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ERTMS USERS GROUP – ENGINEERING GUIDELINE

76. Border Crossings

Reference: 17E087
Version: 4-
Date: 2024-06-28

Modification history

Version	Date	Modification / Description	Editor
0.1	26/06/2017	First draft based on ESG Topic – Border Crossing_V0 12 (Version 2)	Workshop Border Crossings
0.2	31/08/2017	Draft considering the output of the Border Crossing WS and ESG60	GR
0.3	12/09/2017	Review during ESG61	GR
0.4	30/09/2017	Remarks coming from ESG61	GR
0.5	06/10/2017	Update section 3.3.1 and 3.3.3	GR
0.6	12/10/2017	Remarks coming from ESG62 and following contributions from AJM, JA, AB, SMC, DC	GR
0.7	17/11/2017	Feedback from ESG63	GR/DC
0.8	23/11/2017	Figure 1 corrected, location of level transition table corrected	GR/DC
1.0	20/12/2017	Version 1.0	GR/DC
1.1	19/02/2019	Added issue about non-harmonised axle load speed restrictions	AJM
1.2	19/04/2019	Impact Art10SP (2017) incorporated Added issue about informing driver about border crossings	AJM
1.3	24/05/2019	Review during ESG75	AJM
1.4	25/06/2019	Review during ESG76 and remarks SMC, BK	AJM
2.0	10/10/2019	Release of version 2.0	ESG
2.1	07/02/2020	Added appendix A.8	ATJ
2.2	30/03/2020	After ESG 81 comments	ATJ, GR
2.3	06/04/2020	Review during ESG82	ATJ, GR
3.0	19/5/2020	Approved by ESG83	GR
3a	13/04/2021	Split clause 3.3.1.9	ATJ
	2023-05-02	References (reference list and formatting on title page) updated.	A. Bäärnhielm
	2023-05-05	Added appendix A.9 - Simplified Handover	VP

	2024-03-18	Added subchapters 4.2.5 and 5.1.3.4 (Q_NEWCOUNTRY issue at border with linking to different NID_C BG's) Modified chapter titles 4.2 and 5.1	LA
	2024-02-27	Merging Appendix A5 and A9 - removing A9	VP
	2024-04-18	Updates following ESG115	ESG
3b	2024-04-30	Corrections to document style and layout and editorial corrections.	A. Bäärnhielm
	2024-06-18	Picture of communication SHOV	VP
	2024-06-20	Appendices renumbered	A. Bäärnhielm
4-	2024-06-28	Official version	C. Zieleman

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1. Introduction

1.1 Foreword

1.1.1.1 Border crossings are a distinct part of ERTMS implementations; ERTMS being principally designed to act as a mobility enabler for cross border traffic to facilitate continued and harmonised operations across country borders, for example via the freight corridors across Europe. However, safely and efficiently interfacing ERTMS implementations across borders is potentially a complex and difficult implementation exercise, particularly because:

1) often, critical initial situations/requirements at the borders are not available when the implementation on either side of the border are completed;
2) national borders, system borders (ERTMS, Telecommunications etc.) and IM Network borders are not congruent;
3) different national safety standards (NSAs), operational rules, and approval processes exist on either side of the border.

1.1.1.2 However, border crossings are not necessarily only related to crossing borders between countries. The complex technical and operational requirements of ERTMS, and the possibility of extended staged roll-out of ERTMS also introduce border crossing type issues within individual countries, for example at changes in System Version or National Values. For the definition of the “border” considered in the present document see paragraph 2.1.

1.1.1.3 Authors of the document consider that the issues identified and tackled represent the status of the present knowledge and implementations concerning ERTMS border crossing.

1.1.1.4 This guideline is part of a bundle of guidelines with the Overall ETCS guideline [16] 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 The aim of this document is to collect and describe border crossing related issues already identified during implementation of, or specification of requirements for, ERTMS across Europe and provide a recommended trackside solution for the engineering of border crossings.

1.2.1.2 The objective is to support an efficient and safe implementation of ERTMS, from a technical and operational point of view, simplifying and harmonising future system implementations by taking advantage of the experience obtained from projects already in operation or under development.

1.2.1.3 This document provides recommendations concerning both strategy/process and technical choices to design (considerations to be made when specifying

requirements), test, and authorise in commercial operation, an ERTMS border crossing.

1.2.1.4 The recommendations identified aim to provide specific border crossing provisions aiming to allow trains to cross border safely and seamlessly despite the potential change of rules, procedures, and safety principles occurring at a border.

1.2.1.5 The recommendations identified aim to minimise the impact on operation in a transparent way for all users (number of operational handlings by driver and traffic manager).

1.2.1.6 This document is based on ERTMS/ETCS Baseline 2 and 3 (including ERA/OPI/2017-2 [13]) and applicable for ETCS levels 1, 2 and 3 on at least one side of the border. Border crossing involving only national systems are not in scope of this document; provisions in this and other referenced EUG and ERA Guidelines may be applicable also to borders with National systems on both sides and trains equipped with ERTMS and both class B systems.

1.2.1.7 The recommendations identified consider also possible failures and degraded situations.

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

1.2.1.9 To identify operational rules over borders is out of scope of this document.

1.2.1.10 This guideline only considers issues directly related to border crossings.

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

1.2.1.12 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 (this includes on-boards B3MR1, B3R2, B3R2+ERA/OPI/2017-2 [13])

1.3 Document structure

1.3.1.1 Chapter 1 introduces the document, defines the scope and the field of application.

1.3.1.2 Chapter 2 provides definitions, references, terms and abbreviations used in this document and the list of Appendixes.

1.3.1.3 Chapter 3 provides considerations addressing strategy and process when dealing with a border crossing project.

1.3.1.4 Chapter 4 provides the issues to be addressed for engineering of Border Crossings.

1.3.1.5 Chapter 5 provides the recommended solutions to the issues addressed in chapter 4.

1.3.1.6 Appendix A provides a list of National Values with functional and operational impact.

1.3.1.7 Appendix B provides a list of operational scenarios.

1.3.1.8 Appendix C provides an example of a procedure when RBC interfaces are not compatible.

1.3.1.9 Appendix D provides a list of border crossing information relevant to the driver.

2. References and Abbreviations

2.1 Definitions

2.1.1.1 The following table includes terms and definitions which are used in the current document:

Terminology	Definition
ERTMS Border Crossing	A location where operational rules and/or functionality and/or juridical aspects change AND ERTMS/ETCS operation in levels 1, 2 or 3 is available on at least one side of the border.
Border Zone	The smallest possible zone containing all ERTMS Border Crossing arrangements, including any preparation, connecting two areas.
Changes of Operational Rules	Changes affecting National Values with Operational impact and changes affecting national rulebooks.
Changes in Functionality	Changes of engineering rules, System Version, ETCS level, NID_C and National Values with functional impact and changes affecting the communication system.
Changes in Juridical aspects	Changes of users' responsibility, authorisation (NSA) and National Law.

2.2 Abbreviations

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

Abbreviation	Description
ACC RBC	Accepting RBC
ATAF	Automatic Track Ahead Free
B	Baseline
CES	Conditional Emergency Stop
CR	Change request
DeBo	Designated Body
DMI	Driver Machine Interface
EDP	ERTMS Deployment Plan
EOA	End of Authority
ERA	European Union Agency for Railways

ESG	Engineering Support Group (working group @ ERTMS Users Group)
FS	Full Supervision (mode)
GPRS	General Packet Radio Service
GSM-R	Global System for Mobile communication – Railways
HOV RBC	Handing Over RBC
IM	Infrastructure Manager
IXL	Interlocking
KM	Key Management
KMAC	Authentication Key
KMC	Key Management Centre
LS	Limited Supervision (mode)
MA	Movement authority
MoU	Memorandum of Understanding
Mx	Message number x
NL	Non LeadingNon-Leading (mode)
NoBo	Notified Body
NP	No Power (mode)
NSA	National Safety Authority
NTC	National Train Control
NTR	National Technical Rule
NV	National Value
OBU	ETCS On-board Unit
OS	On Sight (mode)
PLMN	Public Land Mobile Network
PT	Post Trip (mode)
Px	Packet number x
RBC	Radio Block Centre
RIU	Radio Infill Unit
RRI	Route Related Information
RU	Railways Undertaking

SR	Staff Responsible (mode)
STM	Specific Transmission Module
SV	System Version
TBD	To Be Determined
TMS	Traffic Management System
TR	Trip (mode)
TRK	Trackside
TSR	Temporary Speed Restriction

2.3 References

2.3.1.1 The following documents and versions apply:

Ref. N°	Document Reference	Title	Version
[1]	SUBSET-026	System Requirements Specification	2.3.0 + SUBSET-108 [2] (B2) 3.4.0 (B3 MR1) 3.6.0 (B3 R2)
[2]	SUBSET-108	Interoperability-related consolidation on TSI annex A documents	1.2.0
[3]	SUBSET-037	EuroRadio FIS	2.3.0(B2) 3.1.0 (BR MR1) 3.2.0 (B3 R2
[4]	SUBSET-038	Off-line Key Management FIS	3.1.0
[5]	SUBSET-039	FIS for the RBC/RBC Handover	2.3.0(B2) 3.1.0 (BR MR1) 3.2.0 (B3 R2)
[6]	SUBSET-093	GSM-R Interfaces: Class 1 Requirements	2.3.0 (B2/B3 MR1)

Ref. N°	Document Reference	Title	Version
[7]	SUBSET-113	ETCS Hazard Log	1.3.0
[8]	SUBSET-114	KMC-ETCS Entity Off-line KM FIS	1.0.0
[9]	SUBSET-137	On-line Key management FFFIS	1.0.0
[10]	17E112	RBC/RBC handovers	2-
[11]	EUG_UNISIG_BCA	Baseline Compatibility Assessment - Final Report	1.0.0
[12]	ERA_BCA_B3R2	Baseline Compatibility Assessment Baseline 3 Release 2- Final Report	1.1.0
[13]	ERA/OPI/2017-2	OPINION of the European Union Agency for Railways to the European Commission regarding CCS TSI Error Corrections	2017-02-04
[14]	010TSA1068	Application guide for the ERTMS trackside approval	1.0
[15]	2016/789 EU	DIRECTIVE (EU) 2016/798 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 May 2016 on railway safety	-
[16]	22E087	Overall ETCS	1-

3. Strategy, process, and general recommendations

3.1 General

3.1.1.1 Based on the projects experience these general recommendations shall be considered when engineering an ERTMS border:

3.1.1.2 Border crossing experience teaches that case by case study is required. However, it is fundamental to ensure appropriate and early identification of dialogue partners (ERA, IM, NSA, RU, NoBo/DeBo, suppliers etc.) across the national borders to guarantee a harmonised approach (share analysis and design documents).

3.1.1.3 Consider carefully if locating the system borders in a different location to the national border; in this case the early involvement of NSAs (and possibly of the Member State) is more important to have a clear identification of the responsibilities and rules to apply (different safety approaches, TSI CCS specific cases and NTRs influence ERTMS engineering rules).

3.1.1.4 Ensure aligning of implementation strategies (masterplan) on both sides of the border (may depend on Freight corridors, national implementation plan).

3.1.1.5 On the one hand, consider the constraint to minimise the impact on existing operational rules of both sides of the border. On the other hand, consider that different operational rules and principles may heavily affect technical solutions.

3.1.1.6 Consider the capacity requirements for cross border services as the capacity across a border may be lower than on the adjacent lines and thus not fulfil the requirements.

3.1.1.7 In case a border has to be located in a long tunnel/bridge, specific precautions/strategy to regulate the traffic /allow evacuation, will have to be considered by both parties in case of incident/regularity problem.

3.1.1.8 Consider locating borders on plain lines not too close to nodes/large stations, if applicable, to simplify the engineering.

3.1.1.9 The characteristics (e.g. train categories, ETCS Baseline, non-mandatory CRs implemented on-board, possible OBU deviation to the standards due to NTRs) of the fleet involved have to be considered.

3.1.1.10 In case one party involved in the border crossing (including RUs) does a modification in its system, an impact analysis has to be performed to identify all possible issues arising from that modification and the relevant recommendations to be considered again.

3.1.1.11 When engineering a border crossing as part of an ERTMS implementation, it should be considered that also the IXL-IXL interface and the TMS-TMS interface should be engineered. I.e. what minimum information is needed at these interfaces to facilitate continued and harmonised operations.

3.1.1.12 Differences in languages at national border crossings would need to be considered as part of any border crossing implementation. Drivers who cross national borders

will need to communicate verbally with foreign signallers in some situations and will need to be able to interpret plain text messages received from a foreign trackside. Fixed text message content and system status messages (shown by the B3 DMI in the language chosen by the driver) may form part of the verbal communication between driver and signaller. To minimise the risk of misinterpretation or miscommunication the following language related issues should be considered:

3.1.1.13 Competency of drivers and other railway staff to converse in the language applicable following a border crossing at an appropriate level;

3.1.1.14 Sharing of plain text messages and their meaning, and any translation of fixed text/ system status messages, between all parties that may be affected by them;

3.1.1.15 Whether it will be necessary for the driver to change the language used for display on the ERTMS/ETCS at the border crossing and if so where this change should be made and to what. This will require the necessary language configurations to be available on-board (potential issue for B2 OBU);

3.1.1.16 Where the border crossing is between two countries that share the same, non-English, language it may be appropriate to harmonise the translation of fixed text/system status messages displayed on the ERTMS/ETCS DMI into that language, and plain text messages transmitted by the trackside, to facilitate correct interpretation and communication in each country.

3.2 Radio

3.2.1 Introduction

3.2.1.1 Based on the project experience these considerations shall be made when engineering a radio border (the following provisions are applicable also for the voice communication):

3.2.1.2 Ensure sufficient radio coverage across the border, if change of GSM-R network is required.

3.2.1.3 Ensure approval from foreign approval bodies according to the cross-border coverage of GSM-R (see above).

3.2.1.4 In case the border has to be located in the middle of a bridge, specific precautions will have to be considered by both parties to avoid interferences (see also 3.2.3).

3.2.1.4.1 Note: Previous requirement is based on experience from the Øresund bridge connecting Denmark and Sweden, which is located very close to the Danish/Swedish signalling system border. It was found that equipping the Øresund bridge, a large and high metal bridge, with two national GSM-R networks, and avoiding interference was such a challenge that the GSM-R network on the bridge had to be completely redesigned.

3.2.1.5 In case of border between packet/circuit switch radio sessions, a detailed analysis has to be performed by both parties to manage possible transition delays on-board.

3.2.2 GSM-R frequency planning

3.2.2.1 To avoid interference between different GSM-R systems on each side of a border, the frequencies/channels used by base stations has to be coordinated.

3.2.2.2 Poor coordination of frequency planning across the border may lead to interference between cells on each side of the border, causing lost communication and in the worst-case brake application. Naturally, this issue is particularly important for border crossings where the topology allows radio signals to propagate a long distance. Examples of such topologies can be over water or in flat landscapes.

3.2.2.3 To mitigate this risk, it is highly recommended to coordinate or create common processes for frequency planning in border areas including the furthest theoretical propagation distance for radio signals from the neighbouring GSM-R system. Cooperation agreements should describe allowed propagation into the neighbouring territory and use of channels in this area.

3.2.3 Radio Interferences from commercial radio networks

3.2.3.1 GSM-R can be sensitive to interference from radio signals outside of the GSM-R domain. For example, there are known issues with public 3G or LTE networks in the 900MHz band interfering with GSM-R. During frequency planning in border areas, potential interference sources on both sides of the border should be mapped. Commercial radio networks can create two types of issues, intermodulation and blocking.

3.2.3.2 Intermodulation will distort GSM-R signals leading to dropped packets. This can be mitigated by frequency hopping, but there are limited possibilities for that in the GSM-R frequency range and system properties. In many cases, the solution will be to build additional base stations for GSM-R to increase the signal/noise ratio.

3.2.3.3 Blocking will jam the GSM-R signal, leading to lost connection. GSM-R receivers have in general a wide range and are sensitive to unwanted signals. Terminals that are less sensitive to blocking have been developed, and partly mitigates the problem. Blocking can also be mitigated by installing bandpass filters. Filters on the on-board equipment can also be hard to implement if there are many trains from different operators running on the line in question. As with intermodulation, blocking problems can be avoided by increasing signal strength of the GSM-R signal. For example, by installing additional base stations.

3.3 Process

3.3.1.1 Border crossings typically involve a number of ETCS and other trackside systems, often from different suppliers, needing to operate in harmony. It is important that all parties have the same understanding of the interfaces, what each system will provide and what each system expects. It is recommended that a series of design reviews are undertaken with all the design authorities/suppliers present to ensure that all the issues are identified early in the process and there is clarity on the requirements.

3.3.1.2 There is no defined functional boundary between an interlocking and an RBC – indeed they may be combined. Each supplier has their own arrangements for sharing information at this interface and for making safe decisions based on that information. Linking the products of two suppliers at a border will nearly always be a bespoke application and will involve both suppliers to define and implement the interface.

3.3.1.3 The operational requirements in the vicinity of the border need to be clearly identified. The technical solution to some operational requirements may be very complex or expensive, it may be necessary to restrict operational flexibility on the approach, across and beyond the border (e.g. different policies for degraded operation: OS or SR). This may include a restriction on modes available from the trackside, the need to avoid a change of direction or start of mission, or requirements that the train must have two available radio mobile terminal.

3.3.1.4 The following steps summarise an example of harmonised process to commission a national border project:

1) Technical preliminary meetings with both IMs and NSAs: bilateral MoU identifying targets, constraints and responsibilities can be helpful;
2) ERA joint involvement (see Application guide for the ERTMS trackside approval [14]);
3) Create joint detailed operational, technical specifications and engineering data (values and format; e.g. BG locations, signal aspects, signal distances, gradient …) at border (see Appendix B as a possible check list) taking into consideration possible NTRs and specific cases;
4) Supplier activities of product development, installation and data preparation can be performed separately but it needs to be reviewed through an integrated process;
5) Create joint test plan;
6) Execute tests together (IMs, RUs for field test, all suppliers involved, NoBo/DeBo);
7) Create joint maintenance specification when useful;
8) Create joint TSR specification;
9) Obtain Subsystems EC declaration of verification separately;
10) Obtain ERA positive decision (according to the “Technical pillar” of the 4th Railways package) and NSA authorisation separately (but NSA having worked together);
11) Commission project together.

3.3.1.4.1 Note: The above steps are based on the 4 different borders between Belgium and Luxemburg.

3.3.1.4.2 Note: Common safety methods should be used during the process, see EU directive 2016/798 on railway safety [15].

3.3.1.5 The EDP Regulation (EU) 2017/6 article 2 comma 3 states that an agreement between IMs at national border is mandatory and it has to be notified to the

Commission no later than one year before the earlier of the deployment dates for the given cross-border section.

3.4 Test & Commissioning Plans

3.4.1.1 The involved parties must consider the development of a joint test and commissioning plan covering the border area. The plan must be agreed by all parties and should consider any phased implementation or migration strategies, testing and commissioning strategies and methodologies employed by all parties.

3.4.1.2 The joint development by the involved parties of operational scenarios covering the border crossing must include a full and detailed consideration of all normal, emergency, abnormal and degraded operations, for all relevant implementation phases, that may occur in the border crossing area. A full and complete set of operational scenarios will not only assist in the development of the border crossing requirements. It will also assist in the mutual understanding of how different systems on each side of the border behave and in the validation of any assumptions made in relation to that behaviour. It provides a basis for which sub-systems and system integration testing can be completed.

3.4.1.3 It is desirable to perform as much of the sub-system and system integration testing in a laboratory environment as possible – this reduces on-site testing work, provides the ability to conform bug fixes/upgrades before on-site implementation and supports flexibility of testing arrangements. For border crossing areas it could be considered to provide a joint test laboratory, or to provide an interface between separate test laboratories to support cross border system integration and validation testing.

3.4.1.4 In Appendix B, a list of possible operational scenarios is reported to be used as input for the definition of the possible test cases.

3.5 Cyber security

3.5.1.1 ETCS relies on data being available to the train and being shared between parts of the trackside. A border crossing requires all the relevant duty holders to share securely relevant data. However, each administration will have their own data security rules and constraints.

3.5.1.2 When connecting different data networks, consideration needs to be given to the confidentiality of information. What restrictions need to be placed on access to data from systems on the other side of the border and can those systems comply with the host’s security protocols?

3.5.1.3 There is a need for the trackside to communicate across the border and this may be by dedicated connections or by routing the information through secure gateways.

3.5.1.4 Trains need to be able to connect to either GSM-R network which may require the two networks to be connected via secure networks.

3.5.1.5 On-line key management requires trains to be able to contact their host key management centres which requires gateways between different countries' networks.

3.5.1.6 Each party needs to analyse the impact on the security and availability of their data networks when connecting them to another network, and to determine the acceptable secure management of the connection without impacting on availability.

4. Issues to be addressed

4.1 Introduction

4.1.1.1 This chapter lists issues that need to be considered for engineering a Border Crossing. The relevant recommended solutions are recorded in the corresponding sections of chapter 5.

4.2 National Values and NID_C

4.2.1 Location of Change of National Values (NID_C)

4.2.1.1 When a balise group message is received, the balise identity information referring to the country or region (NID_C) is used to ensure that the correct National Values are used. If there are no National Values stored on-board for the particular country or region identifier, the default National Values are used as fall-back. The NID_C value is also used as part of the ETCS identity of an RBC, balise group, loop or RIU.

4.2.1.2 Depending on the implementation, National Values are transmitted to the train by balise and/or by RBC. In some RBC implementations, only a single set of National Values can be held which are always sent if applicable (for additional details see guideline RBC/RBC handovers [10]). This could lead to overwriting other National Values which were sent by balises after passing a National Value boundary.

4.2.1.3 If the location of a border is different depending on direction, there is a risk that a train performing a turnback move in the vicinity of the border may have received the National Values applicable to a new area in one direction and will retain these when returning in the opposite direction into the previous area following the turnback move.

4.2.1.4 If using p3 for sending National Values with D_VALIDNV > 0 and NID_C different from NID_C of the header, OBU could apply default National Values when at location D_VALIDNV due to a mismatch between the country or region identifier read from a balise group and the corresponding identifier(s) of the applicable set with which the National Value was received and stored. To avoid this mismatch the distance between the balise antenna and the front end of the train has to be considered as well.

4.2.2 Changes That May Impact Train Operations at Borders

4.2.2.1 Where National Values are changed at border crossings there is a risk that differences in certain National Values might have an undesired operational impact. National Values which might introduce this undesired impact include:

1) When the National Values for mode related speed restrictions (V_NVUNFIT, V_NVREL, V_NVSTFF, V_NVSHUNT) are changed to lower values this could lead to unexpected brake interventions when actual train speed is above the new applicable speed value.
2) Braking curves are based on the National Values for braking curves; in SV 2 by packet 3 and in SV 1.1 by packet 203. Using different values on

each side of a boundary will result in different braking curves. Changing the National Values for braking curves at a border crossing could lead to a more restrictive braking curve being supervised which could lead to unexpected brake intervention. If B2 trains, with no regulated braking model, have to be considered, braking characteristics have to be considered to optimise the engineering of the border crossing (e.g. use of the permitted braking distance function).

3) Using different values for M_NVCONTACT and/or T_NVCONTACT on each side of a boundary could lead to an unexpected reaction if the communication session is disturbed. E.g. if T_NVCONTACT value is lowered or M_NVCONTACT is set to a more restrictive reaction.
4) Using different values for T_NVOVTRP and/or D_NVOVTRP on each side of a boundary could lead to an unexpected reaction while performing the Override procedure. E.g. if T_NVOVTRP and/or D_NVOVTRP values are lowered.

4.2.2.1.1 Note: Appendix A provides a list of National Values with functional and operational impact.

4.2.3 Mixing NV in separate BG (filtered by linking)

4.2.3.1 At national borders, there may be an overlap in the provision of national signalling equipment, for example to facilitate transitions, and it could be difficult to define where the change in NID_C, and the application of the associated National Values, should be. Balise groups associated to country 1 signals will contain a country 1 NID_C. Balise groups associated to country 2 signals will contain a country 2 NID_C. This means that a train running from country 1 to country 2 will read NID_C1 – NID_C2 – NID_C1 – NID_C2, see Figure 1.

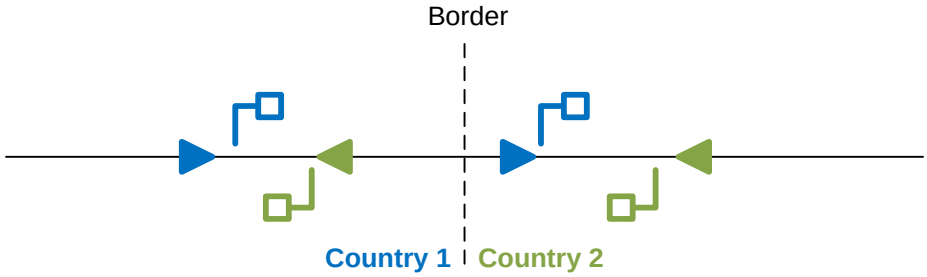


Figure 1: BG overlap at country border

4.2.3.2 In this situation, when driving from country 1 to country 2, it is possible that announced National Values for country 2 will be applicable before a balise group with NID_C1 is evaluated. This will lead to default National Values becoming applicable as a mismatch will be detected between NID_C associated with the National Values and the NID_C in the balise group.

4.2.4 SR, OS, SH supervised speeds across NID_C boundaries

4.2.4.1 If a train is given an SR authorisation or an OS/SH mode profile in NID_C1 and travels into NID_C2 area reading new NV once in the new NID_C area, the train is expected to supervise its speed as follows:

1) Change in V_NVSTFF, driver has not modified the ceiling speed – the on-board would immediately supervise to the new National Value. (see SUBSET-026 [1] 3.11.7.1, 3.18.2.8.1, 4.4.11.1.6.2)
2) Change in V_NVSTFF, driver has modified the ceiling speed – the on-board would continue to supervise to the modified ceiling speed. (see SUBSET-026 [1] 3.11.7.1.3, 4.4.11.1.6.3)
3) Change in V_NVONSIGHT or V_NVSHUNT with V_MAMODE = Use the national speed value of the required mode – the ceiling speed supervised would immediately change to the new National Value. (see SUBSET-026 [1] 3.11.7.1, 3.18.2.8.1)
4) Change in V_NVONSIGHT or V_NVSHUNT with V_MAMODE = speed different to National Value – the V_MAMODE “replaces” the National Value and is the ceiling speed supervised until the mode is left (in OS, MRSP speeds lower than the ceiling speed are also supervised). (see SUBSET-026 [1] 3.11.7.1.1).

4.2.4.2 With reference to 4.2.4.1, in case the new speed to be supervised is lower than the previous one, there is a potential safety impact in bullet points 2 and 4, as in these cases the train will not supervise the lower speed provided by National Values.

4.2.4.3 With reference to 4.2.4.1, in case the new speed to be supervised is lower than the previous one, there is a potential operational impact in bullet points 1 and 3, as in these cases an immediate brake intervention may be applied.

4.2.4.4 With reference to 4.2.4.1, in case the new speed to be supervised is higher than the previous one, there is no safety impact, however there is an operational impact in bullet points 2 and 4, as in these cases the driver will not be able to increase the speed.

4.2.5 Linking to repositioning balise groups with mixed NID_C

4.2.5.1 At borders of NID_C it can happen that the change of NID_C happens in the middle of Linking Information.

4.2.5.2 See example in Figure 2: There is a track coming from Italy which splits into multiple tracks. Somewhere on the tracks on the right side there is the border of the NID_C (NID_C 256 for Italy, NID_C 455 for Switzerland). The BG 256-14491 issues an MA with a Linking Information to an unknown BG since the track splits into four tracks and the Linking Information must be valid for all these four tracks. The balises after the split contain the Repositioning Information to enlarge the MA according to the new track. But these Repositioning BGs have different NID_C values (depending on the location) as shown in Figure 2.

4.2.5.3 There would be a need to set Q_NEWCOUNTRY to unknown since on some tracks NID_C changes (in the example on tracks 6 and 7) on others it doesn't (in the example on tracks 8 and 9). But there does not exist such a value for Q_NEWCOUNTRY. Q_NEWCOUNTRY can only be set to 0 ("same country") or 1 ("not the same country").

4.2.5.4 Both, the use of Q_NEWCOUNTRY set to 0 ("same country") and Q_NEWCOUNTRY set to 1 ("not the same country") might cause problems since the on-board unit might consider the trackside message as not compliant.

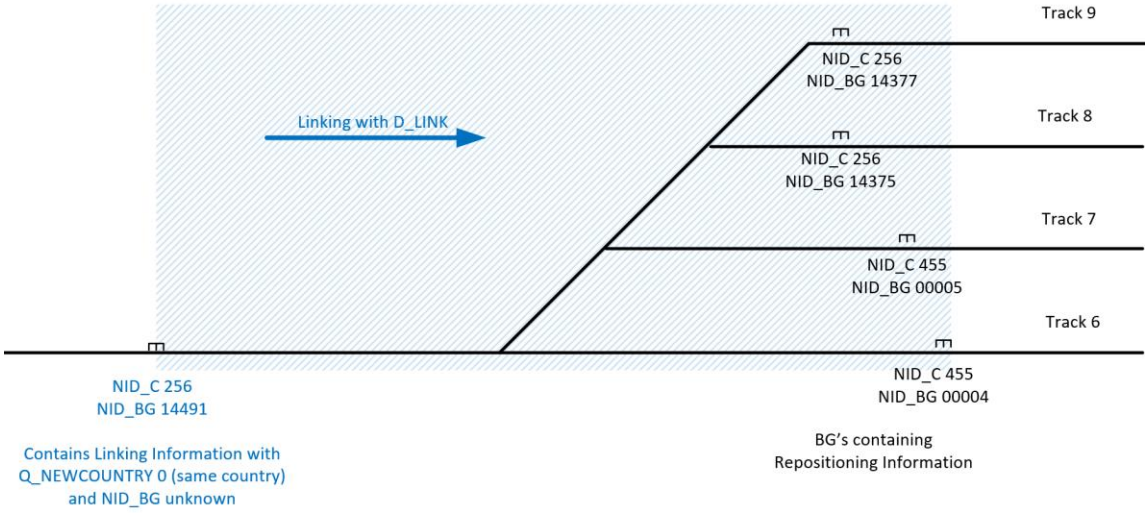


Figure 2: Example of NID_C change in the border station in Chiasso

4.3 Train Data

4.3.1 V_MAXTRAIN

4.3.1.1 According to SUBSET-026 v.2.3.0d [1] 3.18.3.2 d), the maximum train speed entered by the driver is defined as "Maximum train speed, taking into account the maximum speed of every vehicle contained in the train". However, SUBSET-026 [1] 3.11.8.1 states "It shall be possible to define the maximum train speed related to the actual performance and configuration of the train." This could be interpreted to allow the entry of a V_MAXTRAIN value that fits the performance requirements of the train on a certain line.

4.3.1.2 There might be various reasons why a certain V_MAXTRAIN value has been chosen for a train on a certain line:

1) Brake performance.
2) Train length.
3) Train configuration.
4) Axle load (which might or might not be covered by M_AXLELOAD).
5) Train category (which might or might not be covered by NC_TRAIN or NC_CDTRAIN).

4.3.1.3 For harmonisation purpose, the maximum train speed, as it reflects the maximum speed of the slowest vehicle in the train, should be the same value from the start of the journey until the final destination of the journey.

4.3.1.4 However, if the performance requirements of the train on two adjacent lines on which the train runs on during its journey requires different V_MAXTRAIN values, the V_MAXTRAIN would have to be changed at the border (i.e. requiring a new SoM).

4.3.2 Axle load

4.3.2.1 SUBSET-026 v.2.3.0d [1] defines M_AXLELOAD as a value between 0 t and 40 t in 0.5 t steps and a special value for > 40t, for both train and line categorisation. However, it is not clear, whether the axle load entered by the driver as part of data entry is the weight of the heaviest axle of the train (with or without locomotive?) or the mean axle weight, nor is the correlation to the axle load of the infrastructure clear.

4.3.2.2 If the axle load definition on different sides of a border crossing is not harmonised the driver may need to change the axle load value at the border(s) to avoid the incorrect speed profile being used by the train, which leads to a performance or safety impact.

4.3.2.3 For System Version X=2 trains operating on System Version X=1 infrastructure the conversion of axle load parameter (M_AXLELOAD to M_AXLELOADCAT) could lead to unexpected speed profile changes due to the limited number of translation options. Section 6.6.3.2 of SUBSET-026 v.3.4.0 and v3.6.0 [1] includes a lookup table for conversion from M_AXLELOAD to M_AXLELOADCAT – only 6 conversion options are available but M_AXLELOADCAT can define 13 axle loads. As the ERTMS/ETCS on-board equipment considers the most restrictive speed restriction that is associated with any axle load category lower than, or equal to that of the train, there may be instances a lower axle load speed profile becomes applicable when the System Version changes.

4.3.3 Non-harmonised axle load speed restrictions

4.3.3.1 The axle load speed restriction of a line could be such that non-harmonised axle load categories are applicable. In this case the axle load speed profile cannot be used. If at least one non-harmonised axle load category is applicable on this line it is not possible to restrict the speed by a generic speed restriction. The driver is in this situation responsible to supervise the non-harmonised axle load speed restriction and this obligation can be part of the national rules.

4.3.3.2 If the axle load speed restriction on at least one side of a border crossing is non-harmonised this could lead to driver confusion and introduces a risk of going over speed limit when passing this border. For instance in Figure 3, the driver relies on the supervision of axle load speed restrictions (ASP 1) by the on-board at one side (Country 1) and could continue relying on the speed supervision by the on-board at the other side (Country 2), where only a higher generic speed restriction (SSP 2) is in force. But by national rule the driver should use the non-harmonised speed restriction for its specific axle load.

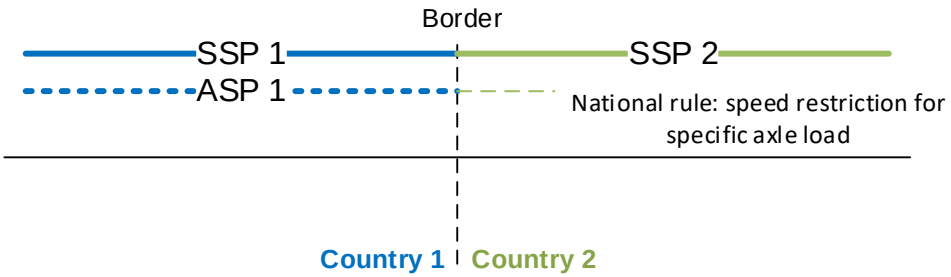


Figure 3: Border crossing between countries with different axle load speed supervision

4.3.3.3 Informing the driver by signs that the operational rules change could be an issue at higher speeds especially in level 2/3 where the driver is not used to get information from lineside signs and signals. Also, the driver should be informed early enough to already adapt to the allowed speed at the other side of the border. Using text messages to inform driver could partly overcome this problem, but there is no harmonised way to inform the driver for this kind of situation.

4.3.3.4 Harmonising the speed constraints on both sides of the border could introduce the same issue at another location outside this border area.

4.3.3.5 A solution is project specific and is not considered in chapter 5.

4.3.4 Brake Percentage Calculation

4.3.4.1 According to SUBSET-026 v.3.4.0 and v3.6.0 [1]**,** the conversion model for Lambda trains “has been designed assuming that all the provisions laid down in the UIC leaflet 544-1, with the exception of sections 9.1.2 and 9.2.2, apply for the acquired brake percentage”. However, the use of UIC544-1 is not mandated for use in calculating the brake percentage value entered as part of the train data, and it is possible that in different countries, brake percentages may be calculated in different ways, and that a brake percentage for a particular train consist that would be considered unacceptable in one country may be acceptable in another. Where the brake percentage values are not harmonised (e.g. eddy current brake contribution) a train crossing the border will be required to stop to allow the driver to re-enter the applicable brake percentage value.

4.3.5 Train Categories

4.3.5.1 The definition of the train categories is not harmonised across Europe (different values of ‘CANT’ deficiency are considered for national train categories’ speeds).

4.4 Level Transition

4.4.1.1 Guidance on level transitions are not provided in this guideline. However, consider if Class B system is available as a fall back in one or both sides of the border, even if the train will cross in ETCS, to design level priority tables.

4.5 Change of System Version

4.5.1 Transitions Between System Versions

4.5.1.1 With the introduction of System Version X=2, a new type of transition has appeared: transitions between System Versions.

4.5.1.2 The problem implied by this new System Version is the incompatibility of System Version X=1 OBUs with System Version X=2 trackside: a train running with an OBU only supporting System Version X=1 trips when reading System Version X=2 balise groups.

4.5.1.3 Guidance on transition from System Version 1.Y to System Version 2.Y for L1/2/3 with NTC fall-back system is not provided in this guideline.

4.5.2 Baseline 2/3 Parameter Differences

4.5.2.1 Between System Version X=1 and X=2 some parameter definitions are changed which could affect the train behaviour. In Baseline 3[1] OBUs, information received from an X=1 trackside is sometimes translated (see section 6 of SUBSET-026 [1]). At System Version boundaries, this could lead to unexpected behaviour.

4.5.2.2 An example of this unexpected behaviour is:

4.5.2.3 conversion of axle load parameter (M_AXLELOAD to M_AXLELOADCAT) could lead to unexpected speed profile changes due to the limited number of translation options - see section 4.3.

4.5.2.4 changes to the brake model behaviour due to different factors contained in the Nnational Values (available factors differ between versions) could lead to unexpected changes in braking information displayed to the driver.

4.5.2.5 Chapter 6 of SUBSET-026 v3.4.0 and v3.6.0 [1] defines a translation between packet 39 in Baseline 2 and packet 39 in Baseline 3. If also defines a translation between M_TRACTION (Baseline 2) and NID_CTRACTION (Baseline 3). Some M_TRACTION values are not translated in NID_CTRACTION. Without the transmission of P239 together with P39, the change of traction will be ignored if the on-board cannot translate the M_TRACTION in NID_CTRACTION.

4.6 Implementation of Non-Mandatory Change Requests

4.6.1.1 There could be some change requests (not mandatory for M_VERSION 1, see the BCA for B3 MR1 [11], the BCA for B3 R2 [12] and ERA/OPI/2017-2 [13]) implemented in the System Version X=1 RBC to facilitate the Baseline 3 OBUs. Differences in the implementation of these non-mandatory change requests on either side of a border crossing could adversely impact train behaviour.

4.6.1.2 This issue can also occur with Baseline 2 foreign trains on a System Version X=1 infrastructure if the implemented non-mandatory change requests are not the same between the two countries.

4.7 SoM with position not known for the RBC in a border zone

[1] An ETCS OBU is either Baseline 2 (compatible with track side System Version X=1) or Baseline 3 (compatible with track side System Versions X=1 and X=2)

4.7.1.1 Due to multiple RBCs, it is possible that during Start of Mission a train reports a valid position relevant to a BG that is not known to the RBC. This train could be rejected or only disconnected by the RBC. This scenario could happen for instance in these 2 cases:

4.7.1.2 Driver selects the wrong RBC at SoM while on-board has valid position

4.7.1.3 After cold movement the on-board is connected with the wrong RBC (last connected); when after SoM the train is accepted (based on invalid position) a BG not known for the RBC could be passed.

4.7.1.4 If the train is rejected, the train position is set to unknown, but when a further attempt to connect is made, the train with an unknown position is accepted. The issue with this is that if a train is connecting to the incorrect RBC, the RBC could issue SR authorisation to a train that is outside its area.

4.7.1.5 If the train is only disconnected, the position remains invalid and the train will never be allowed to connect i.e., at every subsequent attempt at connection, the train will be disconnected again.

4.8 SoM with incorrect data in a border zone

4.8.1.1 National Values and changes to this information are managed by the OBU based on packets received from the trackside.

4.8.1.2 Transitions to No Power (NP) mode do not affect National Values.

4.8.1.3 Where trains are hauled in NP mode over a border and re-awakened in a different location, the National Values stored by the OBU may not be suitable for the awakening location. Using unsuitable National Values could lead to operational hindrance and/or safety risks.

4.9 RBC/RBC Handover

4.9.1.1 Refer to the guideline RBC/RBC handovers [10] for all the issues and the possible recommendations concerning RBC/RBC handover.

4.9.1.2 Refer to Appendix C for examples of possible implementations of RBC/RBC border providing interoperability e.g. when interface versions (see SUBSET-039 [5]) of the RBCs are not compatible or when supplier specific RBC deliveries are not compatible.

4.10 Communication issues

4.10.1 GSM-R/GPRS Network Coverage Overlap

4.10.1.1 At the boundary between ‘current’ and ‘new’ GSM-R networks the on-board modems need to register with the new network and may need to setup a call with a new RBC (normally by RBC transition) using the new network. As these processes take time for a seamless passage it is necessary to have coverage of the adjacent network while still in the ‘current’ network area.

4.10.1.2 If this coverage in the additional area is not provided, trains with the capability of establishing more than one communication session will experience the same potential performance penalties at GSM-R network borders as trains with the capability of establishing only one communication session (See SUBSET-026 [1] clause 3.15.1.1.3.)

4.10.1.2.1 Note: The required network quality for network registration and for setting up a call are different.

4.10.1.2.2 Note: The issue also affects GPRS connections (only available for B2 and B3 R2).

4.10.2 GSM-R Network Registration and Turn back Moves

4.10.2.1 When a train registered with a ‘current’ radio network and approaching a GSM-R boundary receives an order to register to a ‘new’ GSM-R network all inactive modems will register to the new network. If the active modem becomes inactive, e.g. by closing the cab, this modem will also register to the new network when the cab is reopened (see SUBSET-026 [1] clause 3.5.6.5 and 3.5.6.6). If the train is still in rear of the GSM-R boundary when this happens all modems will be registered to the new network while the train is still in the current network area.

4.10.2.2 If the train is to subsequently continue in the reverse direction or continue in the same direction but is rerouted and avoids the GSM-R boundary the wrong network is used. This could lead to several issues when performing Start of Mission and departing such as:

4.10.2.3 loss of connection at some point after departure due to a loss of ‘new’ GSM-R network coverage

4.10.2.4 unable to connect due to insufficient GSM-R signal level. The required signal level for GSM-R network registration is less than that required for connection setup.

4.10.3 Radio Network Identity and RBC Contact Details

4.10.3.1 Refer to the guideline RBC/RBC handovers [10] for the issues and the possible recommendations concerning radio network Identity and RBC Contact Details.

4.10.4 Keys

4.10.4.1 No operational intervention is normally necessary to allow a duly authorised OBU to traverse into several separately controlled ERTMS areas, provided that the relevant preparatory actions have been carried out in advance of arrival at each area. Among these actions, specific key management (KM) functions are required to establish interoperable services. Without the correct keys in both the RBC and OBU, communications between the two will not be possible, leading to performance issues at a border crossing.

4.10.4.2 Symmetric (KMAC) keys are used to sign ETCS messages exchanged between ETCS entities, ensuring secure ETCS operation.

4.10.4.3 KMAC keys are distributed/installed in OBUs, KMCs, RBCs and RIUs manually (off-line KM: SUBSET-038 [4], SUBSET-114 [8]) or without staff action (SUBSET-137 [9]).

4.10.4.4 With off-line KM, all notification/installation of keys needs to be done manually in related ETCS/KMS entities.

4.10.4.5 With on-line KM all assignment/installation/updating of keys can be done automatically in related ETCS/KMS entities, both in the home or in a foreign domain, via the entities' Home-KMC.

4.11 Informing driver about border crossings

4.11.1.1 Drivers should be informed about border crossings, e.g. GSM-R network border, state border and catenary system border. This is especially needed in situations where ETCS does not provide information. This could be in degraded situations or when ETCS has no function to inform the driver.

4.11.1.2 The driver can get information from several sources:

1) On DMI with specific ETCS function
2) On DMI with text message
3) Route book
4) Harmonised lineside signs, i.e. ETCS marker boards and GSM-R marker boards
5) Non-harmonised lineside signs

4.11.1.3 The use of specific ETCS functions and ETCS/GSM-R marker boards will help the driver to receive harmonised information and this will lead to an interoperable border crossing.

4.11.1.4 The use of national text messages and non-harmonised line side signals could lead to misunderstanding and requires drivers to be educated well. The use should be agreed bilateral.

4.11.1.5 Also, the sources of information should be agreed and preferably the same sources should be used per type of border crossings, i.e. GSM-R network border always by GSM-R marker board.

4.11.1.6 With reference to several European countries, Appendix D depicts the current situation how drivers are informed when rules and/or functionalities and/or juridical aspects change.

5. Recommended solution

5.1 National Values and NID_C

5.1.1 Location Change of National Values

5.1.1.1 When changing National Values at a boundary, there shall be an implementation check for undesired consequences due to the required National Values being overwritten by an undesirable set, or the default National Values becoming applicable.

5.1.1.2 It should be considered that not yet applicable National Values will be deleted in specific situations like cab closing, see hazard ETCS-H0005 SUBSET-113 [7] reported here after:

5.1.1.3 In certain degraded situations defined in SUBSET-026 [1], paragraph 3.18.2.5 for v2.3.0, v3.4.0 and v3.6.0, the ERTMS/ETCS on-board shall use Default Values instead of National Values. If these Default Values are less restrictive than the National Values, an unsafe supervision might result.

5.1.1.3.1 Note: The safe ceiling speed in Unfitted will be according to the National Values. Therefore, if passing a border in an unfitted area without border balises, the “old” National Values will still apply.

5.1.1.4 If the National Values have to be changed, it is recommended that at least once per direction/route a NV packet is sent at or just after the NID_C change location in which the distance to start of validity of NV (D_VALIDNV) is zero (B2) or now (B3).

5.1.1.5 If the border for both directions is not at the same place, the implementation should consider the implications of any possible turnback moves in the vicinity of the border on the availability of the necessary National Values and ensure that the correct National Values can be provided to the train.

5.1.1.6 A possible solution to the overlap in signalling provision issue is to define a common NID_C, and/or common National Values, for the border area agreed by all involved parties. Where the two RBCs permit, it is possible to send a common set of National Values which are valid in both NID_C areas. This allows the changes in National Value to be managed within each RBC area through appropriate speed profiles, etc. It is also possible to define a common NID_C, but use different sets of National Values depending on the direction of the train movement.

5.1.1.7 However, creating a common NID_C and common National Values for a border area in effect creates two new borders between the common set at both country sets which could also create new (operational) problems.

5.1.1.8 Alternatively, the validity of the National Values before the overlap could be extended to both country identifiers, i.e. NID_C1 and NID_C2, and then after the overlap reduce the validity of the National Values to the respective country identifier. The set of National Values shall be chosen with respect to the national

signalling equipment and is therefore dependent of the direction of the train movement. This alternative is a solution for a simple topology in a short overlap area, but in extended overlap areas turnback moves shall be considered and secured for additional detail. See also paragraph 5.1.3.

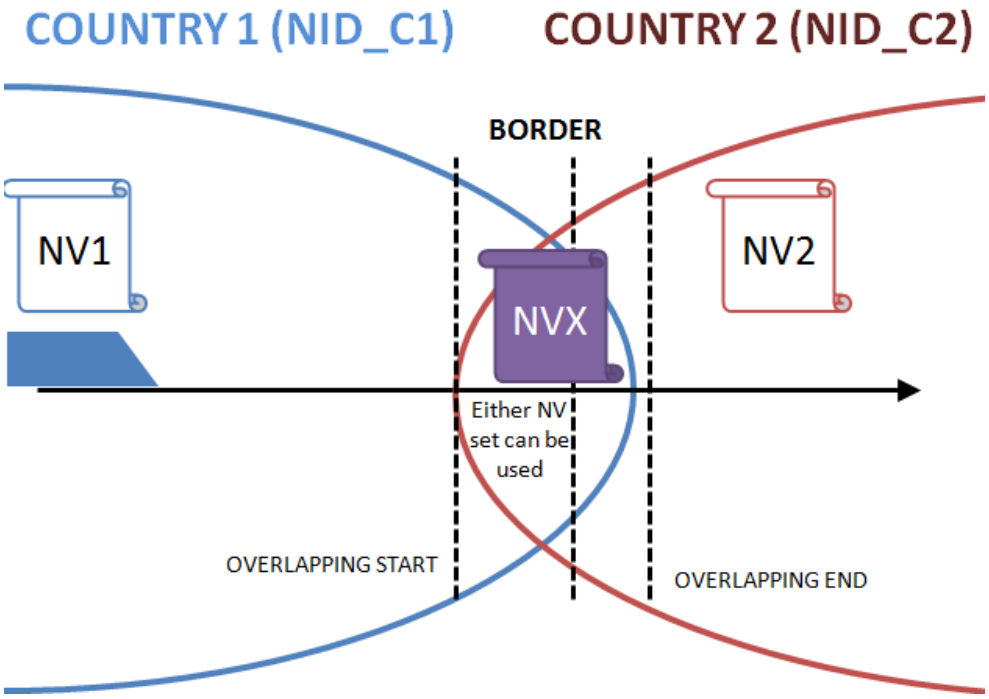


Figure 4: Overlapping National Values

5.1.1.9 Another possible solution to the overlap in signalling provision is to define the NID_C change related to the geographical border i.e. independent of the signalling provision. At the geographical border there is a clear change of ownership of NID_C values.

5.1.1.10 When using D_VALIDNV > 0 and NID_C different from NID_C of the header, SUBSET-026 clause 3.18.2.8.1 specifies that when a new set of national values becomes applicable, it shall always overwrite the one currently applicable regardless of the country or region identifier(s).

5.1.2 Changes That May Impact Train Operations at Borders

5.1.2.1 Consideration of the potential impact of changes in National Values at a border shall form part of the border crossing design – this will require the independent analysis of each difference in the National Values. It may become necessary for some of the changes in National Values (e.g. V_NVSTFF) to be managed by operational rules rather than technical solutions.

5.1.2.2 Analyse braking curves, under the different NVs, to find a location where the sudden change of braking parameters does not cause unwanted braking interventions.

5.1.2.3 For Baseline 3 OBU Braking curve management on Baseline 2 track, P203 (SV 1.1) has to be used from track to train.

5.1.3 Mixing NV in separate BG (filtered by linking)

5.1.3.1 In SUBSET-026 v.3.4.0 and v3.6.0 [1], it is clear that no consistency check shall be performed between National Values available on-board and linked balise groups which are not included in the linking (more generally, if a balise group message is rejected or ignored, it shall not be used for such checks). This allows to use linking to make a seamless National Values transition, if the change of NID_C border is asymmetrical, which means balise groups with different NID_C have to be interlaced at the transition. The following figure represents an example of such a trackside configuration. On this figure, all the balise groups are linked (in the telegram header, Q_LINK = linked).

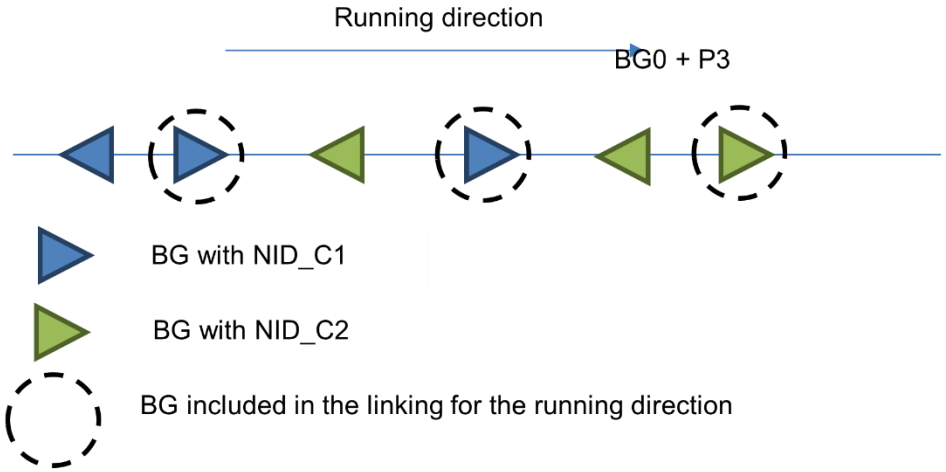


Figure 5: Possible trackside configuration for an asymmetrical border

5.1.3.2 On the previous figure, it is possible to make a National Value change only at BG0, by transmitting them in BG0, with D_VALIDNV = 0 or “Now”. The other BG with NID_C2 will not interfere in the change of National Values.

5.1.3.2.1 Note: The previous solution is only applicable for SV 2.Y lines, as there is an ambiguity in the SUBSET-026 v.2.3.0d [1] on how the on-board should perform checks on the National Values if the on-board encounters a linked BG not included the linking with a NID_C for which it does not have National Values. See CR 1183 fixed in B3 MR1.

5.1.3.3 For SV 1.Y lines, including the one where B2 trains are authorised to operate, it is recommended not to implement such a solution. The following figure describes the track layout to handle a change of National Values for such lines.

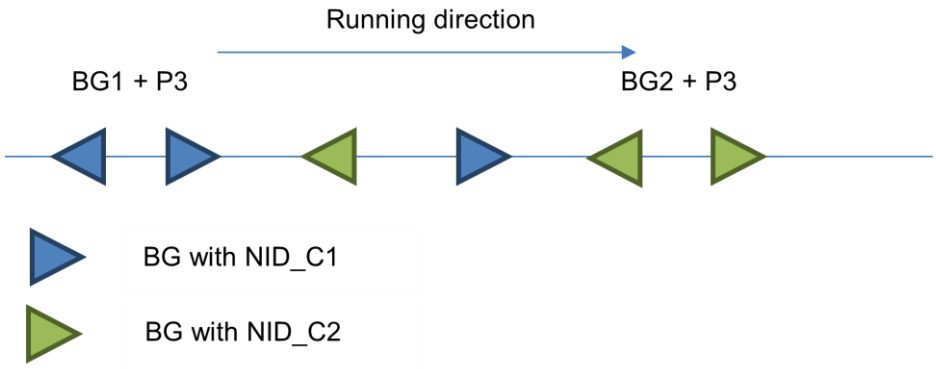


Figure 6: Possible trackside configuration for an asymmetrical border with SV 1.Y

5.1.3.4 For SV 1.Y lines, independently from linking strategy, it is recommended to transmit National Values in BG1 with D_VALIDNV = 0. These National Values have to be applicable both for NID_C1 and NID_C2, to ensure a B2 train will not fall-back to default values when passing a linked balise group (Q_LINK = linked) with NID_C2, even if it is not in the linking. The set of National Values can be different from the one for NID_C1 or NID_C2 areas. Finally, National Values only valid for NID_C2 shall be transmitted by BG2 with D_VALIDNV = 0.

5.1.4 Linking to repositioning balise groups with mixed NID_C

5.1.4.1 It should be avoided to have a linking information with NID_BG unknown linking to multiple repositioning balise groups with mixed NID_C values. Since the value Q_NEWCOUNTRY can only be set to 0 (“same country”) and 1 (“not the same country”) the on-board might consider the trackside message as not compliant. Thus, all announced repositioning balise groups need to have the same NID_C value.

5.2 Train Data

5.2.1 V_MAXTRAIN

5.2.1.1 V_MAXTRAIN (and, ultimately, all other train data) should not depend on the line/country at all. I.e. the SSP and/or the axle load speed profile should be enough for safe supervision, and the maximum train speed should reflect the maximum speed of the slowest vehicle in the train.

5.2.1.2 Where the operator requires that the maximum train speed fits the performance requirements of the train on a certain line, then for a dynamic border transition the maximum train speed entered by the driver should consider the requirements of both lines (i.e. the lowest value should be entered). This means that driver does not need to change train data at the border, and dynamic border transitions are possible.

5.2.1.3 In case V_MAXTRAIN for line A would be higher than for line B, this solution will cause a performance loss on line A for the sake of a dynamic border transition between lines A and B.

5.2.1.4 The implementation must consider that the trackside design might rely on V_MAXTRAIN supervision, i.e. on some lines V_MAXTRAIN might need to be lower than (at least parts of) the SSP based on train category or axle load.

5.2.2 Axle load

5.2.2.1 For operations by System Version X=1 trains on System Version X=1 infrastructure, the axle load entered by the driver should ideally be the maximum axle load of any vehicle in the train consist including the locomotive (for the locomotive, this may be an “operationally relevant axle load rather than the physical axle load, for example in Switzerland, the operationally relevant axle load of locos is 20 t (corresponding to a C2/3/4 axle load category) although almost all are physically heavier). Axle load speed profiles should take this definition into account.

5.2.2.2 Alternatively, at border crossings where a different interpretation of axle load definition exists, the axle load entered by the driver of a train crossing the border should consider the axle load definition of both lines (i.e. the highest value should be entered).

5.2.2.2.1 Note: For System Version X=2 trains operating on System Version X=2 infrastructure, and applying the categorisation processes and categories specified in EN15528, the axle load definition is harmonised. According to section 7 of EN15528, when considering a train, the ruling case for the train shall be the vehicle with the most onerous categorisation with the maximum speed of the train limited to the most restrictive speed requirement. Dynamic border crossings to System Version X=2 areas are not therefore an issue.

5.2.2.3 For System Version X=2 trains operating on System Version X=1 infrastructure, the continued operation over border crossings between the two System Versions without requiring a change of axle load value at the border will be supported as long as the line categorisation in the System Version X=1 area is compatible with the lookup table in section 6.

5.2.2.4 Regarding the axle load conversion table issue, consideration must be given to the axle load speed profiles on either side of a System Version change and the impact of the conversion table once the System Version changes on the MRSP supervised by the train.

5.2.3 Brake Percentage Calculation

5.2.3.1 At border crossings where a different interpretation of brake percentage exists, the impact of these differences must be assessed as part of the border crossing design. It may be necessary for the brake percentage entered by the driver of a train crossing the border to consider the brake percentage definitions of both lines and use a value that is acceptable to all affected areas.

5.2.4 Train Categories

5.2.4.1 Both parties have to share the way they intend to allocate the speed values to the ERTMS train categories to check the possible impact on performance and safety.

5.3 Level Transition

5.3.1.1 See section 4.4.

5.4 Change of System Version

5.4.1 Transitions Between System Versions

5.4.1.1 The transition from System Version X=2 to System Version X=1 can be done under ETCS supervision as OBUs supporting System Version X=2 are also compatible with System Version X=1. The design of the transition between the System Versions shall take into consideration the results of the BCA for B3 MR1 [11] and the BCA for B3 R2 [12].

5.4.1.2 The System Version order packet (packet 2) could be used to command the transition from System Version X=2 to System Version X=1 by balise group only. However, the use of System Version order packet (packet 2) is not recommended for transitions between ETCS equipped areas. This recommendation is especially relevant for level 2/3 tracksides, because the RBC determines the OBU operating System Version while establishing the communication session and will overrule the System Version order.

5.4.1.3 When using the System Version order, hazard ETCS-H0093 SUBSET-113 [7] should be considered if stop-if-in-SR or National Values are used in the same balise group.

5.4.1.4 To support some System Version X=2 functionality (like brake curve calculation) on System Version X=2 OBUs on a System Version X=1 trackside, it is possible to use System Version 1.1 in the track side, (e.g. p203).

5.4.1.5 The transition from System Version X=1 to System Version X=2 can be done under ETCS supervision only if all of the trains running on the lines are equipped with System Version X=2 OBUs. The design of the transition between the System Versions shall take into consideration the results of the BCA for B3 MR1 [11] and the BCA for B3 R2 [12].

5.4.1.6 The transition from System Version X=1 to System Version X=2 cannot be done under ETCS supervision if some trains running on the lines are equipped with System Version X=1 OBUs.

5.4.1.7 One solution is to not allow System Version X=1 trains to cross the border into the System Version X=2 area and to design the trackside implementation to prevent this from happening.

5.4.1.8 However, if it is required that the System Version X=1 train continue over the border then one possible solution is for the train to transition to class B operation at the border, or remain in class B operation, for example:

1) System Version X=1 train in ETCS operation approaching a System Version X=2 ETCS border transitions to Class B operation; to avoid that also System Version X=2 train in ETCS operation could switch to Class B operation, the VBC function can be used.
2) System Version X=1 train in class B operation approaching a System Version X=2 ETCS border remains in class B operation.

5.4.1.9 This solution can only be applicable at border crossings where:

5.4.1.9.1 The area beyond the border supports class B operation, and

5.4.1.9.2 The train has a compatible and available on-board class B system, and

5.4.1.9.3 The train driver is competent to operate under Class B operation.

5.4.1.10 To limit the impact on performance, the trackside application should support this level transition, or lack thereof, to be managed automatically without the train having to stop. An example of how this might be achieved is as follows:

1) Border between System Version X=1 level 2 area and System Version X=2 level 2/Class B area:
2) RBC transition where HOV RBC is System Version X=1 and ACC RBC is X=2.
3) System Version X=2 OBU performs RBC Handover and continues in level 2.
4) System Version X=1 OBU is not accepted by ACC RBC and continues without radio (solved by T_NVCONTACT or Radio hole)
5) System Version X=1 OBU performs a transition to Class B in next signalling block based on transition order in balises which are masked (by linking information) for System Version X=2 train.

5.4.1.11 An alternative solution where the automatic control of a level transition is not available could require the driver to stop and manually change level before proceeding over the border.

5.4.1.11.1 Note: In level NTC/0, OBUs ignore the content of balise groups using incompatible version, and do not provoke a trip of the train. OBUs supporting System Version X=2 will accept the level transition to ETCS System Version X=2.

5.4.1.11.2 Note: If the trackside class B system uses Eurobalise and packet 44 to transmit information to the OBU, tests should be executed to ensure that the packet 44 is accepted by version X=1 OBUs in level NTC/STM/0.

5.4.2 Baseline 2/3 Parameter Differences

5.4.2.1 The implementation design shall identify and address any undesirable consequences for train behaviour resulting from a change in System Version and the associated differences in parameter definitions.

5.5 Implementation of Non-Mandatory Change Requests

5.5.1.1 Adopt System Version 1.1 within the RBC and send the extra packets as defined in SUBSET-026 [1] Chapter 6 of Baseline 3.

5.5.1.2 Ensure a harmonised implementation within a country's borders and check for compatibility between implemented change requests with neighbouring countries as part of the implementation.

5.6 SoM with position not known to the RBC in a border zone

5.6.1.1 The trackside and operational design must consider the impact of train rejection or disconnection during Start of Mission.

5.6.1.2 The UK solution includes the provision of a text message sent by the RBC prior to rejection of a train reporting an invalid or unknown position which guides the driver on what to do.

5.7 SoM with incorrect data in a border zone

5.7.1.1 For tracks using radio communication (level 2 or 3) the RBC should send the correct National Values before authorising the train to drive. For level 1 and in level 2/3 for degraded situations without radio communication the National Values should be repeated at appropriate locations, e.g. where nominal Start of Mission takes place.

5.8 Communication issues

5.8.1 GSM-R/GPRS Network Coverage Overlap

5.8.1.1 To avoid trains with the capability of establishing more than one communication session potentially experiencing performance penalties, an overlap in GSM-R network coverage is required. The required distance of the overlap in rear of the boundary should be based on the time to register to the 'new' network (40s – see SUBSET-093 [6], 6.3.7.3) and (where necessary) the time to set up the communication session with the new RBC (~40s - see SUBSET-037 [3], 7.3.2.3.1) and complete any RBC handover related activities necessary before crossing the border using the maximum track speed.

5.8.2 GSM-R Network Registration and Turn back Moves

5.8.2.1 For Baseline 3 and Baseline 2 implementations, the implications of this issue need to be considered by the technical and operational design. Local instructions could require that drivers physically change the required radio network at start of mission in identified situations, but this will require the driver to power down the OBU (Entry to NP mode) to invalidate the position and level information and is not recommended – also this will only be effective if cold movement detection is not available. Additional registration balise groups could be installed, or registration packets included in existing balises, to force registration to the correct network by trains that will not cross the border, or the RBC could be configured to command connection to the correct network based on the route set.

5.8.2.2 This problem could also be avoided with seamless handover between the different networks i.e. if the network handover is handled for the active modem in a similar way as a cell handover (inter-PLMN handover) and using Packet 45 at the border for idle modems only (connected modems will not switch). This would require that this sort of handover is possible and provided for within the GSM-R system. The active modem will not realise that a network change has occurred, and at subsequent start up the idle modem will connect to correct network (active modem will connect when disconnected).

5.8.2.2.1 Note: CR 1227 has been raised to propose a solution to this issue. The CR 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 document there is no agreed solution.

5.8.3 Keys

5.8.3.1 The OBU needs the key for the RBC it is attempting to connect to, the KM domain and radio network are irrelevant.

5.8.3.2 When borders are crossed and an OBU enters a foreign KM domain the following conditions should be met:

1) the OBU holds a KMAC for the foreign domain RBC
2) this KMAC shall not be expired or revoked.

5.8.3.3 In order to have seamless border transitions bi-lateral agreements across borders must be met to enable the exchange of foreign OBU KMACs into each related KM domain.

5.8.3.4 When on-line KM is in use, an OBU must be able to contact its home KMC from anywhere it may operate. This requires connections between the GPRS networks (cross border) to allow the necessary requests and transfers to be made, including updating “home key” or acquiring key for a third domain while being outside of home domain.

Appendix A List of National Values with functional and operational impact

National Value SUBSET-026 v3.6.0 [1] Paragraph 7.4.2.1.1	Functional impact	Operational impact (driver)	Impact on
V_NVSHUNT		X	Change of allowed speed
V_NVSTFF		X	Change of allowed speed
V_NVONSIGHT		X	Change of allowed speed
V_NVLIMSUPERV		X	Change of allowed speed
V_NVUNFIT		X	Change of allowed speed
V_NVREL		X	Change of allowed speed
D_NVROLL		X	Change of allowed distance to move
Q_NVSBTSMPERM	X		Braking distance
Q_NVEMRRLS		X	Change of allowance driver action
Q_NVGUIPERM		X	Change of information braking
Q_NVSBFBPERM	X		Braking distance
Q_NVINHSMICPERM	X		Braking distance
V_NVALLOWOVTRP		X	Change of allowed speed
V_NVSUPOVTRP		X	Change of allowed speed
D_NVOVTRP		X	Change of allowed distance to move
T_NVOVTRP		X	Change of allowed time to move
D_NVPOTRP		X	Change of allowed distance to move
M_NVCONTACT	X		Failure reaction
T_NVCONTACT	X		Time to detect failure
M_NVDERUN		X	Change of allowance driver action
D_NVSTFF		X	Change of allowed distance to move

National Value SUBSET-026 v3.6.0 [1] Paragraph 7.4.2.1.1	Functional impact	Operational impact (driver)	Impact on
Q_NVDRIVER_ADHES		X	Change of allowance driver action
A_NVMAXREDADH1[2]	X	X	Braking distance or change of information DMI
A_NVMAXREDADH2[2]	X	X	Braking distance or change of information DMI
A_NVMAXREDADH3[2]	X	X	Braking distance or change of information DMI
Q_NVLOCACC	X		Distance to detect failure
M_NVAVADH	X		Braking distance
M_NVEBCL	X		Braking distance
Q_NVKINT	X		Braking distance
Q_NVKVINTSET	X		Braking distance
V_NVKVINT	X		Braking distance
M_NVKVINT	X		Braking distance
N_ITER	X		Braking distance
V_NVKVINT(n)	X		Braking distance
M_NVKVINT(n)	X		Braking distance
N_ITER	X		Braking distance
Q_NVKVINTSET(k)	X		Braking distance
A_NVP12(k)	X		Braking distance
A_NVP23(k)	X		Braking distance
V_NVKVINT(k)	X		Braking distance
M_NVKVINT(k)	X		Braking distance
M_NVKVINT(k)	X		Braking distance
N_ITER(k)	X		Braking distance
V_NVKVINT(k,m)	X		Braking distance
M_NVKVINT(k,m)	X		Braking distance

[2] Impact depends on the use of special values for displaying

National Value SUBSET-026 v3.6.0 [1] Paragraph 7.4.2.1.1	Functional impact	Operational impact (driver)	Impact on
M_NVKVINT(k,m)	X		Braking distance
L_NVKRINT	X		Braking distance
M_NVKRINT	X		Braking distance
N_ITER	X		Braking distance
M_NVKTINT	X		Braking distance

Appendix B List of operational Scenarios

In general, all operational scenarios that are used on both sides of the border are applicable. Scenarios not used in the border area are not to be considered applicable.

The following is an example of list of common operational scenarios.

Normal operation

1) Normal operation (Both directions, Possible asymmetrical, border BG)
   a) Normal passing in FS mode
   b) Normal passing in OS mode
   c) Normal passing in SR mode
   d) Normal passing in SH mode (Shunting movements)
      i) Shunting is not allowed in B2 near border, but is allowed in B3
   e) Normal passing with level transition
      i) Maybe only for trained drivers (specific STM), untrained drivers keep in LNTC
      ii) overlay
   f) Normal passing with mode change
      i) FS->OS
      ii) OS->FS
      iii) FS/OS->SH
      iv) …
   g) Normal passing with SV change
   h) Normal passing with NV change
      i) Slippery track allowance
      ii) Braking curves
      iii) .. all National Values with operational impact
   i) National area
      i) Change of unit of speed (km/h vs mph)
   j) Change of RBC
   k) Change of GSM-R radio network
   l) Change of Track conditions
      i) Change of traction system
      ii) Passing a phase lock
      iii) Tunnel
      iv) …..
   m) Change of GSM-R voice radio
   n) Multiple trains
2) Departure (SoM)
   a) Entering Train data
      i) Train categories handling
      ii) Axle load
      iii) Train running number changes

   b) Start of Mission procedure
      i) Known position (time to announce border)
      ii) Known position (no time to announce border)
      iii) Unknown position
      iv) Wrong system connected (GSM-R/RBC)
      v) RBC not able to provide (FS) MA
      vi) Not able to start Handover
      vii) Stop/driver closing desk in handover area
3) Turn back movement combined with SoM
   a) After passing border
   b) Before passing border
   c) Needed for nominal operation (local traffic)
   d) Needed for degraded operation (out of service of an area, failures)
   e) Connection with the right GSM-R network and right RBC
   f) Asymmetrical borders
   g) RBC not able to provide MA
   h) Not able to start HO
4) Performing EoM in border zone
5) Splitting and combining
6) Shortening of MA's in border zone
   a) Cooperative MA revocation
   b) Emergency stops (CES, UES) including revocation
   c) Shorten MA
7) Use of functions outside the ERTMS spec (i.e. by p44)
   a) Door control
   b) …
8) Passing Level crossings
   a) Different operational procedures
   b) Possible connected to systems from other area
9) Hot axle detectors (hot box)
   a) Different operational procedures
   b) Possible connected to systems from other area

Degraded situations

1) Temporary Speed restriction (TSR)
   a) Application
   b) Revocation
2) Handling emergencies e.g. Signal passed at danger
3) Passing procedurally not cleared signal
4) Degraded systems behaviour
   a) Infrastructure
      i) Lost connection between RBCs
      ii) Failure connection between IXLs (influencing RBC/RBC interface)
      iii) Communication failures
      iv) Defective balises

   b) Train borne
      i) Single modem HO
      ii) Loss of connection
5) Stopping a not allowed train

Maintenance

1) Maintenance activities
   a) Out of service periods (planned)
   b) Mode/level for work trains
   c) Entering/exiting work area
2) Possession of line (e.g. by failed train)
3) Key management
   a) Invalid key for specific area

Appendix C RBC/RBC border when RBC interfaces are not compatible

This problem may occur at locations where two ETCS level 2 systems meet, with incompatible communication over the interface defined in SUBSET-039 [5] due to different versions of RBC or different versions of infrastructure.

There are potential ways to achieve fully interoperable solutions. The interoperable solutions described below are based on the technical proposals of individual countries within the EUG-ESG. The table describes a list of countries using specific technical solutions for RBC/RBC handover.

Countries:	Communication:	Name of technical solution:
Italy	RBC – RBC (NO) IXL – IXL (YES)	RBC – RBC border
Czech Republic	RBC – RBC (NO) IXL – IXL (NO)	Simplified Handover (SHOV)

RBC – RBC border when RBC interfaces are not compatible (Italy)

This specific technical solution is based on RFI's experience. The issue concerns the connection between two high-speed lines equipped with the ETCS L2 system (Milano - Bologna and Bologna - Firenze).

Problem: It is possible that due to different versions of RBC (and time constraints), both RBCs are not compatible through the SUBSET-039 [5] interface.

Solution: As a possible way to realise a fully interoperable solution, the “train supervision transfer function” (referred to Hand Over procedure) can be realised as following (so called Change-over):

- no physical communication between the two RBCs (Handing Over and Accepting); neighbour RBCs don’t know the boundary location; OBUs know the boundary location through a balise group (P131 “RBC Transition order”).
- the two IXLs (Handing Over and Accepting) exchange information concerning an overlapping area (beyond the border)
- the Handing Over RBC sends an MA which covers also the overlapping area thanks to the safe information (to complement the MA) received from the Accepting IXL via the Handing-Over IXL
- specific Balise groups are located on the track for the management of Radio connection sessions (P41) as well as for the transition L2 → L2 at the Change-Over Border.

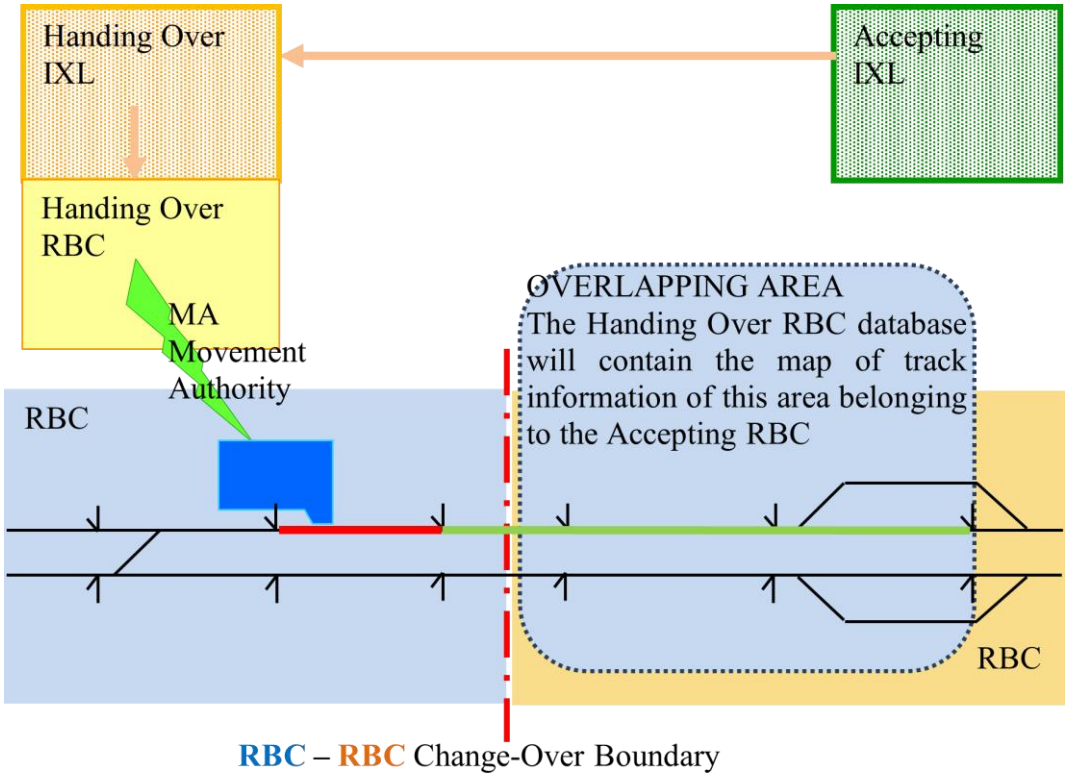


Figure 7 – RBC Handover through IXL interface (Change over)

Simplified Handover – SHOV (Czech Republic)

This solution can be used in case of border section without communication between RBCs and also between IXLs. The interlockings communicate only necessary information regarding train safety on the track (occupancy of the section), but it is not standard transmission of information between IXLs.

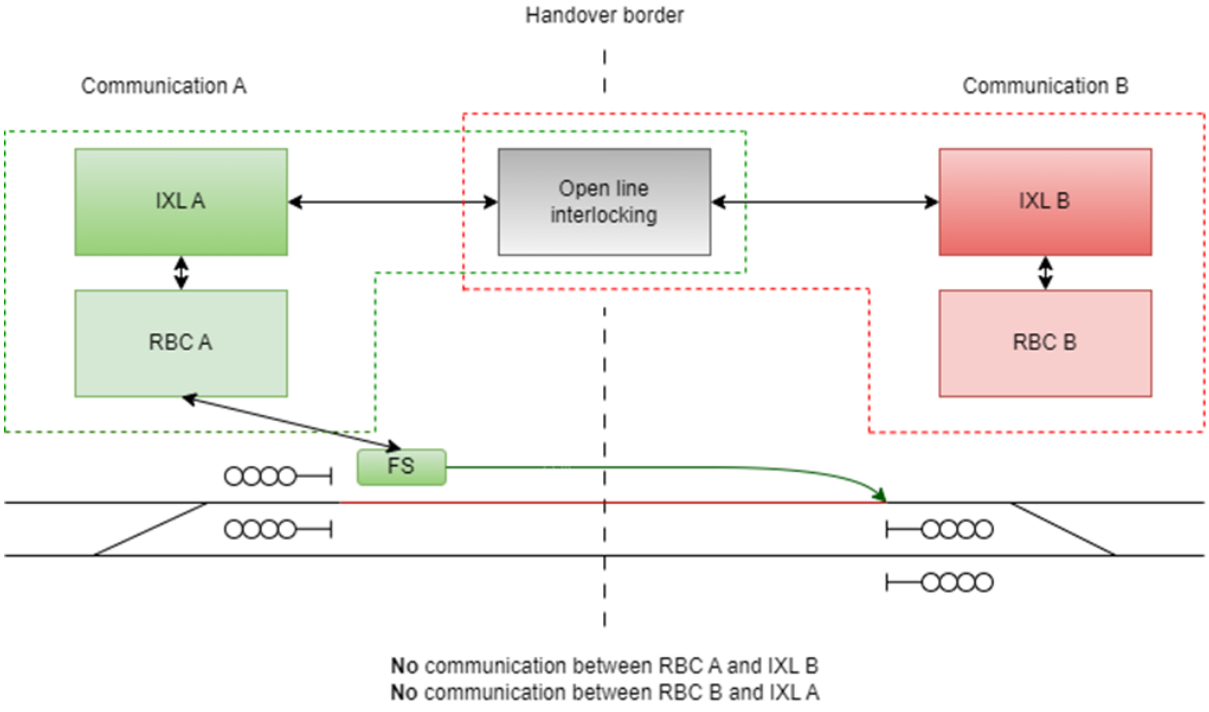


Figure 9 SHOV communication

Simplified Handover can be applied under certain basic condition:

- Open line section must be without the block section signal;
- Required ETCS level – L2;
- GSM-R signal of both countries covers at least the area between the Exit Signals of both stations;
- On the line of track can be just one train in the handover procedure;
- Solution for train speed up to 160 km/h with open line section around 6 000 meters;
- On the track are installed fixed data balises;
- The ETCS relevant data, including balise groups, on the common track must be known by both RBCs;
- Trains passing the RBC borders must be equipped with two mobiles for smooth handover;
- The train must have valid Euroradio keys for both countries where ETCS L2 is active.

The general strategy says that A-RBC sends the MA (Movement authority) at max till the Home signal of the station of B-RBC, because only B-RBC can send the MA over the home signal (when the conditions for the extension of the MA are fulfilled). The new MA with EOA beyond the home signal of accepting B-RBC must be send as soon as possible (i.e. do not wait for the moment until the braking curve limitting effect becomes active).

Time value:	**Seconds [s]**
Max. time for the registration to new GSM-R network	42
Max. time for establishing of a communication session (train – RBC)	50
Max. time for the generation of the MA by the B-RBC (B-RBC is ACC RBC)	15

The table of maximum times is based on the experience of both countries (Czech republic – Austria).

The Simplified handover uses many packets which are uploaded into the fixed data balises. The packets that this case are use is:

Packet:	**Information:**
P3	National Values
P42	Session Management

P45	Radio Network registration
P46	Conditional Level Transition Order
P79	Geographical Position
P131	RBC transition order
P132	Danger for Shunting information
P145	Inhibition of balise group message consistency reaction
P203	National Values for braking curves

Applicable System Versions – Simplified Handover does not use communication between RBCs. Thanks to these aspects the solution Simplified Handover provides backward compatibility. The implementation of SHOV must be interoperable to On Board Unit with UNISING version 2.3.0.d and higher.

An example of using packets from the table in specific fixed data balises are shown in the picture bellow. It is open line section between Bernhardsthal (Austria) – Břeclav (Czech republic). You can see concrete position of BG (Balise group) and their packets for nominal and reverse direction, Level crossings (LX), Signal devices (Exit, Home and Distant) and length of MA issued by concrete RBC.

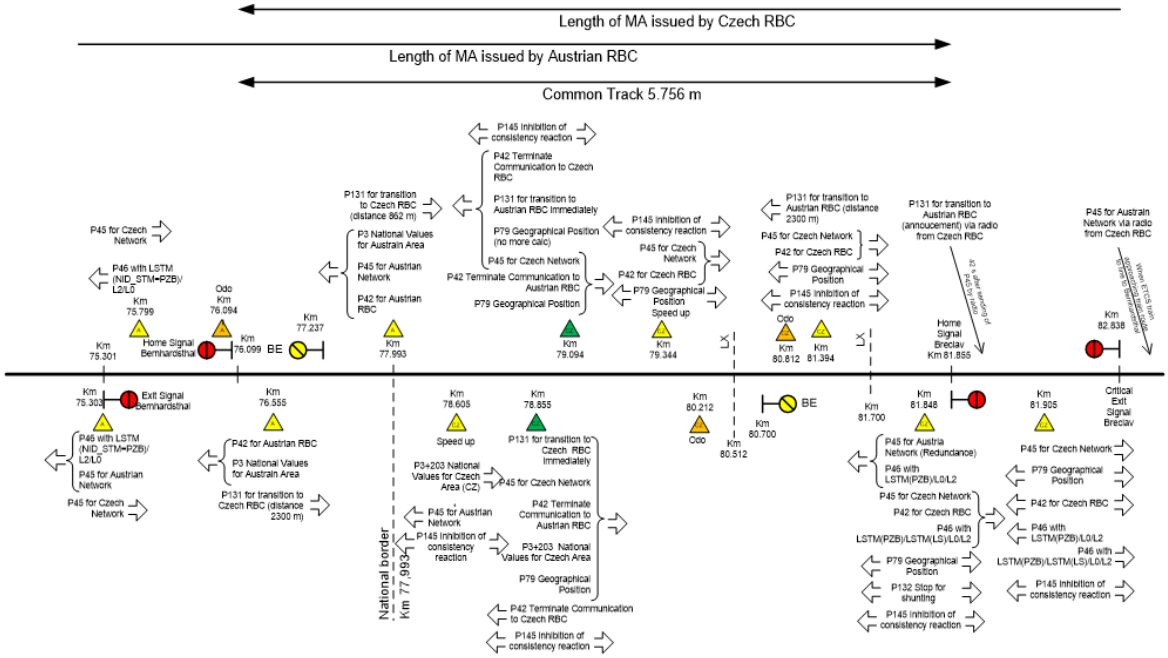


Figure 8: BG packets description for Bernahardsthal-Břeclav border

Warning: In some situation SHOV does not allow full function of ETCS L2 required on the Czech railway network (e.g. when the train has direction to Czech Republic the possibility of immediate reaction in case of a level crossing failure on our territory is not ensured).

For a deeper understading of the border section solution (SHOV), the table below shown a scenario of trains runing in both direction. The scenario refers to a real SHOV application on the track between Bernhardsthal (Austria) – Břeclav (Czech republic).

Step	Direction from Bernhardsthal to Břeclav	Direction from Břeclav to Bernhardsthal
0	0.1: Based on the route setting for exit routes from Bernhardsthal to Břeclav (Exit Signals in Bernhardsthal are R1 and R2), the Austrian RBC will issue a MA with an EOA at the Home Signals of Břeclav (1BL or 2BL). 0.2: The MA will be Full Supervision (FS) or On Sight (OS). 0.3: The MA will contain all relevant data up to the Home Signal of Břeclav. For the level crossing the TSR of 10 km/h set by means of dispatcher command is included in SSP in case of failure of the level crossing. Also other TSRs set by the dispatcher are included in the SSP. 0.4: The distance between the Exit Signal of Bernhardsthal and the Home Signal of Břeclav is 6.554 m. 0.5: Based on the distance between the Exit Signal of Bernhardsthal and the Home Signal of Břeclav the train will have a minimum driving time of 147 s with 160 km/h (assuming, that the train is passing the Exit Signal in Bernhardsthal with maximum line speed).	0.1: Based on the route setting for exit routes Břeclav to Bernhardsthal (the most critical Exit Signals in Břeclav is signal S1 located at 82.838), the Czech RBC will issue a Movement Authority with an EOA at the Home Signals of Bernhardsthal (Z or Y). 0.2: The MA will be Full Supervision (FS) or On Sight (OS). 0.3: The MA will contain all relevant data up to the Home Signal of Bernhardsthal. TSR for level crossing failure will be sent with packet 65. Also other TSRs will be sent with packet 65. 0.4: The distance between the critical Exit Signal of Břeclav (signal S1 located at 82.838) and the Home Signal of Bernhardsthal is 6.744 m. 0.5: Based on the minimum distance between the critical Exit Signal S1 of Břeclav and the Home Signal of Bernhardsthal the train will have a minimum driving time of 155 s because the speed up to location 82.149 is 120 km/h and afterwards 160 km/h.
1	1.1: When the train passes the balise group at km 75.303, the train will read the packet 45 (Radio Network registration to Czech GSM-R network). 1.2: The train will start with the second mobile to register to the Czech GSM-R network. 1.3: Because of redundancy reasons the balise group at location 75.799 will also	1.1: When the route is set from the Exit Signal of Břeclav to the common track and the corresponding MA is sent to the train, the train will also receive the packet 45 (Radio Network registration to Austrian GSM-R network) via radio from the Czech RBC. As backup, packet 45 will be also in the balise group at the Home Signal of Břeclav (81.848).

	contain the packet 45 for the Czech GSM-R network.	1.2: The train will start with the second mobile to register to the Austrian GSM-R network.
2	2.1: The train will need at maximum 42 s driving time to connect to the Czech GSM-R network. With maximum speed of 160 km/h, the train is driving at maximum a distance of 1867 m. 2.2: At the location 76.555 between the Home and Distant-Signal of Bernhardsthal a balise group with the packet 131 (RBC transition order) will be placed (the distance from the balise group with packet 45 is 1252 m).	2.1+2.2: The distance from the critical Exit Signal of Břeclav S1 (82.838) to the balise group with packet 131 (81.394) is 1444 m, so the driving time is about 41 s (the distance is a mix of 120 km/h and 160 km/h and assuming an acceleration of 0.5 m/s^2). Maximum time to register to Austrian GSM-R network is 42 s, because there are no safety critical consequences thus the time should be sufficient. If the train starts from standstill from the critical Exit Signal of Břeclav, the time to register to the Austrian network is sufficient (69 sec. assuming an acceleration of 0.5 m/s^2). 2.3: As backup the Czech RBC will additionally send information regarding “announcement RBC transition Order (packet 131)” by radio 42 s after sending of packet 45 (Radio Network registration to Austrian GSM-R network).
3	3.1: When the train reads the balise group with packet 131 (location 76.555), it will start to establish a communication session with the Czech RBC. This will take at maximum 50 s i.e. 2223 m for speed 160 km/h. When having received the first position from the train, the CZ RBC start to send the MA. Depending the conditions the EOA is at home signal of Břeclav or in advance. 3.2: A balise group with the packet 131 with the distance to transition equal to zero (immediate transition) will be placed at location 78.855 (i.e. 2300 m after balise	3.1: When the train reads the balise group with packet 131 (location 81.394), it will start to establish a communication session with the Austrian RBC. This will take at maximum 50 s i.e. 2223 m for speed 160 km/h. When having received the first position report from the train, the Austrian RBC can dedicate the train to entry signal of Bernhardsthal. If this is in HALT, AT RBC will send (one or more) CES to ensure that the MA on the train is not reaching beyond signal’s position. If the home signal is in proceed aspect, the AT RBC start to send general messages. 3.2: A balise group with the packet 131 with the distance to transition equal to zero (immediate transition) will be placed at location 79.094 (i.e. 2300 m after balise

	group with the announcement of the RBC transition). 3.3: From this balise group, the distance to the Home Signal of Břeclav is 3000 m.	group with the announcement of the RBC transition). 3.3: From this balise group, the distance to the Home Signal of Bernhardsthal is 3000 m.
4	4.1: The train will execute the RBC transition and will be under responsibility of the Czech RBC, afterwards. 4.2: The train will use the MA sent before sent by Czech RBC. 4.3: If no MA was received form Czech RBC yet (degraded situation), the train continues with the existing MA from Austrian RBC. 4.4: The train will close the communication session with Austrian RBC based on the order received from balise group placed at location 78.855 or as backup from balise group at location 79.094.	4.1: The train will execute the RBC transition and will be under responsibility of the Austrian RBC, afterwards. 4.2: The train will still use the MA sent by Czech RBC. 4.3: Having received (one or more) CES, the train will accept them and the AT RBC sends their revocation. When entry signal of Bernhardsthal shows a clear aspect, a regarding MA is sent by Austrian RBC. 4.3: If no MA was received form Austrian RBC yet (degraded situation or HALT on the entry signal), the train continues with the existing MA from Czech RBC. Austrian RBC revokes the previously send CEMs and starts to send the MA as soon as the aspect of the entry signal changes to proceed aspect. 4.4: The train will close the communication session to Czech RBC based on the order received from the balise group placed at location 79.094 or as backup from balise group at location 78.855.
5	5.1: In the worst case scenario the first MA will be received by OBU from the Czech RBC 15 s from the moment when the train has passed the balise group. 5.2: In this time frame the train is driving at maximum 666 m. The distance up to the Home Signal of Břeclav from the RBC transition Order balise group is 3000 m – 666 m = 2334 m. This should avoid, that trains get into the braking curve before the receiving of the MA from Czech RBC.	5.1: In the worst case scenario the first MA will be received by OBU from the Austrian RBC 15 s from the moment when the train has passed the balise group. 5.2: In this time frame the train is driving at maximum 666 m. The distance up to the Home Signal of Bernhardsthal from the RBC transition Order balise group is 3000 m – 666 m = 2334 m. This should avoid, that trains get into the braking curve before the receiving of the MA from Austrian RBC.
6	National Values (packet 3) and National Values for braking curves (packet 203) for	National Values for the Austrian Area will be implemented in the balise group at National

	the Czech Area will be implemented in the balise groups placed at location 78.605 and 78.855. The start of the validity is set to zero (immediately).	Border (77.993) and will be repeated in the balise group at location 76.555.

In case of activation of ETCS exclusion: After passing the departure signal in station **A**, the train switches to the level STM (L0). Back to level 2 (FS mode) the train switches on the track in station **B**. Applies to the opposite direction as well.

Summary:

- Solution for no communication connection between RBCs;
- Required ETCS level - L2;
- The train will always get a MA from the HOV RBC up to the Home Signal;
- MA over the Home Signal can be sent only by ACC RBC;
- Special procedures e.g. TAF at the Home Signals must only be implemented in the one RBC responsible for the Home Signal;
- RBCs doesn`t need any additional information from the interlocking, only normal information exchange between interlockings for block system is necessary.

Degraded situations:

In the event of a failure of the "continue" signal light permitting the train to continue, the the train driver, when running in the mode "Full Supervision' or 'On Sight' control the instructions of the ETCS DMI (mobile part of ETCS).

In the event of a failure of the infrastructure part of the ETCS system in the SHOV area, an ETCS closure is introduced by dispatcher. Since the ETCS closure, the trains are switched to the level STM (L0).

If the train is driving with only one active mobile, the connection to the ACC RBC will be established after termination of the communication session with the HOV RBC ordered by HOV RBC. This will cause the train to cross the braking curve and in some cases be forced to stop at the home signal.

If the train has current Euroradio keys only for the country where it is currently located, an MA will be issued only to the home signal of the following country.

Train with mode On Sight (OS)

Both directions suppose to movement in OS mode. How OS mode works in the SHOV area depends on the RBC configuration.

Train with mode Staff Responsible (SR)

This situation occurs in the case of failure RBC, GSM-R or Interlocking. For this case, National Values must be clearly defined. Trains that have already executed or are executing packet 45 and packet 131 - this will lead to a session with the ACC RBC. The system allows the transition to ETCS L2 FS or OS - depends on the functionality in the responsible RBC.

Failure of Balises

If the BG that provides registration to the relevant network is damaged, communication with the RBC will be established later. This will cause the train to cross the braking curve and in some cases be forced to stop at the home signal.

GSM-R Failure

If there is a GSM-R system failure in the station, the train driver can manually switch to LSTM/PZB or L0/UN. If there is a GSM-R failure during the time period, when the train has passed the Exit Signal the consequences depend on T_NVCONTACT or T_SECTIONTIMER in concrete RBC that issues MA (the train stops after the set time has passed).

RBC Failure

In case of the HOV RBC cannot issue a MA the train can either drive in L2/SR, in L0/UN or in LSTM. If the ACC RBC has a failure the train cannot establish a communication session - because there is no update (extension) of the existing MA, the train will stop at the Home Signal. If the HOV RBC fails after issuing the MA the consequences depend on T_NVCONTACT or T_SECTIONTIMER in concrete RBC that issues MA.

Interlocking Failure

In case of the interlocking fails before the HOV RBC can issue a MA the train can either drive in L2/SR or in LSTM/PZB or L0/UN. In case of the interlocking fails after the HOV RBC issues a MA - the response of the system depends on the settings of each country (in general, the train will always stop).

Emergency situation on the track

The dispatchers have always the possibility to issue an Unconditional Emergency Stop to the train. If a dispatcher issues an order to stop a train, he can only do for the trains in HOV RBC (all trains or just one train). Communication with ACC RBC must be established for the train to stop.

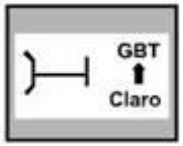
Conclusion:

Both of the aforementioned cases, along with the proposed technical solution, can solved handover in the event of incompatible communication between RBCs and IXLs. This is a technical solution under specific conditions of individual countries, thus the handover technical solution may vary depending on the conditions of each country.

Appendix D List of border crossing information to the driver

Country	Border/change	Driver information	Remarks
Denmark, Danish-German border	GSM-R Voice (to contact dispatcher)	GSM-R network border marker (EN 16494:2015)	
	GSM-R data	n/a	
	Change of operational rules	According to Operational rules for the border line (UIC conform)	
	RBC border	n/a	
	Catenary system change	Catenary signs according to national Danish and German rules	
	State border	According to Operational rules for the border line	
	ETCS border		
Denmark, Danish-Swedish border	GSM-R Voice (to contact dispatcher)	GSM-R network border marker (EN 16494:2015)	Due to safety requirements in the Øresund tunnel the GSM-R network change far inside Denmark
	GSM-R data	n/a	
	Change of operational rules	Dedicated operational rules for the cross-border line (independent Infrastructure manager)	Cross-border area = the fixed Øresund link composed of a tunnel, artificial island and bridge linking Denmark and Sweden

			Rules (supplemented by special signs) also cover the special GSM-R voice solution
	RBC border	n/a	
	Catenary system change	• Automatic switch managed by permanent magnets and on-board voltage measuring • Catenary signs according to national Danish and Swedish rules Signs to be replaced by catenary signs comparable with EN 16494:2015	
	State border	Marked with Danish/Swedish national colours at the bridge	No really need, as the system borders are not located at the national border.
	ETCS border	Start ETCS level 2:  End ETCS level 2: 	
Switzerland	GSM-R Voice (to contact dispatcher)	• GSM-R network border marker (EN 16494:2015) Route book	Route book: Location, phone number
	GSM-R data	• Route book	Route book: Location, phone number ETCS Packet 45 for B2 and B3 locos

	Change of operational rules	Operational rules local (Id: I-30121)	-
	RBC border	RBC/RBC border: • By ETCS RBC/RBC handover (not visible for the driver) • RBC border marker board:  (from RBC “Claro” to RBC “GBT”) RBC – non-RBC border: • CAB marker board: Begin CAB signalling:  End CAB signalling:  • Route book Operations rules local (Id: I-30121)	Route book: Location, phone number Operations rules local (Id: I-30121): RBC Id, location, phone number
	Catenary system change	• Operations rules infrastructure (Id: I-30111) • Operations rules local (Id: I-30121)	-

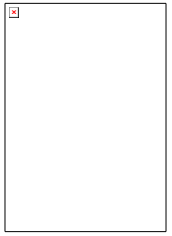
		Catenary signs comparable with EN 16494:2015	
	State border	Operations rules local (Id: I-30121)	No signs outside
	Infrastructure border	Contracts between the infrastructure managers	-
	Maintenance border	MoU between the infrastructure managers	-
France	GSM-R Voice (to contact dispatcher)	 • GSM-R network border marker (EN 16494:2015) Below the GSM-R marker board the virtual channel is added (this is used for the emergency radio group calls) • In ETCS only (under FS mode) an ETCS text message is used: “GSM-R/F: canal 2”	A specific packet 44 is also proposed on the network to automatically change (of GSM network and of virtual channel). The driver can also change manually the GSM-R network, according to route knowledge and the GSM-R border markers
	GSM-R data	• N/A	GSM-R data is exchanged on entering in L2 lines, not at international borders (using P45), except required by neighbouring network.

			If necessary, the driver can also change manually the GSM-R network, according to route knowledge.
	Change of operational rules	No generic rule exists. It depends on bilateral agreements with neighbouring countries: - With Belgium: DMI text message “SIG F” + external sign to show the networks boundary - With Luxembourg: external sign to show the networks boundary - With Switzerland: nothing By default, the type of signal is enough for the driver to know where to change of operations rules.	Driver’s knowledge about the national rules in both countries + specific rules selected on the border section
	RBC border	N/A	There is currently no transition between L2 and another level at French borders. There are technical transitions at the limits of the areas covered by RBCs on a level 2 line: 1) ETCS RBC/RBC handover: not visible for the driver / not operational transition

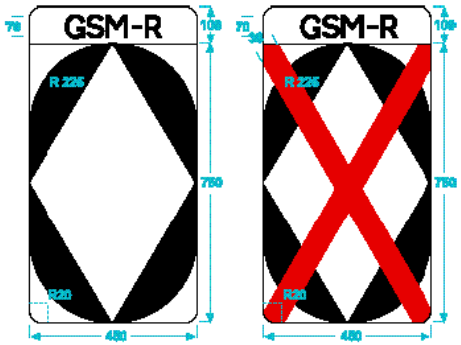
			2) RBC – non-RBC border: We understand ETCS / class B transition. 3) Normal mode: Information by the DMI is self-sufficient. For degraded modes, route knowledge and lateral signaling can be used.
	Catenary system change	On non ETCS lines, specific to each border: Example: French/Italian border change from 1500V DC to 3000V DC (Modane)  On ETCS lines: use of packet 39 or 239 to indicate the change and the type of power (e.g. “25 kV Luxembourg”).	
	State border	There is no generic approach: sign or no sign.	The state border is not relevant for operations.
	Maintenance border	No generic case.	The maintenance border is based on bilateral agreements. The maintenance

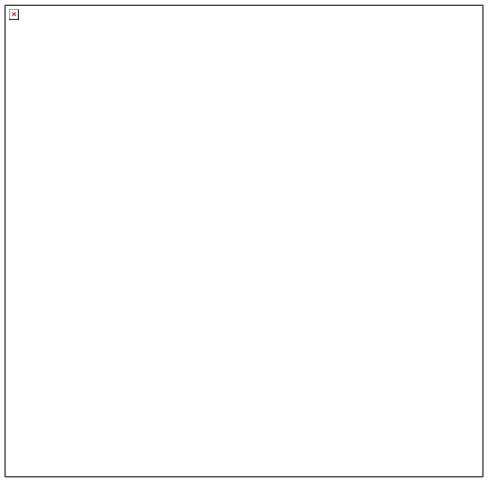
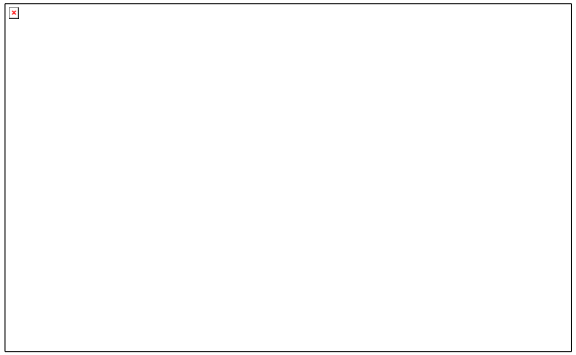
			border can be different from the national border: for example, if there are “foreign” signals on SNCF Réseau network, it is often maintained by the other network. With ETCS deployment on both sides of borders, this might evolve.
Germany	GSM-R Voice (to contact dispatcher)	• GSM-R network border marker (EN 16494:2015) only at HSL-S border Belgium: Text message “GSM-R B”	A panel at the border telling the driver to switch over to the other GSM-R Network
	GSM-R data	• Route book	Packet 45 is sent to the train via balise, which includes the network ID
	Change of operational rules	• Route book	There will be a sign for the driver with something like “Belgium” or “Deutschland”
	RBC border	• Nominal: by ETCS RBC/RBC handover • Degraded: Route book	
	Catenary system change	• Nominal: by ETCS • Degraded: catenary signs comparable with EN 16494:2015	
	State border	• At some borders: small marking (flag) at kilometer signs • Route book	It is in the middle of the Tunnel. There is no “state border sign”
	Level transition exiting ETCS: Change from “German ETCS	• Panel	If you pass this panel and the train is still in ETCS, you must stop and change to NTC

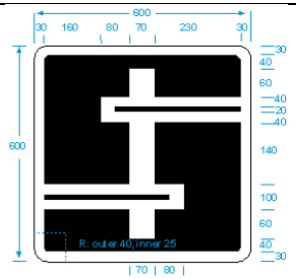
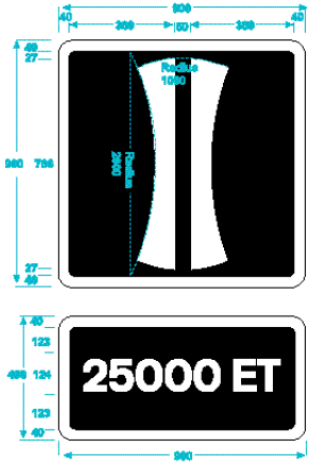
	L1LS" to TBL1+ in Belgium 1 km behind the German border		
The Netherlands	GSM-R Voice (to contact dispatcher)	• GSM-R network border marker (EN 16494:2015) • only at HSL-S border Belgium: DMI Text message "GSM-R NL" / "GSM-R B"	
	GSM-R data	Route book	Route book: location, network ID ETCS Packet 45
	Change of operational rules	• Route book • Border to Belgium, sign according Belgium regulation (not part of Dutch regulation)	Also change of National Values 
	RBC border	• Nominal: by ETCS RBC/RBC handover • Degraded: Route book	Route book: Location, RBC-ID, phone number
	Catenary system change	• Nominal: by ETCS	

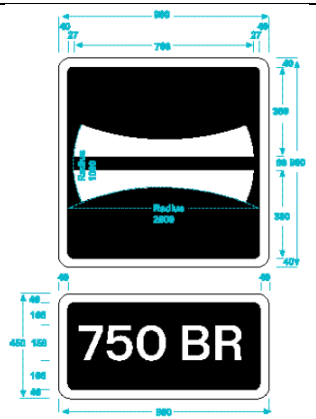
		• Degraded: catenary signs comparable with EN 16494:2015	
	State border	• At some borders: small marking (flag) at kilometer signs • Route book	
	Maintenance border	Contract between the infrastructure managers	
Italy	GSM-R Voice (to contact dispatcher)	• GSM-R network border marker  • Route book	
	GSM-R data	• Route book	Route book: location, RBC-ID, phone number

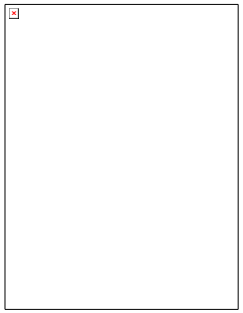
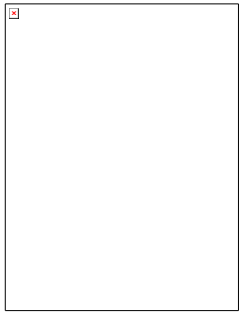
	Change of operational rules	• Route book	Route book: the indication of the type of signalling system is recorded (it could not correspond to the state border)
	RBC border (Hand over)	• Route book	Route book: Location, RBC-ID, phone number
	Catenary system change	• ERTMS track conditions • Route book • The following markers are present:  and the voltage can be indicated as follows (this indication is not always present): 1. 	
	State border	• Only in case the driver must do some specific action (e.g. a dynamic transition of the control command system, also recorded in the route book) the following marker (“state border”) is present:	

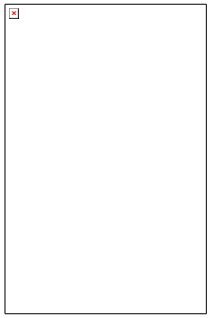
	Maintenance border	• Agreement between IMs	
Great-Britain	GSM-R Voice (to contact dispatcher)	RSSB Sign Reference DC01  • Along with these signs we have an online database of that lists general instructions for the driver called the National Sectional Appendix. This will detail GSM-R data, numbers and locations for each route (http://nesa.corp.ukrail.net/nesa/).	These signs identify a zone in which trains equipped with GSM-R radios are expected to use that system. The National Electronic Sectional Appendix (NESA) contains Table A diagrams, General instructions, Route clearance, Exceptionally poor rail adhesion, Local Instructions and Special working arrangements
	GSM-R data	Detailed in NESA for each route	

	Change of operational rules	• Border between HS1 and NRIL  • Board leaving CTRL and entering NR 	
	RBC border (Hand over)	Detailed in NESA for each route	
	Catenary system change	• Warning of Traction System Changeover (AJ04)	**Warning of Traction System Changeover** - This sign identifies the

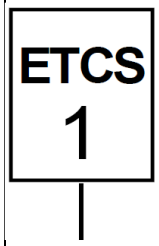
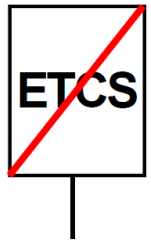
		 • Traction Changeover to 25 kV AC (AJ05)  • Traction Changeover to 750 V DC (AJ06)	commencement of an electrification neutral section. **Traction Changeover to 25 kV AC** - This sign indicates that the train is entering (in this example) Eurotunnel 25kV catenary. **Traction Changeover to 750 V DC** - This sign indicates that the longest train is over (in this example) British 3rd rail traction supply. The pantograph shall remain lowered.

			
	State border	N/A	
	Maintenance border	Agreement between IMs	

Belgium	GSM-R	• GSM-R network border marker
		  
		• Route book
		• Text message
		  ○ Text = “GSM-R x”
		  ▪ x = “B” for Belgium
		  ▪ x = “D” for Germany
			ETCS Packet 45 for each border and at the exit of the workshop (only one value for the entire network)

		▪ x = “NL” for Netherland ▪ x = “F” for France ▪ x = “L” for Luxembourg ○ Q_TEXTCONFIRM = 00, L_TEXTDISPLAY = 32767	
	Change of operational rules	 • Route book • Change of signalling system informed to the driver by text message ○ Text = “SIG x” ▪ x = “B” for Belgium ▪ x = “D” for Germany ▪ x = “NL” for Netherland ▪ x = “F” for France • x = “L” for Luxembourg	-

	Catenary system change	 Route book	
	Level transition exiting ETCS	• Begin CAB signaling (ETCS1 or ETCS2 panels) :  • End CAB signalling:  • Route book • Operations rules local	The panel “end of ETCS area” means that the driver is entering in a class B system area. The panel “beginning of ETCS2 area” means for the train not fitted with ETCS2 that they should operate with the class B system.
Luxembourg	GSM-R Voice	• GSM-R network border marker • Indicates to the drive to proceed a change of GSM-R network • At borders with France: DMI Text message “GSM-R L” as a support for the driver	

		• It is also planned to send/show a text message “GSM-R L” on other borders as a support for the driver, if it is technically allowed.	RF 34a
	Change of operational rules	• RF 13 marks the territorial border between the national railway network of Luxembourg and neighbour networks and materialise the political and juridical limit between the government of Luxembourg and neighbour governments. • RF 13a indicates the entrance to the national railway network of Luxembourg. • RF 13b indicates the exit of the national railway network of Luxembourg to a neighbour network.	 RF 13a  RF 13b
	Transition zone of ETCS	RF 31a indicates the entrance to an ETCS level 1 zone. RF 31c indicates the transition to a zone, which is not equipped with ETCS.	 RF 31a  RF 31 c The transitions are also shown on the DMI as support.