Recommendations for Systems for the Supervision of Enhanced Permissible Speeds and Tilt Enable

Synopsis
This document supports GE/RT8012 and GE/RT8019. It recommends principles to apply to satisfy the requirements mandated by these two standards.

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Part A

Issue Record
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Technical Content
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Part B
Introduction

B1 Purpose

The purpose of this document is to support GE/RT8012 and GE/RT8019. In parts B to E it recommends principles to apply to satisfy the requirements mandated by these two standards. The appendices give further guidance.

B2 Scope

The overall scope of Railway Group Standards is as specified in Appendix A of GA/RT6001.

This document contains recommendations that are applicable to the duty holders of the following categories of Railway Safety Case:

a) Infrastructure controller
b) Train operator

The recommendations concern trains operating:

a) in tilting mode over routes on which they are authorised to operate; and
b) on sections of route on which enhanced permissible speeds are authorised.

This document does not address the requirements of automatic train protection.

B3 Definitions

Alert
An audible prompt given to the driver of a train by a supervision system to indicate to him that a specified event has been detected.

Automatic Train Protection
Automatic Train Protection (ATP) is an automatic system for preventing trains from exceeding the limit of their movement authorities and from exceeding the permissible speed (or enhanced permissible speed, where applicable) and any prevailing speed restrictions.

Balise
A spot transmission device that transmits data to the trains. A balise can also be known as a ‘beacon’ or a ‘transponder’.

Cab Signalling
Provision of in-cab movement authority and speed limit information to the driver of a train.

Clearances
The calculated distance between moving vehicles and fixed structures or between two moving vehicles on adjacent tracks. The requirements are contained in GE/RT8029.

Driver-Machine Interface
The Driver-Machine Interface (DMI) is a set of devices in the cab through which the driver and systems provided to meet the requirements of GE/RT8012 and GE/RT8019 communicate.

Enhanced permissible speed
The authorised maximum speed (higher than the permissible speed) over a section of line which applies to a specific type of train operating at cant deficiencies in excess of those permitted at the permissible speed. Enhanced permissible speeds are detailed in the Sectional Appendix. There may be more than one enhanced permissible speed applicable to a given section of line.
ETCS
European Train Control System. The name given to the system providing cab-signalling and automatic train control functions that are specified to be applicable to the railways of the European Union.

GSM-R
Global System Mobile - Railway. The European Standard specific to railway applications for the transmission by radio of voice and data between train and trackside installations.

Intervention
The function that calls for the application of the train’s brakes in response either to an overspeed condition or to the detection of the train tilting within a section of track where tilt is not authorised.

Permissible Speed
The authorised maximum speed over a section of line, either for all trains or (where differential speeds are applied) for specific types of train as detailed in the sectional appendix, operating up to the cant deficiency limits defined in GC/RT5021.

Speed Supervision
The function of measuring the speed of a train and comparing the value obtained against a limit. If the limit is exceeded the function prompts other functions, for example informing the driver, calling for the brakes.

Target Distance
The computed distance from the location of the train to the intended point of enforcement of one or more of:

a) an enhanced permissible speed
b) a permissible speed
c) cancellation of Tilt Enable.

It is derived by the system on the train from distance data received from the trackside, usually applying from the location of a specific balise. It is decreased as the train moves forward by the distance travelled beyond that balise as measured on the train.

Target Speed
The value of speed that the train should achieve or be less than at the target distance.

Tilt Authority
Tilt Authority is an output to the Tilt Control System that permits the train to be tilted.

Tilt Enable
The information passed from the Tilt Enable and Supervision System to the Tilt Control System that the latter requires in order to operate.

Tilt Control System
A train system that operates and controls the tilting of the vehicle body fitted to tilting trains.

Tilt Enable and Supervision System
A system that enables and supervises the operation of the Tilt Control System.

Tilt Prohibited Section
A section of route where, to maintain clearances, operation of a tilting train in tilting mode is prohibited.
Tilting Train
A train which tilts the train body on curves to reduce the lateral acceleration experienced by passengers, allowing the train to operate at higher speeds through curves than non-tilting trains.

Train Protection and Warning System
Train Protection and Warning System (TPWS) is a system mitigating against Signals Passed At Danger and non-respect of permissible speeds.

Warning
Information, usually audible and visual, given to the driver of a train by a supervision system to indicate to him that intervention is imminent, and the driver should take preventative action.

B4 Introduction

B4.1 Similarities between the implementation of a speed supervision system (required by GE/RT8012 to support enhanced permissible speeds) and the implementation of a tilt enable and supervision system (required by GE/RT8019 to ensure that tilt is only enabled where clearances can be achieved) suggest that the functionality of these systems can be contained in a common system. Such similarities include the means of data transmission, the measurement of distance, determining the need for intervention and the Driver-Machine Interface.

These two systems are comprised of equipment at the trackside and equipment on the train.

Using information from the trackside, the equipment on board the train will establish warning and intervention criteria applicable to the locations of lengths of track where tilt is prohibited and/or an enhanced permissible speed is in force. The braking performance of the train will affect the warning and intervention criteria. The model of the braking system used to determine the intervention criteria should be based on the principles described in Appendix A.

B4.2 Part C recommends the practice that should be adopted for the speed supervision requirements. Part D recommends the practice that should be adopted for the tilt enable and supervision requirements. Part E makes system and operating recommendations common to both speed supervision and tilt enable.

This document quotes the requirements of the respective Railway Group Standards.

B4.3 The systems transmitting data meeting the requirements of GE/RT8012 and GE/RT8019 could be applied to the control of other risks, for example, those relating to speed and to the train’s route availability. The principle of As Low As Reasonably Practicable (ALARP) should be applied to assess the safety implications and benefits of these systems to control other risks.
Part C

Recommendations Specific to GE/RT8012:
Speed Supervision

C1 General Requirements for Operation at Enhanced Permissible Speeds

C1.1

**GE/RT8012 section 5.1**
Provision of speed limit information and speed supervision and control

Tilting Trains shall be permitted to operate at Enhanced Permissible Speeds through curves only if speed limit information and speed supervision and control is provided by one of the following means:

a) use of lineside signs, with a speed supervision and control system, or
b) use of Cab Signalling with an Automatic Train Protection system.

The specific requirements for these arrangements are set out in sections 6, 7 and 8.

This RACOP addresses the requirements for lineside signs complemented by a speed supervision system. The value of the signed enhanced permissible speed and its derivation when several types of train are authorised to operate at enhanced permissible speeds through the section are described in paragraph C2.5.

C1.2

**GE/RT8012 section 5.2**
Use of Cab Signalling

Cab Signalling with an Automatic Train Protection system shall be used to control the speed of Tilting Trains on curves if:

- the Tilting Trains are operating at speeds greater than 125mph on the approach to curves, or
- a Cab Signalling system is in use for controlling the movement of trains, instead of lineside signalling.

Cab signalling requirements, including ATP requirements, are contained in GE/RT8026. The implementation of the requirements of GE/RT8012 within an ATP system should be based upon the data formats referred to in section E5.

C1.3

**GE/RT8012 section 5.3**
Temporary and Emergency speed restrictions

Where lineside signs are provided, Tilting Trains shall travel over Temporary and Emergency Speed restrictions at the same speeds as conventional trains, and the provision of signs and AWS magnets for such speed restrictions in accordance with GK/RT0038 shall reflect this requirement.

For Temporary Speed Restrictions (TSRs), the arrangements for the suspension of any authorisation displayed to the driver to operate up to the applicable enhanced permissible speed should be incorporated into the arrangements for the implementation of the TSR.

For Emergency Speed Restrictions (ESRs), until the arrangements to suspend any authorisation to operate at enhanced permissible speed are implemented, the arrangements described in GO/RT3000 Section U for informing the driver of an ESR apply and the driver is required to act on this information.

The infrastructure controller should publish and implement procedures for enhanced permissible speed suspension and reinstatement.
The information given to driver in the cab should be consistent with the information given at the lineside.

### C1.4

**GE/RT8012 section 5.4**

Review of arrangements for compliance

Prior to the implementation of any change to the Permissible Speed or Enhanced Permissible Speed at a given location, the arrangements for compliance with this document shall be reviewed and amended where necessary.

*GK/RT0007* contains the overall process for planning changes to permissible speeds and enhanced permissible speeds. See also Part E, section E3.1.

### C2 Provision of Lineside Signs

#### C2.1 Enhanced Permissible Speed Indicators

**GE/RT8012 section 6.1.1**

Lineside speed indicators shall be provided at every change in Permissible Speed and Enhanced Permissible Speed on routes on which Tilting Trains operate.

An enhanced permissible speed indicator should be provided for each length of line where authorised by the Sectional Appendix. The value to be displayed on the indicator should be derived in accordance with section C2.5. The position of a speed indicator should take into account the tolerances of the train-borne distance measurement and speed measurement functions so that, when driving in accordance with the sign and with the design of the speed supervision system meeting the requirements of section 7.1 of *GE/RT8012*, it is possible to drive without unjustified interventions.

Appendix A describes the process that the train operator should undertake to apply supervision of enhanced permissible speeds. The process provides the information for ensuring compatibility of the enhanced permissible speed indicator positions with the operation of the supervision system. As described in appendix A, the train operator and the infrastructure controller have the responsibility to ensure that the position of the speed indicator allows the train to be driven according to the signed speeds and the speed displayed in the cab on the speed odometer, without unnecessary interventions being invoked nor the real speed becoming unsafe without intervention.

#### C2.2 Permissible Speed Indicator

**GE/RT8012 section 6.1.2**

Where the same speed applies to both conventional and Tilting Trains, a Permissible Speed indicator shall be provided without an Enhanced Permissible Speed indicator. Where a different speed applies, an Enhanced Permissible Speed indicator shall be provided in addition to the speed indicator(s) for conventional trains. An Enhanced Permissible Speed indicator shall not be provided in isolation.

A permissible speed (PS) value is required with each enhanced permissible speed value so that the driver is aware of the appropriate permissible speed to apply should it not be possible to operate at enhanced permissible speed.

#### C2.3 The Form of Enhanced Permissible Speed Indicators

**GE/RT8012 section 6.1.3**

The Enhanced Permissible Speed indicators shall use a unique and distinctive form so drivers can distinguish them easily from conventional speed indicators.

The form of the indicators is mandated in *GK/RT0033* and is different in both shape and colour from conventional speed indicators.

There are no specific recommendations relating to *GE/RT8012* section 6.1.3.
C2.4  Height of the Enhanced Permissible Speed Indicator Relative to the Permissible Speed Indicator

GE/RT8012 section 6.1.4
An Enhanced Permissible Speed indicator, where provided, shall always be positioned immediately below a Permissible Speed indicator.

There are no specific recommendations relating to GE/RT8012 section 6.1.4.

C2.5  The Enhanced Permissible Speed Value to be Displayed

GE/RT8012 section 6.1.5
Where more than one Enhanced Permissible Speed applies through a given curve, as shown in the Sectional Appendix, only one speed value shall be shown on the Enhanced Permissible Speed indicator. The value shown shall be the highest Enhanced Permissible Speed at which all Tilting Trains authorised to operate on the route can safely traverse the curve without an unacceptable risk of overturning.

Requirements for calculating the Enhanced Permissible Speeds are given in GC/RT5021.

The infrastructure controller should determine the value to be shown on the enhanced permissible speed indicator applicable to a curve in accordance with the recommendations contained in GC/RC5521.

The train operator should advise the infrastructure controller of the probabilities of the speed control system allowing speeds above the value of a given target speed as discussed in Appendix A of this document.

The enhanced permissible speed value represents the speed limit for safety. Drivers of trains who, for the purpose of passenger comfort, are required to follow an enhanced permissible speed profile below that indicated by the lineside indicators, should be provided with a route speed profile which is taken from the Sectional Appendix and which is clear and fit for use in the cab at the speeds concerned. In general, there will not be a simple rule for the drivers of such trains to apply to relate the value on the enhanced permissible speed indicator to the value specified in the Sectional Appendix for the train being driven. It should be arranged that the locations at which changes occur in unsigned enhanced permissible speed profiles coincide with those of the signed profile.

The infrastructure controller should ensure that Table A of the Sectional Appendix documents the enhanced permissible speed of each type of train that is authorised for operation along the route.

The signed enhanced permissible speed values should be reviewed on each occasion that:

a)  a new type of tilting train is introduced

b)  infrastructure changes are made that could affect speed.

(Configuration and change control are addressed in Part E, section E3.1)
C2.6  Limit to the Quantity of Speed Values to be Displayed at a Location

GE/RT8012 section 6.1.6
A total of no more than three speed values shall be shown on the lineside indicators at any one speed change location.

GK/RT0038 states to which type of trains the two values available for trains operating at permissible speeds may apply.

C2.7  Enhanced Permissible Speed Warning Indicators

GE/RT8012 section 6.2.1
Railway Group Standard GK/RT0038 sets out the requirements for providing warning indicators and associated AWS magnets for Enhanced Permissible Speeds. It includes the additional requirements relevant to continuous route signing.

GK/RT0038 sets out the requirements for the installation of permissible speed warning indicators and the Automatic Warning System (AWS) for permissible speeds.

Warning Indicators
The reference to continuous route signing in this context means that additional warning indicators for enhanced permissible speeds should be provided when:

a) they do not cause confusion to drivers
b) there is a benefit to the overall efficiency and safety of operations
c) the degraded mode analysis recommended in section E4.3 indicates that the driver requires advanced warning of the permissible speed applicable for the case when the expected following enhanced permissible speed authority is not displayed in the cab.

A warning indicator is recommended for each location where there is a reduction in enhanced permissible speed, both in the signed and the unsigned speed profiles. A warning board for the corresponding permissible speed value(s) should also be provided where there is a change at the location concerned. Where the permissible speed value(s) in force does not change, the use of a miniature sign to repeat this value with the warning indicator may be considered.

A warning indicator for a reduction in the permissible speed should always be accompanied by enhanced permissible speed information, unless the end of an enhanced permissible speed zone is to be indicated. Where the enhanced permissible speed value in force does not change, the use of a miniature sign to repeat this value with the warning indicator may be considered.

Automatic Warning System
Because of the requirement for a speed supervision system, the installation of the Automatic Warning System (AWS) at reductions of enhanced permissible speed is not required. The installation of the AWS is required at the warning indicator of a section where operation at enhanced permissible speed is not authorised, and the speed reduction from the applicable enhanced permissible speed to the permissible speed meets the criteria of GK/RT0038, unless the appropriate speed supervision data is provided at that location.

The AWS magnets installed for warning of reductions in permissible speed should be assessed by the train operator for their influence upon drivers operating to enhanced permissible speeds. Measures should be taken to ensure that the significance of AWS to these drivers is maintained.
C2.8 The Form of Enhanced Permissible Speed Warning Indicators

GE/RT8012 section 6.2.2

The Enhanced Permissible Speed warning indicators shall use a unique and distinctive form so that drivers can distinguish them easily from conventional warning indicators.

The form of the indicators is mandated in GK/RT0033 and is different in both shape and colour from conventional warning indicators.

There are no specific recommendations relating to GE/RT8012 section 6.2.2.

C2.9 Height of Enhanced Permissible Speed Warning Indicators

GE/RT8012 section 6.2.3

An Enhanced Permissible Speed warning indicator, where provided, shall always be positioned immediately below a Permissible Speed warning indicator applying to the same reduced speed section of line. An Enhanced Permissible Speed warning indicator shall not be provided in isolation.

Where the permissible speed changes at the same location as the enhanced permissible speed, where required for one of these, warning boards should be provided for both.

C2.10 The Enhanced Permissible Speed Warning Value to be Displayed

GE/RT8012 section 6.2.4

The speed value shown on the Enhanced Permissible Speed warning indicator shall be the same as that shown on the corresponding Enhanced Permissible Speed indicator.

There are no specific recommendations relating to GE/RT8012 section 6.2.4.

C2.11 Location of Enhanced Permissible Speed Warning Indicators

GE/RT8012 section 6.2.5

The position of each warning indicator and AWS magnet is determined by the train which requires the greatest braking distance on the approach to the lower speed restriction. The tables of distances and the other requirements for selecting the position of the warning indicator and AWS magnet are set out in Railway Group Standard GK/RT0038.

For a given speed restriction, the warning indicators for permissible speeds and for enhanced permissible speeds being co-located, the following should be considered to determine their location:

a) In the general case, the warning indicators for a reduction in permissible speed will be placed in accordance with GK/RT0038.

b) The reduction in enhanced permissible speed could require a greater warning distance than the associated change in permissible speed, therefore the position of all relevant warning indicators should be reviewed when an enhanced permissible speed is to be put in place.

c) The distance between a warning indicator displaying an enhanced permissible speed and the associated speed indicator should be at least that necessary to ensure that a train being driven correctly to its enhanced permissible speed profile published in the sectional appendix does not suffer intervention by the speed control system. The train requiring the longest warning distance determined in accordance with appendix A, for enhanced permissible speeds, and GK/RT0038, for permissible speeds, should be considered.

d) Where the degraded mode analysis recommended in section E4.3 requires, the warning distance for the signed enhanced permissible speed should be increased so that it is possible for the driver to brake from a prevailing enhanced permissible speed to the permissible speed applicable to the following enhanced permissible speed section before its commencement.
Uncontrolled When Printed

Recommendations for Systems for the Supervision of Enhanced Permissible Speeds and Tilt Enable

This enables the driver to brake to the permissible speed in the event that operation at enhanced permissible speed in that section is not authorised.

e) It is permissible for the warning distances for the trains authorised to operate at enhanced permissible speeds to be based upon their specified braking characteristics as discussed in appendix A.

The intervention curve, and where appropriate the warning curves, within the speed supervision function of the trains able to operate at an enhanced permissible speed should be based upon the braking characteristics of the train in question as discussed in appendix A, not upon the signed warning distance.

<table>
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<tr>
<td><strong>GE/RT8012 section 6.3</strong></td>
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<tr>
<td>Signs provided for Enhanced Permissible Speeds shall be subject to an on-site assessment, to ensure so far as possible that the positioning is adequate, taking into account:</td>
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<td>• the time for which the sign needs to be visible for the driver to observe and assimilate the information conveyed by it;</td>
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<tr>
<td>• other tasks which the driver may be required to perform at the same time as observing the sign.</td>
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The ergonomic requirements relating to speed signage are given in GK/RT0033 and GK/RT0038.

C3 Speed Supervision and Control System

C3.1 Capability of the Speed Supervision System

| **GE/RT8012 section 7.1** |
| The speed supervision and control system shall monitor and be capable of controlling the speed of each Tilting Train on the approach to all curves where an Enhanced Permissible Speed applies, to ensure that, when the train reaches the start of the curve, the train speed does not exceed the Enhanced Permissible Speed applicable to the train by a margin which would give an unacceptable risk of overturning.

‘Controlling the speed’ relates to excess speed being limited by the automatic application of the train’s brakes, either full service or emergency as recommended in Appendix A. There is no requirement for the train to be driven automatically, either on the approach to the enhanced permissible speed section or through it.

The speed supervision system should:

- **a)** be active when approaching an enhanced permissible speed restriction from a preceding permissible speed
- **b)** be active when running through successive adjoining enhanced permissible speed restrictions
- **c)** cancel, if provided, the enhanced permissible speed authority displayed in the cab when it is no longer valid, for example as a consequence of paragraph C1.3, above, or in the event of failure of the tilt control system, or on the approach to a section where only a permissible speed is signed.

Because of the reduced margins of overturning associated with operations at enhanced permissible speeds and the potential for these sections to be long, the speed supervision should be effective until the following permissible speed or enhanced permissible speed as appropriate.

The speed supervision system should be able to supervise the speed to the specific enhanced permissible speed profile of each train along the route as authorised in the Sectional Appendix.
The train and infrastructure assemblies of the speed supervision system should be fully compatible with the protocol referred to in section E5.

C3.2 In-Cab Displays and Warnings

GE/RT8012 section 7.2

7.2.1 No in-cab speed limit information shall be displayed to the driver by the system (in order to avoid any possible conflict of information with lineside signals and speed sign information) unless the system is fitted throughout the route and continuously displays speed limit information to the driver. Where in-cab speed limit information is displayed, it shall be consistent with the Permissible Speeds (or Enhanced Permissible Speeds, where applicable) and speed restrictions on the route, and with the movement authorities given by the signalling system.

7.2.2 It is permissible to provide an audible and/or visual indication to warn the driver, in order that the driver can take action to prevent imminent intervention by the system.

7.2.3 If the system intervenes to reduce the train speed, an audible and/or visual warning shall be given to the driver.

DMI recommendations are given in Part E, section E1.

The reference to route should be interpreted as a significant section of the train’s journey. As ATP/cab-signalling is installed, a train’s journey will be comprised of cab-signalled and lineside signalled sections. Rules to control the risks arising should be established as part of the cab-signalling/ATP programme.

C3.3 Record of System Intervention

GE/RT8012 section 7.3

Intervention by the system to reduce the speed of the train shall be recorded by the train data recorder.

Data recording recommendations are given in Part E, section E2.

C3.4 Interference

GE/RT8012 section 7.4.1

The system shall not cause interference to other infrastructure equipment or train-borne equipment which could jeopardise safe operation.

Recommendations concerning the means to manage precautions against interference are given in Part E, section E4.1.

C3.5 Interfacing Systems

GE/RT8012 section 7.4.2

All other systems and equipment which provide input to the speed supervision and control system shall be designed and maintained to a sufficient level of integrity to ensure that the safety performance of the system is not jeopardised.

There are no specific recommendations relating to GE/RT8012 section 7.4.2.

C3.6 Train-Borne Equipment Failure

GE/RT8012 section 7.4.3

So far as is reasonably practicable, any failure of the train-borne equipment shall be indicated to the driver.

Recommendations concerning displays to the driver are given in Part E, section E1.
C3.7 System Failure

GE/RT8012 section 7.4.4
So far as is reasonably practicable, there shall be no credible failure mode of the system whereby it could fail to provide the required speed supervision and control, except where such a failure is indicated to the driver.

Recommendations concerning system failures are given in Part E, section E4.3.

C3.8 Isolation

GE/RT8012 section 7.4.5
For essential operational purposes (for example, in the event of a system failure), it is permissible to provide facilities for the isolation of the system on the train.

Isolation recommendations are given in Part E, section E3.4.

C3.9

GE/RT8012 section 7.5
Operation and maintenance of speed supervision and control systems
The Infrastructure Controller and Train Operators shall devise and implement appropriate arrangements in respect of the speed supervision and control system for:

- ensuring that only those Tilting Trains that are fitted with a train-borne sub-system which is compatible with the track-based sub-system are authorised to operate at Enhanced Permissible Speeds;
- the maintenance of the system (in accordance with the requirements of GK/RT0170 and GM/RT2004);
- the reporting and investigation of failures of the system (in accordance with the requirements of GK/RT0106);
- enabling the safe movement of trains in the event of a system failure or isolation. These arrangements shall prohibit Tilting Trains from travelling through curves at Enhanced Permissible Speeds under system failure and isolation conditions;
- the configuration management and change control of the system.

Recommendations concerning these arrangements are made in Part E, section E3.

GK/RT0170 is now replaced by GK/RT0210.

C3.10

GE/RT8012 section 7.6
Interface with TPWS or other speed supervision and control systems
Where TPWS (or other speed supervision and control system) is used on the approach to a curve for the safety of conventional trains, its effectiveness in fulfilling that purpose shall not be significantly degraded by the need to operate Tilting Trains over the same curve at Enhanced Permissible Speeds.

Risk assessment shall be applied to assist in deciding whether or not effectiveness has been “significantly” degraded.

Train Protection Warning System (TPWS) functions are mandated in GE/RT8030 to supervise:

a) the approach of trains to selected permissible speed restrictions over certain sections of a route, including sections where an enhanced permissible speed applies

b) speed on the approach to signals and to enforce a train stop in the event of a signal passed at danger.

It is not recommended to operate a train with two speed supervision systems in service simultaneously. Where an enhanced permissible speed applies, the enhanced speed supervision function replaces the TPWS permissible speed supervision function. Therefore, subject to a satisfactory risk assessment of the
means of inhibiting the speed supervision function within the TPWS equipment, the enhanced permissible speed supervision function should be made effective without unnecessary TPWS intervention. The protection afforded by TPWS at signals should not be degraded.

Where there is no enhanced permissible speed applicable to a train fitted with enhanced speed supervision, TPWS/AWS functions should either not be inhibited, or they should be replaced by additional functions within the speed supervision system used for enhanced permissible speed purposes.

C4 Provision of Cab Signalling

C4.1

GE/RT8012 section 8.1

Speed display

A Cab Signalling system which is used to meet the requirements of this document shall, as a minimum, provide a continuous display of speed limit information that is consistent with the Permissible Speeds (or Enhanced Permissible Speeds, where applicable) and speed restrictions on the route, and with the movement authorities given by the signalling system.

Cab-signalling requirements are contained in GK/RT8026.

C4.2

GE/RT8012 section 8.2

Automatic Train Protection

An Automatic Train Protection system shall be provided in conjunction with the Cab Signalling. This system shall, as a minimum, meet the requirements of section 7.

ATP requirements are not in the scope of this document.
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Part D
Recommendations Specific To GE/RT8019:
Tilt Enable

D1 Infrastructure Requirements

D1.1

GE/RT8019 section 5.1
For each specific train design, the routes where the tilting train will operate in tilting mode shall be analysed to identify Tilt Prohibited Sections for each tilting train design and the locations where restrictions on trackside staff are required. This shall include consideration of:

- normal operation and credible tilt failure modes for the vehicle body and pantograph anti-tilt mechanisms;
- all clearances (including clearances for persons on or near the line and electrification clearances between the tilting train and live electrical equipment);
- normal and diversionary routes.

Clearance requirements are contained in other Railway Group Standards. This Railway Group Standard is only applicable when clearances can not be achieved.

GE/RT8019 section 5.2
The relevant Sectional Appendix shall document for each specific type of Tilting Train:

- The routes where Tilting Trains can operate in Tilting Mode; and
- Tilt Prohibited Sections on those routes.

The principal requirements concerning clearances are contained in GE/RT8029 and GM/RT2149.

D1.2

GE/RT8019 section 5.3
Each Tilt Prohibited Section throughout a route shall be equipped with fully functional infrastructure elements of a Tilt Enable and Supervision System before allowing tilting operations over that route.

It is the intention that data is transmitted to each type of tilting train so that the tilting operations can be adapted to the clearances specific to each type. When tilt prohibited sections apply to a given type along any route, its tilt control system should operate only when it has been enabled by data received from the trackside. The expiry and renewal of the enable should be specific to each type of train. The enable data should only apply to those sections of the route in which the type of train concerned has been authorised to tilt.

The infrastructure assembly of the Tilt Enable and Supervision System should be fully compatible with the protocol referred to in section E5. This protocol should also be used if the data transmission means to satisfy these requirements are integrated into another system, for example, transmission based signalling and other implementations of the European Train Control System (ETCS).

The data transmitted should be sufficient for all types of tilting train authorised to tilt on that route. Part E, section E3.1 makes recommendations concerning compatibility and the introduction of new trains.
D2  Train Requirements

D2.1

**GE/RT8019** section 6.1

Tilting trains shall be equipped with a fully functional and operational on-train element of a Tilt Enable and Supervision System when operating in tilt mode on routes where Tilt Prohibited Sections apply to the train.

The *tilt enable* function should be operating on all occasions (including tests and trials of rolling-stock) when a tilting train is required to operate on a route on which there are *tilt* prohibited sections, unless the *tilt* control system is isolated and the vehicle bodies are in the central position. All *tilt* supervision functions should be in service, otherwise it should not be possible to operate the train in tilting mode.

Authorisation is required to allow a train to operate in tilting mode on routes where there are *tilt* prohibited sections at specific locations. Unless specifically authorised, the operation of the *tilt* control system should be disabled. On lines where, for a given type of tilting train, there are no *tilt* prohibited sections, it is permissible to provide data to generally enable the *tilt* functions on these trains. Where there are no *tilt* prohibited sections along any of the routes for which they are authorised, trains need not be equipped with a Tilt Enable and Supervision System.

The train assembly of the Tilt Enable and Supervision System should be fully compatible with the protocol referred to in section E5.

Changes to track geometry, should be assessed to determine whether for each type of train clearances remain adequate to permit tilt to remain authorised.

D2.2

**GE/RT8019** section 6.2

Safety related data associated with the Tilt Control System and Tilt Enable and Supervision System shall be recorded on the train to assist post incident investigations. As a minimum, the information recorded shall include:

- the data received by the train from the infrastructure elements of the Tilt Enable and Supervision System;
- when the Tilt Control System is enabled;
- the train location for each event recorded;
- each intervention by the train Tilt Enable and Supervision System;
- isolation of the Tilt Enable and Supervision System.

The requirements for the provision of train data recorders are contained in GO/RT3272.

*The recommendations concerning the recording of data on board the train are made in Part E, section E2.*

D3  Tilt Enable and Supervision System Requirements

D3.1  Tilt Supervision functions

**GE/RT8019** section 7.1

For each specific train design the Tilt Enable and Supervision System shall authorise the train to tilt only on a section of route where it is permitted to tilt. Where the train commences to tilt before the complete train has left the Tilt Prohibited Section, the Tilt Control System shall ensure that any vehicles that are travelling on the Tilt Prohibited Section do not tilt until they have left the Tilt Prohibited Section.
GE/RT8019 section 7.2
Tilt authority for a set distance shall be provided by the infrastructure elements of the Tilt Enable and Supervision System to the on-train elements. When the train has covered that distance the on-train equipment shall disable tilt unless further authority has been granted. The end of the tilt enable authority shall be no later than the full service braking distance, for the permissible speed at that location, from the start of the Tilt Prohibited Section.

GE/RT8019 section 7.3
The Tilt Enable and Supervision System shall supervise the status of the Tilt Control System to ensure that any part of the train which is between the start of the full service braking distance and the end of the Tilt Prohibited Section does not tilt. If part of the train is tilting when it is between these locations, the Tilt Enable and Supervision System shall:

- command the train to be restored to a non-tilting condition; and
- command the on-train systems to remove traction power and apply the train full service brake to stop the train.

GE/RT8019 assures a safe system by requiring that tilt is enabled for a specific distance. The tilt enable is withdrawn automatically when the specific distance for which the enable authority is valid has been reached (as measured on board the train). No additional information should be required to cause the authority to be withdrawn. The tilt enable and supervision function should:

a) enable tilt on entry to an area where tilt is permitted
b) enable tilt when operating within a section where tilt is permitted continuously
c) remove the enable before entering a section where tilt is prohibited, as described below
d) stop the train if tilting is detected when not enabled.

It is permissible for the tilt control system itself to provide the supervision of the tilt status of individual vehicles. In this case, the tilt enable and supervision system should ensure that if the tilt control system fails, or if it is isolated, then intervention occurs as required by this clause.

Enabling Tilt
The commencement of tilt should be safely controlled by methods which include:

a) By transmitting data to authorise tilt to the train at a location where the rear of the longest relevant train using the route would have left a tilt prohibited section, or by transmitting data at the locations at which the rear of each type of train will have left the tilt prohibited section.

b) By transmitting data to the train to authorise tilt at a distance beyond the transmission reference; this may be combined with on-board data from which the length of the train can be derived, so ensuring that tilt may commence immediately that an entire train has left the zone of restricted clearance.

c) By transmitting data to the train that identifies the point at which the leading vehicle may commence to tilt, and allowing successive vehicles to tilt as they reach this location.

Where tilt enable should be withdrawn
The data transmitted to the train should ensure that the distance between the point at which tilt enable is withdrawn and the start of the tilt prohibited section is equal to or greater than the estimated braking distance (determined according to the principles contained in appendix A) at the speed at which the train is moving.
Recommendations for Systems for the Supervision of Enhanced Permissible Speeds and Tilt Enable

plus a distance required to accommodate the supervision system measurement tolerances and time delays (as indicated in Appendix A).

Where the tilt enable and supervision system issues a demand for the service brake, it should also have the facility to demand the emergency brake, as described in Appendix A. It is permissible to issue a demand for the emergency brake directly in response to intervention, as it should be the most dependable system. If, for the train and location being considered, the emergency braking distance is greater than the full service braking distance, then the end of the tilt enable authority should be no later than the emergency braking distance to the start of the tilt prohibited section.

In accordance with GM/RT2045, traction power should be removed automatically by the train systems in response to the application of either the full service brake or the emergency brake. (Other train safety systems may also cause the brakes to be applied for protection without specifically removing traction power.) When making a demand for the brakes, the tilt enable and supervision system should remove traction power in the case where it is not removed automatically by the train systems.

D3.2 Failure of the Tilt Enable and Supervision System

GE/RT8019 section 7.4
So far as is reasonably practicable, in the event of a failure of the on-train element of the Tilt Enable and Supervision System, the train shall default to a tilt disabled condition and be restored to and maintained in a non-tilting position.

There are no specific recommendations relating to GE/RT8019 section 7.4.

D3.3 The Data Transmission Protocol

GE/RT8019 section 7.5
The Tilt Enable and Supervision System shall operate with the transmission message protocol defined and published by the Infrastructure Controller.

The message protocol that is to be the basis of all implementations of a Tilt Enable and Supervision System is that referenced in Part E, section E5.

D3.4 The Driver Interface

GE/RT8019 section 7.6
The interface between the Tilt Enable and Supervision System and the train driver in the driving cab shall take account of human factors and be designed to ergonomic principles (see GM/RT2161). The driver shall be able, whilst at the driving position, to observe and interpret the display(s)/indications and operate the associated controls (where provided) that are required to be used whilst the train is being driven.

GE/RT8019 section 7.7
Indications shall be given to the driver which enable the determination of:

- whether the Tilt Enable and Supervision System on the train is operational, failed or isolated;
- whether the Tilt Control System is enabled or disabled;
- whether intervention by the Tilt Enable and Supervision System has occurred.

Recommendations concerning displays to the driver are given in Part E, section E1.

D3.5 Consistency of Meaning of the Displays

GE/RT8019 section 7.8
The display of the information in the driving cab provided by the Tilt Enable and Supervision System shall be consistent in meaning for all tilting trains. This display may be incorporated into the functionality of other in-cab displays, provided that safety is thereby not jeopardised.
Recommendations concerning displays to the driver are given in Part E, section E1.

D4 Operating and Faults/Restriction Requirements

D4.1 Failure of the Tilt Control System

GE/RT8019 section 8.1
In the event of a failure of the Tilt Control System the train shall be restored to and maintained in a non-tilting position.

A failure of the tilt control system will be indicated to the driver in accordance with Part E, section E1. The tilt control system, if failed, should as an automatic consequence of the failure restore and maintain the train bodies in a non-tilting position. If this is not the case, then the train should be automatically stopped. Special arrangements for recovery should then be made (see section D4.4 and E3.4 below).

D4.2 Train Limited to Permissible Speed

GE/RT8019 section 8.2
Following a failure of the Tilt Control System or the on-train element of the Tilt Enable and Supervision System, the train shall be operated at speeds no greater than the permissible speed for the train in non-tilting mode.

Recommendations relating to failures are made in Part E, section E3.4.

D4.3 Isolation of the Tilt Enable and Supervision System

GE/RT8019 section 8.3
An isolation device shall be provided for the driver to isolate the on train element of the Tilt Enable and Supervision System in the event of a failure. Operation of the device shall also prevent the train from tilting.

Recommendations concerning isolation and the associated displays to the Driver are set out in Part E, sections E1 and E3.4.

D4.4 Special Operating Arrangements

GE/RT8019 section 8.4
Train Operators in conjunction with the Infrastructure Controller shall devise and implement appropriate arrangements to facilitate the safe movement of all trains when:

- A Tilting Train cannot be restored to and/or maintained in a non-tilting position and for the de-isolating/restoring of a failed tilt system;
- Where there is a temporary sub-standard condition of the infrastructure.

Recommendations relating to failures are made in Part E, section E3.4.

D4.5 Management of Failures

GE/RT8019 section 8.5
The management and investigation of Tilt Enable and Supervision System failures shall be in accordance with GK/RT0106.

Recommendations relating to the reporting and investigation of failures are made in Part E, section E3.3.

D5 System Integrity and Change Control

D5.1

GE/RT8019 section 9.1
The Tilt Enable and Supervision System and all other systems and equipment which provide input to the Tilt Enable and Supervision System shall be designed
and maintained to a sufficient level of integrity to ensure that safety performance is not jeopardised.

This section and the corresponding section C3.5 from Part C are grouped in section E4.2.

D5.2

GE/RT8019 section 9.2

The Infrastructure Controller and Train Operators shall devise and implement appropriate procedures for the management and change control of the Tilt Enable and Supervision System.

Recommendations concerning change control are given in Part E, section E3.1.

D5.3

GE/RT8019 section 9.3

The Tilt Enable and Supervision System and the Tilt Control System shall not cause interference to other infrastructure equipment or on-train equipment that could jeopardise safe operation of trains.

Recommendations concerning precautions against interference are given in Part E, section E4.1.
Part E
Recommendations Common to GE/RT8012 and GE/RT8019:
Systems and Operational Management

E1 Driver-Machine Interface Requirements

GE/RT8012 section 7.2
7.2.1
No in-cab speed limit information shall be displayed to the driver by the system (in order to avoid any possible conflict of information with lineside signals and speed sign information) unless the system is fitted throughout the route and continuously displays speed limit information to the driver. Where in-cab speed limit information is displayed, it shall be consistent with the Permissible Speeds (or Enhanced Permissible Speeds, where applicable) and speed restrictions on the route, and with the movement authorities given by the signalling system.

7.2.2
It is permissible to provide an audible and/or visual indication to warn the driver, in order that the driver can take action to prevent imminent intervention by the system.

7.2.3
If the system intervenes to reduce the train speed, an audible and/or visual warning shall be given to the driver.

GE/RT8012 section 7.4.3
So far as is reasonably practicable, any failure of the train-borne equipment shall be indicated to the driver.

GE/RT8012 section 7.4.5 Isolation
For essential operational purposes (for example, in the event of a system failure), it is permissible to provide facilities for the isolation of the system on the train.

GE/RT8019 section 7.6
The interface between the Tilt Enable and Supervision System and the train driver in the driving cab shall take account of human factors and be designed to ergonomic principles (see GM/RT2161). The driver shall be able, whilst at the driving position, to observe and interpret the display(s)/indications and operate the associated controls (where provided) that are required to be used whilst the train is being driven.

GE/RT8019 section 7.7
Indications shall be given to the driver which enable the determination of:

- whether the Tilt Enable and Supervision System on the train is operational, failed or isolated;
- whether the Tilt Control System is enabled or disabled;
- whether intervention by the Tilt Enable and Supervision System has occurred.
Recommendations for Systems for the Supervision of Enhanced Permissible Speeds and Tilt Enable

GE/RT8019 section 7.8
The display of the information in the driving cab provided by the Tilt Enable and Supervision System shall be consistent in meaning for all tilting trains. This display may be incorporated into the functionality of other in-cab displays, provided that safety is thereby not jeopardised.

GE/RT8019 section 8.3
An isolation device shall be provided for the driver to isolate the on-train element of the Tilt Enable and Supervision System in the event of a failure. Operation of the device shall also prevent the train from tilting.

Cab Functions
The Driver-Machine Interface (DMI) facilities required for tilt enable and enhanced permissible speed supervision should include:

a) an indication of the state of the supervision functions, typically one of:
   - in service, or failed, or isolated (if not “in service” the rolling-stock systems should ensure that the tilt control system is inhibited, see section E4.3, below)
   - supervision function intervening (visual and/or audible)
   - train characteristics data input. For a fixed train set this is not normally provided, but the management of degraded situations can be helped by this facility. If provided, the input terminal need not be at a driving position, but it must meet the requirements of Part D, section D3.4. General data, for example, driver identity should be managed by the data recorder. (See section E2, below)
   - test functions for the driver so that he can confirm the serviceability of the supervision functions when bringing a cab into service, as needed by the installation.

It is permissible to provide the following DMI functions, as determined by the train operator to be necessary to ensure safe and dependable operations:

a) An alert to draw the driver’s attention to the approach to the warning indicator of an enhanced permissible speed restriction.

b) Warning of imminent intervention by a supervision function - visual and/or audible.

c) A warning that the speed supervision system is no longer supervising to an enhanced permissible speed. An acknowledgement from the driver should be required within a defined time period, otherwise the system should intervene.

In addition, information on the status (failed/isolated/in service/enabled/disabled) of the tilt control system should be provided. It is permissible to combine this information with other data within the logic of the DMI. The information given to the driver in the cab should be consistent with the information given at the lineside. The train operator should ensure that the implementation of tilt enable and speed supervision system DMI functions respects a set of consistent generic principles that apply to all rolling-stock operated by that company.

Within the cab, information and warnings should be prioritised, and the sounds and visual attributes of speed supervision information should be clearly attributable to that system. The DMI should be integrated with the cab such that it is effective without compromising the use of other equipment in the cab. GM/RT2161 gives the requirements for driving cabs.

Isolation Facilities
Isolation should be clearly apparent to the driver and technical staff. A visual indication should be provided in front of the driver when the system is isolated. A general indicator, shared with other safety systems, is an acceptable method of informing the driver of the status of the system with a specific indication at the isolation device.
Isolation enables the train to continue running, without the speed supervision in service and with the tilt system disabled. Isolation should be undertaken only when the train is at rest: the driver should not be able to isolate the system from a position in which the Drivers Safety Device (DSD) can be operated or the train be driven. This is to be assured by the installation arrangements.

Recommendations on the use of the isolation facilities are given in section E3.4 below.

E2 Data Recording Requirements

<table>
<thead>
<tr>
<th>GE/RT8012 section 7.3 Record of system intervention</th>
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<tbody>
<tr>
<td>Intervention by the system to reduce the speed of the train shall be recorded by the train data recorder.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>GE/RT8019 section 6.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety related data associated with the Tilt Control System and Tilt Enable and Supervision System shall be recorded on the train to assist post incident investigations. As a minimum, the information recorded shall include:</td>
</tr>
<tr>
<td>• the data received by the train from the infrastructure elements of the Tilt Enable and Supervision System;</td>
</tr>
<tr>
<td>• when the Tilt Control System is enabled;</td>
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<tr>
<td>• the train location for each event recorded;</td>
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<tr>
<td>• each intervention by the train Tilt Enable and Supervision System;</td>
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<tr>
<td>• isolation of the Tilt Enable and Supervision System.</td>
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</tbody>
</table>

The requirements for the provision of train data recorders are contained in GO/RT3272.

The data to be recorded should enable accurate and detailed incident investigation. Where practicable, raw data received from the trackside should be recorded so that the opportunity for data to become corrupted is minimised. The data should be determined by the system design, and may include for example, target speed, target distance, intervention value, measured speed at intervention, identity of the previous balise. The data integrity should be assured in accordance with the requirements of GO/RT3272. Recorded data should be retained for incident investigation for at least 8 hours (a single shift). The data recorder should also record the status of the supervision functions (in service/failed), and any related driver activity.

This requirement has to be placed in the context of the global data set being recorded. For the recording of instances of intervention, and to determine whether they are genuine or spurious other data is essential, for example, regular measured speed values, the data received from the trackside, the prevailing train characteristics data. It is also necessary to have knowledge of the train’s actual braking state. The train operator should select data to be recorded that provides an unambiguous representation of the events and causes.

Consideration should be given to recording the status of the tilt control system (in service/failed), and any related driver activity.

E3 Operations and Management

These requirements pertain to management processes. However, the speed supervision system may be used to provide some assistance to these processes, in which case the failure/absence of this system should also be considered.
E3.1 Compatibility of Infrastructure and On-Train Equipment: Configuration and Change Control

**GE/RT8012** section 7.5
Operations and Maintenance of **Speed** Supervision and Control Systems
The Infrastructure Controller and Train Operators shall devise and implement appropriate arrangements in respect of the speed supervision and control system for:

- ensuring that only those Tilting Trains that are fitted with a train-borne sub-system which is compatible with the track-based sub-system are authorised to operate at Enhanced Permissible Speeds;
- the configuration management and change control of the system.

**GE/RT8019** section 9.2
The Infrastructure Controller and Train Operators shall devise and implement appropriate procedures for the management and change control of the **Tilt Enable** and Supervision System.

Change activities are, for example:

- a) the application and removal of TSRs and ESRs;
- b) the introduction of new tilting trains with other tilt and braking characteristics, or other infrastructure compatibility;
- c) change to infrastructure clearances and their effect upon each type of train;
- d) changes to track parameters and layouts;
- e) modification of the data transmission protocol.

In each case changes to data in the balises should be undertaken in a manner in which physical testing, checking and functional testing is undertaken in accordance with pre-planned verification and validation procedures. The requirements of GK/RT0207 and GK/RT0209 apply.

The design of the system for the supervision of enhanced permissible speeds and **tilt enable** should ensure that:

- a) The tilt control system should not be enabled to operate unless the infrastructure components and the train components of the **tilt enable** and speed supervision system are compatible.
- b) The driver should not be given any indication that an enhanced permissible is authorised unless the infrastructure components and the train components of the speed supervision system are compatible.
### E3.2 System Maintenance

**GE/RT8012** section 7.5
Operations and Maintenance of Speed Supervision and Control Systems
The Infrastructure Controller and Train Operators shall devise and implement appropriate arrangements in respect of the speed supervision and control system for:

- the maintenance of the system (in accordance with the requirements of GK/RT0170 and GM/RT2004);

**GE/RT8019** section 9.1
The Tilt Enable and Supervision System and all other systems and equipment which provide input to the Tilt Enable and Supervision System shall be designed and maintained to a sufficient level of integrity to ensure that safety performance is not jeopardised.

There are no recommendations relating to **GE/RT8012** section 7.5 and **GE/RT8019** section 9.1.

GK/RT0170 is now replaced by GK/RT0210.

### E3.3 Reporting and Investigation

**GE/RT8012** section 7.5
Operations and Maintenance of Speed Supervision and Control Systems
The Infrastructure Controller and Train Operators shall devise and implement appropriate arrangements in respect of the speed supervision and control system for:

- the reporting and investigation of failures of the system (in accordance with the requirements of GK/RT0106);

**GE/RT8019** section 8.5
The management and investigation of Tilt Enable and Supervision System failures shall be in accordance with GK/RT0106.

These requirements concern both the on-board and the infrastructure equipment.

### E3.4 Safe Movement Following Failures

**GE/RT8012** section 7.5
Operations and Maintenance of Speed Supervision and Control Systems
The Infrastructure Controller and Train Operators shall devise and implement appropriate arrangements in respect of the speed supervision and control system for:

- enabling the safe movement of trains in the event of a system failure or isolation. These arrangements shall prohibit Tilting Trains from travelling through curves at Enhanced Permissible Speeds under system failure and isolation conditions;
GE/RT8019  section 8.2
Following a failure of the Tilt Control System or the on-train element of the Tilt Enable and Supervision System, the train shall be operated at speeds no greater than the permissible speed for the train in non-tilting mode.

GE/RT8019  section 8.4
Train Operators in conjunction with the Infrastructure Controller shall devise and implement appropriate arrangements to facilitate the safe movement of all trains when:

- A Tilting Train cannot be restored to and/or maintained in a non-tilting position and for the de-isolating/restoring of a failed tilt system;
- Where there is a temporary sub-standard condition of the infrastructure.

Operating Procedures
To maintain safety, a failure of an automated protection function requires that there should be a prepared operating procedure able to replace it. The degraded modes analysis referred to in section E4.3 is the means to decide which procedures are to be prepared. The consequences of drivers becoming dependent upon the serviceability of systems implementing the requirements of GE/RT8012 and GE/RT8019 should be assessed and appropriate arrangements implemented.

Should failure of either the tilt control system or the supervision functions occur, the requirements of GO/RT3437 apply. When a train vehicle cannot be returned to the central position and the clearance requirements would not be respected measures appropriate for an out-of-gauge movement are required. The means to deal with the extreme case of a train unable to be moved in this state should be prepared before the train starts commercial operations.

The Train Operator should write instructions to prevent the operation of a train at enhanced permissible speeds in the presence of a failure of either the tilt control system or the tilt enable and enhanced speed supervision functions. Train operators should assess the benefits of enforcing compliance with permissible speeds when the train is unable to tilt by means of the speed supervision provided for the purposes of enhanced permissible speeds.

Isolation
Isolation facilities, to ensure that the train may be driven as a non-tilting train under failure conditions, are essential. The isolation facilities are, by definition, external to the systems implementing the requirements of GE/RT8012 and GE/RT8019. Instructions should be written by the Train Operator to direct drivers how to isolate the supervision functions.

System Requirements
The arrangement of the systems on the train should ensure that the tilt control system is disabled when the tilt enable and enhanced speed supervision functions are out of service.

E4  System Integrity

E4.1 Interference

GE/RT8012  section 7.4.1
The system shall not cause interference to other infrastructure equipment or train-borne equipment which could jeopardise safe operation.

GE/RT8019  section 9.3
The Tilt Enable and Supervision System and the Tilt Control System shall not cause interference to other infrastructure equipment or on-train equipment that could jeopardise safe operation of trains.

Current IEC and BSI standards should be used to manage and verify the achievement of these requirements.
E4.2 Compatibility with Interfacing Systems

**GE/RT8012** section 7.4.2
All other systems and equipment which provide input to the speed supervision and control system shall be designed and maintained to a sufficient level of integrity to ensure that the safety performance of the system is not jeopardised.

**GE/RT8019** section 9.1
The Tilt Enable and Supervision System and all other systems and equipment which provide input to the Tilt Enable and Supervision System shall be designed and maintained to a sufficient level of integrity to ensure that safety performance is not jeopardised.

There are no recommendations relating to **GE/RT8012** section 7.4.2 and **GE/RT8019** section 9.1.

E4.3 System Failures

**GE/RT8012** section 7.4.4
So far as is reasonably practicable, there shall be no credible failure mode of the system whereby it could fail to provide the required speed supervision and control, except where such a failure is indicated to the driver.

A degraded modes analysis should be undertaken by the train operator on each system implementing the requirements of **GE/RT8012** and **GE/RT8019**. This analysis should encompass:

a) the consequences for the ergonomics of the driving environment (including for example displays, AWS, Driver Safety Device (DSD), TPWS) and the complexity of the driving task

b) the influences between the system and the other control equipment such as AWS, TPWS.

Measures should be in place such that should a failure of the system or an unusual operation situation occur the safety of the train and its passengers remains assured. Examples of situations that should be considered are:

a) absence of data transmission

b) absence of a speed sign

c) wrong direction movement

d) failures of the onboard system.

The data transmission protocol, see section E5 below, should support these measures where appropriate.

The system should be able to continually test all elements whose failure could result in undetected overspeed or tilt failure. The display of failures to the driver is included in section E1, above.
E5 Transmission Message Protocol

**GE/RT8019** section 7.5
The Tilt Enable and Supervision System shall operate with the transmission message protocol defined and published by the Infrastructure Controller.

The protocol and data formats to be used for all systems meeting the requirements of GE/RT8012 and GE/RT8019 will be set out in a Group Standard.
APPENDIX A

Tilt Enable and Speed Supervision for Enhanced Permissible Speeds

Recommendations for Determining Intervention Criteria

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A.1 Basic Principles

A tilt enable and enhanced permissible speed supervision system should protect a train by:

a) detecting excessive overspeed in the context of an enhanced permissible speed, and then intervening

b) enabling tilting of a vehicle only in those sections where this is authorised.

A.1.1 Intervention Caused by Speed Supervision

A.1.1.1 Not Penalise Correct Driving Behaviour

A speed supervision system should allow a driver who is driving correctly to achieve the lower enhanced speed as indicated on the speedometer display, as seen from a normal driving posture.

A.1.1.2 Reduction of Risk of Overspeed

If the measured speed indicates that the tolerable risk of overturning at the start of the speed restriction is being exceeded, the speed supervision system should intervene. These risks are determined in accordance with GC/RC5521. The system may also:

a) intervene at a speed above the prevailing enhanced permissible speed at or before the point where the risks become unacceptable

b) supervise speed on the approach to a lower permissible speed.

A.1.2 Intervention Caused by the Tilt Supervision Function

The tilt control system should only operate along sections of track where tilt is enabled by data received from the trackside. Before the train reaches the full service braking distance from the tilt prohibited section, the data received should have withdrawn the enable from the tilt control system. When the enable is withdrawn and if tilting of a vehicle is indicated, the tilt supervision function should intervene to prevent the train from entering the tilt prohibited section. The tilting of a vehicle within a tilt prohibited section should also cause the train to be stopped automatically, in accordance with GE/RT8019.

A.1.3 Determining Intervention Criteria

Using information from the trackside, the on-board part should set up warning and intervention criteria that depend upon the measured speed and/or measured location of the train. These criteria will also be a function of the braking performance of the train. The braking performance upon which the supervision system should be based will be derived from that advised by the train manufacturer. To obtain dependable intervention performance some degradation of the braking performance held within the supervision system may be necessary as described below. It is also necessary to take into account the tolerance and precision of measurement which the supervision system is capable of achieving.

A.2 The Influence of Measurement and Control Tolerances

A.2.1 Tolerances to be Considered

This section considers the tolerances on measurement and reading displays. GC/RT5021 section 5.2.3 requires that when determining the enhanced permissible speed the probability of overspeed occurring is taken into account. An analytical approach should be taken. The tolerances which have to be considered should include:

a) Accuracy of the speed measurement system. The following should be considered:

- the accuracy of wheel diameter calibration and the measures in place to enforce it
- the treatment of slip and slide effects
- the basic sensors (e.g., toothed wheels, accelerometers, radars) and processing algorithms.
b) The reading by the driver of the speed display device, its technology and precision.

c) The dynamics of controlling the train’s speed.

Figure 1 shows how such margins to accommodate such tolerances may accumulate.

![Diagram](image)

**Figure 1: Speed margins**

Note: $V_L$ represents the operational speed limit.

### A.2.2 The Relationship between Performance and Tolerances

This section considers the potential for systematic errors that can be present when a train is being properly controlled. The train operator should consider trade-offs between the inaccuracies he is prepared to tolerate in his speed-supervision system, the risk of unwarranted intervention and the attainable enhanced permissible speed in service. The smaller the tolerances allowed, the more difficult it is to avoid unwarranted interventions by the system. A typical value for driver control tolerance is 4 km/h with a mechanical speedometer, and 6 km/h is a good figure for speed measurement precision below 160 km/h.

Higher tolerances may be found to be necessary. With these values, in the worst case with the driver driving correctly to $V_L$ displayed on the speedometer, the train’s real speed would be 10 km/h above $V_L$. Add to this the margin required before intervention takes effect (as a minimum 5 km/h) then with these values the potential for overspeed could reach 15 km/h.

The overspeed/probability characteristic should be assessed, together with the probability that the infrastructure can safely accept this value of overspeed as described in GC/RC5521. It need not be a continuous characteristic. For example, the probability of overspeed occurring within specific speed bands could be adequate. In some cases of systematic errors, e.g., those due to wheel diameter correction factor quantisation effects, a tolerance in place of a probability may be unavoidable.

### A.2.3 Responsibility of the Train Operator

The train operator should advise the infrastructure controller of the tolerances and probabilities of overspeed that will apply to the train. These will then be used as part of the process described in Part C section C2.5 of this document to determine an acceptable value for the enhanced permissible speed limits. See also section A.8.2 of this Appendix.

### A.3 The Management of Intervention

#### A.3.1 Alert/Warning Strategy

The alert/warning strategy depends upon the tolerances in the speed measurement and display systems, the time response of the system to events, and the infrastructure margins. Alerts and warnings are not necessary for safety,
but should be considered as a means to encourage acceptance of the system by drivers through reducing the frequency of interventions, especially where overspeed margins are small. Alerts and warnings are discussed in section A.7 of this appendix.

A.3.2 Braking Strategy
For normal intervention the choice of intervening by means of the emergency brakes or the service brakes has to be made.

The management and blending of the train’s braking systems to achieve the specified performance is a matter for the braking system. The speed supervision system expects the brakes to achieve at least the specified performance and should not need to depend upon the details of the braking systems being used. When considering degraded modes, there could be a case to indicate to the speed supervision system the isolation status of the braking system.

A.3.2.1 If the service brake is used for intervention, being the brake with lower dependability, the speed supervision system should also interface to the emergency brake for use as a last recourse.

A.3.2.2 The call for the service brake should be for the maximum specified application.

A.3.2.3 When the train’s measured speed has been reduced to a value below the intervention curve at the measured location of the train, the speed supervision system should provide the driver with an indication that the measured speed is reduced below the intervention value. When the driver gives an acknowledgement of this indication the system should then cancel the call for the service brakes. This is desirable because bringing a train unnecessarily to a halt can cause severe service disruption, especially where high speeds are normally attained and where the trains are frequent.

A.3.2.4 If the emergency brake is used as the initial response to intervention by the supervision system, its release in the above manner should be supported by an analysis to show that the risk of release when it should not occur is acceptable. Otherwise, it should be possible to release the emergency brake only when the train is at a stand.

A.4 Modelling Braking Performance for Intervention

In this section the braking performance for the purposes of train protection are considered. Examples of performance margins are suggested. If performance margins are not applied in the specified vehicle braking values being considered, these should be re-assessed for the purpose of train protection. The margins applied should be reasoned and documented. The effects of train length, gradient and rotating mass should be taken into account in calculations relating to the matters discussed in this section.

A.4.1 Emergency Brake Intervention Envelope
Intervention by the emergency brake instance is the most important as safety is most dependent upon this.

A model of the braking performance should be used to define a speed/distance envelope within which the train will remain using a set of assumptions that represent the range of circumstances foreseen for normal operations (even though these may be somewhat pessimistic). This is called the emergency brake protection envelope.

A model of emergency brake performance should be constructed as follows:
a) The vehicle(s) will have been designed to meet a nominal emergency deceleration rate (metres per second squared), and associated with this there will be an emergency brake application delay period (seconds). It is necessary to base the intervention envelope on a design deceleration rate degraded to allow for factors such as:

- Any rules for the isolation of brakes allowed for normal operations
- An allowance for brakes in an inefficient state
- Overloading by a percentage
- Effect of low adhesion (with wheel slide protection (WSP) operational). The consequences of some failure of the WSP have to be considered, including how readily these failures are detectable.

b) The result can be termed the guaranteed (or dependable) emergency deceleration rate. It need not be the simple addition of the factors, but the manner in which they are combined should be rational and justifiable.

c) The brake delay period is generally taken to be 50% of the brake build-up time from zero to 90% of full application. The guaranteed emergency deceleration rate is applied from the end of the brake delay period.

For higher speeds, a more sophisticated braking model can be adopted, either a lower brake rate above a defined speed threshold producing a breakpoint in the curve, or the brake rate can be made a function of speed (though this complication is not usually found to be necessary).

The above model gives a braking distance for protection purposes. It applies from the intervention point to a final target speed value at which the call is removed.

The speed/distance curve that triggers the call to the emergency brakes is called the emergency brake intervention curve, and should be determined as described in Appendix A section A.5 below.

A.4.2 Service Brake Intervention Envelope
For a model of the service brake, the specified maximum service braking performance of the train is used, modified by margins which are generally considered necessary, but not to the same extent as for the emergency brake (which should always be the ‘safety net’). The usual margins for fixed-block signalling purposes are normally sufficient for the protection envelope, but this should be verified.

A brake delay period is required and is generally taken to be 50% of the service brake build-up time from zero to 90% of full application.

A complication arises if the guaranteed emergency deceleration rate is less than that of the full service brake. In this case the strategies available should be assessed.

The curve that triggers the call to the service brakes is called the service brake intervention curve, and is determined as described in Appendix A section A.6.

A.4.3 Warning Curve
At the discretion of the train operator, an additional curve for warning of imminent braking intervention can be defined. Section A.7 of this appendix describes warning curves.

A.5 Derivation of the Emergency Brake Intervention Curve

A.5.1 In accordance with GM/RT2045, it is normally the responsibility of the train systems to ensure that the traction system is disabled when the emergency brakes are called. If this is not the case the speed supervision system should provide this function. The emergency brake intervention curve should always assume that the train is on full traction and take the gradient into account.
Figure 2 gives a model of emergency brake intervention.

NOTES:
1. $\alpha$ is due to the time required to remove traction power.
2. $\alpha + \beta$ is due to the emergency brake reaction time.
3. $\varepsilon$ is due to the system delay to issue the call to the brakes once overspeed is detected.
4. $V_{O1}$ is the maximum approach speed to be considered.
5. $V_{L1}$ is the permissible speed applicable to that train on the approach.
6. $V_{O2}$ is the maximum speed acceptable through the target restriction.
7. $V_{L2}$ is the target permissible or enhanced permissible speed.

The intervention should be set back from the (dependable) ‘guaranteed’ braking curve by a distance that is determined from:

a) the system delay to issue the call to the brakes once overspeed is detected ($\varepsilon$);

b) the emergency brake delay period ($\beta$), and at the same time;

c) the system delay to disable traction ($\alpha$) (usually by opening the main circuit breaker);

d) during the system traction disable delay ($\alpha$), the train is assumed to be in full acceleration.

The initial speed value to be assumed should be the measured speed plus the specified margins ($=V_{O1}$), to which is added the speed increase that could occur during the period required to disable the traction. $V_{O2}$ has a similar relationship to $V_{L2}$.

The value of the margins is very much technology dependent. They should include at least the tolerance required to allow normal driving, plus that required for the warning strategy (see below). These are deterministic. A margin is required for speed measurement tolerance; this should be treated on a probabilistic basis, but some sources of error, eg, wheel diameter calibration errors may be more deterministic in nature. It is not possible to pre-judge the technology that could be used.
A.6 Derivation of the Service Brake Intervention Curve

In accordance with GM/RT2045 it is recommended that the vehicle logic causes traction to be disabled when a full service brake application is demanded. Figure 3 gives a model of the situation assuming that there is no traction power. If required, this can be modified to presume full traction power at the moment of intervention. This should not normally be necessary where intervention by the emergency brake is intended if the service brake intervention is not effective.

Figure 3: Intervention curve - service brake

Notes:
1. \( \delta \) is due to the service brake reaction time.
2. \( \varepsilon \) is due to the system delay to issue the call to the brakes once overspeed is detected
3. \( V_{O1} \) is the maximum approach speed to be considered.
4. \( V_{L1} \) is the permissible speed applicable to that train on the approach.
5. \( V_{O2} \) is the maximum speed acceptable through the target restriction.
6. \( V_{L2} \) is the target permissible speed or enhanced permissible speed.

The intervention curve precedes the service brake curve by a distance that is determined from:

a) the system delay to issue the call to the brakes once overspeed is detected (\( \varepsilon \));

b) the service brake delay period (\( \delta \)).

The initial speed value to be assumed should be the measured speed plus the specified margins.

A.7 Alert/Warning Strategy and Intervention

A.7.1 The Reasons for Alerts and Warnings

Intervention will occur when the measured speed exceeds the prevailing speed limit by the chosen margins. The number of interventions can be reduced by adopting an alert/warning strategy. Correctly formulated, this can contribute to reducing the total speed margins required for acceptable operational performance.

A.7.2 Alert/Warning Strategies

Three alternative alert/warning strategies are:

a) Alert, on the approach to an enhanced permissible speed warning indicator;
Recommendations for Systems for the Supervision of Enhanced Permissible Speeds and Tilt Enable

b) Warning of imminent intervention based on fixed speed differentials;

c) Warning of imminent intervention based on lapsed time above a threshold.

The display functions to the driver need not be dependent upon which strategy is chosen, but it is important that there is consistency in the meaning of the indications given to the driver. The requirement determines the strategy that should be chosen, and a different strategy can be chosen according to the context. For example, fixed speed differentials are appropriate to a phase where a reduction in speed is required; lapsed time is suitable where the speed limit is constant.

A.7.2.1 The Use of Alerts and Warnings

The alert should be given, so that with a reasonable allowance to react, the driver is able to respond to a more restrictive speed limit. An alert to an imminent reduction in speed limit may allow a shorter driver reaction time to be assumed. An alert may be used without a warning of imminent intervention.

The warnings indicate that system intervention is imminent and, if ignored the system will intervene within a short interval of time.

A.7.2.2 Warning Strategies

The use of fixed speed differentials for both warning and intervention strategies can lead to quite high overspeed possibilities, and corresponding intervention curves that can impose service performance constraints. This strategy is appropriate for raising a warning of imminent intervention, the value of the differential being determined by the margins in the system, typically between 5 and 10 km/h (3.25 and 6.5mph).

The lapsed time strategy is appropriate to invoking intervention. The system intervenes after a suitable response time allowed to the driver to move from a situation of overspeed to one of deceleration. An acknowledgement of the situation by the driver is not meaningful as it only extends the response period required. The overspeed allowance after the warning is:

\[
\text{Driver reaction time} \times \text{maximum acceleration}
\]

(Usually taken on a downhill slope)

Using typical values of 6 seconds for the reaction time and 0.35 metres per second per second for acceleration, the overspeed could achieve 2.1 metres per second, or 4.7mph, but generally would be less.

A.8 The Position of Lineside Signs

A.8.1 The Principles for Siting Lineside Indicators

For lineside signs, the above curves have to be translated into distances on the ground for the purpose of siting speed indicator and warning indicator boards. The principles that should be applied are:

a) The driver will apply the brakes as he passes the warning indicator.

b) The speed indicator should be placed before the point at which the speed limit physically starts to accommodate certain margins. These margins are the sum of:

- Wrongside distance measurement errors that can cause the system to believe that the train is not as advanced as it is; and
- Rightside distance measurement errors could otherwise cause a spurious intervention when the driver is driving correctly according to the signs.

Normally, the transition curve should be sufficient to provide these margins. Where this is not the case, the enhanced permissible speed value should be reduced, or the speed indicator set back from the start of the transition curve (possibly requiring network change approval).
c) The minimum distance between the warning board and the speed limit board for enhanced permissible speeds is determined from a nominal service braking performance that is less than the full service performance as described in section A.4.2 of this Appendix. Because the warning boards for the reduction in enhanced permissible speed and any associated reduction in permissible speed are co-located, the distance chosen is the longest warning distance of those trains using the route, both those operating to permissible speeds and those operating to enhanced permissible speeds.

Protection requires that the speed/distance intervention envelope is derived from a point set back from the start of the speed restriction by the margin required to accommodate the wrongside system distance measurement tolerances. In addition, the target speed at this point should be less than the safe speed of the enhanced permissible speed section ahead by a margin to accommodate the potential for system overspeed discussed in section A.2, above.

A.8.2 Responsibilities of the Infrastructure Controller and the Train Operator
A.8.2.1 The infrastructure controller has the responsibility to place enhanced permissible speed warning and commencement indicators at the lineside.

A.8.2.2 The train operator has the responsibility to advise the infrastructure controller of the minimum distance he requires before the physical commencement of a speed limit in order to obtain dependable operation from the speed supervision system. The infrastructure controller should then place the speed indicator at a position that provides at least that margin from the physical restriction.

A.8.2.3 The train operator has the responsibility to advise the infrastructure controller of the minimum warning distance he requires as determined from his chosen warning and braking strategy.
A.9 Technology

The technology of the speed supervision system should be a data transmission system and data processing systems based upon European Standards that are being drafted. The usual means to transmit the data to the trains will be a spot transmission device termed a ‘balise’. The specifications also allow the transmission of data by means of loops in the track and by radio.
References

**Railway Group Standards**

- GA/RT6001  Railway Group Standards Change Procedures
- GC/RC5521  Calculation of Enhanced Permissible Speeds for Tilting Trains
- GC/RT5021  Track System Requirements (Programmed to be issued February 2000)
- GE/RT8012  Controlling the Speed of Tilting Trains Through Curves
- GE/RT8019  Tilting Trains: Controlling Tilt to Maintain Clearances
- GE/RT8026  Safety Requirements for Rail Traffic Management and Control Systems
- GE/RT8029  Management of Clearances and Gauging
- GE/RT8030  Requirements for a Train Protection and Warning System
- GK/RT0007  Alterations to Permissible Speeds
- GK/RT0033  Lineside Signs
- GK/RT0038  Speed Restrictions
- GK/RT0106  Management of Safety Related Failures of Signalling and Operational Telecommunications Systems
- GK/RT0207  Signalling Design Production
- GK/RT0209  Testing and Commissioning of Signalling and Operational Telecommunications Equipment
- GM/RT2004  Requirements for Rail Vehicle Maintenance
- GM/RT2045  Braking Principles for Rail Vehicles
- GM/RT2149  Kinematic Gauging Requirements for Railway Vehicles
- GM/RT2161  Requirements for Driving Cabs of Railway Vehicles
- GM/RT2185  Train Safety Systems
- GO/RT3000  Rule Book
- GO/RT3272  Data Recorders on Trains
- GO/RT3437  Defective On-train Equipment