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ERTMS USERS GROUP – ENGINEERING GUIDELINE

80. Hybrid Train Detection engineering

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2-	23/12/2021	Comments from Infrabel and Network Rail Finalised second version for DAP Specific Contract 4	EUG ESG
2a	02/05/2022	Draft Hybrid level 3 only version	AJM
2b	07/10/2022	Comments from ADIF and ESG99 Check Subset-113 v1.5.0	AJM
2c	13/12/2022	Aligned with Principles ERTMS/ETCS Hybrid Train Detection. Upgrade with the following assumptions: • the document is applicable considering the current TSI CCS in law	AJM, GR, ATJ

		(2019) and the new one but only considering the CRs, which are solved at the date of this document (i.e., CR940 and CR1342; concerning CR1342, the term “Level 3” has been removed to make the guideline compatible with TSI implementing or not such CR) • the document refers to the already existing System Version (up to 2.1) and refers to the relevant CRs instead of mentioning the future System Versions.	
2d	19/12/2022	Additional comments ESG	MB, AB, CT, ATJ
3-	19/12/2022	Cleaned version from 2d for official deliverable	ATJ, GR
3a	2023-05-02	Reference list updated	A. Bäärnhielm
3b	2024-04-05	Corrections to document style and layout, and editorial corrections.	A. Bäärnhielm
4-	2024-06-28	Official version	EUG

Table of Contents

1. Introduction

1.1 Foreword

1.1.1.1 When engineering a trackside using the Hybrid Train Detection (HTD) concept some specific decisions must be made and some issues could be encountered. This guideline intends to give guidance on the decisions and to help with engineering such a HTD trackside.

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

1.1.1.3 Authors of the document consider the following information as current best practice, representing present knowledge derived from design and analysis rather than an in-service application.

1.1.1.4 Besides the abovementioned information, reports from X2Rail-5 Moving Block Deliverable D4.1 are used as an input for this guideline, (see Part 3: System Specification [4], Part 4: Operational Rules [5], Part 5: Engineering Rules [6] and Part 6: Safety Analysis [7].

1.1.1.5 This version of the guideline reflects the current specifications and is intended for the short to medium term future.

1.1.1.6 There are 2 main variants to handle block sections, full moving block and fixed virtual block.

1.1.1.6.1 Note: The term “Full Moving Block” has been defined within S2R context.

1.1.1.7 An implementation with fixed virtual blocks using the principle of a Virtual Sub-Section (VSS) is also known as ERTMS/ETCS Hybrid Train Detection and the principles thereof are described in the HTD Principles [3].

1.1.1.8 Based on the considerations of the HTD Principles [3], this document assumes a trackside using fixed virtual blocks together with TTD information to solve several issues when not running under ideal conditions.

- Considerations about the amount of TTD sections are part of this guideline. The use of TTD information solves the following issues:
- Release of tracks when transitioning from a HTD trackside, see 4.2.2.1.
- Managing trains which are not able to send integrity confirmation or are without a radio connection at the transition to a HTD trackside, see 4.2.3.4.
- Reducing the uncertainty in the virtual train position at fixed virtual block borders, see 4.2.4.5 and 4.2.4.6.
- Handling risks at Start of Mission with a train without valid position, see 4.2.11.1.2.
- Handling risks at Start of Mission with a train without connection, see 4.2.11.1.3.
- Handling risk after End of Mission, see 4.2.11.2.1, 4.2.11.2.2 and 4.3.2.2.

- Managing of splitting and joining movements, see 4.2.11.4.2.
- Managing non equipped trains at track works, see 4.2.11.5.3.
- Providing additional information on train location in situations where train positions are not reported (degraded situation), see 4.2.11.6.2, 4.2.12.1 and 4.2.12.2.2.
- Handling the risk of a train with a loss of train integrity, see 4.2.12.6.1.
- Managing the trackside system restart after shutdown, see 4.2.12.7.
- Lowering availability requirements on ETCS and other localisation functions, see 4.3.1.1.
- Detecting all trains within a section with moveable infrastructure to prevent movements under train such as the movement of points, see 4.3.2.1.
- Managing level crossing closing during a degraded situation, see 4.2.14.1.
- Reducing the delay in opening a level crossing or releasing point, see 4.4.2.2.

1.1.1.9 This guideline is part of a bundle of guidelines with the Overall ETCS guideline [10] being the main guideline which will redirect the reader to the relevant guidelines. Be aware that the Overall ETCS guideline may also include recommendations which are related to the topics addressed in this guideline.

1.2 Scope and Field of Application

1.2.1.1 The aim of this document is to describe engineering issues when using the HTD concept and to provide a recommended solution for the engineering of these tracksides, see also 1.1.1.8.

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) in commercial operation.

1.2.1.4 This document is based on ERTMS/ETCS Baseline 3 (including ERA/OPI/2020-2 [2] and the change requests to the ERTMS specifications which have been considered relevant for the HTD concept and which are solved when this document is released.

1.2.1.4.1 Note: CR1304 (error correction, “Safety requirements for the safe train length”) provides a solution in Baseline 4.

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

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

1.2.1.7 Operational rules are out of scope of this document.

1.2.1.8 This guideline only considers issues directly related to HTD tracksides.

1.2.1.9 This guideline can be used for any project using radio-based ETCS. It is not relevant which radio-based ERTMS/ETCS level is used for this trackside engineering.

1.2.1.10 Trackside where the System Version is 1.Y is not analysed in this guideline.

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

- On-board systems supporting System Version 1.Y and 2.Y, with active System Version 2.Y (this includes on-boards B3MR1, B3R2, B3R2+ERA/OPI/2020-2 [2])
- On-board systems supporting version 1.Y, 2.Y and implementing CR940, with active System Version 2.Y or higher

1.2.1.11.1 Note: See chapter 3.4 for information about specific on-board requirements.

1.3 Document structure

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

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

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

1.3.1.4 Chapter 4 provides the issues to be addressed for engineering of a trackside.

1.3.1.5 Chapter 5 provides recommended solutions.

1.3.1.6 Appendix A provides additional information.

2. References and Abbreviations

2.1 Definitions

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

Terminology	Definition
VSS Ambiguous	The trackside has information from a position report that a train is located on the VSS and the trackside is NOT certain that no other vehicle is located in rear of this train on a VSS on which the first train is located.
VSS Free	The trackside is certain that no train is located on the VSS.
VSS Occupied	The trackside has information from a position report that an integer train is located on the VSS and the trackside is certain that no other vehicle is located in rear of this train on a VSS on which the first train is located.
VSS Unknown	The trackside has no information from a position report that a train is located on the VSS, but it is not certain that the VSS is free.

2.2 Abbreviations

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

Abbreviation	Description
CR	Change Request
EOA	End of Authority
HTD	Hybrid Train Detection
PTD	Detection of the train location based on information received from the train in the position report (position, integrity status, safe train length) and, in case of a non-integer train, the train data train length.
SPAD	Signal Passed at Danger
TTD border	A border of a VSS which does coincide with a border between 2 TTD sections.
TTD information	Detection information of a TTD system

TTD section	A section defined by a conventional trackside train detection system, e.g. track-circuits or axle-counters.
TTD system	Trackside Train Detection system (using conventional methods)
VSS	A virtual sub-section, corresponding to a sub-division of a TTD section for which the occupation status is determined using both PTD and TTD information.
VSS border	A border of a VSS which does **not** coincide with a border between 2 TTD sections.

2.3 References

2.3.1.1 The following documents and versions apply:

Ref. N°	Document Reference	Title	Version
[1]	SUBSET-026	System Requirements Specification	3.6.0 (B3 R2)
[2]	ERA/OPI/2020-2	Opinion of the European Union Agency for Railways to the European Commission regarding error corrections of current ERTMS baselines	2020-05-05
[3]	16E042	Principles ERTMS/ETCS Hybrid Train Detection	1F
[4]	X2R5-T4_2-D-SMD-003-12	Deliverable D4.1 Moving Block – Part 3: System Specification	12
[5]	X2R5-T4_2-D-SMD-004-07	Deliverable D4.1 Moving Block – Part 4: Operational Rules	7
[6]	X2R5-T4_2-D-SMD-005-08	Deliverable D4.1 Moving Block – Part 5: Engineering Rules	10
[7]	X2R5-T4_2-D-SMD-006-03	Deliverable D4.1 Moving Block – Part 6: Safety Analysis	3
[8]	18E125	Gradient segmentation	3-
[9]	NA	ERTMS Trackside Approval Issues Log	5
[10]	22E087	Overall ETCS	1-

3. General description of Hybrid Train Detection

3.1 Defining Hybrid Train Detection

3.1.1.1 In an HTD application, information regarding train integrity and train length may be used by the trackside to free the track behind the train. After the confirmation that the track is free, this track could be used for granting a movement authority to another train.

3.1.1.2 Train separation and the method of releasing the track is by fixed blocks, i.e., based on the rear end of the train but only released at pre-defined locations.

3.1.1.3 In situations where the on-board is unable to provide safe information regarding its position, TTD information is used.

3.1.1.4 These main characteristics are typical for an HTD application:

- Sectional release of tracks based on safe rear end sectional with fixed blocks
- TTD information to localise trains in degraded situations. Possibility to release tracks with use of TTD information (in addition to safe rear end)
- Trains running on an HTD line are able to report to trackside safe rear end information, unless the project accepts trains that are not able to report safe rear end information (with impact on capacity as side effect).
- EOA at defined locations, at the border of a fixed block.

3.1.1.5 The use of integrity confirmed by the driver for updating the established rear end of the train location is not recommended unless used in a specific trackside implementation where the risks are acceptable, e.g. low density lines (see 3.4.2.1.2).

3.2 Design choices

3.2.1.1 The choice of the HTD concept 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.

3.2.1.2 When this concept is to be implemented, the project should choose the best applicable configuration for each situation. A choice must be made about the amount of TTD borders.

3.2.1.3 In degraded situations the driver may need to rely on the positions of stop/location marker boards to identify the train location. Installing stop or location marker boards at VSS or TTD borders is optional. Not installing these boards may impact the operational rules.

3.2.1.4 A choice for the amount of TTD borders should be based on (see also 5.1.2):

- Allowed capacity impact for degraded situations (e.g. communication failure, loss of integrity and system recovery from an RBC shut down).
- Implementation and maintenance costs of TTD borders.

- Operational consequences on traffic due to the number of trains which are not able to send integrity confirmation.
- Releasing movable elements (LX or points) safely and effectively (reduction of delay) in nominal conditions and handling degraded situations (loss of radio connection or train integrity) according to existing and consolidated operational principles.
- Migration strategy; re-use of existing TTD systems reduces costs.
- Predictiveness of the release of movable elements and opening level crossings (in time and distance due to safety margins, timing/delays and odometer confidence performance).
- Support for operation with 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).
- Possibilities to detect and handle undue movements of parked coaches or locomotives when disconnected.
- Mitigate operational impact in case of odometer malfunction (large confidence interval).

3.3 Migration strategies

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

3.3.1.2 The migration strategy depends on the planned implementation and from the starting scenario (current implementation), e.g. non-ETCS trackside or radio-based ETCS trackside. When for example the goal is to keep the existing TTD systems, this HTD concept could be deployed over it.

3.3.1.3 If the target system does not allow the normal operation of trains which are not able to confirm their integrity, the whole fleet shall be migrated before commissioning.

3.4 Specific on-board requirements

3.4.1 Introduction

3.4.1.1 When an on-board which maximum operated System Version is 2.0 or 2.1, is intended to run on the HTD trackside, the infrastructure manager should require the on-board to implement the CR940.

3.4.1.2 If it is not immediately feasible to have all involved on-boards implementing CR940, the infra manager could implement the proposed mitigations in annex B of the HTD Principles [3].

3.4.1.2.1 Note: The previous clause answers issue No. 7 of the Trackside Approval Issues Log [9].

3.4.1.3 When the safe integrity of the train length information provided by the on-board is not known to trackside or it is not considered as sufficient, the infrastructure manager should implement specific mitigations (e.g. see 3.4.2.1.2.1).

3.4.2 Train integrity and train length

3.4.2.1 Safety

3.4.2.1.1 From a safety perspective the frequency of integrity reports to the ETCS on-board is not relevant provided that the trackside safety system does not move the min safe rear end of the reporting train until train integrity is confirmed or section is released based on TTD information.

3.4.2.1.2 HTD application uses safe train length information to release track sections behind the train for another train's movement. The train integrity confirmed by the driver does normally not fulfil the required safety level for releasing track sections, and therefore the use of train integrity confirmed by driver to declare an integer train is not recommended. The RBC should treat Q_LENGTH = 2 (Train integrity confirmed by driver) as Q_LENGTH = 0 (No train integrity information available).

3.4.2.1.2.1 Note: In low density lines or in specific scenarios, it is possible that train integrity confirmed by train driver may still be useful, however this is not in the scope of this guideline.

3.4.2.1.3 The safety requirements related to train length provided by the on-board 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 TTD system to estimate a safe train length at the beginning of the HTD area or in case of start of mission inside the HTD area.

3.4.2.2 Performance

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

3.4.2.2.2 The frequency of integrity reports 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.

3.4.2.2.3 The frequency of integrity reports to ETCS on-board should be higher than the position report frequency to avoid performance degradation (see also CR940).

4. Considerations

4.1 Introduction

4.1.1.1 This chapter lists items that need to be considered for engineering an HTD trackside.

4.1.1.2 Initially generic considerations are described followed by concerns which apply to the use of TTD information and to fixed blocks.

4.2 General considerations

4.2.1 Risk of uncertain location of train

4.2.1.1 There are several reasons the on-board may not be able to report its position and train length:

- In nominal situations where train position reports are not foreseen, e.g. SH, SB and SN;
- In degraded situations, e.g. IS, or when train integrity or communication is lost.

4.2.1.1.1 Note: Additional scenarios where train position could not be trustable by trackside (e.g. at SoM) are described in the following chapters.

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 position, or by TTD information.

4.2.1.3 In some situations, the train may have been moving within its MA when the trackside does not receive the train's position reports anymore. 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. Once stopped, a subsequent movement can be further performed without connection due to a mode change.

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. A recommended solution is described in chapter 5.

4.2.2 Transitions from an HTD trackside

4.2.2.1 In case of transition from a HTD trackside to a non-radio-based trackside, the release of sections can only be based on position report information only when the connection with the RBC is kept until the train reports that the whole train has passed the last VSS. This could require additional radio coverage. Release of the last block section by TTD information, as it is foreseen by the HTD concept, solves this problem.

4.2.2.2 In case of transition from a HTD trackside to a non-HTD radio-based trackside, no specific issues have been identified.

4.2.3 Transitions to an HTD trackside

4.2.3.1 Negative impact of propagation (see 5.2.1) towards non-HTD trackside should be avoided, e.g. luminous signals aspects becoming unnecessarily more restrictive should be avoided.

4.2.3.2 If the HTD trackside only supports trains which are able to send integrity confirmation under normal conditions, the entering of trains which are not able to send integrity confirmation (i.e., no position reports with Q_LENGTH = 1) should be prevented to avoid operational issues and performance losses (see 4.2.3.6 for a possible mitigation). It could also be the case with misrouted trains which are not able to send integrity confirmation.

4.2.3.3 If the HTD trackside only supports trains with a radio connection under normal conditions, e.g. no overlay level NTC, the entering of trains without a radio connection should be prevented by making use of a specific relationship between HTD trackside and the other (non-ETCS) trackside.

4.2.3.4 TTD information of the first block of the HTD trackside could be used to mitigate the above-mentioned issues

4.2.3.5 Detection of an unplanned non-connected train entering into a HTD trackside can be based on TTD information. E.g. the RBC cross checks if an occupancy sequence matches with an entering radio connected train; in case of mismatch, the RBC should provide an alert to the signaller.

4.2.3.6 It is possible for the RBC to check through the position report (variable Q_LENGTH) if a connected train approaching an HTD trackside 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 an HTD trackside an acceptable level of performance could still be possible depending on the amount of TTD borders.

4.2.4 Safety margins in train position

4.2.4.1 Besides the train front end, which is determined through position reports, the train rear end can only be safely deduced by the trackside system when trains are able to send integrity confirmation. For trains which are not able to send integrity confirmation only the train front end is reported safely. The safely reported train position of the whole train is based on the confidence interval and already includes the safety margins due to inaccuracy of the distance measured on-board.

4.2.4.2 When integrity information is used to separate trains, a safety 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.

4.2.4.3 The limited roll away distance, defined in D_NVROLL, should be considered together with an additional margin which is necessary to stop the train after the brake is triggered once the D_NVROLL distance is exceeded. Limiting the allowed rolling distance lowers the chance of rolling into a neighbouring section and thus influence the chance to trigger propagation (see 5.2.1.1 for the propagation method).

4.2.4.4 The safety margin could be applicable to the train front end and/or the train rear end.

4.2.4.5 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 TTD border could be used to reduce the uncertainty in the virtual train position.

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

4.2.4.7 When using a TTD 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.

4.2.4.8 The margin could be added to the train rear end of the chased train (see Figure 1 margin A) as the chasing train itself does not have information whether it is chasing another train or not.

4.2.4.9 The end of margin A of Figure 1 can correspond to the EOA, having the SvL at the safe rear end of the chased train (margin C) or it can correspond to the SvL itself (margin B). This prevents undesired track occupation for all trains.

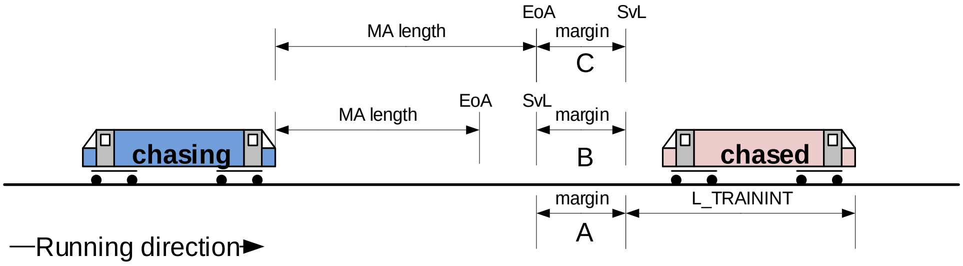

Figure 1: Margins for train position.

4.2.4.10 A recommended solution is described in chapter 5. The required safety margin is project specific. The IM could balance between the mentioned options based on capacity needs, costs of TTD systems and required safety level.

4.2.5 Limit the size of confidence interval

4.2.5.1 The confidence interval influences the safety envelope of the train. This has impact on the occupation of VSSs. This is mainly a performance issue if traffic capacity is critical.

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

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

4.2.6 Position report cycle time

4.2.6.1 The update frequency of the train rear end is not only related to the position report cycle time but also related to update frequency of the train integrity reports to the on-board.

4.2.6.1.1 Note: Loss of integrity itself generates a position report.

4.2.7 Gradients segmentation

4.2.7.1 In the gradients segmentation method as described in guideline Gradients Segmentation [8] the supervised locations (SvL) are considered. As an HTD application could have (far) more SvL when short blocks are used, the gradient segmentation method could be reconsidered.

4.2.8 Speed profiles

4.2.8.1 It is assumed that there is no specific engineering needed for speed profiles compared to a non-HTD application.

4.2.9 Mode profiles

4.2.9.1 It is assumed that there is no specific engineering needed for mode profiles compared to a non-HTD application.

4.2.9.2 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 4.2.11.3.

4.2.10 Impact of change requests on trackside

4.2.10.1 The on-board requirement in CR940 defines that an on-board leaving an HTD trackside 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 trackside, to release all sections before the connection is terminated.

4.2.11 Engineering issues to handle operational procedures

4.2.11.1 Start of Mission

4.2.11.1.1 Determining the departing train location could be the same as a non-HTD application (e.g. cold movement detector, passing balise group). When the train is communicating and has a valid and unambiguous position this could be handled safely.

4.2.11.1.2 In the situation where a train has no valid or no unambiguous position, the train normally must move to get a valid position. When using only TTD information 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. the use of a list of expected balises, which would mitigate partly the risk of moving in a wrong location, and/or the 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.

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

4.2.11.1.4 Another issue is to assure there is no other, non-communicating train at the departure track. Despite using TTD information, 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, to support safe departure (see also 4.2.11.1.2).

4.2.11.1.5 A SoM position report cannot provide the train integrity as confirmed since it is sent before train data is validated, unless CR1408 is implemented, both on-board and trackside. This implies the trackside system is not able to determine whether the train is able to send integrity confirmation at SoM.

4.2.11.1.6 In case it is appropriate to prevent a train without confirmed train integrity information to start its mission, the trackside system will require additional position reports in order to check if integrity is confirmed in the position report (Q_LENGTH = 1). Alternatively, the trackside system could allow the train to start its mission without confirmed integrity, but the consequence is that a non-integer train will likely lead to performance issues.

4.2.11.1.7 When specific measures are taken to limit and control the tracks where a train has performed an EoM (see 4.2.11.2.4), the RBC should assume a piece of track section occupied by a train performing a subsequent SoM (with valid position) not exceeding this section independently from the train confidence interval.

4.2.11.1.8 Despite specific measures are taken to limit and control the tracks where a train has to perform an EoM (see 4.2.11.2.4), the train performing the subsequent SoM could leave this track section occupied (because one or more coaches are left behind):

- in case this happens unintentionally (clause 4.2.11.1.6 allows to detect the case), the presence of TTD provides a mitigation (the entire TTD should be considered as occupied);
- in case this happens intentionally, the RBC can make use of the “train length value” (comparison between the value at previous EoM with the new value at the new SoM) to assign a status different from free to the VSS left by the train or to rely on the status of dedicated TTD (see 4.2.11.4.1).

4.2.11.2 End of Mission

4.2.11.2.1 After performing an End of Mission (e.g. closing cab and/or switch power off) the train will be disconnected and no longer report its location. With TTD information train location is still known at TTD section level.

4.2.11.2.2 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 TTD borders near locations where an End of Mission is likely to occur.

4.2.11.2.3 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 movements 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 used to avoid propagation triggered by roll-away movement.

4.2.11.2.4 Dedicated tracks for End of Mission could be considered, where additional measures could be taken, based on safe localisation of a disconnected train by TTD information.

4.2.11.3 Management of shunting movements

4.2.11.3.1 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 report its location. TTD information needs to be used at the exit of HTD trackside in mode SH to safely release the trackside in rear of the train.

4.2.11.3.2 When leaving a shunting area, the train normally will leave mode SH and reconnect to the RBC by performing a Start of Mission. However, when leaving these areas in an unplanned manner (e.g. SPAD) in mode SH, the movement is not reported and only detected by TTD systems.

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

4.2.11.3.4 For a temporary shunting area in a HTD trackside, 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. To detect leaving a shunting area unintentionally, TTD information can be used if TTD borders coincide with the shunting areas borders.

4.2.11.3.5 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) running on TTDs which are not free.

4.2.11.4 Splitting/joining

4.2.11.4.1 When splitting, the integrity of the former train consist is not confirmed 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).

4.2.11.4.2 Dedicated TTD sections on tracks for splitting and joining can be considered as additional measures to safely localise a disconnected train or wagon.

4.2.11.4.3 A distinction between unintentional and intentional splitting is necessary to avoid undue reaction of the RBC related to unintentional loss of integrity (see 4.2.12.6). Additional, application specific information could be used such as the reported speed of the train or the location where the loss of integrity occurs.

4.2.11.4.3.1 Note: The clauses in the this chapter answer issue No. 32 of the Trackside Approval Issues Log [9].

4.2.11.5 Working areas or trains not equipped with ERTMS

4.2.11.5.1 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.

4.2.11.5.2 Functionality to be able to send confirmation for the yellow fleet could be a challenge because standardised solutions are often not possible.

4.2.11.5.3 Operational procedures (e.g. interruption of operation) should be put in place every time a vehicle not equipped with ERTMS needs to be run over a HTD trackside. This is more complex if no mitigations against unconnected trains or trains not reporting its integrity is confirmed are implemented.

4.2.11.6 Traffic management information

4.2.11.6.1 When engineering a HTD trackside it must be considered which information (e.g. VSS borders information) is needed for the signaller to handle normal operational procedures.

4.2.11.6.2 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. Also, for example in case of emergencies in tunnels, the signaller could need additional information of train locations in order to manage escape areas and also to guide other train movements or emergency services in the tunnel.

4.2.11.7 Reversing

4.2.11.7.1 When reversing is allowed a recommendation similar as for a non-HTD trackside should be put in place, e.g. it would be enough to engineer an area as a single VSS, as this will prevent normal authorisations into that section until it is free.

4.2.12 Engineering issues to handle degraded situations

4.2.12.1 Introduction

4.2.12.1.1 To handle degraded situations such as loss of radio connection or trains which are not able to send integrity confirmation, recommendations are given in chapter 5.

4.2.12.2 Traffic management

4.2.12.2.1 In degraded situations the driver needs to have the possibility to find out the train location to be able to communicate safely with the signaller and perform specific operational procedures on the location. Geographical positioning provided by ETCS, lineside markers or other orientation methods, e.g. GNSS based systems, could be used.

4.2.12.2.2 The need for harmonised operational rules is essential, because in degraded situations the HTD application relies more on operational procedures to prevent trains entering occupied tracks. This is applicable when it is allowed, under normal conditions, to have multiple trains in the same TTD section.

4.2.12.2.3 In case the trackside system does not know the position of the whole train, e.g. when the communication is lost, also the traffic management system has invalid train position information and only rough TTD information. Based on this invalid train position information a signaller could give erroneous procedural authorisations to this or other trains.

4.2.12.3 Loss of radio connection

4.2.12.3.1 In addition to the scenarios of EoM (see 4.2.11.2) and shunting movements (see 4.2.11.3), 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 system should be able to restore to a normal situation.

4.2.12.3.2 If there is no radio connection at Start of Mission, the train should not depart due to the risk of not reporting its position. Based on rough TTD information departure could be allowed with specific operational procedures.

4.2.12.3.3 While the connection is lost during the mission, the trackside cannot be immediately freed from the last reported position up to the supervised location. Using TTD information only free TTD sections could be released. At busy locations this could have an impact on the capacity of other trains.

4.2.12.4 Lack of radio coverage

4.2.12.4.1 For locations without radio coverage the radio hole functionality could be used. When entering and leaving such an area, TTD information should be used to release tracks behind the train.

4.2.12.4.2 When radio holes exist, it should be considered that no extensions of the authorisation to move can be provided to a train inside the radio hole area.

4.2.12.4.3 Radio hole area should always be included inside the same VSS due to 4.2.12.4.2.

4.2.12.4.4 When a radio hole is present, it should be considered that the RBC warns the signaller when a train having entered a radio hole does not provide a position report within a certain time. Therefore, a radio hole timer could be defined. The start and stop event of this timer could be the last position report before and the first position report after the radio hole, respectively. The timer length could be defined considering the frequency of the position reports, the lowest speed profile (a reduction by 20% to allow for acceleration, braking and drivability is reasonable) and the time needed to re-establish the radio connection once the radio hole is passed.

4.2.12.4.4.1 Note: The clauses in the this chapter answer issue No. 89 of the Trackside Approval Issues Log [9].

4.2.12.5 Maintenance radio coverage

4.2.12.5.1 The provisions in 4.2.12.4 could also be considered to predefine possible temporary radio hole areas with the intention to deal with possible radio failure due to maintenance purposes. This is a project specific decision.

4.2.12.6 Loss of train integrity

4.2.12.6.1 The loss of train integrity, (i.e., Q_LENGTH = 3) besides splitting, is a degraded situation. The handling depends on the size of TTD sections.

4.2.12.7 Trackside system restart after shutdown

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

4.2.12.7.2 In case the trackside system performs a restart, the system must assume a safe state of the trackside (IXL/RBC), 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 occupied TTD sections should be swept by communicating trains that have confirmed their integrity to resume safely.

4.2.12.7.3 If the TTD system cannot guarantee detection of all trains after a restart, other train localisation methods could be considered. A TTD system based on axle counter information cannot detect train after a restart. 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.

4.2.12.7.3.1 Note: After some time, information may not be valid anymore.

4.2.12.8 Sweeping

4.2.12.8.1 It is not in the scope of this document to provide sweeping rules and clearance criteria but only to indicate how sweeping can be performed under ETCS.

4.2.12.8.2 Performing sweeping in mode OS has the benefit that the driver is aware of possible track occupation, the system could authorise only specific track parts and mode OS provides a higher level of protection compared to SR (e.g. the level crossing protection is not available in SR).

4.2.13 Combination with Automatic Train Operation (ATO)

4.2.13.1 No specific issues are known.

4.2.14 Level crossings

4.2.14.1 It is possible to close safely a level crossing by means of position reports without integrity confirmed in case trains are running with an MA. However, for degraded situations where no MA is issued or when trains are not communicating to the trackside, TTD information is to be used.

4.2.14.2 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 quicker opening and for degraded situations, e.g. if integrity or communication is lost, the opening of a level crossing using TTD information should be considered.

4.3 Considerations related to TTD information

4.3.1 Availability

4.3.1.1 With large TTD sections the availability of ETCS on-board must be higher in order to make the impact on operation in case of degraded situations acceptable.

4.3.1.2 By combining position reports, train integrity information and physical TTD information, it is possible to detect wrong section occupation status due to the same TTD section that unduly reports to be occupied or the same TTD section that cannot detect train occupancy (e.g. in case of rusty rails or not correctly tuned track circuits). With reference to the HTD Principles [3], see 4.4.2.2.1.

4.3.1.3 Example of a possible way to address a wrong occupation status in case of mismatching information coming from TTD and train position report with train integrity information are (provided clause 4.3.6.1 is considered):

- to provide a warning to the signaller;
- the RBC to consider as occupied the TTD section that cannot detect train occupancy;
- the RBC to consider as free or unknown the TTD section unduly reporting to be occupied.

4.3.2 Detection train/wagon on track elements

4.3.2.1 Without TTD borders near points or movable bridges, it could be a problem to detect trains/wagons on only the point/bridge itself to allow point/bridge movement only when not physically occupied.

4.3.2.2 A generic issue is that trains could physically move after End of Mission (e.g. closing cab and/or switch off power). This can be detected with TTD information. However, large TTD sections could delay detection of this movement.

4.3.2.3 A possible solution 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, so propagation is prevented. These deflecting points are set and locked in a way to impede convergence with the main track.

4.3.3 Use of TTD information for safety

4.3.3.1 The safety and operational issues mentioned in this document are solved by using TTD information. Locations of TTD borders are recommended solution and described in chapter 5.

4.3.3.2 When choosing TTD borders and section lengths, the issues around sweeping should be considered.

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

4.3.3.3.1 Note: If a TTD section is in state occupied due to broken rail (if detected by TTD system), all VSSs on this TTD will nevertheless become free after sweeping. The infrastructure manager should take appropriate mitigation measures in this case.

4.3.4 Use of TTD information for handling trains not being able to send integrity confirmation

4.3.4.1 Existing TTD systems could be useful in nominal situations (e.g. trains which are not able to send integrity confirmation) or in degraded situations for the handling of trains, which temporarily are not able to send integrity confirmation (e.g. integrity reporting failure).

4.3.4.2 When the handling of trains which are not able to send integrity confirmation is needed, the following should be considered:

- number of trains which are not able to send integrity confirmation compared to the ones which are able to send integrity confirmation
- traffic capacity needs
- TTD that is already required for safety and operational issues.

4.3.5 Use of TTD information for traffic capacity

4.3.5.1 The use of TTD borders near some locations could reduce traffic capacity perturbation by a more predictable release of movable trackside elements, e.g. points.

4.3.5.2 The use of TTD borders 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 TTD borders could assist:

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

4.3.6 Multiple sources to determine train location

4.3.6.1 Using both TTD information and reported train position, there are multiple sources of similar information for the train location. However, due to latency the train location information could be different at the same moment. This difference must be considered while using this information in operational procedures.

4.4 Considerations for fixed blocks

4.4.1 Position report cycle time/MA extension frequency

4.4.1.1 The update frequency of track release and thus MA extension should be considered in relation to the typical update frequency of integrity reports. The on-board will report no integrity available between integrity confirmed train position reports if the integrity report frequency is less than the position report frequency (see also 3.4.2.2.3).

4.4.1.2 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 undesired driver behaviour, e.g. not braking when indicated.

4.4.2 Management of points

4.4.2.1 The release of points is affected by position report cycle time and integrity report frequency. Points shall only be moved when not occupied. Non-communicating trains should also be considered.

4.4.2.2 By using TTD information "free" to release a point section the issue that the train still reports occupying the point when the TTD section already reported a cleared point or vice-versa, is solved.

4.4.2.2.1 Note: This could be useful to keep/move a point in a desired position for instance for flank protection after a SPAD.

4.4.3 Approaching the end of an MA at the VSS border

4.4.3.1 Approaching the end of an MA at the VSS border, i.e., parameters EOA/SvL/release speed, could be the same as in a non-HTD application if the EOA is indicated by a marker board. However, it should be prevented that the trackside system could consider the next VSS at an EOA as occupied in order to avoid undue occupancy of track with possible consequences on the command of movable infrastructure. A recommended solution is described in chapter 5.

4.4.3.2 A dedicated VSS in advance of the end of a section could be used as overlap to have a margin distance before the additional section can be considered as occupied.

4.4.3.3 As shown in Figure 2, another solution is to use two dedicated VSS in advance of the end of a section as overlaps: if the shorter overlap is occupied by the tail of the chased train (case a), 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 (case b), 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 (case c), 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.

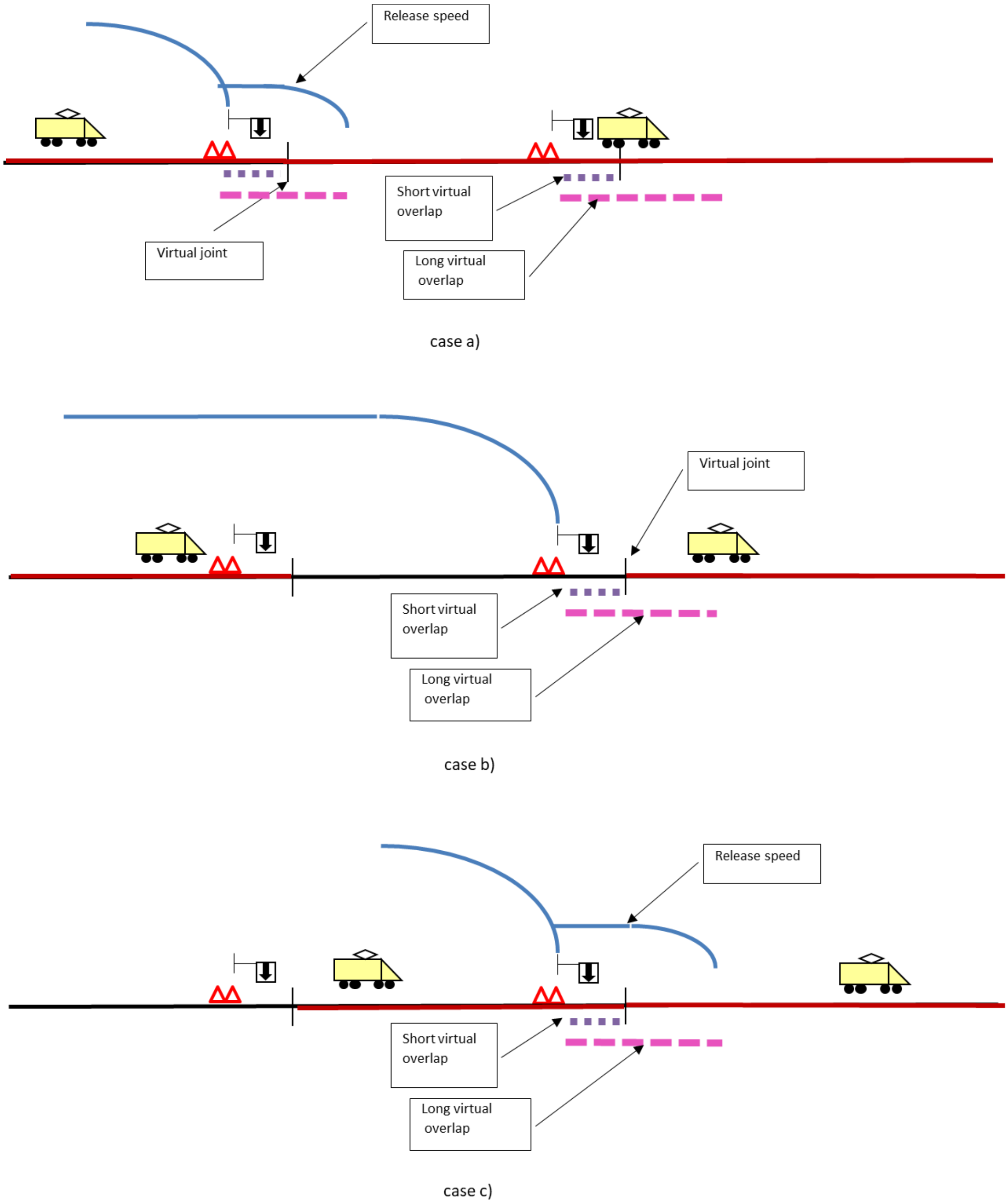

Figure 2: MA depending on different overlap occupation

4.4.3.4 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.

4.4.3.5 At all ends of VSSs stop or location marker boards could be placed depending on the operational situation. If the amount and/or spacing between marker boards, when engineering short sections, could hinder ergonomics for the driver and/or signaller, the use of marker boards should be reconsidered.

4.4.3.6 The use of a release speed is a project specific decision. This is related with the approach of stop/location marker boards. The stop/location marker board location should be seen in relation with the projected EOA and SvL locations.

4.4.4 Number and length of sections

4.4.4.1 Theoretically an unlimited amount of VSSs are possible, also very small blocks are possible. However, the number of blocks in the system could have impact on the system performance. Small length could introduce additional risk and operational issues (see 4.4.4.2). Also, sequential section release checking could be affected by very small blocks.

4.4.4.2 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 implying the radio connection is terminated and impeding the RBC from intervening for dangerous situations already in the block section before the last one in rear of the shunting area.

4.4.4.3 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.

4.4.4.4 When defining a maximum length of VSSs in addition to the common consideration related to capacity, the possible impact on the sweeping procedure should be considered. For instance, long driving times in OS mode might lead to driver attention loss to possible track occupations.

5. Recommended solutions

5.1 Basic considerations

5.1.1 Recommendation for implementing HTD

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

5.1.1.2 If the main reason for implementing the HTD concept is to reduce costs, and the possible impact on operation during a degraded scenario is acceptable (for instance due to low traffic application), less TTD sections should be used.

5.1.1.3 The use of TTD sections should be dependent on whether there are still trains running which are not able to send integrity confirmation and the issues mentioned in 5.1.2 Also, the need for shunting movements or the support of non-connected/non-ERTMS trains must be considered.

5.1.1.4 If the main reason for implementing HTD trackside is to gain traffic capacity, small VSSs should be used (see 4.4.4).

5.1.1.5 The number and length of track sections should be investigated. A trade-off between traffic capacity for trains which are not able to send integrity confirmation, handling of degraded situations and amount of trackside equipment should be made.

5.1.1.6 When refitting an existing trackside, keeping the present TTD system could be considered. VSSs could then be added to increase traffic capacity.

5.1.1.7 When the TTD 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.

5.1.2 Recommendation for TTD borders

5.1.2.1 At the following locations it is recommended to use TTD borders near the following object/locations to solve referenced issues:

- points, see 4.3.2.1
- level crossings, see 4.2.14.1, and 4.4.2.2
- movable bridges, see 4.3.2.1
- tunnels with safety systems (e.g. escape area or additional system enabling to guide other train movements in the tunnel or emergency services to the right location), see 4.2.11.6.2
- borders to non-HTD trackside, see 4.2.2.1 and 4.2.3.4.
- borders to permanent and temporary shunting areas, see 4.2.11.3
- locations where Start of Mission, End of Mission could occur, see 4.2.11.1.2, 4.2.11.1.3, 4.2.11.2.1, 4.2.11.2.2, 4.2.11.6.2 and 4.3.2.2
- locations where splitting and joining movements could occur, see 4.2.11.4.2 and 4.2.11.6.2
- locations where the impact of system restart must be low, see 4.2.11.6.2 and 4.2.12.7.

- locations where the impact of loss of train integrity or communication must be low, see 4.2.11.6.2, 4.2.12.1 and 4.2.12.6.1
- locations where uncertainty of the train position should be reduced, see 4.2.4.5 and 4.2.4.6

5.2 Recommended specific solutions

5.2.1 Solution Risk of uncertain location of train

5.2.1.1 To mitigate the risks of an uncertain location of a train, the method of propagation is used. This means that based on some triggers, e.g. communication loss detected at a certain time, the system assumes that the train location is enlarged forward and/or backward.

5.2.1.2 For propagation, the following timers are used, which are also foreseen in the HTD Principles [3]:

- Mute timer: timer to detect the loss of communication at the trackside.
- Disconnect propagation timer: timer to start propagation after train is disconnected
- Wait integrity timer: timer to detect abnormal time between integrity reports
- Integrity loss propagation timer: timer to start propagation after train lost integrity.
- Shadow train timer: timer to detect a shadow train could be available
- Ghost train propagation timer: timer to start propagation after a TTD section becomes unexpectedly occupied.

5.2.1.3 The timers are detailed in Appendix A.

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

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

5.2.1.6 Propagation could be stopped by engineering TTD borders around these trackside elements. This only stops propagation issues if these sections are actually free.

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

5.2.1.8 For section-based timers, a speed dependent propagation could be considered, i.e., the propagation is delayed in time based on an assumed maximum train speed and section length. This could prevent an operational impact on other trains movements; however, it could also introduce additional risks due to incorrect assumptions. This is a project specific decision.

5.2.2 Solution safety margins in train position

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

5.2.3 Solution approaching VSS border

5.2.3.1 It is recommended to use the minimum safe front end at EOA to occupy the next VSS instead of the maximum safe front end as described in the HTD Principles [3]. See also 4.4.3.1.

Appendix A Defining the system timers

A.1 Aim of this appendix

A.1.1.1 Each system timer is described with its purpose, recommended value (range) and how to limit the impact on the operational process.

A.2 Mute timer

A.2.1.1 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.

A.2.1.2 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 TTD information, will also be treated as “unknown”.

A.2.1.3 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, the mute timer is stopped and will not expire. However, the system will treat the VSS of the last known train location as “unknown”. Nominally, no other track sections are part of the movement authority anymore and treated as “unknown”.

A.2.1.4 This timer enables an earlier trackside system reaction than waiting for expiration of the communication session timer as defined in SUBSET-026 [1]. 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.

A.2.1.5 When using a route release timer based, among other things, on the value of T_NVCONTACT, the mute timer is indirectly related to the route release.

A.2.1.6 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 and sent to the train, the marking of these track sections for train movement as “unknown’” by the trackside will have no direct performance impact. However, other related timers, e.g. the disconnect propagation timer, could start earlier.

A.2.1.7 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.

A.2.1.8 The use of TTD information could limit the operational impact.

A.2.1.9 It is recommended the mute timer is comparable to the value given to T_NVCONTACT.

A.3 Disconnect propagation timer

A.3.1.1 When propagation is used after train disconnection, a disconnect propagation timer could be used at the trackside for each track section to consider after a defined time that an “unknown” track section should be propagated.

A.3.1.2 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.

A.3.1.3 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 TTD information.

A.3.1.4 This risk depends on conditions of the track section, e.g. on hilly track section unintended movement could occur more easily. After some time, the brakes will not guarantee standstill on certain gradients, e.g. approx. 30 minutes. The timer should be smaller than this.

A.3.1.5 The risk depends also on operational procedures, e.g. which time after disconnection (possibly due to EoM) could a procedural authorisation (new SoM or not) 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.

A.3.1.6 If the risks of unintended movement and of movements with procedural authorisation (movement allowed by the signaller but not protected by ETCS) are acceptable, this timer could be omitted or set to infinity.

A.3.1.7 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

A.3.1.8 This timer could be used for an earlier system reaction than waiting for expiration of the communication session timer as defined in SUBSET-026 [1].

A.3.1.9 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.

A.3.1.10 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.

A.3.1.11 The use of TTD information could limit the operational impact.

A.3.1.12 Recommended is a value in range of 5 to 15 minutes.

A.4 Wait integrity timer

A.4.1.1 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”.

A.4.1.2 The system treats the track section where that train is as “unknown”.

A.4.1.3 Due the asynchronous reporting of integrity to the on-board and the position reporting frequency, the on-board could report that no integrity information is available while the integrity of the train is still confirmed to the on-board. The wait integrity timer prevents an early system reaction.

A.4.1.4 The integrity 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.

A.4.1.5 The wait integrity timer is not directly safety related. If “train integrity lost” is reported independently on the integrity reporting frequency (this is the case when CR940 is not implemented), a longer timer could be used.

A.4.1.6 If the timer is too short, trains with integrity confirmed which report “no train integrity information available” due to a lower integrity reporting frequency will be treated as integrity lost. Other related timers, e.g. the integrity loss propagation timer, could start earlier. This could also impact performance.

A.4.1.7 If the timer is too long, it is possible that a train loses its integrity without any system reaction.

A.4.1.8 Recommended is a value comparable to the position report cycle time.

A.5 Integrity loss propagation timer

A.5.1.1 When propagation is used after integrity loss, an integrity loss propagation timer could be used at the trackside for each track section to consider after a defined time that an “unknown” track section should be propagated.

A.5.1.2 The system should propagate the “unknown” track section, when there is a risk that train without train integrity confirmed moves undetected backwards to other track sections which cannot be guaranteed free, e.g. by TTD information.

A.5.1.3 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.

A.5.1.4 The risk depends also on operational procedures, e.g. after which time could a train (or a piece of it) 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.

A.5.1.5 A consequence of propagation is that the track section in rear of the train becomes unknown and can only be guaranteed free based on TTD information, 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 since sweeping will take longer.

A.5.1.6 If the risks of unintended movement are acceptable (depending also on the type of rolling stock operating on the line), this timer could be omitted or set to infinity.

A.5.1.7 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

A.5.1.8 If the timer 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.

A.5.1.9 If the timer is too long, it is possible that a piece of 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.

A.5.1.10 The use of TTD information could limit the operational impact.

A.5.1.11 Recommended is a value in range of 5 to 15 minutes.

A.6 Shadow train timer

A.6.1.1 When using train position reports to separate trains in a track section, it is possible that a not-connected train follows shortly after a train with integrity confirmed 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 TTD information this situation could be detected at TTD borders, because when the connected train passed this border the previous track section stays occupied for some additional time due to the shadow train.

A.6.1.2 However, due to asynchronous information from position reports and from the TTD system, there could in the normal situation already be a delay between the TTD system reporting the track section free and the position being reported that the section is clear of the train.

A.6.1.3 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 TTD system. This delay would be typically in the range of 0-10 seconds.

A.6.1.4 A shadow train timer for each TTD section for each direction and for each connected train on the TTD section, could be used to prevent wrongful detection of shadow trains.

A.6.1.5 The shadow train timer depends on the position report cycle time and could be shortened if a position report is triggered when passing the TTD border.

A.6.1.6 If the risks of wrongful detection of shadow trains are acceptable, this timer could be omitted or set to infinity.

A.6.1.7 The risk could also be mitigated by a TTD system that has information of passing a TTD 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.

A.6.1.8 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

A.6.1.9 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 TTD information.

A.6.1.10 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 train with integrity confirmed, the track section is wrongfully treated as free, and another train could get an authorisation for this track section.

A.6.1.11 Recommended is a value in range of 5 to 10 seconds.

A.7 Ghost train propagation timer

A.7.1.1 When using train position reports to detect trains in a track section, it is possible that a non-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 TTD information 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 TTD section can be treated as “unknown”.

A.7.1.2 There is a risk that the ghost train moves to the next TTD section. If this next section is occupied by a train with integrity confirmed, this will not be detected.

A.7.1.3 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.

A.7.1.4 A ghost train propagation timer for every TTD section could be used to prevent the risk of undetected ghost trains.

A.7.1.5 The ghost train propagation timer depends on the needed time to pass the TTD section based on the possible speed of trains without movement authority, e.g. allowed speed in mode SR and/or mode SH.

A.7.1.6 If the risks of unintended movement are acceptable, this timer could be omitted or set to infinity.

A.7.1.7 If the risk is comparable for all track sections, a single timer value could be chosen to limit the complexity of engineering.

A.7.1.8 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 TTD information.

A.7.1.9 If the timer is too long, it is possible that a ghost train has moved to another track section undetected. This could lead to the risk that, if the next track section is left by the train with integrity confirmed, the track section is wrongfully treated as free, and another train could get an authorisation for this track section.

A.7.1.10 Recommended is a value considering the expected time a TTD section could be passed by a ghost train, i.e., based on the length of the TTD section and the highest allowed speed in modes SR or SH.