Rail Industry Standard
RIS-7706-INS
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Process for Adding, Removing or Modifying Lettered Differential Permissible Speeds

Synopsis

This document sets out requirements and guidance to support the process of adding, removing or modifying a Lettered Differential Permissible Speed (LDPS) on the Great Britain (GB) mainline railway network.

Published by RSSB

Issue Record

Issue	Date	Comments
One	03/09/2022 [proposed]	Original document. Sets out the methodology for adding, removing or modifying Lettered Differential Permitted Speeds.

This document will be updated when necessary by distribution of a complete replacement.

Superseded Documents

This standard does not supersede any other Railway Group documents.

Supply

The authoritative version of this document is available at www.rssb.co.uk/standards-catalogue. Enquiries on this document can be submitted through the RSSB Customer Self-Service Portal https://customer-portal.rssb.co.uk/

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Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This Rail Industry Standard (RIS) sets out requirements and guidance for adding, removing or updating a Lettered Differential Permissible Speed (LDPS) on the GB mainline network. The requirements and guidance set out in this RIS are applicable to the consideration of an LDPS. Rather than being a complete set of all requirements for use of an LDPS, the content of this RIS is complementary to requirements and guidance set out in other RISs, Railway Group Standards (RGSs) and National Technical Specification Notices (NTSNs).

1.1.2 This RIS also includes, in the appendices, case studies of potential and actual applications of LDPSs on the network. The content of this document is informed by the output of the RSSB research project T1163 (2020).

1.1.3 RIS-2711-RST sets out industry-agreed criteria for rolling stock to be permissible to operate at differential speeds identified by the letters 'SP', 'MU' and 'HST' and gives guidance on the means of determining compliance with these criteria. This is to help railway undertakings (RUs), vehicle manufacturers and infrastructure managers (IMs) determine whether or not a type or design of rail vehicle, multiple unit or train formation (whether existing or proposed) can be permitted to make use of differential speeds identified by the letters 'SP', 'MU' and 'HST'.

1.1.4 From 01 January 2021, the European Union (EU) Technical Specifications for Interoperability (TSIs) have ceased to apply in the United Kingdom (UK) and have been replaced by National Technical Specification Notices (NTSNs) pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011 (as amended). The technical content of TSIs have been substantially reproduced in the NTSNs except where there are GB specific alternatives identified as specific cases in the relevant NTSNs.

1.2 Introduction

1.2.1 The maximum speed at which rolling stock can travel over a section of line is governed by infrastructure features, rolling stock features and a business need. On some routes a single maximum permissible speed is set for all rolling stock. However, to recognise different rolling stock features, differential speeds can be applied provided the infrastructure is capable and there is a business need.

1.2.2 Differential Speeds is the term used to describe the situation where rolling stock types with significantly different characteristics (for example axle loading or braking capability) are permitted to travel at different maximum speeds on the same section of line. There are two main types of differential speeds:

a) Standard Differential Speeds – A type of differential that restricts certain types of rolling stock, in most cases freight trains, to a slower speed than other rolling stock.
b) Lettered Differential Permissible Speeds (LDPSs), also known as Non-standard Differential Speeds, are a type of speed differential that provides a permission to allow certain rolling stock to travel at a higher speed than other vehicles over a particular section of line.

1.2.3 There are other types of permissible speeds, for example enhanced permissible speeds, temporary speeds, emergency speeds, blanket speeds, but this document only covers the application of LDPSs.

1.2.4 Key stakeholders in the use of LDPSs are the infrastructure manager (IM) and maintainer, railway undertakings (RU), asset owners and equipment suppliers, such as rolling stock manufacturers.

1.2.5 For the purposes of this standard, the term 'infrastructure' includes all the fixed subsystems including infrastructure, energy and track-side CCS.

1.2.6 Rules for the provision and characteristics of signage for differential speeds are out of scope of this standard.

1.3 Application of this document

1.3.1 Compliance requirements and dates have not been specified because these are the subject of internal procedures or contract conditions.

1.3.2 If you plan to do something that does not comply with a requirement in this RIS, you can ask a Standards Committee to comment on your proposed alternative. If you want a Standards Committee to do this, please submit your deviation application form to RSSB. You can find advice and guidance on using alternative requirements on RSSB's website www.rssb.co.uk.

1.4 Health and safety responsibilities

1.4.1 Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. 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.

1.5 Structure of this document

1.5.1 This document sets out a series of requirements that are sequentially numbered. This document also sets out the rationale for the requirement, explaining why the requirement is needed and its purpose and, where relevant, guidance to support the requirement. The rationale and the guidance are prefixed by the letter 'G'.

1.5.2 Some subjects do not have specific requirements, but the subject is addressed through guidance only and, where this is the case, it is distinguished under a heading of 'Guidance' and is prefixed by the letter 'G'.

1.5.3 The main content of this document is structured into discrete Parts (supported by associated appendices), which will assist users to identify relevant content.

1.5.4 The document is structured to provide requirements that can be used by industry to support the use of Lettered Differential Permissible Speeds to enhance the performance of sections of the network.

a) Part 1 introduces Lettered Differential Permissible Speeds.

b) Part 2 sets out the required process for modifying or adding an LDPS to a track section.
c) Part 3 sets out the route and infrastructure characteristics to be considered in reviewing an LDPS.
d) Part 4 provides background to the development of LDPSs, describes some of the historical applications and sets the framework for future applications.
e) Part 5 provides guidance on other characteristics that may be relevant
f) Part 6 provides information on the areas where potential benefits have been identified from the use of LDPSs.
g) Part 7 provides guidance on assessing benefits and an introduction to some case studies.
h) The Appendices contain case studies of representative routes that show some of the potential benefits of applying an LDPS.

1.6 Approval and authorisation of this document

1.6.1 The content of this document will be approved by Infrastructure Standards Committee on 10 May 2022 [proposed].

1.6.2 This document will be authorised by RSSB in September 2022 [proposed].

Part 2 Processes to be applied

2.1 Updating or removing an existing LDPS

2.1.1 As a minimum, the following factors shall be included in the assessment of any potential change to an existing LDPS:

a) Is new or cascaded rolling stock being introduced to the route?
b) With which categories of LDPS is the rolling stock compatible?
c) Has the infrastructure on the route been upgraded?
d) Is the infrastructure suitable for a different category of LDPS?
e) Are any increased maintenance costs justified by the business benefits?

Rationale

G 2.1.2 Understanding the capability of the infrastructure and rolling stock will enable the most appropriate speeds to be determined.

Guidance

G 2.1.3 A process for assessing the capability of the infrastructure and rolling stock is shown in *Figure 1*.

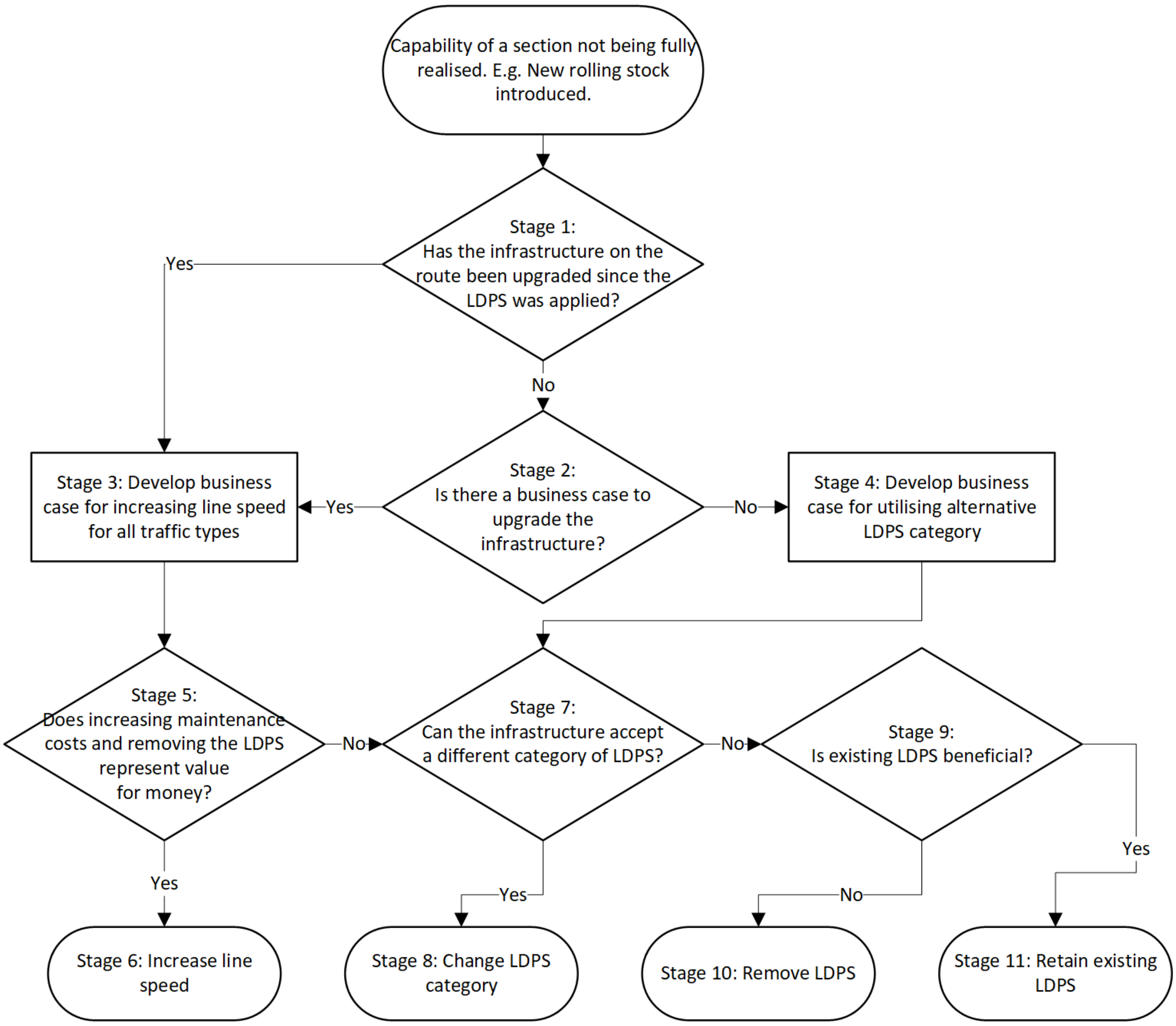

Figure 1: Process for reviewing a current LDPS

G 2.1.4 Introduction of new rolling stock onto a route with an existing LDPS may enable performance improvements. It is good practice to consider whether the infrastructure, including track, signalling or structures, has been upgraded since the existing LDPS was applied.

G 2.1.5 **Stage 1:** If the infrastructure has been upgraded, it is good practice to review the infrastructure to understand the scale of benefits that may be generated by increasing the line speed for all traffic and the additional ongoing costs, for example, because of increased forces on track and structures. The assessment of benefits would include potential for resource efficiencies in trains and traincrews, additional revenue from increased demand and socio-economic and environmental impacts.

G 2.1.6 **Stage 2:** Review whether there is a business case to upgrade the infrastructure to fully realise the capability of a track section. See *Part 6* for further guidance on developing the business case.

G 2.1.7 *Part 3* provides more information on assessing the capability of the infrastructure.

G 2.1.8 **Stage 3:** Based on the outcome of the business case, it is then possible to assess whether the benefit from an increase in line speed for all traffic can justify the increase in maintenance costs; this would not necessarily be an increase to the speed permitted by the LDPS.

G 2.1.9 **Stage 4:** In the case where the infrastructure has not been upgraded, it is good practice to consider the potential costs and benefits of using a different category of LDPS to extend some, or all, of the previous benefits to any new rolling stock.

G 2.1.10 **Stage 5:** Where new rolling stock cannot use existing LDPS categories on a route, a decision is made on whether a change of category of LDPS is justified in order to maintain the previous benefits with the new stock. This would not necessarily match the speed of the existing LDPS or be applied at all the sections of track with an existing LDPS.

G 2.1.11 **Stage 6:** If the infrastructure can accommodate all traffic at the speed previously associated with the LDPS, and a line speed increase justifies the increase in maintenance and inspection costs, the line speed can be increased.

G 2.1.12 **Stages 7 and 8:** Application of a new LDPS category on a route is appropriate where new rolling stock cannot use the existing LDPS, but the review identifies a net benefit from the use of an alternative category. This will not necessarily be at the same speed, or cover all the same sections of route, as the existing LDPSs.

G 2.1.13 The process for determining an appropriate type of LDPS is given in *2.3*.

G 2.1.14 **Stages 9 to 11:** Where no benefit is identified for using a new LDPS category, the outcome may be the retention of the status quo, or removal of LDPS signage altogether if no future benefits for retention are identified.

2.2 Adding a new LDPS

2.2.1 As a minimum, the following factors shall be included in the assessment of any introduction of a new LDPS:

a) Does the existing line-speed use the most efficient speed profile for operational requirements?
b) Does the infrastructure condition permit a higher line speed?
c) Is the higher line speed within the current track category?
d) Are any increased costs justified by the business benefits?
e) Is there scope to improve energy performance or reduce carbon emissions and air pollution?
f) Does use of an LDPS improve the balance of costs and benefits?

Rationale

G 2.2.2 Understanding the capability of the infrastructure and the potential costs and benefits will enable the most appropriate speeds to be determined.

Guidance

G 2.2.3 A process for adding an LDPS is shown in *Figure 2*.

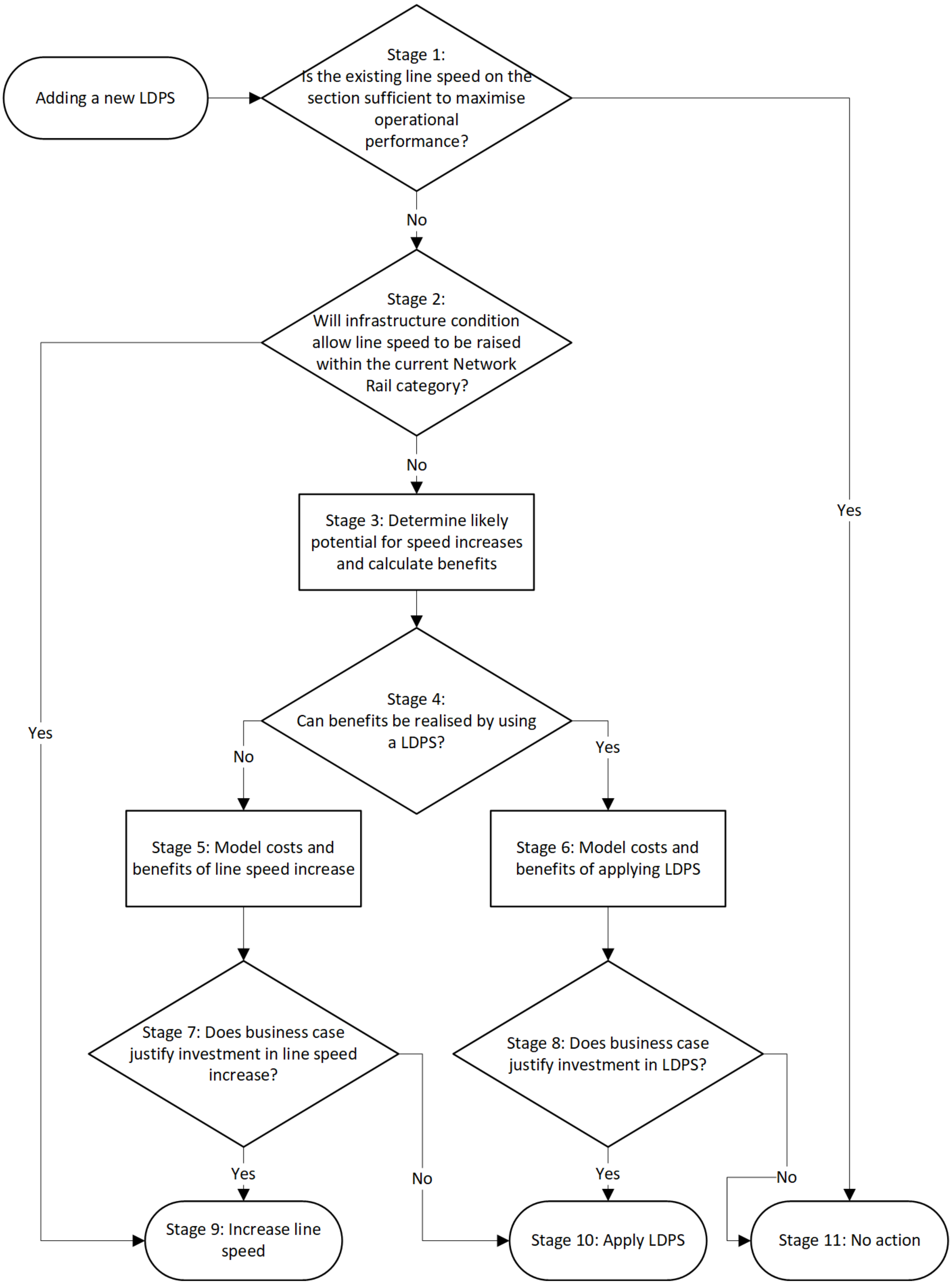

Figure 2: Process for adding a new LDPS

G 2.2.4 **Stage 1:** If the existing line speed on a route is sufficient to maximise the performance of the existing and planned rolling stock in use on the route, then there is no basis for a line speed increase or use of an LDPS.

G 2.2.5 **Stage 2:** Where the existing line speed does not allow the passenger rolling stock using the route to take advantage of its maximum speed, it is good practice to assess whether the current condition of the infrastructure, track components and geometry can support an increase in speed for all rolling stock in use on the route.

G 2.2.6 Track category may initially be used as a proxy for maintenance and inspection costs associated with the route, allowing changes in speed which are likely to significantly increase maintenance costs to be identified.

G 2.2.7 *Part 3* provides more information on assessing the capability of the infrastructure.

G 2.2.8 **Stage 3:** For routes where scope for an increase in speed is identified, the capabilities of the current infrastructure and rolling stock are reviewed. This includes considering the physical and operational limitations on maximum speed based around at least the following factors:

a) track geometry;
b) track components;
c) track condition;
d) structures;
e) signal sighting;
f) relevant Network Rail Standards.

G 2.2.9 The likely benefits are then assessed of achievable increases in line speed from resource efficiencies in trains and traincrews, additional revenue from increased demand and socio-economic and environmental impacts.

G 2.2.10 **Stages 4 and 5:** The output from the analysis of capability and likely benefit is used to decide whether the benefits of a speed increase would justify the investment. This decision takes into account a calculation of the journey-time savings achievable by some or all services, an estimation of the likely benefits from a change in demand for rail services (both in a purely financial sense and when socio-economic and environmental factors are included), and/or reduction in resource usage (both trains and traincrew).

G 2.2.11 Examples of potential benefits are given in *Part 6*.

G 2.2.12 **Stage 6:** If the rolling stock on the route complies with the identified and defined rolling stock criteria in RIS-2711-RST, then use of an LDPS such as MU, SP or HST may be appropriate.

G 2.2.13 **Stages 7 and 8:** The process for determining the most appropriate LDPS is given in *2.3*.

G 2.2.14 If an LDPS is not appropriate, then an increase in line speed for all traffic is considered.

G 2.2.15 In all cases, it is good practice to consider if there is a business case for an infrastructure upgrade, either as an LDPS or through an increase in line speed for all traffic. The business case sets out the strategic and economic rationale for an intervention with the objective of identifying the correct combination of costs and benefits, to deliver a scheme that represents best value-for-money. This takes a holistic approach potentially including:

a) specification and costing of track, signalling or structures interventions;
b) estimation of journey time savings;
c) estimated demand and revenue impacts;
d) estimation of socio-economic and environmental benefits, including consideration of potential abstraction from car journeys.

G 2.2.16 **Stage 9:** Where a line speed increase is identified as feasible for the existing infrastructure, or a case can be made for an intervention to increase the line speed, then funding can be sought and the proposed intervention implemented.

G 2.2.17 **Stage 10:** Where an LDPS is identified as feasible for the existing infrastructure, or a case can be made for an intervention to implement an LDPS, then funding can be sought and the proposed intervention implemented.

G 2.2.18 **Stage 11:** Where a case cannot be made for a change to the status quo, or no opportunity to raise train speeds is identified, no action is taken.

2.3 Choice of type of LDPS for a route

2.3.1 Prior to the introduction of a new LDPS the most appropriate type of LDPS (SP, MU or HST) shall be determined.

Rationale

G 2.3.2 Different LDPS options have different potential costs and benefits.

Guidance

G 2.3.3 Where rolling stock can be classified in multiple categories (for example both MU and SP), it is important to consider which LDPS category is most appropriate for the section of track.

G 2.3.4 A process to determine the most appropriate type of LDPS is shown in *Figure 3.*

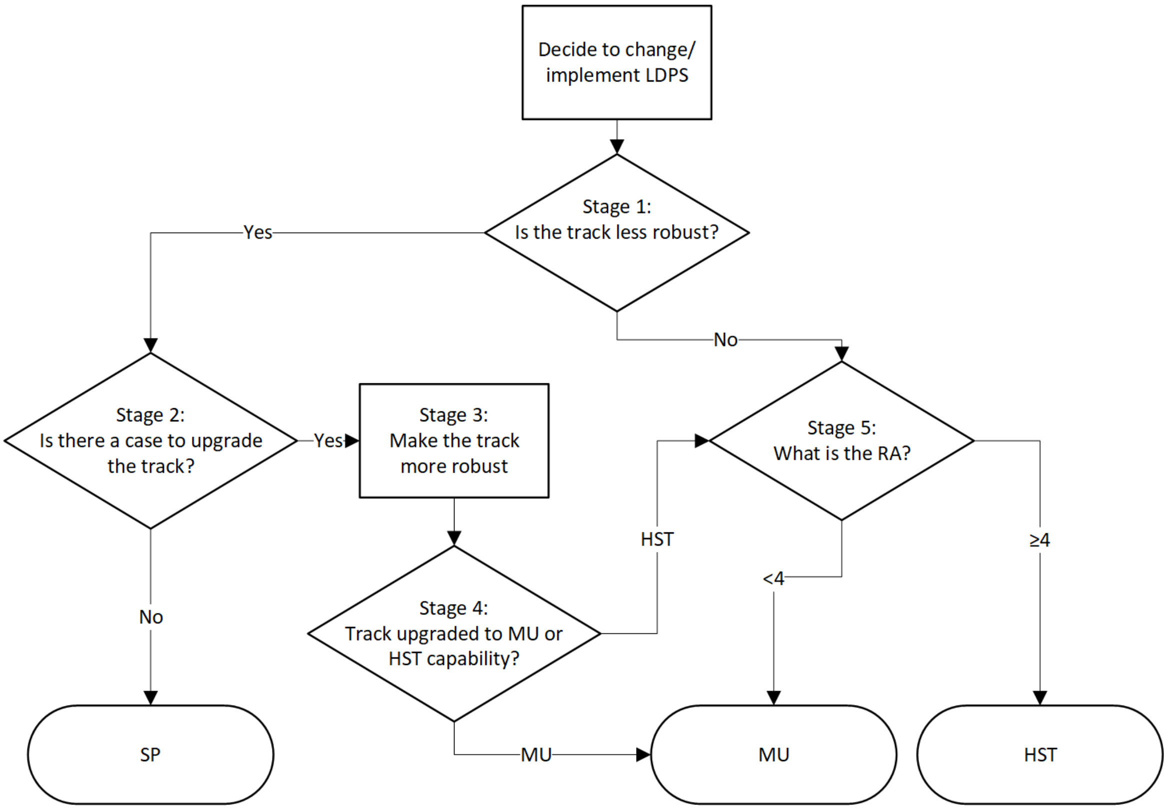

Figure 3: Process for choice of LDPS

G 2.3.5 The different options can be summarised as:

- **SP –** Very low track force rolling stock, capable of running over less robust track at higher speeds than higher track-force stock;
- **MU -** Low track force rolling stock, which can operate at a higher cant deficiency and have lower track force than other permitted stock on the route and is capable of HST braking performance;
- **HST** – Rolling stock with higher braking performance, and therefore shorter stopping distances, than other permitted locomotive-hauled stock on a route.

G 2.3.6 Background information on the different types of LDPS is given in *4.2*

G 2.3.7 **Stage1:** If the track is less robust, then an SP differential is likely to be the most appropriate.

G 2.3.8 **Stages 2 to 4:** There may be a business case for some limited intervention on the track to enable other types of LDPS.

G 2.3.9 **Stage 5:** The RA capability of the structures on the route may determine the most appropriate LDPS.

Part 3 Route and infrastructure characteristics

3.1 Characteristics to be considered

3.1.1 When assessing the capability of the infrastructure for a new or modified LDPS the following aspects shall be considered:

a) Track layout – curves, cant, transitions, curving rules;
b) Underline structures and RA classification;
c) Jointed track or Continuous Welded Rail (CWR), track components;
d) Switch & crossing locations;
e) Track category and inspection requirements;
f) Signal spacing, signal sighting, warning times for speed restrictions;
g) Level crossings;
h) Existing speed restrictions and their justification;
i) Driveability.
j) Other line-side signage;

Rationale

G 3.1.2 The maximum speed at each location on a route depends on a wide range of aspects, all of which are important.

Guidance

G 3.1.3 Guidance on several of the different aspects is given below.

3.2 Track layout; curves, cants, transitions, curving rules

Guidance

G 3.2.1 When applying an LDPS, track geometry requirements set out in GCRT5021 apply. Features such as cant deficiency and the rate of change of cant deficiency for each train on each curve of the section of track are taken into account.

G 3.2.2 The following aspects of track geometry are considered when determining the permissible speed of a section of track:

a) The curve radius;
b) The applied cant;
c) The permitted values of cant deficiency;
d) The permitted values of rates of change of cant and cant deficiency on the transition curves either side of the circular curve.

G 3.2.3 Maintenance tolerances are also considered when calculating maximum permissible speeds.

3.3 Underline structures and Route Availability (RA)

Guidance

G 3.3.1 The Route Availability (RA) system is the method used on the GB mainline railway to check the compatibility of rolling stock axleloads and spacings with underline structures such as bridges, viaducts and culverts. MU and HST LDPS criteria have particular RA categories associated with them such that rolling stock meeting those criteria will be compatible, for loading of underline structures, with route sections that also meet the relevant categories.

G 3.3.2 The criteria for determining RA categories are set out in GERT8006 and the process for checking compatibility is set out in RIS-8706-INS. As can be seen, there are several stages to demonstrating compatibility of which simple comparison of the RA numbers for the rolling stock and the infrastructure is the first and simplest.

G 3.3.3 If rolling stock meets the other criteria for MU or HST as set out in RIS-2711-RST, but exceeds the specified RA value, then the compatibility will need to be assessed on a case-by-case basis for each relevant underline structure at the relevant speed. Use of an LDPS may still be appropriate but such rolling stock will need additional checks.

3.4 Track type and construction; sleepers, rails, fastenings

Guidance

G 3.4.1 When applying an LDPS, the performance of the track system is set out in the Network Rail Standard NR/L2/TRK/2102, which defines the maximum permissible speed for various types of track components (such as rail section, sleeper or baseplate type) and construction, which are considered when imposing, changing or removing a differential speed.

3.5 Switch and crossing locations

Guidance

G 3.5.1 When considering implementing an LDPS, the location and maximum permissible speed of any Switch and Crossing (S&C) locations is taken into account. The Network Rail standard NR/L2/TRK/2102 sets out the speed limits over various configurations of S&C.

3.6 Track category and inspection implications

Guidance

G 3.6.1 Track inspection and maintenance is carried out depending on the relevant track categorisation (as set out in the Track Category matrix in Network Rail Standard NR/L2/TRK001/MOD2 Issue 7). If an LDPS is applied on a section, the track category may change. This may lead to increased inspection commitments, such as basic visual inspection (BVI) and ultrasonic rail flaw detection, as well as more onerous minimum actions for faults being applied, for example, a reduced timescale for rail defect removal.

G 3.6.2 Any revised inspection and maintenance schedule is factored into the business case for applying an LDPS to a section of track.

3.7 Passive (user worked and footpath) level crossings

Guidance

G 3.7.1 Crossing users at these level crossings can use them safely providing a sufficient sighting time exists. The available sighting distance and time will have been assessed against the existing permissible speed and will be reassessed against any increased permissible speed.

G 3.7.2 This assessment would lead to one of the following conclusions:

a) The sighting distance and time is still sufficient for the higher permissible speed;
b) Additional sighting distance and time can be achieved at minimal cost, for example by vegetation clearance;
c) Additional sighting distance and time can only be achieved with significant expenditure;
d) It will not be possible to achieve the required sighting distance and time, so the crossing could only be regarded as acceptably safe for a higher permissible speed by the provision of additional technical controls such as a telephone or miniature stop lights.

G 3.7.3 The impact on risk of a higher permissible speed will be considered using a risk assessment such as the All Level Crossing Risk Model (ALCRM).

G 3.7.4 An increase in permissible speed for the remainder of a line of route, but retaining the existing permissible speed approaching one or more passive level crossings can lead to a more complex speed profile than that which existed previously with the following possible consequences (see *3.10* for guidance on driveability):

a) The route becomes less easily driveable;
b) An increase in the number of instances where the train must brake and accelerate, with additional wear and tear and fuel consumption, leading to increased carbon impact;
c) A more complex and less easily comprehensible speed profile, increasing the possibility of over-speeding and an increased risk to level crossing users as a consequence.

G 3.7.5 Retaining the existing permissible speed approaching a passive level crossing can lead to a situation in which the speed reduction would require the provision of Advanced Warning Indicators and associated AWS (see RIS-0734-CCS).

G 3.7.6 At a considerable number of passive level crossings, a temporary speed restriction (TSR) has been imposed because of sighting deficiencies that cannot be overcome without significant investment. When reviewing an existing permissible speed profile, which would not include any TSRs, these TSRs will be very relevant, as they can result in a complex speed profile with a greater degree of deceleration and acceleration due to the increased permissible speed. The effect could also be to reduce or completely eliminate any benefits of a reduced journey time from a higher permissible speed over the remainder of the route.

G 3.7.7 An increase in permissible speed can create a deficiency in sighting distances and times that did not exist previously, but if the mitigation proposed would be a temporary speed restriction, similar considerations would apply as for a pre-existing TSR.

G 3.7.8 A TSR associated with a level crossing that remains in force for more than 12 months is required to be supported by the provision of TPWS.

3.8 Manually controlled level crossings

Guidance

G 3.8.1 An increase in permissible speed on a line that passes over a level crossing protected by non-block signals can result in the sighting or braking distance for those signals being no longer adequate. A similar situation could arise for block signals controlled by a signaller, although this would be considered as part of any review of signal sighting and braking distances.

3.9 Existing permissible speeds and their justification

Guidance

G 3.9.1 A review of permissible speeds over a line of route can be initiated where certain characteristics of rolling stock or infrastructure are reconsidered. This may be because there is a possibility of increasing speeds by re-evaluation of the constraints imposed by these characteristics. There may be reduced permissible speeds at certain locations on the route that have historically been applied for reasons that are no longer relevant. As part of any review, it is good practice to identify the reasons for those restrictions to confirm:

a) Whether they are still relevant, considering any engineering change that may have taken place;
b) Whether there is a possibility of increasing the speed for all trains, or for those types of trains for which an increased permissible speed is intended.

3.10 Driveability

Guidance

G 3.10.1 Driveability is defined as the ease and reliability with which train drivers are able to perform train operations in accordance with rules and procedures, throughout the range of operational and ambient conditions applicable to each train, within the operational context and while performing typical required duties (see RIS-0713-CCS).

G 3.10.2 Driveability assessment is undertaken in relation to lineside signalling, but it is good practice to apply this to a proposed improvement in permissible speeds which would include the following considerations:

a) More frequent variations in permissible speeds than those previously in force complicate the task of absorbing and applying the speed profile;
b) A reduction in the number of variations would ease that task;
c) Variations in permissible speed over short distances can make it impossible for the rolling stock to attain a higher speed before it is necessary to reduce speed in readiness for a lower permissible speed.

Part 4 Background to Lettered Differential Permissible Speeds

4.1 Permissible speeds and rolling stock compatibility

Guidance

G 4.1.1 The route compatibility process set out in RIS-8270-RST is the agreed industry process for confirming suitability of particular rolling stock to operate at particular speeds at each location. This process is followed for any change to rolling stock, infrastructure or operations.

G 4.1.2 Checking of differential categories is NOT sufficient evidence of compatibility at the differential speed, as many other factors are also relevant.

G 4.1.3 There are practical and human factor limitations on how many different maximum speeds can be applied over each section of line, with an adopted upper limit of three maximum speed limits (see RIS-0734-CCS).

4.2 Types of differential permissible speeds

Guidance

G 4.2.1 Differential permissible speeds have been used since the 1980s and offer, at a reduced cost, a very effective way of enabling specific higher speeds without costly infrastructure upgrades.

G 4.2.2 Over the years, differential permissible speeds have been implemented via route or regional local mechanisms, sometimes without holistic consideration of network wide application.

G 4.2.3 The use of differential permissible speeds needs to be carefully considered from an operational and engineering perspective, and there is a long-established hierarchy:

a) One maximum speed that is applicable to all categories of rolling stock, or
b) If this cannot be achieved the following hierarchy is applied:
   i) use of standard differential speeds
   ii) use of MU non-standard differential speeds
   iii) use of other non-standard differential speeds (e.g. HST, SP) and Enhanced Permissible Speed (EPS) for specific purposes only.

G 4.2.4 This hierarchy recognises the importance of a consistent 'message' being provided to the driver by avoiding the mixing of different types of signs on the route applicable to a particular category of rolling stock.

G 4.2.5 The hierarchy acknowledges that rolling stock can be relocated to different routes, and so the decisions on the use of LDPSs needs to take a longer-term view compared to just one fleet.

G 4.2.6 The hierarchy also recognises that most new passenger rolling stock fleets are types of multiple units and therefore the MU category is expected to be widely applicable.

G 4.2.7 Given the range of new rolling stock in service, and many sections of line having been upgraded since the 1990s, there is an opportunity, on a range of different routes, to exploit further the use of LDPSs based on clear engineering criteria and a sound business case.

G 4.2.8 GERT8000-SP sets out the range of LDPSs that are used across the GB network, see Figure 4.

Where permissible speeds are shown with letters, they apply only to the trains shown by the letters. You can allow your train to travel at no more than that speed, providing it is a train of the type to which the permissible speed applies.

This is what the letters mean.

HST	High speed trains
MU	Multiple-unit trains
DMU	Diesel multiple-unit trains
EMU	Electric multiple-unit trains
SP	Sprinter multiple-unit trains
CS	Class 67 locomotives

The classes of train that can travel at these speeds are shown in the *Sectional Appendix.*

Figure 4: Non-standard differential speeds from GERT8000-SP

G 4.2.9 RSSB Research projects T996 (2014) and T1163 (2020) studied the use of LDPSs on the network and developed clear, numerate criteria for categorisation of rolling stock as SP, HST or MU. T1163 (2020) also concluded that there was no justification for the separate categories of EMU and DMU.

G 4.2.10 This document sets out the process for adding, removing or updating HST, MU and SP differentials on the infrastructure. RIS-2711-RST sets out the criteria for categorisation of different rolling stock formations against these lettered categories. The two documents are designed to work together.

G 4.2.11 Some background to the different differentials is given below; further information is in RIS-2711-RST.

4.3 History of HST differential

Guidance

G 4.3.1 The HST differential was introduced in the 1970s / 1980s to permit InterCity 125 trains to operate at higher speeds than locomotive-hauled trains given their better braking performance, higher permitted cant deficiency and no increase in track forces.

G 4.3.2 The InterCity 125 was required to stop with a full service brake application from 125 mph (200 km/h) in the same stopping distance as the existing trains required from 100 mph (160 km/h). This would therefore enable the higher speeds without changes to the signal spacings on the routes.

G 4.3.3 The required full service braking performance for the earlier passenger trains was the 'W curve', which was based on physical testing of a benchmark train rather than calculation with a defined deceleration rate. This recognised that the achieved deceleration rate, with cast iron tread brakes, varied during a braking stop and was approximately equivalent to a 6 % or 7 % *g* deceleration.

G 4.3.4 The InterCity 125 performance, using disc brakes, was more consistent and generally characterised as 9 % *g*.

G 4.3.5 The InterCity 125 was capable of operating at 150 mm (6 inches) of cant deficiency compared to 110 mm (4¼ inches) for earlier vehicles, allowing higher speeds in appropriate curves.

G 4.3.6 For track forces, the requirement was to remain within the existing limits, set out at that time in GMTT0088, in spite of the higher speed.

G 4.3.7 This initial application to HST sets, composed of Class 43 Power cars and Mark 3 coaches, was later broadened to include other vehicle types, which are generally believed to meet the original aims.

G 4.3.8 The original High Speed Trains, for which the differential speed was developed, were diesel powered and there is no record of the differential considering any electrification.

G 4.3.9 The compatibility with underline structures, according to the Route Availability (RA) number set out in GERT8006, did not form part of the original requirements for HST lettered differentials, but RA requirements have been taken into account in developing differentials at some locations.

G 4.3.10 RA criteria were introduced in 2009 and documented in the Network Capability Statement which described RA values for the various differentials.

G 4.3.11 For the HST differential, this states:

- RA4 or less for weight evenly distributed down the train
- RA5 if weight is concentrated in power cars, separated by RA1 coaches (that is like an InterCity125 set).

G 4.3.12 Certain vehicles or units with higher RA classification have been permitted to operate at HST differential speeds at specific locations, but these do not have full network wide HST classification.

G 4.3.13 There are a number of route and rolling stock specific applications of HST LDPSs that exist across the network. It is therefore important that each location is considered on its own merits, especially if signal spacing is revised or line speed changes are proposed. It cannot be assumed that all existing signage is consistent with the original intentions.

G 4.3.14 RIS-2711-RST sets out the criteria for new rolling stock to be categorised as HST.

4.4 History of MU, DMU, EMU differentials

Guidance

G 4.4.1 Although considered as a grouping of similar types of suburban or inter urban vehicles, MU, DMU, EMU were originally applied to a broad range of multiple units. This was based on regional allocations and whether or not the route was electrified.

G 4.4.2 A particular principle was that the signs used should not be intermixed within the same route, nor, as far as possible, within different routes worked by the same drivers.

G 4.4.3 The MU category was by far the most widely used.

G 4.4.4 The categories MU, DMU, EMU were not designed to include train types other than 'suburban' or 'interurban'. The only 'multiple-unit' of the 'intercity' variety at the time was the HST, which was seen as being a quite different engineering category.

G 4.4.5 Since inception, RA criteria have been adopted for MU, DMU, EMU with an RA3 limit for network wide application based on routes with particular underline bridge limitations. There is though the precedent that rolling stock with a higher RA could be shown to be compatible on a local or route basis.

G 4.4.6 Following a detailed investigation into the current use of MU, DMU and EMU LDPSs in T1163 (2020) it became clear that the three categories can be simplified into a single MU category. There is no suggestion that existing DMU and EMU speed signs should be changed, unless this is considered appropriate for specific examples. However, if an LDPS is to be established or changed then, depending on other signage on the route, one type of sign can be adopted.

G 4.4.7 RIS-2711-RST sets out the criteria for new rolling stock to be categorised as MU.

4.5 History of SP differentials

Guidance

G 4.5.1 SP LDPSs were introduced to realise speed improvements from lighter weight rolling stock. They were applied to lengths of track considered to be less robust with properties that made it more susceptible to rapid deterioration at a certain threshold of train loading. T996 (2014) analysed the influence of vehicle speed and track forces, with a particular focus on aspects such as track stability, rail joint failure and fastening failure.

G 4.5.2 RIS-2711-RST sets out the criteria for new rolling stock to be categorised as SP and contains more background on these differentials.

4.6 Types of rolling stock to consider

Guidance

G 4.6.1 Between them the LDPSs HST, MU and SP can be used for all common types of rolling stock configurations, for example rolling stock that uses electrical contact systems, self-powered, loco hauled, short and long formations.

4.7 Future use of differential permissible speeds

Guidance

G 4.7.1 The long-term strategy for the GB mainline rail network is to migrate to a control system based on the European Train Control System (ETCS). More information on this is given in the Digital Railway Long Term Deployment Plan (LTDP). ETCS does not support the use of lettered differential speeds and so such differentials have a limited life. However, the likely length of time before ETCS is installed on the routes best-suited to benefit from LDPSs means that a systematic roll-out of standardised LDPSs is still likely to deliver a material net performance and commercial benefit to the GB mainline network.

G 4.7.2 In considering the use of differential speeds, there are a number of decision-making points:

a) Infrastructure utilisation planning – When looking at future customer needs for a route together with infrastructure investment decisions the early consideration of LDPSs can help to exploit the latent capability of the route, minimise costs and accelerate journey time improvements.
b) Planning for introduction of new fleets – Deciding which LDPSs are to be applicable for new fleets is an early project decision but then, in planning how they can best be deployed, it is useful to consider LDPS opportunities in advance of fleet introduction.

G 4.7.3 The MU LDPS category has been shown to encompass most modern multiple units, therefore this is likely to continue to be the most widely applicable LDPS.

G 4.7.4 The mix of traffic on a route together with the inherent limitations on line-speed of, for example, horizontal curvature and transition length influence the merits of having a single line speed or differential speeds.

G 4.7.5 Whilst there might be some current infrastructure limitations, such as sections of older track or particular level crossings, the mix of traffic types is likely to be the key driver of whether a single line speed or an LDPS is the optimal approach.

G 4.7.6 For example, in the case where a section of route sees a high volume of freight traffic, the aim would be to have a minimum line speed capability to keep the freight trains moving as fast as they can whilst safely braking, but then using LDPSs, to allow passenger trains to travel faster. This case is borne out with the most common MU and SP LDPSs being 60/MU70, 50/MU75 and 75/SP90.

G 4.7.7 History has shown that changing the speed profiles of routes outside of a route upgrade programme takes a long time. Even though there are progressive infrastructure improvements over the years, principally for the track system, it is complex and difficult to justify as a continual improvement initiative. This is helped by now having clear criteria for rolling stock LDPSs that can be used to proactively and incrementally implement minor speed enhancements with low investment costs.

Part 5 Other characteristics to be considered

5.1 Compatibility

Guidance

G 5.1.1 RIS-8270-RST sets out the process for determining compatibility of rolling stock and infrastructure. This section gives guidance on some of the characteristics for consideration in this assessment.

5.2 Gauge clearance

Guidance

G 5.2.1 With any line speed improvement project, there may be changes in gauge clearance due to the likely increased dynamic envelope of the rolling stock type. Clearances to structures and through bridges and tunnels are a particular focus, but there could also be an effect on passing clearances.

G 5.2.2 If structure or passing clearances are compromised then, provided there is enough of an available envelope, a track realignment scheme may be practical at relatively modest cost to preserve or improve the existing clearance, as well as to achieve the target maximum speed profile.

G 5.2.3 A design aspect to be considered with respect to gauge clearance is to check on site that the commencement sign for the LDPS can be located without compromising gauge clearance and that this still allows adequate visibility for drivers.

5.3 Braking distance and adhesion levels

Guidance

G 5.3.1 Both MU and HST differentials require the rolling stock to meet the full service stopping distances defined by the curves C1 or C2 in GMRT2045 (nominally 9 % *g* deceleration), as appropriate for the train formation.

G 5.3.2 Even if the rolling stock is capable of achieving these higher deceleration rates, the stopping distances can only be realised if the required level of wheel-rail adhesion is available.

G 5.3.3 If this braking performance is required for implementation of the proposed LDPS, then consideration is given to confirming that there are no known location-specific concerns over adhesion levels.

G 5.3.4 If there are known adhesion issues, then further assessment may be required to consider if mitigation measures on the infrastructure or the rolling stock are appropriate. Such mitigation could include the use of double variable rate sanders on the rolling stock or changes to the rail head treatment regime.

5.4 Aerodynamic considerations

Guidance

G 5.4.1 The aerodynamic effects of trains passing is important in any proposed speed increase. Relevant issues may include, but are not limited to:

a) Requirements for station platforms and markings where trains do not stop. For passenger trains requirements are altered above 100 mph (160 km/h), so a change to the line speed to take a platform location above this limit will require further consideration (see RIS-7016-INS);
b) Aerodynamic effects on structures such as station canopies, footbridges and other structures close to the track (see GCGN5612);
c) Criteria for pressure pulses on passenger train comfort levels in tunnels;
d) Criteria for track side access.

G 5.4.2 Descriptions of train slipstream effects are given in EN14067-4:2013+A1:2018 and in RSSB Research Report T248 (2003).

G 5.4.3 It is assumed that any project considering use of an LDPS is not intended to increase freight train speeds. If freight train speeds are affected, for example by an increase in line speed, then additional aerodynamic considerations may be important.

5.5 Energy sub-system compatibility

Guidance

G 5.5.1 RSSB research T1163 (2020) determined that there was no continuing need to differentiate between MU, DMU and EMU speed differentials in the permissions provided by lettered LDPSs.

G 5.5.2 There are a few locations on the network which require special consideration, where the maximum speed of rolling stock which is utilising the overhead contact line or conductor rail systems may be reduced compared to self-powered rolling stock. This particular aspect is not in scope of LDPS and the existing control measures remain applicable.

Part 6 Benefits of Lettered Differential Permissible Speeds

6.1 Assessment of benefits

Guidance

G 6.1.1 There are five main potential benefits from reducing sectional running times by increasing the permissible line speed on route sections. These are listed below in probable order of scale of benefit:

a) Improved resource utilisation, with shorter journey times allowing the same service to be operated with fewer trainsets and traincrew, or more services to be run without requiring a proportional increase in trainsets and crews;
b) Increased revenue through shorter journey times making rail more attractive to travellers;
c) Improved performance through increase in station dwells or turnround time at terminal(s);
d) Additional station calls within existing end-to-end timings; this can be of particular benefit where paths through major stations are fixed at one or both ends of the route ;
e) Reductions in energy consumption (and therefore carbon emissions, particularly but not exclusively on diesel stock) through constant or optimal speed running, reduction in braking / acceleration requirements and/or increased use of "direct drive" on diesel mechanical multiple units (usually around 40 mph or 65 km/h) – fuel savings of up to 30 % can be realised.

G 6.1.2 When the infrastructure condition allows, for instance following refurbishment or renewal of assets, the optimum approach is to increase line speeds for all traffic. However, where there is a significant disparity in either track force or braking capability between different types of rolling stock on the route, it may be possible to deliver a significant proportion of the overall potential benefit at a fraction of the cost through the use of an LDPS.

G 6.1.3 The objectives that might be addressed through a review of LDPSs can be summarised as follows:

a) Realise the opportunity to reduce journey times presented by new rolling stock;
b) Realise the opportunity to raise speed limits for existing rolling stock;
c) Optimise track maintenance costs to improve value-for-money of rail services;
d) Reduce the capital costs of interventions needed to reduce journey times;
e) Simplify and optimise presentation of signage to reduce human factors issues;
f) Optimise journey profiles for energy and carbon efficiency;
g) Reduce costs related to acceleration and braking, including energy consumption and carbon emissions.

G 6.1.4 Further guidance on several of these areas is given below.

6.2 Operational efficiencies and performance

Guidance

G 6.2.1 An increase in permissible speed that results in reduced sectional running times can lead to benefits including the following:

a) A shorter overall journey time can allow the same level of service to be provided with a reduced level of rolling stock or traincrew, or alternatively an increased level of service can be provided without requiring any additional resources;
b) Improved resilience against delay by allowing increased station dwell times, or a longer turnround allowance at terminal points;
c) Additional station stops can be included without extension of overall journey times, which can be of benefit if a commercially desirable stop could not be included without introducing pathing conflicts elsewhere in the journey;
d) Avoidance of pathing conflicts by allowing presentation at a time which provides a sufficient margin within timetable planning rules for junction movements, headways in relation to other trains or platform re-occupation times;
e) Possible avoidance of the need for insertion of pathing allowances;
f) A reduced running time can allow an alternative acceptable path to be obtained after the inclusion of engineering and performance allowances;
g) The service pattern can be improved by adopting even-interval timings where these are not achievable because of pathing constraints imposed by the previous running times;
h) Additional connectivity can be achieved by adopting arrival or departure times that allow additional opportunities for connections between trains.

G 6.2.2 It is also possible that the potentially improved path cannot be taken advantage of because it creates a conflict with another service that cannot be resolved.

6.3 Passenger revenue

Guidance

G 6.3.1 An increase in passenger demand and revenue is likely to be demonstrated by the following potential timetable improvements from an increase in permissible speeds:

a) A shorter overall journey time;
b) An increase in service frequency;
c) Additional station stops increasing service frequency at those locations;
d) A more regular interval service pattern;
e) Additional journey opportunities through improved connectivity.

G 6.3.2 The impact of passenger demand and revenue can be modelled using software such as MOIRA, which is a demand forecasting tool capable of modelling the impact of timetable changes.

6.4 Rolling stock and staff utilisation

Guidance

G 6.4.1 Through speed enhancement there is the inherent benefit of enhanced rolling stock utilisation, and coupled with that is increased productivity from train crews.

G 6.4.2 For services with shorter end-to-end journeys there can be the potential to redeploy rolling stock and crews to other routes if there is a reduction in journey time.

G 6.4.3 The targeted use of appropriate LDPSs, likely to be MU or SP for these shorter journey types, could be sufficient to save the use of a train and crew and still achieve the service frequency.

G 6.4.4 An idealised example would be where the end-to-end journey time on a two-track railway was just less than an hour on a route with an hourly service. Allowing for turnround times would mean that three trains would be needed for the service. However, if particular LDPSs could be established to reduce the journey time by a few minutes, then it could be possible to deliver the service with only two trains.

6.5 Rolling stock and staff costs

Guidance

G 6.5.1 An increase in permissible speed that allows economies in rolling stock or traincrew can result in a reduction in operating costs for a train service. If the increase in permissible speeds allows the operation of a revised train service which requires additional rolling stock or traincrew, this is likely to lead to an increased cost of operations to be balanced against potential revenue improvement.

G 6.5.2 A possible outcome of a permissible speed improvement is that advantage can be taken of a change in the type of rolling stock used, for example one that has the ability to operate at that higher speed, whereas the rolling stock previously in use could not. It is important to consider the impact of doing so on the costs of both rolling stock provision, and of training requirements for traincrew.

6.6 Other trackside signage

Guidance

G 6.6.1 The introduction of revised permissible speeds over a route can affect the number of permissible speed indications that are necessary:

a) If there are fewer changes of permissible speed, the number would be reduced;
b) If more changes are introduced, it would be increased; and
c) If the number of changes remains the same, but the indicated speed is different, an equal number of signs would require replacement.

G 6.6.2 In all cases, there is an impact on costs of signage provision and maintenance to be considered. Any increased number will result in an increase in trackside access for installation and maintenance purposes, and a consequent increase in the exposure to trackside risks.

6.7 Energy consumption and carbon emissions

Guidance

G 6.7.1 Preliminary work by some TOCs has indicated that smoothing the speed profile of trains between stations so that they accelerate to running speed, cruise at that speed and then brake smoothly into their next stop could save up to 20 % of the tractive energy for that journey, and thus 20 % of traction carbon emissions resulting from that journey, when compared with existing journey profiles.

G 6.7.2 Existing journey profiles are often driven by line-speed restrictions and therefore relaxing these, where appropriate, by use of LDPS will have a beneficial effect on energy consumption.

G 6.7.3 Increasing the speed of a train by about 20 mph (32 km/h) typically doubles the power required, so any unnecessary braking and acceleration is inherently wasteful. Being able to smooth journey acceleration, cruising and braking profiles between timetabled stops will maximise energy and carbon efficiency of that journey.

G 6.7.4 The operational carbon impact of varying the speed of trains varies in linear terms with the energy required to make particular journeys. This is, in turn, a factor of the power needed to accelerate trains to an efficient running speed to meet timetabling requirements.

G 6.7.5 Recent work under the COF-IPS programme by Loughborough University (COF-IPS 02) modelled aspects of this, and identified some of the key factors affecting speed and therefore carbon emissions. The speed adjustment to achieve the arrival time was, by some considerable degree, the single biggest factor affecting carbon emissions on the modelled journeys. This showed similar scales of emissions attributable to line-speed as the initial work mentioned.

6.8 Infrastructure works and costs avoided

Guidance

G 6.8.1 There are a number of areas where use of an LDPS, rather than a line-speed improvement for all train types, may avoid substantial costs. Avoiding infrastructure works will also limit carbon and energy impacts, although it is not proportionate to quantify this.

G 6.8.2 Utilising LDPSs on secondary and regional lines on the GB mainline rail network allows the benefit of reduced journey times to be achieved without the need for significant infrastructure upgrades. Where sections of track have the capability to support higher speeds the benefit of shorter journey times can be delivered for negligible capital spend on infrastructure. Where infrastructure requires capital investment to implement an LDPS, the use of LDPSs, rather than a full line speed increase, can ensure the scale of the work is cost-effective as upgrade work can be scaled down.

G 6.8.3 Additionally, an increase in permissible speed on curves for certain trains will result in them operating at higher levels of cant deficiency, which can reduce the growth of Rolling Contact Fatigue (RCF).

6.9 Consequential impacts of LDPSs

Guidance

G 6.9.1 There are also some potential consequential impacts from the use of LDPSs.

G 6.9.2 There can be an impact on slower traffic. For example, when speed increases were considered on the Newport to Shrewsbury line, additional loop lines were needed to maintain freight paths between the accelerated passenger services, thereby significantly increasing freight journey times.

G 6.9.3 There can also be an engineering cost to running trains round curves at widely differing speed. For example, canting the track for high-speed operation of passenger trains could result in more severe low-rail damage from slow and heavy freight trains.

6.10 Safety of staff on the track

Guidance

G 6.10.1 An increase in permissible speed over any portion of line has implications for the safe systems of work that are possible to adopt, and it is important to consider at least the following:

a) Increases in required sighting time, the ability to obtain these and the need to review and apply safe systems of work appropriate to the assessed level of risk;
b) Any works necessary to provide suitable positions of safety;
c) Modifications to Automatic Track Warning Systems (ATWS), Semi-Automated Track Warning Systems (SATWS) and Train Operated Warning Systems (TOWS) to provide sufficient warning time.

Part 7 Overview of case studies and assessing value-for-money

7.1 General considerations

Guidance

G 7.1.1 To complement the technical assessment of the use of LDPSs it is important to consider the commercial drivers for the change, and seek to ensure that business benefits are likely to follow from the investment.

G 7.1.2 There are general guidelines on how to investigate the business case benefits, but given the different route types, passenger preferences and competing (largely road) options there is no standard approach that fits all cases.

G 7.1.3 Case studies of typical examples can illuminate the type of potential options, challenges and solutions that can be found.

G 7.1.4 Many routes have been upgraded with jointed track replaced with Continuous Welded Rail (CWR) that is capable of a higher speed, and with track components designed to give long service life with higher axle loads and speed.

G 7.1.5 In some areas an existing differential may no longer be required. This is especially in areas where the passage of trains that would not be permitted to use a differential is rare, and therefore the marginal impact on track wear of such trains (for example locomotive-hauled charter trains) would be limited.

7.2 Consideration of speeds

Guidance

G 7.2.1 A related consideration is the maximum speed applied by an LDPS.

G 7.2.2 In the 1980s the maximum speed of the SP generation of trains was either 75 mph (120 km/h) for Classes 150 to 156 (tread braked), or 90 mph (145 km/h) for Classes 158 & 159 (disc braked). Since then new trains that can be classified as SP, such as Class 170 and Class 195, are disc braked with a maximum speed of 100 mph (160 km/h).

G 7.2.3 It is likely, therefore, that there are areas where these more modern trains are restricted artificially by a speed restriction as:

a) The original purpose of the LDPS has been superseded by track renewals;
b) The maximum speed permitted by an LDPS was determined by the class of rolling stock in use on the route at the time the LDPS was introduced, and may therefore be artificially capped at 75 mph (120 km/h) or 90 mph (145 km/h).

G 7.2.4 A further situation where circumstances may have changed relates to the introduction of trains that are capable of delivering the journey times achieved with a differential, but can do so within the permanent speed restriction for other trains. Typically, this would apply over shorter distances, where newer trains can apply higher rates of acceleration and braking performance.

G 7.2.5 In this case, it may be possible for an LDPS to be removed while maintaining existing journey times, or a dual benefit could be achieved by allowing the new train to run at the LDPS speed (if possible) and use its superior acceleration to further reduce journey times.

7.3 Consideration of benefits

Guidance

G 7.3.1 The decision-making processes in *Part 2* highlight the need to establish value-for-money when considering LDPSs, especially when compared to alternatives such as infrastructure investments. Further information can be found in T1163 Appendix D.

G 7.3.2 To assess value-for-money the following areas are generally considered:

a) Change in train operating costs - When assessing a change in rolling stock, (rather than enhancing the use of existing rolling stock on a route), consider the costs associated with such rolling stock, and similarly consider cost savings related to reduced journey times such as train crew savings.
b) Change in track costs - There are two areas of track costs that are considered. The first is the marginal impact on wear and tear of services operating at higher speed, driven by changes in lateral and vertical track forces. This will draw on route and rolling stock specific data. The second area relates to the impact of any change in speed on the track category. Relative to the very granular approach that can be achieved with costing for track damage, the track categorisation system is relatively unsophisticated. It is, however, important because funding for track maintenance varies with track category and, as track categories vary with Equivalent Million Gross Tonnes Per Annum (EMGTPA), and speed there is often very little headroom between a given speed and a given track category, except on routes with large volumes of freight that incur a large EMGTPA.
c) Change in capital costs - While LDPSs do not typically require significant capital investment, there are points within the process where a wider investment scheme may be considered for comparison. In addition, where a case exists for an LDPS scheme for short sections of track where, for example, track components represent a limit on maximum speed amongst other sections of track that can accommodate an LDPS, there may be a case for early renewal, to achieve a wider benefit from higher-speed operation.
d) Change in demand and revenue - Central to the case for an LDPS is the impact that it has on demand and revenue. Understanding the relationship between speed and demand on a route-specific basis is critical to understanding the case for an LDPS. The rate of increase in demand in relation to speed determines the speed at which an LDPS is set. This is because there is little point in increasing speed, and therefore cost, if it fails to generate a financial return. A change in speed may not just have an impact on demand on existing services. It may also have an impact on the frequency of services if either more services can be delivered for a given level of resource or where a reduction in journey time will have a disproportionate impact on demand, which in turn justifies a service enhancement. T1163 used the MOIRA software, which is a demand forecasting tool capable of modelling the impact of timetable changes.
e) Socio-economic impacts - An increase in demand has a number of secondary impacts that can be captured through the DfT TAG appraisal framework. A range

of monetised benefits can be captured that relate to passengers. These include value of time savings and marginal external congestion costs, which include the impacts of mode shift from cars, such as reduction in congestion and noise. While such impacts contribute to the value-for-money, they do not support a commercial financial case. The Rail Social Value Tool may be useful in identifying relevant elements and assessing their impacts.

f) Changes in carbon emissions and air pollutants - Again, these can be assessed through the TAG appraisal framework to produce a monetised value for any resulting impact variations. These may contribute to value for money assessments but may also be driven by statutory requirements. Care is taken to ensure that any such statutory requirements that generally apply, but may also relate to the sites of specific proposals, are not overlooked.

G 7.3.3 The factors considered in the points above can be drawn together to form a DfT TAG compliant economic appraisal that, for each case study, will support the decision processes in the flow diagrams and help determine the conclusions for each route and use case.

7.4 Overview of case studies

Guidance

G 7.4.1 A number of case studies have been undertaken to illustrate the range of application. These are listed below, and more detail on each is in the relevant Appendix:

- York – Scarborough (see *Appendix A*);
- Skipton – Carlisle (see *Appendix B*) ;
- Skipton – Lancaster (see *Appendix C*);
- North Cotswold Line (see *Appendix D*) ;
- Newport to Crewe (see *Appendix E*);
- Anglian Branches (see *Appendix F*).

G 7.4.2 The review of York – Scarborough was undertaken by Network Rail; the other studies were part of T1163 and more detail for them is available in the project report.

G 7.4.3 These case study routes demonstrate the potential for realising 'bankable' benefits from the application of LDPSs across a variety of rolling stock / infrastructure combinations. These are only examples, and each potential application will be different.

G 7.4.4 In most cases, the absence of regular workings of freight or locomotive-hauled passenger stock means that the use of an LDPS, rather than simply increasing the line speed, allows the relatively lightweight and better braked stock currently in use to take advantage of opportunities for higher-speed operation on existing or lightly upgraded infrastructure while avoiding major works to track, structures or signalling and managing the risk of accelerated asset degradation.

G 7.4.5 The post-COVID rail industry is likely to be in need of low-cost / quick impact initiatives to help to restore the attractiveness of train travel.

Appendices

Appendix A York to Scarborough

Note: This appendix is provided for guidance.

A.1 Overview of the route

A.1.1 The route from York to Scarborough is approximately 42 miles. It traditionally had SP differentials, but the current passenger rolling stock is not authorised to use these differentials as it does not meet the criteria for SP. The normal line speed is a maximum of 75 mph (120 km/h) with SP differentials up to 90 mph (145 km/h). Infrastructure work has been carried out since the SP differentials were installed, and this may mean that the line speed could be increased in some areas for all passenger rolling stock.

A.1.2 A line-speed assessment was carried out in 2019 using the current SP LDPS, infrastructure data and candidate rolling stock data to investigate the potential for low-cost line-speed improvements. The route was chosen because of significant lengths of SP differentials, and the potential opportunity to use newer rolling stock for shorter journey times and improved passenger experience.

A.2 Application of LDPS

A.2.1 The assessment used a number of infrastructure data sources affecting line-speed:

a) GEOGIS/RINM for track type and construction, local track section factor values, track category, structures, signal locations, level crossings;
b) Track geometry data;
c) Sectional Appendix;
d) 5 mile diagrams;
e) Gradient data;
f) National Gauging Database.

A.2.2 Figure *5* is a plot to show the possible speed profile using existing Track categories, as this would not alter track monitoring frequencies.

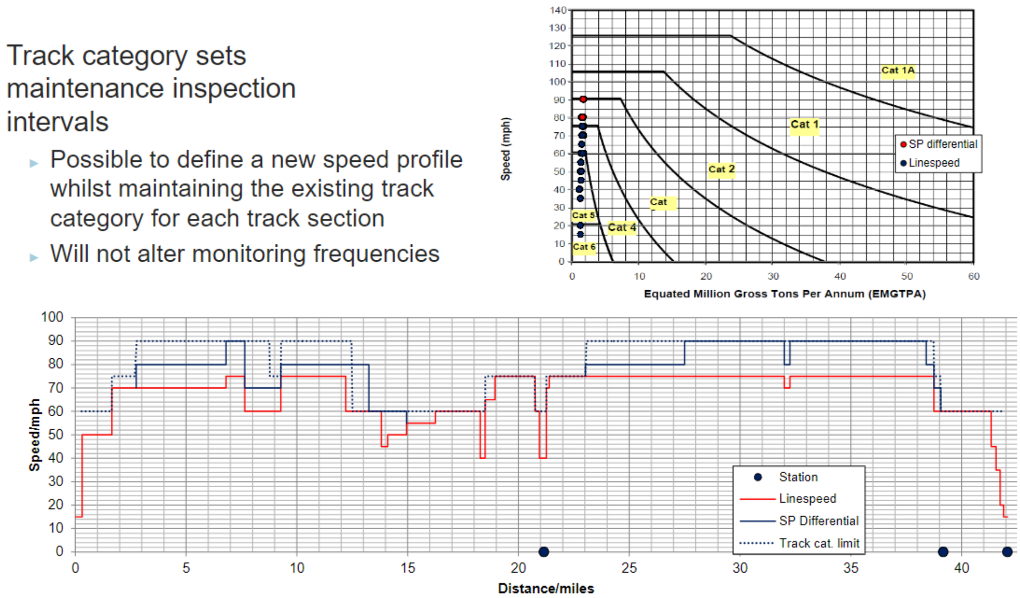

Figure 5: York to Scarborough possible speed profile

A.2.3 There are a number of level crossings on the route, ranging from User Worked Crossings to Automatic Half Barriers. The existing 'strike-in' points of the level crossings on the line are already located to suit the 'Sprinter differential' line speed.

A.2.4 The increased train speeds were considered unlikely to affect the existing ALCRM individual and collective risk rankings of individual level crossings. However, it was noted that it would be prudent to recalculate individual FWI scores to inform future investment in safety improvements at each level crossing.

A.2.5 Composite speed profiles were produced (see figure *6*) that showed the existing speed profiles and constraints, as well as potential enhancements (see figure *7*) based on each feature, noting that compatibility with structures and level crossings would need to be assessed separately due to other factors not directly related to speed.

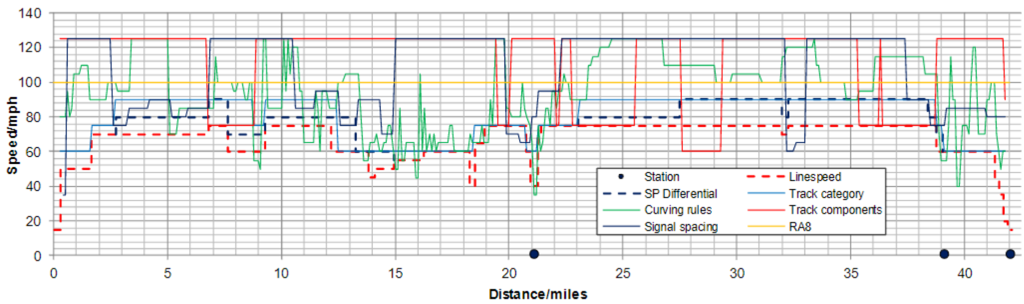

Figure 6: York to Scarborough composite speed profile

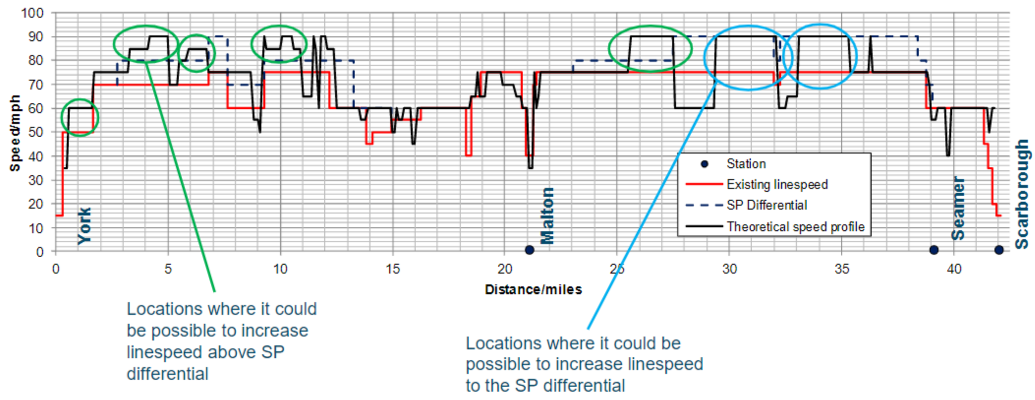

Figure 7: York to Scarborough locations of possible speed increase

A.2.6 It was noted that in very specific locations the existing line-speed was greater than the theoretical speed of the components. This is most likely caused by an anomaly in the component data.

A.2.7 The speed profile and constraints analysis provided a clear and visual way of indicating where, and to what extent, a speed enhancement would be possible. The next step using these bounded limits of feasibility would be to assess:

a) Any gauging issues that arise from the increased vehicle dynamic movements;
b) Effects on level crossings risk management;
c) The driveability of the identified speed changes from an operational and rolling stock capability perspective.

A.2.8 The key finding from this line-speed assessment case study was that there were many sections of line where there looked to be the potential to raise the line speed for all passenger trains to the SP LDPS.

A.2.9 This enhancement would be achievable without carrying out infrastructure enhancement work, which means at much reduced cost.

Appendix B Skipton to Carlisle

Note: This appendix is provided for guidance.

B.1 Overview of the route

B.1.1 The Skipton to Carlisle route currently has a ruling line speed of 60 mph (100 km/h), but historically was designed to accommodate speeds as high as 90 mph (145 km/h). The route was downgraded in the 1960s and 1970s when it ceased to be regarded as a main Anglo Scottish route.

B.1.2 The route was formed almost entirely of jointed flat bottom track until the early 2000s but, despite being a secondary route served by Sprinter trains, LDPSs were never used.

B.1.3 The route was almost entirely relayed in the 2000s to serve its role as a heavy freight route; indeed track renewal was in large part prompted by deterioration in track quality as a result of freight traffic.

B.1.4 At this point the speed restriction was not raised, as 60 mph (100 km/h) was adequate for the predominantly Class 6 and Class 7 trains.

B.1.5 Since the early 2000s freight traffic has declined. However the number of locomotive-hauled charter trains has increased with a number of regular workings across the year, especially in summer.

B.1.6 There has been considerable interest from stakeholders, such as Transport for the North (TfN), in increasing the line speed for passenger services.

B.2 Application of LDPS

B.2.1 Services on the route are currently formed of Class 158 units with a maximum speed of 90 mph (145 km/h), which could therefore take full advantage of a Sprinter differential.

B.2.2 The route was used until the mid-2000s by diverted West Coast Main Line (WCML) services, but the significant additional journey time relative to bus replacement services via the M6 was a contributory factor in the ending of diversions. Journey time reductions on the S&C, along with new Class 80X units used by Avanti West Coast, may allow services to be diverted once again.

B.2.3 While there is stakeholder engagement in the route, the current service is relatively sparse and revenues are comparatively low, suggesting that any increase in line speed would need to be achieved in a low-cost way.

B.2.4 The route does however have the potential to relieve congestion on other routes for example by abstracting Glasgow –West Yorkshire trips from other routes via Preston or Edinburgh.

B.2.5 The route-specific objectives considered in the T1163 case study were to:

a) reduce journey times between Skipton and Carlisle to improve regional connectivity between Cumbria and West Yorkshire, and Anglo Scottish connectivity between West Yorkshire and Western Scotland;

b) support more attractive sustainable transport options for shorter-distance movements within and between Cumbria and North Yorkshire;
c) achieve an increase in service frequency, within overall signalling and track configuration limitations, without a proportional increase in resources;
d) minimise the additional impact on track maintenance costs.

B.2.6 Based on the objectives above and the character of the route, the application of an LDPS may be appropriate. In many respects, the Settle & Carlisle is a classic example of a route on which LDPSs were applied in the 1980s; the main difference being that the track has subsequently been upgraded from jointed track to CWR.

B.2.7 T1163 looked at existing track and civil engineering infrastructure arrangements, current and foreseeable rolling stock and signalling/level crossings.

B.2.8 Modelling of the benefits of journey time reductions was considered alongside resource savings.

B.2.9 A number of speed enhancement options were considered with a key point being that the route, as well as generating new passenger demand, could also be an alternative route for other lines.

B.2.10 The results indicated that an increase in line speed, provided in a low-cost way, would be likely to represent value-for-money.

B.2.11 The scale of journey time reductions potentially achievable suggests it may be possible to increase demand further by increasing service levels without a disproportionate increase in resources.

B.2.12 The analysis in T1163 suggested (subject to further detailed work) that a case exists for increases in speed, and reduction in journey times, to increase demand.

B.2.13 The condition of the track suggests that almost all of the route could accommodate 90 mph (145 km/h) operation and 42 % could accommodate speeds higher than 90 mph (145 km/h), although it is acknowledged that more detailed work is required to confirm this.

B.2.14 To increase speed, there appear to be three options:

a) Increase line speed for all traffic on the route, including freight and charter services;
b) Introduce an HST or MU LDPS to deal with issues around signal spacing;
c) Introduce an SP or MU LDPS to limit the impact on track condition.

B.2.15 The first option may be possible, but risks increasing wear and tear from other types of train including freight traffic running as Class 4 (75 mph or 120 km/h) or passenger traffic including locomotive-hauled passenger trains.

B.2.16 The introduction of an HST or MU LDPS would mitigate the issues above and address concerns around the spacing of signals, by only allowing rolling stock with specific braking characteristics to use the route at a higher speed.

B.2.17 Historically the route has been used as a diversionary route for WCML passenger services, though this has declined in recent years. An HST LDPS may support the use of the line as a diversionary route as Class 80X and 22X units can utilise HST LDPSs.

B.2.18 An SP LDPS superficially appeared to be the most suitable for the route, as it would minimise track maintenance impacts and fits with the rolling stock available. However an SP differential would include Class 150 and 156 units, which have lower braking performance. These are therefore not included as HSTs or MUs and would have issues with signal spacing.

B.2.19 Overall, the suggestion was that an HST or MU LDPS may be the most suitable approach.

Appendix C Skipton to Lancaster

Note: This appendix is provided for guidance.

C.1 Overview of the route

C.1.1 The regional route between Skipton and Carnforth was once part of the Midland Railway's main line to Scotland as far as Clapham and, as with the Settle and Carlisle line, the geometry of the entire route is suitable for significantly higher speeds than the current 40 to 60 mph (65 to 100 km/h) restrictions in force.

C.1.2 The recent replacement of higher track-force Pacer stock means that the introduction of SP or MU differentials can be considered. T1163 studied the opportunities for modest improvements in journey times while remaining within the context of the mostly less robust track assets on this route.

C.1.3 The route is not currently used by freight traffic. However, it is utilised fairly extensively by West Coast Railways who are based at Carnforth. They use the line principally for empty coaching stock movements for charter trains and locomotive test runs. These are typically formed of either a diesel locomotive, such as Class 47 or 37, and Mark 1 coaches, or a steam locomotive, and unusually are often vacuum braked. The use of trains which could potentially utilise a SP LDPS could help to address two objectives for the route:

a) Journey time reductions as a result of higher speeds would increase demand for services, providing a greater contribution to operating costs;
b) Reduced journey times would help to increase turnround times at Lancaster and Morecambe. The increase in service frequency on the route has to some extent come at the cost of more efficient rolling stock workings, which have squeezed turnround times and thus reduced punctuality and reliability.

C.1.4 The majority of the track components are capable of operation at 75 mph (120 km/h) or higher speeds, with the exception of some short sections of track.

C.1.5 The signalling on the route is very limited. The line is formed of a single block section between Settle Junction and Carnforth Station Junction, a distance of around 25 miles. This limits capacity to a service every 45 minutes, although it has been sufficient to meet demand for many years.

C.1.6 Within the constraints of the current permanent way, the maximum realistic speed that could be achieved on the route is 75 mph (120 km/h). This is because only very limited sections of the line could achieve speeds higher than this without relaying work.

C.2 Application of LDPS

C.2.1 Were an LDPS to be introduced it would not be proposed to alter any of the existing permanent speed restrictions that are below 60 mph (100 km/h). This is because all of them are close to stations where all services stop, would require very substantial investment (S&C renewals at Settle Junction or works to Melling Tunnel), or are determined by geometry (Carnforth East Junction to Carnforth Station Junction).

C.2.2 The application of an LDPS rather than a general raising of the line speed is appropriate due to the used life of the existing assets, and the use of the route by heavy locomotive-hauled passenger trains. This also rules out the application of a passenger/freight differential.

C.2.3 Of the remaining types of LDPS, an SP differential would seem the most appropriate. While this risks constraining the route for other types of multiple unit in the future, (for example those that meet MU but not SP classification), it is a differential that limits the negative impact of speed on the track.

C.2.4 This issue of using an LDPS which excludes some future rolling stock types is relevant. However the example here does reflect well the issues faced in the late 1980s when LDPSs were initially introduced.

C.2.5 Were an LDPS to be introduced, the track category would move from Category 5 to 4 due to the change in speed (rather than tonnage). The use of video systems for plain line inspection and continuing to apply lower permitted speeds over S&C assets will minimise the additional inspection costs associated with this change in category. The restriction to lightweight SP rolling stock will minimise the additional asset degradation requiring additional maintenance and/or earlier renewal of assets.

C.2.6 Based on initial modelling work undertaken in T1163 it was assumed that a journey time reduction of seven minutes is achievable between Skipton and Carnforth with an LDPS of 75mph (120 km/h). This assumes a two-minute reduction between Skipton and Settle Junction and a five-minute reduction over the 24 miles from Settle Junction to Carnforth. Not all of this may be realisable without the renewal of some track between Wennington and Carnforth, which is limited by its components to 60 mph (100 km/h). Therefore an assumed journey time reduction of six minutes was used for the benefit calculations below.

C.2.7 Due to the lower overall market for this route compared to the Settle & Carlisle route, it was assumed that the train service specification on the route remains as it is now, with the benefits restricted to journey time reductions rather than the additional train services assumed for Settle & Carlisle.

C.2.8 Rolling stock utilisation is relatively efficient on the route, and the current level of demand and revenue is unlikely to support the step change in service required to support additional rolling stock, although a reduction in journey times would help to support a move towards this in the long term.

C.2.9 Revenue and socio-economic benefits can be derived in the following ways:

a) Reduction in journey times for existing passengers on existing services, and those abstracted from other routes;
b) Revenue generated from new passengers attracted by reduced journey times;
c) Increase in demand generated by improved performance arising from increased, and therefore more robust, turnround times at Lancaster and Morecambe.

C.2.10 The latter issue of performance is not insignificant. Historically turnround times at Lancaster and Morecambe were relatively generous. However, the increased service level since 2018 has improved rolling stock utilisation and reduced turnrounds, with some turnrounds at Morecambe being only eight minutes. This has two impacts. Firstly, it means that even relatively minor delays on inward services may prompt return services to have a late start. Secondly, as services heading to Morecambe have to reverse at Lancaster, there is an increased risk of part cancellations of inward services to allow return services to depart Lancaster on time.

C.2.11 Increased turnround times would help to mitigate this issue, and a seven-minute reduction in journey times, if fully realised, would provide a much greater buffer potentially worth around 2,500 delay minutes per annum, based on analysis of Network Rail Historic Delay Attribution Data.

C.2.12 Using guidance contained within the RDG Passenger Demand Forecasting Handbook, T1163 estimated an increase in demand, based on this reduction in delay minutes, of around 1 % per annum on the route as a whole.

C.2.13 The table below presents the benefits associated with these proposals, with and without the performance impact. This is appraised over a 30-year period with values discounted to give Present Values for the DfT Base year of 2010 (2010 PV).

C.2.14 The impacts assessed include value of time savings, revenue and marginal external costs of congestion. The latter includes the positive impact of abstraction from road to rail and covers congestion, carbon emission, air quality, road safety and the negative impact on the treasury of reduced fuel duty income.

Benefit	Without performance	With performance
Revenue	£783,262	£2,338,233
Value of Time Savings	£2,854,856	£2,869,075
Marginal External Costs	£1,024,688	£2,575,589
TOTAL	£4,662,807	£7,782,896

Table 1: Discounted benefits of Skipton – Carnforth LDPS (2010 PV £)

C.2.15 Even without changes to the service, the scheme generates a reasonable level of benefits purely from the journey time reduction, and the addition of a performance benefit adds substantially.

C.2.16 To achieve a Benefit Cost Ratio of 2.00, representing high value-for-money, the scheme could support discounted capital costs of between £2.3m and £3.89m. This type of cost suggests that an LDPS, with new signage and refurbishment of track sections, could be afforded, but substantial renewals to allow the line speed to be raised for all traffic would not represent value-for-money. T1163 therefore suggested that an SP LDPS intervention, managing the risks from track degradation by freight and diverted passenger traffic, be considered for this route.

Appendix D North Cotswold lines

Note: This appendix is provided for guidance.

D.1 Overview of route

D.1.1 Train services between Hereford or Worcester and Oxford or London have been operated by a mixture of HSTs and Class 165 stock since the 1990s, during which time the infrastructure has been upgraded and service frequency enhanced.

D.1.2 All services on the core route are now operated by Class 802 Stock, which is both higher-performing and has a lower track-force than the HST. Services between Worcester and Hereford are now operated by Class 170 units, which are soon to be replaced by Class 196 units. Both of these have a maximum speed of 100 mph (160 km/h) and fall under the SP differential classification.

D.1.3 Although the previous stock mix would have allowed either HST or SP LDPSs, there are currently none on the route. T1163 looked at the potential for introducing either MU or HST differentials to maximise the opportunities from the introduction of the new stock. This could deliver either performance improvements, helping to mitigate impacts of the single line sections, or journey time saving benefits on top of existing proposed improvements, potentially enabling additional stations to be served within the existing timetable.

D.1.4 The North Cotswold Line is a secondary mainline, which has had a varied history over the last 50 years. The line was originally double track throughout, but was substantially singled in the 1970s. At the same time, the opportunity was taken at a number of locations, principally at the east end of the route, to increase line speeds, including easing curves by slewing the remaining single line to the centre of the formation. This has allowed speeds of up to 100 mph (160 km/h) to be achieved.

D.1.5 Around 2011, sections of the route were doubled to increase capacity and support improvements in train performance. The section of route between Worcester and Hereford has lower line speeds, and is substantially single track between Great Malvern and Shelwick Jn. The existing maximum of 100 mph (160 km/h) dates from when the route was operated by locomotive-hauled trains; the Class 50 locomotives then in use would have had relatively high track forces.

D.1.6 The track components are capable of accepting speeds of up to 125 mph (200 km/h). The current line speed on the route is quite variable with significant sections having speeds of 100, 90 and 75 mph (160, 145 and 120 km/h). The lowest speeds are typically in the Worcester stations area, where speeds at and between Foregate St and Shrub Hill stations are low. The Worcester – Hereford section has a ruling speed of 70 mph (112 km/h). The choice of 70 mph (112 km/h) may perhaps reflect the maximum speed of first generation DMUs, which will have been in use on this section of line when the route was singled in 1984.

D.1.7 The signalling on the route is predominantly absolute block, with semaphore signals still in use at a number of locations, although the section from Oxford to Ascott-under-Wychwood utilises track circuit block operation.

D.1.8 The line has a significant number of level crossings, including a number of footpath crossings; this may impact on the cost of any LDPS interventions if mitigation works are required.

D.1.9 Over recent years stakeholders on the route have been developing the case for further improving train services. This has taken two forms. The first is the North Cotswold Line where a Task Force has been developing the case for improved links between Worcestershire and London, with the aims of reducing journey times and increasing service frequencies to two trains per hour. The second has been driven by Midlands Connect with the objective again of reducing journey times and increasing frequency between Hereford and Birmingham.

D.2 Application of LDPS

D.2.1 The Oxford to Worcester section was almost exclusively worked by Class 80x IET trains (Class 165 units work two trains per day each way), while Worcester – Great Malvern – Hereford is formed of a mixture of Class 170 and Class 802 units with the former to be replaced by Class 196 units. This leads to the suggestion that there may be two applications for a differential on the route, which in both cases would utilise the MU differential. The applications would be to:

a) reduce journey times for Class 802 units between Worcester & Oxford, while preventing any heavier trains that might occasionally use the route from operating at a higher speed and excessively damaging the track;
b) reduce journey times between Worcester & Hereford, and allow all MU trains to take advantage of journey time reductions.

D.2.2 The advantage of a MU differential in this context is that all trains using the route meet key criteria around braking capacity and axle loadings/track force. This situation has only recently arisen with the withdrawal of HSTs from GWR services and the removal of Class 150 units from West Midlands Trains services. The former would not meet the defined MU axle loading criteria, while the latter would not meet the braking criteria.

D.2.3 The ability to include braking criteria within the differential is important in this context, as it reduces the need for signals to be relocated.

D.2.4 T1163 undertook a review of existing speeds on the route with a view to reducing journey times. It was identified that it may be possible to reduce journey times by up to nine minutes between Oxford and Worcester based on the following changes:

a) Increase from 100 to 110 mph (160 to 175 km/h) between Wolvercote Jn and Charlbury;
b) Introduction of some 100 mph (160 km/h) sections between Shipton and Moreton-in-Marsh;
c) Selected increases in line speed towards 90 mph (145 km/h) between Aston Magna and Evesham;
d) Maximum of 110 mph (175 km/h) operation between Evesham and Worcestershire Parkway;
e) Increase from 70 to 90 mph (112 to 145 km/h) between Ledbury and Hereford.

D.2.5 Within the structure of the timetable at the time it was not possible to save any rolling stock diagrams. Therefore the main benefits would come from an increase in passenger demand through journey time reductions, improvement in performance or both. An alternative use of the time saved between Worcester and Hereford would be to provide time in the timetable to allow a new station to be developed between Great Malvern and Worcester. This is a scheme that a number of stakeholders have suggested, but it is hindered by the current timetable and single line sections between Great Malvern and Hereford.

D.2.6 Based on the assumption of a five-minute journey time reduction between Worcester and Oxford and a four-minute reduction between Worcester and Hereford the estimated discounted benefits of the proposal are presented below:

	£
Revenue	£9,630,000
Value of Time	£33,970,000
Marginal External Costs	£11,730,000
TOTAL (PVB)	£55,330,000

Table 2: Discounted Benefits associated with Cotswold Line (30-year 2010 PV £)

D.2.7 The results suggest that the scheme would generate total benefits of around £55m over 30 years. However, the value of revenue generated across all services would be only around £10m. This would suggest that, for the scheme to break even in commercial terms only, investment of £9.63m (2010 Present Value) could be supported. This scale of benefit is much more likely to be deliverable through an LDPS than with interventions requiring substantial re-signalling or track works.

Appendix E Newport to Crewe

Note: This appendix is provided for guidance.

E.1 Overview of the route

E.1.1 This route has a complex history, comprising both London North Western and Great Western Railway lines. This history still manifests itself in the split in management of the route between the Wales & Western and North West and Central Regions of Network Rail, and a function of this history is differing approaches taken to speed restrictions and infrastructure.

E.1.2 The Marches Line was primarily operated by 90 mph (145 km/h) Class 158 stock until the introduction of the 100 mph (160 km/h) Class 175 units around 20 years ago.

E.1.3 These units can take advantage of the MU differentials which were applied by British Rail's London Midland Region between Craven Arms and Crewe, where line speed is typically 65 to 75mph (105 to 120 km/h), but with MU LDPSs allowing 80 to 90 mph (130 to 145 km/h) operation. The former Western Region section of the route, between Newport and Craven Arms, has line speeds in the range of 75 to 90mph (120 to 145 km/h) with no LDPSs.

E.1.4 The Marches Line is a busy secondary mainline, utilised by a combination of passenger and heavy freight trains. The route is served by two main passenger services:

a) The Manchester – Cardiff – West Wales service, which operates at an hourly frequency and is currently formed of Class 175 units.
b) A broadly two hourly Holyhead – Chester – Shrewsbury – Cardiff service. This service is formed of a mixture of Class 158, 175 units and short locomotive-hauled trains using Class 67s.

E.2 Application of LDPS

E.2.1 T1163 looked at the opportunities for further increasing speeds through a consistent use of LDPSs, and also the possibility of increasing passenger train speeds generally on this busy freight route, which has benefitted from significant investment in track and structures since the LDPSs were introduced.

E.2.2 The combination of line speeds and track component maximum speeds suggests that, purely on the basis of the track components, the need for the LDPSs may largely have expired. On many routes this would be academic. However on the Marches Line (and accompanying Shrewsbury to Chester line) this is a factor that limits the demand for rail services.

E.2.3 As well as services operated by Class 158 and 175 units, the line is also used by a number of short locomotive-hauled trains powered by Class 67s. The limited trailing load of these services means that they are capable of achieving MU speeds between stations. The sectional running times for certain sections (Chester – Wrexham for example) are actually lower for locomotive-hauled trains than for certain MU trains.

E.2.4 The differential speeds south of Shrewsbury, in particular, restrict journey times on these routes. For example, MU trains running non-stop between Ludlow and

Shrewsbury take 23 minutes whereas locomotive-hauled services are timed for 26½ minutes.

E.2.5 The solution to this issue, which would at the margins stimulate demand, and provide a performance buffer, would be to replace the existing differential with a passenger/freight differential. This could also simplify human factors issues for train crew.

E.2.6 The costs of doing this would be very limited (the cost of replacement signage), but would simplify the operation and future-proof the route against any other types of rolling stock using the route in the future. The use of a passenger/freight differential would avoid any additional impact from freight traffic (notably Class 4 freight trains) imposing additional wear and tear at higher speeds.

Appendix F Anglian Branches

Note: This appendix is provided for guidance.

F.1 Overview of the routes

F.1.1 The regional routes radiating from Norwich to Cromer, Sheringham and Cambridge are primarily passenger routes, which have been mostly operated by SP trains (Classes 156/158/170) since the 1980s. This was when a large number of SP LDPSs were introduced to take advantage of the performance of the new stock on the relatively less robust infrastructure assets.

F.1.2 The routes have benefitted from progressive investment in signalling and track modernisation and, since 2019, introduction of a new fleet of Class 755 stock to replace the 30-year-old SPs. These units have an unusual Bo-2-2-2-2-Bo wheel arrangement, and power is provided by a short wheelbase four-wheeled diesel power car in the centre of the consist.

F.1.3 This consist has a relatively high axle-loading such that, whilst it does conform to the MU LDPS designation, it does not conform to the SP LDPS designation.

F.1.4 T1163 looked in detail at the Norwich – Cromer – Sheringham route as an example of a typical Anglian route with Sprinter differentials in place, though many of the comments could apply to similar routes in the area. Commentary was extended to the application of Class 755 units to Norwich – Cambridge services where certain features of operation are more pronounced.

F.1.5 The Norwich – Sheringham route is a double track railway between Norwich and Hoveton & Wroxham station, and is single track thereafter with a passing loop at North Walsham. At Cromer services reverse to access the single line to Sheringham.

F.1.6 The signalling on the route is controlled from Trowse Swing Bridge box, and utilises Track Circuit Block with axle counters in place.

F.1.7 The majority of train services on the route call at all stations, with an hourly service frequency in place. Significant sections of the route have LDPSs in place; the scale of which varies significantly.

F.2 Application of LDPS

F.2.1 The LDPSs on the route varied from 45/SP55 to 35/SP55 and 45/SP75.

F.2.2 The maximum permitted speed of track components suggested that, since the LDPSs were introduced, there have been substantial renewals including the introduction of CWR, although there are a number of locations where older track remains in place.

F.2.3 This suggested that the need for LDPSs on the route (on the grounds of track condition) is being eroded. This is to some extent backed up by the used life of the rail and sleepers. With a few notable exceptions, the majority of the track has a substantial life left in it. It is clear that there are short sections which are theoretically life-expired, but it might be expected that these would be renewed in coming years.

F.2.4 This review of the asset condition suggested that it may be possible to remove the existing LDPS or alternatively amend them to something less restrictive. As a SP (rather than HST) differential was in use, it was assumed that restrictions on the route related historically to track condition rather than signal or level crossing sighting.

F.3 New rolling stock

F.3.1 Since 2019 Class 755 units have been introduced to routes across East Anglia, replacing Class 156 and 170 units. Based on analysis undertaken in T1163, Class 755 units do not meet the criteria to be classified as SP LDPS trains. This is due to a combination of the four-wheeled 'power car' in the centre of the train, where the diesel engines are located, and the unusual wheel arrangement where vehicles are articulated. Whilst lowering the total mass of the train, this increases the axle loadings.

F.3.2 Since December 2019 services across East Anglia have been retimed around Class 755 timing loads. When T1163 was developing this case study it was initially assumed that the Class 755 would not be able to use its full potential. While, over short distances, it would be able to accelerate better than Class 156 or Class 170 units, it would not be able to maintain higher speeds over long distances if it was unable to take advantage of the SP LDPSs. Ultimately the removal of a differential or the use of a less restrictive differential, would allow higher speeds.

F.3.3 In practice, it was discovered that the issue had already been resolved.

F.3.4 A review of both the working timetable and Network Rail BPLAN data (which provides timing data for all types of train across the GB rail network), showed that the Sectional Running Times (SRTs) for Class 755s were the same as those previously in use for Sprinter units. SRTs are relatively crude as they require point-to-point journey time to be rounded to the nearest half minute and it is assumed these are rounded up relative to actual journey times. Over short distances between station calls, therefore, it is plausible that a Class 755 would be able to achieve the same timing as SP units. This is due to improved acceleration and only a limited part of a particular journey requiring the differential for the SP to achieve the SRT.

F.3.5 While the above provided a satisfactory case for the use of SP SRTs with Class 755 units over shorter distances it did not provide a rationale for their application over longer distances. A good example of this was found on the Ely to Norwich route, where the Sectional Appendix showed a substantial number of long LDPSs. Between Ely North Junction and Lakenheath station the following speed restrictions apply:

a) Ely North Junction (71 Miles 72 Chains) to 72 Miles 2 Chains: 50 mph (80 km/h);
b) 72 Miles 2 Chains to 81 Miles 56 Chains: 45 mph/75 mph Sprinter (72 / 120 km/h);
c) 81 Miles 56 Chains to Lakenheath Station (82 Miles 39 Chains): 75 mph (120 km/h).

F.3.6 For the majority of the 10 miles between Ely North Junction and Lakenheath the speed that could be achieved by Class 755 units is only 45 mph (72 km/h) relative to 75 mph (120 km/h) achieved by SP trains.

F.3.7 Most of the trains on the route run non-stop between Ely North Jn and Lakenheath and Class 158s operated by East Midlands Railway on Liverpool to Norwich services have total journey times for this section of nine minutes. Class 755 units operating Stansted Airport to Norwich services also have an SRT of nine minutes.

F.4 Solution adopted

F.4.1 The Sectional Appendix updated to August 2020 showed the SP LDPS differential as still being in place, but it was then clarified that Class 755 trains had been allocated an MU designation and the LDPSs had been re-designated, through the Network Change process, from SP LDPS to MU LDPS to allow the new trains to maintain the benefits of the differential speeds.

F.4.2 This is therefore a good example of how this process can be used to create, or maintain, benefits from this initiative previously applied in very different circumstances in the 1980s.

Definitions

axle load	The total vertical load exerted by both wheels on an axle on to the track caused by the weight of the vehicle, including the self-weight of the wheels and the axle.
cant deficiency	The difference between actual cant and the theoretical cant that would have to be applied to maintain the resultant of the weight of the vehicle and the effect of centrifugal force, at a nominated speed, such that it is perpendicular to the plane of the rails.
cant	Expressed as the design difference in level, measured in millimetres, between rail head centres (generally taken to be 1500 mm) of a curved track.
differential speed	A value of permissible speed or speed restriction that is only applicable to certain trains. Differential speeds include: a) Standard differential speed – Two values of permissible speed, or two different speed values for a temporary speed restriction, each of which is applicable to one of two standard categories of trains, as defined in the Rule Book. b) Non-standard differential speed – A permissible speed for a specific type of train, which is different from that for other types of trains on the same section of line. This comprises 'Permissible speed indicators with letters' and 'Enhanced permissible speed indicators' as described in the Rule Book. Non-standard differential speeds are not applicable to temporary or emergency speed restrictions.
DMU	Diesel Multiple Unit.
EMGTPA	Equivalent Million Gross Tonnes Per Annum (EMGTPA) is a measure of the annual tonnage carried by a section of track, taking into account variations in track damage caused by normal traffic types. EMGTPA is a key component in the calculation of track category.
EMU	Electric multiple unit.
enhanced permissible speed (EPS)	The speed permitted over a section of line that applies to a specific type of train operating at cant deficiencies in excess of those permitted at the permissible speed. There may be more than one enhanced permissible speed applicable to a given section of line.
infrastructure manager (IM)	Has the meaning given to it in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended), but is limited to those infrastructure managers who hold a safety authorisation issued in respect of the mainline railway. Source: *ROGS*

infrastructure	All the network subsystems including: infrastructure, energy and track-side CCS, as defined in RIR.
Lettered Differential Permissible Speed (LDPS)	Non-standard differential speed identified by letters as described in the Rule Book, and applying only to the classes of trains and multiple units identified by those letters as shown in the Sectional Appendix.
maximum design service cant deficiency	The maximum cant deficiency at which a train is designed to travel.
MOIRA	Demand forecasting tool capable of modelling the impact of timetable changes
permissible speed	The authorised maximum speed over a section of line, either for all trains or (where differential or enhanced permissible speeds are applied) for specific types of trains, as set out in the Sectional Appendix.
railway undertaking (RU)	Has the meaning given to the term 'transport undertaking' in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 as amended, but is limited to any private or public undertaking the principal business of which is to provide rail transport services for goods and/or passengers, with a requirement that the undertaking must ensure traction. Source*: ROGS*
Route Availability (RA)	The assessed capacity of the underline bridges on a route to carry the vertical static and dynamic loads of rail vehicles or the static load characteristic of a rail vehicle type expressed as a route availability (RA) number as set out in GERT8006.
Sprinter	Multiple unit which meets the requirements set out in RIS-2711-RST, and which can be permitted to operate to lettered differential speeds signed 'SP'.
tilting train	A train having a system which tilts the train body to reduce the lateral acceleration experienced by passengers when operating around curves, allowing the train to run at higher speeds through curves than non-tilting trains.

References

The Standards Catalogue gives the current issue number and status of documents published by RSSB. This information is available from http://www.rssb.co.uk/railway-group-standards.co.uk.

RGSC 01	Railway Group Standards Code
RGSC 02	Standards Manual

Documents referenced in the text

Railway Group Standards

GKRT0007	Alterations to permissible speeds
GKRT0075	Requirements for Minimum Signalling Braking and Deceleration Distances
GMTT0088	Permissible Track Forces for Railway Vehicles
GMRT2045	Compatibility Requirements for Braking Systems of Rail Vehicles
GMRT2141	Permissible Track Forces and Resistance to Derailment and Roll-Over of Railway Vehicles
GCRT5021	Track System Requirements
GERT8000-SP	Rule Book Module SP - Speeds
GERT8006	Route Availability Number for Assessment of Compatibility between Rail Vehicles and Underline Bridges
GERC8517	Recommendations for Systems for the Supervision of Enhanced Permissible Speeds and Tilt Enable

RSSB Documents

RIS-0713-CCS	Lineside Signalling Layout Driveability Assessment Requirements
RIS-0734-CCS	Signing of Permissible Speeds
RIS-2711-RST	Rail Vehicle Lettered Differential Speeds Classification
RIS-7016-INS	Interface between Station Platforms, Track, Trains and Buffer Stops
RIS-7704-INS	Calculation of Enhanced Permissible Speeds for Tilting Trains
RIS-8270-RST	Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure
RIS-8706-INS	Route Level Assessment of Technical Compatibility between Rail Vehicles and Underline Bridges
T248 RSSB (2003)	Review of train slipstream effects on platforms
T996 RSSB (2014)	Categorising the relationship between track condition, line speed and vehicle forces

T1163 RSSB (2020)	Criteria for assigning differential speed categories

Other Documents

COF-IPS 02	Loughborough University, Decarbonising High-Speed Bi-Mode Railway Vehicles through Optimal Power Control
EN 14067-4:2013+A1:2018	Railway applications — Aerodynamics — Part 4: Requirements and test procedures for aerodynamics on open track
LTDP	Digital Railway Long Term Deployment Plan as published by Network Rail
NR/L2/SIG/30021 Issue 2	Alterations to authorised line speeds (Network Rail)
NR/L2/TRK/2102 Issue 8	Design and Construction of Track (Network Rail)
NR/L2/TRK001/MOD2 Issue 7	Inspection & Maintenance of Permanent Way: Track Inspection (Network Rail)
Sectional Appendix	Sectional Appendix as published by Network Rail