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ERTMS USERS GROUP – ENGINEERING GUIDELINE

66. Level transition from SV1.Y to SV 2.Y with NTC fallback

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1. Introduction

1.1 Foreword

1.1.1.1 The procedure for level transitions is technically defined in chapter 5 of the SRS (see SUBSET-026 v2.3.0 [1] including SUBSET-108 [2], v3.4.0 [3], and v3.6.0 [4]). The harmonized ETCS rules apply (see TSI OPE [5]).

1.1.1.2 However, these documents are not enough to implement a level transition from a line equipped with ETCS (level 1, 2 or 3) using System Version 1.Y to a line equipped with ETCS (level 1, 2 or 3) using System Version 2.Y with an NTC system as a fallback. This configuration is often used when a line was first equipped with ETCS SV 1.Y, connected to another line then equipped with ETCS SV 2.Y with an NTC fallback, to still allow the Baseline 2 trains to run on the ETCS SV 2.Y line.

1.1.1.3 The aim of this document is to propose a recommended technical trackside solution for engineering such transitions for the benefit of future ETCS projects. The aim is to support an efficient and safe implementation of ERTMS, both from a technical and operational point of view, simplifying and harmonizing future system implementations and taking advantage of the experience learned from projects already in operation.

1.1.1.4 The recommended solution only focuses on the change of System Version between the two lines. Therefore, does not take into considerations the specificities implied by the level transition or RBC/RBC handover (L2/L2 or L2/L3) itself.

1.1.1.5 Even if this solution does not describe how the level transition should be engineered, it exports some constraints on the level transition engineering.

1.1.1.6 This guideline is part of a bundle of guidelines with the Overall ETCS guideline [9] being the main guideline which will redirect the reader to the relevant guidelines. Be aware that the Overall ETCS guideline may also include recommendations which are related to the topics addressed in this guideline.

1.2 Scope and Field of Application

1.2.1.1 This guideline is applicable for all System Version changes combined with a level transition where:

- the origin level of the level transition is amongst level 1, 2 and 3 using System Version 1.Y;
- the destination level of the level transition is amongst levels 1, 2 and 3 using System Version 2.Y, and the line has a fallback system with a national train control system (level NTC/STM).

1.2.1.2 When operating the considered lines, it is forecast that:

- The trains equipped with a Baseline 2 on-board will operate in ETCS (level 1, 2 or 3) on the System Version 1.Y line, and in NTC/STM on the line equipped with System Version 2.Y
- The trains equipped with a Baseline 3 on-board will operation in ETCS (level 1, 2 or 3) for both lines (System Version 1.Y and 2.Y).

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

- Preventing trains that are not fitted with neither Baseline 3 ETCS on-board nor appropriate NTC/STM system from entering the ETCS SV 2.Y/NTC area is out of the scope for this document.
- The route suitability check in rear of such an area depends on many local issues such as national procedures, national rules, type of unsuitability, and geographical location of the unsuitability and places to stop trains if not suitable. Thus, the route suitability function is considered out of scope for this document.
- Track conditions information is considered as general information to be sent to the train independently from the transition and thus out of scope for this document.
- The specific national trackside equipment requirements are project specific and not part of this guideline.
- Optical signals, for the Level STM, Level 0 or Level 1 Limited Supervision area, are project specific and out of the scope of this guideline.

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 describes the functional steps involved in a transition from an SV 1.Y line to a SV 2.Y line with NTC fallback.

1.3.1.4 Chapter 4 provides the criteria and risks to be addressed for engineering the transition from a SV 1.Y line to a SV 2.Y line with NTC fallback.

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

1.3.1.6 Chapter 6 provides a brief description of an alternate solution to that described in chapter 5.

2. References and Abbreviations

2.1 Abbreviations

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

Abbreviation	Description
1.Y	System Version 1.0 or 1.1
2.Y	System Version 2.0 or 2.1
ATP	Automatic Train Protection
B2	Baseline 2
B3	Baseline 3
NTC	National Train Control
STM	Specific Transmission Module
SV	System Version

2.2 References

2.2.1.1 The following documents and versions apply:

Ref. N°	Document Reference	Title	Version
[1]	SUBSET-026	System Requirements Specification	2.3.0
[2]	SUBSET-108	Interoperability-related consolidation on TSI CCS Annex A documents	1.2.0
[3]	SUBSET-026	System Requirements Specification	3.4.0
[4]	SUBSET-026	System Requirements Specification	3.6.0
[5]	TSI OPE, Appendix A	Appendix A to Technical Specifications “Operation and traffic management”	4
[6]	SUBSET-091	Safety requirements for the Technical Interoperability of ETCS in Levels 1 & 2	2.5.0
[7]	SUBSET-091	Safety requirements for the Technical Interoperability of ETCS in Levels 1 & 2	3.4.0

Ref. N°	Document Reference	Title	Version
[8]	SUBSET-091	Safety requirements for the Technical Interoperability of ETCS in Levels 1 & 2	3.6.0
[9]	22E087	Overall ETCS	1-

3. System Version change from 1.Y to 2.Y

3.1 Functional steps

3.1.1.1 The transition from an SV 1.Y line to an SV 2.Y line with NTC fallback is divided into the following functional steps:

1) Step 1: Announce Virtual Balise Covers
2) Step 2: Level transition for B2 trains
3) Step 3: Cancel Virtual Balise Cover
4) Step 4: Level transition for B3 trains

3.1.1.1.1 Note: Step 2 and step 4 are not detailed in this guideline unless they are necessary for a full comprehension of the guideline, in which case they are basically described in this guideline.

3.2 General track layout

3.2.1.1 Figure 1 describes the general track layout of the function to be implemented.

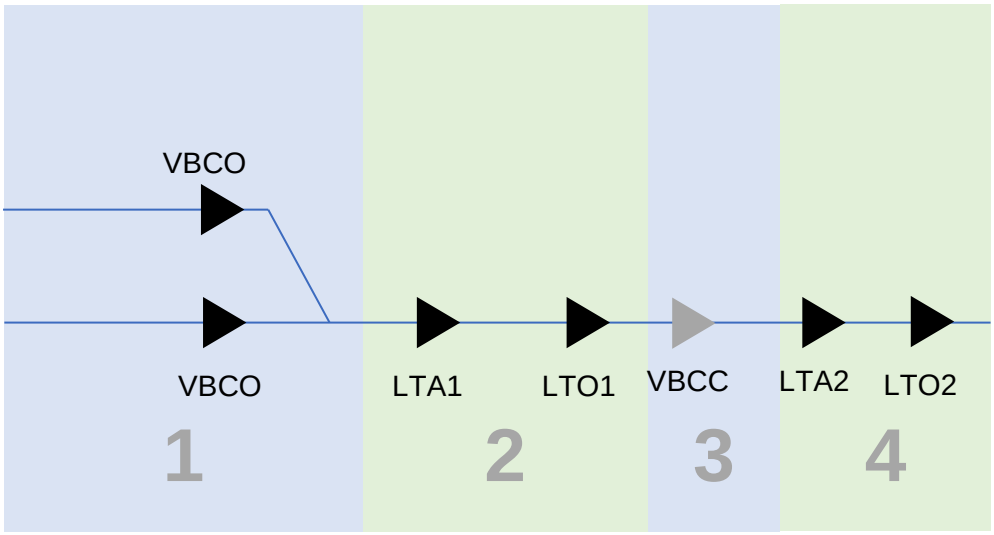

Figure 1: General track layout

3.2.1.1.1 Note: The track layout of steps 2 and 4 are simplified to the maximum.

3.2.1.1.2 Note: If the applicable level before step 1 is level 2 or 3, this solution imposes a transition to STM/NTC by balise group. If this is not possible, see the alternate solution chapter 6.

3.2.1.2 If step 4 is a level transition to level 2 or 3, and the level approaching VBCO is not level 2 or 3, the step 4 is replaced by the step 4bis using the track layout on Figure 2.

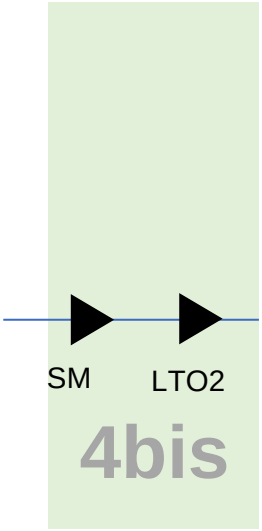

Figure 2: Track layout of step 4bis

3.2.1.3 Step 4 can be a transition between RBC (hand-over), from level 2 or 3 to level 2 or 3, the step 4 is replaced by the step 4ter using track layout on Figure 3.

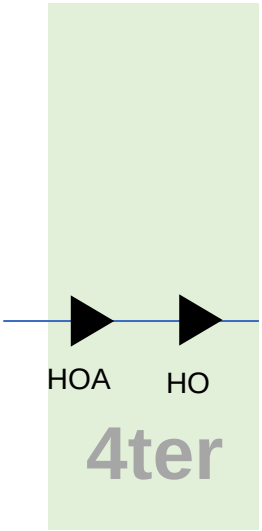

Figure 3: Track layout of step 4ter

3.2.1.4 Table 1 describes the content of the BG used to implement the proposed solution.

BG	BG DESCRIPTION	SYSTEM VERSION	BG INFORMATION (ETCS PACKETS and HEADER if required)
VBCO	*Virtual balise cover order*	*1.1*	***Packet 6:*** *Virtual balise cover order* - NID_VBCMK: Use the same value as the one in packet 200 in LTA1 and LTO1 - NIC_C: Use the same value as in the header of LTA1 and LTO1 - Q_VBCO: Set the Virtual Balise Cover - T_VBC: Different from 0

BG	BG DESCRIPTION	SYSTEM VERSION	BG INFORMATION (ETCS PACKETS and HEADER if required)
LTA1	*Level Transition Announcement*	*1.1*	***Header:*** *Use the same NID_C as for VBCO.* ***Packet 200:*** *Virtual Balise Cover* - NID_VBCMK: Unique value for the area (see value for VBCO) ***Packet 41:*** *Level transition Order* - D_LEVELTR ≠ 0 or “Now” - M_LEVELTR = Level STM
LTO1	*Level Transition Order*	*1.1*	***Header:*** *Use the same NID_C as for VBCO.* ***Packet 200:*** *Virtual Balise Cover* - NID_VBCMK: Unique value for the area (see value for VBCO) ***Packet 41:*** *Level transition Order:* - D_LEVELTR = 0 or “Now” - M_LEVELTR = Level STM **OR** ***Packet 46:*** *Conditional Level transition Order:* - M_LEVELTR = Level STM
VBCC	*Virtual balise cover cancelation*	*1.1 or 2.Y*	***Header:*** *Use the same NID_C as for VBCO.* ***Packet 6:*** *Virtual Balise Cover Order* - NID_VBCMK: same value as for LTA1 and LTO1. - NID_C: Use the same value as in the header of LTA1 and LTO1 - Q_VBCO: Remove the Virtual Balise Cover **OR** ***Header:*** *Use a NID_C different from the one used for VBCO.*
LTA2	*Level Transition Announcement*	*2.Y*	***Packet 41:*** *Level transition Order*

BG	BG DESCRIPTION	SYSTEM VERSION	BG INFORMATION (ETCS PACKETS and HEADER if required)
LTO2	*Level Transition Order*	*2.Y*	***Packet 41:*** *Level transition Order* **OR** ***Packet 46:*** *Conditional Level transition Order*

Table 1: BG description and content

3.2.1.5 In case the second level transition is a level transition to level 2 or 3, and the level before VBCO is not level 2 or 3, the BGs LTA2 shall be replaced by the BG described in Table 2.

BG	BG DESCRIPTION	SYSTEM VERSION	BG INFORMATION (ETCS PACKETS)
SM	*Session Management*	*2.Y*	***Packet 42:*** *Session management* - Q_RBC = Establish communication session

Table 2: Step 4bis BG description

3.2.1.6 In case step 4 is an RBC transition (hand-over), from level 2 or 3 to level 2 or 3, the BGs LTA2 and LT0 shall be replaced by the BG described in Table 3.

BG	BG DESCRIPTION	SYSTEM VERSION	BG INFORMATION (ETCS PACKETS)
HOA	*Hand-over announcement*	*2.Y*	***Packet 131:*** *RBC transition order* If a change of Level is foreseen: ***Packet 41:*** *Level transition order*
HO	*Hand-over*	*2.Y*	***Packet 131:*** *RBC transition order* If a change of Level is foreseen: ***Packet 41:*** *Level transition order*

Table 3: Step 4ter BG description

3.3 General sequence diagram

3.3.1 General sequence diagram for B2 trains

3.3.1.1 Figure 4 represents the general sequence diagram for B2 trains.

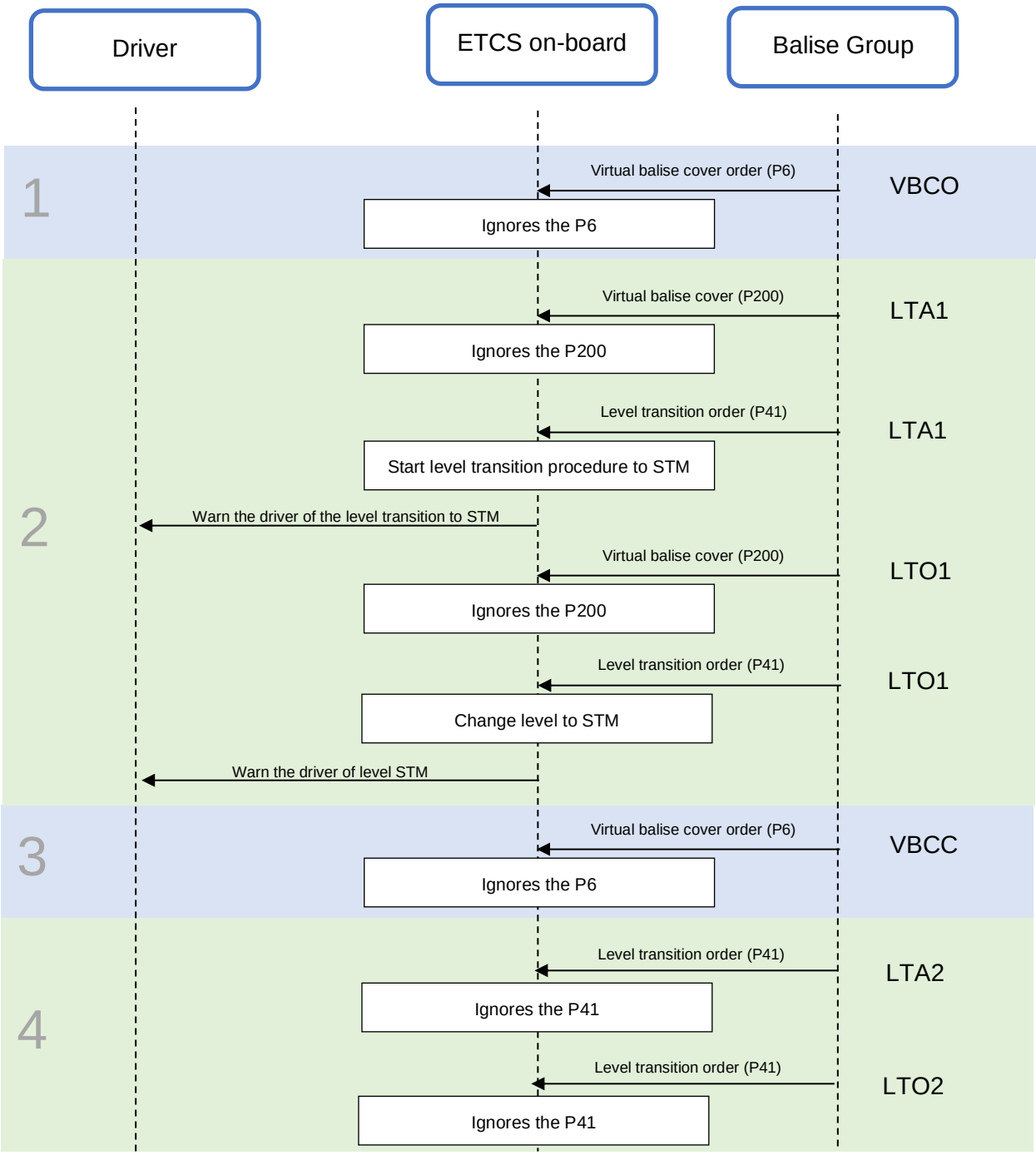

Figure 4: General sequence diagram for B2 trains

3.3.1.2 The detailed steps of the level transition (step 2) are not described on this scheme as they are not relevant for this guideline.

3.3.1.3 In steps 1 and 3, the packet 6 is ignored by the Baseline 2 on-board because this packet is undefined for Baseline 2 see clause 3.17.3.11 of SUBSET-026 v2.3.0 [1].

3.3.1.4 In step 2, the packet 200 is ignored by the Baseline 2 on-board because this is undefined for Baseline 2 see clause 3.17.3.11 of SUBSET-026 v2.3.0 [1].

3.3.1.5 In step 4, the packets 41 are ignored because the System Version used in the balise groups transmitting these packets is 2.Y and is not amongst the one supported by the Baseline 2 on-board, and the train is in STM (see clause 3.17.3.12 of SUBSET-026 v2.3.0 [1]). No reaction is applied by the train.

3.3.1.6 In case the entered level is level 2 or level 3 with a STM/NTC fallback, the step 4 is replaced by the step 4bis described in Figure 5.

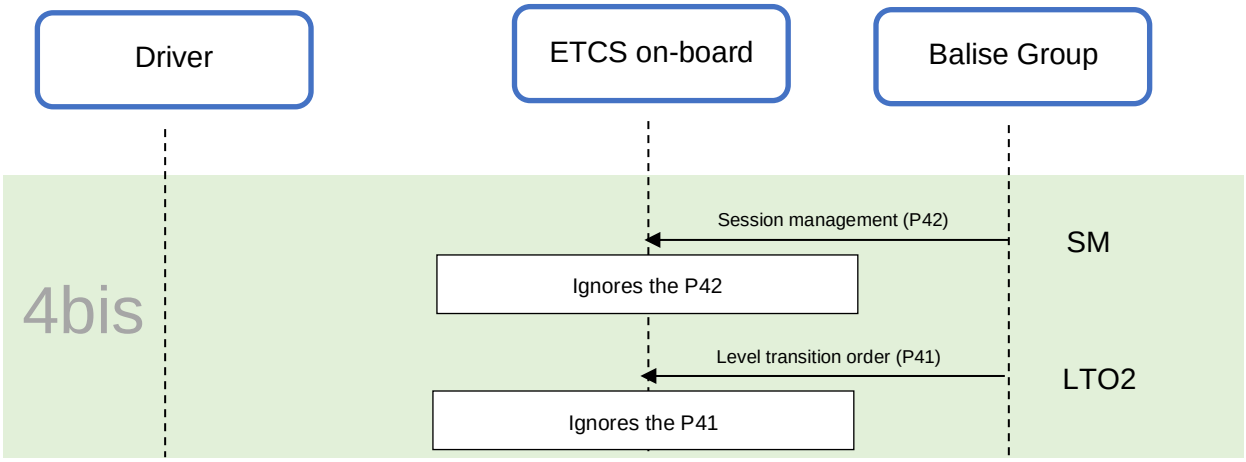

Figure 5: Alternate step 4 for level transition to level 2 or 3

3.3.1.7 In step 4bis, the packets 42 and 41 are ignored because the System Version used in the balise groups transmitting these packets is 2.Y and is not amongst the one supported by the Baseline 2 on-board, and the train is in STM (see clause 3.17.3.12 of SUBSET-026 v2.3.0 [1]). No reaction is applied by the train.

3.3.1.7.1 Note: The step 4bis does not take into consideration the level transition announcement as usually level transition to level 2 or 3 are announced through radio. In case it is not, the LTA2 is managed the same way as other balise groups of step 4bis.

3.3.2 General sequence diagram for B3 trains

3.3.2.1 Figure 6 describes the general sequence diagram for B3 trains.

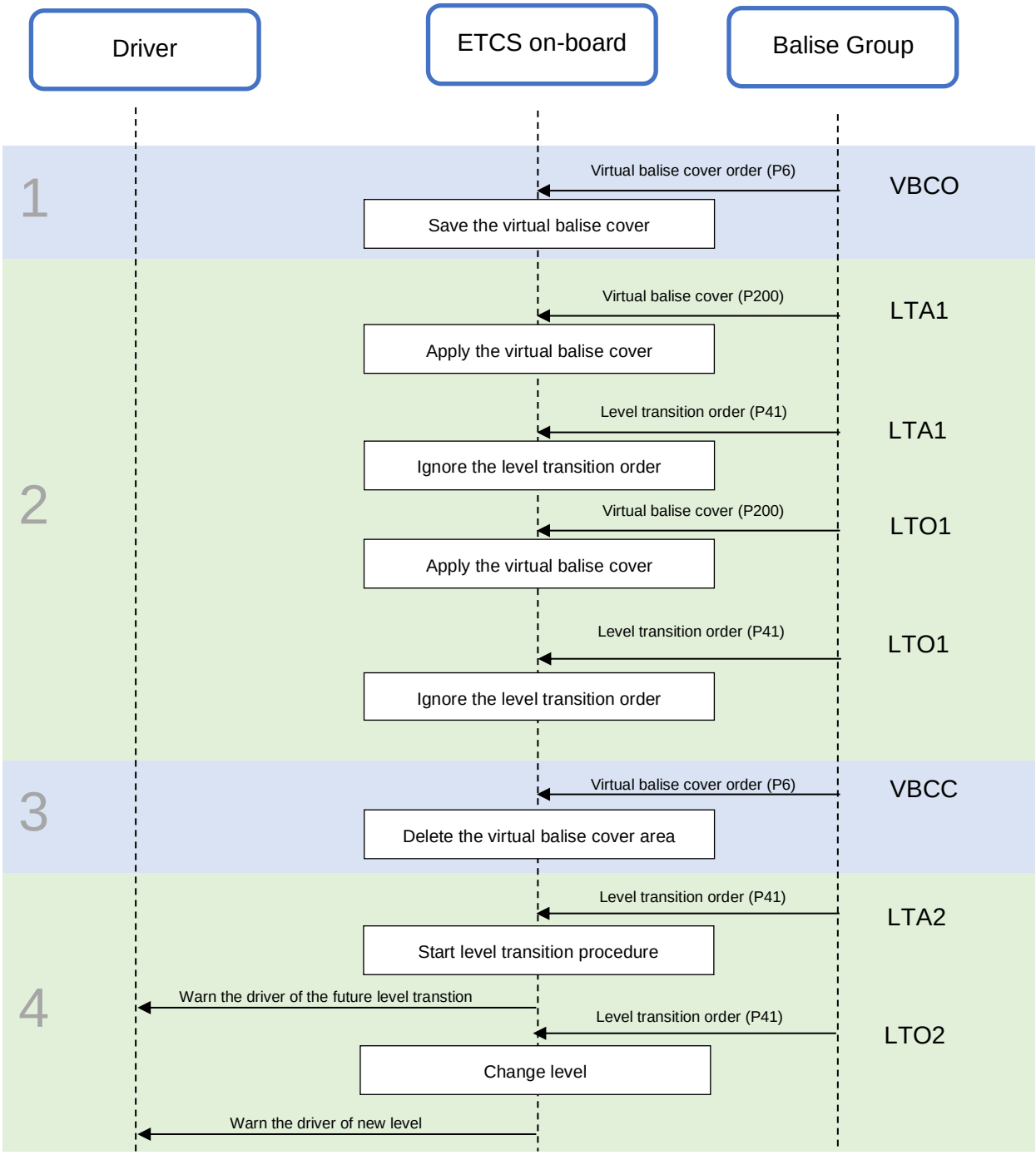

Figure 6: General sequence diagram for B3 trains

3.3.2.2 The detailed steps of the level transition (step 4) are not described on this scheme as they are not relevant for this guideline.

3.3.2.3 In step 2, the packet 41 is ignored by B3 trains as the balise groups are virtually covered (see 3.15.9.3 of SUBSET-026 v3.4.0 [3] or v3.6.0 [4]).

3.3.2.4 In case the entered level is level 2 or level 3 with a STM/NTC fallback, the step 4 is replaced by step 4bis described in Figure 7.

3.3.2.4.1 Note: The step 4bis does not take into consideration the level transition announcement as usually level transition to level 2 or 3 are announced through radio. In case it is not, the LTA2 is managed the same way as other balise groups of step 4bis.

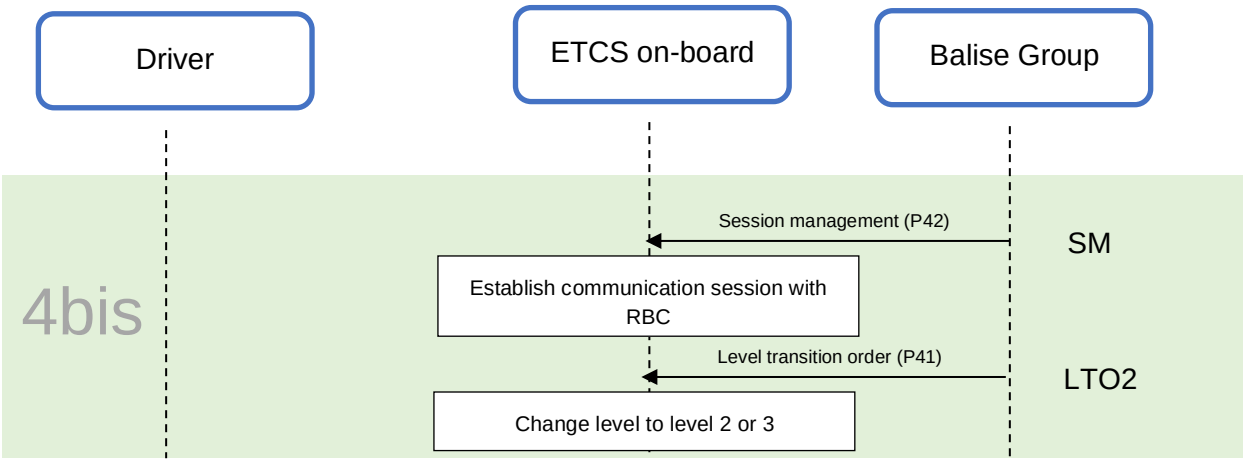

Figure 7: Alternate step 4 for transitions to level 2 or 3

4. Criteria and risks to be addressed

4.1 Prevent trips at the border

4.1.1.1 The main risk for changes of ETCS System Version is the trip of trains equipped with ETCS on-boards only supporting System Version 1.0 when reading a balise group with System Version 2.Y. This risk is addressed by the combination of the functional step 2 in chapter 5.3.

4.2 Ensure B2 trains are in level STM

4.2.1.1 The design shall ensure that the Baseline 2 trains are in level STM when reading the first STM device in the STM area. This is class B and project specific and therefore not developed in this guideline.

4.3 Ensure B3 trains are in level 1, 2 or 3

4.3.1.1 The design shall ensure that the Baseline 3 trains:

- Remain in the origin ETCS level (not STM/NTC) up to the LTO2 BG. This is achieved thanks to the combination of functional steps 1 and 2 (see chapter 5.1 and 5.3).
- Is in the appropriate level after the LTO2 BG (1, 2 or 3). This is achieved thanks to the functional step 3 (see chapter 5.4).

4.4 Ensure the active System Version is correct for B3 trains.

4.4.1.1 The active System Version of B3 train shall be 2.Y when reading the first BG in the System Version 2.Y area. The B3 train will automatically switch to System Version 2.Y on reading a BG with System Version 2.Y (i.e. LTA2 or SM BG). This topic is fully addressed and does not need more precision.

4.5 Ensure virtual balise covers are activated

4.5.1.1 Baseline 3 trains must have the correct virtual balise covers activated on board. The risk of an inactive virtual balise cover on-board a Baseline 3 trains can have several origins:

- The information “Virtual balise cover order” was never transmitted to the train. This risk is addressed in chapter 5.2.1.1.
- The information “Virtual balise cover order” was transmitted to the train with the qualifier Q_VBCO set to the value “Remove the Virtual Balise Cover”. This risk is addressed in chapter 5.2.3.
- The NID_C used in the header of a balise group between the announcement of the VBC area and the virtually covered balise groups is different from the NID_C attached to the virtual balise cover area (in the packet 6) (see clause 3.15.9.5 d of SUBSET-026 v3.4.0 [3] and v3.6.0 [4]).
- The “Virtual balise cover area” is disabled between the “Virtual balise cover order” and the virtually covered balise groups.

4.6 Limit the number of changes in operational rules

4.6.1.1 Changing of operational rules (implied by a level transition) implies a lot of changes for a driver. The number of level transitions in a reduced time should be limited as much as possible (SUBSET-091 v2.5.0 [6], v3.4.0 [7] and v3.6.0 [8] recommend less than two per hour).

4.6.1.2 The recommended solution limits the change in the operational rule to one change per type of train (Baseline 2 or 3).

4.6.1.3 The alternate solution in chapter 6 proposes two level transitions in a very short distance (one section).

4.7 All other risks implied by level transitions

4.7.1.1 All the other risks to be addressed for level transitions are not addressed in the present document.

4.8 Prevent display of “Trackside not compatible”

4.8.1.1 In case a B2 train tries to establish a session with an SV 2.Y RBC, the session establishment will fail due to System Version mismatch. This results in the display of “Trackside not compatible” on the DMI (see clause 3.17.3.8 of SUBSET-026 v2.3.0 [1] or clause 3.5.3.7.d of SUBSET-026 v3.4.0 [3] and v3.6.0 [4].

4.8.1.2 The message “Trackside not compatible” is also displayed in case a train passed a BG using a System Version higher than the ones supported by the on-board and the train is in Level 1, 2 or 3. This will also cause the train to transition to trip mode. See 4.1 for more information.

4.8.1.3 When “Trackside not compatible” is displayed on the DMI, the driver shall contact the dispatcher and apply non harmonized rule (see clause 6.43 of TSI OPE [5]).

4.8.1.4 The specific case of the display of “Trackside not compatible” due to a failed session establishment is taken into consideration in functional step 4bis and chapter 5.5.

5. Recommended solution

5.1 General recommendations

5.1.1.1 For cost reasons, when the real track layout allows this, it is highly recommended to only use fixed balises to realize the described transition.

5.1.1.1.1 Note: If one of the level transitions implies level 1, the use of signal balise groups to achieve one of the functional steps is also possible.

5.1.1.2 For availability reasons, it is highly recommended to use duplicate balise groups and include all of them in the linking (packet 15). However, considering CFC03 and the upcoming change request about interaction between virtual balise covers and linking (among other uncertainty about how VBC are handled), it could be required to use unlinked balise groups, to ensure B3 trains do not apply any linking reaction.

5.1.1.3 To ensure the VBC order is not deleted by the on-board, the NID_C used in packet 6 shall be the same as the one used for all the BG headers between VBCO (included) and VBCC, including the BG not displayed on the figures, but installed in the track to accomplish other functions.

5.2 Announce Virtual Balise Covers

5.2.1 Basic considerations

5.2.1.1 The basic considerations for this functional step are not addressed in this guideline.

5.2.2 Handle virtual balise covers

5.2.2.1 The way virtual balise covers are handled can create problems in terms of both safety and performance.

5.2.2.2 To prevent this situation a combination of several measures can be implemented:

- The BG VBCO can be composed of two duplicate balises and included in the linking. This prevents a single failure of a balise in the group.
- A repetition of the BG VBCO can be added to manage the case when the VBCO BG is not read, possibly due to being removed or damaged.

5.2.2.3 To ensure the VBC is not disabled between VBCO and its use with LTA1 and LTO1, the same NID_C shall be used in the header of VBCO, in the packet 6 included in VBCO, in the header of LTA1, LTO1 and in the header of any balise group located in between. According to clause 3.15.9.5.d of SUBSET-026 v3.4.0 [3] and v3.6.0 [4], a VBC has to be disabled in case a balise group with a NID_C different form the one in the virtual balise cover order is encountered. A particular care should be taken case of the use of temporary unlinked balise groups to transmit TSR or any other temporary information.

5.2.2.4 In case a turn-around movement usually occurs between BG LTO2 and VBCO, and therefore a train could not have the virtual balise cover order saved on-board, it is recommended to move the BG to a location where they do not occur. In case

it is not possible to do this, the following technical or operational measures can be implemented to mitigate the consequences:

- Manually entry or checking of the virtual balise covers by the driver at the start of mission (see clause 3.15.9.2 of SUBSET-026 v3.4.0 [3] or v3.6.0 [4]). This mitigation implies a driver's action and is not recommended.
- Repeat the virtual balise cover order as much as necessary between VBCO and LTO2 (e.g. every signal). This solution is not described more precisely as it is a project specific implementation.
- Transmit the virtual balise cover order for the other running direction. On Figure 8, the hashed triangles represent the balise groups to be added to implement this solution. The content of each BG is described in Table 4.

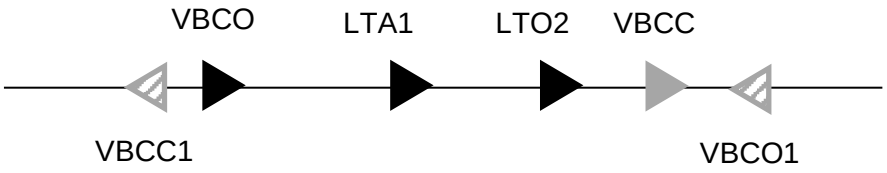

Figure 8: Location of Virtual Balise Cover BG for the opposite running direction

BG	BG DESCRIPTION	SYSTEM VERSION	BG INFORMATION (ETCS PACKETS)
VBCO1	*Virtual balise cover order*	*1.1 or 2.Y*	***Packet 6:*** *Announce the virtual balise covers used to "hide" step 2 to Baseline 3 trains* - NID_VBCMK: Use the same value as the one in packet 200 in LTA1 and LTO1 - NIC_C: Use the same value as in the header of LTA1 and LTO1 - Q_VBCO: Set the Virtual Balise Cover
VBCC1	*Virtual balise cover cancelation*	*1.1*	***Packet 6:*** *Virtual Balise Cover Order* - NID_VBCMK: same value as for LTA1 and LTO1. - NID_C: Use the same value as in the header of LTA1 and LTO1 - Q_VBCO: Remove the Virtual Balise Cover

Table 4: Content of additional BG

5.2.2.5 In Table 4, the System Version of VBCC1 must be 1.1 as the balise group can be read by Baseline 2 trains operating in level 1 or level 2. Using a System Version 2.Y would cause these trains to trip on reading the BG (see clause 3.17.3.5 of SUBSET-026 v2.3.0 [1] and clause 3.17.3.5.d of SUBSET-026 v3.4.0 [3] or v3.6.0 [4]). As the BG VBCO1 can be read only by Baseline 2 trains in level STM or Baseline 3 trains in level 1,2 or 3 the System Version can be 1.1 or 2.Y.

5.2.2.6 VBCC1 and VBCO can be merged into a single balise group; two packet 6 would be transmitted, on for each running direction. The same can as well be done for VBCC and VBCO1.

5.2.3 Managing the virtual balise covers ID

5.2.3.1 Mixing virtual balise cover areas could lead to using the name NID_VBC for two distinct areas, and therefore lead to an unwanted deactivation or activation of a virtual balise cover area. A clear partition of use of NID_VBC should be done among the same NID_C area so that the same NID_VBC is not used for two distinct areas.

5.3 Level transition for Baseline 2 trains

5.3.1 Basic considerations

5.3.1.1 The basic considerations for this functional step are not addressed in this guideline.

5.3.2 Use of packet 46 in LTO1

5.3.2.1 In case a packet 46 is used at the border of the level transition for Baseline 2 trains, it is necessary to ensure all the Baseline 2 trains will react as expected. SUBSET-026 v2.3.0 [1] does not precisely describe how an on-board shall handle level transition orders coming both from packet 41 and 46, which Baseline 3 does. It is then not possible to ensure that the packet 46 in LTO1 will be taken into consideration only if the packet 41 of LTA1 has not been received, as a Baseline 3 train would do (see exception [11] of clause 4.8.3 of SUBSET-026 v3.4.0 [3] and v3.6.0 [4]). It is then recommended to use packet 41 in LTO1 if such a behaviour cannot be insured for all the Baseline 2 trains.

5.4 Cancel virtual balise cover order

5.4.1 Handle virtual balise covers

5.4.1.1 In order to prevent the misuse and the mix between virtual balise cover orders, it is highly recommended to cancel virtual balise cover orders as soon as the last balise group virtually covered is passed by the train. This is achieved by using the VBCC BG.

5.5 Level transition for Baseline 3 trains

5.5.1 Basic considerations

5.5.1.1 The basic considerations for this functional step are not addressed in this guideline.

5.5.2 Prevent the display of “Trackside not compatible”

5.5.2.1 In case the B3 trains have to transition to level 2 or 3, a session has to be established ahead of the border, to ensure the transmission of MA before the level transition. The establishment of the session is usually considered to need 40s to be finalized.

5.5.2.2 To cope with such delays, the session management or RBC transition order packets are located far ahead of the level/RBC transition location.

5.5.2.3 A B2 train trying to establish a communication session with a System Version 2.Y RBC will result in closed session and the display of “Trackside not compatible” to the DMI (see clause 3.17.3.8 of SUBSET-026 v2.3.0 [1]). To prevent such a situation, a B2 on-board shall never try to establish the communication session. For that, the System Version used in the balise group transmitting the session management packet (P42) shall be set to 2.Y, and located after the border for B2 trains.

6. Alternative solution

6.1.1.1 The recommended solution imposes the use of balise groups to make the transition to STM/NTC so that they can virtually be masked for the Baseline 3 trains, including when the trains are coming from a level 2 or 3 System Version 1.Y line. In case it is not possible to use BG for level transitions from level 2 or 3, it is necessary design two consecutive level transitions:

- The first level transition is done to reach the level STM or L0. This level transition is applicable for all trains
- The second one is to transition to the ETCS level System Version 2.Y (level 1, 2 or 3). This level transition is applicable only for B3 trains. The used System Version in the balises is then 2.Y.

6.1.1.2 It is highly recommended to carefully analyse the location of the two borders, as Baseline 3 trains will have to do two level transitions. The safety demonstrations of ETCS, provided by SUBSET-091 v2.5.0 [6], v3.4.0 [7], and v3.6.0 [8], rely on a mean of 2 level transitions per hour, it is therefore recommended to analyse all the journeys through these two level transitions to ensure they still fit this value.