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ERTMS USERS GROUP - ENGINEERING GUIDELINE

80. Level 3 Engineering

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Modification history

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0.1	14/10/2019	First draft	AJM
0.2	06/12/2019	Comments ESG78	AJM
0.3	26/03/2020	Comments ESG80, WL, JA, GR, Input SMC par 3.4	AJM
0.4	06/05/2020	TBD ESG83 elaborated	AJM
0.5	10/05/2020	Additional comments for ESG83	GR
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1-	30/04/2021	Finalised first version for DAP Specific Contract 3	EUG ESG

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1 Introduction

1.1.1.1 When engineering a level 3 trackside some specific decisions must be made and some issues could be encountered. This guideline intends to give guidance on the decisions and help with engineering a level 3 trackside.

1.1.1.2 The main focus is interoperability and standardisation of the level 3 trackside design in order to achieve increase of capacity and/or cost savings due to trackside asset reduction.

1.1.1.3 Authors of the document consider the issues identified and tackled represent the status of present knowledge and implementations concerning ERTMS/ETCS level 3.

1.1.1.4 Besides the abovementioned information, reports from X2Rail-1 Moving block are used as an input for this guideline, [X2R D5.1], [X2R D5.2] and [X2R D5.3].

1.2 Scope and Field of Application

1.2.1.1 The aim of this document is to describe level 3 engineering issues and to provide a recommended trackside solution for the engineering of level 3 tracksides.

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 authorisation in commercial operation, for an ERTMS level 3 trackside

1.2.1.4 This document is based on ERTMS/ETCS Baseline 3 (including [OPINION ERA 2020-2]).

1.2.1.5 This document is based on the following key differences which characterise the level 3 track implementation:

- the usage and layout of block sections: full moving or fixed virtual block sections
- usage of trackside train detection (using conventional methods) or not

1.2.1.6 With these characteristics 4 different main variants of level 3 implementation are possible:

[1] Level 3 Full Moving Block[1], no trackside train detection

[2] Level 3 Full Moving Block[1], with trackside train detection

[3] Level 3 Fixed Virtual Block, no trackside train detection

[4] Level 3 Fixed Virtual Block, with trackside train detection

1.2.1.7 The last variant is also known as Hybrid ERTMS/ETCS level 3 and the principles are described in [Principles HL3].

1.2.1.8 Variants [2] and [4] can be also implemented with a minimum number of trackside train detection system placed in specific location (e.g. where LX or specific switches are).

[1] The term "Full Moving Block" has been defined within S2R context, for the rest of the document. The term "Moving Block" will be used instead.

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

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

1.2.1.11 Operational rules for level 3 are out of scope of this document.

1.2.1.12 This guideline only considers issues directly related to level 3 tracksides.

1.2.1.13 It is not defined that only level 3 could be used to facilitate the functionality as described in this document. The ETCS functional differences between level 3 and level 2 are only related to an icon on the DMI. The choice could be made to use level 2 with the described functionality in this document if there are no operational differences for the driver.

1.3 Applicable system versions

1.3.1.1 Table 1 describes which trackside and on-board system versions are managed by this guideline.

	Trackside System Version	
On-board System Version	1.Y	2.Y
1.Y	To be defined	Not applicable
2.Y	To be defined	**This guideline**

Table 1: System version management

1.3.1.2 This guideline is applicable for a trackside where system version is 2.Y.

1.3.1.3 Trackside where system version is 1.Y is not analysed in this guideline.

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

– On-board systems supporting version 1.Y and 2.Y, with active system version 2.Y (this includes on-boards B3MR1, B3R2, B3R2+Art10SP[2])

1.4 Document structure

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

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

1.4.1.3 Chapter 3 provides considerations addressing strategy and process when dealing with a level 3 trackside project.

1.4.1.4 Chapter 4 provides the issues to be addressed for engineering of a level 3 trackside.

[2] In the publication of Art10-related technical opinions, ERA recommends implementing the CR solutions proposed in the technical opinion, only on B3R2 onboards, as a service pack. B3R2 + Art10 should be understood as an onboard fully compliant with the B3R2 specifications and the CR solutions published in the last version of the Art10-related technical option.

2 Definitions, Abbreviations and References

2.1 Definitions

2.1.1.1 According to [SS023], the level 3 is “a level of ERTMS/ETCS that uses radio to pass movement authorities to the train. Level 3 uses train reported position and integrity to determine if it is safe to issue the movement authority”. In a level 3 application the vehicle provides, partially or entirely, the track occupancy function.

2.1.1.2 The state of a track section can be

- “occupied”: the system detects that a train/wagon is present at the specific track section.
- “not occupied”: the system detects that no train/wagon is present at the specific track section.
- “unknown”: the system cannot determine with certainty that the specific track section is “occupied” or “not occupied”.

2.2 Abbreviations

2.2.1.1 TIM: train integrity monitoring (the function)

2.2.1.2 TIMS: train integrity monitoring system (the device)

2.2.1.3 LX: Level Crossing

2.3 References

The following documents and versions apply:

Ref. N°	Document Reference	Title	Version
[SS026]	SUBSET-026	System Requirements Specification	3.6.0 (B3 R2)
[SS023]	SUBSET-023	Glossary of Terms and Abbreviations	3.3.0
[SS113]	SUBSET-113	ETCS Hazard Log	1.3.0
[OPINION ERA 2020-2]	Opinion ERA-OPI-2020-2	OPINION ERA/OPI/2020-2 OF THE EUROPEAN UNION AGENCY FOR RAILWAYS for European Commission regarding CCS TSI Error Corrections	-
[Principles HL3]	16E042	Principles Hybrid ERTMS/ETCS Level 3	1D
[X2R D5.1]	X2R-T5.3-D-SIE-102-17	Deliverable D5.1 Moving Block System Specification	2.0
[X2R D5.2]	X2R-SC-OE-D-NRI-009-17	Deliverable D5.2 Moving Block Operational and Engineering Rules	3.0
[X2R D5.3]	X2R-WP05-D-SIE-012-14	Deliverable D5.3 Moving Block Preliminary Safety Analysis	2.0
[SoM GL]	19E045	START OF MISSION in Level 2/3, B3	1.0
[Gradient GL]	18E056	Gradient segmentation	2.0
[LX GL]	17E054	Handling of Level Crossings with Baseline 3	3-

2.4 Appendixes

The following Appendixes apply and are attached at the present document:

Ref. N°	Title
[A.1]	N.A.

3 General recommendations

3.1 Define the variant of level 3 trackside

3.1.1.1 The choice of level 3 can be driven by the need to improve traffic capacity and/or to reduce trackside signalling costs including installation, operation, maintenance and possible simplification concerning changes of the trackside layout during rail life cycle.

3.1.1.2 When level 3 is to be implemented, the project should choose the best applicable variant for each situation.

3.1.1.3 The choice of a level 3 variant could be based upon:

- Traffic capacity needs.
- Installation/operation/maintenance costs reduction needs (less trackside equipment).
- Performance impact for releasing movable devices based by using safe rear end information of the train (e.g. delay opening a level crossing).
- Operating traffic with or without TIM onboard.
- Impact on operational rules.
- Impact on existing devices (e.g. Interlocking, TMS, planning systems).
- Migration strategy.

3.1.1.4 The following characteristic is applicable for all variants

- Release of tracks based on safe rear end in nominal condition
- Localisation of trains using balises in normal situations

3.1.1.5 The following characteristics are typical for each variant

- Level 3 Moving Block, no trackside train detection
  - Continuous[3] release of tracks based on safe rear end
  - No trackside train detection to localise trains in degraded situations
  - All trains are to be equipped with a TIM unless train integrity confirmed by the driver shall be considered as acceptable
  - EoA possible[4] at any location

- Level 3 Moving Block, with trackside train detection
  - Continuous[3] release of tracks based on safe rear end

[3] In practice the release is periodically based on the system performance and cycle time position reports
[4] At some fixed defined locations, i.e. in rear of danger points / movable elements (point/ movable bridges), EoA are anyway required and at some location an EoA must be prevented (e.g. tunnels, bridges, LX)

  - Possibility to release track with use of trackside train detection (in addition to safe rear end)
  - Trackside train detection to localise trains in degraded situations
  - Trains not equipped with TIM can be operated, however with impact on traffic capacity since headway will be based on physical section release and moving block operation cannot be achieved anymore
  - EoA possible[4] at any location

- Level 3 Fixed Virtual Block, no trackside train detection
  - Sectional release of tracks based on virtual blocks
  - No trackside train detection to localise train in degraded situations
  - All trains are to be equipped with TIM unless train integrity confirmed by the driver shall be considered as acceptable
  - EoA at defined locations

- Level 3 Fixed Virtual Block, with trackside train detection
  - Sectional release of tracks based on virtual blocks
  - Possibility to release track with use of trackside train detection (in addition to safe rear end)
  - Trackside train detection to localise trains in degraded situations
  - Trains not equipped with TIM can be operated, however with impact on traffic capacity since headway will be based on physical section release
  - EoA at defined locations

3.1.2 Advantages and disadvantages

3.1.2.1 When choosing level 3 for a trackside project, the specific variant must be considered. These variants can be distinguished in two ways considering the type of block (moving or fixed) and the presence/absence of trackside train detection systems.

3.1.2.2 Moving block has the following advantages:

- Full traffic capacity improvement can be achieved without the need to configure a big number of blocks (less trackside engineering is needed to engineer blocks).
- Flexibility in the track layout changes with cost reduction along the life cycle

3.1.2.3 Moving block has the following disadvantages:

- Most current Traffic Management Systems (TMS) and trackside systems are not prepared for moving block.

- Handling of operational rules has to be changed (marker boards position has to be identified or use of different devices such as hand terminals with specific application have to be introduced to inform the driver about train location)

3.1.2.4 Fixed virtual block has the following advantages:

- Adaptation should have less impact on most current TMS and trackside systems
- Short virtual blocks could be almost comparable with moving block in terms of traffic capacity achievement (a comparison between delays due to the update frequency of position reports against trackside train detection system reaction has to be performed also considering the consecutive update of the MA and the safety margin).
- For degraded situations stopping locations have a lineside reference to fulfil operational needs (less impact on existing operational rules)

3.1.2.5 Fixed virtual block has the following disadvantages

- In order to achieve high capacity, short fixed virtual blocks need to be configured (see 3.1.2.11) and this could lead to frustrate the advantage of a limited impact on the TMS and trackside systems.
- More trackside engineering is needed to engineer blocks (for moving block no blocks are needed to be engineered). However, automatic configuration tooling could support simple engineering.

3.1.2.6 The use of additional trackside train detection should be based on:

- The amount of trains without TIM.
- Possible safety risk mitigation cost reduction by making use of consolidate technology according to rail traffic conditions and achieving acceptable time and complexity when handling degraded situations (e.g. to consider movable elements such as points or LX free from train).
- Migration strategy.

3.1.2.7 Not using a trackside train detection system has the following advantages:

- No trackside equipment to be installed; lower implementation costs.
- Less maintenance required and fewer points of failure.

3.1.2.8 Not using a trackside train detection system has the following disadvantages:

- All trains need to be equipped with a TIM.
- Releasing of movable elements and opening level crossings could be less predictive (in time and distance due to safety margins, timing/delays and odometer confidence performance) compared to releasing/opening on trackside train detection, with consequences on traffic management performances mainly if train is at standstill.
- When a TIM fails, possibly larger operational impact in case of high traffic track.

- When communication with train fails, possibly larger operational impact in case of high traffic track.
- System recovery from an RBC shut down could lead to large operational impact in case multiple trains are on the route and in station areas.
- Trains without active communication both in nominal or degraded scenarios (e.g. in SH mode, after EoM, due to on-board system failure or maintenance trains not equipped by ETCS) cannot be moved safely without additional measures.
- Standstill of trains/coaches must be guaranteed, or large areas must be blocked for other trains for an acceptable safety level.

3.1.2.9 Using a trackside train detection system has the following advantages:

- Trains without TIM/failing TIM could continue to operate despite the impact on operational capacity.
- Operational impact in case of TIM failure is limited to the TTD section where the train is located.
- Operational impact in case of communication failure is limited to the TTD section where the train is located.
- Operational impact in case of System recovery from an RBC shut down is limited.
- Faster release of movable elements and opening of level crossings.
- Less impact on operational mitigations to be put in place in order to achieve the needed level of safety for the closing LX or moving points in degraded scenarios.
- Limited operation impact in case of odometer malfunction (large confidence interval).

3.1.2.10 Using a trackside train detection system has the following disadvantages.

- Trackside equipment to be installed and maintained
- Operational consequences on traffic in case of failures of the trackside train detection.

3.1.2.11 The real difference in traffic capacity between moving block and fixed block is dependent on various aspects and could be less than expected at first sight. E.g. a position report cycle time of 5 seconds and a speed of 160 km/h for moving block gives a possible update frequency comparable with 225 m block length when using fixed blocks, see Figure 1 for a comparison with different speeds and update frequencies. This example has not to be considered as a detailed capacity analysis because it does not include the impact of dynamic follow up of trains (e.g. approach to speed restrictions).

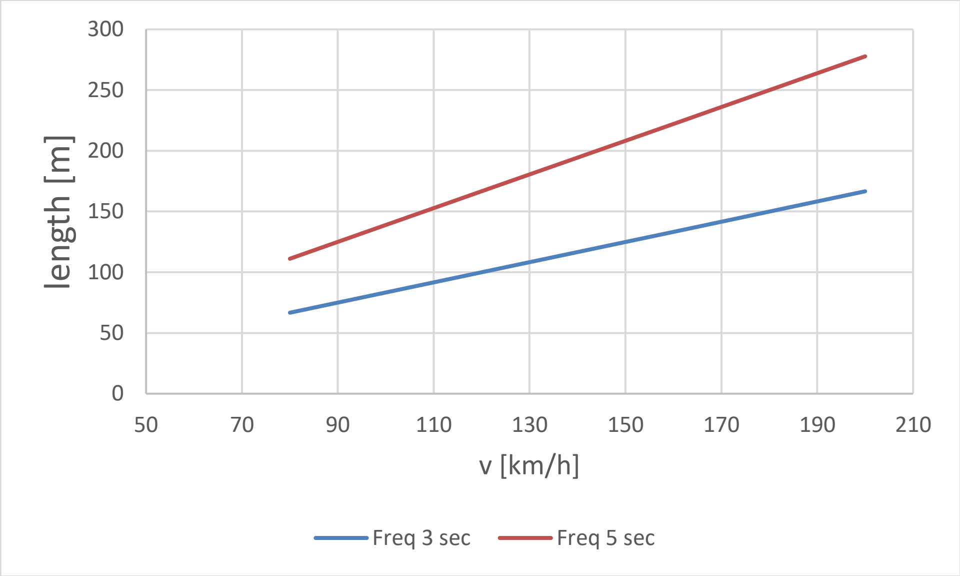

Figure 1: Fixed block length versus update frequency

3.1.3 Recommendation for Implementing L3

3.1.3.1 Based on project needs the following recommendations could be made.

3.1.3.2 If the main reason for implementing level 3 is to reduce costs and the possible impact on operation in case of degraded scenarios can be considered as acceptable (for instance due to low traffic application), no or less trackside train detection should be used. The use of trackside train detection should be dependent on whether there are still trains running that are not equipped with a TIM, the need to fast detect that a train has passed a certain location for example a point or level crossing, the need for fall back operation in degraded situations and system restart. Also, the need for shunting movements or the support of not-connected/non-ERTMS trains must be considered.

3.1.3.3 If the main reason for implementing level 3 is to gain traffic capacity, small virtual blocks or moving block should be used.

3.1.3.4 When using a trackside train detection system, the number and length of track sections should be investigated. A trade-off between traffic capacity for trains without TIM, handling of degraded situations and amount of trackside equipment should be made.

3.1.3.5 When refitting a current track, keeping the present track detection system could be considered. Virtual sections could then be added to increase traffic capacity. It could also be considered to only use trackside train detection system on locations where operational benefits are to be expected.

3.1.3.6 When the trackside train detection system is renewed, train detection systems around points and level crossing may be selected to remain. At these locations power and communication is still present and easier to maintain.

3.1.3.7 At level 3 boundaries and at movable trackside elements the need for trackside train detection should be investigated.

3.2 Migration strategies

3.2.1.1 When defining a migration strategy, impact on existing blocks marker boards and both TMS and the safety system, e.g. interlocking system and RBC and its underlying trackside systems, e.g. trackside train detection are to be considered.

3.2.1.2 The migration strategy depends on the planned level 3 variant and the current implementation, e.g. non-ETCS trackside or level 2. When for example the goal is to keep trackside train detection equipment, level 3 could be deployed over the existing trackside train detection equipment.

3.2.1.3 When migrating from level 3 which also allows normal operation of trains without TIM to a variant which does not allow normal operation of trains without TIM, all the relevant fleet must be fitted with TIM before commissioning.

3.3 Train integrity module

3.3.1 Safety

3.3.1.1 There are currently no harmonised safety requirements and there is a possibility that different countries could define different Safety Integrity Levels (SIL) for their TIM. Each trackside project must assume a safety level of the TIM until a harmonised requirement is defined (see also CR1304).

3.3.1.2 From a safety perspective the frequency of TIM report to ETCS on-board is not relevant provided that the trackside does not move the rear end of the proceeding train until train integrity is confirmed.

3.3.1.3 Level 3 application requires a higher safety level of the train length information than for level 2 or 1, because in general a level 3 application will less rely on trackside train detection and more on the onboard localisation information, especially to release track sections after passing for another train’s movement. A driver input of the train length does not fulfil this higher safety level, although this could be acceptable in level 2 and 1 for braking curve calculation and train length delay at speed increase.

3.3.1.4 A higher safety level could be reached by

- Train data provided automatically and safely by a Digital Automatic Coupling (DAC).
- Train data provided automatically and safely from trainset itself while it cannot be coupled with additional wagons or trainsets.
- RBC using information from the trackside train detection system to estimate a safe train length.

3.3.2 Performance

3.3.2.1 The performance requirements on TIM (frequency of reports to ETCS on-board) is not standardised. Therefore, project specific requirement should be settled.

3.3.2.2 The frequency of TIM report to ETCS on-board should be defined considering traffic capacity and other operational situations that are reliant on train position reports e.g. re-opening of LXs.

3.3.2.3 The frequency of TIM report to ETCS on-board shall be higher than the position report frequency to avoid performance degradation (see also CR940).

3.3.2.4 A TIM report to ETCS on-board is not possible before the SoM position report is sent. A SoM position report is sent before train data is validated.

3.4 Change requests relevant for L3 applications

3.4.1.1 The solution to CR940 (Minimum Safe Rear End position and position reporting ambiguities), as included in [OPINION ERA 2020-2], provides the following:

- A clear, concise and harmonised definition of the meaning and calculation of safe train length information reported by the on-board (L_TRAININT in packet 0 and 1). This minimises the risk of trackside implementations incorrectly assuming that safe train length information from different on-board implementations has the same meaning which could lead to an incorrect identification of the location of the danger point on a level 3 railway.
- Clarification on the conditions that result in a change in on-board train integrity state and the reporting of it by the on-board (Q_LENGTH in packet 0 and 1). Train integrity state can now be reported in any level, not just in level 3 which supports the reporting of integrity information following a transition from level 3 to another level and ensures the trackside can correctly confirm that a train has left the level 3 area and was integer when it did so. Also, the on-board can only report Train Integrity confirmed if the RBC has acknowledged receipt of train data – this addresses hazard H0086 that could result from splitting trains.
- Changes to requirements around the termination of communication sessions following a level transition or RBC/RBC handover to avoid situations where trains previously operating in level 3 terminate their communication sessions before that trackside can confirm that a train has left the RBC control area and was integer when it did so.
- Introduction of requirements for the juridical recording of Train Integrity status information – previously only driver confirmation of train integrity was recorded.
- Clarification on the behaviour when the safe train length cannot refer to the estimated front end due to only passing unlinked balise groups.

3.4.1.2 CR1304 (Missing Level 3 safety requirements), mentioned in Annex 1 of [OPINION ERA 2020-2] clarifies the missing level 3 safety requirements. However, no solution nor mitigation is provided.

3.4.1.3 CR1340 (Maximum D_LRBG exceeded), as included in [OPINION ERA 2020-2], clarifies among other things the problem with overflow of the safe train length parameter. The impact of this CR1340 on safe train length is only theoretical.

3.4.1.4 CR1342 (Unpractical coexistence between level 2 and level 3) mentioned in Annex 1 of [OPINION ERA 2020-2] clarifies unpractical coexistence between level 2 and level 3. However, no solution nor mitigation is provided.

3.4.1.5 CR1353 (Undefined term "the level is configured on-board"), as included in [OPINION ERA 2020-2], clarifies the undefined term "the level is configured on-board". For on-boards with this CR it is clarified that level 3 is available for use independently whether or not a TIM is available. A mitigation for on-boards without this CR is provided, being that the trackside should send a level transition order with only level 3 including an MA if an on-board in LNTC needs to perform the transition on a combined L3+LNTC track with level 3 supported for trains without TIM.

3.4.1.6 CR1350 (Always connected, always reporting) aims to minimise the condition when an on-board is disconnected from an RBC. Discussion on the solution is still ongoing.

3.4.1.7 CR1367 (Cab anywhere supervision) aims to enhance the protection of shunting movements under ERTMS and together with CR1350 can provide a significant improvement for the management of shunting movements in a level 3 area without trackside train detection systems. Discussion on the solution is still ongoing.

3.4.1.8 CR0149 (TIMS data missing) aims to clarify possible still missing information relevant for interoperability coming from TIM. Discussion on the need for a solution (in addition to what is still provided by CR940) is still ongoing.

3.4.1.9 CR1378 (CMD mandatory) aims to introduce as mandatory the CMD on-board. This could bring benefit to manage the SoM in any ETCS level however it could result to be particularly beneficial in a level 3 area without trackside train detection systems. Discussion on the approval is still ongoing.

3.4.1.10 CR1363 (Standstill report to trackside) clarifies when a position report has to be considered at standstill. This could bring benefit in any ETCS level however it could result to be particularly beneficial in a level 3 area without trackside train detection systems. Discussion on the solution is still ongoing.

3.4.1.11 CR1368 (enhanced onboard localisation) and CR1389 (Reaction when confidence interval of the odometry is exceeding the accuracy requirement of 5m+5%), aim to improve the localisation accuracy in order to keep short the train confidence interval and to manage the scenarios where the vehicle is not able to fulfil the accuracy target. Discussion on the solution is still ongoing.

4 Considerations

4.1.1.1 This chapter lists considerations that need to be considered for engineering a level 3 trackside.

4.1.1.2 Considerations are applicable to all variants of level 3 trackside.

4.1.1.3 Initially generic considerations are described followed by concerns which apply merely to specific variants. However, it is advised to check all provisions as some could be also valid, in specific cases, for a different variant.

4.2 General considerations

4.2.1 Risk of uncertain location of train

4.2.1.1 There are several reasons the on-board will not safely report its position and train length. This could be at SoM, before train data has been acknowledged by RBC due to loss of communication, loss of integrity or intended terminated communication, e.g. by closing the desk by the driver or when changing to mode SH.

4.2.1.2 The impact of not having the safe position of the whole train is that the system must assume the location of the train. This could be based on the last reported location, or by other means of localisation.

4.2.1.3 In some situations, the train may have been moving when the train location updates stopped. The system must then assume the movement of the train. For example, it could be assumed that the train is located between the last reported position and the end of its movement authority. Residual risks are that a train makes a SPAD, e.g. due to slippery tracks, performs a reverse movement or any other movement without connection to the RBC, e.g. in mode SH, IS, UN, SN.

4.2.1.4 When losing communication, in case M_NVCONTACT is not equal to “No reaction”, the train will be braked to standstill after the expiration of T_NVCONTACT and a maximum movement could be derived.

4.2.1.5 When the train was at a standstill, an assumption must be made whether the train moved or not after a certain time, with or without procedural allowance, e.g. rolling back/forward on hilly tracks.

4.2.1.6 The need for mitigations is project specific based on the acceptable risk level per situation.

4.2.1.7 A solution is to use the method of propagation. This means that based on some triggers, e.g. communication loss detected and a certain time, the system assumes that the train location is enlarged forward and/or backward.

4.2.1.8 When using propagation, the following timers could be used:

- Mute timer: timer to detect the loss of communication at the trackside.
- Wait integrity timer: timer to detect abnormal time between integrity reports
- Disconnect propagation timer: timer to start propagation after train is disconnected
- Integrity loss propagation timer: timer to start propagation after train lost integrity.

4.2.1.9 The timers are detailed in chapter 4.7.

4.2.1.10 Difference in risks per situation/location could lead to different behaviour for forward and backward propagation.

4.2.1.11 When propagation occurs, it is possible that trackside elements, e.g. points, level crossing, become virtual occupied. This could lead to unexpected behaviour, like closing a level crossing.

4.2.1.12 When using trackside train detection, propagation could be stopped by engineering detection sections around these trackside elements. This only stops propagation issues if these sections are actually free.

4.2.1.13 When using a trackside train detection system which could monitor the passage of a certain location, e.g. axle counter head passage, this could also be used to stop propagation.

4.2.1.14 Alternative mitigation can be provided by a potential on-board solution impeding the train to move when not connected to trackside, unless coupled with a rescue loco.

4.2.2 Transitions from a level 3 area

4.2.2.1 In case the release of tracks is based on position report information, it must be guaranteed that the connection with the RBC is kept until the train reports that the whole train has passed the last moving/virtual block section when leaving a level 3 area so that the block section can be released. This could require additional radio coverage or could be solved by using trackside train detection in the last block section. The slightly different behaviour at level transitions (e.g. from level 3 to level NTC) and RBC transitions (e.g. from level 3 to level 2) should be considered.

4.2.3 Transitions to a level 3 area

4.2.3.1 Negative impact of propagation towards systems with lineside luminous signals or where route shortening is not allowed should be avoided, e.g. it could be prevented that signals aspects become unnecessarily more restrictive by making use of a specific relationship between L3 system and the legacy system.

4.2.3.2 If the level 3 trackside only supports trains with TIM under normal conditions, the entering of trains without a working TIM should be prevented to avoid operational issues. It could be also the case with misrouted trains without TIM.

4.2.3.3 If the level 3 trackside only supports trains with a radio connection under normal conditions, e.g. no overlay with level 1, level 0 or level NTC, the entering of trains without a radio connection should be prevented by making use of a specific relationship between L3 system and the other system.

4.2.3.4 Additional requirements for the first/last block of the level 3 area would mitigate the abovementioned issues, .g. by using trackside train detection in the first/last block these issues can be prevented.

4.2.3.5 There should be special attention to the risks of entering trains without ETCS on-board and trains with ETCS on-board not providing TIM . The prevention of the entrance of these trains without communication session or without TIM on a level 3 trackside without trackside train detection system require additional measures.

4.2.3.6 Note: independently on TIM, it should not be assumed that all on-boards support level 3 even if they support level 2 due to products implementation which deviates from the ERTMS specification (e.g. switch to SF when the level 3 transition order is received from trackside).

4.2.3.7 For example, it is possible to get information from the detection system adjacent to an L3 area to detect a forbidden movement into the level 3 area (e.g. level 3 RBC cross checks if an occupancy sequence of adjacent track circuits matches with an radio connected entering train; in case of mismatch, level 3 RBC provides an alert to the signaller; additional mitigations can be also put in place such as MA shortening to possible level 3 trains approaching the exit of the level 3 area).

4.2.3.8 It is possible for the level 3 RBC to check if a connected train approaching a level 3 area has the train integrity function available. In case the use of the train integrity function is not ensured, mitigations could be implemented in order not to significantly disrupt operation. On a level 3 trackside with a trackside train detection system an acceptable level of performance could be still possible.

4.2.4 Transition between different variants of level 3

4.2.4.1 The entrance of unsuitable trains, e.g. train without TIM coming from a trackside with virtual fixed blocks and trackside train detection, should be prevented based on the applicable variant (chapter 4.2.3 provides provisions valid in this case as well).

4.2.5 Safety margins in train position

4.2.5.1 The whole train position, i.e. train front end and train rear end, is reported safely when using TIM. Without TIM only the train front end is reported safely.

4.2.5.2 When TIM information is used to separate trains, a margin could be needed to prevent a collision with a chased train when a chasing train suffers brake performance issues or to have a minimum separation distance for operational reasons.

4.2.5.3 The limited roll away distance, defined in D_NVROLL, should be considered. Limiting the allowed rolling distance lowers the chance of rolling into a neighbouring section and thus influence the chance to trigger propagation.

4.2.5.4 Additional (safety) margins could be based on the confidence interval, keeping the confidence interval low will limit the needed margins and no additional margin is needed.

4.2.5.5 The required margin could be applicable for the train front end and/or for the train rear end.

4.2.5.6 Using a safety margin at the train front end could lead to passing a location only virtually while the physical location is not passed. This is especially relevant at an EoA location where the track in advance of the EoA could be used by other train. A trackside train detection border could be used to reduce the uncertainty in the virtual train position.

4.2.5.7 Using a safety margin at the train rear end could lead to undesired track occupation while the track is physically free. A trackside train detection border could reduce the uncertainty in the virtual train position.

4.2.5.8 When using a trackside train detection border, it should be considered that the first/last axle counter location does not coincide with train front/rear end and the overhanging part is not detected.

4.2.5.9 The margin could be added to the train rear end of the chased train (see Figure 2 margin A) as the chasing train itself does not have information whether it is chasing another train or not. This avoids the risk of virtually passing an EoA i.e. max safe front end passes EoA and the real front does not pass the EoA.

4.2.5.10 The margin at the rear end could also be solved by replacing the EoA and SvL of the chasing train (see Figure 2 margin B). This prevents undesired track occupation for all trains. Another solution is to only replace the EoA location and keeping the SvL at chased rear end (see Figure 2 C).

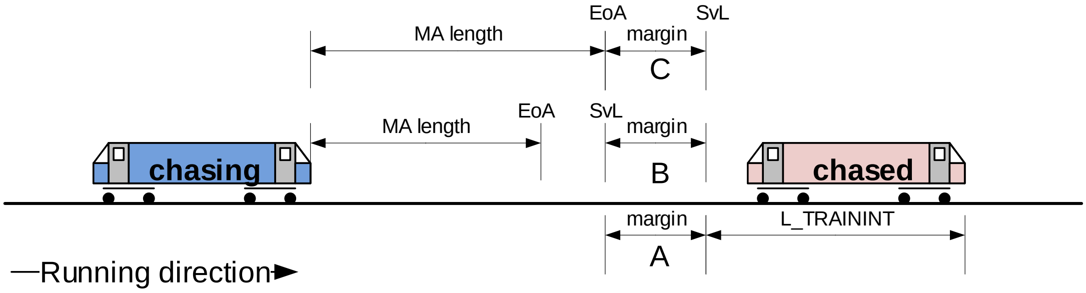

Figure 2: margins for train position

4.2.5.11 It is recommended to restrict the MA of the chasing train and not add any margin to the safety envelop of the train as this would lead to undesired track occupation.

4.2.5.12 The required safety margin is project specific. The IM could balance between the mentioned options based on capacity needs, costs of trackside train detection and required safety level.

4.2.6 Limit size confidence interval

4.2.6.1 The confidence interval influences the safety envelop of the train. This has impact on size of the moving blocks and the occupation of virtual subsections. This is mainly an issue if traffic capacity is critical.

4.2.6.2 Limiting the growth of the confidence interval is possible by adding linked balise groups at certain locations or every certain distance.

4.2.6.3 Also, defining a low value of Q_LOCACC together with accurate positioning of balise groups limits the size of the confidence interval.

4.2.7 Position report cycle time

4.2.7.1 The update frequency of the train rear end is not only related to the position report cycle time but also related to TIM update frequency.

4.2.7.2 Releasing the infrastructure quickly when passed, e.g. release of fixed virtual or moving blocks, will increase traffic capacity.

4.2.7.3 Note that loss of integrity itself generates a position report.

4.2.8 Gradients segmentation

4.2.8.1 In the gradients segmentation method as described in guideline Gradients Segmentation [Gradient GL] the supervised locations (SvL) are considered. As level 3 could have (far) more SvL the gradient segmentation method could be reconsidered. Moving block even will, in most cases, have no fixed SvL location. Therefore, the method described within guideline Gradients Segmentation is not suitable for level 3 moving block.

4.2.9 Speed profiles

4.2.9.1 It is assumed that there is no specific engineering needed for speed profiles compared to other ETCS levels.

4.2.10 Mode profiles

4.2.10.1 It is assumed that there is no specific engineering needed for mode profiles compared to other ETCS levels.

4.2.10.2 However, for the transition to mode SH it must be considered that the connection will be terminated when the on-board switches to mode SH. See also 4.2.12.3.

4.2.11 Impact of change requests (see 3.4) on Trackside

4.2.11.1 The on-board requirement in CR940 defines that an on-board leaving a level 3 track will not request to terminate the connection when the train rear passes the border. The CR940 defines that the trackside system is responsible in this case to terminate the connection. The trackside system should be able, after a train has left its area, to release all level 3 sections before the connection is terminated.

4.2.11.2 CR1340 clarifies the out of range handling of L_TRAININT. Although this is a theoretical issue, the trackside system could take provisions to handle not realistic train lengths.

4.2.12 Engineering issues to handle operational procedures

4.2.12.1 Start of Mission

4.2.12.1.1 Determining the departing train location could be equal as under a level 2 system (e.g. cold movement detector, passing balise group). When the train is communicating and has a valid position this could be handled safely (see Guideline SoM [SoM GL]).

4.2.12.1.2 In the situation where a train has no valid position, the train normally must move to get a position. Without trackside train detection there is a risk that the train is at another location than expected. For this movement in mode SR additional measures could be taken, e.g. use of a list of expected balises allowing SR authority to mitigate partly the risk of moving in a wrong location and use of a dedicated route for movements in SR mode which reserve a part of the track and will only be released if assured that the train has left this track.

4.2.12.1.3 The risk of movements in SR mode without a communication session should be considered.

4.2.12.1.4 Another issue is to assure there is no other, non-communicating, train at the departure track. This could be a challenge without trackside train detection and, despite using trackside train detection, another train could be in the same section. The use of dedicated tracks for Start of Mission could be considered, where additional measures could be taken, e.g. the use of trackside train detection or other methods to support safe departure (see also 4.2.12.2).

4.2.12.1.5 In case it is appropriate to prevent a train without available train integrity information to start its mission, the trackside system could check if TIM reported integrity confirmed information in the position report to only allow movements if train is known and integer. The trackside system could also only move the known rear end when the train confirms integrity, a not integer train will lead to performance issues.

4.2.12.2 End of Mission

4.2.12.2.1 After performing an End of Mission (e.g. closing CAB and/or switch off power) the train will be disconnected and not reporting its location. Without trackside train detection another method is needed to know the train location.

4.2.12.2.2 If propagation after disconnecting is implemented, an End of Mission can result in propagation. Undesired effects on operation may result from (unlimited) propagation . This could be prevented with trackside train detection at locations where an End of Mission is likely to occur.

4.2.12.2.3 After an End of Mission, standstill is controlled (e.g. by standstill supervision in mode SB or by commanded emergency brake in mode NP). However, if there are slopes, rolling could occur after some time. The standstill supervision in mode SB still allows movement of a certain distance based on the National Value D_NVROLL and also the braking distance should be considered. A margin on the train location after End of Mission could be to solve these issues as alternative for propagation.

4.2.12.2.4 Dedicated tracks for End of Mission could be considered, where additional measures could be taken, e.g. the use of trackside train detection or other methods to support safe localisation of a disconnected train. Also, physical boundaries like deflecting point could be considered (see also 4.5.2.4 when no trackside train detection systems are used).

4.2.12.3 Management of shunting movements

4.2.12.3.1 In areas like depots, permanent shunting areas and temporary shunting areas trains will possibly move in mode SH. When entering such an area the on-board needs to switch to mode SH just before or at the area border, while the rear end is still in a controlled area. When switching to mode SH, the train will be directly disconnected and no longer reporting its location. Trackside train detection system is needed at the exit of level 3 controlled area to safely release the trackside in rear of the train.

4.2.12.3.2 When leaving the above-mentioned area, the train normally will leave mode SH and reconnect to the RBC. However, when leaving these areas in an unplanned manner in mode SH, the movement is not reported and without trackside train detection, not detected.

4.2.12.3.3 Physical boundaries could be also considered to prevent a train leaving these areas not connected to the RBC.

4.2.12.3.4 For a temporary shunting area in a L3 area without trackside train detection systems, SH should be authorised by the RBC only if the shunting area has been set. The shunting area should be released only when all trains in mode SH have left SH and connected again to the RBC.

4.2.12.3.5 Note: possible track within the former shunting area where coaches may have been left, should be put out of service through operational procedure (similarly as it can happen for coaches which do not occupy track circuits).

4.2.12.3.6 When the temporary shunting area of a station is released, additional mitigation can be put in place such as the use of OS mode for the first train (sweeping train).

4.2.12.3.7 Another mitigation is to not allow the use of mode SH in level 3 areas without trackside train detection.

4.2.12.4 Splitting/joining

4.2.12.4.1 When splitting, the former train consist is not integer anymore and this will be reported to the trackside system as a train data change, directly at the moment of splitting or when performing new start of mission. With all new train consists, e.g. 2 leading engines or 1 leading engine and wagons, it must be assured that no engine or wagons are left undetected when leaving the track with 1 leading engine (e.g. former total train length can be stored and used by RBC for checking).

4.2.12.4.2 Dedicated tracks for splitting and joining could be considered where additional measures could be taken, e.g. the use of trackside train detection or other methods to support assurance of free track.

4.2.12.5 Working areas or trains not equipped with ERTMS

4.2.12.5.1 Trains and other track vehicles may not be communicating with the trackside system, possibly some vehicles will not have an ERTMS on-board. Forward and backwards movements will be common and will not be in mode OS and FS.

4.2.12.5.2 TIM functionality for the yellow fleet could be a challenge because standardised solutions are often not possible.

4.2.12.6 Operational procedures (e.g. interruption of operation) shall be put in place every time a vehicle not equipped with ERTMS needs to be run over a level 3 trackside. This is more complex if no mitigations against not-connected trains or non-integer trains are implemented.

4.2.12.7 Traffic management information

4.2.12.7.1 When engineering a level 3 trackside it must be considered which information is needed for the signaller to handle normal operational procedures.

4.2.12.7.2 As mentioned in some situations the train location will not be reported by the train. For these situations the signaller could need additional information of train locations to allow train movements.

4.2.13 Engineering issues to handle degraded situations

4.2.13.1.1 To handle degraded situations, information from trackside train detection system can be used or, alternatively, a different onboard train localisation system can be used provided that train localisation and safe length information can be sent to trackside.

4.2.13.2 Traffic management

4.2.13.2.1 In degraded situations the driver needs to have the possibility to orientate the train location to be able to communicate safely with the signaller and perform specific operational procedures on the location. When no fixed blocks are used, impact on operational rules could be higher. Lineside markers or other orientation methods, e.g. GPS based systems, could be used.

4.2.13.2.2 The need for harmonised operational rules is essential, because in degraded situations level 3 relies more on operational procedures to prevent trains entering occupied tracks. This is applicable for variants without any trackside train detection or for all variants where it is allowed under normal conditions to have multiple trains in the same trackside train detection section.

4.2.13.3 In case the system does not known the position of the whole train, e.g. when the communication is lost, also the traffic management system has invalid train position information if no other train detection system is available. Based on this invalid train position information a signaller could give erroneous procedural authorisations to this or other trains.

4.2.13.4 Loss of radio connection

4.2.13.4.1 There are 2 situations to distinguish. No radio connection at Start of Mission and loss of radio connection during the mission. When the connection does return, the level 3 system should be able to restore to a normal situation.

4.2.13.4.2 While the connection is lost during the mission, the trackside cannot be freed from the last reported position up to the supervised location. At busy locations this could have a large impact on the capacity of other trains.

4.2.13.5 Lack of radio coverage

4.2.13.5.1 For locations without radio coverage the radio hole functionality could be used. When entering and leaving such an area measures should be taken to release tracks behind the train, e.g. trackside train detection.

4.2.13.6 Radio holes should not include devices such as level crossings or switches otherwise additional mitigations must be put in place (e.g. use of trackside train detection systems).

4.2.13.7 Loss of train integrity

4.2.13.7.1 The loss of train integrity, besides splitting, is a degraded situation. The handling depends on the level 3 variant. Especially without any trackside train detection the location and movement of the left train part cannot be detected.

4.2.13.8 Level 3 system restart after shutdown

4.2.13.8.1 Different restarting strategies should be put in place according to the time of the shut down and information available.

4.2.13.8.2 In case the level 3 trackside system performs a restart, the system must assume a safe state of the trackside, i.e. “unknown”. Methods are needed to resume to a known state. Trains that are reporting their position could be used, but non-communicating trains could still exist. In these cases, all the track should be swept by integer communicating trains to resume safely or alternative solutions have to be put in place (e.g. see 4.2.1.14).

4.2.13.8.3 If trackside train detection is not available, other train localisation methods must be defined, e.g. store on RBC non-volatile memory the status of track sections, trains modes, MAs and SR authorised distance, or use (in addition) procedural information from train drivers, or the risk of non-detected trains could be accepted by specific projects. Note that after some time information may not be valid anymore.

4.2.13.9 Sweeping

4.2.13.9.1 Performing sweeping in mode OS has the benefit that the driver is aware of possible track occupation and the system could authorise only specific track parts. Another option could be mode SR, but communication is required.

4.2.13.10 Short sections, i.e. shorter than the minimum train length used on the network, could be assumed known clear if both surrounding section area are also clear.

4.2.14 Combination with Automatic Train Operation (ATO)

4.2.14.1 No specific issues are known.

4.3 Considerations for level 3 variants using Moving Block

4.3.1 Route setting/MA issuing

4.3.1.1 With moving block there are no fixed blocks in the system and thus can have a higher impact on the commonly used block-based route setting. Therefore, special arrangements are required to handle certain situations.

4.3.1.2 Stopping of trains at an undesirable location, e.g. non-stopping area, point section, level crossing, shall be prevented. It could be permanently prevented that an EoA is at an undesirable location by excluding any EoA at this location.

4.3.1.3 Another option is that an EoA is only prevented when the chased train has insufficient authorisation to release the track in advance of the undesirable stopping location, requiring the chasing train to stop at this undesirable location. Assuming trains move to the end of their authorisations.

4.3.1.4 A solution could be to use a functionality to exclude an EoA at certain locations and/or under certain conditions. This creates areas with usage conditions or stopping constraints. The impact on traffic capacity should be checked due the change from moving to pseudo fixed block then back again to moving block.

4.3.1.5 A minimum extension length of MA should be considered to prevent short and many sequential updates. E.g. based on a minimum time or a minimum length between updates.

4.3.1.6 Running towards a track part, where there is another train, is not an issue when that other train’s position is safely known, e.g. communicating its safe position. In fact, this could be done in mode FS (depending how close the train needs to approach and the confidence interval, OS may be also needed) till the occupied track part.

4.3.2 Approaching end of moving block/EoA

4.3.2.1 Normally when running in release speed the driver uses marked locations to orientate the EoA. When using moving block and the EoA is the rear end of another train, there are no fixed marked locations possible and the use of release speed is not recommended.

4.3.2.2 The SvL is normally located at/in rear of the physical danger point and the EoA at the marked end of route. The distance between SvL and EoA improves the driveability while approaching the EoA. When using moving block these locations should be reconsidered as the SvL and EoA are moving continuously until, the chased train stops, a switchable track element, e.g. point, needs to be moved or when the track itself ends. If the chasing train must approach the EoA in order to clear the track behind the chasing train, the driveability should be considered. See also 4.2.5 about margins.

4.3.2.3 When using fixed EoA location, e.g. at points, the issues mentioned in paragraph 4.4 could also be applicable.

4.3.3 Position report cycle time/MA extension frequency

4.3.3.1 The update frequency of track release and thus MA extension should be considered in relation to the typical update frequency of TIM. The on-board will report no integrity available between integrity confirmed reports if the TIM report frequency is less than the position report frequency.

4.3.3.2 The MA extension frequency should also be based on human factors, the driver should not be distracted by continuous MA updates, e.g. Sinfo sound when in TSM or continuous updates of the planning area in CSM and TSM. Also, the expectation of MA updates should not lead to unsafe driver behaviour, e.g. not braking when indicated.

4.3.4 Management of points

4.3.4.1 The release of point is affected by position report cycle time and TIM update frequency. Points should only be moved when not occupied. Non-communicating trains should be considered.

4.3.4.2 When using trackside train detection to release/move points an issue could be that the train still reports occupying the point when the trackside train detection already reported a cleared point or vice-versa. This could lead to additional delay if trackside train detection is not used to clear the point regardless of the reported train position.

4.4 Considerations for level 3 variants using Fixed Virtual Block

4.4.1 Approaching end of fixed virtual block

4.4.1.1 Approaching the end of a fixed virtual block, i.e. EoA/SvL/release speed, could be the same as in level 2 if the EoA is marked. However, reporting the next virtual block at an EoA as occupied should be prevented. The HL3 principles recommend using the minimum safe front end at EoA to occupy the next virtual block instead of the maximum safe front end.

4.4.1.2 A dedicated virtual block in advance of the end of a section could be used as overlap.

4.4.1.3 As shown in Figure 3, another solution is to use two dedicated virtual blocks in advance of the end of a section as overlaps: if the shorter overlap is occupied by the tail of the chased train, the MA of the chasing train cannot be extended to the end of the section. In case the short overlap is free but the long one is occupied by the chased train the MA of the chasing train can be extended to the end of the section but without release speed. In case both the short and the long overlaps are free, the MA of the chasing train can be extended to the end of the section and a release speed can be calculated considering the long overlap.

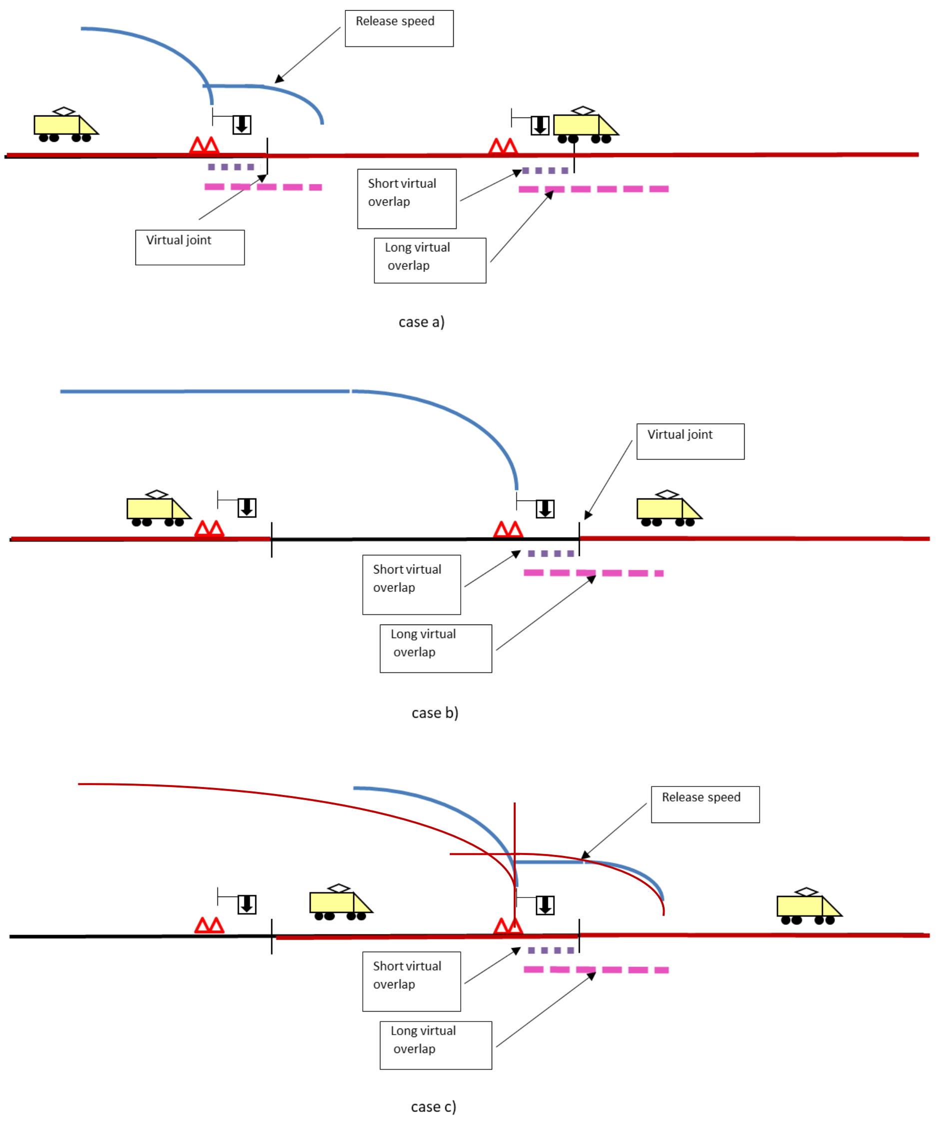

Figure 3:
Case a) chased train still occupies short virtual overlap
Case b) chased train still occupies long virtual overlap
Case c) chased train set short and log virtual overlap free

4.4.1.4 It should be considered that a chased train losing its integrity will keep this virtual overlap occupied and will hinder the approach of the EoA by the chasing train.

4.4.1.5 At all end of fixed virtual blocks where an EoA can exist, stop or location marker boards should be placed depending on the operational situation.

4.4.1.6 It is a question if the driver needs to distinguish an EoA at a virtual border or a trackside train detection border.

4.4.2 Number and length of sections

4.4.2.1 Theoretically an unlimited amount of fixed virtual blocks are possible, also very small blocks are possible. However, the number of blocks in the system could have impact of system performance. Small length could introduce additional risk and operational issues. Also, the method of sequential section release checking could be affected by very small blocks.

4.4.2.2 When using small blocks, acknowledgement windows, e.g. OS or SH, could overlap another block border. A special risk exists for the SH acknowledgement window, this could have already been acknowledged in the previous block meaning the radio connection is terminated.

4.4.2.3 When using small blocks with marker board, the release speed monitoring could start in rear of another block border and the driver could get confused which stop marker board is the EoA.

4.4.2.4 A maximum length of fixed virtual blocks should be considered based on possible operational impact of failures and possible sweeping issues.

4.5 Considerations for level 3 variants when not using trackside train detection

4.5.1 Availability

4.5.1.1 Without trackside train detection systems, the availability of ETCS and localization functions must be higher in order to make the impact on operation in case of degraded situations acceptable.

4.5.2 Detection train/wagon on track elements

4.5.2.1 Without trackside train detection, it is a problem to detect all trains/wagons on points to allow point movement only when not physically occupied.

4.5.2.2 It is possible to close safely a level crossing by means of position reports without integrity confirmed in case trains are running with MA, see Guideline Level Crossings [LX GL]. However, for degraded situations where no MA is issued or when trains are not communicating to the trackside, trackside train detection is required.

4.5.2.3 When using position reports with integrity confirmed for opening a level crossing this could be delayed due to position report inaccuracy and position report cycle time. For degraded situations, e.g. if integrity or communication is lost, the opening of a level crossing using another detection method should be investigated.

4.5.2.4 A generic issue is that trains could physically move after End of Mission (e.g. closing CAB and/or switch off power). This cannot be detected without trackside train detection unless a continuous active train localisation device is available. This risk should be investigated.

4.5.2.5 A possible solution, in addition to the use of a continuous active train localisation device, is that each piece of track could be configured to allow, or not to allow, train radio disconnection; EoM leading to train disconnection could be allowed only where there are deflecting points, and these are set and locked in a way to impede convergence with the main track.

4.6 Considerations for level 3 variants when using trackside train detection

4.6.1 Use of trackside train detection for safety

4.6.1.1 Some of the safety and operational issues mentioned in this document could be solved by using trackside train detection.

4.6.1.2 When choosing trackside train detection border locations and section lengths, the issues around sweeping should be considered.

4.6.1.3 The following locations are candidate to use trackside train detection:

- point sections
- level crossings
- movable bridges
- tunnels with safety systems
- border to non-level 3 areas
- border to uncontrolled areas
- temporary uncontrolled areas
- work areas

4.6.1.4 The type of detection method, e.g. spot detection like axle counters and continuous detection like track circuits, could lead to other procedures. For example, with a complete system reset occupations of non-communicating trains can only be set with a continuous detection method.

4.6.2 Use of trackside train detection for handling trains without TIM

4.6.2.1 When the handling of trains without TIM is needed, the following should be considered:

- number of trains without TIM compared to with TIM available
- traffic capacity needs
- trackside train detection that is already required for safety and operational issues

4.6.3 Use of trackside train detection for traffic capacity

4.6.3.1 The use of trackside train detection could reduce traffic capacity perturbation at some locations by a more predictable release of movable trackside elements, e.g. points.

4.6.3.2 The use of trackside train detection could increase traffic capacity in some situations as less operational procedures could be needed as the system could detect all trains. In the following situations trackside train detection could assist:

- Departure track, with joining, splitting, turn-back movements
- Long open track to limit propagation (if used)

4.6.4 Multiple sources to determine train location

4.6.4.1 When using trackside train detection and reported train position there are multiple sources of similar information for the train location. However, due to latency the information could be asynchronous at the same moment. This difference must be considered while using this information in operational procedures.

4.7 Defining the system timers

4.7.1.1 Each system timer is described with its purpose, recommended value (range) and how to limit the impact on the operational process.

4.7.2 Mute timer

4.7.2.1 A mute timer could be used at the trackside for each connected train to consider after a defined time that the communication with that train is lost, i.e. no new messages received from the train.

4.7.2.2 The system treats the track section of the last known train location as “unknown” and will assume that the train continues to move within its movement authority. All track sections within the movement authority which cannot be guaranteed free, e.g. by trackside train detection, will also be treated as “unknown”.

4.7.2.3 In case of termination of the communication session due to normal processes, e.g. when the train has stopped at its destination and performs an EoM or when entering mode SH, the mute timer is stopped and will not expire. However, the system will treat the track section of the last known train location as “unknown”. Nominally, no other track sections are part of the movement authority anymore and treated as “unknown”.

4.7.2.4 This timer enables an earlier system reaction than waiting for expiration of the communication session timer as defined in [SS026]. The mute timer should be shorter than the communication session timer and longer than the time needed for an on-board to recover from a temporary loss of connection. The latter could be related to the T_NVCONTACT value.

4.7.2.5 When using a route release timer based on among other things the value of T_NVCONTACT, the mute timer is indirectly related to the route release.

4.7.2.6 If the timer is too short the track sections in advance of the train will be treated as “unknown” while no risk of real occupation exists. As the movement authority has already been reserved, these track sections for train movement will have no direct performance impact. However, other related timers, e.g. the disconnect propagation timer, could start earlier.

4.7.2.7 If the timer is too long, it is possible that a train could move undetected (in rear of its (former) EOA) to other track sections. A possible scenario is that the route over these track sections is revoked and used for another train’s movement.

4.7.2.8 The use of trackside train detection could limit the operational impact.

4.7.2.9 Recommended is a value comparable to T_NVCONTACT.

4.7.3 Disconnect propagation timer

4.7.3.1 When propagation is used after disconnecting, a disconnect propagation timer could be used at the trackside for each track section for the train to consider after a defined time that an “unknown” track section should be propagated.

4.7.3.2 Also, in case of termination of the communication session due to normal processes, e.g. when the train has stopped at its destination and performs an EoM, the disconnection propagation timer is active.

4.7.3.3 The system should propagate the “unknown” track section, when there is a risk that a disconnected train moves undetected outside its movement authority or backwards, to other track sections which cannot be guaranteed free, e.g. by trackside train detection.

4.7.3.4 This risk depends on conditions of the track section, e.g. on hilly track section unintended movement could occur easier. After some time, the brakes will not guarantee standstill on certain gradients, e.g. approx. 30 minutes. The timer should be smaller than this.

4.7.3.5 The risk depends also on operational procedures, e.g. after which time could a procedural authorisation be given to the train driver to move. This could be location dependent, e.g. difference between stations and open track, or generic for all locations.

4.7.3.6 If the risks of unintended movement and of movements with procedural authorisation are acceptable, this timer could be omitted or set to infinity.

4.7.3.7 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

4.7.3.8 This timer could be used for an earlier system reaction than waiting for expiration of the communication session timer as defined in [SS026], however this is not required.

4.7.3.9 If the timer is too short, the track sections in advance of the movement authority and in rear of the train will be treated as “unknown” while no risk of real occupation exists. These track sections could be already reserved for other train movements and this will result in emergency revocation of movement authorities.

4.7.3.10 If the timer is too long, it is possible that a train moves undetected (in advance of its (former) EoA or backwards) to other track sections. The possibility of movements depends for example on the value of M_NVCONTACT (no reaction keeps the MA), when the driver uses the Override EoA procedure or closes/opens the desk and SR is prompted at SoM due lack of communication session. A possible scenario is that the train moves (forwards or backwards) to a track section which is reserved for another train’s movement.

4.7.3.11 The use of trackside train detection could limit the operational impact.

4.7.3.12 Recommended is a value in range of 5 to 15 minutes.

4.7.4 Wait integrity timer

4.7.4.1 A wait integrity timer could be used at the trackside for each connected train to consider after a defined time that the integrity of that train is lost when no integrity information is available, i.e. while receiving position reports received with “no train integrity information available”.

4.7.4.2 The system treats the track section where that train is as “unknown”.

4.7.4.3 Due the asynchronous reporting of integrity by the TIM and the position reporting frequency the on-board could report that no integrity information is available while the train is still integer. The wait integrity timer prevents an early system reaction.

4.7.4.4 The TIM reporting frequency is on-board dependent, but a worst-case time between reports could be agreed. The frequency should be in the range of the position report cycle time, T_CYCLOC. The wait integrity timer could be related to this frequency.

4.7.4.5 The wait integrity timer is not direct safety related. If “train integrity lost” is reported independently on the TIM reporting frequency, a longer timer could be used.

4.7.4.6 If the timer is too short, integer trains which report “no train integrity information available” due to a lower TIM frequency will be treated as integrity lost. Other related timers, e.g. the integrity loss propagation timer, could start earlier.

4.7.4.7 If the timer is too long, it is possible that a train loses its integrity without any system reaction.

4.7.4.8 Recommended is a value comparable to the position report cycle time.

4.7.5 Integrity loss propagation timer

4.7.5.1 When propagation is used after integrity loss, an integrity loss propagation timer could be used at the trackside for each track section train to consider after a defined time that an “unknown” track section should be propagated.

4.7.5.2 The system should propagate the “unknown” track section, when there is a risk that a non-integer train moves undetected backwards to other track sections which cannot be guaranteed free, e.g. by trackside train detection.

4.7.5.3 This risk depends on conditions of the track section, e.g. on hilly track section unintended movement could occur easier. After some time, the brakes will not guarantee standstill on certain gradients, e.g. approx. 30 minutes. The timer should be smaller than this.

4.7.5.4 The risk depends also on operational procedures, e.g. after which time could a train perform an unintended movement after splitting i.e. 5 to 15 minutes. This could be location dependent, e.g. difference between stations and open track, or generic for all locations.

4.7.5.5 A consequence of propagation is that the track section behind the train becomes unknown and can only be guaranteed free based on trackside train detection, if available, and/or sweeping which will lead to performance loss. To prevent the need for sweeping the timer could be such that the chance of entering that same section by another train is lowered. Especially for long track sections this is recommended as sweeping will take longer.

4.7.5.6 If the risks of unintended movement are acceptable, this timer could be omitted or set to infinity.

4.7.5.7 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

4.7.5.8 If the time is too short, the track sections in rear of the train will be treated as “unknown” while no risk of real occupation exists. These track sections could be already reserved for other train movements and this will result in emergency revocation of movement authorities.

4.7.5.9 If the timer is too long, it is possible that a train moves undetected to other track sections. A possible scenario is that the train moves to a track section which is reserved for another train's movement.

4.7.5.10 The use of trackside train detection could limit the operational impact.

4.7.5.11 Recommended is a value in range of 5 to 15 minutes.

4.7.6 Shadow timer using trackside train detection

4.7.6.1 When using train position reports to separate trains in a track section, it is possible that a not-connected train follows shortly after an integer train without being detected properly, i.e. a shadow train. This could happen for example after Start of Mission in case of erroneous overpassing of a signal at danger. Using trackside train detection this situation could be detected at trackside train detection borders, because when the connected train passed this border the previous track section stays occupied for some additional time.

4.7.6.2 However, due to asynchronous information from position reports and from the trackside train detection, there could in the normal situation already be a delay between the trackside train detection reporting the track section free and the position being reported that the section is clear of the train.

4.7.6.3 The delay depends at one side on the position report cycle time and possible position reports triggered by passing a balise group and at the other side on the delay in the trackside train detection system. This delay would be typically in the range of 0-10 seconds.

4.7.6.4 A shadow timer for every trackside train detection border for each direction could be used to prevent wrongful detection of shadow trains.

4.7.6.5 The shadow timer depends on the position report cycle time and could be shortened if a position report is triggered when passing the trackside train detection border.

4.7.6.6 If the risks of wrongful detection of shadow trains are acceptable, this timer could be omitted or set to infinity.

4.7.6.7 The risk could also be mitigated by a trackside train detection system that has information of passing a trackside train detection border and the number of axles of the involved trains, e.g. by comparing the number of passed axles or by using axle counter head information to detect an unintended movement.

4.7.6.8 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

4.7.6.9 If the timer is too short, the trackside must assume a shadow train and keep the track section occupied while there is no risk. A next train must sweep this section or the whole track section must be freed based on trackside train detection.

4.7.6.10 If the timer is too long, it is possible that a real shadow train is undetected. This could lead to the risk that, if the next track section is left by the integer train, the track section is wrongfully treated as free and another train could get an authorisation for this track section.

4.7.6.11 Recommended is a value in range of 5 to 10 seconds.

4.7.7 Ghost train propagation timer using trackside train detection

4.7.7.1 When using train position reports to detect trains in a track section, it is possible that a not-connected train unintendedly moves without being detected properly, i.e. a ghost train. This could happen for example after Start of Mission in case of erroneous overpassing of a signal at danger. Using trackside train detection this situation could be detected at track sections, because when the ghost train starts to occupy a free track for which no MA is given, this whole trackside train detection section can be treated as “unknown”.

4.7.7.2 There is a risk that the ghost train moves to the next trackside train detection section. If this next section is occupied by an integer train, this will not be detected.

4.7.7.3 The system should propagate the “unknown” track section, when there is a risk that a not-connected train moves undetected forwards or backwards, to other track sections.

4.7.7.4 A ghost train propagation timer for every trackside train detection section could be used to prevent the risk of undetected ghost trains.

4.7.7.5 The ghost train propagation timer depends on the needed time to pass the trackside train detection section based on the possible speed for trains without movement authority, e.g. allowed speed in mode SR and/or mode SH.

4.7.7.6 If the risks of unintended movement are acceptable, this timer could be omitted or set to infinity.

4.7.7.7 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

4.7.7.8 If the timer is too short, the trackside must assume a ghost train and set adjacent track sections to “unknown” while there is no risk. A next train must then sweep this section or the whole track section must be freed based on trackside train detection.

4.7.7.9 If the timer is too long, it is possible that a ghost shadow train has moved to another track section undetected. This could lead to the risk that, if the next track section is left by the integer train, the track section is wrongfully treated as free and another train could get an authorisation for this track section.

4.7.7.10 Recommended is a value based on the length of the trackside train detection section and the highest allowed speed in modes SR or SH.