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General information

Each infrastructure manager or railway undertaking is reminded of the need to consider its own responsibilities to ensure health and safety at work and its own duties under health and safety legislation. The Rail Safety and Standards Board (RSSB) does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.

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ERTMS National Values – D_NVROLL

1 Introduction

1.1 General

1.1.1 This document has been produced by RSSB on behalf the National ERTMS Programme to define one of the nationally defined values (D_NVROLL).

1.1.2 D_NVROLL specifies the distance to be used in roll away protection, reverse movement protection and standstill supervision before the system demands a brake application.

1.1.3 D_NVROLL is a trackside parameter which is used to configure the behaviour of the onboard. It is uploaded to the train when the train transitions into a new area, or at startup. Prior to this the train retains its previous set of national values. A default value for D_NVROLL is defined, but this is only used if no other value has ever been uploaded.

1.1.4 D_NVROLL is used to configure the following supervision:
   a) rollaway
   b) standstill
   c) reverse

1.1.5 The available range of the parameter is from 0 to 327.66 km with a default value specified in the European Train Control System (ETCS) System Requirement Specification (SRS) of 2m [RD3]. Although defined, the actual use of this default parameter will be very rare for the reason that as soon as the train is first registered on a network it will take on that set of values including D_NVROLL and retain these until updated.

1.1.6 A 2004 RSSB research report [RD2] has recommended the current set of ERTMS national value for the GB mainline railway. This includes the D_NVROLL parameter where a value of 2m was recommended. The value recommended by the RSSB research report into national values is 2m.

1.1.7 The ERTMS Level 2 Overlay operational concept [RD4] has, at present, included a requirement for trains to be able to couple in Standby mode (SB). It has been raised as an issue that the value of 2m may be overly restrictive for this manoeuvre, resulting in an unnecessary brake application.

1.1.8 This report has been prepared to evaluate if a larger value of D_NVROLL such as 3m or 4m, which would be more operationally useful [RD5] would increase risk to an unacceptable level.

1.1.9 There is not a detailed justification available for the default value. The value of 2m derived in [RD2] did include a degree of analysis but it did not consider the operation of coupling in standby mode and therefore did not consider the operational constraint this value places on this operation.

1.1.10 A review of national values used in Europe by different infrastructure providers has been produced [RD6]; this shows that values for D_NVROLL of 2m, 5m, 10m and 30m are currently in use in Europe. The most common individual value is 5m.

1.2 Purpose of this document

1.2.1 The purpose of this document is to provide the safety justification to enable the National ERTMS Programme to define the value of D_NVROLL.
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1.3 Target audience
1.3.1 The target audience for this document are members of the National ERTMS Programme, particularly those personnel responsible for defining system requirements and writing technical specifications.

1.3.2 No other interested parties have been identified.

1.4 Scope of this document
1.4.1 The scope of this document is the safety justification for defining the nationally defined ETCS value D_NVROLL. At present national values cover the whole GB rail network, however in future it may be desirable to have different values for different regions or types of line. The analysis here is intended to be generic but should be revisited if it is decided to scope a set of national values to a region smaller than the GB mainline network,
2 Safety argument

2.1 Introduction

2.1.1 The D_NVROLL parameter is used in association with three types of protection:

- Standstill protection
- Rollaway protection
- Reverse movement protection.

2.1.2 Standstill protection is only active in Standby mode and demands a brake application if a movement is detected in either direction once the distance D_NVROLL has been exceeded. In Standby mode there is no ERTMS movement authority.

2.1.3 Rollaway protection is applied based upon the setting of the direction controller on the active driving desk. If the controller is set to forward, the protection is applied in the reverse direction (and vice versa). If the direction controller is in the neutral position, the protection applies in both directions. If the train is detected to move more than the value of D_NVROLL, a brake application is demanded.

2.1.4 Reverse movement protection makes a brake demand when a train has an ERTMS movement authority and movement of more than the value of D_NVROLL in the opposite direction to the ERTMS movement authority is detected.

2.1.5 There are three key hazards that could be affected by the D_NVROLL parameter, these are:

- collisions where a train rolls back and hits a buffer
- the train running away (in either direction) and fouling some points and derailing on the points or colliding with another train
- Collision between two trains in station

In addition to the effect on safety of D_NVROLL there is also an effect on operational performance through additional emergency brake applications and the starting of trains on gradients, principally but not exclusively in relation to the operation of freight trains on gradients.

2.1.6 The following sections discuss the three types of protection in relation to the three main hazards and also discuss the performance impact of having different values for D_NVROLL.

2.2 Collisions where a train rolls back and hits a buffer

2.2.1 General

2.2.1.1 Rollback collisions with buffers are most likely to be mitigated with standstill protection and rollaway protection. The reason for this is that this type of accident is most likely to occur when a train is left at a stand in a terminal having completed an inward journey. In this case a movement authority for the move out of the station is unlikely to have been given to the onboard system. Reverse move protection only functions when a movement authority has been provided.

2.2.1.2 In the event of a train starting to roll towards a buffer for a distance greater than D_NVROLL, the train will not stop immediately. There are three main factors that influence the distance the train travels; the brake build-up time, the gradient (which affects the speed of the train and the effectiveness of the braking), and the braking rate.
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2.2.2 Roll back collisions where a train rolls back and hits a buffer – passenger trains with a short brake build-up time:

2.2.2.1 Calculations have been performed to assess the effectiveness protection based on D_NVROLL in mitigating a buffer stop collision with different values of D_NVROLL. The calculations are based upon a realistic worst case assumption of a gradient of 1 in 50 towards the buffers and a brake build-up time of two seconds (which is pessimistic for modern electrical braking systems typically on passenger trains). The results are shown in Table 1.

Table 1 The effectiveness of roll away protection for different levels of D_NVROLL for modern electrical braking systems

<table>
<thead>
<tr>
<th>D_NVROLL (m)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>Speed reduction</td>
<td>Effective</td>
<td>Effective</td>
<td>Effective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>Speed reduction</td>
<td>Effective</td>
<td>Effective</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td></td>
<td></td>
<td>Effective</td>
<td></td>
</tr>
</tbody>
</table>

2.2.2.2 As can be seen from the table, any value of D_NVROLL equivalent to, or greater than, 2m provides no protection where a train stops less than 5m from the buffer. At 9m or above, the setting of D_NVROLL between 2 and 4m does not influence the risk as the rollback protection is effective in bringing the train to a stand before it hits the buffer. For trains stopping between five and nine metres from the buffer there is a safety benefit from a smaller value of D_NVROLL.

2.2.2.3 The overall risk from rollback buffer stop collisions is 0.004 Fatalities and Weighted Injuries (FWI) per year from 2.4 rollbacks into buffer stops per year [RD1]. A significant portion of the risk would be mitigated by the implementation of D_NVROLL. There would be some erosion of the safety benefit if D_NVROLL was set to 4m instead of 2m, but the residual level of risk with either value would be very small.

2.2.3 Roll back collisions where a train rolls back and hits a buffer – non passenger trains with a significant brake build-up time:

2.2.3.1 For stock types with a significant brake build-up times (e.g., freight trains without electro-pneumatic braking), the setting of D_NVROLL is unlikely to make a significant difference to the likelihood or speed of a buffer collision as the brake build-up time is the dominant factor in the overall distance travelled. Such an event is also unlikely to affect passengers; therefore the setting of D_NVROLL should not be based upon the rollback collision risk for non-passenger trains as it is likely to be an insignificant factor in the overall level of risk.

2.2.4 The train running away and fouling points and derailing or colliding with another train

2.2.4.1 Depending upon the circumstances, this event could occur in Standstill, Rollaway or Reverse movement protection.

2.2.4.2 Based upon a review of v7 of the Safety Risk Model (SRM) [RD1], the risk from passenger train runaways that is not caused by brake failure, coupling failure or vandalism is 0.018 FWI [RD1] per year. The equivalent risk for non-passenger trains is 0.25 FWI [RD1]. It should be noted that the vast majority of the non-passenger train risk would not be mitigated by the protection provided by the D_NVROLL parameter as most runaways of freight trains will start from depots and sidings where the train desk will be in No Power mode, or wagons are stabled without a locomotive, in such cases, no protection by D_NVROLL is afforded.
2.2.4.3 Assuming a credible worst case gradient of 1 in 50 and a two second brake build-up time, the maximum distance travelled and maximum speed of a rollback/runaway are summarised in Table 2. These values would be representative of a realistic worst case for passenger trains with modern electrical braking.

Table 2 - D_NVROLL stopping distances with modern electrical braking

<table>
<thead>
<tr>
<th>D_NVROLL value (m)</th>
<th>Distance travelled (m)</th>
<th>Max Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5.3</td>
<td>2.3</td>
</tr>
<tr>
<td>3</td>
<td>7.1</td>
<td>2.7</td>
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<tr>
<td>4</td>
<td>8.8</td>
<td>3.4</td>
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2.2.4.4 As can be seen from Table 2, there is a relatively small difference in the distance travelled between a value of 2 and 4m for D_NVROLL. Normally, a rollback of 8.8m (the worst case from Table 2 with a D_NVROLL of 4m) would not be sufficient for a train to roll back sufficiently to reach a conflict point. However, there are undoubtedly a number of locations and rolling stock configurations on the network where trains are within 8.8m of the conflict zone of a set of points. Hence, for passenger trains, there would be a small erosion of the safety benefit afforded by increasing the value of D_NVROLL.

2.2.4.5 For non-passenger trains with a significant brake build-up time, the value of D_NVROLL is less critical as this is relatively small contributory factor in the overall assessment of how far the vehicle travels. Furthermore, much of the risk estimated from the SRM is likely to be from stabled wagons that do not have a locomotive attached. Where it is a locomotive, it is likely to be in No Power mode in which case, no protection is provided via the D_NVROLL parameter.
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2.2.5 Collision between two passenger trains in station (permissive working)

2.2.5.1 When a train moves into an occupied platform, current practice is to leave a gap of greater than 2m between the trains [RD8]. An objective of leaving a gap greater than 2m is to minimise the potential for a braking misjudgement or low adhesion to cause a collision. The train that is moving towards the stationary train is likely to be carrying passengers and therefore a collision is likely to cause onboard injuries. The current risk from permissive working in stations by passenger train (that are potentially high speed) is 0.054 FWI per year [RD1].

2.2.5.2 The coupling move, depending upon the mode in which it is completed in, may be constrained by D_NVROLL in the direction of the move; i.e., if the coupling is undertaken in standby mode, rollaway protection is active. Exceptions to this are when:

- The coupling is completed in On-Sight Mode (OS) under the Movement Authority (MA) that the train had when it entered the platform.
- The coupling is in staff responsible mode, where a written order might be required.
- The coupling is completed in Shunt mode where permission would be required from the Radio Block Controller (RBC).

2.2.5.3 The location, type of service and movement immediately prior will influence the mode in which the coupling is undertaken.

2.2.5.4 For situations where there is movement protection from D_NVROLL, in order to prevent a brake application in standby mode during the coupling of the trains, the trains would have to be brought to a stand within 2m. Reducing required distance between the trains would increase the risk from collisions caused by misjudgement/reduced adhesion. It is hard to estimate the increase in risk that would result from the first train aiming to stop within 2m of the stationary train, although some increase in the risk would be anticipated.

2.2.5.5 The RSSB Rule Book Module SS2 on shunting [RD5] gives several distances in relation to current shunting practise.

   a) When attaching a traction unit to a train or vehicles it specified to stop 2 metres from the vehicle.

   b) For automatic couplers, it specified that the vehicles must be stopped at least 2 metres apart

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RD8 specified that for permissive working the train must be stopped at least 2 metres short of the train in front.
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2.2.5.6 A value for D_NVROLL of 2m would therefore seem unsuitable as there exists a high possibility that a driver operating under normal rules may stop at or just outside 2m. During the resulting coupling the on board system may then demand a brake application which is unnecessary.

2.2.6 Impact on performance

2.2.6.1 There are circumstances where the implementation of protection using the D_NVROLL parameter causes operability issues due to unwarranted brake demands. If an emergency brake application results, it may take a significant duration to reset the emergency brake. Potential causes of unwarranted application are:

- When a stationary locomotive of a freight train attempts to commence an uphill movement. It is possible that the locomotive is dragged downhill by the weight of the wagons as the train brakes are released and before it has the opportunity to develop sufficient power and traction to move in the desired direction. This downhill movement would result in the train’s brakes being applied if the downhill movement of the locomotive exceeded the value of D_NVROLL. This issue could be managed with a holdover device (such devices are fitted to some rolling stock [RD7]), although this would be outside of the scope of ETCS.

- When two trains need to be coupled following a permissive move, if there is a gap greater than D_NVROLL between the trains, it is likely that standstill protection (if the train is in Standby mode) or rollaway protection (if the train is not in Standby mode and does not have a movement authority) will demand a brake application.

- Odometry error; small values of D_NVROLL could result in emergency brake applications being made in response to small movements with no potential impact on safety.

2.2.6.2 There is an operational requirement to minimise the occurrences of unwarranted brake demands, however, the unwarranted demands above are not going to have a significant impact on safety because there will not normally be passengers in the train in the above situations.
3 Overall conclusion

3.1 From the analysis performed as part of this report there appears to be minor safety benefits and disbenefits from a small increase in the value of D_NVROLL from the default value of 2m.

3.2 There are also some operability benefits from increasing the value above 2m. Hence it is recommended that the national value for D_NVROLL is kept to a value that is constrained to manage the risk from runaways, but sufficiently large to manage the risk from permissive moves. A value of four metres would seem to satisfy both criteria.

3.3 A value for D_NVROLL of 4m is recommended.
4 References


[RD3] UNISIG, ERTMS and ETCS, System Requirements Specification, Chapter 3, Principles v2.30d


[RD6] European Economic Interest Group (EEIG) ERTMS Users Group, Official national_and_default_values_updated_with_T_NVCONTACT_from_ADIF(1)
EEIG 14-06-2012.xls

[RD7] NIR2702 concerning Bombardier Electrostar electric multiple units: https://www.nir-online.net/