Background

Railway Group Standard (RGS) GK/RT0075 Lineside Signal Spacing and Speed Signage contains a number of braking tables including Appendix A (applicable to all trains) and Appendix X (deceleration distances for speed restrictions) that are based on historic freight and passenger fleets. It was thought that many of the freight trains currently running on the national network consist of vehicles that can brake in significantly shorter distances than those shown within these appendices. Network Rail and the railway undertakings asked for a review and revision of the values in the braking tables. Using more up-to-date values could allow a safe increase in the capacity of the network.

On behalf of the Control, Command and Signalling (CCS) Standards Committee, the findings of the research are that in general the RGS remains valid as written. However, the data for freight trains operating on passenger brake timings, shows that the train consists examined could run with adequate braking performance if train speed was 10mph less than the signalled speed. A single 'line-speed minus 10' option could prove to be acceptable following appropriate analysis and risk assessment. Consideration could also be given to defining a lower speed below which the freight train could be permitted to run at the passenger line-speed.

Aims

The aims of this research were:

1. A review of the braking tables and braking performance safety margins - Following a review of the braking performance of individual freight wagons and representative freight locomotives and consists, a review of RGS GK/RT0075 Appendix A - Signalling Braking Distance Data for All Trains and Appendix X - Deceleration Distances (to speed restrictions of 10mph to 100mph) to understand the safety margin between the limits of braking performance allowed for by the tables and the braking performance of the individual wagons, locomotives and consists studied.
2 A review of signalling braking distances for passenger and freight trains - Further to the above, a review of Appendix B - Signalling Braking Distances for Passenger Trains, and Appendix C - Signalling Braking Distances for Trains with Enhanced Braking (9%g mean), to understand the relative braking performance of the freight locomotives and consits studied and to compare these to the minimum permissible braking performance for passenger trains as defined by the tables.

3 A review of the current range of differential speeds to identify whether the full range, incremented by 10mph between 10mph and 100mph could be reduced in number, leading to the possible simplification of signage for permissible speeds and speed restrictions.

4 The possible development of a strategy to replace the 'two thirds' rule, in use on the former Southern Region of Network Rail. Network Rail document NR/L2/SIG/30009 - D225 already provides this, but it is thought that the emerging findings of the research could provide a more informed solution.

5 A review of the procedures for implementing temporary and emergency speed restrictions (ESR), possibly leading to a simplification of the rules surrounding these and mindful that ESRs have to be imposed at short notice.

Findings

The findings of the research are:

Task 1 - Obtain and analyse Rolling Stock Library vehicle data

The Rolling Stock Library data for braking of freight wagons is comprehensive, including some 33,000 vehicles of 1,400 different types, but contains a number of anomalies and errors. (About 85% of the data was considered reliable, some 15% was discounted.)

Analysis of the variability in braking distances of the GB fleet, even using a censored set of the database, gives performances that are outside the currently accepted performance limits for the braking distances from the various speeds that are defined within the RGS. This prevents any generic relaxation in the basic stopping distance standards.

The research found that there has been a very small improvement in braking performance over the last 60 years. However the
general variability in performance, even across the modern members of the fleet, totally masks this trend; so it is clear that a generic benefit cannot be achieved by creating new stopping distance curves within the RGS, based on wagon age.

Figure 1 - Scatterplot and trending: full data

Task 2 - Select modern vehicles and obtain data

This task compared 3 methods of calculation of braking distance for a small sample of representative types of locomotives and modern freight wagons.

These calculations were checked against slip-test data\(^1\).

Even with a limited set of ten wagon types it is difficult to obtain definitive data to allow a differential calculation of braking performance, with only 30% having sufficient data to determine the braking performance by all three methods. The research found that there is a significant variation in data across data sources. Nevertheless, when the data sets were collated and normalised it was possible to obtain parameters that could be used in braking performance calculations.

\(^1\) This involves the physical uncoupling of a test vehicle from a moving train and measuring its emergency braking performance.
The analysis showed that most of the wagons studied had an 'inception speed dependent' braking characteristic. This is considered to be linked to a variable braking effort profile over the deceleration interval.

**Task 3 and 4 - Calculate detailed braking curves and compare with Rolling Stock Library data**

When plotted against the measured data, most calculations based on the Rolling Stock Library showed reasonable agreement with the normalised slip-test results. This implies that the Rolling Stock Library data can be relied upon to give a good prediction of the stopping distance\(^1\) in approximately 60% of the cases. However the actual figure may be better than this as the exact sub-type (or variant) of vehicle tested was not defined within the data and with some vehicle sub-types having up to 10 variants, it is possible that an exact match between the vehicle shown and the sub type tested could not be confirmed.

**Task 5 - Margin assessment**

Collating all the slip test data gives the results for tare and fully laden tests respectively. The stopping distance (assuming uniform deceleration) would be expected to vary by approximately plus or minus 24% (>99% confidence) for both the tare and laden conditions, as measurement has shown that braking performance can vary significantly between vehicles of the same type. Through combining the probabilities of over and under performance for individual wagons, this level of uncertainty drops to about 4% for a consist with 40 wagons of the same type.

**Task 6 - Computation of signalling braking distances**

Twenty-six sample consists of freight trains were identified. These were taken by observing the published operating consists of current freight train paths and by filtering these to contain wagons of more recent design.

It was found that only 1 consist could satisfactorily perform to the speeds of the 'passenger' (Appendix B) curve, but that approximately half of the consists could satisfactorily perform if operated at 5mph below the 'passenger' speed and that all the consists could perform satisfactorily if operated at 10mph below

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\(^1\) To approximately ± 5% level of confidence.
the ‘passenger’ speed. (This was found to apply at all speeds up to the maximum permissible freight speed of 75mph.)

Figure 2 - Example of comparison with passenger and all vehicles curves

The research found that for these (example) consists, modern vehicle designs have better braking performance than RGS GK/RT0075 Appendix A and almost achieve Appendix B in emergency braking. These stopping distances were calculated using emergency brake timings, as is normal practice.

Task 7 - Provision of guidance

Opportunities were considered for:

- Reduced signal spacing
- Assigning freight trains to higher speed categories
- Creating a new speed category
- Procedural solutions

These were considered in the context of possible amendment to RGS GK/RT0075 - Lineside Signal Spacing and Speed Signage and Rail Industry Guidance Note (RIGN) GK/GN0675 - Guidance on Lineside Signal Spacing and Speed Signage.
In general, it was found that the braking distance values defined within the RGS and RIGN remain valid and should not be changed as a result of this research.

Task 8 - Impact assessment

The impact of this research was considered in the context of:

- Train Classification - as defined in Rule Book Module TW1, Clause 6
- Timetabling
- Defensive driving
- European Train Control System (ETCS)

The findings of the research have been supportive of each of these areas and no changes are recommended as a result of these.

Task 9 - Recommendations

The research report gives recommendations on how potential benefits could be implemented; such as for fixed formation trains, through line or route running, for each of the vehicles and consists identified in Task 2.

The optimum approach recommended is to progress the 10mph offset for applicable consists on a procedural basis. The data analysis for freight trains operating on passenger brake timings, shows that the train consists examined could run with adequate braking performance at 10mph less than the signalled speed. A single 'line-speed minus 10' option may well prove to be acceptable but will need appropriate analysis and risk assessment. Consideration should also be given to defining a lower speed below which the freight train could be permitted to run at the passenger line-speed.

However, although the research has shown that some trains with defined consists could brake to Appendix B +10% + contingencies, most of the railway is signalled to Appendix A, so any easement could only apply in the form of differential (higher) speeds for trains with certain defined consists.

For a railway undertaking or transport operator to use this option it would need to apply its company change management process to identify the risk as acceptable. This would require:

- For vehicles in the study, the use of TRUST data (this may not be possible) or through carrying out confirmatory testing.
For vehicles not in the study, the same process of base data gathering, calculation, and testing:

This requirement is thought to be onerous and may prove to be a significant obstacle to taking this approach forward.

Other potential barriers to change could include the need to modify the settings for the Train Protection Warning System (TPWS), changes to Permanent Speed Restrictions (PSRs) and signage.

Other enabling tasks would include:

RSSB:
- Including this option in the Rule Book

Train operators:
- Modifying their driver competence management systems to include this option.
- Modifying their train preparation process to identify trains where this option would be applicable, including taking account of crippled vehicles.
- Analysis and risk assessment of the additional driver and train preparer tasks.

**Deliverables**

These deliverables have been provided through this research:
- A summary report - providing a findings summary for Tasks 1-9.
- Braking Model Spreadsheet and user guide - available to RSSB members on request. This provides an opportunity for a freight operator to 'build' and to predict the braking performance of a large number of consist combinations.

The summary report, with its supporting technical documents, is available to all registered readers on www.SPARKrail.org

Representatives of freight operators have supported the research throughout and are aware of the research findings.

**Method**

This research analysed the braking performance of freight vehicles currently authorised to operate on Network Rail lines. It used:
- The Rolling Stock Library calculations embodied in GE/RT2040 Calculation of Brake Force Data for Rolling Stock Library.
- Calculations based on manufacturer design data.
Calculations based on EN14531- Railway applications. *Methods for calculation of stopping and slowing distances and immobilization braking; step by step calculations for train sets or single vehicles*, which include allowance for natural deceleration phenomena (such as rolling resistance and aerodynamic effects), and inertial mass of the rotating components.

These calculations were checked against comparable slip-test data. Analysis of the data showed that the variability of the test conditions had a significant influence on the results.

The research also included an option to undertake practical trials at the Network Rail national testing facility.

Consultation and co-operation with stakeholders (train, freight and rolling stock operating companies, plant operators, and Network Rail) has helped to ensure a successful outcome.

The research was delivered as tasks 1-9 outlined above, with the aim of providing guidance on the application of signal braking distance data, speed restriction braking data, lineside signage, and braking characteristics on European Train Control System signalled lines.

During the early stages of the research, it was noted that the review of differential speeds, two-thirds rule, and review of the procedures for implementing temporary and emergency speed restrictions were dependent on the outcome of the review of the RGS braking tables. To date, the review of the braking tables has been completed and, from an examination of the analyses performed, some discussion of the implications and opportunities for the remaining areas has been possible. However, in view of the general conclusion that amendment to the RGS is not recommended, the opportunity for further work in these areas appears to be more limited than was originally thought.

Next Steps

The findings of this research were presented to the members of the CCS Standards Committee during July and September 2014. The committee recognised the value of the research, and endorsed the research findings.

The committee supported the view that the proposed procedural change(s) could offer significant commercial benefit to the industry by helping to determine the optimum distances for trains to decelerate, improved headways and providing an opportunity to increase speeds for applicable freight categories. This would
include the need to further validate the spreadsheet model (which has so far been developed on a wholly mathematical basis) by carrying out practical trials, adding Class 66 data when this becomes available and a consideration of further wagon types.

The committee has agreed to support the discussions on implementation of the research findings and proposed procedural changes, subject to further interest and support from the rail industry.

Contact

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1 As the Class 66 braking data could not be made available during the period that the RSSB Project T999 has been carried out (requiring an approximation to be developed by the supplier), CCS Standards Committee has advised that the actual Class 66 data will need to be included in the analysis before any changes are introduced onto the railway network.