline 3 RBCs with at least one RBC that is operating with System Version X=1 is covered by SUBSET-039 v3.1.0 and v3.2.0 [3] chapter 6.

1.3 Document structure

1.3.1.1 Chapter 1 introduces the document and defines the scope.

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

1.3.1.3 Chapter 3 provides the general functional steps for the RBC/RBC handover.

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

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

2. References and Abbreviations

2.1 Abbreviations

2.1.1.1 The following table includes acronyms and abbreviations which are used in the current document:

Abbreviation	Description
ACC RBC	Accepting RBC
AR	Announcement RBC transition
EOA	End of Authority
HOV RBC	Handing Over RBC
IXL	Interlocking
MT	Mobile Terminal
NR	Radio Network Registration
NRBC	Neighbour RBC
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
[1]	SUBSET-026	System Requirements Specification	2.3.0 + SUBSET-108 [6][8] (B2) 3.4.0 (B3 MR1) 3.6.0 (B3 R2)
[2]	SUBSET-037	EuroRadio FIS	2.3.0(B2) 3.1.0 (BR MR1) 3.2.0 (B3 R2
[3]	SUBSET-039	FIS for the RBC/RBC Handover	2.3.0(B2)

Ref. N°	Document Reference	Title	Version
			3.1.0 (BR MR1) 3.2.0 (B3 R2)
[4]	SUBSET-040	Dimensioning and Engineering rules	2.3.0 (B2) 3.3.0 (B3 MR1) 3.4.0 (B3 R2)
[5]	SUBSET-093	GSM-R Interfaces: Class 1 Requirements	2.3.0 (B2/B3 MR1)
[6]	SUBSET-108	Interoperability-related consolidation on TSI annex A documents	1.2.0
[7]	SUBSET-113	Report from UNISIG Hazard Log	1.2.29
[8]	SUBSET-129	FIS for the RBC/RBC Handover involving a Baseline 2 RBC	1.0.0
[9]	ERA/OPI/2020-2	Opinion of the European Union Agency for Railways to the European Commission regarding error corrections of current ERTMS baselines	2020-05-05
[10]	N/A	ERTMS Trackside Approval Issues Log	5
[11]	22E087	Overall ETCS	1-

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 SUBSET-026 [1] 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 Figure 1 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.

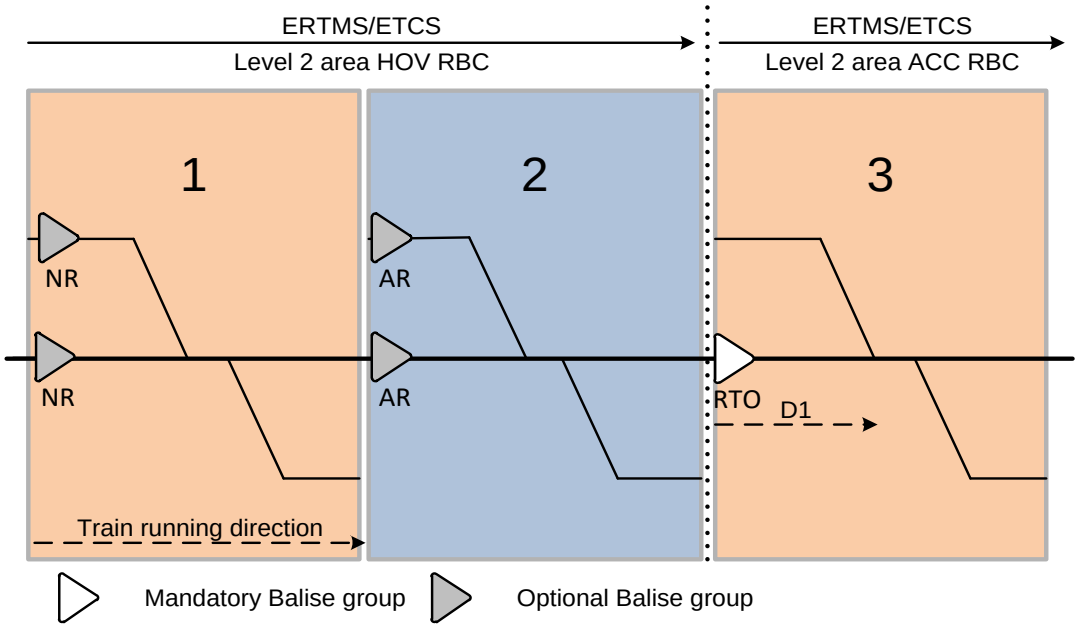

Figure 1: Generic track layout for RBC transition

3.3.1.2 Table 1 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 1: 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 on-board 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 SUBSET-026 [1] 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 on-board 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 sequence diagram in Figure 2 shows the relevant information that is exchanged between the main actors when performing the 3 functional steps listed in 3.2.1.1 above.

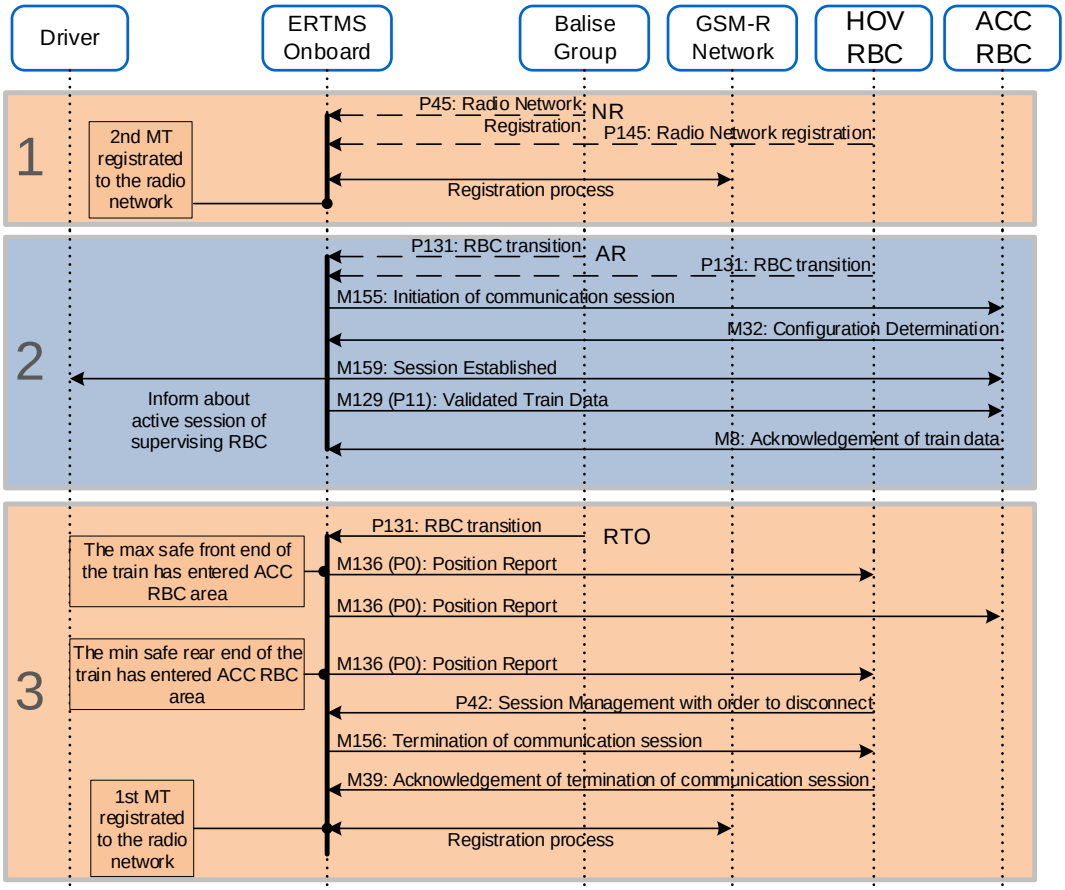

Figure 2: General sequence diagram for RBC transition

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

3.4.1.3 In case of an on-board 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 in Figure 2 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 in chapter 5.

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.
- Distance to nearby RBC borders, due to uncertainties related to two consecutive RBC/RBC handovers.

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 in chapter 5.

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).
- 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 on-board (See SUBSET-040 [4] 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 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 * maximum driving speed + train length + 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 on-board, or pre-indication on other on-boards (see section 5.3.6.1).

- The minimum MA length should preferably be (T_NVCONTACT * maximum driving speed + 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 on-board 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 on-boards, or pre-indication on other on-boards.

4.2.3.2 This issue is further elaborated in the recommended solution in chapter 5.

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 in chapter 5.

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 the recommended solution in chapter 5.

4.2.6 Supervision gap in RBC/RBC handover

4.2.6.1 The switch of RBC supervision in the on-board at the RBC/RBC handover is performed when the on-board reports the position passing the RBC/RBC border with the max safe front end (see SUBSET-026 [1], 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 ACC 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 SUBSET-113 [7].

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

4.2.6.5 Some mitigations are described in the recommended solution in chapter 5.

4.2.6.6 After the switch of RBC supervision to the ACC RBC, the on-board does only accept a disconnection order from the HOV RBC (see SUBSET-026 [1] 3.15.1.3.5). When the switch of supervision takes place a part of the train can still be in the area of the HOV RBC. If in this case a safety relevant condition arises in the area of the HOV RBC, the HOV RBC cannot send a restrictive message to the train (e.g. UES) itself or by the RBC-RBC interface. Especially if a IXL-IXL border coincides with the RBC-RBC border this could be an issue. A project specific solution should be considered, for example a simple border track layout without specific risk-locations or an overlap of IXL area.

4.2.7 On-boards handling only one communications session

4.2.7.1 In clause SUBSET-026 [1] 3.15.1.1.3 it is described that performing an RBC/RBC handover with an on-board 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 SUBSET-026 v3.6.0 [1] an RBC/RBC handover with an on-board which can only handle one communication session is seen as degraded situation (see also section 5.3.8).

4.2.7.5 Some mitigations are described in the recommended solution 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 on-board 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 on-board 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 on-board components have been changed out, the data communication information may be unknown or incorrect for the maintenance location.

4.2.8.3.1 Note: The available National Values in the on-board could also not be suitable for the awakening location.

4.2.8.4 Some mitigations are described in the recommended solution in chapter 5.

4.2.9 Train data changed during RBC/RBC handover

4.2.9.1 In SUBSET-039 v2.3.0 [3], 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 SUBSET-113 [7]. 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 SUBSET-113 [7].

4.2.9.3 This issue is not elaborated in the recommended solution in chapter 5.

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 SUBSET-039 v2.3.0 [3]. 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 SUBSET-113 [7]. 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 SUBSET-113 [7].

4.2.10.3 This issue is not elaborated in the recommended solution in chapter 5.

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 SUBSET-026 v3.4.0 [1] 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 SUBSET-113 [7]. Mitigation can be found in SUBSET-113 [7]. For ERTMS/ETCS Baseline 3 Release 2 on-boards this is solved by CR933.

4.2.11.3 This issue is not elaborated in the recommended solution in chapter 5.

4.2.12 RBC/RBC transition order not to be combined with session management

4.2.12.1 The on-board 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 in chapter 5.

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 in chapter 5.

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 “Enter in 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 “Enter in 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 “Enter in FS/OS” message and the driver is responsible for any applicable temporary speed restriction.

4.2.14.4 Some mitigations are described in the recommended solution 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 in chapter 5.

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 (see SUBSET-026 [1] 5.10.1.5). The location of the actual RBC transition is based on the max safe front end (see SUBSET-026 [1] 5.15.2.2.5).

4.2.16.3 Based on this behaviour it is possible that an on-board 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 in chapter 5.

4.2.17 Reference time stamp of T_NVCONTACT during RBC/RBC handover

4.2.17.1 When an RBC/RBC handover has been announced, the current on-board time shall be compared with the time stamp of the latest consistent message from the HOV RBC until the train considers the ACC RBC as the supervising one. From then on, the current on-board time shall be compared with the time stamp of the latest received consistent message from the ACC RBC (see SUBSET-026 [1] 3.16.3.4.1.2).

4.2.17.2 This change in supervision occurs when the following conditions are fulfilled:

- The on-board shall send to both RBCs a position report (see SUBSET-026 [1] 3.15.1.3.4)

- Once the position report is sent directly to the ACC RBC, it shall use the information received from the ACC RBC (see SUBSET-026 [1] 3.15.1.3.5)

4.2.17.3 A degraded situation that might occur, is that the on-board and the ACC RBC are unable to establish a radio communication session during an RBC/RBC handover. However, since these conditions are not fulfilled, the latest received message of the HOV RBC remains the timer reference in this degraded situation.

4.2.17.4 This issue is not elaborated in the recommended solution in chapter 5.

4.2.18 Reference time stamp of T_NVCONTACT in a combined RBC/RBC handover and manual level transition

4.2.18.1 If the on-board equipment cannot open a session with the ACC RBC during an RBC/RBC handover, the train is stopped at the latest when it has reached the EOA given by the HOV RBC. For passing the EOA the driver may select “override”, or manually change the level (see SUBSET-026 [1] 5.15.4.2).

4.2.18.2 When the min safe rear end of the train has passed the RBC/RBC handover border, the radio communication with the HOV RBC is ordered to be terminated by the HOV RBC. In this degraded situation the on-board has nor with ACC RBC nor with the HOV RBC a communication session alive. Changing manually of level as suggested by SUBSET-026 [1] 5.15.4.2, the time stamp of the level transition becomes the reference time stamp of T_NVCONTACT as per SUBSET-026 [1] 3.16.3.4.1.1. Since there is no communication with the ACC RBC, the transition of the reference time stamp towards the time stamp of the latest received message from the ACC RBC (see SUBSET-026 [1] 3.16.3.4.1.2) cannot be fulfilled.

4.2.18.3 This issue is not elaborated in the recommended solution in chapter 5.

4.2.19 Missing requirements for RBC/RBC handover cancellation procedure

4.2.19.1 The RBC/RBC handover procedure for a train approaching an RBC border is cancelled if the ACC RBC receives a pre-announcement message from the HOV RBC after the first RRI Request message. Consequently, the communication session of the on-board with the ACC RBC is terminated, because the ACC RBC considers this as a cancellation condition for the already ongoing transaction (see SUBSET-039 [3] 4.3.1.4).

4.2.19.2 SUBSET-026 [1] brings forward two cancellation conditions that triggers the cancellation procedure.

- Route of the approaching train does not anymore include the border;
- The approaching trains performs an end of mission (“End of Mission” information is sent to the HOV RBC).

4.2.19.3 However, the cancellation procedure might result in a hazard. The termination of the communication session with the on-board can perfectly occur when the train is not at standstill and might cross the RBC/RBC border, while the routes in the ACC RBC area are released in the meantime. Therefore, if possible, it should be

guaranteed that the train will not cross the border to the ACC RBC area before cancelling the ongoing transaction.

4.2.19.4 This issue is not elaborated in the recommended solution in chapter 5.

4.2.20 Pre-Announcement in mode OS

4.2.20.1 The scenario describes a track layout where the the IXL border is located in advance of the RBC/RBC border, see Figure 3 and Figure 4.

4.2.20.2 The ACC RBC must be informed from the HOV RBC, if the MA in the RRI must be extended with an OS mode profile. This is because the ACC RBC doesn't know the on sight signal aspect of the last signal before the RBC border. If the last signal before the RBC/RBC border shows on sight aspect and the beginning of the train detection section is in advance of the NRBC border signal, mode OS is therefore needed for a certain distance in advance of the NRBC border signal until the beginning of the train detection section.

4.2.20.3 The attribute M_MODE in the pre-announcement message 201 contains the current operating mode of the train known to the HOV RBC, when it sends this message to the ACC RBC (see SUBSET-026 [1] 3.15.1.2.1). The following two situations are applicable.

4.2.20.4 Situation 1: The HOV RBC shall only pre-announce an RBC/RBC transition in OS mode, if the MA contains a mode profile in OS mode until the RBC/RBC border.

4.2.20.5 In this situation, the ACC RBC must only extend the MA with OS mode profile in RRI beyond the RBC/RBC border, if the train is pre-announced with M_MODE in OS mode and therefore also reaches the RBC/RBC border in OS mode. See Figure 3 for a visual representation of situation 1.

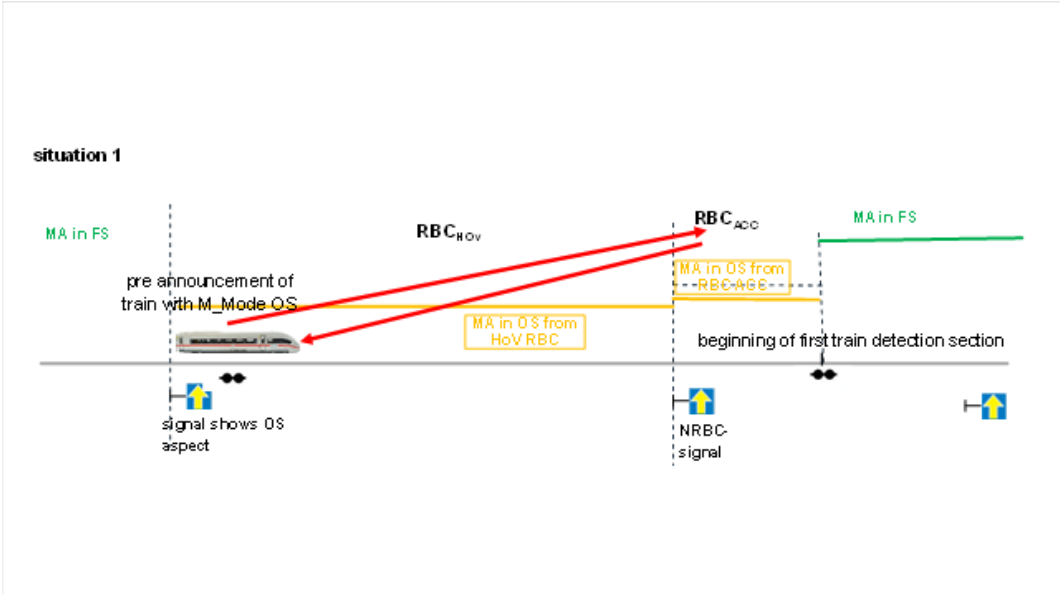

Figure 3: Visual representation of situation 1

4.2.20.5.1 Note: The required OS section in the ACC RBC area in advance of the RBC/RBC border normally depends on the beginning of the trackside train detection system section or block section.

4.2.20.6 Situation 2: If there is no continuous OS mode profile until the RBC/RBC border, the pre-announcement message must be delayed until the train leaves the last OS mode profile section before the RBC/RBC border, because the ACC RBC should not extend the MA with an OS mode profile in this situation (received M_MODE should not be OS mode). See Figure 4 for a visual representation of situation 2.

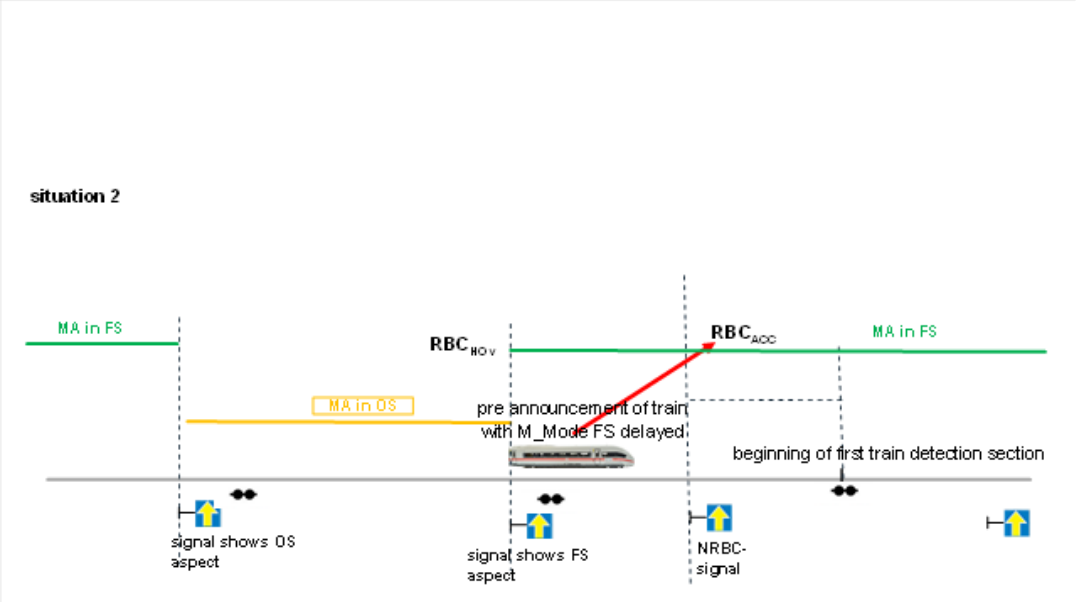

Figure 4: Visual representation of situation 2

4.2.20.7 The ACC RBC and the HOV RBC must both implement this solution, otherwise it might result in safety relevant incompatibility.

4.2.21 Route Cancellation in HOV RBC

4.2.21.1 The ACC RBC must be informed by the HOV RBC with a cancellation message 204, if the route in the HOV RBC area is cancelled and the pre-announced train with message 201 will not pass the RBC/RBC border.

4.2.21.2 If the ACC RBC receives a cancellation message 204 from the HOV RBC, the already set route in the ACC RBC area can then be allocated to a new train and a movement authority can be provided to this train.

4.2.21.3 If the ACC RBC does not release the route in the ACC RBC area after having received message 204 from the HOV RBC, this might result in a deadlock situation and requires manual route release.

4.2.21.4 If the train approaching the RBC/RBC border was already pre-announced to the ACC RBC with message 201, then the HOV RBC should send a cancellation message 204 to the ACC RBC in the following situations:

- If the route to the RBC/RBC border in the HOV RBC area was cancelled and the train in mode FS/OS/LS has accepted and confirmed a CES or

UES message or shortened MA and the train is at standstill before the RBC/RBC border

- If the train changes to mode NP, SB, SL, SH, PS, SR, NL, UN, TR, SN, RV (RBC transition is deleted according to SUBSET-026 [1] section 4.10.1.3) and the train is at standstill before the RBC/RBC border

4.3 Functional constraints RBC/RBC handover

4.3.1 Introduction

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.

4.3.2.1.1 Note: For this issue CR1193 was raised.

4.3.2.2 The Conditional Emergency Stop function could be used for depart authorisationwhen ATAF is used.

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 in chapter 5.

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.

4.3.4.2.1 Note: CR1366 was raised to propose a solution to this issue, but this has not been incorporated into the relevant specifications yet, and as of the date of issue of this guideline document there is no agreed solution.

4.3.4.3 This issue is not elaborated in the recommended solution in chapter 5.

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 on-board 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 in chapter 5.

4.3.6 List of balises for SH area 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 on-board 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 in chapter 5.

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 on-board 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 in chapter 5.

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 in chapter 5.

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 in chapter 5.

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 in chapter 5.

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 the recommended solution 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 SUBSET-039 v2.3.0 [3] 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 in chapter 5.

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 in chapter 5.

4.3.14 RRI confirmation

4.3.14.1 RRI confirmation is not mandatory on the RBC/RBC interface for Baseline 2 according to SUBSET-039 v2.3.0 [3] 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 in chapter 5.

4.3.15 Constraints for packets and messages

4.3.15.1 In SUBSET-039 v2.3.0 [3] 6.3.1 and SUBSET-039 v3.1.0 and v3.2.0 [3] 5.3.1 the following additional constraints are described for packet and messages (see SUBSET-039 [3] 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 in chapter 5.

4.3.16 Repetition of relevant information to OBU by ACC RBC after Taking Over Responsibility

4.3.16.1 There are numerous hazards and issues related to information losses around an RBC/RBC border caused by loss of contact between the HOV RBC and the OBU before passing the border. Restrictive information sent by ACC RBC to the train through RRI can not be received or is not accepted by the OBU. Furthermore, the ACC RBC has no way to ensure that the OBU has received the information, since the acknowledgement is only a confirmation that the HOV RBC has received the updated RRI.

4.3.16.2 Some mitigations are described in the recommended solution in chapter 5.

4.3.16.2.1 Note: There might be confusion between the definition of M_ACK in SUBSET-026 [1] sent through M146 from RBC to on-board and the definition of M_ACK in SUBSET-039 [3] sent over the RBC/RBC interface. These variables M_ACK indicate both whether the message must be acknowledged but are used over different interfaces (i.e. train-track and RBC-RBC, respectively).

4.3.17 Acquiring the list of available networks whilst communication session is established

4.3.17.1 In a situation where an on-board with 2 mobile terminals both in communication sessions during RBC/RBC handover (in CS mode) or an on-board with 2 mobile terminals but only one working and this one being used for a communication session the driver is not able to acquire a list of networks if the driver elects to modify the Radio Network ID. To do so, the on-board has to request the release of the safe connection with trackside before the list of available networks can be acquired.

4.3.17.2 For trains whose on-board does not contain CR1267, requesting the release of the safe connection might have an impact on the on-board behaviour as in the situation above. However, the impact of this issue on the on-board behaviour depends on the applicable set of specifications.

4.3.17.3 For ERTMS/ETCS Baseline 2 and Baseline 3 Maintenance Release 1 on-boards, the on-board might not be able to acquire the list of available radio networks in case it is necessary to change the Radio Network ID during the SoM and the procedure would be stuck in step S3 of 5.4.3.2 in SUBSET-026 [1].

4.3.17.4 For ERTMS/ETCS Baseline 3 Release 2 on-boards, the issue is narrowed down to changing the radio network by the driver outside the SoM procedure thanks to CR1087, but which is not considered as normal service.

4.3.17.5 CR1267 was raised in ERA/OPI/2020-2 [9] and has a solution for next TSI CCS.

4.3.17.6 This issue is not elaborated in the recommended solution in chapter 5.

4.3.18 Unnecessary functions

4.3.18.1 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.

4.3.18.2 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.

4.3.18.3 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.

4.3.18.4 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.

4.3.18.5 RBC/RBC transition order (p131): as one RBC can only act as the HOV RBC in one RBC/RBC handover transaction at a time, this HOV RBC is not able to announce a second RBC/RBC handover from the ACC RBC area into a third RBC area.

4.3.18.6 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.

4.3.18.7 This issue is not elaborated in the recommended solution in chapter 5.

4.4 Trackside Approval Issues Log

4.4.1 Introduction

4.4.1.1 This chapter describes the shunting related issues listed in the ERA Trackside Approval Issues Log [10], with recommended mitigations found in chapter 5.5.

4.4.2 Network Registration not to be combined with session establishment or RBC transition (issue 10.3.3)

4.4.2.1 The on-board reaction to a network registration (P42) received together with a session establishment (P45) or RBC transition order (P131) is not unambiguously defined. CR1312 of ERA/OPI/2020-2 [9] has a solution for next TSI CCS.

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 where 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, see 4.2.1
- Defining RBC/RBC border location, see 4.2.2
- Operational processes, see 4.2.3
- Location of NID_C change in relation to RBC/RBC border, see 4.2.5
- Supervision gap in RBC/RBC handover, see 4.2.6
- On-boards handling only one communications session, see 4.2.7
- Radio network identity and RBC contact details, see 4.2.8
- TSRs in the RBC/RBC handover area, see 4.2.14
- Conditional Emergency Stop function, see 4.3.2
- Radio hole function, see 4.3.11
- Repetition of relevant information to OBU by ACC RBC after Taking Over Responsibility, see 4.3.16

5.2 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, stations, changes of traction system, 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.

- Avoiding locations where ETCS functions which cannot be passed over the RBC/RBC interface 4.3) absolutely have to be used.
- In the same position of an existing IXL/IXL border, whenever possible, to optimize the number of variables and conditions to check.

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 SUBSET-037 [2], 7.3.2.3.1) and (where necessary) the time to register to the 'new' network (40s – see SUBSET-093 [5], 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 on-boards 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) 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 on-board 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 on-board 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 on-board 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 (see Figure 5).

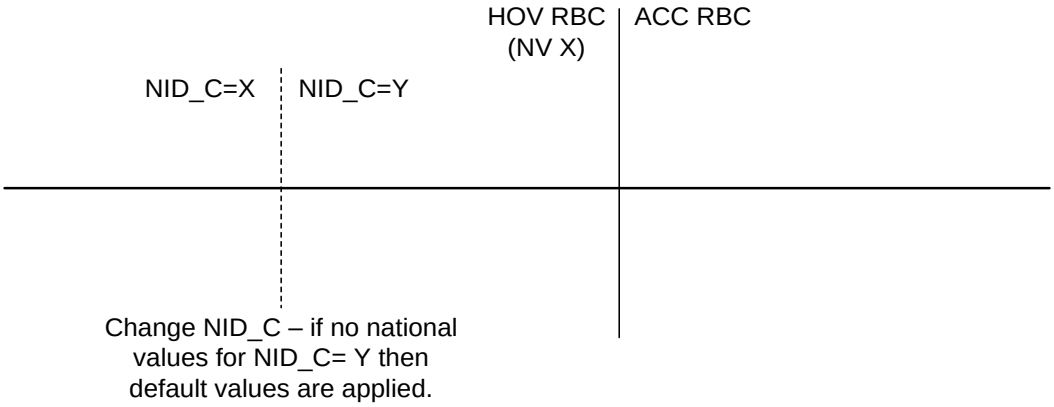

Figure 5: NID_C change at different location than the RBC/RBC border

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 “Enter in 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 means to accurately determine the appropriate communication information for locations where they regularly perform start of mission and the communication information stored on-board 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.

5.3.7 Solution for Handover involving 3 RBCs

5.3.7.1 It may happen that two RBC-RBC borders are in such a proximity that an ongoing RBC/RBC handover procedure between RBC1 and RBC2 is interrupted by newly announced handover between RBC2 and RBC3. This might happen when a route assigned to a train already extends into the RBC3 area, but the rear of the train has not yet left the RBC1 area.

5.3.7.2 A minimum distance between two consecutive RBC/RBC handover borders should be respected to ensure that the first RBC/RBC handover between RBC1 and RBC2 is successfully completed before a new handover procedure can start. To determine this distance, the sum of worst-case time of 1) terminating the communication session with RBC1 and 2) establishing a communication session with RBC3 multiplied with the applicable line speed. On top of this distance, the maximum train length should be added as the max safe front end engages the communication establishment with RBC3 and the min safe rear end triggers the connection termination with RBC1 (see section 4.3.18.5).

5.3.8 Solution to minimize the risk of information loss between OBU when passing RBC/RBC border

5.3.8.1 To minimize the risk of information loss to the OBU when passing an RBC/RBC border, the latest relevant information that has been relayed in the latest RRI should be re-sent to the OBU as soon as the ACC RBC has received a position report detecting the OBU max safe front end past the border (SS026- 5.15.2.2.5).

5.4 On-board recommendations

5.4.1.1 The on-board 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 on-boards are already required to handle at least two communications sessions simultaneously, see SUBSET-026 v3.6.0 [1] 3.5.2.4.

5.4.1.3 The optional on-board function Cold Movement Detector should be provided to minimize RBC data entry on trains performing start of mission in the RBC/RBC handover area.

5.5 Trackside Approval Issues Log

5.5.1 Introduction

5.5.1.1 This chapter describes recommendations to mitigate the shunting related issues listed in the Trackside Approval Issues Log [10], which are described in chapter 4.4.

5.5.2 Network Registration not to be combined with session establishment or RBC transition (issue 10.3.3)

5.5.2.1 A mitigation is provided in ERA/OPI/2020-2 [9] for all Baselines, i.e. in areas where there is an overlap of several radio networks coverage, P45 should never be sent together with P42 or P131 (or P143 for Baseline 3 Release 2 on-board) requesting the establishment of a communication session.