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T HR SC 10031 ST

Standard

Signalling Design Principle – ETCS Level 1

Version 1.0

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Standard governance

Owner: Lead Signals and Control Systems Engineer, Asset Standards Authority

Authoriser: Chief Engineer, Asset Standards Authority

Approver: Executive Director, Asset Standards Authority on behalf of the ASA Configuration Control Board

Document history

Version	Summary of changes
1.0	First issue

For queries regarding this document,
please email the ASA at
standards@transport.nsw.gov.au
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Preface

The Asset Standards Authority (ASA) is a key strategic branch of Transport for NSW (TfNSW). As the network design and standards authority for NSW Transport Assets, as specified in the *ASA Charter*, the ASA identifies, selects, develops, publishes, maintains and controls a suite of requirements documents on behalf of TfNSW, the asset owner.

The ASA deploys TfNSW requirements for asset and safety assurance by creating and managing TfNSW's governance models, documents and processes. To achieve this, the ASA focuses on four primary tasks:

- publishing and managing TfNSW's process and requirements documents including TfNSW plans, standards, manuals and guides
- deploying TfNSW's Authorised Engineering Organisation (AEO) framework
- continuously improving TfNSW's Asset Management Framework
- collaborating with the Transport cluster and industry through open engagement

The AEO framework authorises engineering organisations to supply and provide asset related products and services to TfNSW. It works to assure the safety, quality and fitness for purpose of those products and services over the asset's whole-of-life. AEOs are expected to demonstrate how they have applied the requirements of ASA documents, including TfNSW plans, standards and guides, when delivering assets and related services for TfNSW.

Compliance with ASA requirements by itself is not sufficient to ensure satisfactory outcomes for NSW Transport Assets. The ASA expects that professional judgement be used by competent personnel when using ASA requirements to produce those outcomes.

About this document

This standard forms a part of the TfNSW suite of railway signalling principles that detail the requirements and the design principles. This standard specifically covers the implementation of ETCS level 1.

To gain a complete overview of signalling design requirements, this standard should be read in conjunction with the suite of signalling design principle standards.

This standard has been developed by the ASA in consultation with other TfNSW agencies and industry representatives.

This standard is a first issue.

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1. Introduction

European train control system (ETCS) is a standardised automatic train protection (ATP) system that provides various options to permit flexible application across different railway jurisdictions.

ETCS onboard equipment receives information related to the track ahead from ETCS trackside equipment and together with train parameters uses this information to determine speed and distance supervision parameters. If a supervision limit is exceeded, then the onboard equipment triggers one or more of the following:

- audible and visual warnings to the driver
- traction cut-off
- service brake application
- emergency brake application

2. Purpose

This standard specifies the requirements and design principles for ETCS level 1 trackside implementation to mitigate derailment and collision risks.

2.1. Scope

This standard specifies the requirements and design principles for ETCS level 1 trackside implementation in the electrified areas of the rail passenger network.

The trackside implementation complements the fitment of onboard ETCS equipment on Electrical Multiple Units (EMU) only, however; the onboard system is out of scope of this document.

Any requirements in this document that are an amendment from the European Union Agency for Railways (ERA) ETCS specifications are explicitly stated as such.

2.2. Application

This standard applies to Authorised Engineering Organisations (AEOs) engaged to carry out the preliminary and detailed signal design for new and existing installations in the rail passenger network within the area bounded by Newcastle (in the north), Richmond (in the northwest), Bowenfels (in the west), Macarthur (in the southwest) and Bomaderry (in the south), and all connection lines and sidings within these areas, but excluding private sidings, freight lines and non-electrified lines.

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3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

International standards

ERTMS/ETCS Dimensioning and Engineering rules – Subset-040

ERTMS/ETCS FFFIS for Eurobalise – Subset-036

ERTMS/ETCS System Requirements Specification Chapter 3 Principles - Subset-026-3

ETRMS/ETCS System Requirements Specification Chapter 4 Modes and Transitions – Subset-026-4

ERTMS/ETCS System Requirements Specification Chapter 7 ERTMS/ETCS Language - Subset-026-7

ERTMS/ETCS System Requirements Specification Chapter 8 Messages - Subset-026-8

Transport for NSW standards

EGG 1656 Balise Placement and Metal Mass Assessment Guide

ESC 210 Track Geometry and Stability

ESC 250 Turnouts and Special Trackwork

ESG 100 Signal Design Principles - ESG 100.3 Braking Distance

SPG 0706 Installation of Trackside Equipment

T HR SC 00003 ST Circuit Design Standard – ETCS Level 1 Interface Circuits

T HR SC 01650 SP ETCS Onboard Equipment

T MU AM 01007 TI Asset Reference Codes Register

Transport for NSW drawings

M05-500-599 ATP Construction Drawings

Other reference documents

NSY 514 Special Proceed Authority

4. Terms and definitions

The following terms and definitions apply in this document:

AEO Authorised Engineering Organisation

ASA Asset Standards Authority

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ATP automatic train protection

BMM big metal mass

CBI computer-based interlocking

DMI driver machine interface

DPU data pick-up unit (track circuit pin-point detector)

EMU electric multiple unit

EOA end of authority

ERA European Union Agency for Railways (formerly European Railway Agency)

ERTMS European Rail Traffic Management System

ETCS European train control system

FFFIS form fit functional interface specification

FS full supervision (mode)

GIS Geographic Information System

HR relay caution (home) relay

JRU juridical recording unit

L0 ETCS level 0 (zero)

L1 ETCS level 1

LEU lineside electronic unit

LS limited supervision (mode)

LSp relay low speed relay

LSSMA lowest supervised speed within the movement authority

MA movement authority

outer signal a signal one or more blocks in rear of:

- the home signal of a turnout, or
- the protecting signal of a high-risk overrun

protecting signal a stop signal immediately in the rear of a hazard point for a high-risk overrun

SPA special proceed authority

SR staff responsible (mode)

SSP static speed profile

SvL supervised location

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TfNSW Transport for New South Wales

TSM target speed monitoring

TSW temporary speed warning

TSR temporary speed restriction (ETCS function)

VAD vertical alignment database

VBC virtual balise cover

5. Balises and balise groups

A balise group consists of 1 to 8 balises located within specified distance limits and identified as belonging to the same group within the ETCS data. Each balise within the group is identified individually by its position in the group.

Where a balise group consists of more than one balise, the order of reading the balises allows the onboard equipment to determine whether the train has passed the balise group in the 'nominal' direction or in the 'reverse' direction. Where the group consists of a single balise, the direction in which the balise group has passed may be assigned using the information received from a prior balise group.

Each balise transmits a telegram to the train. The combination of telegrams from all balises in the group makes up the balise group message. Each telegram is made up of packets and a header, with different packets defined for different functions. The packets can convey information applicable to trains travelling in the nominal direction, the reverse direction, or for trains in either direction. Separate information can be given for each direction by using a separate packet for each direction.

The nominal direction shall be in accordance with the primary purpose of the balise group, unless a repositioning requirement overrules. Refer to Section 6.2.4 for more details on repositioning.

Where a balise group performs more than one function, the primary purpose may be unclear. In such situations, the following shall apply:

- for controlled balise groups, the primary purpose shall be in accordance with the controlling function
- for fixed balise groups, the primary purpose shall be in accordance with the following priority order:
    - buffer stop protection
    - speed sign

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- speed sign in the normal running direction (for back-to-back speed signs on a bidirectional line)
- speed sign in the Down direction (for back-to-back speed signs on a single line)
- speed update after a turnout
- yard entry

Balise groups shall consist of two balises, with the following exceptions:

- calibration balise groups shall consist of one balise
- buffer stop balise groups shall consist of one balise where the distance between the operational stopping location and the buffer stop is less than or equal to 10 m

The use of an additional balise within a balise group is permitted where needed to cater for the amount of data to be transmitted. Additional balises shall be assigned during data design activities.

For a balise group composed of controlled and fixed balises, the controlled balise shall be the first to be read in the nominal direction of travel.

5.1. Balise identification

Each balise shall be uniquely identifiable. Balises and balise groups shall have a name, for asset management purposes, and a number for ETCS functional purposes.

5.1.1. Balise identification numbers

Balise identification consists of two elements, namely the balise group identity number (NID_BG) and the balise position in group number (N_PIG).

Allocation of NID_BG shall be made from a master register to ensure no duplicate allocation is made.

The N_PIG is an integer. The first balise of a balise group passed in the nominal direction is termed as the reference balise. The value of zero shall be allocated to N_PIG for this balise.

5.1.2. Balise naming

Each balise shall be assigned a unique name that complies with the following naming structure:

WWWXXXXXXXX_YYYY_Z_T

The underscores shown shall be included in the balise name.

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WWW

WWW shall be the three-letter location code as listed in T MU AM 01007 TI *Asset Reference Codes Register*.

For balises in a fixed balise group, WWW shall be the location code of the nearest station to the reference balise of the balise group.

For balises in a controlled balise group, WWW shall be the location code according to the connecting lineside electronic unit (LEU); that is, the location code of the nearest station to the interfaced signal.

The station kilometrage reference given by the Geographic Information System (GIS) of the rail infrastructure manager (RIM) shall be used in determining the nearest station.

XXXXXXXX

XXXXXXXX shall be a maximum of eight characters that describe the signal name, points number or balise group kilometrage.

Signal name

The signal name shall be used for balises in controlled balise groups, using the name of the signal interfaced to the LEU.

The signal name shall be used for balises in fixed balise groups where the primary purpose of the balise group requires it to be positioned in a relative distance to a signal. Examples include the following:

- dedicated balise groups that toggle-off the display of the lowest supervised speed within the movement authority (LSSMA) near the protecting signal of a high-risk overrun
- wrong running entry or exit balise groups on plain line
- dedicated balise groups near signals that perform an early mode change after a train turns back

Where the signal name is used, XXXXXXXX shall be in accordance with the signal identification plate; however, the signal name shall not include spaces, decimal points or any suffix denoting the line name.

Where more than one balise group on the same line is required to be named after the same signal, a suffix shall be appended to the signal name to maintain uniqueness. Examples of suffixes include ‘L’ for toggling-off LSSMA, ‘C’ for an early mode change after turning back, ‘A’ for an approach balise group or ‘A1’, ‘A2’ and so forth for multiple approach balise groups, starting at 1 for the approach balise group farthest in advance.

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Points number

The points number shall be used where the primary purpose of the balise group is for repositioning. The points-end letter is only included where required to achieve a unique name. No interlocking prefix is required.

Kilometrage

The approximate kilometrage of the reference balise shall be used for balises that are not required to include the signal name or points number. The kilometrage shall be based upon kilometrages given by the GIS, rounded off to the nearest 10 m. The decimal point shall be omitted. The kilometrage used in the balise name shall consist of five digits, padded with leading zeros where necessary.

YYYY

YYYY is the four–character track code as listed in T MU AM 01007 TI *Asset Reference Codes Register*, an abbreviation of the line name shown on the signalling plan.

Z

Z shall be the value allocated to the data variable N_PIG.

T

T shall be the balise type as follows:

- ‘C’ for a controlled balise
- ‘F’ for a fixed balise

Table 1 provides examples of different balise names established using the convention described in this section.

Table 1 - Balise naming convention

Balise name	Explanation
BTN03575_UPSB_0_F BTN03575_UPSB_1_F	The two fixed balises in a speed sign balise group on the Up Suburban at 35.745 km, near Blacktown.
NMHHY17_DNMN_0_C NMHHY17_DNMN_1_F	The two balises in a balise group for a high-risk turnout on the Down Main near Normanhurst. The controlled balise is interfaced to Hornsby signal HY17.
HBY502_DNMN_0_F HBY502_DNMN_1_F	The two fixed balises in a repositioning balise group on the Down Main that is passed after travelling through the ‘A’ end of Hornsby 502 facing points in the normal position. The nearest station is Hornsby.

The balise group ID (used in the ETCS balise tables) shall be in accordance with the balise name without the ‘position in group’ or balise type suffix; that is, WWWXXXXXXXX_YYYY.

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5.2. Balise placement

All references for balise placement refer to the centre of the balise.

Balises shall have a minimum longitudinal separation of 2.3 m in accordance with ERTMS/ETCS *FFFIS for Eurobalise* – Subset-036. Balises within the same balise group shall have a maximum longitudinal separation of 12 m in accordance with ERTMS/ETCS *Dimensioning and Engineering rules* – Subset-040. Balises within the same balise group shall be installed at the minimum separation achievable for a given site.

Balises should not be installed in crossovers, except for balises for yard entry and exit. This is to minimise the amount of infrastructure between the running lines.

A balise shall not be installed closer than 1.5 m from the running face of the nearest rail of an adjacent track, as a train on the adjacent track could otherwise receive the balise telegram. This results in the prevention of balises being installed in or adjacent to a turnout until the running faces are separated by at least 0.8 m. This effectively prevents the installation of balises in a crossover where the main line track centres are less than 4.5 m.

Balises shall not be installed in emergency crossovers, as it is desirable to minimise the number of balises classified as seldom-used signalling apparatus.

Balises shall only be installed on track with a horizontal radius greater than 180 m. They shall only be installed longitudinally on track with a horizontal radius greater than 300 m.

To avoid any possible interaction, balises shall not be installed within 10 m of a train radio transponder or within 1.5 m of a track circuit data pick-up unit (DPU).

To ensure that the metal mass in fishbolts does not affect the onboard transmission equipment, balises shall not be installed where the body of the balise is within a 0.3 m longitudinal distance from a fishplate.

Balises should not be placed in tunnels, bridges, viaducts or platforms.

5.2.1. Controlled balises near replacement points

Controlled balises shall not be installed less than 5.0 m in rear of the replacement point of the connected signal, as the balise could otherwise be read after the signal is replaced. Where a train is required to stop close to a signal, then one of the following special arrangements are required:

- relocating the replacement point (with or without relocating the signal)
- placing the controlled balise closer to the replacement point and providing additional controls to maintain the correct balise information as the train passes the replacement point without affecting the operation of the signal

Refer to T HR SC 00003 ST *Circuit Design Standard – ETCS Level 1 Interface Circuits*.

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The replacement point of the signal shall be deemed to be one of the following:

- the insulated rail joint, or the one farther in advance where there is a stagger
- 3.5 m in advance of the first tuning unit connection
- the axle counter head
- the centre of the DPU

5.2.2. Balises near signals

Balises for ETCS trainstops shall not be installed greater than 8.9 m in rear of the signal, as the balise can otherwise be read before the train stops at the signal. This is based on a train stopping with its coupling face at a minimum of 5.0 m from the signal, in addition to the position and reading range of the onboard antenna.

Balises for ETCS trainstops at platform departure signals shall be installed in advance of all operational stopping locations. Operational stopping locations are typically the car markers, if they exist, or the platform railing.

Balises at outer signals used for protecting high-risk turnouts and high-risk overruns should not be installed greater than 8.9 m in rear of the signal. This allows for a less restrictive speed profile to be transmitted for a train waiting at the signal if the protecting signal in advance clears, or the home signal of the turnout clears for the straight route. It is permissible for these balises to be installed greater than 8.9 m in rear of the signal to achieve the correct braking distance or to minimise cable trenching costs.

5.2.3. Guard rails and derailment plinths

Balises should not be placed within a derailment plinth or between guard rails, unless unavoidable.

To ensure both cross-talk protection and reliable transmission, guard rails at balises shall be provided with a special purpose insulated joint.

Balises between guard rails shall be installed longitudinally. This requirement prevents balises being installed between guard rails where the horizontal track radius is less than 300 m.

Refer to ERTMS/ETCS *FFFIS for Eurobalise* Subset-036 and SPG 0706 *Installation of Trackside Equipment*.

6. Data functions

The telegram transmitted by a balise consists of a balise header and a series of packets.

Each balise group function requires certain packets to be transmitted. The packets used are shown in Table 2.

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Table 2 – Packets used

Packet number	Packet name
0	Virtual balise cover marker
3	National values
5	Linking
6	Virtual balise cover order
12	Level 1 movement authority
16	Repositioning information
21	Gradient information
27	International static speed profile
41	Level transition order
65	Temporary speed restriction
67	Track condition: big metal masses
72	Plain text messages
80	Mode profile
132	Danger for shunting information
137	Stop if in staff responsible
180	LSSMA display toggle order
181	Generic LS function marker
254	Default balise, loop or RIU information
255	End of information

Refer to ERTMS/ETCS *System Requirements Specification Chapter 7 ERTMS/ETCS Language* Subset-026-7 for packet syntax and ERTMS/ETCS *System Requirements Specification Chapter 8 Messages* Subset-026-8 for balise header syntax.

Certain figures in this document show packet information for balise group messages. For completeness, all packets transmitted are shown, excluding packet #255, which is transmitted as a finishing flag for every telegram. Packet information that is pertinent to the particular balise group function is shown in boldface in the figures.

6.1. Confidence Interval

The onboard computer's estimated position of an announced balise group may not be at its actual position, mainly due to inaccuracies in the odometer. The actual position can be up to one half of the confidence interval distance, either side of the estimated position.

For any trackside design calculation that requires an estimation of the confidence interval, it shall be assumed as:

± (10 m + 5% * distance travelled from the last reference location).

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The 10 m encompasses the location accuracy national value of 5 m (Q_NVLOCACC) plus 5 m for the balise reading accuracy.

6.2. Linking

Linking is the announcement of balise groups in advance. The aim of linking is:

- to determine whether a balise group has been missed or not found within the expectation window and take the appropriate action
- to assign a coordinate system to balise groups consisting of a single balise
- to correct the confidence interval due to odometer inaccuracy

Refer to ERTMS/ETCS *System Requirements Specification Chapter 3 Principles* - Subset-026-3 for more information.

6.2.1. Q_LINK qualifier

The balise header contains the data variable Q_LINK, applicable to both directions, which marks the balise group as linked (Q_LINK=1) or unlinked (Q_LINK=0). Balise groups marked as unlinked are always processed by the onboard computer. Unexpected balise groups marked as linked are ignored by the onboard computer, unless no balise groups are expected.

All balises shall be marked as linked (Q_LINK=1) except for temporary speed warning (TSW) balise groups and those for yard entry and exit.

6.2.2. Packet #5

Packet #5 is used for linking to balise groups in advance.

In the signalled direction, all balise groups shall be linked to (by the balise group(s) in the rear), with the following exceptions:

- unlinked (Q_LINK=0) balise groups
- big metal mass announcement balise groups in level 0 territory
- level 0 to level 1 transition announcement balise groups

In the unsignalled direction, only the following balise groups shall be linked to:

- both balise groups announcing a level crossing
- the first (or only) wrong running entry balise group

  The exception to this is where the approach to the wrong running entry balise group is always after a trip order, such as from an ETCS trainstop at a fixed red signal. This is because the stored linking information is deleted from the onboard computer when the trip order is received.

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For a balise group that transmits linking (packet #5), it shall link to two balise groups that transmit a static speed profile (packet #27) and linking applicable to the direction of travel. All other balise groups in between that are marked as linked shall also be linked. Exceptions to this requirement are as follows:

- Balise groups in rear of an ETCS trainstop balise group shall not link to a balise group in advance of this ETCS trainstop balise group. This is because the stored linking information is deleted from the onboard computer if a service brake linking reaction occurs as a result of the ETCS trainstop balise group being missed.
- Balise groups in rear of a repositioning balise group shall not link to a balise group in advance of this repositioning balise group. This is due to expectation window issues.

Yard entry and yard exit balise groups cannot perform linking as they are marked as unlinked.

A value of 5 m shall be allocated to the data variable Q_LOCACC.

6.2.3. Reaction

For a balise group that is linked to, it is expected to be read within a distance expectation window. This distance is calculated by the onboard computer, based on the true distance to the balise group (assigned to the data variable D_LINK) and the confidence interval on either side of it. If a balise group that is linked to is missed or the message from it is deemed inconsistent, then a linking reaction occurs. The type of reaction is transmitted by the data variable Q_LINKREACTION.

When linking to an ETCS trainstop, the linking reaction shall be to command the service brake. When linking to all other balise groups, the linking reaction shall be 'no reaction'; however, the onboard equipment will be configured such that a message appears on the driver machine interface (DMI).

The onboard equipment has an inbuilt safety feature. If two consecutive balise groups announced by linking are not detected and the end of the linking expectation window of the second balise group has been passed, then the onboard equipment commands the service brake regardless of the linking reaction.

6.2.4. Repositioning

At facing points, it is not always possible to know which balise group to link to. Therefore, a special value for an unknown identity is used in the linking information. A balise group that links to an unknown identity is termed as a ‘repositioning announcement balise group’. The repositioning announcement function does not require a dedicated balise group. The function shall be combined with the balise group that is first in rear of the facing points.

The first balise group in advance of facing points (in each position) is termed as a repositioning balise group. It contains packet #16.

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The D_LINK distance in the repositioning announcement balise group shall be the distance to the farthest repositioning balise group.

The expectation window for repositioning extends from the last repositioning announcement balise group to one half of the confidence interval in advance of the D_LINK distance. Only one balise group shall be passed in the repositioning expectation window.

In the signalled direction, repositioning shall be used for all facing turnouts - low-risk and high-risk, regardless of whether there are signalled moves through both point positions and if the balise group that will be passed next is known. This solution minimises the signalling interface and provides a simple and consistent method.

> *This application of repositioning differs in part from the ERA intent, in so far as repositioning is not used to provide an extension to the movement authority.*

Repositioning is not required where there is no requirement for linking. For example, there is no requirement to link to a yard entry balise group. Repositioning is not required where there is no balise group through one of the turnout positions. For example, there is no requirement for repositioning for a turnout to an unfitted siding.

In the unsignalled direction, repositioning shall only be provided where there is a requirement for linking.

The repositioning balise groups that are linked to from a given repositioning announcement balise group shall all have the same nominal direction; however, this nominal direction may be different to the repositioning announcement balise groups. This requirement needs consideration where the Up and Down directions change at a facing junction, for example at a triangle. A dedicated repositioning balise group may be required on the fork that has the change of direction. This requirement also needs consideration where repositioning is combined with a balise group of the opposite nominal direction.

As a repositioning balise group cannot contain a movement authority for the same direction, a repositioning balise group cannot be combined with another function that requires a movement authority for the same direction. As a mode profile is always accompanied by a movement authority, a repositioning balise group cannot be combined with another function that requires a mode change for the same direction. In other words, packet #16 cannot be combined in a balise group that has packet #12 or packet #80 for the same direction.

A balise group used for initiating target speed monitoring (TSM) shall not contain repositioning information for the same direction. This is to ensure that a train travelling in staff responsible (SR) mode is transitioned to limited supervision (LS) mode when approaching a hazard. This requirement does not apply to redundant TSM balise groups.

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Thus a repositioning balise group cannot be combined with the following functions for the same direction:

- ETCS trainstops
- TSM-initiating balise groups (for buffer stops, high-risk speed signs, high-risk turnouts, high-risk overruns and wrong running level crossings)
- buffer stop balise groups
- buffer stop redundant TSM balise groups
- mode change balise groups providing an early change to LS mode after a train turns back

See Section 7.8.1 where a repositioning balise group is required to be used as a wrong running entry balise group. See Section 7.8.2 where a repositioning balise group is required to be used as a wrong running exit balise group.

Repositioning for low-risk turnouts

For a low-risk turnout, the repositioning balise group on the diverging line typically transmits the new line speed. The preferred position is as close as possible (up to 10 m) in advance of the end of the (last) turnout or crossover. See Figure 1. A position that is less than 160 m in advance of the end of the (last) turnout or crossover is permitted to allow the repositioning function to be combined in a balise group performing another function. See Figure 2. The 160 m maximum distance avoids the operational restriction of providing a line speed update after the rear of a typical 8-car electric multiple unit (EMU) has cleared the points. A position greater than 160 m is permitted if there is no speed difference on the diverging line.

The end of a crossover is assumed to be at the toe of the trailing end. The end of a turnout is assumed to be at the first insulated joint past the clearance point.

Apart from the expectation window requirements and those described in Section 5.2, the repositioning balise group on the non-diverging line has no specific positioning requirements. The repositioning function will typically be combined in a balise group performing another function.

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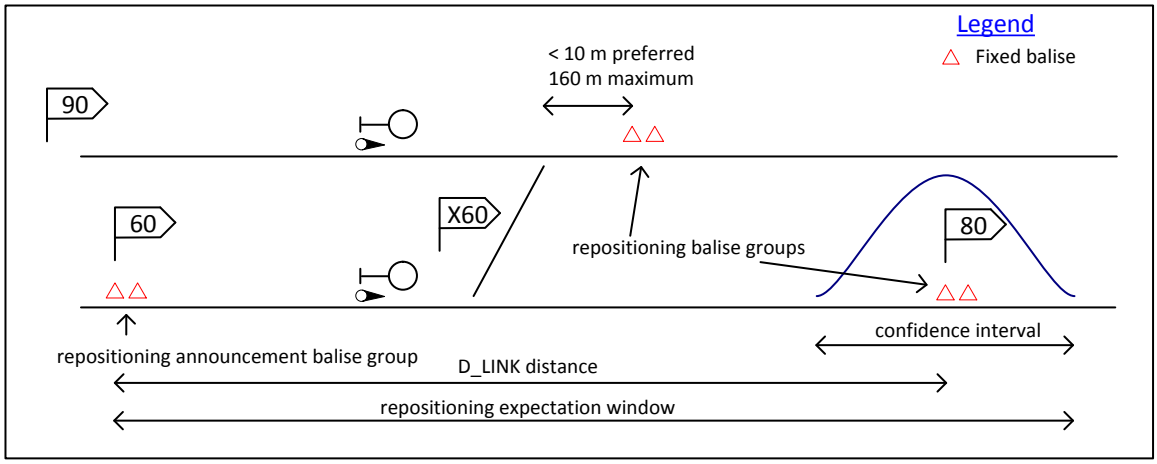

Figure 1 - Repositioning – low-risk turnout through a crossover

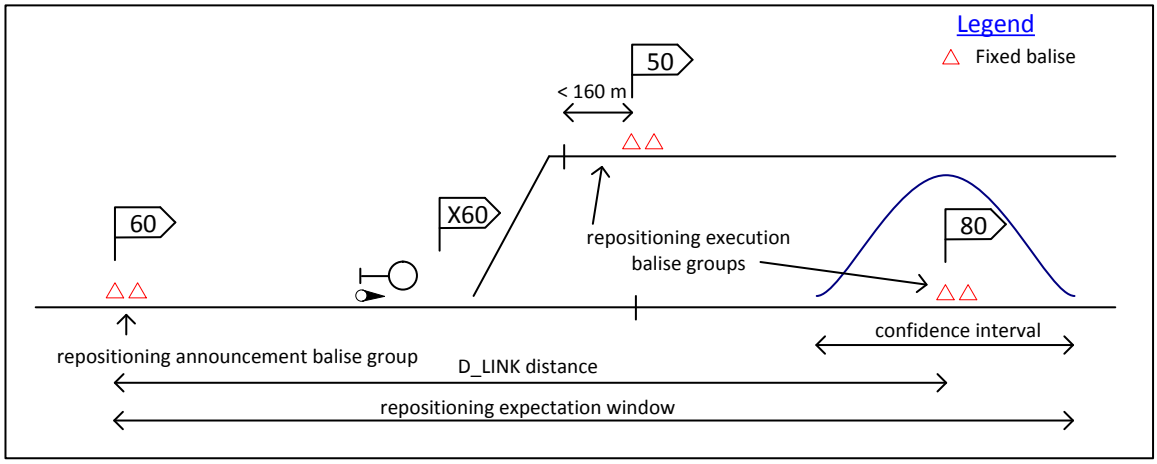

Figure 2 - Repositioning – low-risk turnout to a refuge line

Repositioning for high-risk turnouts

For a high-risk turnout, the repositioning balise groups shall toggle-off the display of the LSSMA when required and typically transmit line speed.

The repositioning balise group on the diverging line shall be in advance of the end of the turnout or crossover. The preferred position is 160 m in advance of the end of the last turnout or crossover. It may be up to 200 m in advance of the end of the last turnout or crossover. The position is not as critical as a low-risk turnout, as the diverging line speed is typically sent as an iteration by the repositioning announcement balise group. Refer to Section 8.3.2 for more information on when the diverging line speed is sent. The 160 m and 200 m distances aim to minimise the operational restriction for EMUs, consisting of 8 cars and 10 cars respectively. This is achieved by providing a line speed update in the situations where either the diverging line speed has not been sent by the repositioning announcement balise group or where the repositioning balise group is missed.

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The distances also aim to achieve the following:

- maintain the display of the LSSMA while the train is traversing the points
- minimise the distance that the LSSMA is displayed after the rear of the train has cleared the points, as the value of the LSSMA may step up to line speed

The repositioning balise group on the non-diverging line shall be in advance of the turnout and as close to the turnout as possible.

6.3. ETCS onboard equipment modes

Refer to T HR SC 01650 SP *ETCS Onboard Equipment* for details specific to onboard subsystem.

6.3.1. Modes used

Where a mode transition is ordered from the trackside subsystem, the mode transition is achieved by transmitting packet #80, which contains the mode profile associated with a movement authority.

Refer to ETRMS/ETCS *System Requirements Specification Chapter 4 Modes and Transitions* - Subset-026-4 for a full description of all mode transitions and the conditions required for each transition.

This section shows the following:

- the modes used by the onboard equipment
- some of the common mode transitions
- details specific to the trackside subsystem

Limited supervision

Limited supervision (LS) is the desired mode on running lines for both signalled and unsignalled moves. The LS mode cannot be selected by the driver. The order to change to LS mode shall be transmitted whenever a movement authority (MA) is transmitted for a given direction.

After a train has been tripped, re-entering LS mode cannot be achieved until a valid message is received from a balise group that transmits a movement authority and the order to change to LS mode for the applicable direction.

In LS mode, balise groups shall transmit the maximum network speed of 160 km/h for the V_MAMODE variable in packet #80, except for wrong running situations. Refer to Section 7.8 for details.

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Trip

Trip (TR) mode commands the emergency brake.

Post trip

Post trip (PT) mode can be entered from TR mode if certain conditions are met, including the train being at a standstill. PT mode removes the emergency brake command.

Staff responsible

Staff responsible (SR) mode allows drivers to move trains under their own responsibility. SR mode may be selected by the driver from PT mode. SR mode is also used after the onboard equipment starts-up. A train is required to be in SR mode before it exits an ETCS-protected yard. Speed is limited by the SR mode speed limit (V_NVSTFF) of 40 km/h.

Shunting (SH)

Shunting (SH) is the desired mode for movements within yards, where speed is limited by the SH mode speed limit (V_NVSHUNT) of 25 km/h. The order to change to SH mode shall be transmitted when entering an ETCS protected yard. Operational procedures specify that SH mode should be manually selected by the driver for amalgamating, dividing or setting back, if not already in SH mode.

Other modes used are as follows:

- sleeping (SL)
- non-leading (NL)
- isolation (IS)
- system failure (SF)
- standby (SB)
- unfitted (UN)

6.3.2. Modes not used

- full supervision (FS)
- no power (NP)
- on sight (OS)
- national system (SN)
- reversing (RV)
- passive shunting (PS)

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6.3.3. Stop if in SH mode

Certain balise group functions transmit packet #132, which contains the 'Danger for Shunting' information. This packet transmits the 'Stop if in SH mode' order to trip the train if in shunting mode.

6.3.4. Stop if in SR mode

Certain balise group functions transmit packet #137, which contains the 'Stop if in Staff Responsible' information. This packet transmits the 'Stop if in SR mode' order to trip the train if in staff responsible mode.

6.4. Movement authorities

Packet #12 contains the MA. The data shall treat the MA as a single section.

The section length of all movement authorities shall be of the maximum value allowed in the data, with the following exceptions:

- ETCS trainstop balise groups when transmitting a trip order
- buffer stop balise groups
- buffer stop TSM-initiating balise groups
- buffer stop redundant TSM balise groups

The order to change to level 1 (using packet #41) and the order to change to LS mode (using packet #80) shall be transmitted whenever an MA is transmitted for a given direction. The exception is that packet #80 shall not be transmitted at buffer stop balise groups.

Balise groups in a level 0 area shall not transmit an MA, unless announcing a transition to level 1. Balise groups transmitting an immediate transition order to level 0 shall not transmit an MA for the same direction.

6.5. Gradient

Packet #21 contains gradient information and is transmitted for the applicable direction from the following balise groups:

- those transmitting packet #12 for the same direction
- redundant TSM balise groups
- TSM-initiating balise groups

Each gradient section shall be expressed as per mille (‰), safely rounded down to the nearest integer. For example, a 1.43% rising grade would be expressed as 14‰, and a -1.43% falling

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grade would be expressed as -15‰. The term 'lower gradient', used below, implies a lower per mille value. For example, -3‰ is lower than 2‰.

The gradient of the line shall be transmitted when the onboard computer is required to calculate a TSM braking curve. The default gradient of -35‰ shall be transmitted otherwise.

The vertical alignment database (VAD) shall be the source of gradient information. For a section containing a vertical curve (easement), the VAD shows the section split in two, with each half becoming part of the adjoining gradient section. This approach shall also be used for gradient information that cannot be sourced from the VAD.

This requirement differs from ERTMS/ETCS System Requirements Specification Chapter 3 Principles - Subset-026-3.

The gradient of the line shall be provided from a point 120% of the braking tool ‘permitted’ braking distance in rear of the farthest target point, up to the farthest target point. The extra 20% is to allow the onboard computer to accurately calculate the TSM braking curve.

Where the approach to a target point traverses a crossover, the gradient for the crossover shall be assumed to be the lower of the lines.

The braking tool has a maximum of 10 gradient sections. If there are more than ten sections of gradient over the required distance, then a gradient simplification process shall be followed to reduce the number to no more than ten. An iterative process may be required as the braking tool results and the gradient simplification results are dependent upon each other.

To limit the amount of data transmitted, a maximum of 12 gradient sections shall be transmitted for each direction. These sections shall consist of the (maximum 10) sections as used in the braking tool, plus the default gradient at either end.

6.5.1. Gradient simplification

The steps for gradient simplification shall be applied in the following order until there are no more than 10 gradient sections. Within step 1 and step 3, the simplification is to be applied in the order of travel.

Step 1:

For a gradient section of less than 150 m adjoining a lower gradient section at one end, the section shall be assumed to be part of the lower gradient section.

For a gradient section of less than 150 m adjoining lower gradient sections at both ends, the section shall be assumed to be part of the section with the higher gradient of the two.

Step 2:

The initial sections shall be combined and assumed to have a gradient of the lowest of these sections. The initial sections shall be assumed to start at the 120% point described above and

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end at the point where the braking tool emergency brake deceleration (EBD) curve is 10 km/h above the line speed.

Step 3:

Step 1 shall be repeated, without the 150 m constraint.

6.6. Target speed monitoring

Target speed monitoring (TSM) is where train speed is supervised to an onboard calculated braking curve, braking to a target speed at a target point. The TSM target information is transmitted by balise groups in rear of the target.

TSM shall be used when approaching buffer stops, high-risk speed signs, high-risk turnouts, high-risk overruns and wrong running level crossings. All possible approaches to these hazards shall be considered.

6.6.1. Redundancy

The TSM target information shall be sent from two balise groups.

The first transmission is for redundancy purposes, providing a fail-safe solution for these high risk locations if the second transmission is missed. This first transmission is typically transmitted from a balise group provided for another purpose. The balise group is termed the ‘redundant TSM balise group’. A dedicated balise group may be necessary in certain layouts, for example where the target point is in advance of a facing turnout.

This redundant TSM shall be transmitted regardless of the signalling controls and can be transmitted from a fixed balise group. It shall be the most restrictive TSM associated with the hazard.

The second transmission is from a balise group termed the ‘TSM-initiating balise group’. One balise in this balise group shall be controlled by an LEU if the TSM is dependent upon signalling controls.

6.6.2. Lowest supervised speed within the movement authority

The display to the driver of the lowest supervised speed within the movement authority (LSSMA) is toggled on or off by the use of packet #180. Packet #181 shall always accompany packet #180, enabling this toggling.

The LSSMA shall be displayed when TSM is used approaching high-risk overruns and approaching and traversing high-risk turnouts. The LSSMA shall also be displayed for high-risk turnouts under any of the conditions where TSM is used; for example, where the home signal of the turnout is at stop at the time of passing the TSM-initiating balise group.

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The LSSMA shall not be displayed for a high-risk converging junction, as TSM is always applied.

On an approach that includes a turnout or crossover, the design shall ensure that the LSSMA speed displayed to the driver is not higher than the turnout speed on the approach.

The toggle-on order shall be transmitted by the TSM-initiating balise group. The toggle-off order shall be transmitted by all other balise groups, except where it is possible that a cascading function requires the display of the LSSMA to remain toggled on.

After traversing a high-risk turnout, the display of the LSSMA is to remain toggled on until passing the repositioning balise group.

For a high-risk overrun, the display of the LSSMA is to remain toggled on until passing the protecting signal or until passing the balise group associated with the protecting signal. The toggle-off order shall be transmitted by a balise group up to 8.9 m in rear of, or up to 10 m in advance of the protecting signal. This balise group shall be fixed unless the toggle-off function is combined with a function requiring a controlled balise group.

6.6.3. Braking tool

The braking tool is a customised version of the European Union Agency for Railways (ERA) braking curves tool. The ERA publishes an accompanying handbook for this tool.

The braking tool has been customised by applying the following:

- service brake
  - deceleration rate of -0.76 ms^{-2} (derived from the GE76 braking curve)
  - brake delay of 1.7 seconds
- emergency brake
  - deceleration rate of -0.6 ms^{-2} (derived from the GE52 braking curve)
  - brake delay of 3.1 seconds

The 'permitted distance' results given by the braking tool shall be used as an input for all TSM design. The TSM-initiating balise group shall not be closer to the target point than this permitted distance.

Buffer stops shall use the 'EOA or SvL' (end of authority or supervised location) option with fixed release speed. All other TSM calculations shall use the 'LOA/MRSP' (limit of authority or most restrictive speed profile) option.

The location accuracy of all ‘relocation balises’ shall be 5 m. Refer to ERTMS/ETCS *System Requirements Specification Chapter 3 Principles* Subset-026-3 for the balises that are considered as relocation balises.

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6.7. National values

National values are variables applicable to the whole network. Packet #3 contains the national values.

National values shall be transmitted for movements in both directions at all yard exit balise groups, and at all level transition announcement and border balise groups. The values shall be applicable immediately when received.

Table 3 specifies the applicable national values.

Table 3 – National values

Variable	Explanation	Value
NID_C	Identity number of the country or region	540
V_NVSHUNT	SH mode speed limit	25 km/h
V_NVSTFF	SR mode speed limit	40 km/h
V_NVONSIGHT	On sight mode speed limit	30 km/h
V_NVLIMSUPERV	LS mode speed limit	40 km/h
V_NVUNFIT	Unfitted mode speed limit	160 km/h
V_NVREL	Release speed	40 km/h
D_NVROLL	Roll away distance limit	2 m
Q_NVSBTSMPERM	Permission to use service brake in TSM	Yes
Q_NVEMRRLS	Permission to revoke the emergency brake command	Only at standstill
Q_NVGUIPERM	Permission to use the guidance curve	No
Q_NVSBFBPERM	Permission to use the service brake feedback	No
Q_NVINHSMICPERM	Permission to inhibit the compensation of the speed measurement inaccuracy	No
V_NVALLOWOVTRP	Speed limit allowing the driver to select the override function	0 km/h
V_NVSUPOVTRP	Override speed limit to be supervised when the override function is active	25 km/h
D_NVOVTRP	Maximum distance for overriding the train trip	100 m
T_NVOVTRP	Maximum time for overriding the train trip	45 s
D_NVPOTRP	Maximum distance for reversing in post trip mode	0 m
M_NVCONTACT	T_NVCONTACT reaction	No reaction
T_NVCONTACT	Maximum time without new safe message	∞ s
M_NVDERUN	Entry of driver ID permitted while running	Yes
D_NVSTFF	Maximum distance for running in SR mode	∞ m
Q_NVDRIVER_ADHES	Qualifier for the modification of trackside adhesion factor by driver	Not allowed

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Variable	Explanation	Value
A_NVMAXREDADH1	Maximum deceleration under reduced adhesion conditions (1)	1.0 ms^{-2}
A_NVMAXREDADH2	Maximum deceleration under reduced adhesion conditions (2)	0.7 ms^{-2}
A_NVMAXREDADH3	Maximum deceleration under reduced adhesion conditions (3)	0.7 ms^{-2}
Q_NVLOCACC	Default accuracy of the balise location (absolute value)	5 m
M_NVAVADH	Weighting factor for available wheel or rail adhesion	0
M_NVEBCL	Confidence level for emergency brake safe deceleration on dry rails	9
Q_NVKINT	Qualifier for integrated correction factors	0

6.8. Data variables

The data variables shall be set as indicated in Table 4.

Table 4 - Data variables

Variable	Explanation	Value
Q_SCALE	Qualifier for the distance scale	1 m
Q_UPDOWN	Balise telegram transmission direction	Up link telegram
M_VERSION	Version of ETCS system	2.0
Q_MEDIA	Qualifier to indicate the type of media	Balise
M_DUP	Duplicate balise	No duplicates
V_MAIN	Signalling related speed restriction (where there is no trip)	160 km/h
V_LOA	Permitted speed at the limit of authority (where there is no trip or not approaching a buffer stop)	160 km/h
V_LOA	Permitted speed at the limit of authority (trip order or approaching a buffer stop)	0 km/h
T_LOA	Validity time for the target speed at the limit of authority (where there is no trip or not approaching a buffer stop)	∞ s
T_LOA	Validity time for the target speed at the limit of authority (trip order or approaching a buffer stop)	0 s
Q_DANGERPOINT	Qualifier for danger point description (not approaching a buffer stop)	0
Q_DANGERPOINT	Qualifier for danger point description (approaching a buffer stop)	1
Q_ENDTIMER	Qualifier to indicate whether end section timer information exists for the end section in the MA	0
Q_OVERLAP	Qualifier to tell whether there is an overlap	0

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Variable	Explanation	Value
L_SECTION	Length of section in the MA (in a repositioning balise group not in advance of a buffer stop TSM-initiating balise group)	32767 m
L_SECTION	Length of section in the MA (in a repositioning balise group in advance of a buffer stop TSM-initiating balise group)	Distance to EOA
L_ACKMAMODE	Length of the acknowledgement area in rear of the start of the required mode	0 m
L_MAMODE	Length of the area of the required mode	Infinite length
Q_MAMODE	Qualifier to indicate the supervision of the beginning of the mode profile	0

The data variable for the message counter, M_MCOUNT shall have values assigned as indicated in Table 5.

Table 5 - M_MCOUNT values

Balise type	Function	M_MCOUNT
Fixed	All	255
Controlled	Default telegram	254
Controlled	Line speed	1
Controlled	ETCS trainstop trip	2
Controlled	High-risk overrun: protecting signal at stop	3
Controlled	High-risk turnout: home signal at stop (unless this aspect has been assigned an M_MCOUNT for another function)	10
Controlled	High-risk turnout: home signal clear for its only turnout	11
Controlled	High-risk turnout: home signal clear for a turnout (values allocated from least to most restrictive) (values to be equal for equal speed profiles)	11 to 19

In a cascading function situation where a message covers more than one TSM, the M_MCOUNT value shall be assigned according to the most restrictive TSM.

6.9. Virtual balise cover

The virtual balise cover (VBC) function allows a balise group or a set of balise groups to be ignored by the onboard computer.

This function may be used to allow trains to ignore balise groups that have been installed and not yet commissioned. This shall be achieved by installing dedicated temporary balise groups on each approach to the yet-to-be commissioned area. Using packet #6, these VBC order balise groups shall either set or remove the VBC for the applicable direction.

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The VBC order function shall be transmitted from two consecutive balise groups for redundancy. VBC orders shall have a validity period of 7 days.

For a balise to be able to be ignored, it is required that the balise transmits a marker identification in packet #0. All balises shall transmit packet #0 except for big metal mass announcement balise groups in level 0 territory, yard exit balise groups (in their final configuration) and TSW balise groups. The marker identification shall be the number 63 for balises in VBC balise groups and the number 1 for all other balises that transmit packet #0.

Yard exit balise groups shall transmit packet #6 to remove any VBC that may be stored. Where a yet-to-be commissioned area is in advance of the yard exit, the yard exit balise groups shall transmit packet #0.

7. Fixed balise group functions

A fixed balise group is a balise group that always transmits the same message; that is, the message is not dependent upon any signalling controls and thus an LEU is not required. The functions described in this section, in addition to repositioning and LSSMA toggle-off, shall be implemented using fixed balise groups, except where these functions can be combined with other functions requiring a controlled balise group.

7.1. Level transitions

Level transitions shall be provided between level 0 and level 1 territory.

The electrified areas not fitted with ETCS are defined as level 0 territory. This includes the areas not yet fitted, in addition to the electrified portions of metropolitan freight lines. The only balise groups used in level 0 territory are for big metal masses, temporary speed warning signs, VBC orders and announcement of level transitions.

Packet #41 contains the level transition information.

7.1.1. Level transition borders

There are level transition borders where level 0 territory meets level 1 territory.

A balise group shall be placed within 3 m of each level transition border. It shall transmit an immediate level transition, achieved by the data variable D_LEVELTR assigned the value of 32767. The order to change to level 1 shall additionally be transmitted by other balise groups whenever an MA is transmitted for a given direction.

On a unidirectional line, the level transition balise group shall transmit a level 1 transition for one direction and a level 0 transition for the other. Figure 3 shows a unidirectional double line with level transition borders.

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On a single line or bi-directional line, the up and down level transition borders should coincide or be placed in close proximity. If the borders coincide, then this reduces the number of balises required. If the borders are in close proximity, then this aids drivers' route knowledge.

Where there are multiple lines, the level transition borders for each line should be in close proximity to aid drivers' route knowledge.

Where the level 0 and level 1 border transitions do not coincide on a given line, the 'BEGIN ATP' and 'END ATP' signs shall be placed adjacent to their relevant reference balise. Where the transitions coincide, the back-to-back 'BEGIN ATP' and 'END ATP' signs shall be placed adjacent to the reference balise, with the primary purpose of the balise group deemed to be for the normal running direction.

The location of level transition borders should be chosen where the driver is less likely to be concentrating on other critical tasks. To achieve this and to minimise certain risks associated with the transition, the following provides guidance on the location of level transition borders:

- level transition borders should be placed as follows:
  - in automatic sections or outside of yard limits
  - in areas with good sighting
  - where the first signal in the level 0 area has a trip arm style trainstop
- level transition borders should not be placed as follows:
  - close to stations, interlockings or level crossings
  - in areas of closely spaced signals
- level transition borders shall not be placed:
  - in areas where if a driver fails to acknowledge a transition, it will result in the train stopping in a tunnel, on a bridge or on a viaduct
  - in areas of insufficient braking in rear of hazards requiring ETCS protection, when entering level 1 territory
  - less than 1 km in the rear of what would be deemed a high-risk speed sign, high-risk turnout or high-risk overrun, when entering level 0 territory

To allow the driver to select either level 0 or level 1, packet #41 shall transmit the following in addition to the immediate transition:

- for a transition from level 0 to level 1, an iteration containing level 0 as a lower priority
- for a transition from level 1 to level 0, an iteration containing level 1 as a lower priority

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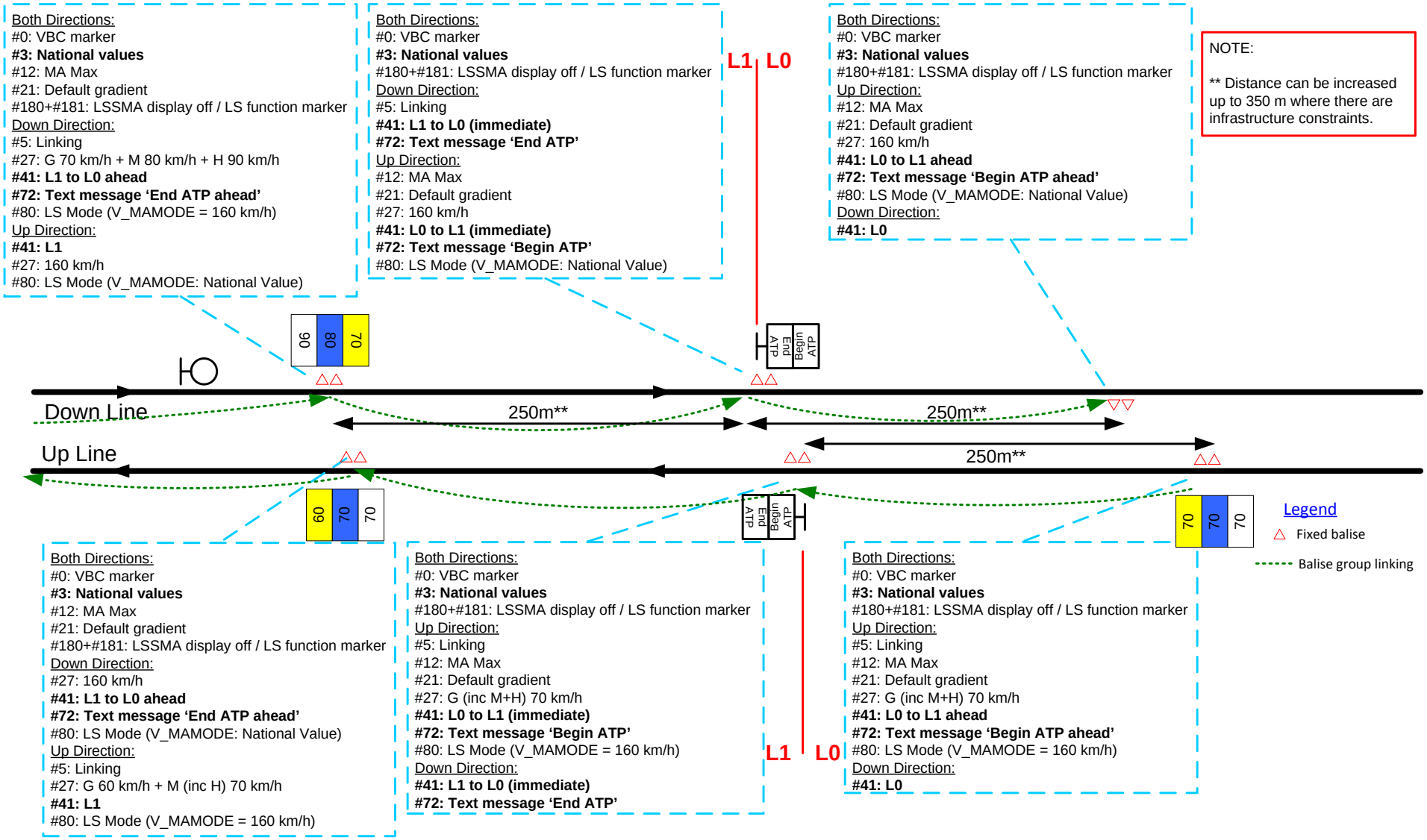

Figure 3 – Level transition

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7.1.2. Level transition announcement

Announcement balise groups shall be provided on both approaches to level transition borders. The preferred position is 250 m in rear; however, it may be up to 350 m if infrastructure constraints do not permit. The exception to this is for the level 1 to level 0 transition announcement for the unsignalled direction. There is no positional requirement for this function. Therefore this function typically does not need a dedicated balise group, and is typically combined in the balise group closest to the transition border.

Announcement balise groups should be placed at a speed sign, unless a speed sign is not present in the vicinity. This allows the driver sufficient distance to react to the speed sign before reaching the level transition. It can also allow the balise group to be reused for the speed sign in a subsequent stage.

The announcement balise group shall transmit a distance-delayed level transition order, providing redundancy for the level transition border balise group. The distance shall be the distance to the level transition border plus half the confidence interval.

7.1.3. Text messages

Level transition and announcement balise groups shall transmit ‘important’, ‘plain’ text messages to be displayed to the driver. Packet #72 contains the text for the message. Driver acknowledgment shall not be requested.

The message transmitted by the level 0 to level 1 transition announcement balise groups shall be 'Begin ATP ahead'.

The message transmitted by the level 1 to level 0 transition announcement balise groups shall be 'End ATP ahead'.

These level transition announcement messages shall be displayed immediately upon passing the announcement balise groups, and shall continue to be displayed until the level changes.

The message transmitted by the level 0 to level 1 transition border balise groups shall be 'Begin ATP'.

The message transmitted by the level 1 to level 0 transition border balise groups shall be 'End ATP'.

These level transition border messages shall be displayed immediately upon the level change, and shall continue to be displayed for 5 seconds.

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7.2. Speed signs

The scope for speed signs includes all permanent track speed sign, except for the following:

- advisory speed signs
- turnout speed signs
- yards speed signs
- intermediate trainstop speed signs
- freight speed signs

A balise group shall be placed at each speed sign in the scope, except where a balise group placed there could unintentionally revoke TSM. For such speed signs, the speeds shall be transmitted as a distance-delayed iteration by the TSM-initiating balise group in rear of the speed sign.

The speed sign balise group shall preferably have the reference balise adjacent to the speed sign. This balise may be placed up to 20 m in rear or advance of the speed sign for a speed increase or up to 20 m in advance for a speed decrease.

Figure 4 and Figure 5 show examples of balise groups at speed signs.

Packet #27 transmits the static speed profiles (SSP). Three profiles shall be transmitted as general, medium and high as published in the Train Operating Conditions (TOC) Manual and subsequent weekly notices.

The speeds for normal, multiple unit (MU) and express passenger train (XPT) speed signs shall be transmitted as the general, medium and high profiles respectively.

The general profile shall be the ‘basic’ profile transmitted. The medium profile shall be transmitted utilising the variables Q_DIFF=0 and NC_CDDIFF=1.The high profile shall be transmitted utilising the variables Q_DIFF=0 and NC_CDDIFF=2. To reduce the amount of data transmitted, medium or high speed profiles, or both, shall not be sent if they are the same speed as a transmitted lower speed profile.

Any discrepancies between the TOC manual and installed speed signs shall be resolved before the design is finalised.

Train length delay shall not be enforced at a speed sign.

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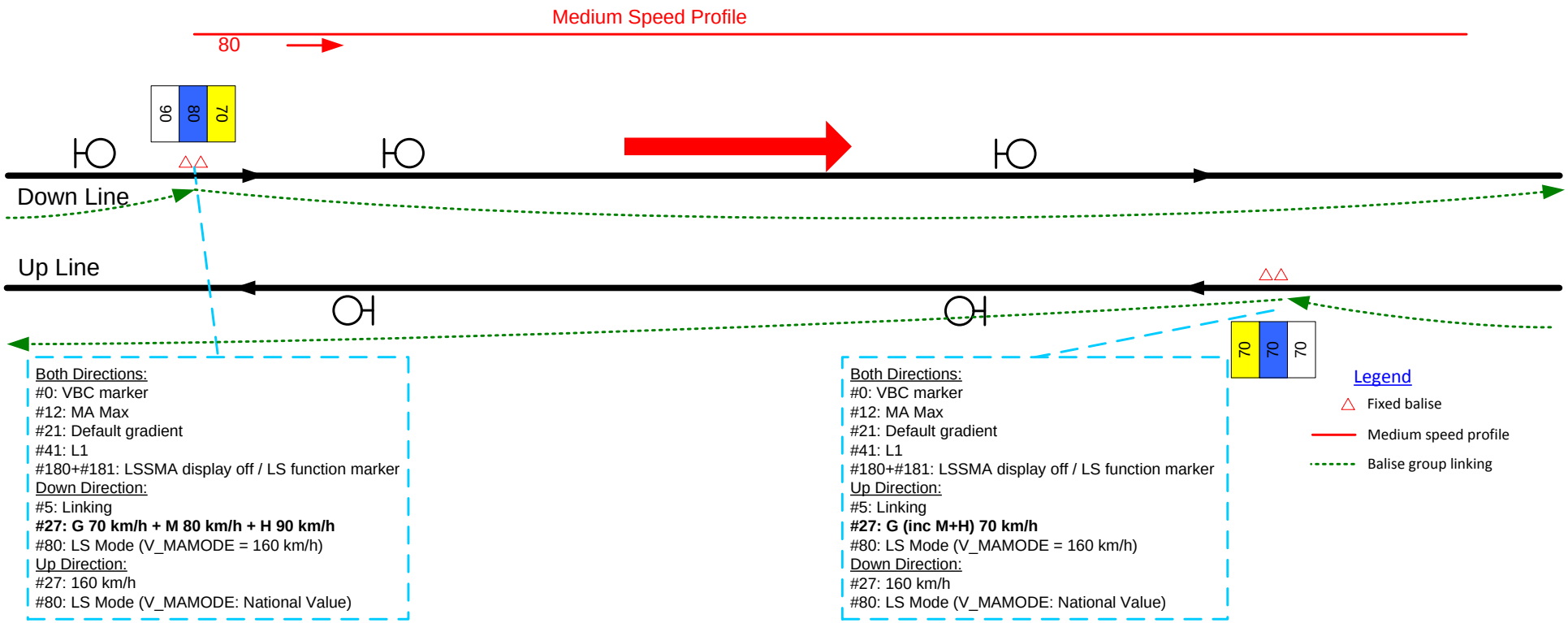

Figure 4 – Speed signs – unidirectional line

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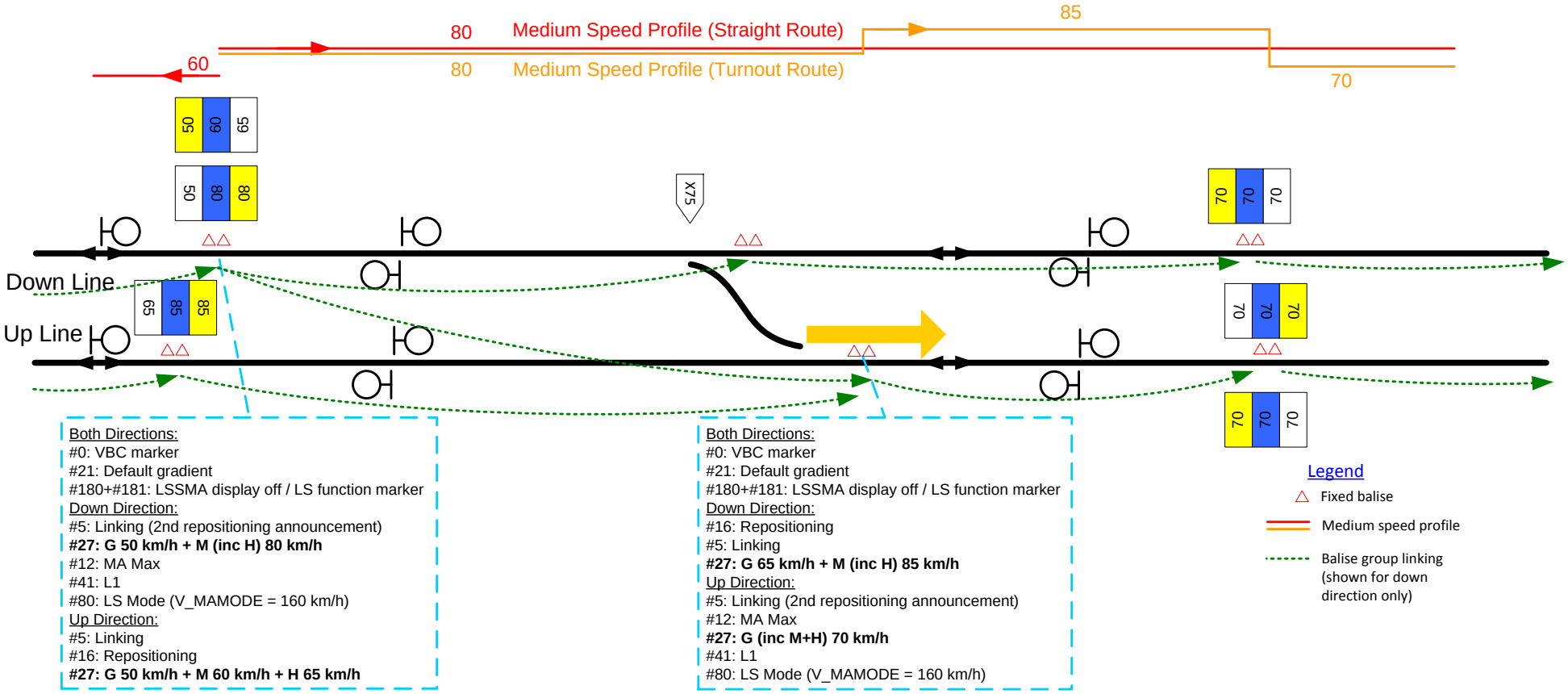

Figure 5 – Speed signs – bidirectional lines

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7.2.1. High-risk speed signs

Speeds signs in the scope as specified in Section 7.2 are classified as either low-risk or high-risk.

Balise groups at low-risk speed signs provide ceiling speed monitoring (CSM), where speed is supervised without the need to brake to a target. Where a low-risk speed sign indicates a reduction in line speed, the train is not supervised to this new line speed until the speed sign is passed. Where there is a deemed risk of a train travelling faster than the new line speed at (or just in advance of) the speed sign, then the speed sign is deemed high-risk, and is protected by announcing it from a balise group in the rear, using TSM with the speed sign as the target. See Figure 6.

The braking tool shall be used to determine which balise group in rear of the high-risk speed sign becomes the TSM-initiating balise group.

Speeds signs can only be deemed high risk if they indicate a reduction in line speed for the medium or high profiles. The general profile does not need to be considered in determining high-risk speed signs.

A speed sign shall be deemed high-risk if there is a specified hazard within the deceleration distance in advance of the speed sign, assuming deceleration does not start until the train is at the speed sign. This deceleration distance shall be calculated as the distance travelled in 2 seconds at the approach line speed, plus the distance travelled to decelerate to the posted line speed at a deceleration rate of -0.6 ms^{-2}.

The specified hazards are as follows:

- a timed level crossing approach where over-speeding would result in a warning time less than the minimum required
- a deemed high-risk level crossing protected by controlled signals
- a manually controlled level crossing
- a platform

If the above specified hazards do not exist in the deceleration distance, then the following shall apply:

- The speed sign shall be deemed low-risk if the speed reduction is 17% or less.
- If the speed reduction is greater than 17% and less than or equal to 25%, then the speed sign shall be deemed as high-risk if the track in the deceleration distance is curved horizontally. In this context, being curved is defined as having any curve tighter than 500 m radius, or having any curve tighter than 950 m radius if the approach line speed is greater than 115 km/h.

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- If the speed reduction is greater than 25%, then the speed sign shall be deemed high-risk.

Speed reductions shall be calculated as a percentage of the posted line speed. For example, a reduction from an approach line speed of 100 km/h to a posted line speed of 80 km/h shall be considered a 25% speed reduction.

For high-risk turnouts and high-risk overruns, the determination of those being high-risk is generally based on the approach speed to the first warning signal protecting the hazard. For situations where a speed sign exists between the first warning signal and the hazard, it may be possible to sufficiently mitigate the hazard by treating the speed sign as high-risk. If this is possible, then this solution shall be implemented, as it can be achieved by the use of fixed balise groups.

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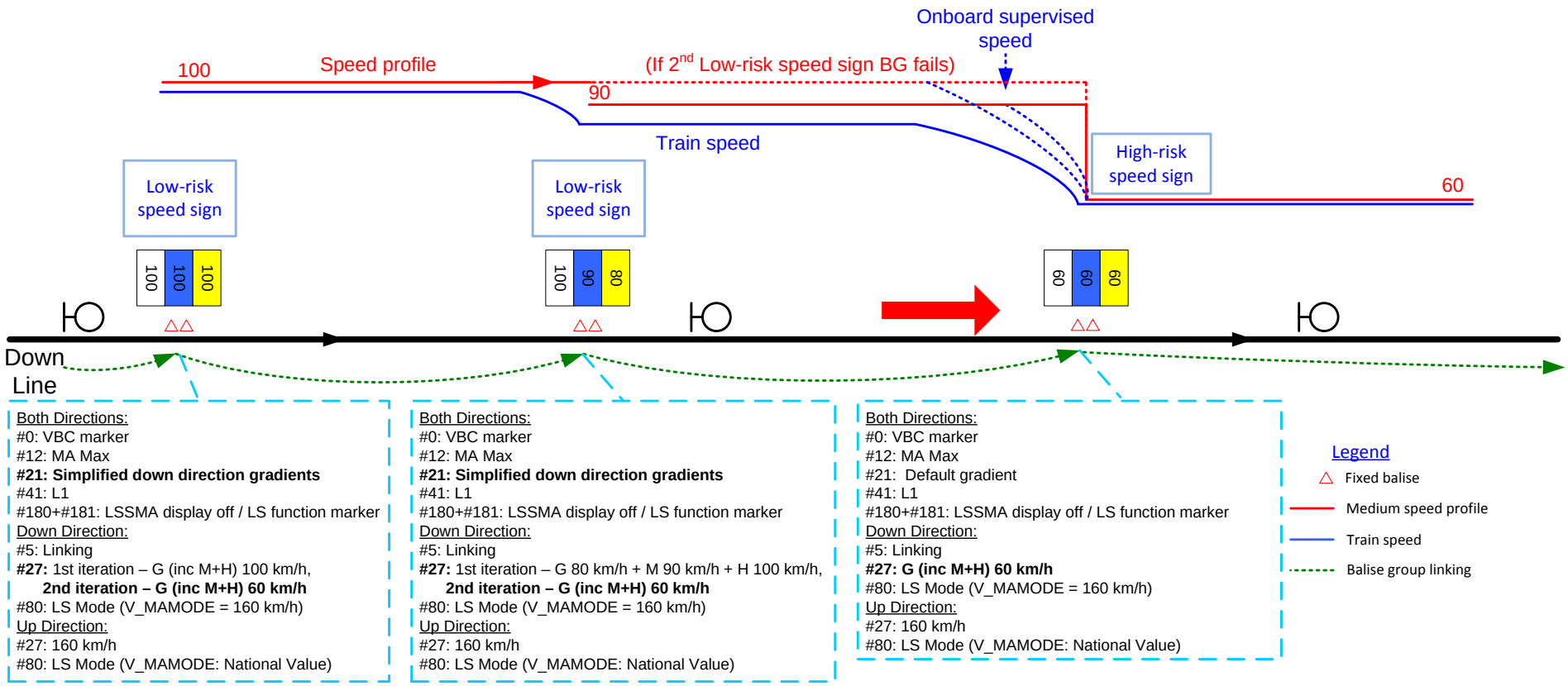

Figure 6 – High-risk speed sign

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7.2.2. Converging junctions

For a converging junction, the criteria for determining high-risk turnouts shall apply, as the derailment risk is based upon track geometry.

The protection for a high-risk converging junction shall be according to a high-risk speed sign. A balise group is not required at the turnout speed sign. The display of the LSSMA shall not be toggled on.

The same protection shall apply to facing turnouts where the only signalled moves are through the points in the turning out lay.

The line speed in advance of the convergence shall be sent as an iteration from the balise group in rear of the convergence. This avoids the need for a balise group that provides a speed update in advance of the convergence.

7.2.3. Level crossing speed signs

Balise groups at level crossing speed signs shall send the indicated speed and an iteration for the line speed applicable in advance of the level crossing. The iteration shall apply at a distance of 20 m in advance of the level crossing departure edge.

7.2.4. Speed sign deficiencies

Certain portions of track on the network do not have track design speeds indicated by speed signs. These deficiencies typically occur on loop lines and where trains turn back or turnout onto track in the opposite direction of normal running.

Where the track design speeds are unknown, they shall be assumed to be the following:

- If speeds are indicated in the opposite direction, then the track design speeds shall be assumed to be the lower of either the opposite direction speeds or those on the next speed sign in advance (which may be a turnout speed sign or an implied X25 km/h speed sign at a converging junction). If this assumption results in speeds lower than the turnout speed entering this portion, then a risk-based approach shall be followed.
- If speeds are not indicated in the opposite direction, then the track design speeds shall be assumed to be the lower of either the speeds on the speed sign in rear (typically a turnout speed sign, posted or implied) or the speeds on the speed sign in advance (which may be a turnout speed sign, posted or implied, at a converging junction).

An assumed track design speed shall never be higher than that suitable for the existing signalling system.

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7.2.5. Temporary speed signs

Temporary speed signs include the warning, caution and clearance signs for speed-restricted areas. Where there is a requirement to protect a speed-restricted area with ETCS equipment, a temporary speed warning (TSW) balise group shall be installed at the warning sign, with the reference balise preferably placed adjacent to the sign. See Figure 7. The reference balise may be placed up to 20 m in advance of the warning sign.

TSW balise groups shall transmit ‘important’, ‘plain’ text messages to be displayed to the driver. Packet #72 contains the text for the message. The message transmitted shall be 'Warning: Temporary Speed Restriction'. The message shall be displayed immediately upon passing the balise group and shall continue to be displayed until acknowledged by the driver. The service brake shall be commanded if the message is not acknowledged within 5 seconds.

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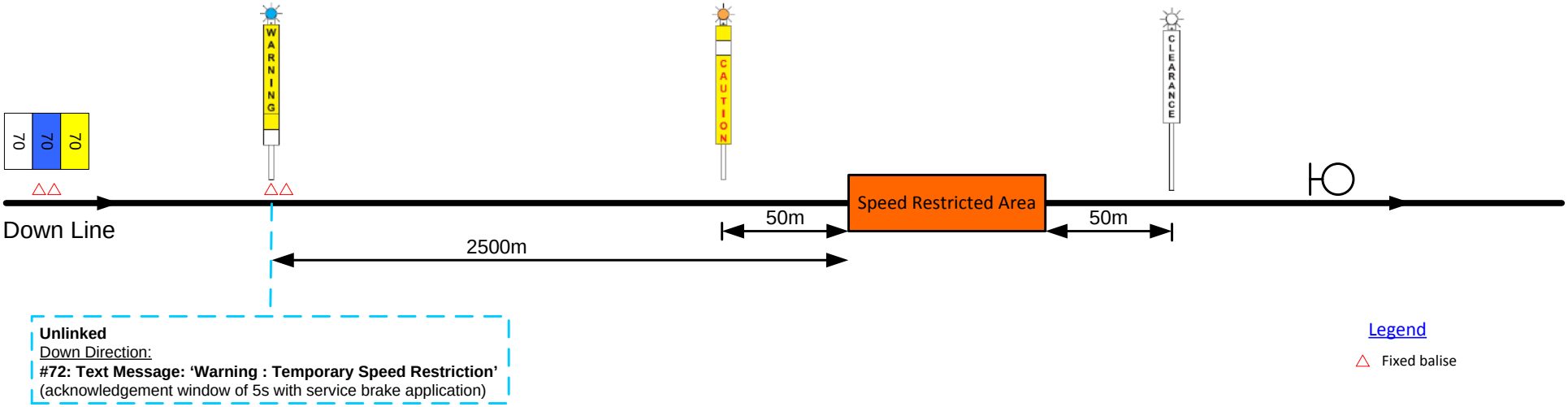

Figure 7 – Temporary speed signs with TSW balise group

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7.3. Calibration

Calibration balises are used for the purpose of correcting the confidence interval and maintaining the odometer accuracy.

Where the TSM-initiating balise group for a high-risk speed sign is required greater than 2 km in rear of the high-risk speed sign, a calibration balise shall be installed if its addition would either reduce the braking tool 'permitted' braking distance by more than 150 m or reduce the travel time by more than 4 seconds. Figure 8 shows an example of the calibration balise arrangement where the position improvement distance is greater than 150 m.

The travel time reduction shall be calculated by subtracting the time taken to travel the position improvement distance at the approach line speed, from the time taken to travel the position improvement distance at the posted line speed.

The preferred location for the calibration balise is at the 'permitted' braking distance in rear of the speed sign, calculated without the calibration balise present.

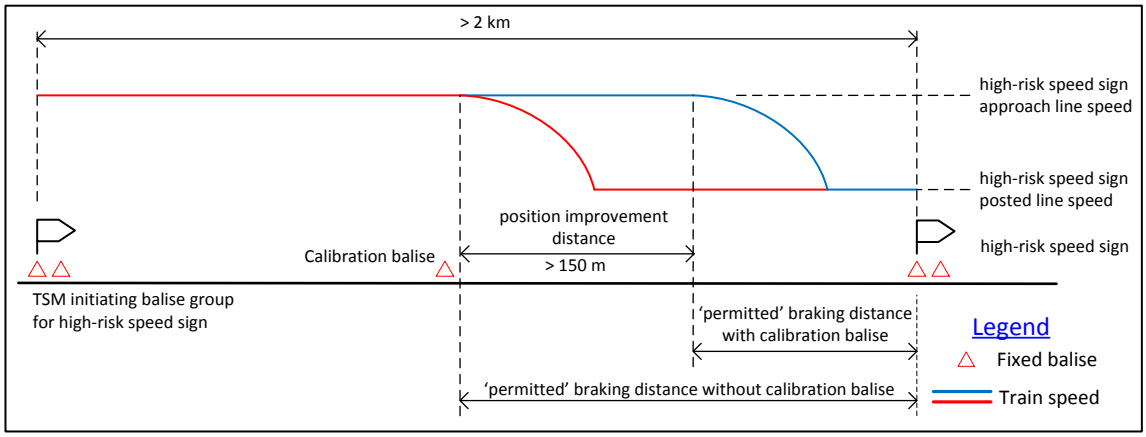

Figure 8 – Calibration balise

7.4. Buffer stops

TSM shall be used when approaching a buffer stop on a running line, with release speed monitoring (RSM) used in the vicinity of the end of authority (EOA). An end-of-line without a buffer stop shall be treated as though there is a buffer stop at the end of the line.

Balise group configuration differs depending on the distance between the operational stopping location and the buffer stop.

The operational stopping location at a platform leading to a buffer stop shall typically be the 8 (or last) car marker, if one exists, or the platform railing.

The supervised location (SvL) shall be defined at a point 100 m in advance of the EOA. This distance is sufficient to avoid supervision of the SvL interfering with the approach to the EOA.

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7.4.1. Short overrun distance available

Where the distance between the operational stopping location and the buffer stop is less than or equal to 10 m, then the buffer stop balise group shall consist of one balise. The configuration shall be as follows:

- The EOA shall be the buffer stop.
- A TSM-initiating balise group shall be placed no closer than the braking tool 'permitted' distance in rear of the EOA.
- A single balise shall be placed 3.3 m in rear of the EOA. For movements in both directions, this balise shall transmit a trip order that immediately commands the emergency brake. It shall also transmit 'Stop if in SH mode' and 'Stop if in SR mode'.
- The release speed shall be 10 km/h.

See Figure 9.

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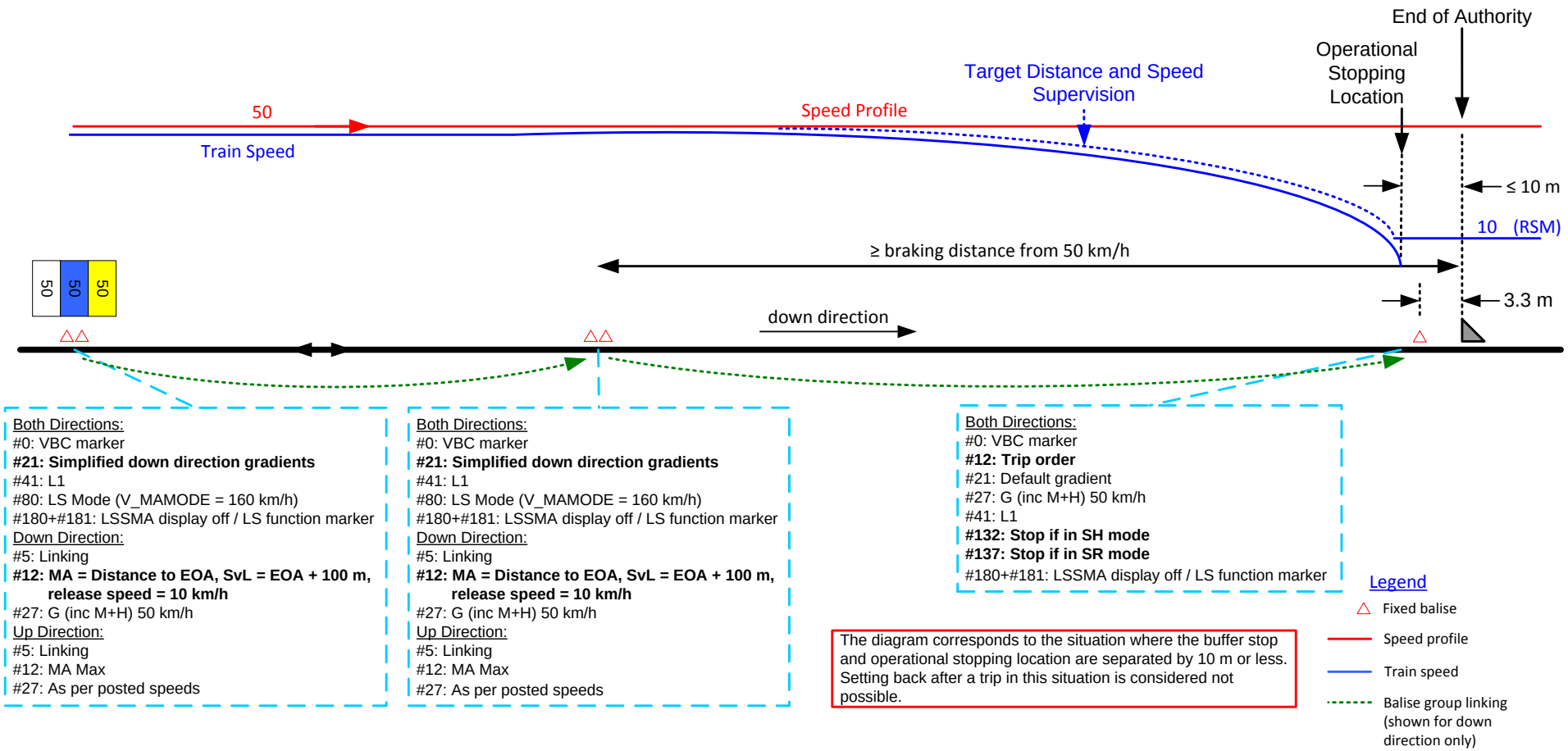

Figure 9 – Buffer stop – short overrun distance available

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7.4.2. Longer overrun distance available

Where the distance between the operational stopping location and the buffer stop is greater than 10 m, then the buffer stop balise group shall consist of two balises. This allows a train that has overrun to set back without a further brake intervention. The configuration shall be as follows:

- The EOA shall be 5 m in advance of the operational stopping location.
- A TSM-initiating balise group shall be placed no closer than the braking tool ‘permitted’ distance in rear of the EOA.
- A balise group shall be placed with the reference balise at the EOA. For movements towards the buffer stop, this balise group shall transmit a trip order that immediately commands the emergency brake. It shall also transmit ‘Stop if in SH mode’ and ‘Stop if in SR mode’.
- The release speed depends on the length of the confidence interval at a position just before reaching the EOA and the distance between the EOA and the buffer stop. Where this distance is at least 30 m greater than the confidence interval, the release speed shall be 15 km/h, otherwise it shall be 10 km/h. See Figure 10.

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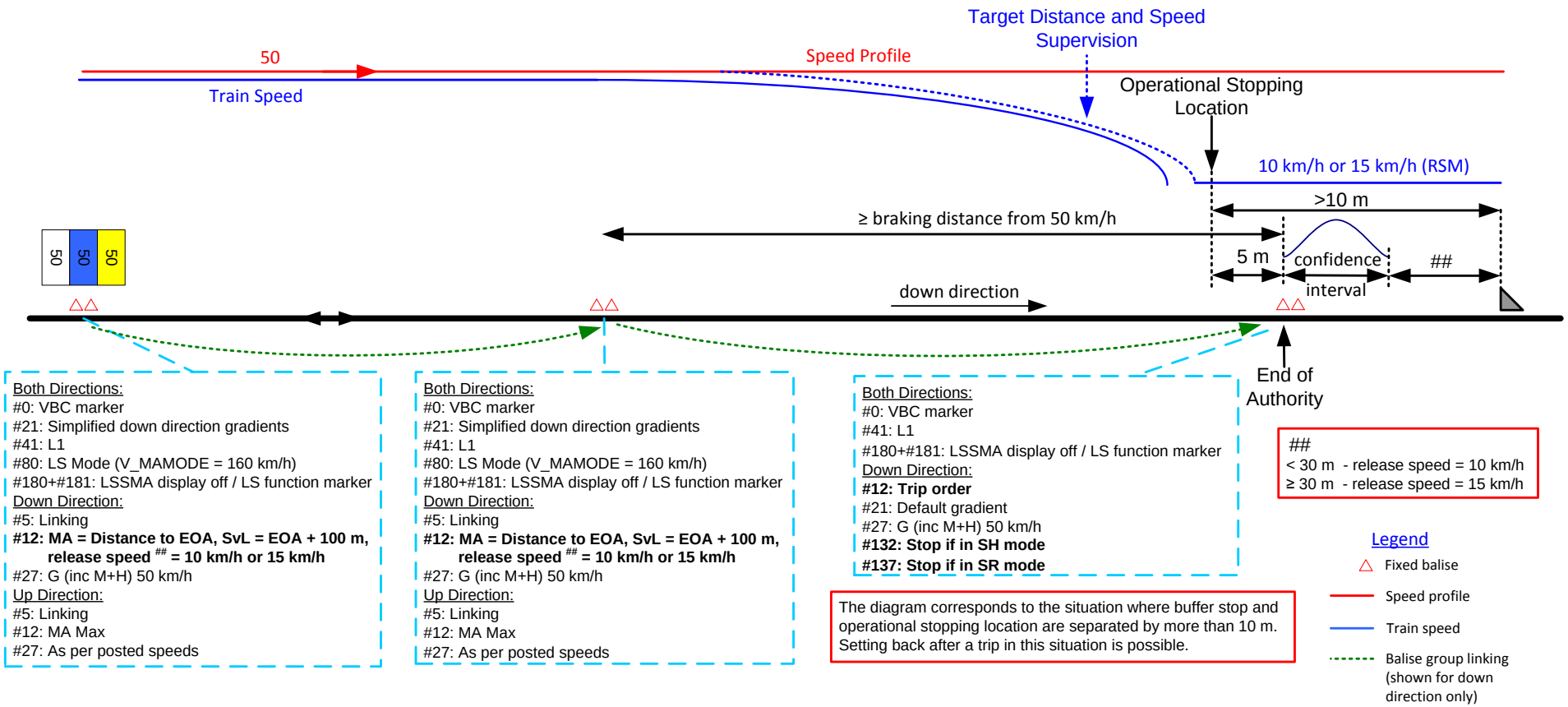

Figure 10 – Buffer stop – long overrun distance available

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7.5. Yards

In the context of this document, a yard refers to any unsignalled line(s) or any line(s) that are signalled with shunt class routes only. Running lines adjacent to yards shall not be treated as part of the yard. Only electrified yards need to be considered for ETCS protection.

Yard exit balise groups are provided to avoid the risk of a train travelling on a running line in SH or SR mode, without the protection provided by LS mode. The yard exit balise groups also remove the operational restriction of a train's speed being limited to the 40 km/h SR mode speed limit until the train passes the next balise group (that transmits an MA for the applicable direction) on the running line. They also remove the operational restriction of a train's speed being limited to the 25 km/h SH mode speed limit where the driver fails to complete the procedure that changes the mode to SR.

Yard entry balise groups are provided to avoid the risk of a train travelling in a yard faster than the 25 km/h SH mode speed limit.

A yard shall be provided with yard exit and yard entry balise group under any of the following circumstances:

- where there is a deemed risk of collision of trains in the yard. This risk shall be deemed to exist where both the following conditions are true:
  - a particular road or siding exists that fits more than one 8-car train
  - entrance to the yard is via a signalled move, not involving ground frame points in the reverse position
- yards where trains regularly enter service from stabling, maintenance or initially
- yards where trains regularly amalgamate or divide

7.5.1. Yard exit

Yard exit balise groups shall be provided for signalled moves out of ETCS protected yards. Two balise groups shall be provided, transmitting duplicated information for redundancy.

They shall transmit an immediate order to change to LS mode. They shall also transmit 'Stop if in SH mode'.

The static speed profile transmitted shall include the line speed at the balise group, the turnout speed and the safe speed(s) in advance of the turnout. The safe speeds in advance of the turnout shall be the most restrictive of the line speed and any target speeds applicable.

Yard exit balise groups should be placed such that any running move is supervised in LS mode as soon as possible after passing the running signal. See Figure 11.

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Yard exit balise groups should be placed such that they are not passed by a movement wholly within the yard, as this would cause an emergency brake intervention for this type of movement with a train in SH mode.

To minimise the number of balises installed, it is preferable that the functions provided by yard entry and yard exit balise groups be combined into the same two balise groups. Where combined, the requirements for yard exit take precedence over yard entry.

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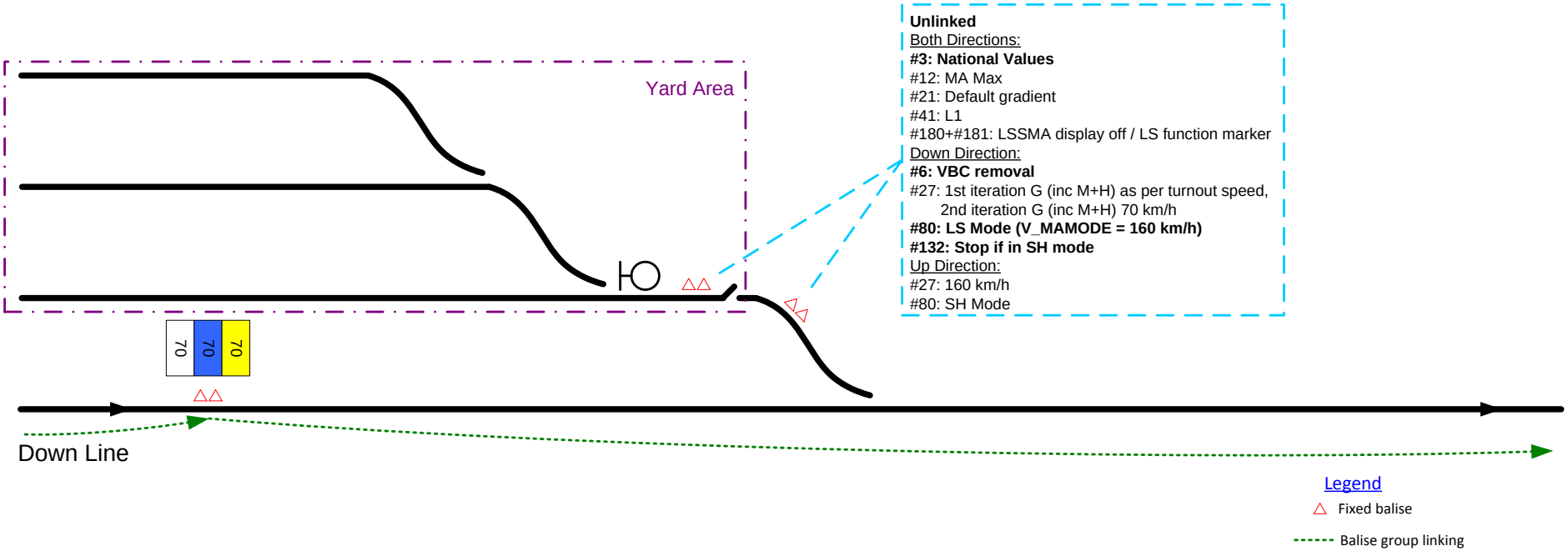

Figure 11 – Yard exit

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7.5.2. Yard entry

Two balise groups shall be provided for yard entry. The balise groups shall both transmit an immediate order to change to SH mode, providing redundancy.

Yard entry balise groups should be placed as close as possible in advance of the point where only shunting or signalled shunt class movements are allowed. See Figure 12.

They shall not be placed on running lines, as this would cause trains to change to SH mode when remaining on a running line.

Where the yard has a specific speed limit lower than 25 km/h, it remains the driver's responsibility to avoid exceeding the specified speed limit.

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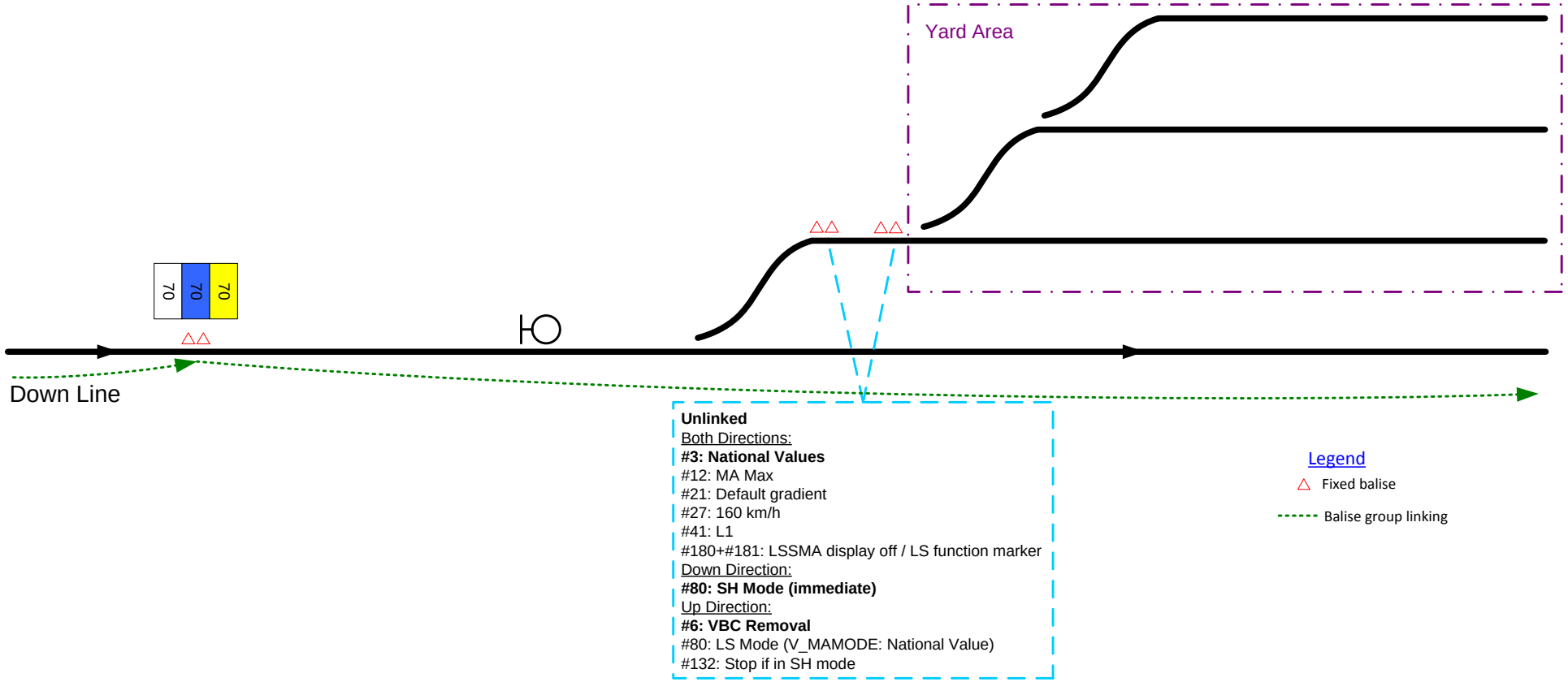

Figure 12 – Yard entry

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7.6. Turning back

When a train terminates and is required to turn back, the driver changes end and starts a new mission, typically in SR mode. The maximum speed in SR mode is 40 km/h. The next balise group that is passed (that transmits an MA for the applicable direction) will change the mode to LS, thus allowing the train to run at line speed.

An additional balise group providing an earlier change to LS mode should be provided where there is a significant operational benefit in doing so.

7.7. Big metal masses

Metal masses on or beneath the track structure can obstruct the ability of the onboard transmission equipment to function correctly, which in turn can cause alarms on the DMI. These alarms are suppressed when the metal mass is announced.

A metal mass larger than the dimensions specified in ERTMS/ETCS *FFIS for Eurobalise* Subset-036 shall be classified as a big metal mass (BMM). See EGG 1656 *Balise Placement and Metal Mass Assessment Guide* for the identification of big metal masses.

Packet #67 contains the BMM information. The distance to and length of the BMM shall be transmitted by a BMM announcement balise group.

In level 1 territory, big metal masses longer than 10 m shall be announced. In level 0 territory, big metal masses longer than 300 m shall be announced.

A BMM shall be announced on all possible approaches to it.

A BMM announcement balise group shall not be placed less than 75 m from the BMM. This distance is based on the network maximum speed of 160 km/h and a 1.5 second onboard delay. Where infrastructure constraints prevent standard placement, the maximum allowable speed for the section of line may be used in calculating the minimum distance.

A BMM announcement balise group shall not be placed more than 500 m from the BMM. This is to limit the confidence interval either side of the BMM.

See Figure 13, Figure 14 and Figure 15 for examples of announcing big metal masses.

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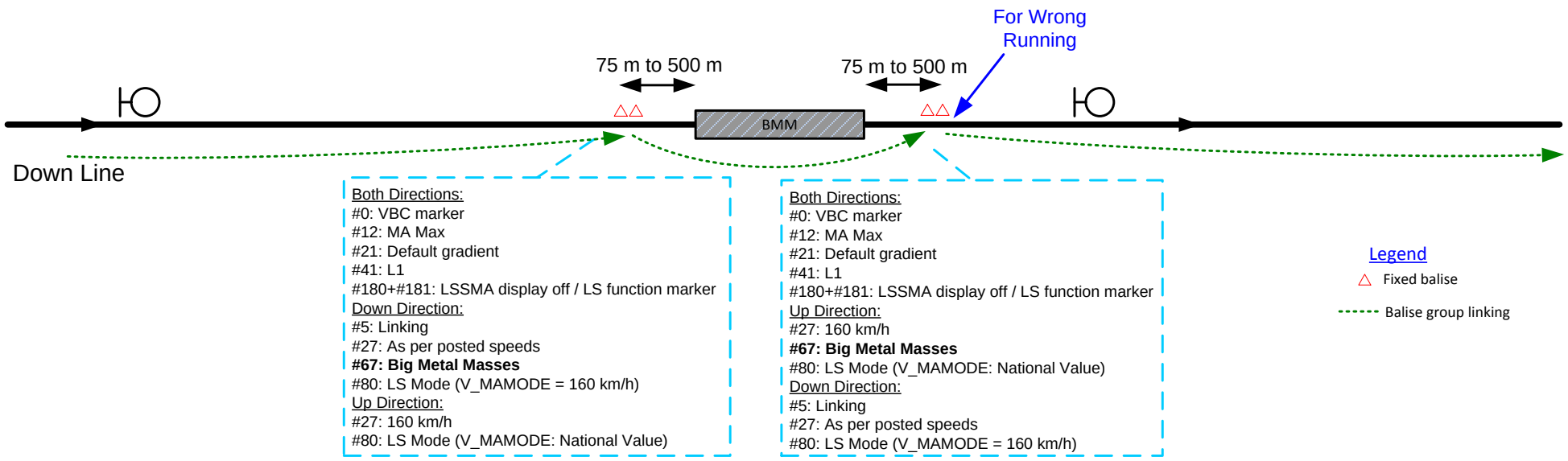

Figure 13 - Big metal masses – unidirectional line

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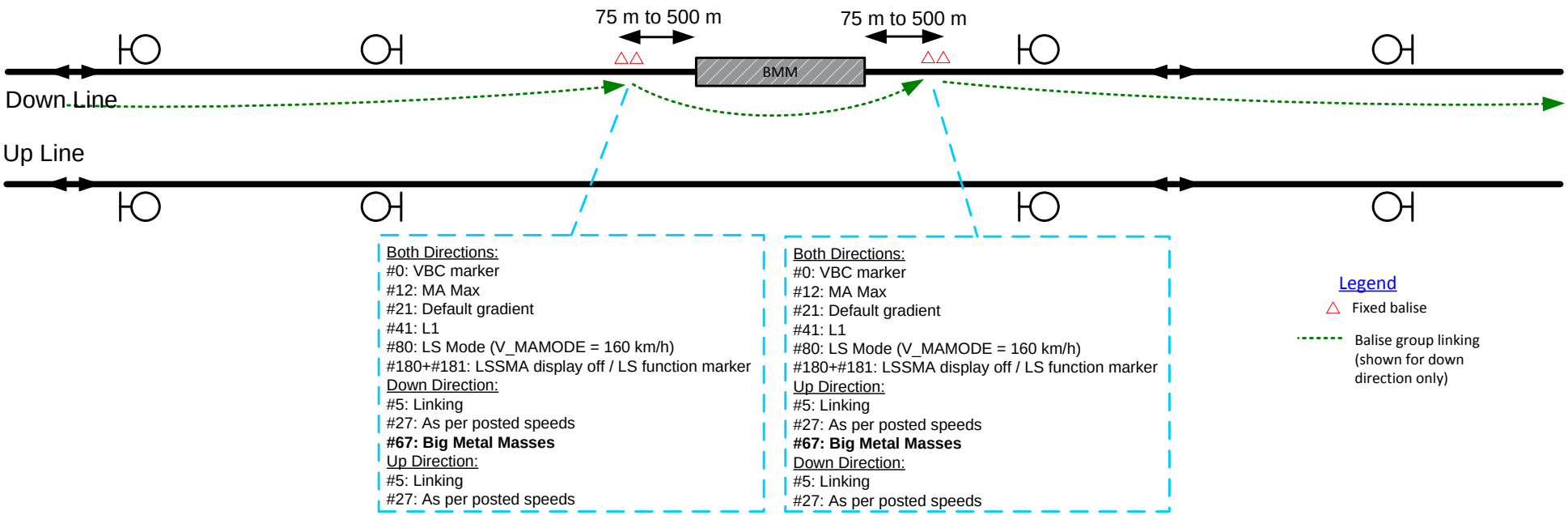

Figure 14 - Big metal masses – bidirectional line

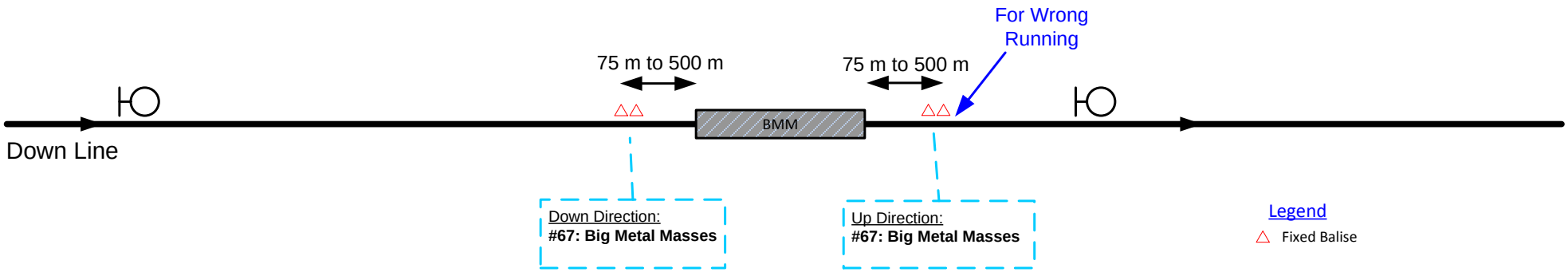

Figure 15 - Big metal masses – level 0 territory

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Balise groups shall not be placed in the BMM area or within the confidence interval either side of it.

Where the separation of two or more big metal masses is small enough to prevent individual announcement due to confidence interval constraints, then the BMM announcement balise group shall announce all the big metal masses.

The BMM announcement function shall not be combined in a balise group with another function. This is to avoid loss of the BMM announcement under various failure scenarios, including the transmission of a default telegram.

A BMM announcement shall not be transmitted to a train that diverges away from a BMM, unless it avoids the use of an LEU and there are no balises on the diverging line within the bounds of the resulting confidence interval.

7.8. Wrong running

Wrong running refers to train movements on running lines in the unsignalled direction. All wrong running movements shall be supervised to a maximum speed of 40 km/h, in accordance with NSY 514 *Special Proceed Authority* (SPA).

In general, the speed supervision of wrong running movements shall utilise packet #80 (mode profile), indicating (with the use of the V_MAMODE variable) to use the national value V_NVLIMSUPERV of 40 km/h, rather than limiting the speed through packet #27 (static speed profile). This approach allows a possible future alteration to the maximum SPA speed while minimising the number of balises requiring a data alteration.

7.8.1. Wrong running entry

The wrong running entry point shall be assumed to be at the point where there is no signalled move in the applicable direction over that portion of track.

A wrong running entry balise group shall be placed at a nominal 10 m in advance of the wrong running entry point. However, a distance up to 160 m is permitted (based on typical 8-car EMU) to allow the wrong running entry function to be combined in a balise group performing another function, provided there is no additional safety risk. See Figure 16.

Two situations exist for a wrong running entry balise group, depending on whether the balise group also transmits packet #16 in the applicable direction as a repositioning balise group.

Where the balise group does not transmit packet #16, the balise group shall transmit packet #80, indicating via the V_MAMODE variable that speed is to be monitored to the national value. Packet #27 shall transmit the network maximum speed of 160 km/h. Figure 16 depicts this situation.

Where the balise group transmits packet #16, it cannot also transmit packet #80. The balise group shall utilise packet #27 to transmit a speed of 40 km/h. The next balise group in advance

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shall transmit packet #80, indicating via the V_MAMODE variable that speed is to be monitored to the national value. Packet #27 at this next balise group shall transmit the network maximum speed of 160 km/h. Figure 17 depicts this situation.

An ETCS trainstop balise group cannot be combined with a wrong running entry function in the same direction, as the trip order issued by the ETCS trainstop changes the onboard mode to trip mode. When trip mode is entered, certain information that is stored onboard is deleted. Refer to ERTMS/ETCS *System Requirements Specification Chapter 4 Modes and Transitions* - Subset-026-4 for more details. A preferred separation of 100 m, up to a maximum of 160 m, shall be provided between an ETCS trainstop balise group and a wrong running entry balise group to allow a tripped train to come to a stand. Refer to Figure 20, which shows a wrong running entry balise group in advance of a fixed red signal fitted with an ETCS trainstop balise group.

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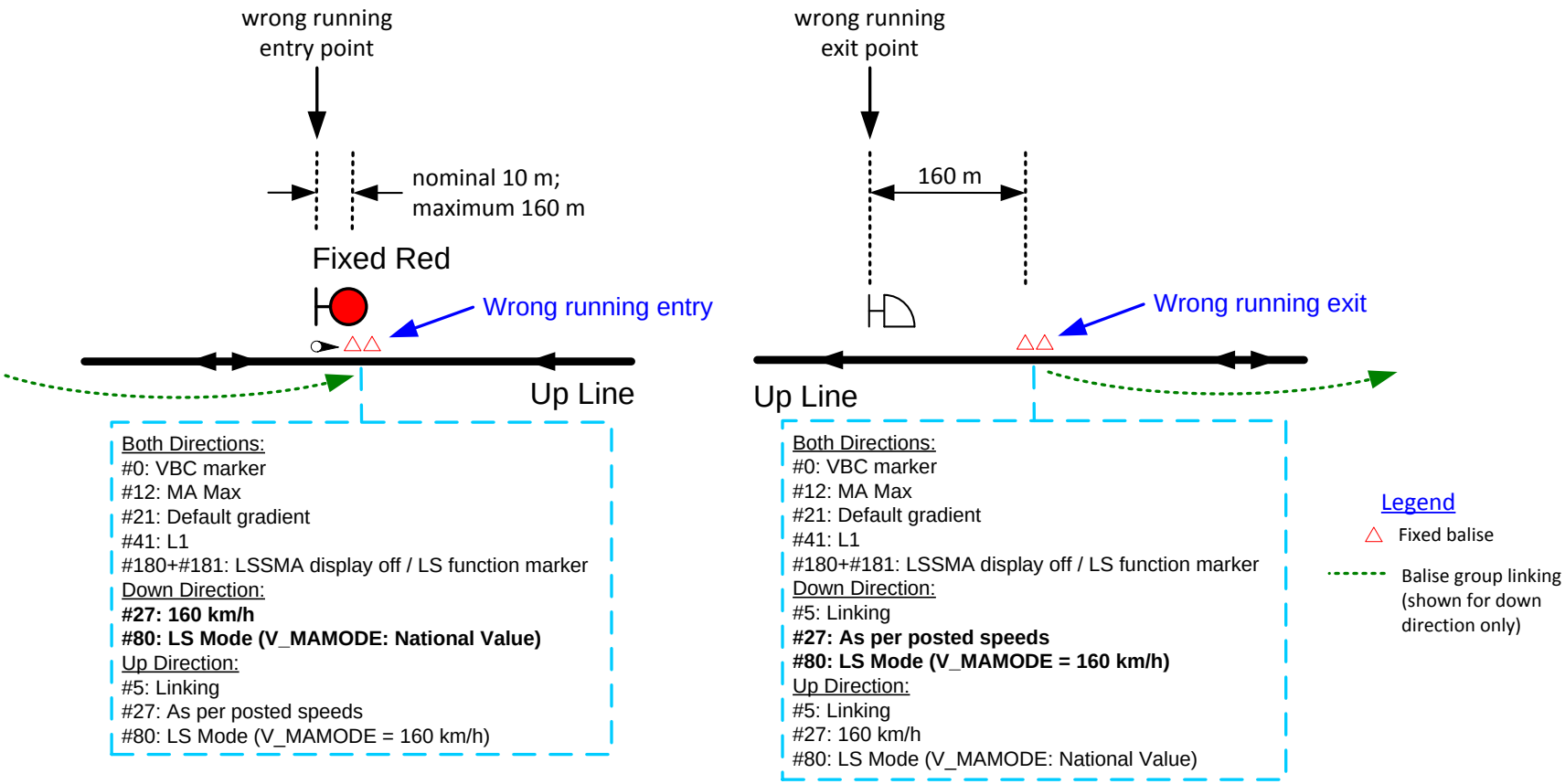

Figure 16 - Wrong running entry and exit – without combination with repositioning

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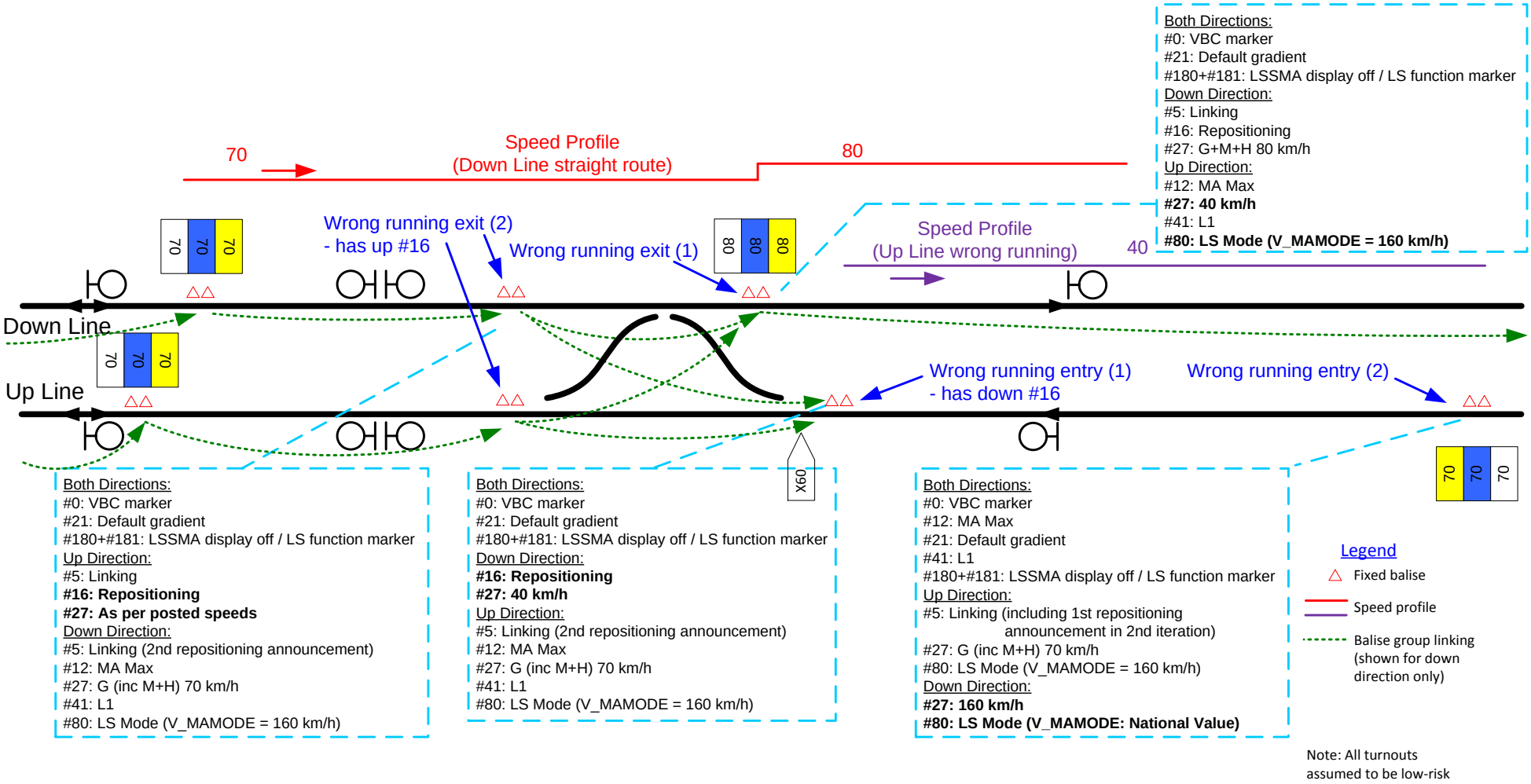

Figure 17 - Wrong running entry and exit – with combination with repositioning

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7.8.2. Wrong running exit

The wrong running exit point shall be assumed to be at the point where there is a signalled move in the applicable direction over the portion of track.

A wrong running exit balise group shall be placed at 160 m (based on typical 8-car EMU) in advance of the wrong running exit point except in the following situations:

- A distance less than 160 m is permitted to allow the wrong running exit function to be combined in a balise group performing another function.
- A distance greater than 160 m is permitted to avoid unintentionally revoking TSM. Refer to Section 10.2 for details.

Two situations exist for a wrong running exit balise group, depending on whether the balise group also transmits packet #16 in the applicable direction as a repositioning balise group.

Where the balise group does not transmit packet #16, the balise group shall transmit packet #80, reverting the V_MAMODE variable back to the network maximum speed of 160 km/h. Packet #27 shall transmit the line speed. Figure 16 depicts this situation.

Where the balise group transmits packet #16, it cannot also transmit packet #80. Packet #27 shall transmit the line speed. The balise group first in rear shall transmit packet #80, reverting the V_MAMODE variable back to the network maximum speed of 160 km/h. This balise group in rear shall utilise packet #27 to transmit a speed of 40 km/h. Figure 17 depicts this situation.

7.8.3. Wrong running level crossings

Speed supervision in the unsignalled direction shall apply to protected level crossings and protected pedestrian level crossings that have no active protection for movements in the unsignalled direction.

An ETCS temporary speed restriction (TSR) shall be used for this protection. Packet #65 contains the TSR. A target speed of 15 km/h shall apply at a target point of 50 m in rear of the level crossing approach edge. The length of the TSR shall be 1 m.

The TSR shall be transmitted from two balise groups. The first transmission is for redundancy purposes, transmitted from a balise group at a minimum distance of 300 m from the level crossing approach edge. The second balise group shall be at least the ‘permitted distance’ from the TSR target point. See Figure 18. The permitted distance shall be obtained from the braking tool, using 40 km/h as the initial speed.

The redundant balise group shall transmit an ‘important’, ‘plain’ text message to be displayed to the driver. Packet #72 contains the text for the message. Driver acknowledgement shall not be requested. The message shall be ‘Warning: level crossing’. The message shall be displayed from 300 m until 49 m in rear of the level crossing approach edge.

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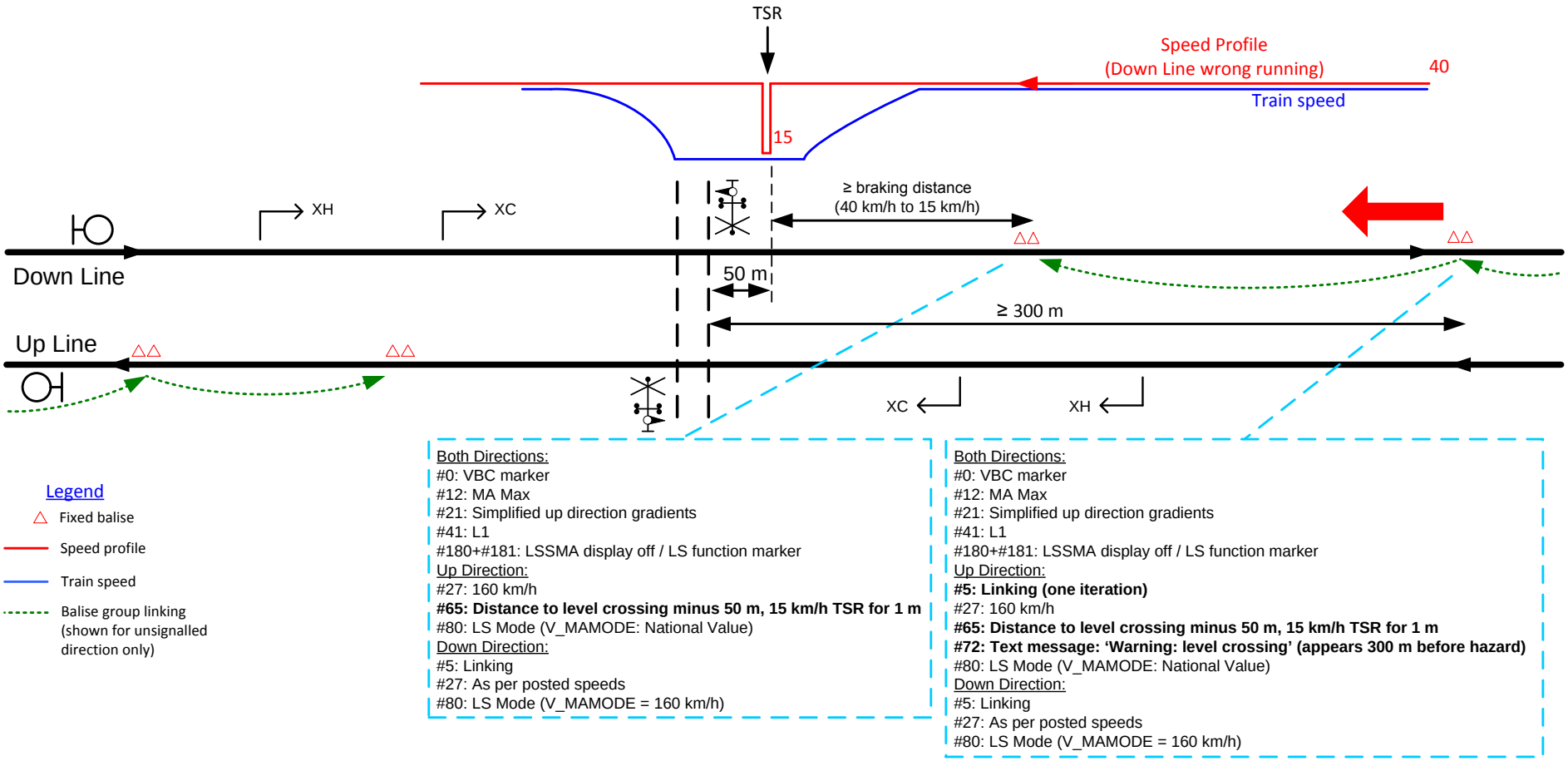

Figure 18 - Wrong running level crossing

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8. Controlled balise group functions

A controlled balise group is a balise group that can vary the message that it transmits depending on the state of the signalling controls. Controlled balise groups shall be provided for ETCS trainstops, high-risk turnouts and high-risk overruns. Controlled balise groups are required for approach balise groups.

A controlled balise group typically consists of one controlled balise and one fixed balise. The fixed balise always transmits the same telegram, whereas the controlled balise transmits a telegram selected by a connected LEU.

ERA documents also use the term ‘switchable balise’ for a controlled balise.

8.1. Lineside electronic units

A lineside electronic unit (LEU) receives vital inputs from the conventional signalling system and sends outputs to one or more controlled balises.

The Alstom Micro-coder type 1 module is the only LEU with type approval.

> *This document is currently written to support the Alstom Micro-coder type 1 module; however this document will be updated to support other type approved LEUs.*

An LEU shall not control balises on more than one line. An LEU shall not interface to both Up and Down signals.

8.1.1. Lineside electronic unit naming

Each LEU shall be assigned a unique name, complying with the following naming structure:

WWWXXXXXX LEU A

> *Note that spaces separate certain parts.*

Underscores shall replace spaces in filenames.

WWW

WWW is the three–letter location code as listed in T MU AM 01007 TI *Asset Reference Codes Register*.

It shall be the location code of the nearest station to the interfaced signal.

The station kilometrages in the TS TOC 3 *Train Operating Conditions (TOC) Manual – Track Diagrams* shall be used in determining the nearest station.

The location code shall be omitted from the name of LEU sub-assets, such as terminals, power supply units and ethernet switches.

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XXXXXX

XXXXXX is a maximum of six characters that describe the signal name of the interfaced signal.

XXXXXX shall be in accordance with the signal identification plate; however, it shall not include spaces, decimal points or any suffix denoting line name.

LEU

The text 'LEU' shall form part of the LEU name.

A

Each LEU name shall have a sequential alphabetical suffix, with the first or only LEU using 'A'. Subsequent locally networked LEUs shall use 'B' and 'C'.

The following are examples of LEU names established using this convention:

- CWDCD29 LEU A
- CWDCD29 LEU B
- WRE643 LEU A
- CTND342 LEU A
- ARNSM810 LEU A

8.1.2. Signalling inputs

Two forms of input arrangement are possible - relay contact sensing and lamp current sensing. When the Alstom Micro-coder type 1 module is used as the LEU, contact sensing is achieved using current sensing inputs with a series load resistor.

Contact sensing shall be used where signals are operated by relays. Current sensing shall be used where signals are not operated by relays, that is, where computer-based interlocking equipment directly drives the signal lamps. The exception is that turnout repeaters operated by relays shall use current sensing where computer-based interlocking equipment directly drives the running aspect signal lamps, such that standard LEU data can be utilised. Contact sensing shall be used for route indicators, when required, where they are operated by relays.

In a contact sensing arrangement, inputs shall disregard the lamp proving status.

A vital relay interface to facilitate contact sensing shall be provided where controls of mechanically operated signals are required as LEU inputs.

A bypass terminal shall be provided for each current sensing input to retain the displayed aspect of a signal when it is necessary to disconnect the LEU.

Alstom Micro-coder type 1 modules have a maximum of six physical inputs (from the signalling system) and a maximum of two physical outputs (to controlled balises). These LEUs may be

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networked to accommodate a higher number of inputs or outputs. The balise message selection table can consider a maximum of 16 inputs. The controlled balise(s) should be connected to the first LEU.

The standard input allocation shown in T HR SC 00003 ST *Circuit Design Standard – ETCS Level 1 Interface Circuits* applies to the Alstom Micro-coder type 1 module and allows standard LEU data to be utilised. Spare inputs of an LEU shall be used if it avoids the provision of an additional LEU.

8.1.3. Location of LEUs

LEUs shall be installed in the signal control output location wherever practical.

A cabinet compliant to the M05 500-599 *ATP Construction drawings* may be provided where space is insufficient. This option allows single cutting of contact sensing inputs.

8.1.4. Default telegrams

If a controlled balise loses communication with the LEU, for example due to an LEU failure, then the balise transmits its default telegram. If the inputs of an LEU are not a valid combination, for example, due to a relay failure, then the LEU selects its default telegram. The default telegram header shall allocate a message counter value of 254 to the M_MCOUNT variable. This value deems the message inconsistent for both directions, triggering a linking reaction. The failure is reported to the driver by a system text message displayed on the DMI.

Additional ‘important’, ‘plain’ text messages shall also be sent to the train to be logged in the juridical recording unit (JRU); however, these are not reported to the driver. The text messages shall be valid for both directions. The message shall be 'DEF_BAL' for the default balise telegram and 'DEF_LEU' for the default LEU telegram. The messages shall start immediately, shall not require driver acknowledgement and shall have no ending conditions.

Controlled balises shall always transmit packet #254, indicating that the telegram can contain default information. It shall be valid for both directions.

8.1.5. Power arrangements

The power for the LEU shall be derived from the same power source as the signalling system.

Each LEU shall have its own power supply unit. A power supply unit can additionally supply power to an ethernet switch where the LEU has no outputs to balises. Each power supply unit shall be separately fused.

A fuse shall be provided for each signal for the inputs in a contact sensing arrangement. The fuse shall be located in the same location enclosure as the LEU.

Surge protection shall be provided at the 120 Vac bus supplying the LEU equipment if no inbuilt surge protection is provided on this bus.

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8.2. ETCS trainstops

An ETCS trainstop is an alternative to the trip arm style trainstop.

Where an ETCS trainstop balise group is provided for a signal that is required to provide 'no trip' for one or more aspects, it shall consist of one controlled balise and one fixed balise. See Figure 19.

For a fixed red signal, or for a signal or sign that is always required to provide a trip for the applicable direction, the ETCS trainstop balise group shall consist of two fixed balises. See Figure 20.

When an ETCS trainstop balise group is required to trip a train, for example when a signal is displaying a stop aspect, the balise group shall transmit a trip order to command the emergency brake. 'Stop if in SH mode' and 'Stop if in SR mode' shall also be transmitted.

When an ETCS trainstop balise group is required to provide no trip, for example, when a signal is displaying a proceed running aspect, the balise group shall not transmit a trip order. 'Stop if in SH mode' and 'Stop if in SR mode' shall not be transmitted. The balise group shall transmit the standard maximum length MA.

A shunt route may allow the balise group to provide no trip where there is an operational need, subject to a risk assessment. The risk assessment shall consider whether it is necessary to prove the speed of the approaching train has suitably reduced, and whether it is necessary to prove the section clear.

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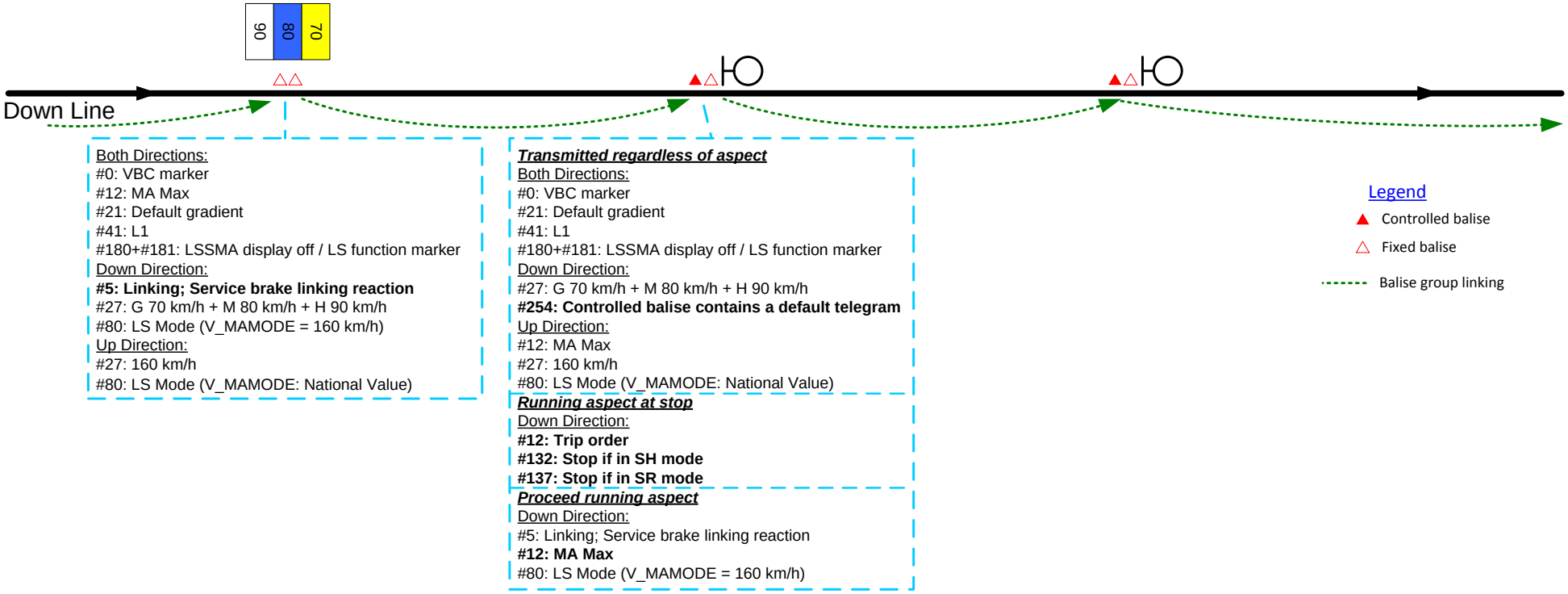

Figure 19 – ETCS trainstop

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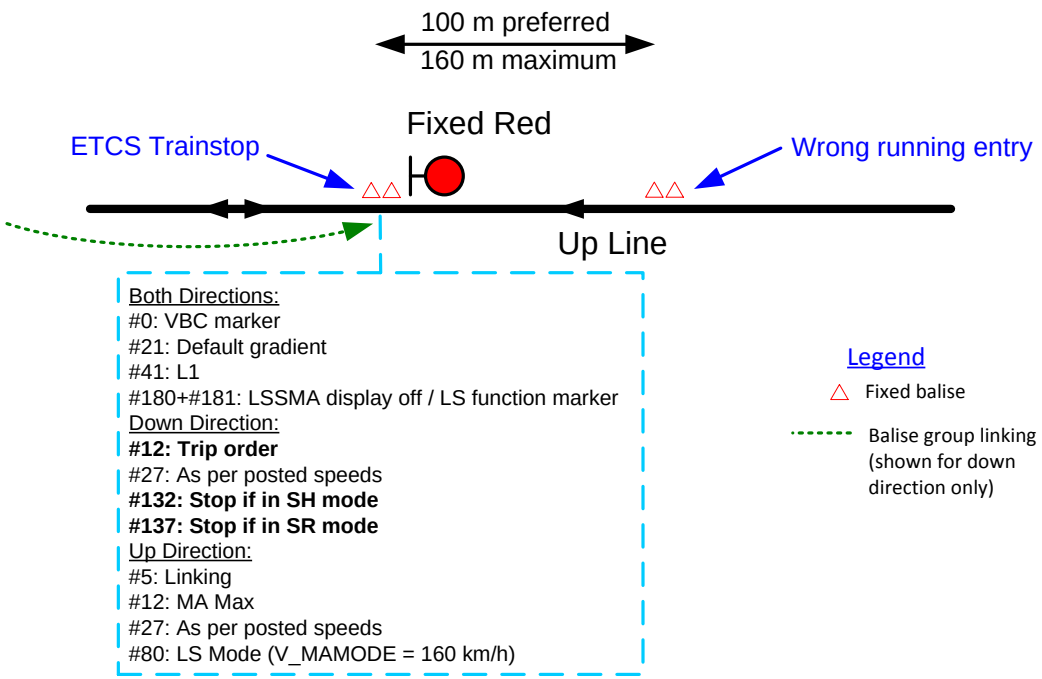

Figure 20 - ETCS trainstop – fixed red signal

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8.2.1. Contact sensing arrangement

In a contact sensing arrangement, the LEU requires only one input, indicating when no trip is required. This is typically the HR relay or the LSp relay, or both. The replacement track shall be added in series to gain the protection provided by the track stick function.

8.2.2. Current sensing arrangement

In a current sensing arrangement, the LEU requires inputs from the following lamps:

- running aspects, including low speed aspects
- marker lights
- close-up aspects

The LEU does not require inputs from the following lamps:

- co-acting signals
- turnout repeaters
- route indicators
- shunt aspects
- other subsidiary aspects

In the event of lamp failure, the ETCS trainstop shall transmit a message consistent with the most restrictive combination of the remaining illuminated lamps.

In the event of an invalid signal indication, the LEU inputs shall be deemed an invalid combination, resulting in the LEU selecting its default telegram, triggering the linking reaction and commanding the service brake.

8.3. High-risk turnouts

A balise group using TSM shall be provided on approach to a turnout that is deemed high-risk. This minimises the risk of a derailment resulting from excessive speed.

8.3.1. Assessment

Each turnout shall be deemed either high-risk or low-risk.

A turnout shall be deemed high-risk if the following are true:

- there is a main class route through it or there is a possible main class overlap through the turnout
- the approach speed is greater than the maximum turnout speed

Medium and high speed profiles only shall be considered when assessing turnouts.

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Where there are multiple or consecutive turnouts from the same signal, each turnout shall be separately assessed. The most restrictive case shall be transmitted by the redundant TSM balise group.

Approach speed

The approach speed is generally the line speed on approach to the first warning signal of the turnout.

Where there is an increase in line speed between the first warning signal and the turnout, the new line speed shall be used as the approach speed if the speed sign is greater than 157 m from the turnout. The 157 m distance is used as the length of the shortest 8-car EMU.

Where there is a decrease in line speed between the first warning signal and the turnout, the new line speed shall be used as the approach speed if the speed sign is of a sufficient service braking distance from the turnout, using the applicable braking curve specified in ESG 100.3 *Braking Distance*. Where the speed sign is not of a sufficient service braking distance from the turnout, it may be possible to sufficiently mitigate the hazard from the high-risk turnout by treating the speed sign as high-risk. See Section 7.2.1.

Maximum turnout speed

The maximum turnout speed is not necessarily equal to the published or posted speed. The maximum turnout speed is the track discipline's design speed with a possible overspeed allowance added to it. For design speed, refer to ESC 210 *Track Geometry and Stability* and ESC 250 *Turnouts and Special Trackwork*.

Overspeed allowance

The geometry of some turnouts provides a reduced risk of derailing with a train speed faster than the design speed. The overspeed allowance is the maximum speed added to the design speed where the derailment risk is not significantly greater than at design speed.

No overspeed allowance applies in the following circumstances:

- crossovers, except for tangential type with a turnout radius of 800 m or greater
- a turnout with a diamond less than or equal to 10 m in advance of it
- a slip within the turnout
- more than two consecutive turnouts with each separation less than or equal to 13 m
- a turnout where the non-diverging line is not straight

If none of the above circumstances apply, then the following overspeed allowances shall apply:

- 5 km/h for standard conventional turnouts with a crossing rate of 8.25 or 9

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- 10 km/h for standard tangential turnouts with a turnout radius between 160 m and 500 m inclusive
- 5 km/h for standard tangential turnouts and crossovers with a turnout radius of 800 m or 1200 m

A crossover is defined as two turnouts having less than 13 m of straight track separating them.

8.3.2. High-risk turnout balise group

A high-risk turnout balise group shall consist of one controlled balise and one fixed balise. The preferred position of the balise group is at the 'permitted distance' obtained from the braking tool, using the turnout as the target point and the published turnout speed as the target speed.

The balise group may be positioned farther than the 'permitted distance', including at an outer signal that is one or more blocks in rear of the home signal of the turnout. See Figure 21.

When determining the position of the balise group, the following factors shall be considered:

- braking distance
- cable trenching costs
- the need for look-ahead
- the need for additional LEUs
- the need for approach balise groups

The balise group shall transmit a static speed profile for the straight route with the home signal of the turnout clear for the straight main class route and all other intermediate signals clear between the balise group and the home signal. This static speed profile revokes the redundant target speed information sent from the balise group in rear.

The balise group shall transmit a static speed profile for the turnout route with the home signal of the turnout clear for the main class turnout route and all intermediate signals clear. The static speed profile shall additionally include an iteration for the line speed of the diverging line. Train length delay shall not be enforced.

Where neither of these conditions is satisfied, for example, when the home signal of the turnout is at stop, the balise group shall transmit a static speed profile that is consistent with the most restrictive turnout route; however, it shall not transmit an iteration for the line speed of any diverging line.

The LEU controlling the controlled balise typically interfaces with an outer signal. There are situations where it interfaces with the home signal of the turnout, either due to a relatively short braking distance, or where an additional balise group is required for approach purposes. Refer to Section 8.5 for the requirements of approach balise groups.

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There shall be sufficient inputs to the LEU to positively identify each main class route (requiring a different TSM response) cleared at the home signal of the turnout, regardless of which signal the LEU is interfaced to. Multiple routes may be combined in one LEU input, where each combined route has the same TSM response regarding turnout speeds, associated target points and line speeds of the diverging line in advance of the turnouts. Further combination of inputs is possible where the line speeds of the diverging lines do not need to be identified at the TSM-initiating balise group due to these speeds being transmitted from an approach balise group. Refer to Section 8.5 for details. Where the required input functions are not available in the same location as the LEU, look-ahead is required. Refer to Section 8.6 for details. Refer to T HR SC 00003 ST for examples of inputs to LEUs.

Where a shunt route is clear at the home signal of a turnout, the TSM shall be revoked or relaxed if both the following conditions are true:

- the LEU interfaces with the home signal of the turnout
- there is an identified operational restriction in applying the most restrictive TSM

The TSM shall be revoked or relaxed by applying the static speed profile applicable to the main class route of the same destination.

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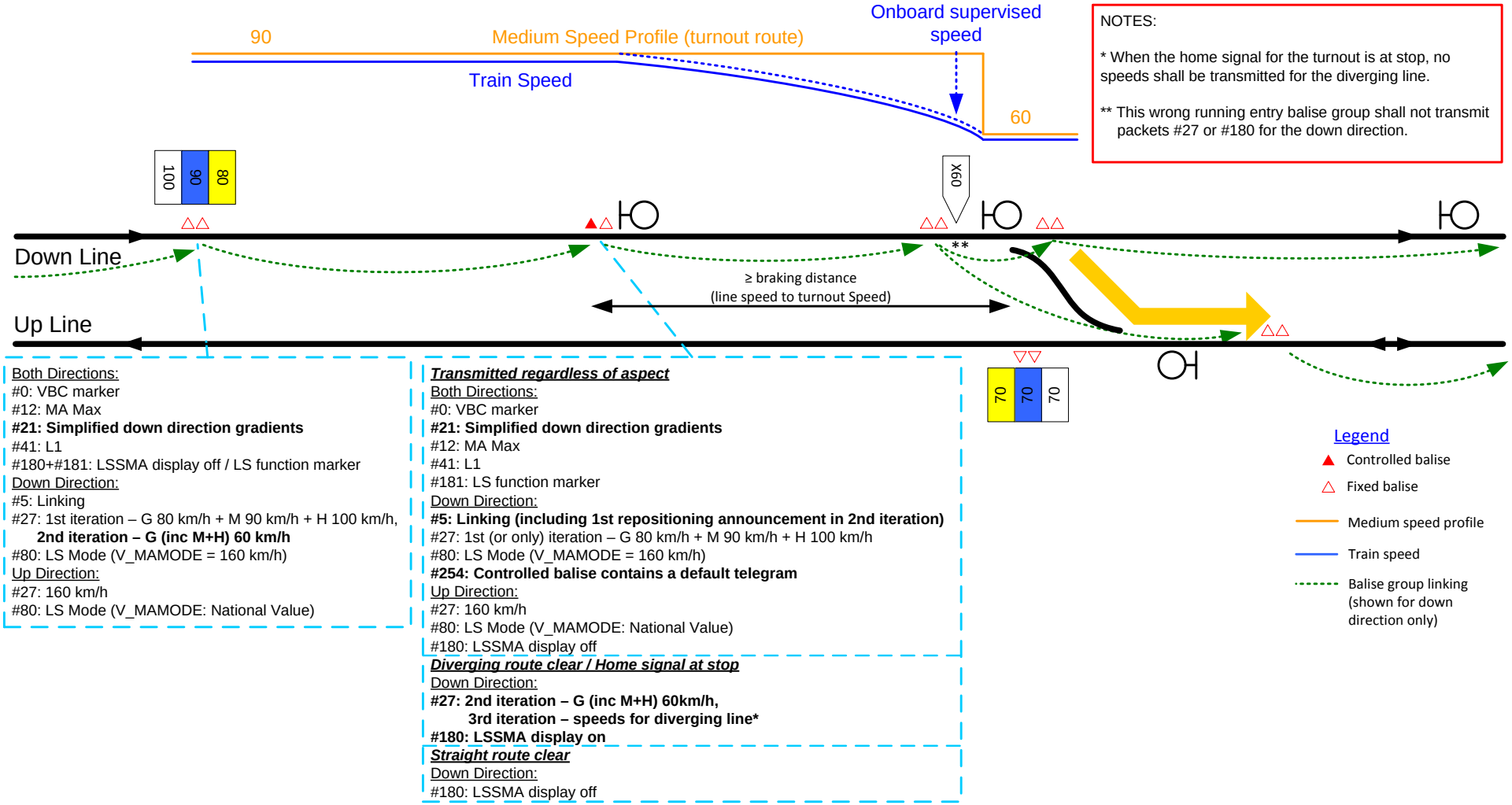

Figure 21 - High-risk turnout

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8.3.3. Contact sensing arrangement

In a contact sensing arrangement, each LEU input shall apply to one route from the home signal of the turnout, unless routes can be combined. The input shall consist of the control relays for the first or higher proceed aspect clear for the applicable main class route and all intermediate signals clear. Multiple routes from the home signal shall be combined into one input where the routes have the same TSM response regarding turnout speeds, target points and line speeds of the diverging line in advance of the turnouts.

Input 1 of the LEU shall be allocated to the straight route at the turnout. TSM shall be revoked when this input is made. Additional controls shall be added to this input if TSM is required to be revoked for other reasons, such as where there would be an operational impact in applying TSM to a train that will be routed away before reaching the turnout.

Input 2 of the LEU shall be allocated to the turnout route, or to the least restrictive turnout route where there are multiple high-risk turnouts from the same signal.

Further inputs shall be allocated in increasing restriction order where there are multiple high-risk turnouts from the same signal.

The replacement track shall be added in series to all inputs to gain the protection provided by the track stick function. The exception to this is where a shunt route revokes or relaxes TSM, and it is possible for the route to clear with the replacement track occupied. In this situation, the shunt control portion of the input shall bypass the replacement track.

8.3.4. Current sensing arrangement

In the event of lamp failure in a current sensing arrangement, the balise group shall transmit a message consistent with the most restrictive combination of the remaining illuminated lamps.

In the event of an invalid signal indication, the LEU inputs shall be deemed an invalid combination, resulting in the LEU selecting its default telegram. Speed will be supervised to the profile transmitted by the redundant TSM balise group.

Outer signals

Where the LEU interfaces to an outer signal, the LEU requires inputs from the following lamps:

- running aspects in the main heads
- marker lights
- turnout repeaters (preferably using current sensing, even if relay-driven, where the running aspects use current sensing)

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- bands of lights and any necessary main line route indicators in the following situations:
  - the route leads to the home signal of the turnout
  - there is a requirement to revoke TSM for a train routed away before reaching the turnout

The LEU does not require inputs from the following lamps:

- low speed aspect
- close-up aspects
- co-acting signals
- miniature route indicators
- shunt aspects
- other subsidiary aspects

Home signals

Where the LEU interfaces to the home signal of the turnout, the LEU requires inputs from the following lamps:

- yellow and green aspects of single light signals
- marker lights
- all aspects in the top head of double light signals
- lower green aspect of double light signals
- low speed aspects
- close-up aspects
- bands of lights
- main line route indicators (using contact sensing if relay-driven)
- shunt aspects and any applicable route indicators necessary to positively identify any shunt routes that revoke or relax TSM

The LEU does not require inputs from the following lamps:

- red aspects of single light signals
- red and yellow aspects in the lower head of double light signals
- co-acting signals
- turnout repeaters
- other subsidiary aspects

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8.4. High-risk overruns

The determination of whether an overrun past a signal at stop is deemed high-risk is outside the scope of this standard.

Where an overrun is deemed high risk, it is due to one or more of the three types of identified hazard, namely deficient overlaps, high-risk catchpoints and high-risk level crossings. The signal that is overrun is termed the 'protecting' signal.

In determining a high-risk overrun, the trip speed would generally have been assumed to be the line speed on approach to the first warning signal. Where there is a decrease in line speed between the first warning signal and the protecting signal, it may be possible to sufficiently mitigate the hazard from the high-risk overrun by treating the speed sign as high-risk. See Section 7.2.1. Where this solution is not possible, a balise group using TSM shall be provided on approach to the protecting signal.

8.4.1. High-risk overrun balise group

A high-risk overrun balise group shall consist of one controlled balise and one fixed balise. The preferred position of the balise group is at the 'permitted distance' obtained from the braking tool, using the protecting signal as the target point. See Figure 22.

The target speed shall be the safe overrun speed, that is, the maximum speed that allows a train that has tripped at the protecting signal to stop before the hazard point. For the medium speed profile, the applicable GE52 or GE52A braking curve shall be used in determining the safe overrun speed. For the high speed profile, the GX2M braking curve shall be used in determining the safe overrun speed.

The hazard point for a deficient overlap shall be at the end of the signalling overlap.

The hazard point for catchpoints shall be the nearest end of the throw-off rail.

The hazard point for a level crossing shall be the nearest edge of the crossing.

The balise group may be positioned farther than the 'permitted distance', including at an outer signal, one or more blocks in rear of the protecting signal.

When determining the position of the balise group, the following factors shall be considered:

- braking distance
- cable trenching costs
- the need for look-ahead
- the need for additional LEUs
- the need for approach balise groups

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The balise group shall transmit line speed for the static speed profile with any main class route clear at the protecting signal and all other intermediate signals clear. This static speed profile revokes the redundant target speed information sent from the balise group in rear. Where these conditions are not satisfied, for example when the protecting signal is at stop, the static speed profile transmitted by the balise group shall be the greater of the safe overrun speed or 10 km/h.

The 10 km/h minimum is for operational reasons. The medium safe overrun speed shall apply to both the medium and general speed profiles. The safe overrun speed transmitted for each speed profile shall not exceed the line speed for that profile.

Where the safe overrun speed (or the 10 km/h minimum) is transmitted, the static speed profile shall additionally include an iteration for the line speed at a position of 1 m in advance of the target point. Train length delay shall not be enforced.

The LEU controlling the controlled balise will either interface with the protecting signal or with an outer signal, one or more blocks in rear. Where the required input functions are not available in the same location as the LEU, look-ahead is required. Refer to Section 8.6 for details. Refer to T HR SC 00003 ST for examples of inputs to LEUs. There are situations where an additional balise group is required for approach purposes. Refer to Section 8.5 for the requirements of approach balise groups.

Where the LEU interfaces with the protecting signal and the safe overrun speed is less than 25 km/h, TSM shall be revoked with a shunt class route clear at the protecting signal where an operational restriction would exist if the safe overrun speed was transmitted instead. This operational restriction will typically exist only where the shunt route lowers the trainstop (or the ETCS trainstop transmits no trip order) with no approach control of the trainstop or where the timing speed for the approach control of the trainstop is greater than the safe overrun speed.

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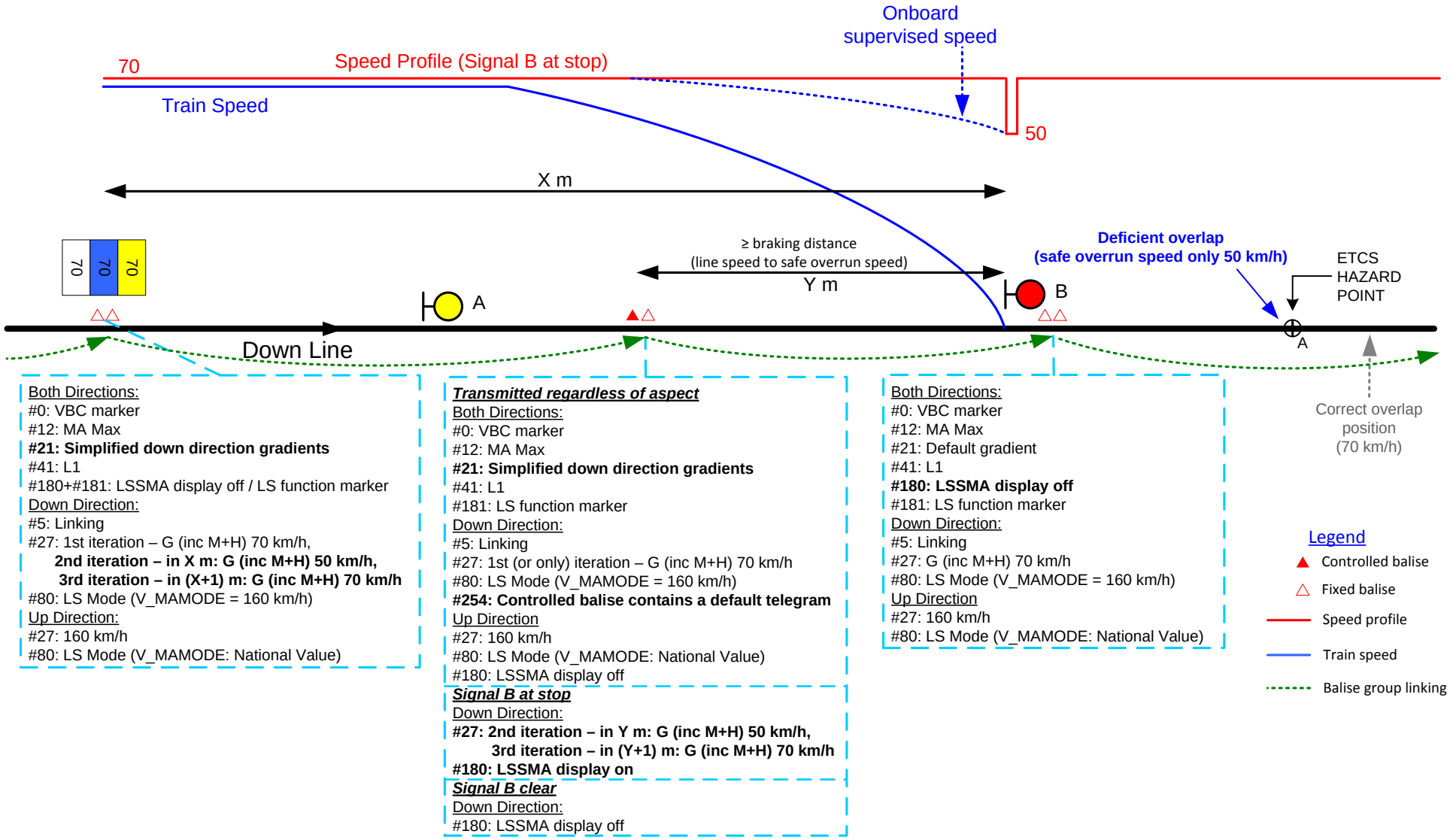

Figure 22 - High-risk overrun – deficient overlap

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8.4.2. Contact sensing arrangement

In a contact sensing arrangement, only one LEU input is required. This shall be Input 1 of the LEU. TSM shall be revoked when this input is made. The input shall consist of the control relays for the first or higher proceed aspect clear at the protecting signal for any main class route and all intermediate signals clear. Additional controls shall be added to this input if TSM is required to be revoked for other reasons; for example, where a train will be routed away before reaching the protecting signal, or where necessary to avoid an operational restriction when subsidiary aspects are clear at the protecting signal.

The replacement track shall be added in series to the input to gain the protection provided by the track stick function. The exception to this is where a shunt route revokes TSM, and it is possible for the route to clear with the replacement track occupied. In this situation, the shunt control portion of the input shall bypass the replacement track.

8.4.3. Current sensing arrangement

In the event of a lamp failure in a current sensing arrangement, the balise group shall transmit a message consistent with the most restrictive combination of the remaining illuminated lamps.

In the event of an invalid signal indication, the LEU inputs shall be deemed an invalid combination, resulting in the LEU selecting its default telegram. Speed will be supervised to the profile transmitted by the redundant TSM balise group.

Outer signals

Where the LEU interfaces to an outer signal, the LEU requires inputs from the following lamps:

- running aspects in the main heads
- marker lights
- bands of lights and any necessary main line route indicators where the route leads to the protecting signal or there is a requirement to revoke TSM for a train routed away before reaching the protecting signal

The LEU does not require inputs from the following lamps:

- low speed aspects
- close-up aspects
- co-acting signals
- miniature route indicators
- turnout repeaters

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- shunt aspects
- other subsidiary aspects

Protecting signals

Where the LEU interfaces to the protecting signal, the LEU requires inputs from the following lamps:

- running aspects, including bands of lights
- marker lights
- shunt aspects and any applicable route indicators necessary to positively identify any shunt routes that revoke TSM

The LEU does not require inputs from the following lamps:

- co-acting signals
- route indicators
- turnout repeaters
- other subsidiary aspects

Due to the inconsistent application of low speed and close-up aspects, each occurrence shall be assessed to determine whether it is necessary to revoke TSM to avoid an operational restriction with one of these aspects displayed.

8.5. Approach balise groups

A driver should ideally be able to accelerate to an appropriate speed when they see a signal clear to a less restrictive aspect. However, where a target speed has been transmitted by a TSM-initiating balise group to a train approaching a high-risk turnout (or a high-risk overrun), and the home signal of the turnout subsequently clears for the straight route (or the protecting signal subsequently clears), the driver is forced to continue braking to the target speed until after the turnout (or the protecting signal) is passed. The addition of an approach balise group provides an update of the speed profile, allowing a train to take early advantage of a signal clearing to a less restrictive aspect, thereby reducing the operational restriction caused.

One or more approach balise groups can be provided to achieve a time gain for the travel time of a train. Time gain calculations shall assume the worst-case scenario, that is, when the home signal of the turnout clears for the straight route (or the protecting signal clears) immediately after the train has passed the TSM-initiating balise group. The time gain is calculated by subtracting the travel time with the approach balise group(s) provided, from the travel time without the approach balise groups provided.

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The LEU controlling the controlled balise of the approach balise group shall interface with the signal at the approach balise group, or with the next signal in advance of the approach balise group.

Where the home signal of the turnout has not cleared for the straight route (or the protecting signal has not cleared), the approach balise group shall resend the TSM speed profile according to the TSM-initiating balise group. Where the home signal of the turnout has cleared for a turnout route, the approach balise group shall send an updated TSM speed profile, including an iteration for the line speed of the diverging line. The iteration for the line speed of the diverging line of a high-risk turnout may be omitted from the TSM-initiating balise group where it is sent from an approach balise group, potentially reducing or avoiding look-ahead requirements.

8.5.1. Approach balise group types

The following are two types of approach balise group to consider:

- The first type is a balise group placed at, or in the last block approaching the home or protecting signal. The LEU in this case interfaces with the home or protecting signal. See Figure 23.

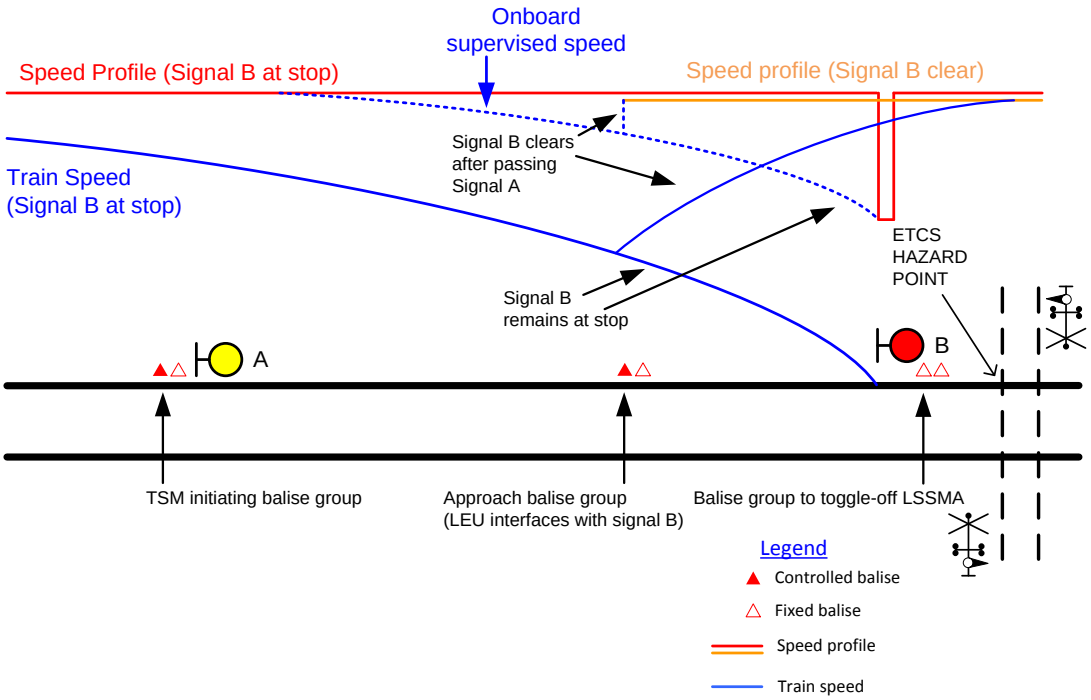

Figure 23 Approach balise group in the last block

- The second type occurs where the TSM-initiating balise group is more than one block in rear of the home or protecting signal. The approach balise group is placed at or in rear of an intermediate signal between the TSM-initiating balise group and the home or protecting signal. The LEU in this case interfaces with this intermediate signal. See Figure 24.

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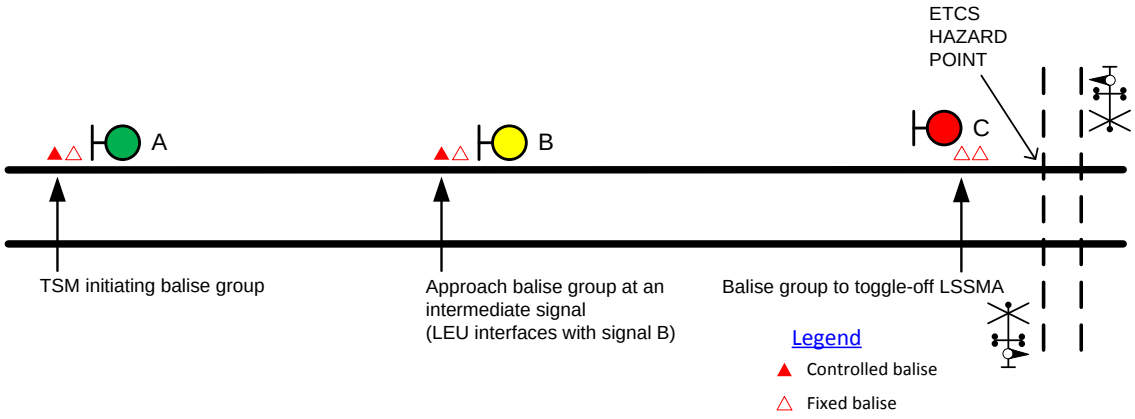

Figure 24 - Approach balise group at an intermediate signal

Approach balise groups can potentially be provided as follows:

- at one or more intermediate signals
- one or more in the last block approaching the home or protecting signal
- at the home signal

8.5.2. Selection of approach balise groups

Not every approach to a high-risk turnout and high-risk overrun requires an approach balise group. The selection of approach balise groups requires qualitative judgement on any significant, regular operational benefit in providing them.

The greater the time gain, the more significant the operational benefit can be.

The greater the distance (or travel time) between the TSM-initiating balise group and the home or protecting signal, the more likely a significant operational benefit is gained by the approach balise group.

A regular operational benefit is likely only to exist where timetabled trains are running closer than the headway allows or where the signaller regularly clears a signal after a train has passed the TSM-initiating balise group. This includes the scenario of a train turning out with a closely following train taking the straight route from the same signal.

An operational benefit is unlikely to exist in the following circumstances:

- where all trains stop at a platform in the vicinity of either side of the TSM target point
- in the last block approaching an automatic signal protecting a deficient overlap

  This is because when the signal clears, it will only clear to first aspect, thereby preventing the following train from accelerating fully.

A significant operational benefit is unlikely to exist where the difference between line speed and the target speed is relatively small.

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8.5.3. Position of approach balise groups

The positioning of an approach balise group also requires qualitative judgement, as there is an engineering trade-off involved. The closer the approach balise group is to the TSM-initiating balise group, the more time gain can be achieved. However the closer the approach balise group is to the home or protecting signal, the greater the number of trains would benefit from it.

The operational benefit is insignificant in positioning an approach balise group farther from its interfaced signal than the sighting point of this signal. This is because a driver is unlikely to accelerate, based purely on the absence of the display of the LSSMA.

For an approach balise group interfaced to an intermediate signal, there can be a benefit in positioning the balise group at the signal (as opposed to farther in rear of the signal), if the signal regularly clears at the same time or after the home or protecting signals clear.

Where a regular, significant operational benefit has been identified, consultation with network operators shall be made in determining the need and positioning of an approach balise group.

8.6. Look-ahead

Where a controlled balise interfaces to an outer or intermediate signal for a high-risk turnout or a high-risk overrun, in some situations the locally available signal control relays and aspects are insufficient to provide the LEU with the required input information. In these situations, additional information is required to be brought back from a signal in advance. The arrangement for providing this additional information is termed ‘look-ahead’.

The following are three methods of implementing look-ahead:

- splitting signal aspect control relays
- additional computer-based interlocking (CBI) outputs
- networking LEUs

Examples of each method are shown in T HR SC 00003 ST.

Where LEUs are networked, the local LEU shall be provided with one or more additional local inputs where these inputs can revoke TSM independently of the inputs at the remote LEU. This is to minimise the operational restriction caused by a failure in the LEU networking arrangement.

Where a new relay function is created to provide look-ahead, the design shall ensure that a failure of the relay to energise does not go undetected. This shall be achieved by restricting the aspect of the signal that the LEU is interfaced with.

Where a new relay function is created to provide look-ahead, the design shall ensure that a failure of the relay to de-energise does not present an unsafe situation for a subsequent train. This shall be achieved by back proving the relay in the track stick function.

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8.6.1. Splitting signal aspect control relays

This method requires multi-core signalling cables between locations to provide extra relay functions to be input to the LEU.

This method would typically be used in areas with existing multi core signalling cables between locations, such as in relay based interlockings or in automatic sections.

8.6.2. Additional CBI outputs

This method requires new output relay functions from a CBI to be input to the LEU.

This method would typically be used in areas where a computer-based interlocking outputs to lamps or relays in a lineside signalling location.

8.6.3. Networking LEUs

This method requires connecting LEUs in different locations using ethernet switches and optical fibre cable. The logic in the LEU connected to the controlled balise can then use inputs from the LEU interfaced to a signal in advance.

This method would typically be used in CBI areas where the process and cost of altering the data in the CBI precludes providing additional CBI outputs.

9. Combining functions

The number of balises installed shall be minimised by combining functions where there is an overall benefit in doing so.

Certain combinations are not possible or prohibited, as described elsewhere in this document.

Judgement is required when determining the benefit of combining functions. For example, where additional trenching is required to combine a high-risk turnout balise group with a speed sign balise group in rear, the potential extra cost of trenching together with the greater potential operational restriction may influence the decision whether to combine the functions.

10. Cascading functions

When more than one function requires ETCS protection in the same vicinity, one function can affect the others. This cascading effect can affect the number, positioning and data of the required balise groups.

Some layouts have cascading functions, for example a high-risk speed sign followed by a high-risk turnout. Individual assessment of each hazard shall be made to determine if protecting one hazard removes the need to protect the other, or whether both hazards need protection.

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10.1. Low-risk turnouts in rear of high-risk speed signs

When turning out through a low-risk turnout results in a speed reduction from the original line to the diverging line, the speed of the diverging line shall require assessment as a high-risk speed sign. See Figure 25.

If the assessment deems it as a high-risk speed sign, then the turnout shall have protection according to a high-risk turnout.

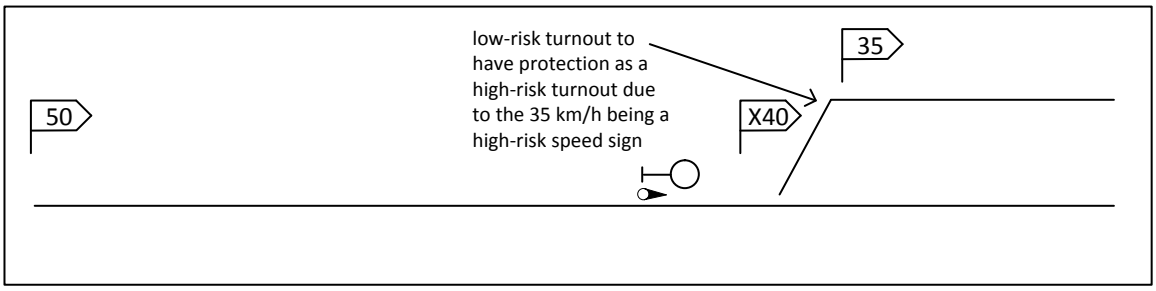

Figure 25 - Low-risk turnout in rear of high-risk speed sign

10.2. Speed signs and speed updates inside TSM areas

In a given direction, a balise group transmitting a fixed SSP packet shall not be placed between a TSM-initiating balise group (where the TSM is conditional on signalling inputs) and the TSM target point, as this can unintentionally revoke the TSM.

For example, where a speed sign is located between the TSM-initiating balise group and a high-risk turnout, a balise group shall not be installed at the speed sign. Instead, the relevant speeds shall be transmitted as iterations from the TSM-initiating balise group. See Figure 26.

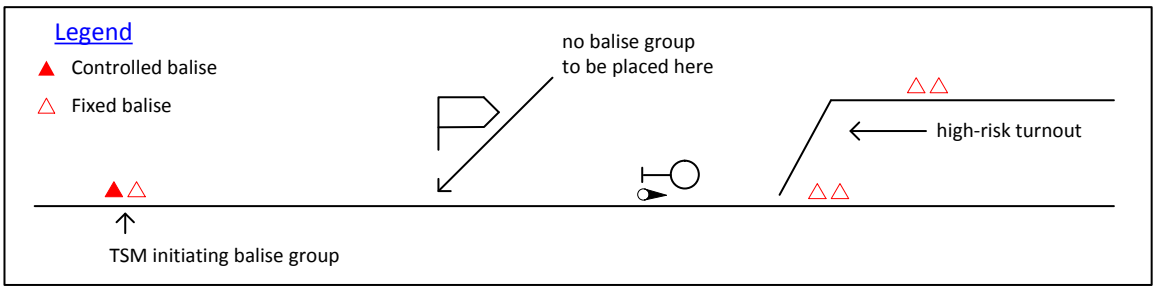

Figure 26 - Speed sign inside TSM area

Another example is where a train can enter the TSM area through a trailing turnout from a wrong running direction move. See Figure 27. There would be no significant operational restriction in preventing the train accelerating to line speed until the end of the TSM area, as it would not be a regular move. If an approach speed of 40 km/h to the TSM target point is deemed high-risk, then this approach shall also be considered for protection.

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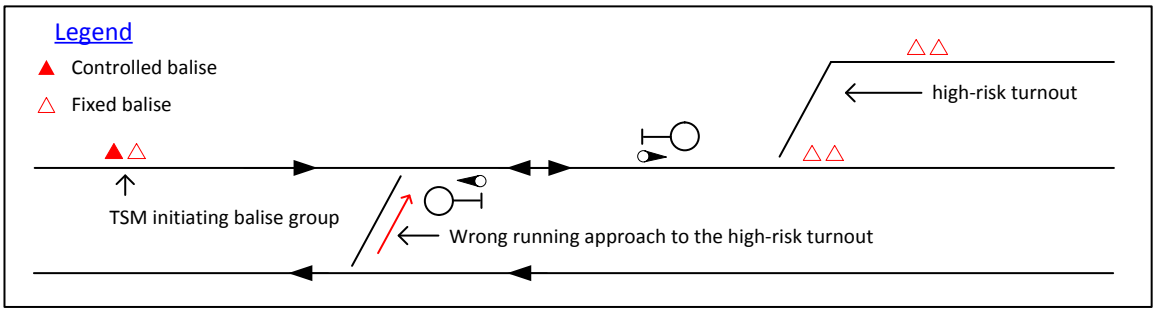

Figure 27 - Wrong running exit into TSM area

For a balise group that is not transmitting an SSP packet (#27) in a given direction, it cannot be used as a mode change balise group for that direction, as packet #80 can only be sent with packet #12, and packet #12 requires packet #21 and packet #27 to accompany it. See Figure 28.

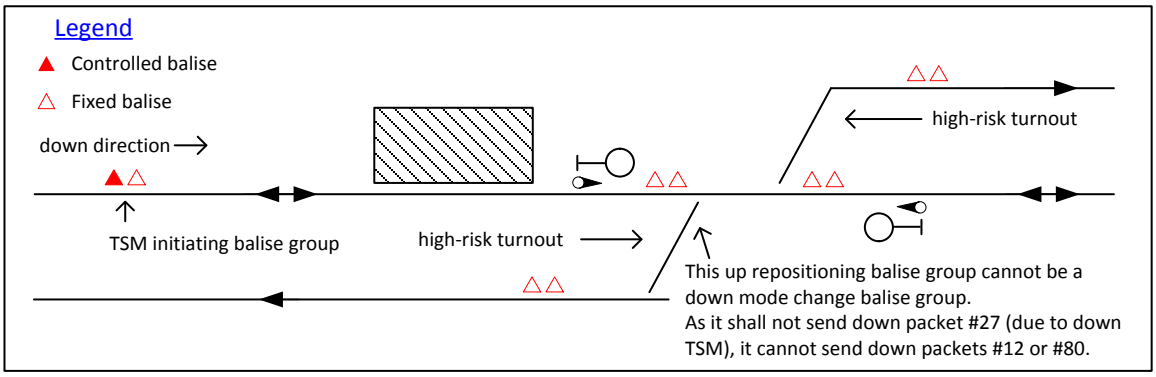

Figure 28 - Mode change not possible inside TSM area

10.3. LSSMA value considerations

The display of the LSSMA on the DMI may cause operational restrictions where there are cascading functions. If a restriction is considered significant, then an extra balise group can be provided to reduce the restriction.

For example, consider a TSM-initiating balise group transmitting an SSP packet containing the iterations 90/60/90/25 km/h, where 90 km/h is the line speed, 60 km/h is for a high-risk overrun with the protecting signal at stop, and 25 km/h is transmitted as a redundant TSM for a high-risk turnout farther in advance. See Figure 29. The DMI displays an LSSMA of 25 km/h, as it is the lowest of the speed iterations. This can cause an operational restriction approaching the high-risk overrun protecting signal if it clears after passing the TSM-initiating balise group. This is because the driver may notice the display of 25 km/h on the DMI, and can be misled into believing that accelerating faster than 25 km/h would cause warnings or brake interventions.

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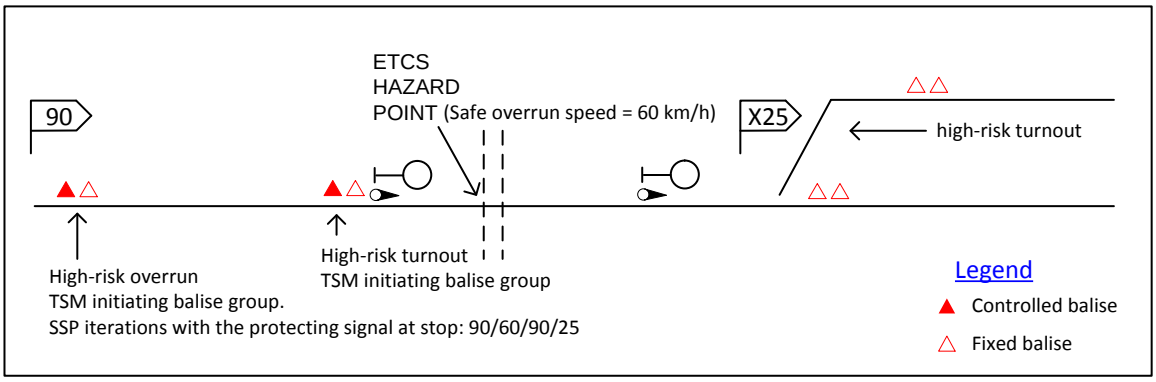

Figure 29 - High-risk overrun followed by high-risk turnout

10.4. LSSMA display considerations

The display of the LSSMA shall not be toggled-off where it is required to remain toggled-on. An example of a cascading function where this needs consideration is a high-risk overrun followed by a high-risk turnout.

The standard arrangement for a high-risk overrun includes a balise group at (or up to 10 m in advance of) the protecting signal whose purpose is to toggle-off the display of the LSSMA. See Figure 29. Where the display of the LSSMA is toggled-on for another reason when passing this protecting signal, for example, approaching a high-risk turnout, the display of the LSSMA shall remain toggled-on, potentially removing the need for a balise group at the protecting signal.

Where a controlled balise group is required at the protecting signal, it shall conditionally toggle-off the display of the LSSMA.

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