RAIL SAFETY AND STANDARDS BOARD

Report

Assessing the benefits of enhanced freight speed differentials on the GB network

T1348

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Executive summary

Due to their heavier weight and different braking systems, freight trains require a longer stopping distance than passenger trains travelling at the same speed. But often when signalling systems are installed, the distance between the signals is linked to the required stopping distance of a passenger train. That means freight trains have to travel at a lower speed to be able to stop in the same distance. This reduction in speed is known as the 'freight differential speed'.

This project developed an improved model for calculating the braking distance of freight trains, that takes into account of number and type of wagons, load, and locomotive type. This was used to investigate the potential to reduce these differentials by comparing the signal spacing with the recalculated freight train braking distance in a selection of case study routes. For sections where the signal spacing would support a reduced freight differential, the project then considered any other constraints, such as speed limits due to infrastructure (curving track or level crossings), to see whether improved freight speeds could be achieved.

Signal spacing varies along a route as train stopping distance varies along the route, depending on the gradient of the track. Seven case studies were considered in detail to better understand how practical freight speed limits (as determined by signal spacing and stopping distance) could vary along a given route. This also enabled the quantification of benefits that could be delivered by increasing freight speeds.

As well as considering route-specific opportunities to improve freight speeds, this project drew conclusions about the general relationship between signalling design speeds and permissible freight speeds. These findings are particularly applicable to the Southern Region, where the relationship between permissible freight speed and signalling design speed has been historically determined by the conservative Two Thirds Rule.

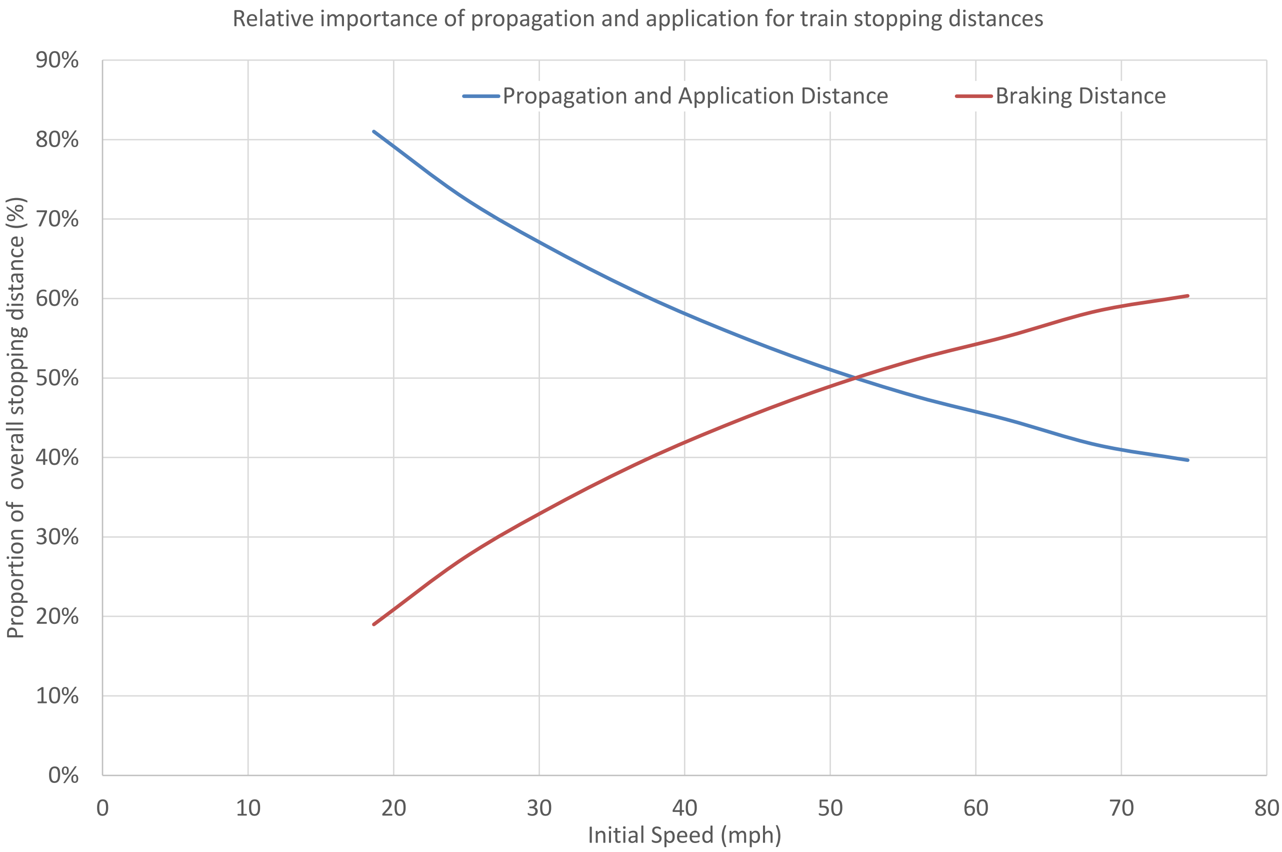
Braking

The first section of the report takes a 'first principles' approach to calculating freight train braking distances for different combinations of representative loads, wagons and locomotive type. It also considers whether the trains are travelling in 'Goods (<G>)' or 'Passenger (<P>)' brake timings. These 'timings' relate to the speed of brake application, with the application of the brakes being over three times faster in <P> setting than in <G>.

This is an important point. When driving our cars the brakes act immediately. But in a long freight train it can take a minute from when the driver applies the brakes for the brakes on the last wagon to be activated. This gives an average brake application time of 30 seconds along the train. So if the train is travelling at 60 mph (one mile per minute), the train will travel half a mile (805 m) before all of the wagon brakes are activated. The train's braking distance is therefore 800 m plus the distance for the brakes to stop the train.

The chart below (Figure 1) shows the relative significance of brake application time for the longest freight trains. Above 50 mph, over half the distance taken to stop the train is related to the time taken for the whole train's brakes to be fully applied (even in <P> timings).

Figure 1 Comparison of braking distance and stopping distance

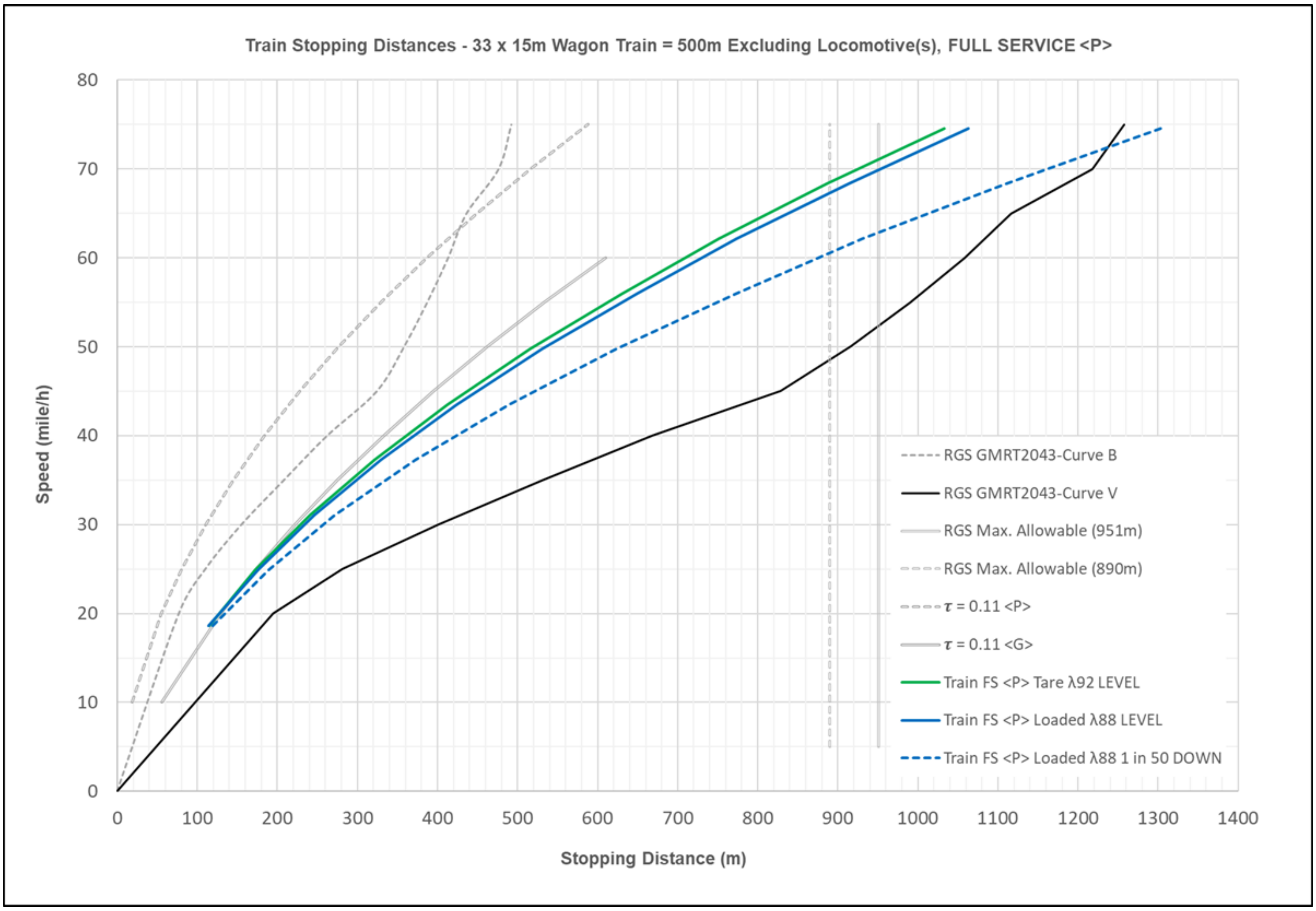


A sophisticated Excel-based model was developed to calculate the required braking distance for a train against a number of different parameters. These included train length, loaded and unloaded status, speed, and the widely-used adjustment factors for train length and mass (known as *kappa* and *lambda*).

The model was developed in accordance with *Railway Group Standard GMRT2045, Issue 4, March 2016, Compatibility Requirements for Braking Systems of Rail Vehicles* and *Railway Group Standard GKRT0075, Issue 5, December 2018, Requirements for Minimum Signalling Braking and Deceleration Distances.*

Figure 2 shows a typical simplified output of the model for an extremely heavy aggregate train.

Figure 2 Output of brake model



The green and blue solid lines represent the modelled required braking distances for the train when loaded and in tare (unloaded, only wagon self-weight to be braked). These lines are very close together indicating that the braking distance of a wagon is relatively insensitive to variations in load.

The dashed blue line shows the required braking distance on an extreme 1:50 downwards hill. At 60 mph, the loaded braking distance increases from 740 m to 880 m, an increase of just under 20%, but still well within the allowable threshold within the standard.

The grey and black lines represent the thresholds laid out in the various standards. If the calculated curve (shown in dashed blue) is to the left of these, the wagon could be ‘over braked’. This could lead to wheel slip when there is insufficient adhesion on the rail head to enable the train to fully brake. If the curve is to the right the train could be ‘under braked’ and stopping distance may exceed the maximum permitted leading to signals passed at danger and possible collisions or derailments.

This analysis enabled several input tables to be developed and incorporated into the new braking model. This was then applied to specific track geometry and signal spacing to confirm the maximum freight speed at that specific location.

Signal spacing and speed comparison

The location and type of signal was obtained from Network Rail's records and combined on to a geographic model of the network—the first time this has been done in a significant way. The model also had passenger and freight line speeds added and from this a comparison of the existing speed differentials could be displayed visually.

The size of the differential was used to colour code a map, with grey being no differential and colours from pale yellow (5 mph differential) though orange to red (the maximum 60 mph being dark red). This made it possible to visually compare different parts of the network. Also, to identify the routes where the greatest benefit could be realised by removing or reducing freight speed differentials (the speed differentials are both large and affect a long distance).

The area to the south and east of London, shown in Figure 3 , was found to have multiple key freight routes with lengthy speed differentials.

Figure 3 Freight differentials in-and-around London

Case study selection

Using this information, a list of ten sites was drawn up based on the potential for improvement and their importance to the freight industry. Following a review of the key infrastructure constraints (both physical, such as track curvature, and intangibles such as network capacity), this was reduced to four case study sites. They were:

- Barking to Stanford Le-Hope
- Ashford to Swanley
- Charlton to Lewisham via Sidcup and Slade Green (North Kent)
- Tonbridge to Dartford.

For each case study, the SRTcalc model—developed for Rail Safety and Standards Board (RSSB) projects T1302 and T1301—was used to calculate running times for defined trains using existing and proposed enhanced freight linespeeds. The revised timings were then compared with the current timetable to assess the potential for retiming or using different paths.

Case study evaluation

Table 1 below gives a summary of the results of the timing analysis for the case studies.

Table 1 Summary of findings for the first four case studies

Location	Timing considerations	Journey time improvement	Pathing considerations
Barking – Stanford Le-Hope	30 mph and 45 mph speed restrictions at Purfleet and Tilbury caused by tight radius track. These are difficult/very expensive to mitigate. Currently high freight speed against the line speed (50 mph against 60 mph) so limited opportunity for improvement.	Nothing significant.	No repathing undertaken.
Ashford - Swanley	Current freight speed is generally 50 mph and the passenger speed is generally 75 mph. There are four significant speed restrictions (1 x 45 mph, 2 x 30 mph and 1 x 25 mph) linked to either track curvature or track geometry at junctions on the 74 km route.	For a Clas 66: 6 min., eastbound (10%), 5 min westbound. Including mitigation of 1 min. of existing 'insufficient' timing.	9 minute reduction (14%) in eastbound journey time for path 6O27 (Class 66). 11 minute reduction (17%) in eastbound journey time for path 6O27 (Class 66). Train can depart 11 minutes later and arrive at the same time.
Angerstein – Lewisham via Crayford	From Angerstein/Charlton to Dartford the first 8.5 km of the journey is mainly 35/30 or 20 mph running due to track curvature. Beyond Woolwich there is opportunity to raise the freight speed from 40 to 50 mph over the next 10 km. From Dartford to Hither Green there is opportunity to raise the freight speed from 35/40 mph to 50 mph over 13 km.	For a Clas 66: 1.5 min. from Angerstein (<1%), and 5 mins to Angerstein, including mitigation of 1 min. of existing 'insufficient' timing.	No improvement from Angerstein although trailing weights could be increased from the current 2000 t to 2600 t within the sane timing run. Running to Angerstein the train could run 7 minutes faster.
Tonbridge to Crayford	In 8 locations on the 72 km route there are curvature and pointwork related speed restrictions of between 30 mph to 15 mph. In between the freight speed is 45 mph, against a passenger speed of 60 mph.	For a Clas 66: 5 min. from Tonbridge (<1%), and 1.5 mins to Tonbridge, including mitigation of 1.5 min. of existing 'insufficient' timing.	No significant improvement possible. Between Crayford and Stroud where is a dense passenger service and alignment of windows between Paddock Wood and Stroud, and Gravesend and Dartford.

Effect on freight train differential speeds

Table 2 below provides a guide to the reduced differentials which can be expected.

Table 2 Potential maximum freight speeds, differentials and improvements vs current speeds for Class 4 <P>, Class 6 <P> and Class 6 <G> for the maximum permissible speeds in Table A.

Current permissible speed (mph) From Sectional Appendix Table A		Recommended maximum speed (mph)			Recommended speed differential (mph)			Improvement vs either current max permitted speed or max train speed (mph)		
Maximum permissible speed ('signalling design speed')	For Class 6, 7 and 8 freight trains (Two Thirds Rule)	Class 4	Class 6 <P>	Class 6 <G>	Class 4	Class 6 <P>	Class 6 <G>	Class 4	Class 6 <P>	Class 6 <G>
90	60	75	60	60	0*	0*	0*	0	0	0
85	55	75	60	60	0*	0*	0*	0	+5	+5
80	50	70	60	60	-5	0*	0*	-5	+10	+10
75	50	65	60	60	-10	0*	0*	-10	+10	+10
70	45	60	60	60	-10	0*	0*	-10	+15	+15
60	40	55	55	50	-5	-5	-10	-5	+15	+10
55	35	50	50	50	-5	-5	-5	-5	+15	+15
50	30	50	50	50	0	0	0	0	+20	+20
45	30	45	45	45	0	0	0	0	+15	+15
40	**25**	40	40	40	0	0	0	0	+15	+15
35	**20**	35	35	35	0	0	0	0	+15	+15
30	30	30	30	30	0	0	0	0	0	0

*0: Speed limited by Class 4 or Class 6 maximum train speeds rather than stopping performance

The first two columns show the 'two-thirds' relationship of the maximum freight speed to the maximum permissible signalling design speed. Note, this is sometimes greater than the selected maximum passenger train speed for some section of routes. The third column shows that, in reality, this is often rounded slightly down to provide only 5 mph increments in speed definition. The centre columns show the maximum practical freight train speeds for Class 4 (75 mph) trains and Class 6 trains (60 mph), in both passenger and goods timings.

The longer Class 4 freight trains now being considered require a longer braking distance, so the Class 4 timings become slightly longer. However, the Class 6 timings are generally significantly better. Better understanding of the actual propagation speed of the pressure reduction along the brake pipe or the use of End of Train devices (EOTDs) would mitigate the disbenefits for longer Class 4 trains.

A single freight speed is needed for lineside speed signage. For most maximum permissible speeds, the maximum freight speeds for each of the three cases Class 4 <P>, Class 6 <P> and Class 6 <G> are either identical to the maximum linespeed or limited by the maximum train speeds (for example Class 6 to 60 mph). That is, it is effectively the Class 4 speed. However, for 60 mph maximum permissible, speed the situation is more complicated. The recommended max speed for Class 6 <G> is lower than for Class 4 or Class 6 <P> due to the slower propagation of the brake command, and slower application of the brakes in <G> brake setting. This results in longer stopping distances as shown in Table 3 (this limitation is highlighted in yellow in the table).

Table 3 Potential maximum freight speeds, differentials and improvements vs current speeds for the maximum permissible speeds in Table A.

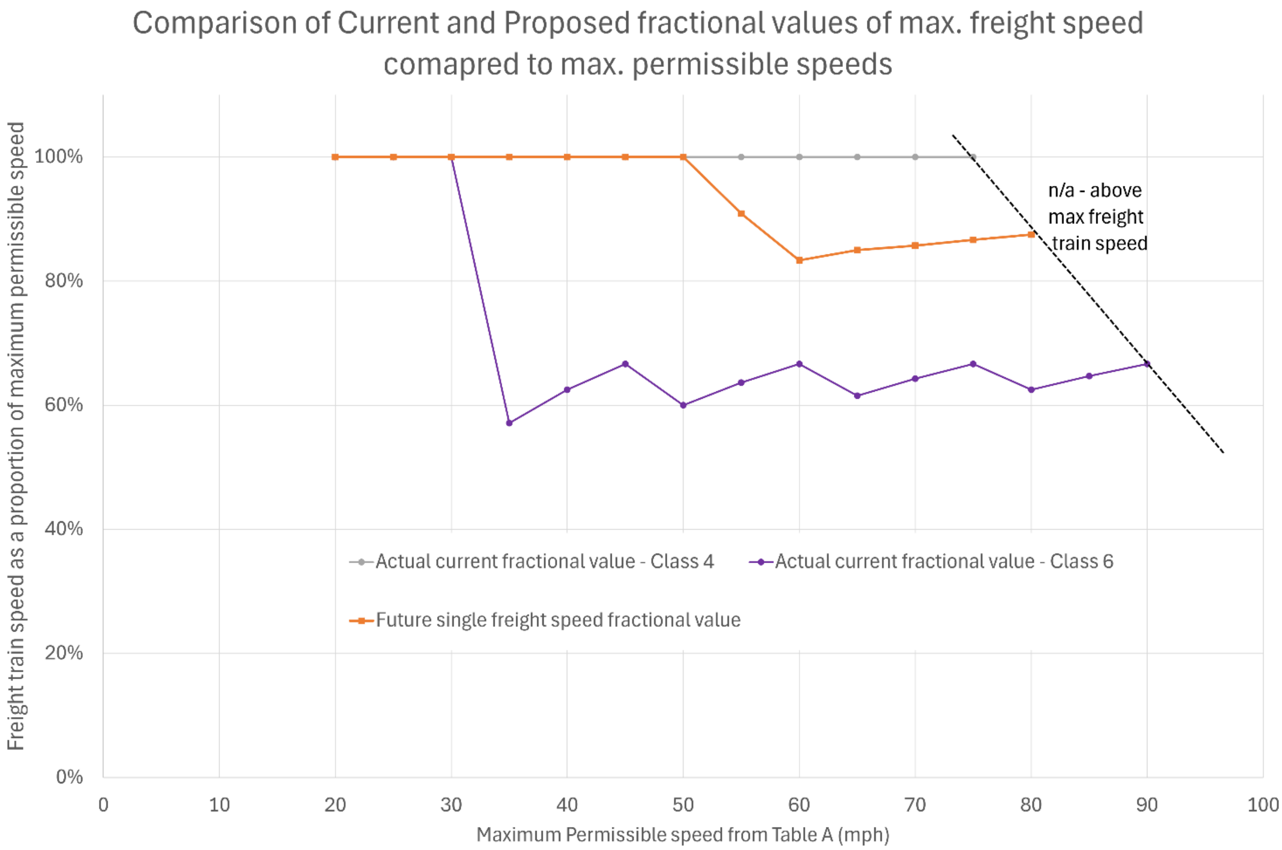
Current maximum permissible speed (mph)		Potential realistic speed differential (mph)			Improvement vs either current max permitted speed or max train speed (mph)	
From Sectional Appendix Table A 'signalling design speed'	For Class 6, 7 and 8 freight trains (excluding MPVs, OTMs & parcels)	Potential practical single freight speed to be used on signage	Class 4 differential	Class 6 differential (mph)	Class 4 improvement over existing	Class 6 improvement over existing
90	60	75	0*	0*	0	0
85	55	75	0*	0*	0	+5
80	50	70	-5	0*	-5	+10
75	50	65	-10	0*	-10	+10
70	45	60	-10	0*	-10	+15
60	40	50	-10	-10	-10	+10
55	35	50	-5	-5	-5	+15
50	30	50	0	0	0	+20
45	30	45	0	0	0	+15
40	**25**	40	0	0	0	+15
35	**20**	35	0	0	0	+15
30	30	30	0	0	0	0

In summary, the historical Southern Region Two Thirds Rule can now be replaced with the following:

- At 50 mph or below the restriction can be completely lifted.
- Above 50 mph the restriction can be broadly lifted to 85% of the line speed, rather than the previous 67%.
- The longest Class 4 intermodal trains with Class 66 traction should have their top speed reduced from 75 mph to 65 mph when the line speed is 75 mph (5 mph at 80 mph, zero for line speeds above this).

These changes are shown visually in Figure 4 .

Figure 4 Recommended and existing differentials as a percentage of maximum speeds



Timing benefits on three key routes

The modelled timings were compared to timetable white space on the passenger network to see what opportunity there was for accelerating freight speeds. Three routes were considered:

- Reading – Basingstoke
- Mitre Bridge to Lewisham, consolidating previous routes, and
- Brighton mainline (BML).

In the first two routes, there was no opportunity for increased capacity due to:

- limited headway between passenger trains
- misalignment of timetable whitespace between co-joining 'networks', for example transfer from the South London Line to the West London Line
- some existing SRTs not adequately allowing sufficient time, for example when accelerating away from PSRs (reduces the timing benefits within the reworked timings).

On the BML, the opportunity for one additional hourly path running from East Croydon to Clapham Junction via Streatham Hill was identified.

On all routes faster freight train running in places was possible which will enable more resilient performance in the future. Also, in most circumstances, it is possible to run heavier trains within the present Sectional Running Times.

Workshops and implementation

Two stakeholder workshops were held to discuss the timing work with extensive representation from Network Rail (NR), train operating companies (TOCs) and freight operating companies (FOCs).

Implementation of the changes was discussed at the workshops and the consensus was that a project had to be established within NR to enable this. The proposal to increase line speed would need to be walked around all the relevant NR internal stakeholders, such as track and structures as well as Control, Command and Signalling (CCS)..

It was observed that:

- there was no clear process for implementing line speed changes outside of a signalling upgrade project
- any change needed a sponsor and project manager, who haven't been identified
- a budget would be needed for the project costs and making any lineside signage changes.

Consensus at the workshops was that this should be done by Network Rail and that the Network Change process could provide a vehicle for this change.

Conclusions

1. In all of the case studies there was opportunity to raise the freight train operating speed.
2. Leading on from the conclusion above, freight train braking, while complex, is not necessarily the primary constraint on freight train maximum operating speeds. There is therefore considerable scope in most locations to exceed the maximum permitted operating speed defined using the Two Thirds Rule, which was historically used on the Southern Region to limit the freight train operating speeds to two-thirds of the line's design speed:
    a) At 50 mph or below the restriction can be completely lifted.
    b) Above 50 mph the restriction can be broadly lifted to 85% of the line speed, rather than the existing 67%.
    c) The longest Class 4 intermodal trains with Class 66 traction have to have their top speed reduced from 75 mph to 65 mph when the line speed is also 75 mph.
3. All the principal opportunities for reducing the freight speed differential are on the old Southern Region network.
4. Geographical constraints such as curvature and speed restrictions linked to level crossings reduce the benefits which can be gained from reducing the freight speed differential.
5. The time taken to apply the train brake is very important and can be responsible for over 50% of the train's stopping distance.
6. Further investigation into the time taken for the brakes on all the wagons along the length of a consist to be applied including both propagation rates along the train and application rates on individual vehicles is required. Also, the time taken to release the train brake is not well quantified and would benefit from further research.
7. Investigate the benefits of moving from stopping calculations based on the more simplistic average train braking performance to more accurate calculations based on individual wagon performance with stepwise time increment calculations. This should result in reductions of calculated stopping distances of circa ~5%.
8. Speeds for stopping distance calculations are currently specified in 10 kmh increments as set out in the braking standards. The conversion and rounding-down to 5 mph increment process introduces significant unevenness in the differentials at higher speeds. A potential improvement would be to introduce 5 kmh increments for the stopping distance calculations as this speed increment is smaller than 5 mph so, after rounding, will align better with 5 mph spaced speed limit. This will also be minimising impacts from European Train Control System (ETCS) roll out.
9. In America train braking is enhanced by an EOTD which releases the brakes at the rear of the train simultaneously with the brake release at the locomotive. The use of such a device in the UK could halve the time required for brake application and reduce the risk of a signal passed at danger (SPAD).

10. The maximum recommended wagon Lambda (**λ**) for operation on the GB mainline is 90. This is consistent with the 0.11 maximum wagon wheel-rail adhesion (tau or **τ**) permitted by the National Technical Specification Notice (NTSN) – Rolling Stock – Wagons, when composition brake blocks are used and the wagon is not fitted with wheel slide protection (WSP).
11. The methodologies and reference values set out in BS EN16834:2019 for the determination of Lambda (**λ**) and Kappa (**κ**) would benefit from further research. This should be aimed at improving their suitability for use when calculating the stopping performance for GB mainline wagons and freight trains.
12. Table 3 above provides a guide to the reduced differentials which can be expected.
13. No differentials are necessary at or below 50 mph. Significant percentage improvements in freight train speed will be achieved given the Two Thirds Rule was applied at speeds above 30 mph.
14. In every case study there were historic issues with the actual train timings which needed extra time put into the train plan. These usually arose from an assumption that a train can accelerate immediately after a speed restriction with no time allowance for the whole train to go through the speed restriction.
15. Notwithstanding the above, in every case study end to end journey times could be reduced.
16. In practice timing gains were small, largely because of conflicts with the passenger network and overcoming historic under-timings. However, in places trains could depart later and arrive at the same time or run with a heavier weight in the same path.
17. It is recommended that a project is established with Network Rail to implement these changes and internal stakeholder consultation needs to be undertaken within the organisation before making any changes. Network Change was considered probably the best process to make these changes. A budget will be required to fund the internal costs and also to make any physical lineside changes. It should be noted that this will require an update to GMRT2045 and GKRT0075 RGSs to provide documented basis for any speed changes proposed.

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Contents

1 Introduction

1.1 Background

On significant parts of the GB rail network, passenger trains can run faster than freight trains, often because of the longer braking distance required by freight. Where signal spacing is optimised for high-frequency suburban passenger trains' braking distances, freight trains need to run slower to be able to stop in the same distance. Other factors (mostly infrastructure related) can also influence freight speed limits, such as the geology of the East Anglian Fens. However, many of the current differentials were specified a considerable time ago. In the 1970s, signals were being upgraded to accommodate electric passenger units that had much better braking performance than the freight locomotives and wagons of the time. Since then, the braking capabilities of freight trains have improved significantly, but the speed differentials remain.

Modern locomotives have rheostatic braking and better performing disc brakes, which are not included in braking calculations. At many locations therefore, the continued use of speed differentials is likely to be slowing freight trains more than is necessary, increasing their costs, reducing pathing opportunities, and increasing the network capacity required to accommodate them. Of particular interest is the part of the network subject to the former Southern Region's Two Thirds Rule without any train-specific exemptions, which can result in the most restrictive differentials. See Section 4 for a detailed discussion of the background to the Two Thirds Rule and how it is calculated. It is therefore likely that beneficial freight speed improvements could be implemented if stopping distances were reviewed to take account of the performance of modern rolling stock and using up-to-date methods for modelling braking.

RSSB commissioned this research project (T1348) to investigate the opportunities to reduce the existing differentials in maximum permissible speeds between passenger and freight trains on the GB rail network by adopting 'Enhanced Freight' (EF) speeds. This was to be achieved by calculating the required braking distances for freight trains (for representative loads, wagons and traction) and comparing these distances with the available length for stopping between signals. This will identify locations where the signal spacing will permit trains to run at a higher speed. This calculation requires consideration of the gradient on the line, the payload of the train, and the braking characteristics of the locomotive(s) and wagons.

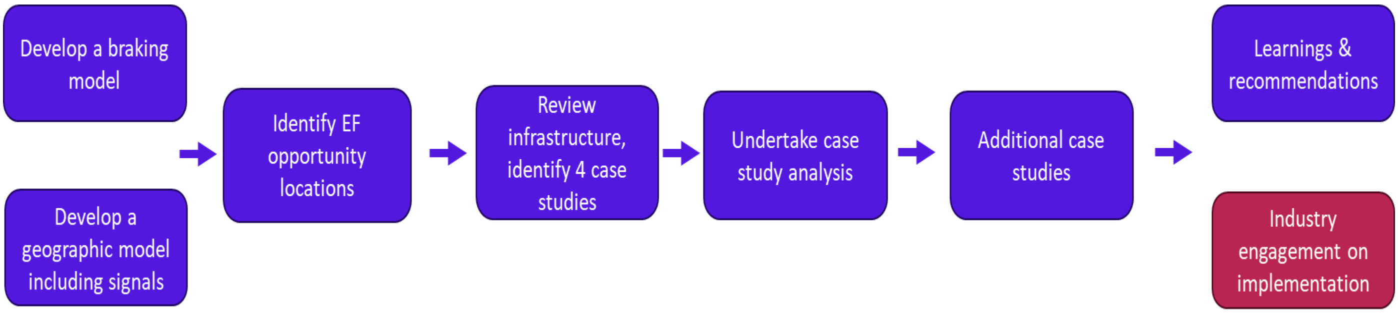
1.2 Methodology

The work involved the following tasks, summarised in Figure 5:

- An Excel-based model was developed to determine the required braking distance and the Minimum Signal Spacing (MSS) based on gradient, line speed, and wagon type, number and loading.
- A geographic model of the network was built that considers line speed differentials, signal spacing and route geography; the entire network was categorised according to whether there was any existing speed differential between passenger and freight limits.
- Initial selection of potential sites with an opportunity for enhanced freight speeds through comparison of the braking and geographic models

- A review of the suitability of the infrastructure for higher speeds, leading to selection of four case study routes for which EFs were proposed and their impact on timings calculated and the potential for timetable benefits assessed.
- A further four case studies were then investigated to consider a broader range of situations on the network to enable the conclusions to have wider applicability.
- The findings from the case study were then discussed with industry stakeholders to develop recommendations for how the implementation of EFs can be taken forward.

Figure 5 Summary of project methodology



1.3 This document

This document is the final project report. It covers:

- development of a braking model (Section 3)
- background to the Southern Region two-thirds rule and how it is calculated (Section 4)
- development of the geographic model and initial opportunity selection (Section 5)
- assessment of infrastructure and development of proposed EF speeds for initial case studies (Section 6)
- assessment of the timing and pathing impact of the proposed EFs (Section 7)
- additional case studies chosen to investigate a wider range of signalling design speeds (Section 8)
- general learnings on the relationship between passenger speeds and freight speeds (Section 9)
- consideration of how EFs can be implemented by the rail industry (Section 10).

2 Abbreviations, terms, and definitions

The following abbreviations, terms, and definitions have been used in this document.

Term or abbreviation	Definition
'dynamic brake'	Brake equipment type which generates the brake force using the motion of the vehicle or its functional elements, but not involving friction (for example electro-dynamic brake, hydro-dynamic brake, and more). *EN14478:2017 – Railway applications – Braking - Generic Vocabulary.*
EF trains	A train which has an Enhanced Freight differential speed. This is a train whose braking characteristics have been analysed and when these are applied to local route geography its speed can be increased beyond the normal maximum freight speed on the route.
EOTD	End of Train Device
ETCS	European Train Control System (ERTMS sub-system)
FOC	Freight operating company
<G>	Goods Brake Timing
GB mainline	Network Rail controlled infrastructure
κ (kappa)	Long train correction factor, applied to the train lambda (λ)
λ (lambda)	Brake Weight Percentage (Quotient of braked weight and vehicle mass x 100)
NTSN	National Technical Specification Notice, Rolling Stock - Freight Wagons (WAG), January 2021
<P>	Passenger Brake Timing
RGS	Railway Group Standard
RSSB	Rail Safety and Standards Board
SPAD	Signal passed at danger
τ (tau)	Coefficient of adhesion between wheel and rail
TiPLocs	**Ti**ming **P**oint **Loc**ation**s**
tph	trains per hour, (each way service frequency of the passenger network)
WAG	National Technical Specification Notice, Rolling Stock - Freight Wagons (WAG), January 2021
'wheel slide'	Condition where the circumferential speed of a wheel or wheelset is lower than the true train speed. [Ref. 9.6] *EN14478:2017 – Railway applications – Braking - Generic Vocabulary*.

‘wheel lock’	Extreme condition of wheel slide where the wheel or wheelset ceases to rotate during braking, while the train is in motion. [Ref. 9.6] *EN14478:2017 – Railway applications – Braking - Generic Vocabulary.*
‘wheel spin’ or ‘wheel slip’	Condition where the circumferential speed of a wheel or wheelset is higher than the true train speed.
WSP	Wheel slide protection

3 Development of a braking model

3.1 Composition of the braking model

3.1.1 Structure

In the first phase of the project, a freight train braking model was developed in the form of a workbook using Microsoft Excel. To aid the user, this workbook comprises separate worksheets:

- **Index** – providing an overview of the content of this workbook.
- **Calculation 1 to Calculation 5** – separate braking calculations, based on selected train configurations, and potential operating scenarios.
- **Lambda (λ)** – information of relevance to this key parameter, including standards extracts, and more.
- **Kappa (κ)** – information of relevance to this key parameter, including standards extracts, and more.
- **RGS & NTSN** – extracts from Railway Group Standards and the National Technical Specification Notice, Rolling Stock - Freight Wagons (WAG), January 2021, principally concerning the permitted coefficient of wheel-rail adhesion when braking.
- **Halcrow Data** – extracts from Halcrow Transmark report 'Effect of Train Length on Braking Distance, May 1997', principally concerning brake pipe pressure propagation along the train.
- **Comparisons** – selection of braking performance charts from Calculation 1 to Calculation 5.
- **Notes** – guidance for the workings of the brake calculations, and the assumptions employed for the calculations, and more.

Each calculation determines the train speed and train stopping distance relationship for emergency braking and full service braking scenarios on level track. Thereafter, these calculated level track stopping performances are adjusted to take account of the rising and falling track gradients on the route. The tare and loaded wagon conditions are considered, as are <P> passenger, and <G> goods brake timings. A look-up table is included in each calculation, relating the speed, stopping distance, load condition, and brake timing.

The calculation rationale utilises a wagon Lambda (λ) value as the basis for wagon stopping performance determination. The corresponding wagon braked weights are calculated and then summed to give the train's braked weight, which is then used to determine the train Lambda (λ). For train lengths > 500 m (excluding the locomotives), Kappa (κ) is used to factor the train Lambda (λ), and in so doing compensate for the impact that the longer train brake pipe propagation time has on the development of the train brake force, and the corresponding train stopping distance. For all calculations the distance travelled during the brake application phase is based upon the mean wagon brake application time, or mean train brake application time.

Where considered appropriate train static brake test data has been referenced, with a view to it improving the accuracy of the results calculated, and more. This includes importing some data from the Halcrow Transmark report '*Effect of Train Length on Braking Distance, May 1997*'. This data has been used to verify that, if using a 'step-by-step' approach for calculating the distance travelled during the brake application phase, the outcome differs insignificantly from that distance determined using the mean train brake application time. The distance determined for a 500 m train using the step-by-step approach is ~6% shorter than when using the mean train brake application time. The model output is summarised in the form of speed vs stopping distance curves, examples of which are shown later in this section.

3.1.2 Technical assumptions

The wagon braking performance and the train braking performance have been calculated using the approach set out for freight trains in two standards. They are *Railway Group Standard GMRT2045, Issue 4, March 2016, Compatibility Requirements for Braking Systems of Rail Vehicles,* and *European Standard BS EN 16834:2019, Railway applications – Braking – Brake performance.*

Together, these standards facilitate the determination of the relationship between the wagon Lambda (λ) and wagon stopping distance, using different *Factor C* and *Factor D* values. They relate to the speed at which the wagon brake is demanded, and the brake application timing employed. The *Factor C* and *Factor D* values selected for use in these brake calculations are values that relate to the use of composition brake blocks when <P> passenger brake timings are used. It is considered that most wagons that operate on the GB mainline utilise composition brake blocks although, it should be noted that, their friction performance in this environment does vary to an extent.

Together, these standards also facilitate the determination of the relationship between the train Lambda (λ) and the train stopping distance, again using *Factor C* and *Factor D* values. They relate to the speed at which the train brake is demanded, and when <P> passenger brake timings are used, but only for 120 kmh and 100 kmh and while emergency braking. This project requires the determination of stopping distances for speeds lower than 100 kmh, and the stopping distances achieved when the full service brake is used.

It has been assumed that:

- The above-described wagon *Factor C* and *Factor D* can be used for determining the wagon emergency stopping distance for each speed of interest, while using <P> passenger timing. The wagon emergency retardation force can then be determined for each speed of interest using an appropriate value for the brake timing. In this case, it is 4 seconds (this being the mean wagon brake application time when operating in single-pipe mode). This approach has also been used for estimating the locomotive stopping distance and locomotive retardation force for the purpose of this study. The wagon and locomotive retardation forces determined can then be summed for each speed of interest, to give the corresponding train retardation force.
- The above-described train *Factor C* and *Factor D* can be used for determining the train emergency stopping distance for 120 kmh and 100 kmh. Associating these emergency stopping distances with the train emergency retardation forces, facilitates the determination of the corresponding emergency train brake application times. In the absence of more pertinent data, it is considered practicable to use the maximum emergency train brake application time in conjunction with the emergency train retardation forces determined for each speed of interest for estimating the corresponding emergency train stopping distance.
- The train retardation force when service braking will be very nearly the same as the train retardation force when emergency braking. It is just the train brake application time that will be longer, thus the train stopping distance will increase. Therefore, the full service stopping distance can be determined

for each speed of interest, using that considered to be an appropriate full service train brake application time, in conjunction with the train retardation force determined for emergency braking.

- The above described approaches can be used for determining the emergency and full service stopping distances for trains in the tare and loaded conditions. Working in appropriate values for the <G> goods train brake application time, facilitates the determination of the corresponding train stopping distances when <G> goods brake application timing is used.
- It has been assumed that the trains are operating in single pipe mode, this being the most common mode for freight train operation on the GB mainline. And once the train brake has been fully applied, the train retardation force does not vary throughout the remainder of the stop concerned.

3.1.2.1 Wagon Lambda (λ)

RSSB project T1266 determined that there is potential for 500 m long enhanced freight (EF) trains to operate on the GB mainline, providing the wagon Lambda (λ) is ≥ 90. Therefore, brake calculations have been executed on the basis that the loaded wagon Lambda (λ) will be 90 or greater. It has been assumed that when wagon brake system tolerances and brake system degradation between wagon maintenance exams, are considered they will not negatively impact this Lambda (λ) value.

Experience indicates that if a wagon brake system is designed to achieve a wagon Lambda (λ) of 90 in its loaded condition and composition brake blocks are used, a higher tare wagon Lambda (λ) value of around 101 can be expected. This is due to a slight increase in dynamic coefficient of friction between the brake block and the wheel. These calculations have therefore been undertaken using a tare wagon Lambda (λ) of 101 to illustrate the impact that this higher value has on wagon and train stopping distance.

It should be noted that, the maximum wagon wheel-rail adhesion (τ) permitted in Section 4.2.4.3.4 of *National Technical Specification Notice, Rolling Stock - Freight Wagons (WAG), January 2021*, is 0.11, when the wagon(s) concerned are not fitted with WSP. To illustrate the impact of this wheel-rail adhesion requirement, equivalent stopping distances have been estimated for <P> passenger and <G> goods brake timings. They have been shown alongside the calculated wagon stopping distances in the charts produced by the spreadsheet model (as shown in Figure 2).

The calculated wagon stopping performance, based on a loaded wagon Lambda (λ) of 90 and tare wagon Lambda (λ) of 101, is at the maximum permitted distance, albeit at a relatively low speed, (at speeds < circa. 30 mph). Consequently, we believe that there is little or no scope for increasing the wagon Lambda (λ) to a value > 90 -101 with a view to reducing the achievable train stopping distance, unless the consequential increase in wagon wheel slide risk is mitigated by fitting suitable WSP to the wagons concerned.

Historically, the minimum recommended stopping distance for avoiding wheel slide on GB mainline wagons was depicted by Curve B in *Railway Group Standard GMRT2043, Issue 2, June 2011, Braking System and Performance for Freight Trains*. Curve B is now obsolete, having been superseded firstly by the introduction of the *Technical Specification for Interoperability, Rolling Stock – Freight Wagons,* the TSI-WAG, circa. 2013Also, more recently, by *National Technical Specification Notice, Rolling Stock - Freight Wagons (WAG), January 2021*. Both specifications permit a higher wagon wheel-rail adhesion than depicted by Curve B.

Curve B is shown on the output charts (as shown in Figure 2), to illustrate the evolution of the wheel-rail adhesion utilisation for relatively older wagons, versus more modern wagons. It could be argued that the wagon wheel slide risk has already increased, and is a likely contributory factor to the wagon wheel damage currently being experienced on some GB mainline wagons. This adds weight to the argument that the Lambda (λ) should not be increased above 90 – 101 for the loaded wagon and tare wagon respectively.

3.1.2.2 Locomotive braking

The calculations have been based on the use of either two Class 66 locomotives or one Class 66 locomotive, this being the most commonplace type of locomotive currently in use on the GB mainline for hauling freight trains. The Class 66 locomotive Lambda (λ) assumed is 65, this value having been taken from a typical TOPS printout, along with the locomotive length, and the locomotive mass. Other locomotive types could be considered if required, it just being necessary to suitably adjust the key parameters—the number of locomotives, locomotive Lambda (λ), locomotive length, and locomotive mass. More modern locomotives than the Class 66 can deliver more brake force and have enhanced Lambda (λ) values. For example, Class 70 has a lambda value of 75 and Classes 68, 88, 93 and 99 have Lambda (λ) values of 86.

These calculations are based upon the locomotive air brakes and the wagon air brakes combining to form a continuous train air brake system. Train brake applications are initiated by the locomotive driver, and they are communicated to the locomotive and all wagons in the train via the train brake pipe. A key characteristic in this regard is the time taken for the brake command to cascade or propagate along the train brake pipe. The magnitude of this time will ultimately have a bearing on the achievable train stopping distance. This characteristic has been very carefully considered in these brake calculations, using some (albeit limited) static train brake test data. The Kappa (κ) factor has been used when the train being considered, excluding the locomotive(s), is > 500 m long.

Given the target Lambda (λ) chosen for the wagons, 90 – 101, it is inevitable that, with a locomotive Lambda (λ) of 65 the wagons assist the retardation of the locomotive(s). The retardation force contributed by the wagons is lower when the train is being hauled by one locomotive than when two locomotives are used. Hence, from a train braking perspective, there is merit in using just the one locomotive (if that locomotive can cope with traction duties and more).

A locomotive dynamic brake force contribution has not been considered in these calculations, but it could be if there was a requirement for assessing its potential. For example, with a view to achieving more eco-friendly freight train operation, and reduced friction brake wear and tear and maintenance.

3.1.2.3 Factors of safety

There has been some discussion between stakeholders regarding GB mainline signalling distances and their relationship with the train stopping distance. This discussion considered elements of the Two Thirds Rule currently in use when determining the maximum permitted freight train operating speed, as it relates to the maximum operating speed for passenger trains for a given section of track.

Wagon and train stopping performance requirements set out in *Railway Group Standard GMRT2045, Issue 4, March 2016, Compatibility Requirements for Braking Systems of Rail Vehicles* have been reviewed. This was in conjunction with the requirements set out in *Railway Group Standard GKRT0075, Issue 5, December 2018, Requirements for Minimum Signalling Braking and Deceleration Distances*.

For this study, the key conclusions from these Railway Group Standards are:

- The target wagon Lambda (λ) should be 90-101, for the loaded wagon and tare wagon respectively. The calculations have determined that this is the maximum Lambda (λ) permitted if the maximum permitted wagon wheel-rail adhesion is not to be exceeded, and wagon wheel slide risk elevated beyond the level currently deemed tolerable, when the wagons concerned are not fitted with WSP.
- For illustration purposes only, the calculated wagon stopping distances based on a wagon Lambda 90-101 should be graphically compared with the 950 m and 890 m individual wagon stopping distances mandated by Section 2.3.2.5 and Section 2.3.2.6 of *Railway Group Standard GMRT2045, Issue 4, March 2016, Compatibility Requirements for Braking Systems of Rail Vehicles.*
- A 20% margin shall be added to the calculated train FULL SERVICE stopping distances - the resultant distances shall not exceed the distances depicted by Curve V. This margin comprises 10% to allow for speedometer and other errors, and 10% to allow for the effects of low wheel-rail adhesion. If the calculation shows that Curve V is exceeded, the maximum train operating speed shall be suitably reduced.
- It is implicit that the corresponding train **emergency** stopping distances are shorter than the stopping distances achieved when the train **full service** brake is used. This is because, while the train retardation force is the same for **full service** and **emergency** braking, the longer **full service** train brake application time causes the train to travel a greater distance during the train brake application phase.

To account for real-world GB mainline freight train operating scenarios, where wagons without an air brake are hauled from time to time, and/or wagons with non-operational brakes are hauled, calculations have been performed for trains including ‘through-piped’ wagons. *Rule Book Module GERT8000-TW4, Issue 2, December 2023, Preparation and working of freight trains*, sets out the requirements relating to train operation with through-piped wagons. These include the maximum number of such wagons allowable, their location in the train, and the minimum train brake force that must be achieved by the remaining fully functional wagons and locomotive(s).

For this study, calculations have been performed for two train operating scenarios where there are three through-piped wagons incorporated into the train. Given the limited information available regarding the impact that through-piped wagons have on train brake pipe propagation, these three wagons have been positioned at the locomotive end of the train. Clearly, the mass of each of these wagons is retained for the calculation, but their retarding force contribution is 0kN.

Inevitably, all other influential factors remaining equal, the train stopping distance increases. It may be necessary to compensate for that increase by reducing the maximum train operating speed, while retaining the 20% margin, and in so doing avoiding exceeding the stopping distance limit mandated by Curve V.

3.2 Output and comparison with existing constraints in standards

3.2.1 Discussion of output

Figure 6 shows the calculated stopping performance for an individual wagon, in the tare and loaded conditions, for an EMERGENCY braking scenario on level track, with <P> passenger brake timing. The wagon Lambda (λ) is 90 for the loaded condition, and 101 for the tare condition. The key conclusions from this chart are:

- The wagon stopping distance, for all speeds up to 75 mph, is less than 890 m – 950 m.
- At speeds < circa. 30 mph, the wagon wheel-rail adhesion is at the permitted limit.

Figure 6 Calculated stopping performance for an individual wagon with Lambda (λ) 90-101.

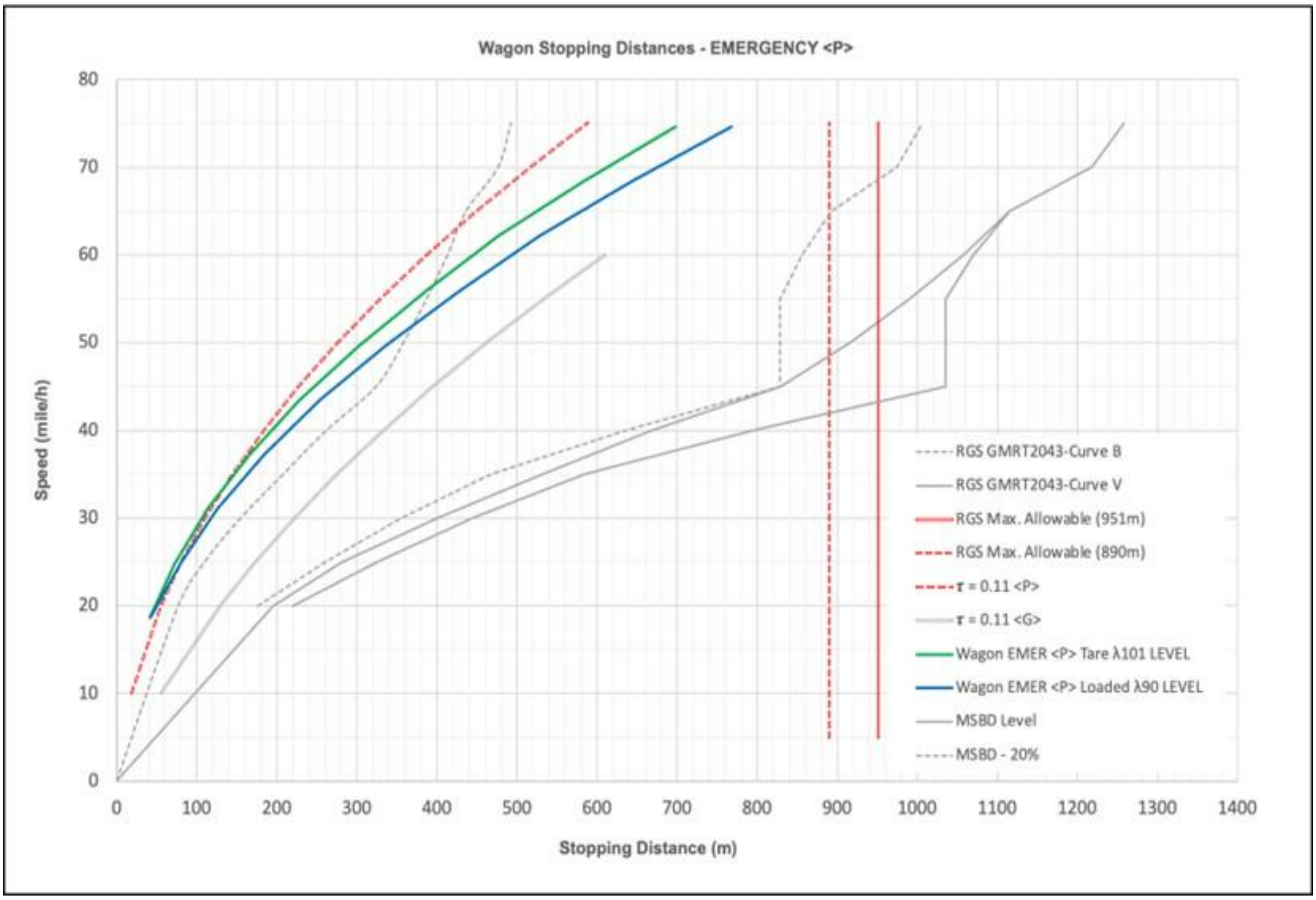
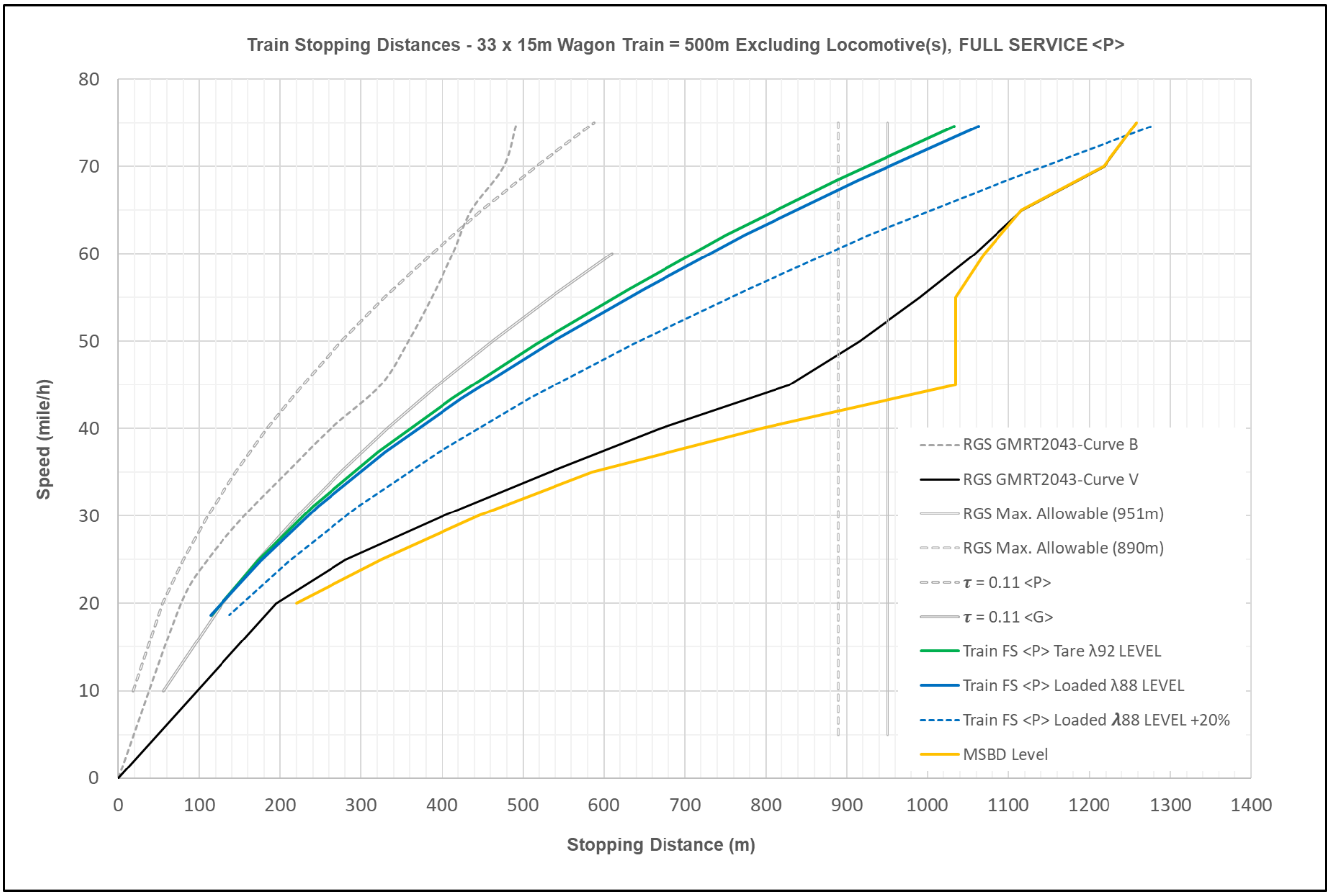


Figure 7 shows the calculated stopping performance for a train comprising 2 x Class 66 locomotives, and 33 x 15 m long wagons, in the tare and loaded conditions, for a FULL SERVICE braking scenario on level track, with <P> passenger brake timing. The wagon Lambda (λ) is 90 for the loaded condition (solid blue curve), and 101 for the tare condition (solid green curve) and the train stopping distance for the loaded condition +20% (dashed blue curve).

The key conclusions from this chart are:

- The train stopping distance + 20%, for all speeds up to very nearly 75 mph, is less than Curve V.
- The (loaded) train stopping distance + 20% (dashed blue curve), for all speeds up to very nearly 75 mph, is less than the MSBD (yellow curve which over lap at higher speeds with the GMRT2043 Curve V) at that speed before initiating braking mandated for level track by *Railway Group Standard GKRT0075, Issue 5, December 2018, Requirements for Minimum Signalling Braking and Deceleration Distances.*

Figure 7 Calculated stopping performance for a train with individual wagon Lambda (λ) of 90 for loaded wagons and 101 for tare wagons.



4 Introduction to the two-thirds rule

4.1 Background to the Two Thirds Rule and how it is calculated

BR Southern Region introduced the Two Thirds Rule 45 years ago after concerns over the relative stopping distance of passenger and freight trains in the 1970s. Passenger braking, and hence stopping distances, had been improving and signal spacings in many Southern Region route sections were based on maximising passenger (EMU) capacity, especially in the peak when no freight was running. The Southern Region Two Thirds Rule freight train speed was introduced in January 1980 as part of a more scientific approach to signal spacing.

The Southern Region of British Railways had previously adopted a local signal spacing standard which was at variance to the national SSP34 standard. This was driven by a desire to more closely match signal spacing to the characteristics of the multiple unit trains almost universally in use for Southern Region Passenger services. Both passenger and freight braking have further improved (in different ways) in the intervening years since the introduction of this Two Thirds Rule. The thinking—in the era before dual speed signage was created with GK/RT0038 in 1996—was to introduce a simple 'catch-all' rule so that freight services would run slower under some circumstances. The stopping distances, and hence signal spacing, would be then suitable for both passenger and freight. The freight trains assumptions behind this simple 'catch-all' rule needed to consider the conservatively common typical train characteristics of the time which are much worse than current characteristics for assumption purposes. For example, much lower locomotive brake force (for example Class 73 lambda (λ) is 40), much lower wagon braking performance, and <G> brake times as the default. By defining a suitably conservative 'worst-case' lower maximum permissible speed for freight trains, signal spacing could generally be designed to maximise line capacity on intensively worked suburban passenger lines where line speeds were typically in the range of 60 to 70 mph. The resulting freight train speed of 40 or 45 mph was not dissimilar to the speed these freight trains could achieve in practice. GK/RT0038 was later superseded by GK/RT0075 in 2011.

When the Two Thirds Rule was introduced, Class 6 freight was split into three sub categories based on maximum wagon speeds and brake force (either Table E(i) or Table E2(ii)). This resulted in the maximum Class 6 speeds of 60, 50, or 45 mph, with brakes in <G> mode and with fully brake-fitted wagons. Freight trains were unable to match passenger stopping performances at the time so there was some further discussion in developing what became two-third rule as to how many of these sub-categories would be covered. With subsequent rule changes in 1983, Class 6 (50 mph) and Class 6* (45 mph) freight trains effectively became the current Class 7 (45 mph). However, in the intervening years, the minimum braking /stopping performance has improved significantly due with improvements in locomotive and wagon brake equipment and increases in the minimum number of braked wagons in a consist.

The situation is different for Class 4 trains, which at the time of introduction of the two-thirds rule were assumed to be able to match passenger stopping performances when operating with brakes in <P> mode. This is usually based on passenger using 7% g full service braking rates at that time. However, while EMU braking has since further improved (now typically 9% g), Class 4 freight trains have typically got significantly longer, resulting in increased brake propagation times and hence increased stopping distances. This means that many current longer Class 4 services would not be able to stop on the Southern Region within the stopping distances for signal spacing on Southern Region routes between 55-80 mph if starting to brake from within 5-10 mph of that maximum speed. This is discussed in far greater detail later.

The Two Thirds Rule was intended to be a simple solution based on restricting Class 6 freight speeds to two-thirds of the maximum permissible speed for the route (as shown in Table A at the start of the Sectional Appendix for each LOR), rounded down to the nearest 5 mph.

Table 44 shows the two columns from the Sectional Appendix Table A, the maximum permissible speed for the section of route and maximum permissible speed of Class 6, 7 and 8 freight trains. Also shown is the ratio between the maximum permissible speed of route and the two-thirds speed. It can be seen that this is frequently less than two-thirds after rounding.

Routes with a maximum permissible speed less than or equal to 30 mph are exempt from the Two Thirds Rule. This is because the difference between passenger and freight stopping distances at these lower speeds is smaller (the absolute stopping distances are shorter). Consequently, a perverse step occurs at 30 mph whereby a route with a higher maximum permissible speed (35 mph) will restrict Class 6 freight services to a lower speed (20 mph).

Table 4 Speed from Sectional Appendix Table A with commentary on the relationship between two speeds

Maximum permissible speed of line as shown in Table A diagrams aka 'signalling design speed' (mph)	Maximum permissible speed of Class 6, 7, and 8 freight trains (excluding MPV's, OTM's & parcels trains) (mph)	Actual current fractional value	Notes on current actual fractional value
90	60	67%	
85	55	65%	Value below 2/3rds
80	50	63%	Value below 2/3rds
75	50	67%	
70	45	64%	Value below 2/3rds
65	40	62%	Value below 2/3rds
60	40	67%	
55	35	64%	Value below 2/3rds
50	30	60%	Value below 2/3rds
45	30	67%	
40	**25**	63%	Value below 2/3rds
35	**20**	57%	Value below 2/3rds
30	30	100%	
25	25	100%	
20	20	100%	

At the start of each Line of Route (LOR) description in the Section Appendices for the Kent, Sussex, and Wessex Regions the relevant maximum permissible speed(s) along the LOR are set out. The simplest case is illustrated in Figure 8 where a single Maximum Permissible Speed applies for this entire LOR. The Maximum Permissible

Speed is 80 mph which leads to a maximum permissible speed for Class 6, 7, and 8 freight trains (excluding MPVs, OTMs, and parcels trains) of 50 mph (80 x 2/3rd = 53 mph, rounded down to 50 mph). The are also several sections on this LOR with local speed restrictions, for example around Maidstone East station, which apply identically to both passenger and freight as only a single speed restriction is physically signed. In other locations local speed restrictions can have dual speed signage for passenger and freight.

Figure 8 Example of the maximum permissible speed

LOR	Seq.	Line of Route Description	ELR	Route	Last Updated
SO140	001	Swanley to Ashford	SBJ	Kent / Sussex	19/03/2016
Location	Mileage M Ch	Running lines & speed restrictions		Signalling & Remarks	
		MAXIMUM PERMISSIBLE SPEED BETWEEN SWANLEY AND ASHFORD - 80 MPH		TCB Victoria SB (VS)	GSM-R

Other LORs can be more complex with changes in maximum permissible speed along the LOR or different in maximum permissible speed for fast and slow lines or up and down lines along the same section of route.

4.2 What are the main problems caused by the Two Thirds Rule?

Since the Two Thirds Rule was introduced, dual-speed signage has been introduced where necessary and has been rolled out in all other NR regions. There has been a long-term aim to roll out dual signage across the whole NR network and so eliminate the Two Thirds Rule in the Southern Region, but this has been progressing slowly. Originally the aim was to eliminate the Two Thirds Rule extremely quickly with dual speed signage by 2003 (outlined in GK/RT0038 Issue 2). But on detailed investigation this was discovered to be an impractically fast change to implement in practice and would also be unduly restrictive on freight speeds in many cases.

The differential freight speeds for Class 6 and Class 7 due to application of the Two Thirds Rule were typically far larger than differentials in other NR regions. This unduly restricted the maximum speed of current Class 6 and Class 7 services.

In the decades since the introduction of the Two Thirds Rule, Class 4 services have got longer (thus with extended times for the brake command to propagate down the train) and Passenger (MU) braking has further improved. The late 1970s assumption that Class 4 freight are able to approximately match passenger stopping distances no longer holds in all conditions and circumstances. This is taken account of in calculating speed differentials in other NR regions, but not where the Two Thirds Rule applies.

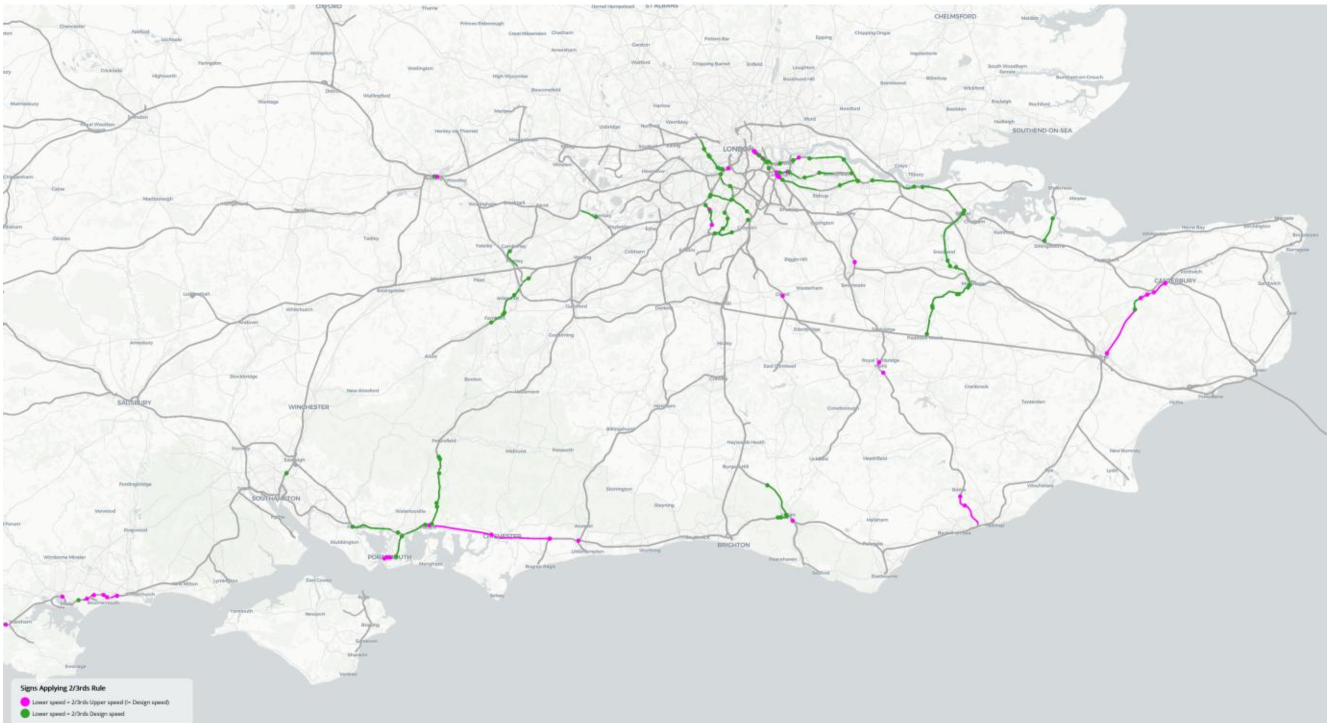
There has been some progress in eliminating the Two Thirds Rule over the last circa twenty years. Railtrack, and later Network Rail, started introducing dual speed signage initially when resignalling areas but this often created more issues:

- All freight services on those sections were then restricted to Two-Thirds Rule speeds, including Class 4.
- Sometimes freight speeds were calculated using freight stopping distances (best outcome but rare).
- Sometimes freight speeds used the two-thirds rule speed for the freight speed (easiest and most common outcome); the sections of line where this applies is shown in green in maps in Figure 9.
- Sometimes freight speeds were calculated using the two-thirds rule incorrectly applied to the local speed on each sign, rather than using the Table A speed. The sections of line where this applies is shown in magenta in maps in Figure 9 below.

The resulting speed restrictions were therefore far greater than they would have been had they been calculated on the basis of what is needed for safe stopping reasons.

The map in Figure 9 below shows routes in, and adjacent to, the NR Southern region. The tracks on the map have been colour coded by whether two-third rule speeds are used for dual-speed signage. Green shows where the Two Thirds Rule speeds have been rolled out into dual signage using the Table A speed (an easy option as it avoids any detail calculations). Magenta shows where the Two Thirds Rule speeds have been rolled out into dual signage using the locally signposted speed. Grey sections of route show where the Two Thirds Rule has not been incorporated into dual speed signage so far.

Figure 9 Map showing routes with dual signage based on Two Thirds Rule



Section 5 of this report covers the development of the geographic model and identification of freight speed differential in detail.

5 Development of a geographic model

5.1 Overview of the modelling approach

This section describes the development of a geographic model of the network, its interface with the braking model described in the previous section and their combination to assess line speed and signal spacing. The output from this work was a 'long list' of routes where there are significant differences between freight and passenger speeds, as well as signal spacing sufficient to accommodate higher speeds. A more detailed assessment of these routes is described in section 6.

The long listing process involved consideration of two key criteria:

- the extent to which there is a differential between freight and passenger speeds
- whether the spacing between signals is sufficient to enable freight speeds to be increased.

On routes that do not have significant route mileage with large differences between freight and passenger speeds there is no opportunity to consider freight enhancements. Therefore, there would be no benefit in conducting a detailed signal spacing assessment of those routes. For this reason the long-listing was a sequential filtering process:

- development of a GIS map of speed limit differentials across the network
- selection of routes where there are significant differences between the line speeds for freight and passenger traffic
- mapping signal locations onto routes meeting the linespeed differential criteria
- calculating signal spacing headways
- comparison of headways to stopping distances in order to determine potential EF speeds.

The opportunity was taken to also incorporate gradient data onto the geographic model alongside signal spacing and line speed, to enable a more accurate assessment of the required braking distance to be undertaken.

The geography and signal spacing modelling was undertaken using scripts developed in the R coding language.

5.2 Composition of the geographic model

5.2.1 Data used in geographic model

A summary of the data used in the development of the geographic model is given below:

- **Signal attribute data** (including signal name, type, track ID number, ELR code, and miles and yards location along the ELR) was provided by Lampada (the commercialisation arm of the University of Hull).
- **Network Rail Track Model**, a geospatial representation of the UK rail network, sourced from Network Rail during previous work undertaken for RSSB by Railfreight Consulting and Aether.

- Track characteristics data, namely **linespeeds** (including upper/passenger and lower/freight speed limits, tied to ELR and track ID), and **track gradients** (both in percentage and '1 in X' terms, and tied to ELR and track ID), were also sourced from Network Rail during previous project work for RSSB.

During the development of the long list (see Section 5.3), linespeeds were validated against the Sectional Appendix. Limitations in available data meant corrections were made, particularly around Lewisham to reflect resignalling work over the last couple of years.

Significant manual checks were also made on signal locations and aspects during the assessment of candidate routes to prevent unrepresentative short spacings being used in comparison with braking distance. This process is detailed in Section 5.3.

5.2.2 Development of speed differential maps

The first task in developing the geographic model was to focus the geographic scope on areas of potential interest. For this, the linespeeds data for the entire network was categorised according to whether there was any existing speed differential between passenger and freight limits. Any route sections where there was found to be a 0 mph delta (no difference) between passenger and freight speeds, or less than a 5 mph delta, were excluded, as there is no opportunity to enhance freight speeds. The remaining sections were classified according to whether the freight speed limit exceeded the maximum permissible speed of Class 4, 6, and 7 trains (45 mph, 60 mph and 75 mph, respectively). The classified linespeeds were then joined to the geospatial track model data using the ELR, track ID, and linespeed section start and end distances. These were matched to the corresponding ELR, track ID, and start and end distance attributes of the rail links within the track model.

This process enabled the generation of three interactive maps of the linespeeds (Classes 4, 6, and 7) on the network, from which a visual analysis could be performed to identify areas of opportunity for enhanced freight speeds for each of the respective train classes. One example of the interactive speed differential maps is shown in Figure 10 below, where the colour of the lines indicates the degree of speed differential. Colours in the yellow to red gradient indicate some form of speed differential, with darker colours representing larger differences. Grey represents any excluded sections comprising less than a 5 mph delta.

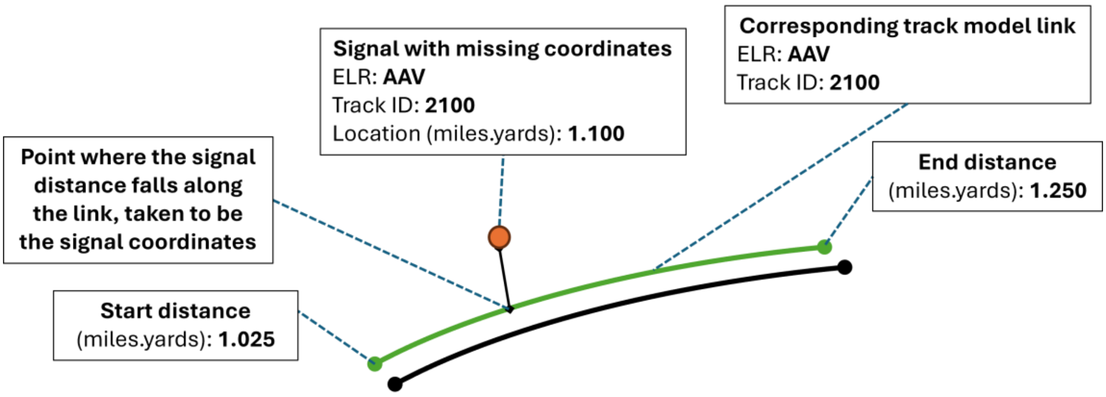
Visual analysis of the speed differential maps, together with the professional knowledge of the rail network, specifically on the locations of key freight traffic flows, from senior project team members, identified some broad geographical areas of interest to take forward. The locations to be further analysed with the full geographic model were largely concentrated in and around London, with a mix of locations north and south of the River Thames.

Figure 10 Screenshot of one of the interactive differential speed maps

5.2.3 Mapping signal location data

In a further development of the geographic model, the signals data was processed and subsequently joined to the track model. To begin with, some of the signals within the data had missing geospatial coordinates. For these signals, coordinates were derived manually using the miles and yards location attributes. A corresponding rail link was found in the track model matching the ELR and track ID of a given signal, and where the miles and yards location of the signal fell within the start and end distances of the rail link. The point where the signal fell along the link was then taken as the coordinates of the signal. Figure 11 illustrates this.

Figure 11 Diagram of the process to derive missing signal coordinates

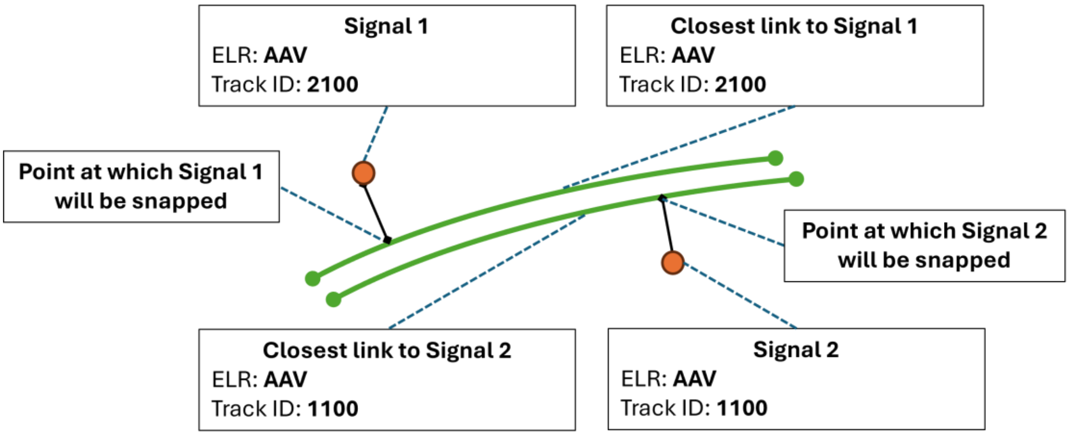


The signal and link attributes given above are purely indicative and not intended to be reflective of reality.

Any signals for which a corresponding track model link could not be found were excluded on the basis of poor data quality. Banner repeater signals were also excluded at this stage on the basis that they were not relevant when calculating the signal spacings. These were easily discernible within the data. It was agreed that other signals that would also need omitting from the distance calculations, but could not be distinguished within the data alone, would be manually excluded later through interrogation of route maps and plots (see Section 5.3). Finally, the signals were filtered on location to only include those relevant to the areas of interest identified in the preceding differential speed analysis.

The final step to producing the signal spacing model was to map the filtered signal locations, as well as TiPLocs (Timing Point Locations) representing the start and end route locations (also filtered to within the areas from the differential speed analysis) to the track model. This process involved taking the coordinates of the signals and TiPLocs—the majority of which did not fall precisely on the track model links—and 'snapping' them to the closest point on the closest link. Figure 12 illustrates this process.

Figure 12 Diagram of the process to snap signals and TiPLocs to the track model



The signal and link attributes given above are purely indicative and not intended to be reflective of reality.

Finally, the gradient data was also joined to the track model using the same process as when joining the linespeeds, described in the previous section. This was in aid of summarising the ruling grade along signal sections when calculating signal spacings, enabling consideration of the impact of gradient when calculating stopping distances.

5.2.4 Calculating the signal spacing

An application was built using the Shiny package (part of the R coding language) to apply the geographic model to build and visualise routes between an origin and destination TiPLoc and calculate the signal spacings between those two locations. A simple user interface (UI) was developed consisting of a series of dropdowns, firstly to select an origin and destination point, and any midpoints required to help guide the routing algorithm along the correct path. Further dropdowns were included to help reverse the directionality of the model network, allowing the user to force the routing down specific tracks and pass specific signals thereby, to ensure the route was as faithful to reality as possible. A final dropdown was included for the user to specify particular signals they would like to be omitted from the speed and stopping distance calculations. The rest of the interface included three panels to display the output route in different forms. One contains an interactive map of the route. Another contains an interactive plot of the passenger, freight, any two-thirds design speeds or proposed design speeds along the route, as well as signal and TiPLoc locations, and the location of any limiting infrastructure such as underbridges. The final panel housed a table displaying the signal sections along the route with the following additional information necessary for calculating SPL/EF speeds:

- whether the first signal in a section had **four aspects**
- the **one-block distance** (from Signal B to Signal C in Figure 18), in metres
- the **two-block distance** (also incorporating the distance from Signal C to Signal D in Figure 18), in metres
- the **average gradient** across the signal section, weighted by distance, expressed as '1 in X'
- the **ruling grade** (the steepest negative/declining gradient across the signal section, or the shallowest positive/inclining gradient if none are declining), expressed as '1 in X'.

The appearance of each of the UI elements of the application is captured in the screenshots (Figure 13 to Figure 17) below. An example route of Hither Green to Chislehurst is shown in each.

Figure 13 The user input controls of the signal spacing app

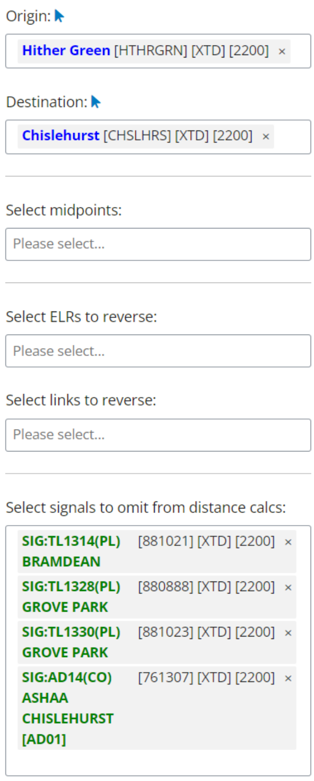


Figure 14 Snapshot of Interactive map showing the location of signals (green) and TiPLocs (blue) along the route (yellow)

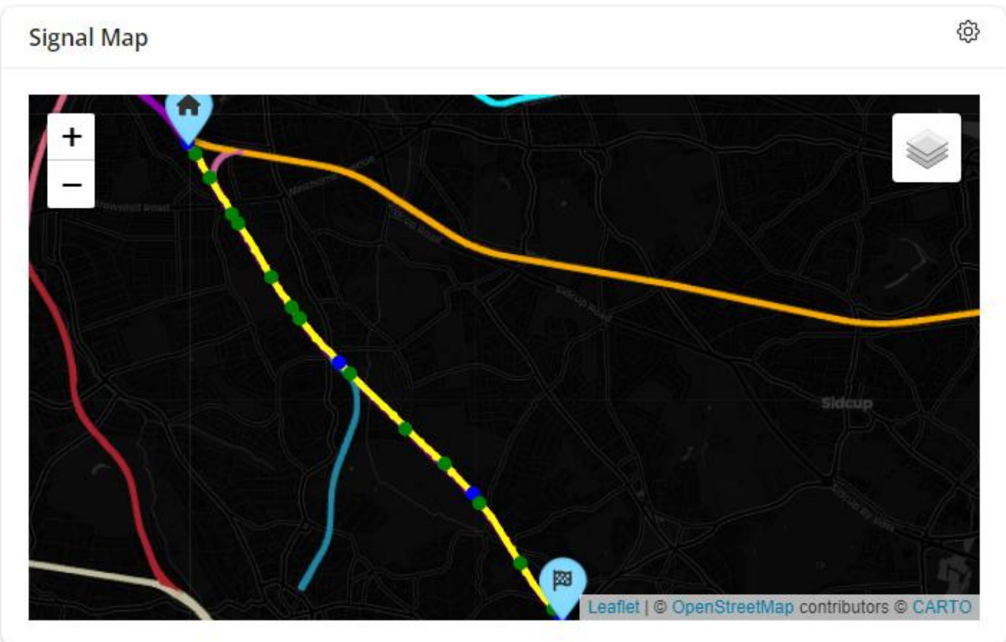


Figure 15 Interactive plot showing the different speed limits along the route (red and orange lines) as well as the locations of signals (green), TiPLocs (blue) and underbridges (black)

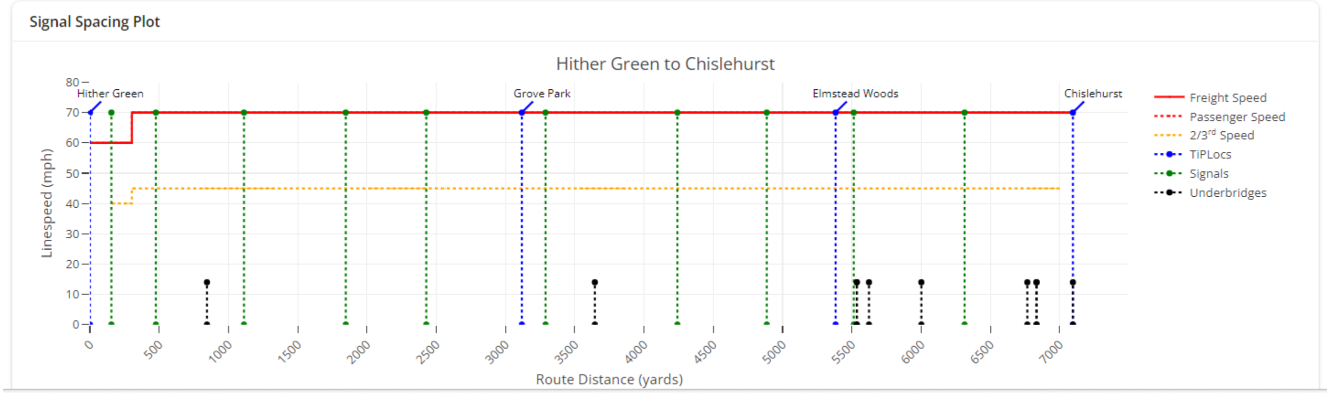


Figure 16 Screenshot of table showing all signal-to-signal sections along the route, the distance of each section (one block), the combined distance of the current and next section (two block), and the ruling grade of each section

Signal Spacing Table

SectionID	Signal.From	Signal.To	One.Block.Metres	Two.Block.Metres	Ruling.Grade
1	TL295	TL356	294	875	-113
2	TL356	TL303	582	1,254	-125
3	TL303	TL307	672	1,203	-125
4	TL307	TL313	531	1,319	-113
5	TL313	TL317	787	1,658	-34
6	TL317		871	1,460	-98
7			590	1,164	-112
8		AD9	574	1,306	-117
9	AD9	AD13	732		-140

Figure 17 Screenshot of table summarising linespeed sections along the route

Build route Full route table Linespeeds table

SectionID	Node.Start	Node.End	StartYardage	EndYardage	LinespeedUpper	LinespeedLower	DesignSpeed	Class6Speed	Section.Dist.Metres
1	HTHRGRN_XTD_2200	XTD_0261	12,672	12,980	60	60	60	40	281
2	XTD_0261	CHSLHRS_XTD_2200	12,980	19,778	70	70	70	45	6,208

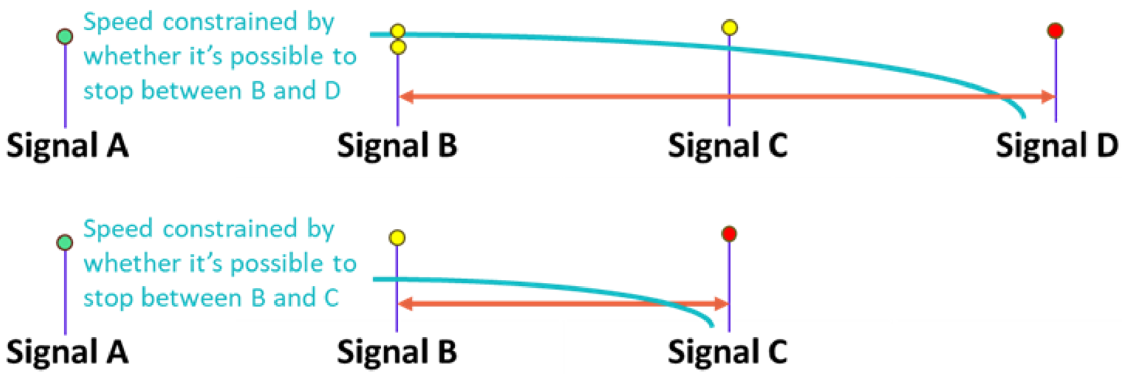
5.2.5 Calculating Stopping-Performance Limiting (SPL) speed

The signal spacings along the route were compared with the stopping distances determined by the braking model for a typical freight consist. The highest speed for which the stopping distance was shorter than the signal spacing—the train would be able to stop within the distance between the signals, was defined as the Stopping-Performance Limiting (SPL) speed.

The stopping distance used for comparison with the signal spacing was calculated for the mean gradient within that signal section. If the mean gradient was more extreme than 1:200 then clauses 1.5.6 and 1.5.7 of the SSpaM User Manual v2.1 were applied. Consequently a 10% margin was added to stopping distances where the mean gradient was not as extreme as 1:100 (unless the stopping distance for the steepest falling grade within the section was shorter). Clause 1.5.7 recommends a detailed evaluation for sections with a mean gradient steeper than 1:100. This was deemed out of scope for this project, however a warning was outputted for the small number of sections effected by this clause, allowing their recommended speeds to be interpreted in this context.

Where a signal has four aspects (is capable of displaying double yellow), the two-block distance is used for the purpose of calculating stopping distance. This is because a driver will be exposed to two restrictive aspects (double yellow and yellow) before they are required to stop at a red signal. Hence the driver has two signal blocks in which to bring the train to a stop from the first restrictive aspect. The diagram in Figure 18 shows this situation and the difference from 3-aspect signalling where a driver has just one signal warning that a red aspect is upcoming and hence the required stopping distance is compared with just the single block distance.

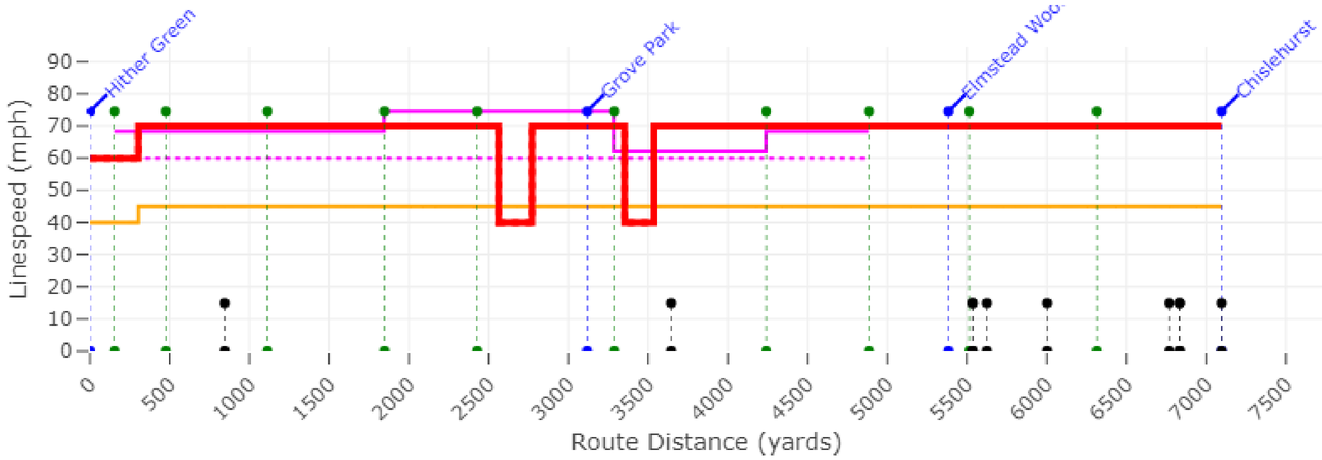
Figure 18 Relationship between number of signal aspects and signal spacing



Separate SPL speeds were calculated for trains in <G> brake setting and <P> brake setting. The calculation for <P> brake setting used a typical Class 4 consist and calculated speeds were capped at 75 mph. A typical Class 6 (aggregate) consist was used for the calculation of speed limits for trains with <G> brake settings. These speeds were capped at 60 mph.

For routes taken forward to the calculation of EF speeds, two magenta lines were added to the signal space plot originally demonstrated in Figure 15. Figure 19 shows the updated version of this plot where blue (TiPLoc) and green (signal) lines have been dimmed. The solid magenta line shows the SPL speed for trains in <P> brake setting; the dashed magenta line shows the SPL speed for trains in <G> brake setting.

Figure 19 Snapshot of Interactive plot showing existing and proposed speed limits between Hither Green and Chislehurst



Current signed speed (red), Two Thirds Rule speed (orange), SPL speed with <P> brake setting (magenta), SPL speed with <G> brake setting (dashed magenta), Signal locations (dashed green), TiPLoc locations (dashed blue), underbridges (dashed black)

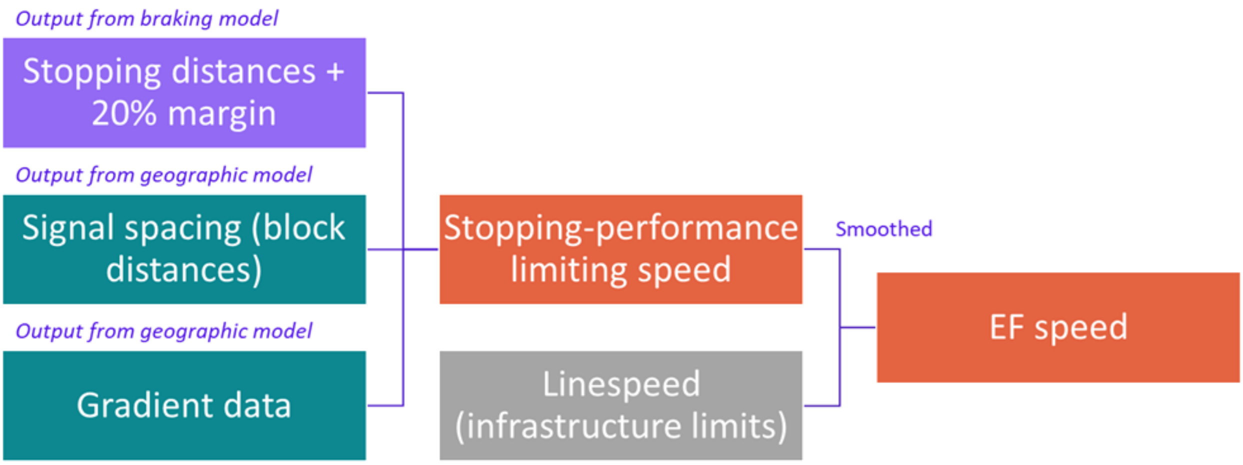
5.2.6 Calculating EF speeds

The EF speeds for a given route were determined on a manual basis through smoothing SPL speeds. This was done to ensure that the proposed speeds were 'drivable' (they wouldn't require frequent speed changes). In general, the EF speed was taken to be the lowest SPL speed between two low linespeed limits.

Consideration was given to the performance of freight trains as well. For example, after clearing a 20 mph limit a freight train is likely to take several miles to accelerate up to 50 mph. If the train is exposed to an infrastructure speed restriction below 50 mph while still accelerating then having a 55 mph EF speed has no benefit over 50 mph.

Figure 20 summarises the process explained in sections 5.2.5 and 5.2.6. Outputs from the braking model and the geographic model to determine the SPL speed. Smoothing, with consideration of infrastructure limits, transforms this into an EF speed.

Figure 20 Process for determining EF speeds



5.3 Selecting routes for the longlist

5.3.1 Definition of the long list

Following the development of the Shiny application, an iterative process of analysis was undertaken within the app. Signal spacings were generated between two defined locations and the map, plot, and tables were assessed to determine whether the route sections presented opportunity for further analysis.

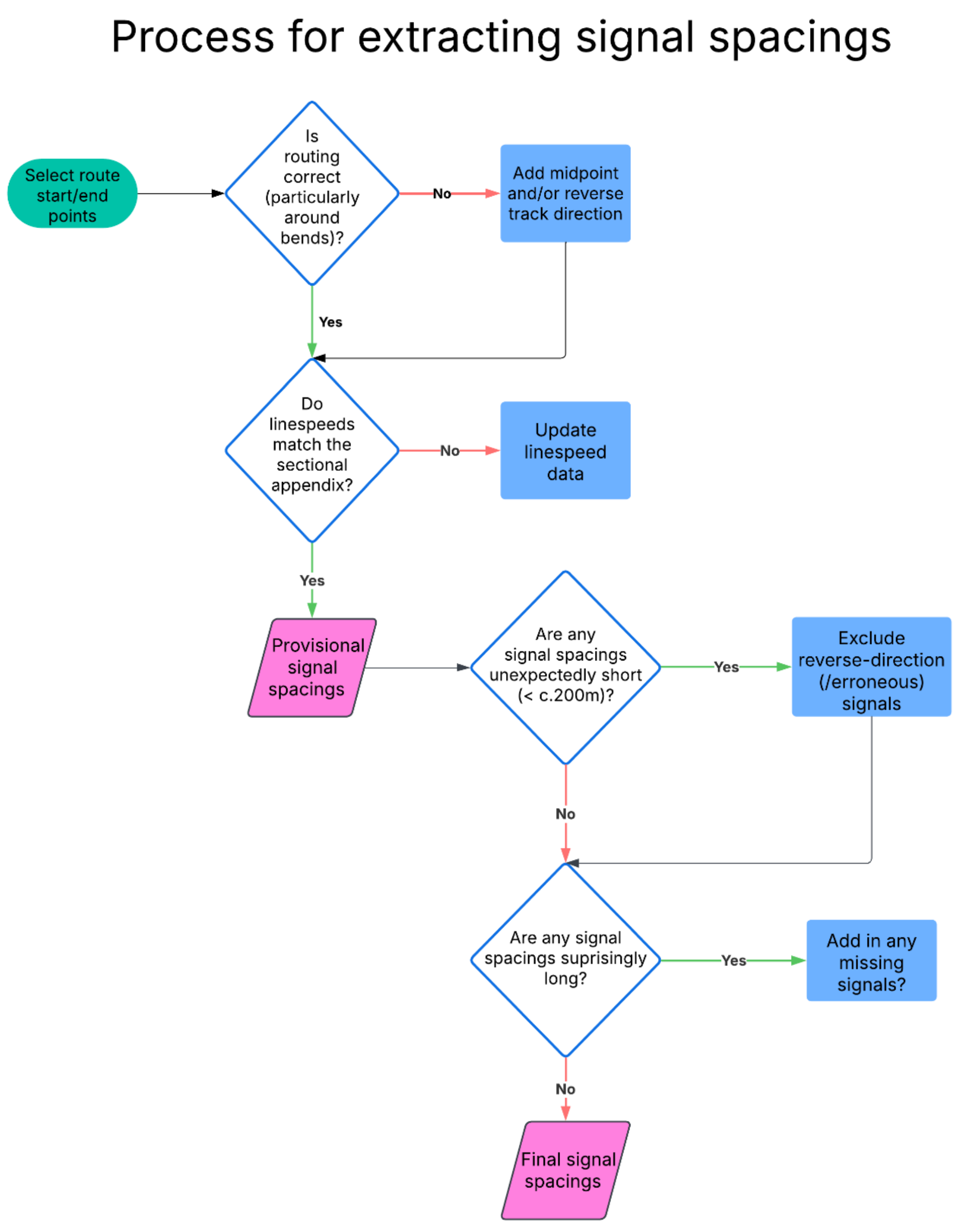
Previous analysis resulted in identification of the following candidate routes for the longlist:

- South London
    - Tonbridge – Dartford
    - Dartford – Lewisham (3 routes through Woolwich/Eltham/Sidcup)
    - Lewisham – Clapham
    - Hither Green – Chislehurst
    - Bat & Ball – Swanley
    - Ashford – Swanley
- North London
    - Willesden – Channelsea Junction
    - Barking – Stanford-Le-Hope.

The majority of candidate routes were selected from visual analysis of the speed differential maps (section 5.2.2), with consideration given to size of differential, length of differential(s), and freight traffic intensity along the route. Most routes also correspond with problem locations identified by key project stakeholders (and ongoing resignalling work around Lewisham). Ashford – Swanley was identified as a candidate route notwithstanding no speed differential being observed between freight and passenger speeds. This was because Class 6/7 traffic on this route is subject to the Two Thirds Rule despite very good infrastructure provisions (the route was upgraded in the 1990s when it was one of the main Channel Tunnel freight routes).

For each candidate route explored within the Shiny application, significant checks were made to ensure accurate linespeed data and signal spacings were outputted for each route. This process is outlined in Figure 21. Manual oversight was required to exclude signals that control reverse direction moves (these typically have a plate number suffixed with 'X' or a 4-digit plate number when surrounding signals have 3-digit plate numbers), or signals that were duplicates/erroneous. While care was taken to produce an accurate sequence of signals along each route, full verification couldn't take place due to lack of publicly available information.

Figure 21 Flowchart for signal spacing filtering



Because of limitations in some of the available signalling data, manual QA checks were also undertaken to verify the number of aspects possessed by individual signals. This was important to confirm whether the one-block or two-block distances should be used for comparison with the modelled stopping distance. The Network Rail Asset Register occasionally contains information on the number of aspects signals have however QA checks suggests this information is not always up to date. Consequently, signalling diagrams, when they were made available by Network Rail, were used for identifying where 4-aspect signalling was present, as well as publicly available cab videos.

As described in section 5.2.3, graphical outputs were produced to aid the analysis of candidate routes. Tables of two-block distances allow for comparison with stopping distances produced by the braking model described in Section 3. Tables of linespeed sections enable examination of the length of opportunity and size of differential.

5.3.2 Example outputs for longlist

Figure 22 shows selected signal spacings for Swanley – Ashford. This route has a significant distance with signed speeds over 60 mph (there are no lower signed speeds, but domestic Class 6/7 traffic is subjected to the Two Thirds Rule) presenting opportunities for improved freight running speeds. Three-aspect signalling means one block distances must be used for stopping distance comparisons, as opposed to two block distances when considering other routes. In the extract there are a number of one block distances over 2000 m (larger than required stopping distance even accounting for gradient-sensitivity). This output indicates analysis of linespeed sections should determine distances for which higher-speed operation is possible.

Figure 22 Screenshot of example output table of signal sections along a route, summarising the one- and two-block distances, and ruling grades

SectionID	Signal.From.Desc1	Signal.To.Desc1	One.Block.Metres	Two.Block.Metres	Ruling.Grade.1inX
19	ME163	ME165	2572	4883	118
20	ME165	ME167	2311	4505	-498
21	ME167	ME169	2195	4927	-186
22	ME169	ME171	2732	4871	-236
23	ME171	ME16	2139	3129	156
24	ME16	ME21	990	2985	-191
25	ME21	ME191	1994	4483	-67
26	ME191	ME193	2489	4398	-61
27	ME193	ME195	1909	4524	-63
28	ME195	ME197	2615	4924	-76
29	ME197	ME199	2309	4835	-76
30	ME199	ME201	2526	3549	-72
31	ME201	ME334	1022	2622	-105
32	ME334	ME211	1600	4382	602

The 'ruling grade' (for this project the steepest downhill gradient) has been included in the signal spacing table. For Figure 22, where spacings are relatively long compared to stopping distances, this is of limited use. In general, a positive ruling grade can indicate gradient sensitivity can be discounted for a particular section (depending on spacing). A steep downhill ruling grade tends to necessitate further investigation to determine the length over which the gradient applies.

To inform decisions on size of opportunities, sections of continuous linespeed have also been outputted in table form, with the minimum two block distance and ruling grade identified.

For Lewisham – Dartford via Eltham, Figure 23 provides an example of this data.

Figure 23 Screenshot of example output table of linespeed sections along a route, summarising minimum two-block distance and ruling grade

SectionID	LinespeedUpper	LinespeedLower	DesignSpeed	Class6Speed	Section.Dist.Metres	Minimum.Two.Block.Meterage	Ruling.Grade
1	20	20	60	40	240	940	-193
2	60	40	60	40	1620	933	-122
3	20	20	60	40	287	1132	-138
4	60	40	60	40	2290	1137	-48
5	30	30	60	40	904	931	-70
6	60	40	60	40	1809	932	-74
7	60	35	60	40	1166	1110	226
8	60	40	60	40	2832	1020	-1064
9	60	30	60	40	3378	1001	-1064
10	35	35	60	40	497	892	98
11	20	20	60	40	80	892	-820
12	60	40	60	40	1718		-385
13	40	40	60	40	516		2439
14	20	20	60	40	280		-168

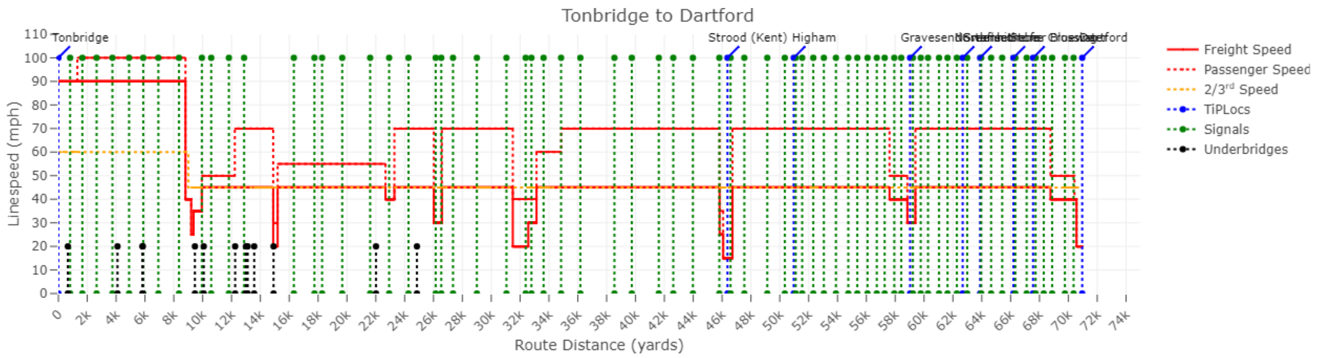
Section 5 and 10 correspond to low linespeeds, suggesting infrastructure limits. This was investigated in phase 2. From section 6-9, passenger linespeed is 60 while freight linespeeds do not exceed 40 mph. These sections cover c.9 km.

This limited opportunity for improvement may be further constrained by signal spacings just over 1000m. Section 6, with shortest spacing of 900 m and a ruling grade of -1 in 74 necessitates more detailed exploration.

Overall, routes on the longlist offer a range of opportunities, and barriers to realising them. Tonbridge – Dartford has a number of sections with passenger/freight speed differentials, shown in Figure 24.

These sections are periodically interrupted by sections of low linespeed (likely infrastructure limitations). Shorter signal spacings (green) between Higham and Dartford mean larger benefits are likely to be realised between Tonbridge (9000 yards from start) and Higham.

Figure 24 Plot of linespeeds and signal spacing for Tonbridge to Dartford

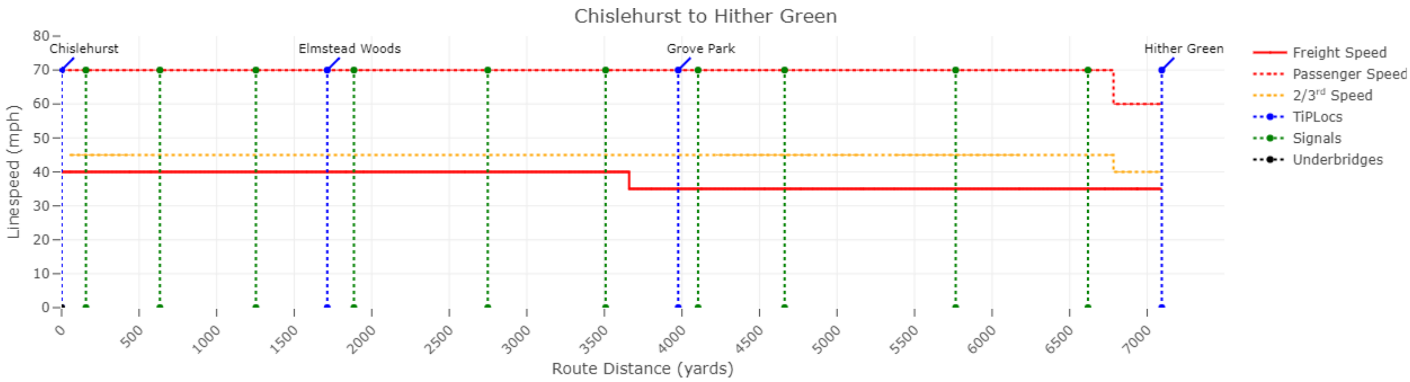


Chislehurst – Hither Green, a much shorter route, presents an equivalent plot shown in Figure 25.

Unlike the Southbound version of the same route, there is a signed freight speed (solid red). The signed freight is lower than the limit (45 mph) produced through application of the Two Thirds Rule to this route's design speed.

Two block distances here are low enough (1002 m and 1055 m in the worst cases) to prevent sustained 70 mph operation yet will be high enough to permit increases to the existing freight speed.

Figure 25 Plot of linespeeds and signal spacing for Chislehurst to Hither Green



6 Infrastructure compatibility and potential EF speeds

6.1 Introduction

The long list of sites identified in the previous section was then assessed to consider whether the infrastructure was suitable for enhanced speeds and to quantify the potential range of EFs. This assessment was used to select three routes from the long list to be used as case studies for in depth analysis of the potential benefits of EFs in the next phase of the work.

6.2 Initial analysis of the longlist locations

The locations were initially assessed by looking at the existing passenger train frequency and speed. These are 'non-physical' infrastructure constraints as:

- on a route with a high passenger train frequency the opportunity to accelerate freight trains is very limited as they will quickly catch up with the train in front
- on a route with many stops the average passenger train speed can be very low, meaning opportunity to accelerate freight trains is very limited as they will quickly catch up with the train in front.

Table 5Table 5 below shows the result of this analysis.

Table 5 Evaluation of initial long list opportunities

	Route	Passenger service frequency	Average speed of 'slow' trains
1	Paddock Wood – Dartford (Strood)	Off peak 1 tph e/way	27 mph
2a	Dartford – Lewisham (via Woolwich)	Off peak 6 tph e/way (to Plumstead)	22 mph
2b	Dartford – Lewisham (via Eltham)	Off peak 6 tph e/way	22 mph
2c	Dartford – Lewisham (via Sidcup)	Off peak 4 tph e/way	20 mph
3	Lewisham – Clapham	Off peak 6 tph e/way Clapham High Street – Peckham Rye	17 mph
4	Hither Green – Chislehurst	Off peak 4 tph e/way on slow lines	22 mph
5	Bat & Ball – Swanley	Off peak 2 tph e/way stopping Thameslink, plus 2tph semi fast	28.5 mph (stopping train)
6	Ashford – Swanley	Off peak 1 tph e/way	37 mph
7	Willesden – Channelsea Jcn	Off peak 6tph e/way	16 mph
8	Barking – Stanford-Le-Hope	Off peak 2 tph e/way, 4 tph from Grays	39 mph

6.2.1 High frequency, low speed routes

Lewisham to Clapham along the South London Line (Opportunity 3), the North London Line between Willesden and Channelsea Junction (Opportunity 7) and the Eltham branch line (Opportunity 2b) all have a 6 train per hour (tph) service and respective average speeds of 17 mph, 16 mph and 22 mph respectively.

These service constraints preventing these locations being short-list locations as significant freight train speed improvement is not possible with these passenger frequencies and speeds.

Hither Green to Chislehurst (Opportunity 4) has a 4 tph service and an average speed of 22 mph. Freight train acceleration would be difficult here and other routes offer better opportunity for improvement.

6.2.2 Overlapping and complementary routes

The Bat and Ball to Swanley route (Opportunity 5) could be consolidated into the wider Ashford – Swanley route (Opportunity 6) so the latter was taken forward.

The Woolwich branch (Opportunity 2a) combines with the Sidcup branch (Opportunity 2c) to provide the routing for many freight trains from the Angerstein and Isle of Grain freight terminals. These were therefore consolidated into one opportunity: Charlton, Slade Green, Sidcup, Lewisham.

6.2.3 Conclusion of initial analysis

The following four opportunities were taken forward to more detailed analysis:

- Barking – Stanford Le-Hope
- Ashford – Swanley
- North Kent: Charlton to Lewisham via Sidcup and Slade Green
- Tonbridge to Dartford

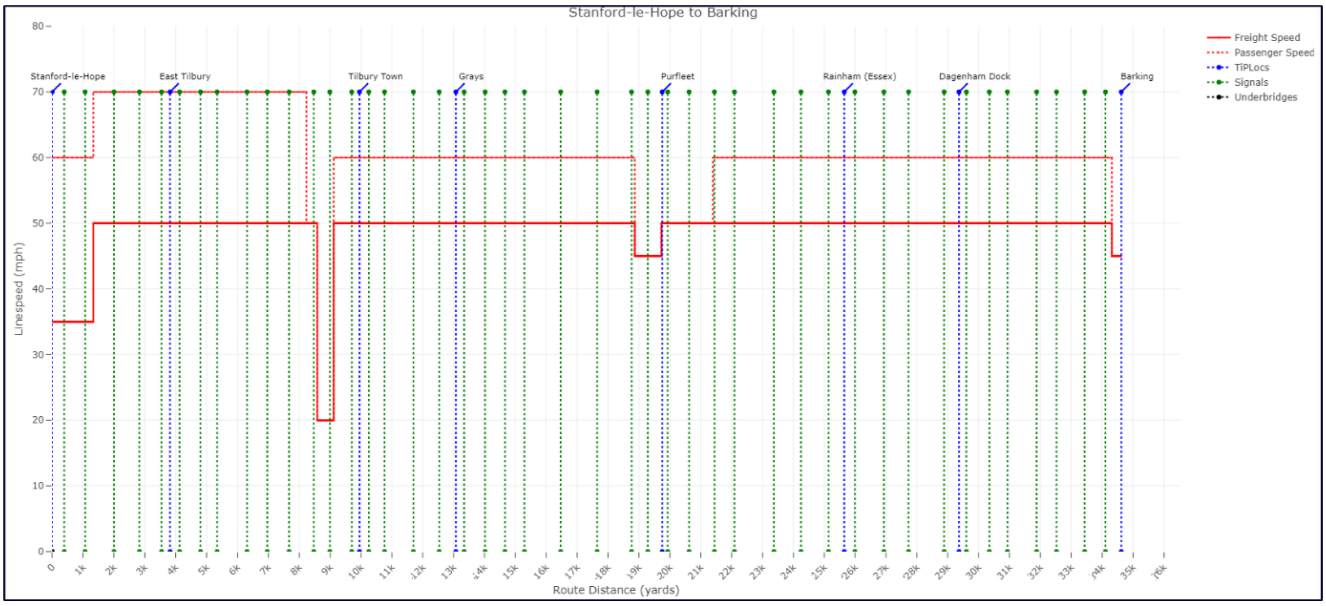
6.3 Individual route analysis

6.3.1 Barking – Stanford Le-Hope

6.3.1.1 Local constraints

Figure 26 below shows the current freight speed (50 mph generally: solid red line) and line speed (60 mph generally: faint red line). For context, the position of signals (vertical green lines) and TiPLocs (vertical blue lines) along the route are shown.

Figure 26 Barking - Stanford Le-Hope line speed



London Gateway Port is around 2 km from Stanford-le-Hope. There is a 30 mph speed restriction approaching Tilbury East Station (9 km from Stanford), a 45 mph speed restriction at Purfleet (20 km from Stanford), and another 45 mph speed restriction approaching Barking (24 km from Stanford).

Without raising these speed restrictions, particularly at Purfleet, there is little possibility of raising the freight speed, and only a 10 mph benefit if that can be achieved.

Note: notwithstanding the speed restrictions, if the whole line speed could be raised from 50 mph to 60 mph from Gateway to Barking the saving would be around 2.5 minutes.

The 30 mph speed restriction is caused by track curvature coming into Tilbury East, see Figure 27 below, from Google Maps.

Figure 27 Route curvature east of Tilbury East station

The ‘U’ shaped curve can be clearly seen and there is a reverse curve immediately to the east of this where the track alignment enabled an old connection into Tilbury Docks through the gap between the parked cars at the bottom of the image.

Due to the lineside development a significant reduction of this curvature is not possible and, as the track is electrified, any alignment would be very expensive.

A similar curvature issue approaching Purfleet station from the east limits to the line speed to 45 mph within a narrow rail corridor.

This combination of difficult/impossible to change speed restrictions and limited absolute improvement in time saving led the project team to decide this route was not one of the three locations to be considered for more detailed timing work.

6.3.2 Ashford – Swanley

6.3.2.1 Local constraints

The local infrastructure speed restrictions are shown in Table 6 below.

Table 6 Ashford - Swanley local infrastructure restrictions

Swanley – Ashford: list of local speed restrictions			
ID	**Location**	**Description**	**Possible reason for speed reduction**
1	East of Swanley station	25 or 20 mph depending on the line.	Pointwork, switch crossing
2	Swanley – Otford	55 mph line restriction	Approximate to lowest of signal spacing allowances
3	Otford – Otford Junction	40 mph and then 30 mph through junction	Curvature after Otford Junction, 600 m where R = 400 m
4	Barming – Maidstone East	60 mph then 50 mph restriction	Curvature. 1800 m where R = 860 m
5	Maidstone East	25 mph either side and through station	Curvature. 350 m at R = 400 m, 700 m at R = 800 m
6	Approach to Bearsted stn.	50 mph on approach	Curvature. 600 m where R = 620 m
7	Harrietsham - Hollingbury	70 mph	Possibly weak structure, presence of rail viaduct
8	Approach to Ashford Station	40 mph across Maidstone junction	Pointwork

There are significant 20 mph speed restrictions at Swanley and Maidstone East stations, 30 mph at Otford Junction and 40 mph approaching Ashford station. These restrictions are all linked to track curvature and, in some locations, the crossing of relatively low speed junctions. These restrictions also apply to passenger traffic and so cannot be mitigated without significant cost (or they would have been sorted out), so we have considered them ‘fixed’ for the purposes of our further analysis.

There are three level crossings on the route, but as they are considered acceptable for interface with higher speed passenger trains, we do not consider them a constraint on developing improved freight timings. There do not appear to be any other infrastructure constraints on the route.

6.3.2.2 EF opportunities

Figure 28 below show the existing line speeds and potential EF speeds (magenta) based on stopping distance.

Figure 28 Ashford - Swanley line speeds and applicable Two Third Rule speeds

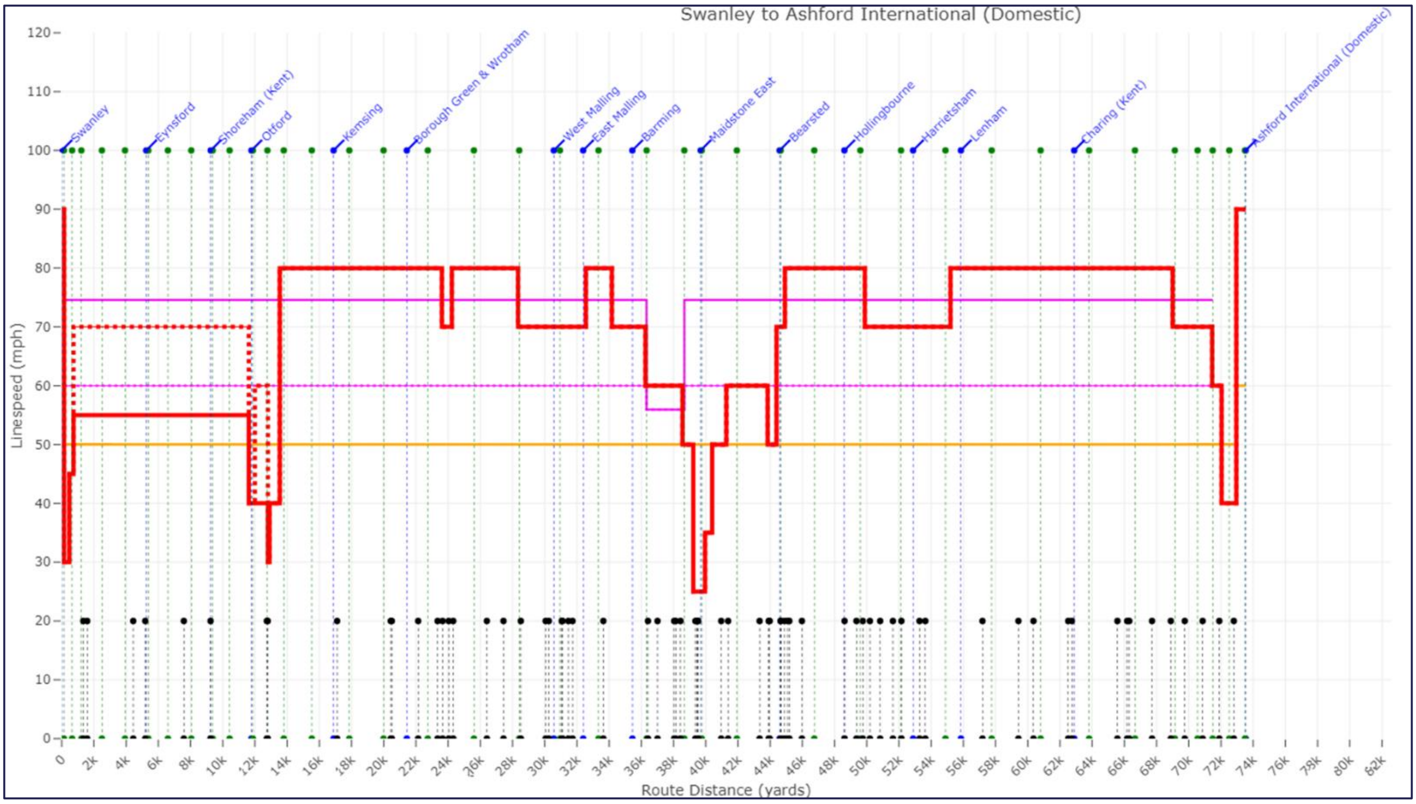


Table 7 below shows the EF speeds which can be achieved on this route.

Table 7 EF opportunities between Swanley and Ashford

Location	Current (mph)	EF speed		
		<P> timings (mph)	<G> timings (mph)	Length (km)
Swanley – Otford	50/55	70	60	10
Otford – Bearstead	50	70	60	19
Bearsted – Ashford	50	70	60	26

We do not believe that there are any other infrastructure constraints which will stop the adoption of these EF opportunities, but they will clearly have to be approved by the Southern Region’s track, gauging and bridge engineers.

6.3.3 North Kent: Charlton to Lewisham via Sidcup and Slade Green

6.3.3.1 Extension to Angerstein Wharf

When analysing this route it became obvious that the majority of traffic using this opportunity will be aggregate trains in to and out of Angerstein Wharf. Angerstein Wharf is a terminal primarily for the importation of sea dredged aggregate for the London and South East market, with Tarmac, Cemex, and the Day Group having active rail terminals there which generate around 15 freight trains a day. This puts in the top ten of locations within the country which generate freight traffic.

We therefore extended the route analysis from Chalton to Angerstein Wharf to make the results of this research more useful to the rail freight market.

6.3.3.2 Local constraints

The local infrastructure speed restrictions are shown in Table 8 below.

Table 8 North Kent lines local infrastructure restrictions

Angerstein terminal to Lewisham by Slade Green and Sidcup			
ID	**Location**	**Description**	**Possible reason for speed reduction**
1	Angerstein Junction	15 mph	Pointwork
2	Through Woolwich Dockyard and Woolwich stations	30 mph	Ch 8.14 to 9.21, then 40 mph to ch 9.75. Curving profile R = 450 to 900.
3	Plumstead to Dartford	40 mph	Two Thirds Rule
4	Crayford curve	10 mph	Curvature R = ~250m
5	Crayford – Mottingham	40 mph	2/3rd limit (?)
6	Bexley – Sidcup	35 mph on down line	Unsure
7	Hither Green Junction	20 mph	Pointwork
8	Courthill Loop	20 mph	Pointwork and curvature

The Angerstein Wharf connecting curve has a sharp radius and the pointwork there is restricted to 15 mph. The track then ‘snakes’ through Charlton and Woolwich through a series of tunnels and reverse curve track arrangements with a 30 mph speed restriction.

At Plumstead the line takes a much straighter alignment, probably indicating the edge of the urban area when the line was built. The route is then primarily speed-restriction free all the way to Lewisham with the exception of the connecting chords at Crayford, Hither Green and the Courthill ‘Loop’ (not actually a loop but two adjacent lines which are both steeply curved and have a high gradient). These introduce 10 mph and 20 mph local speed restrictions.

As these restrictions are all linked to track curvature, or the crossing of relatively low speed junctions, and also apply to passenger traffic, we believe they cannot be mitigated without significant cost, so we have considered them ‘fixed’ for the purposes of our further analysis.

There is only one level crossing on the route, immediately before Charlton station, but this is not a location where EF speeds are being proposed. There do not appear to be any other infrastructure constraints on the route.

6.3.3.3 EF opportunities

Figure 29 and Figure 30 below show the existing line speeds and potential EF speeds based on braking distance. We have split this route into two graphs.

Figure 29 Lewisham - Dartford line speeds via Woolwich

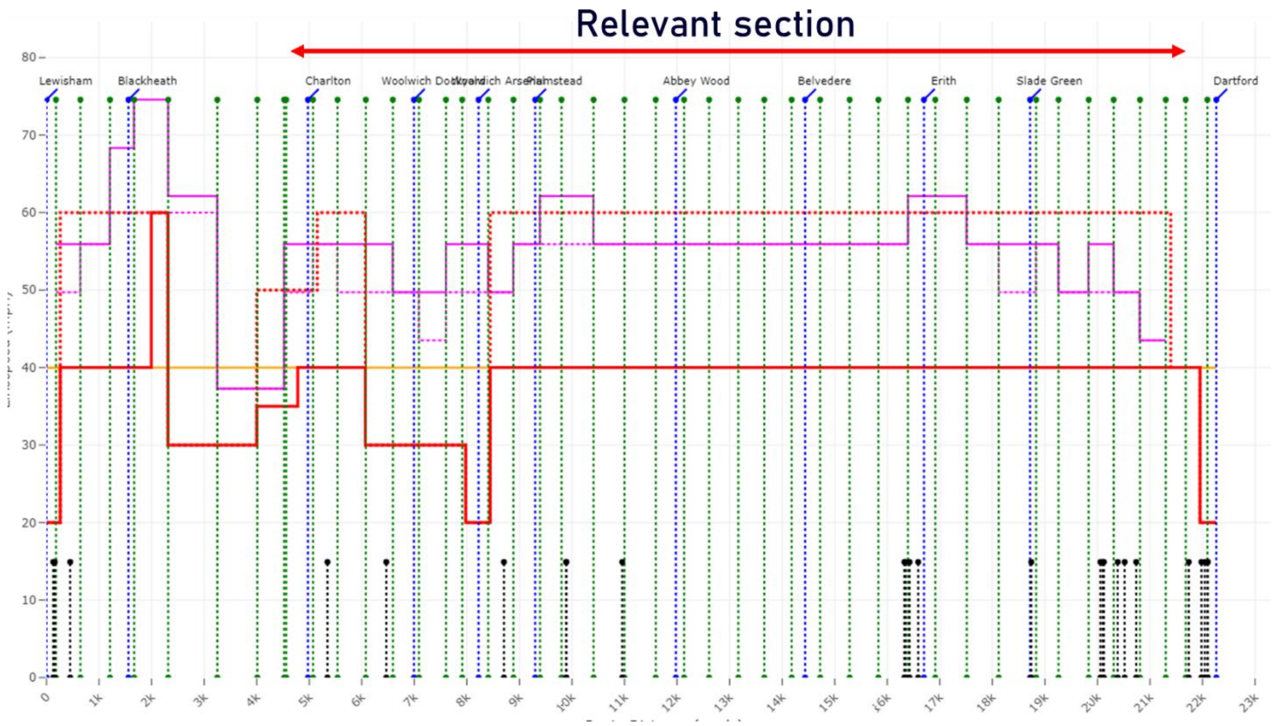


Figure 30 Lewisham - Dartford line speeds via Sidcup

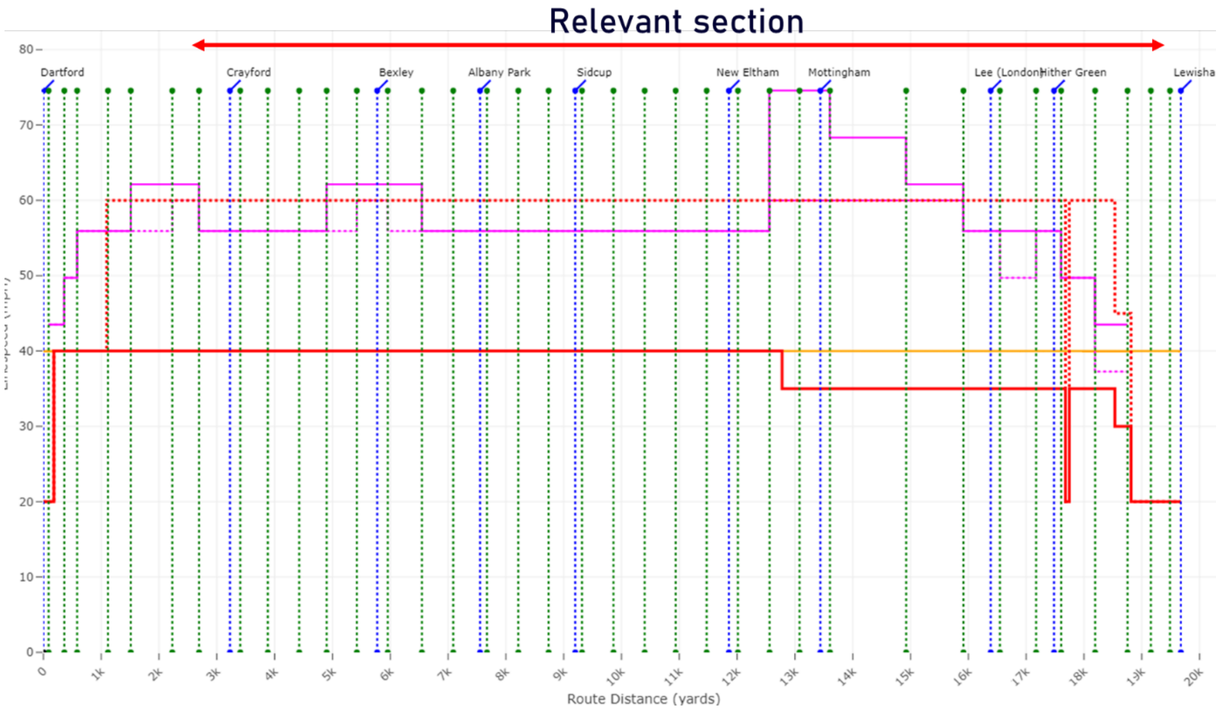


Table 9 below shows the Ef speeds which can be achieved on this route.

Table 9 Opportunities between Plumstead and Hither Green

Location	Current (mph)	EF speed		
		<P> timings (mph)	<G> timings (mph)	Distance (km)
Plumstead – Slade Green	40	55	50	10
Crayford Junction – Hither Green	40	55	50	13

We do not believe that there are any other infrastructure constraints which will stop the adoption of these EF opportunities, but they will clearly have to be approved by the Southern Region's track, gauging and bridge engineers.

6.3.4 Tonbridge to Dartford

6.3.4.1 Local constraints

The local infrastructure speed restrictions are shown in Table 10 below.

Table 10 Tonbridge - Dartford line speeds

Dartford to Tonbridge – list of local speed restrictions			
ID	**Location**	**Description**	**Possible reason for speed reduction**
1	Dartford station	20 mph running through and adjacent to the station	Curvature R = 400 to 800 m for 800 m and possible lack of signal overrun length
2	Gravesend station	30 mph running through and adjacent to the station	Curve. R = 800/650 for 800 m through station
3	Strood station	15 mph running through and adjacent to the station	Curve. R = 250/300 m over 200 m to the north of the station followed by junction (20 mph)
4	Aylesford	30/35 mph running through and adjacent to the station	Curve. R = 400 to 900 over 1800 m around station
5	Maidstone West	30 mph running through and adjacent to the station	Curve. Continuous curving from Maidstone West through to East Farleigh. R range from 400 to 800 m over this track length.
6	Yalding	20 mph running through and adjacent to the station	Curve. R = 850 for around 600 m through station
7	Paddock Wood station	25 mph through station	Curvature through station and movement across various pointwork

There are eight local speed restrictions all linked to track curvature, which in places are very severe. This leads to very low speed restrictions, for example 15 mph around Stroud station and 20 mph through Yalding. They also apply to passenger traffic and so we believe they cannot be mitigated without significant cost. We have therefore considered them ‘fixed’ for the purposes of our further analysis.

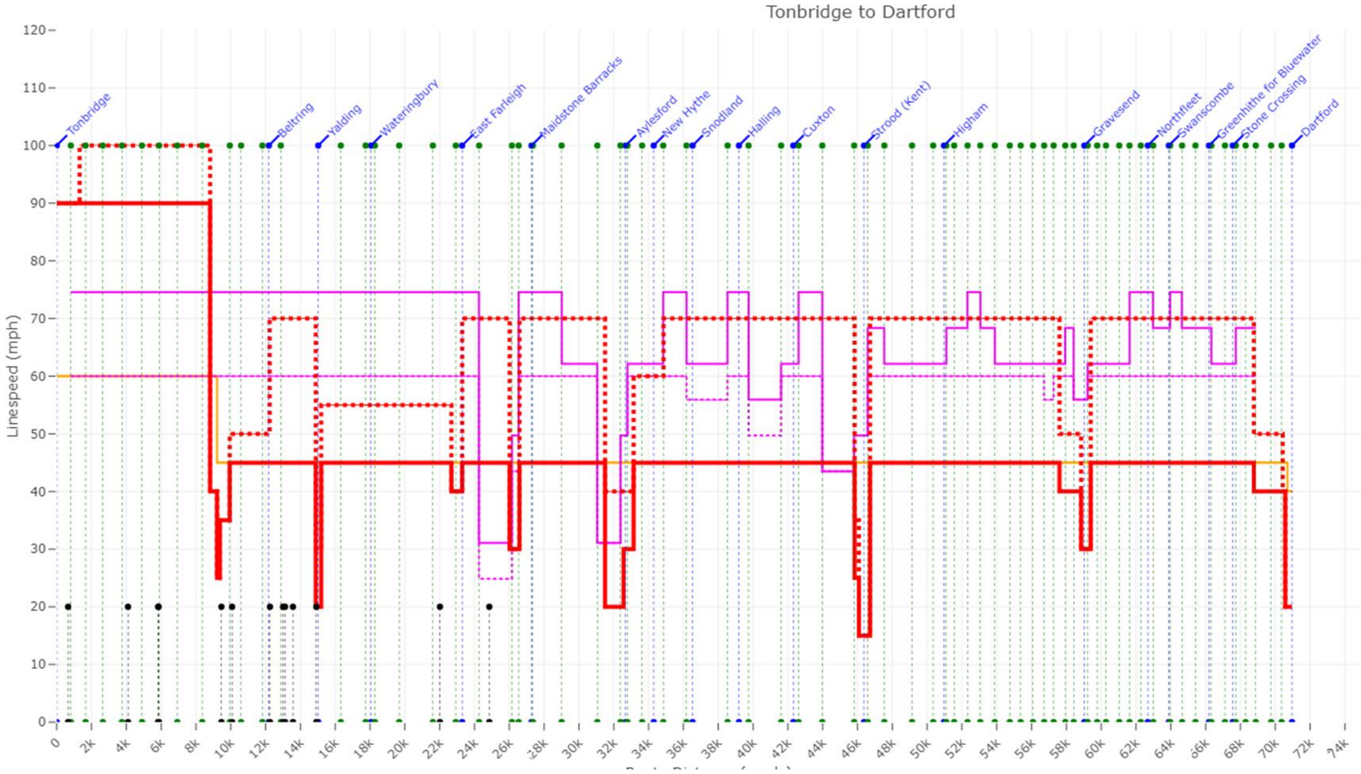
There are 22 level crossings on the route, most of which are between Ashford and Maidstone. However, they are all cleared for the higher passenger line speed so they could accommodate an EF speed. There do not appear to be any other infrastructure constraints on the route.

6.3.4.2 EF opportunities

Location	Current (mph)	EF speed		
		<P> timings (mph)	<G> timings (mph)	Distance (km)
Yalding – Maidstone Barracks	45	60 (40 at East Farleigh)	60 (40 at East Farleigh)	11
Maidstone Barracks – Aylesford	45	60	60	4
Aylesford – Strood	45	55	55/50	11
Stroud – Gravesend	45	60	60/55	10
Gravesend – Dartford	45	60	60	9

Figure 31 below shows the existing line speeds and potential EF speeds (magenta) based on stopping distance.

Figure 31 EF opportunities between Tonbridge and Dartford



Although the signal spacing generally allows faster running the number and proximity of the local speed restrictions restricts their practical usage.

Between Tonbridge and Paddock Wood the current freight line speed is already 90 mph as part of the Channel Tunnel route.

Table 11 below shows the EF speeds which can be achieved on this route.

Table 11 EF opportunities between Tonbridge and Dartford

We do not believe that there are any other infrastructure constraints which will stop the adoption of these EF opportunities, but they will clearly have to be approved by the Southern Region's track, gauging and bridge engineers.

6.4 Summary of proposed enhanced freight speeds

Table 12below shows the proposed enhanced freight speeds from the above analysis.

Table 12 Summary of proposed Enhanced Freight (EF) speeds

Route	Location	Current (mph)	EF speed		
			<P> (mph)	<G> (mph)	Length (km)
Swanley - Ashford	Swanley – Otford	50/55	70	60	10
	Otford – Bearstead	50	70	60	19
	Bearsted – Ashford	50	70	60	26
Angerstein Wharf – Lewisham via Woolwich & Sidcup	Plumstead – Slade Green	40	55	50	10
	Crayford Junction – Hither Green	40	55	50	13
Tonbridge - Dartford	Yalding – Maidstone Barracks	45	60 (40 at East Farleigh)	60 (40 at East Farleigh)	11
	Maidstone Barracks - Aylesford	45	60	60	4
	Aylesford – Strood	45	55	55/50	11
	Stroud - Gravesend	45	60	60/55	10
	Gravesend - Dartford	45	60	60	9

Over the three routes 135 km of line has been identified as suitable for EF speed running. Generally, a minimum 15 mph increment has been identified, representing a nearly 40% speed increase on the North Kent route and a 33% increase on the Tonbridge – Dartford Route.

7 Impacts of enhanced freight speeds on timing and train paths

7.1 Introduction

To assess the potential benefits the following analysis was undertaken for each of the selected case study routes:

- Using the SRTcalc model, developed in the T1302 project, new timings were calculated for each case study area, working within the maximum speed threshold defined by the braking distance calculator and its comparison with the signal spacing.

- Generally new timings were calculated for two different train weights and two different locomotives to enable an appreciation of the sensitivity of the results and the difference between locomotive classes

- The new timings were then input into the ATTune train planning software to identify the opportunity for improved train pathing for a selected typical freight headcode.

7.2 Development of revised Sectional Running Times

For each of the three case study routes, a representative path from the timetable was identified (if available) and its consist determined. This took place for both directions of each case study, giving 6 services to be modelled.

Initial modelling focused on a typical consist and used T1302 modelling assumptions. The T1302 project identified problems with existing SRTs (for example including not correctly accounting for the length of the trains). Therefore, services were also modelled with T1302 assumptions to give an accurate baseline to compare T1348 improvements against. T1301 applied the T1302 methodology to several case studies to further explore the reasons for problems with existing timings.

Modelling also took place on passenger line speeds to provide a comparative passenger baseline for the definition of EF margins. For example, if Stopping-Performance Limiting (SPL) speeds (see Section 5.2.5) oscillated between 70 and 75 mph but a modelled train was only able to run above 70 mph for 2 miles, a consistent EF speed of 70 mph was set).

Once potential EF speeds had been calculated for the 6 services they were remodelled with Class 70 traction. The Class 66 modelling gave a like-for-like comparison with the initial modelling, enabling the quantifying of time benefits offered by EF speeds. Modelling with a Class 70 locomotive enables an understanding of the sensitivity of benefits and whether additional traction power would bring additional benefit when combined with higher speeds.

7.3 Route specific assessment

7.3.1 Methodology

The modelled run times for specific paths were converted to SRTs using the rounding methodology specified in the National Timetable Planning Rules (TPRs). These were then passed on to the project's train planning team for input into ATTUne to determine whether these could have a meaningful impact on the train path. The amended timings were input as adjustments to the existing SRTs. Paths were investigated for a Wednesday using the May 2025 timetable (prior Working Timetable Version) obtained from Network Rail. The investigation focused on:

- possible improvements to journey times
- possible increases in the timing load of the train
- any other benefits the revised methodology could provide.

ATTUne checks the compliance of each train path with the latest (2025 v4) version of Network Rail TPRs. Where non-compliances were flagged up within the study area these were corrected. Paths remained unchanged beyond the study area. Suggestions for minor changes to paths of adjacent trains were proposed where appropriate.

7.3.2 Ashford – Swanley

The paths studied were:

- 6O27: 06:06 Whatley Quarry – Hothfield Siding 12:57 (Freightliner, Class 66, 1800t timing load, heavy axle-load, 60 mph)
- 6M45: 06:52 Dollands Moor Sidings – Daventry International RFT 12:48 (DB Cargo, Class 66, 1800t timing load, 60 mph).

7.3.2.1 Towards Ashford

The path of train 6O27 was selected despite it not traversing the entire length of the section. It was selected because of its characteristics in terms of maximum speed and time of day. A service destined for Hothfield works was modelled as far as Beechbrook Farm sidings (where the service waits a significant period before crossing the mainline and entering Hotfield sidings). Subsequent timings have not been modelled as they include a large portion of off-network running, which T1301 demonstrated were difficult to calibrate, and cover low speed manoeuvres unlikely to take place under pressure from other traffic on the network.

Table 13 Swanley – Beechbrook section timings

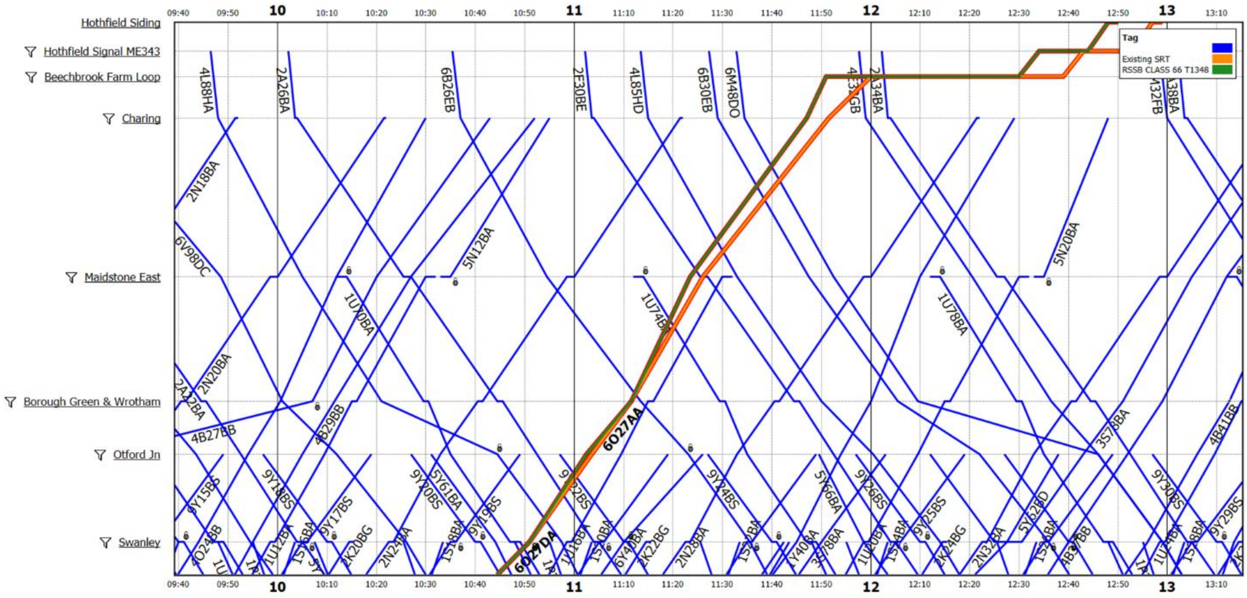
Route section	Current SRT	Modelled IRT	Delay
SWLY - OTFORDJ	11	11	0
OTFORDJ - BORWGAW	8	9	1
BORWGAW - MSTONEE	14	11.5	-2.5
MSTONEE - CRNG	24.5	23.5	-1
CRNG - BCHBKFM	7.5	4	-3.5

Table 13 displays the current SRTs for this route alongside the rounded modelled timings produced with the T1302 methodology and enhanced speeds identified in Chapter 6. The first four sections coincide with trains pathed from Swanley to Ashford.

The first opportunity section, between Otford Junction and Maidstone East, has modelled timings 90 seconds faster than modelling with the existing linespeed limits. The modelled time between Otford Junction and Borough Green is 9 minutes in both cases, suggesting this current SRT is inaccurate.

The second opportunity section, covering the final two SRT sections, similarly has 90 seconds difference between modelled times at existing and enhanced linespeeds. Modelled times are significantly faster than modelled times in the final section to Beechbrook Farm. This SRT is only 1 minute faster than the corresponding SRT to Ashford which covers roughly double the distance, suggesting modelled times are reasonable.

Figure 32 Time-distance graph showing different versions of path towards Ashford



The graph shows the section of route between Swanley and Hothfield siding with two versions of path 6O27 (orange = existing SRTs, green = modelled SRTs). Timings between Beechbrook Farm and Hothfield Siding have not been modelled or otherwise altered. The modelled timings allow for a reduction of journey time of 9 minutes in total; however, this includes a 3.5-minute reduction in journey time on the last section of the path, between Charing and Beechbrook Farm Loop.

The relatively low frequency of passenger trains on the section between Swanley and Ashford (1 tph to/from Maidstone East, 1 tph to/from Ashford International) means that these do not hinder the path of the freight train studied. The entirety of the difference between existing and modelled SRTs could thus be translated into a journey time reduction.

Table 14 displays end-to-end modelled times alongside the current SRTs. A 3-minute reduction is possible to the more accurate T1302 baseline, 3-minute benefit is offered by enhanced speeds, a further 2.5 minute reduction could be achieved operating with Class 70 traction.

Table 14 Summary of Swanley – Beechbrook timings

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs	65	-
T1302	62	-3
T1348 (enhanced speeds)	59	-6
T1348, with Class 70	56.5	-8.5

7.3.2.2 Towards Swanley

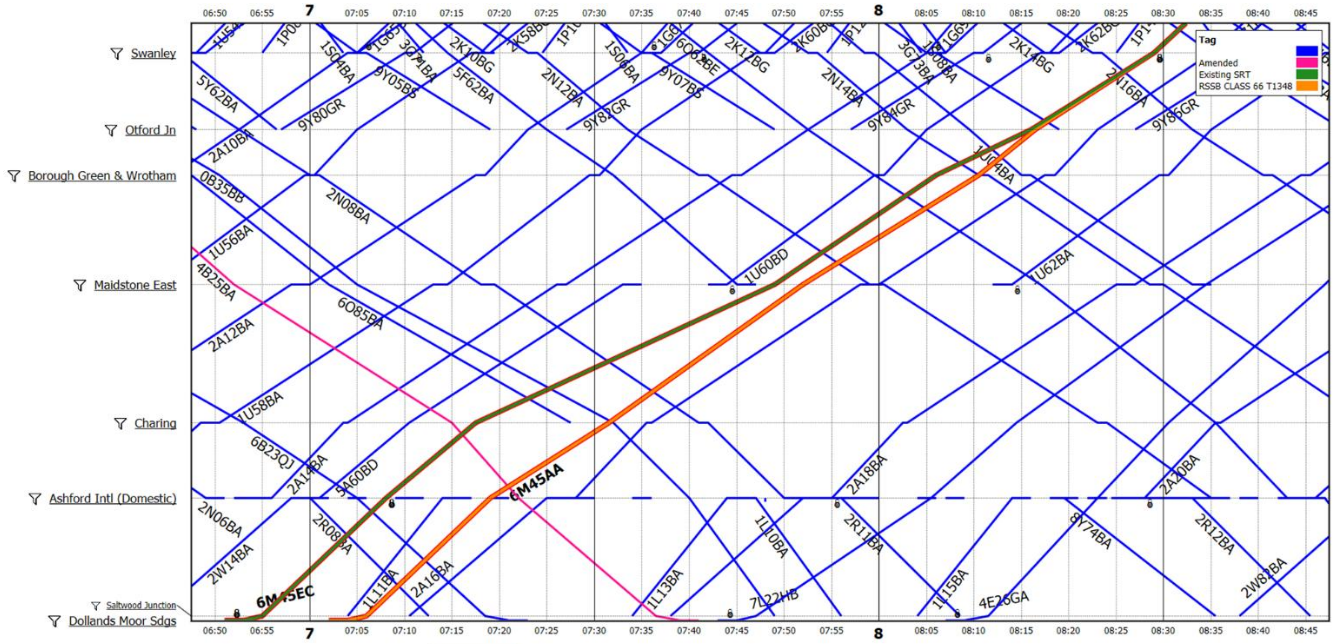
In the reverse direction, Ashford – Swanley, the entire route was modelled. Table 15 summarises the end-to-end timings.

Table 15 Ashford – Swanley timing summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs	66.5	-
T1302	65.5	-1
T1348 (enhanced speeds)	61.5	-5
T1348, with Class 70	58.5	-8

Similar to Swanley – Beechbrook, the T1302 baseline is slightly faster than existing SRTs. EF speeds offer a total of 4 minutes benefit (relative to the T1302 baseline). Up to 8 minutes reduction of the existing SRTs is possible with Class 70 traction which permits more rapid acceleration to higher speeds.

Figure 33 Time-distance graph showing different versions of path towards Swanley



The graph shows the section of route between Dollands Moor Siding and Swanley with two versions of path 6M45 (green = existing SRTs, orange = modelled SRTs). The modelled timings are 5 minutes faster than existing SRTs. However, this reduction, together with a reduction of pathing time contained within the path and a slight amendment to path 4B25 (shown pink on the graph above) in the Ashford area, allows the overall journey time for path 6M45 to be reduced by 11 minutes. As with path 6O27 in the opposite direction, this is largely possible by the relatively low frequency of passenger trains between Ashford and Swanley.

Table 16 shows the difference between modelled timings (with EF speeds) and current SRTs. In two sections increases to the current timings are necessary, these are offset by time reductions in the following section (the first increase is only 30 seconds. T1302 identified consecutive SRTs may be adjusted by 30 seconds to ensure a train ran ahead of schedule). The two opportunity sections (covering the first pair of SRTs, 3rd, and 4th SRTs) allow 1.5-minute and 2.5-minute reduction to current SRTs, respectively.

Table 16 Ashford – Swanley section timings

Route section	Current SRT	Modelled IRT	Delay
ASHFKI - CRNG	9.5	10	0.5
CRNG - MSTONEE	18	16	-2
MSTONEE - BORWGAW	17	18.5	1.5
BORWGAW - OTFORDJ	10	6	-4
OTFORDJ - SWLY	12	11	-1

The section Borough Green and Otford Junction features a significant portion of downhill running (in contrast to the reverse direction which has more uphill running) yet has a SRT 2 minutes longer than the reverse direction. The SRTs between Maidstone East and Otford Junction are inaccurate and hence modelled times with existing linespeeds are used as a baseline.

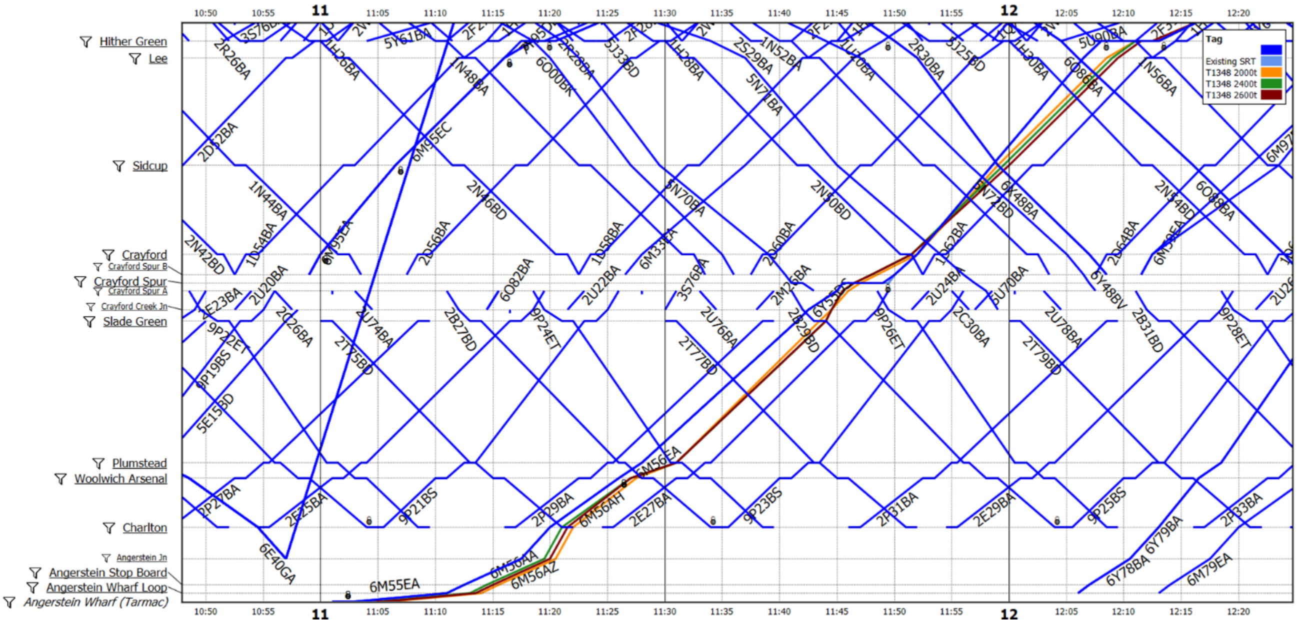
7.3.3 North Kent: Charlton to Lewisham via Sidcup and Slade Green

The paths studied were:

- 6M56: 11:03 Angerstein Wharf – Cricklewood Aggregates DBC 14:36 (DB Cargo, Class 66, 2000t timing load, heavy axle-load, 60 mph)
- 6O59 03:42 Wembley Receptions 1-7 – Angerstein Wharf 05:44 (GB Railfreight, Class 66, 2000t timing load, heavy axle-load, 60 mph).

7.3.3.1 Towards Lewisham

Figure 34 Time-distance graph showing different versions of path towards Lewisham



The modelled SRTs provide a run time reduction of 1.5 minutes compared to existing timings. This is a small reduction that does not permit a journey time decrease on this route, especially given the frequency of passenger trains operating in the study area. As such, the modelled SRTs represent an opportunity for increased resilience of the path in terms of performance.

Further tests were also carried out to determine whether this decrease in journey time means that this train can operate with a heavier timing load without a significant increase of journey time compared to today. It was determined that this train could potentially have a timing load of up to 2600t, however, this does not take into account any further operating restrictions and limitations on the portion of the path outside the study area.

The end-to-end timing benefit is only 1.5 minutes due to increases to certain SRTs that are required by the T1302 methodology. Timings calculated with the T1302 methodology (and existing linespeeds) are 1.5 minutes slower than existing SRTs. This means the net benefit of the EF speeds is 3 minutes.

Table 17 Angerstein – Lewisham timing summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs	41	-
T1302	42.5	1.5
T1348 (enhanced speeds)	39.5	-1.5
T1348, with Class 70	37.5	-3.5

The most notable increase to current SRTs is around Crayford Spur. T1302 highlighted the impact of not accounting for train length within existing timings. Failing to account for the requirement for the rear of trains to pass a linespeed increase before accelerating has a significant impact at low linespeed (the linespeed is 10 mph at Crayford Spur).

Table 18 Summary of proposed Enhanced Freight (EF) speeds

Route section	Current SRT	Modelled IRT	Delay
ANGRSTJ - CRLN	2.5	1.5	-1
CRLN - WOLWCHA	3.5	4	0.5
WOLWCHA - PLMS	2	1.5	-0.5
PLMS - SLADEGN	8.5	7.5	-1
SLADEGN - CRFDCKJ	1	0.5	-0.5
CRFDCKJ - CRFDSPA	1.5	1	-0.5
CRFDSPA - CRFDSPR	0.5	1	0.5
CRFDSPR - CRFDSPB	0.5	1.5	1
CRFDSPB - CRFD	1	3.5	2.5
CRFD - SIDCUP	6	6.5	0.5
SIDCUP - LEEE	8	6	-2
LEEE - HTHRGRN	1.5	1	-0.5
HTHRGRN - PKBGJUNCTION	3	2.5	-0.5
PKBGJUNCTION - LEWISHM	1.5	1.5	0

The first opportunity section (two SRT sections) between Plumstead (PLMS) and Crayford Creek Junction (CRFDCKJ) would enable this service to run 90 seconds faster than existing SRTs. A further 2.5 minutes benefit are available in the second opportunity section between Sidcup and Hither Green (Hither Green).

7.3.3.2 Towards Angerstein

In the reverse direction, similar increases to existing SRTs are required around Crayford.

Table 19 Timing comparison between Lewisham and Angerstein

Route section	Current SRT	Modelled IRT	Delay
LEWISHM - PKBGJUNCTION	1.5	1.5	0
PKBGJUNCTION - HTHRGRN	2	2.5	0.5
HTHRGRN - LEEE	2	2	0
LEEE - SIDCUP	9	8.5	-0.5
SIDCUP - CRFD	5	3.5	-1.5
CRFD - CRFDSPB	1	1	0
CRFDSPB - CRFDSPR	0.5	1.5	1
CRFDSPR - CRFDSPA	0.5	1	0.5
CRFDSPA - CRFDCKJ	1.5	3	1.5
CRFDCKJ - SLADEGN	1	1	0
SLADEGN - PLMS	8.5	6.5	-2
PLMS - WOLWCHA	1.5	1	-0.5
WOLWCHA - CRLN	4	4	0
CRLN - ANGRSTJ	2.5	1	-1.5
ANGRSTJ - ANGRSTB	3.5	1	-2.5

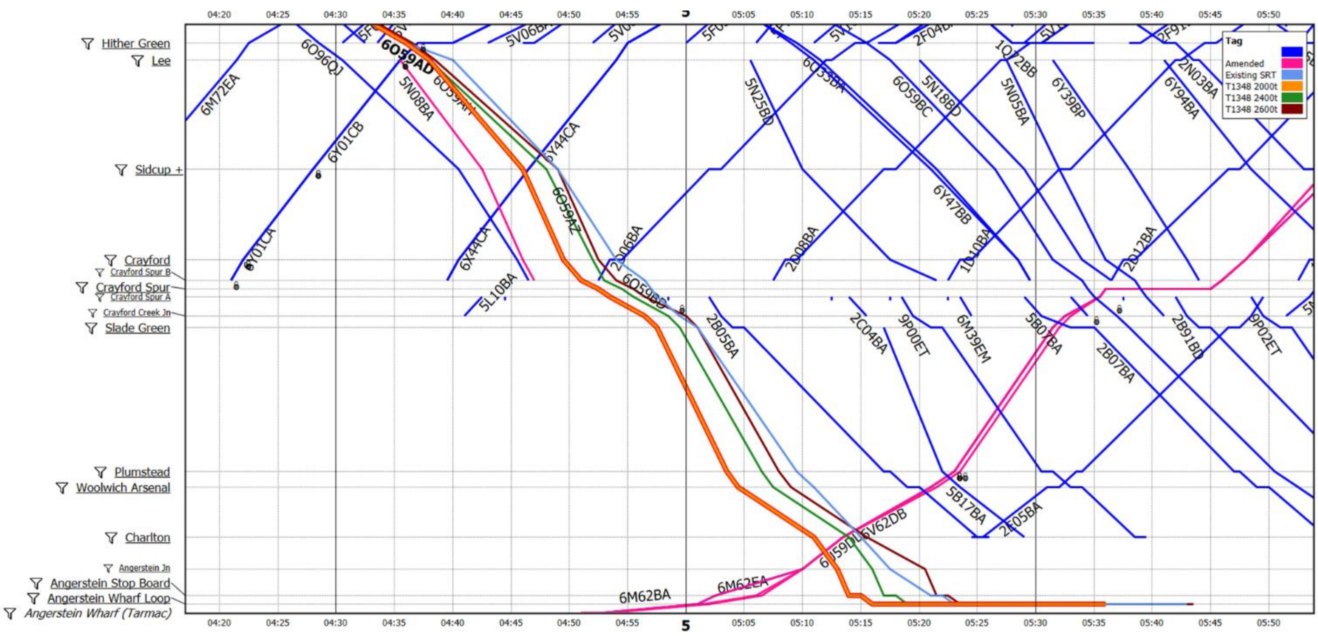
The opportunity sections offer 2 minutes (Lee – Crayford) and 2.5 minutes (Slade Green – Plumstead) runtime reduction against current SRTs. In this direction, we aren't able to accelerate above the current linespeed until just before Sidcup. This explains why more timing benefit is between Sidcup and Crayford instead of Sidcup and Lee.

Significant reductions to the final two SRTs could take place (including the off-network Angerstein Junction – Angerstein Stop Board). This has impact on end-to-end timings, offsetting the timing loss around Crayford Spur.

Table 20 Lewisham – Angerstein timing summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs	44	-
T1302	43.5	-0.5
T1348 (enhanced speeds)	39	-5
T1348, with Class 70	38	-6

Figure 35 Time-distance graph showing different versions of path towards Swanley



The modelled SRTs provide a run time reduction of 5 minutes compared to existing timings. However, four of the 5 minutes gained are between Charlton and Angerstein Wharf – right at the very end of the section studied. In the case of path 6O59, it was possible to reduce the journey time by 7 minutes in total, through a slight alteration of an empty coaching stock move that operates immediately before this path; as well as the departure time of path 6M62, which would need to depart Angerstein Wharf earlier in order to allow 6O59 to enter Angerstein Wharf earlier. Furthermore, this journey time reduction was largely possible thanks to path 6O59 running early on in the day. It is unlikely a reduction in journey time of a similar order of magnitude could be achieved by a freight operating in the middle of the day, among dense passenger traffic. Nonetheless, the difference between modelled and existing SRTs could at the very least be used to improve the performance of the path.

Further tests were also carried out to determine whether this decrease in journey time means that this train can operate with a heavier timing load without a significant increase of journey time compared to today.

It was determined that this train could potentially have a timing load of up to 2600t, however, this does not take into account any further operating restrictions and limitations on the portion of the path outside the study area.

7.3.4 Tonbridge to Crayford

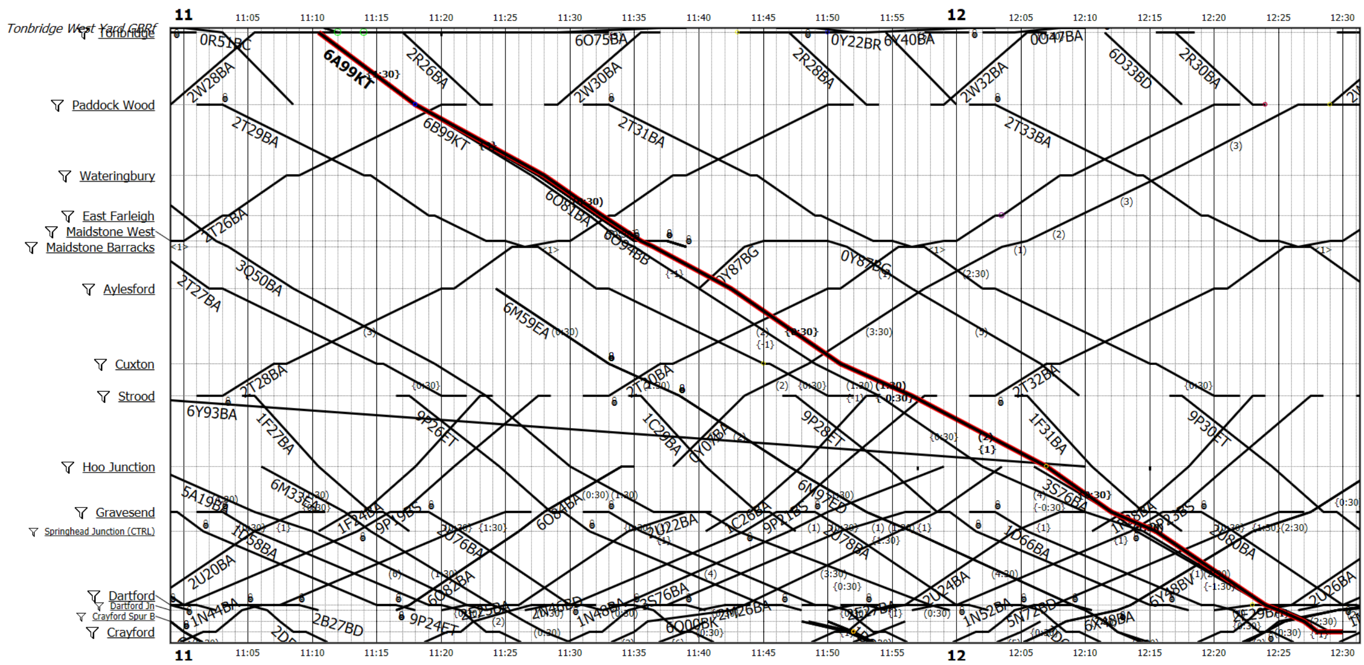
7.3.4.1 Timing Methodology

As there are no existing freight paths that traverse the whole route, it was not possible to estimate the impact of the modelled times on an actual path. As such, 'dummy' paths traversing the whole route were generated using existing and modelled SRTs and placed into the timetable around the middle of the day. The impact of the modelled SRTs was then estimated from this exercise.

7.3.4.2 Towards Crayford

The journey time using modelled SRTs is 5 minutes faster in total than the existing SRTs. However, the density of traffic (particularly between Dartford and Gravesend), as well as the alignment of the gaps between trains on the route between Crayford and Strood; and between Strood and Paddock Wood means that it is not possible to take advantage of any journey time improvements. The original 'dummy' path contains 14 minutes of pathing time between Tonbridge and Crayford, and the path created using modelled SRTs had to have 5 additional minutes of pathing time added to it to fit within the same gap as the original one. This does, however, provide an additional buffer that could improve the performance of this path.

Figure 36 Time-distance graph showing path towards Crayford



Modelling with the T1302 methodology is 1.5 minutes slower than the existing SRTs, some of the reasons for the are explored in Table 21. Across the multiple sections where faster, EF, speeds are possible, a time reduction of 6.5 minutes is achievable (5 minutes reduction to existing SRTs). An additional 1.5 minutes time saving could be delivered, using Class 70 traction.

Table 21 Crayford - Tonbridge timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs	70.5	-
T1302	72	1.5*
T1348 (enhanced speeds)	65.5	-5
T1348, with Class 70	64	-6.5

*TPR contain 1.5 minute adjustment

Table 22 shows the difference between current SRTs and modelled performance with EF speeds, following the T1302 methodology. This shows some of the faster timings possible with EF speeds, notably a 2-minute time reduction for the opportunity between Aylesford and Strood. Also shown are a number of sections (for example following Gravesend) where increases in SRTs are necessary. These increases are present in the baseline modelling where they are not offset by the benefits of enhanced speeds.

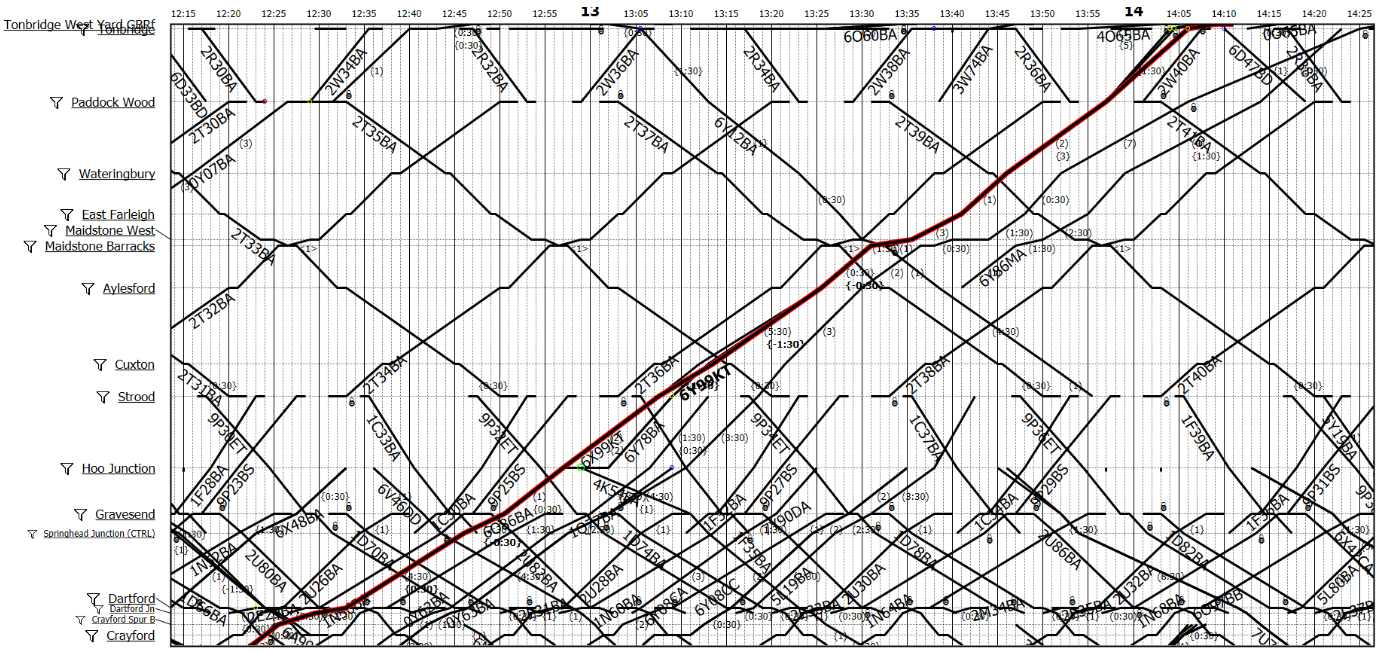
Table 22 Section times for Tonbridge - Crayford

Route section	Current SRT	Modelled IRT	Delay
TONBDG - PKWD	6	6	0
PKWD - WTRNGBY	10	9	-1
WTRNGBY - EFARLGH	4	4	0
EFARLGH - MSTONEW	3	2.5	-0.5
MSTONEW - MSTONEB	1	1	0
MSTONEB - AYLESFD	6	5	-1
AYLESFD - CXTN	8.5	7	-1.5
CXTN - STROOD	4	3.5	-0.5
STROOD - HOOJ	8.5	8.5	0
HOOJ - GRVSEND	5	4.5	-0.5
GRVSEND - SPHEADJ	2	3	1
SPHEADJ - GNHT	4	3.5	-0.5
GNHT - DARTFD	4.5	3.5	-1
DARTFD - DARTFDJ	1	1.5	0.5
DARTFDJ - CRFDSPB	2	1.5	-0.5
CRFDSPB - CRFD	1	1.5	0.5

7.3.4.3 Towards Tonbridge

The journey time using modelled SRTs between Crayford and Tonbridge is only 1 minute faster than the existing SRTs. As with the path in the opposite direction, it was not possible to capitalise on this difference due to the volume of passenger trains between Strood and Dartford; as well as the alignment of timetable windows between passenger trains on the sections between Paddock Wood and Strood; and between Gravesend and Dartford. This can, however, be potentially used as an additional performance buffer for this path.

Figure 37 Time-distance graph showing path towards Tonbridge



Initial modelling following the T1302 methodology suggest a 2 minute 30 second increase to current SRT is necessary for baseline timings (Table 23). This is due to required increases in sections following low linespeeds to reflect delayed acceleration waiting for the rear of the train to clear a linespeed restriction (explored further in Table 24). A 4 minute time reduction is possible to the baseline when running at EF speeds. A further 2 minutes of benefit could be extracted if using Class 70 traction.

Table 23 Crayford - Tonbridge timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs	68.5	-
T1302	71	2.5*
T1348 (enhanced speeds)	67	-1.5
T1348, with Class 70	65	-3.5

*TPR contains 1.5 minute adjustment

Table 24 shows the section times. There are a large number of sections where model times are faster than existing SRTs due to following the more accurate T1302 methodology. A handful of sections feature modelled times sizeably longer than existing SRTs. These typically follow linespeeds restrictions such as those at Dartford (20 mph), Strood (15 mph) and Maidstone West (30 mph).

Table 24 Section times for Crayford – Tonbridge

Route section	Current SRT	Modelled IRT	Delay
CRFD - CRFDSPB	1	1	0
CRFDSPB - DARTFDJ	1.5	0.5	-1
DARTFDJ - DARTFD	1	1	0
DARTFD - GNHT	4.5	6	1.5
GNHT - SPHEADJ	4.5	3.5	-1
SPHEADJ - GRVSEND	2.5	2	-0.5
GRVSEND - HOOJ	5.5	5	0
HOOJ - STROOD	8.5	6	-0.5
STROOD - CXTN	4.5	6	1.5
CXTN - AYLESFD	8	6.5	-1.5
AYLESFD - MSTONEB	5.5	5	-0.5
MSTONEB - MSTONEW	1	0.5	-0.5
MSTONEW - EFARLGH	3	3.5	0.5
EFARLGH - WTRNGBY	4	4	0
WTRNGBY - PKWD	10	7.5	-2.5
PKWD - TONBDG	6	9	3

There is a significant difference between the modelled time and SRT in the final section (Paddock Wood to Tonbridge). This follows the modelled train being exposed to a 25 mph linespeed limit before leaving the branch line and joining the mainline.

The SRT is based on an assumed pathing from Ashford. In that case a train would be up to speed, running at speeds far exceeding 25 mph. The TPR contains a 1.5 minute adjustment for this section which is insufficient to offset the speed differential.

7.4 Summary

Location	Timing considerations	Journey time improvement	Pathing considerations
Barking – Stanford Le-Hope	20 mph and 45 mph speed restrictions at Purfleet and Tilbury caused by tight radius track. These are difficult/very expensive to mitigate. Currently high freight speed against the line speed (50 mph against 60 mph) so limited opportunity for improvement.	Nothing significant.	No repathing undertaken.
Ashford - Swanley	Current freight speed is generally 50 mph and the passenger speed is generally 75 mph. There are four significant speed restrictions (1 x 45 mph, 2 x 30 mph and 1 x 25 mph) linked to either track curvature or track geometry at junctions on the 74 km route.	For a Clas 66: 6 min., eastbound (10%), 5 min westbound. Including mitigation of 1 min. of existing 'insufficient' timing.	9 minute reduction (14%) in eastbound journey time for path 6O27 (Class 66). 11 minute reduction (17%) in eastbound journey time for path 6O27 (Class 66). Train can depart 11 minutes later and arrive at the same time.
Angerstein – Lewisham via Crayford	From Angerstain/Charlton to Dartford the first 8.5 km of the journey is mainly 35/30 or 20 mph running due to track curvature. Beyond Woolwich there is opportunity to raise the freight speed from 40 to 50 mph over the next 10 km. From Dartford to Hither Green there is opportunity to raise the freight speed from 35/40 mph to 50 mph over 13 km.	For a Clas 66: 1.5 min. from Angerstein (<1%), and 5 mins to Angerstein, including mitigation of 1 min. of existing 'insufficient' timing.	No improvement from Angerstein although trailing weights could be increased from the current 2000 t to 2600 t within the sane timing run. Running to Angerstein the train could run 7 minutes faster.
Tonbridge to Crayford	In 8 locations on the 72 km route there are curvature and pointwork related speed restrictions of between 30pmh to 15 mph. In between the freight speed is 45 mph, against a passenger speed of 60 mph.	For a Clas 66: 5 min. from Tonbridge (<1%), and 1.5 mins to Tonbridge, including mitigation of 1.5 min. of existing 'insufficient' timing.	No significant improvement possible. Between Crayford and Stroud where is a dense passenger service and alignment of windows between Paddock Wood and Stroud, and Gravesend and Dartford.

8 Case studies of wider implications of proposed new differentials

A further three case studies were evaluated to investigate a wider range of design speeds (40, 45, 50, 75 mph) and also to consider the implications of the reduced speed for long Class 4 trains that was identified earlier in the project.

8.1 General methodology

As with the previous case studies, new running times were modelled using SRTcalc with the revised freight speeds applied to the route. The resulting Indicative Run Times (IRTs) were taken through to the ATTUne software suite, where they were applied to train paths to see what difference they made in the context of the wider timetable. The key difference from the methodology applied to previous case studies was that these timings were not applied to specific train paths, but were modelled using generic 'dummy' paths. These were then used to determine the potential of timetable changes on the studied routes across the whole day. For the purposes of this study, the analysis focussed on the May 2025 working timetable (WTT) for Wednesday 21May 2025.

8.2 Basingstoke – Southcote Junction

8.2.1 Introduction

As discussed in Section 4, there is concern that current long Class 4 services may have stopping distances that are longer than the current signal spacings. This would result in max speeds of 65 mph rather than 75 mph. The aim of this case study is to investigate the impact of the reduced speeds on running times and the timetable on a key intermodal route.

The Basingstoke to Southcote Junction route was resignalled around 25 years ago from 2 to 3 aspect to reduce headways and allow increased traffic. This was based on a 75 mph design speed for intermodal services that were shorter than are now currently run on that route. At the time the braking standard used dated from the 1970s when intermodal traffic was typically up to 300 m in length. This standard has not been updated to take account of the longer 500-750 m trains that currently operate. The freight braking requirements in GMRT2045 and GKRT0075 do not currently make explicit reference to longer train issues as both attempt to deliver a 'one size fits all' rule for freight braking calculations.

The May 2025 weekday timetable has three passenger trains per hour (tph) operating on this route: two stopping services between Basingstoke and Reading (operated by Great Western Railway) and an hourly Cross Country service that operates between Bournemouth or Southampton and Manchester Piccadilly. This service does not stop at any intermediate stations between Basingstoke and Reading.

There is generally a maximum of two freight services per hour operating on this route in the off-peak. This is a mix of Class 4 container trains running between Southampton and one of the container terminals in the Midlands or further to the North; and various Class 4 or 6 services, carrying aggregates, construction materials, or cars.

8.2.2 Northbound

Signal spacing analysis in this direction indicated that Class 4 services should be limited to 65 mph. This resulted in an increase in modelled timings of 1-minute (compared to baseline modelling).

Table 25 Basingstoke – Reading Oxford Road Junction timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs (Cl. 66, 1600t)	15.5	-
T1302	16	0.5
T1348 ('enhanced' speeds)	17	1.5
T1348, with Class 70	16.5	1

The modelled baseline is 30 seconds longer than the existing SRTs due to an increase in the first section (Basingstoke – Bramley). This increase arises when accounting for the length of the train, which causes a threefold increase in the distance travelled at 25 mph (the train is restricted from accelerating until the rear of the train has cleared the restriction).

A one-minute time increase (spread over the subsequent sections) occurs when reducing the linespeed from the current 75 mph to the calculated 65 mph. When operating with more powerful traction (Class 70) net timings would be reduced by 30 seconds. However, the impact of speed reduction in the two sections between Bramley and Reading Oxford Road Junction would not be affected. This is because a Class 66 has sufficient power to operate at or close to the revised linespeeds in these, mostly downhill, sections.

The time of presentation of northbound freight services at Basingstoke is generally dependent on the structure of the passenger timetable on the line between Basingstoke and Eastleigh. Most freight trains will generally need to recess in Wallers Ash Loop to allow passenger services to pass and will then generally run immediately behind one of the Basingstoke – Reading stopping services. This means they will already have up to 5-6 minutes pathing time in their schedules between Basingstoke and Southcote Junction. Despite the modelled IRTs being slower than existing timings on this section, the amount of pathing time in the schedules means that this will generally have no impact on the actual running time of freight services operating during the day.

8.2.3 Southbound

In contrast to the Northbound direction, most of this route section is uphill, reducing the required stopping distance for a train. However, as signal spacing is tighter in this direction, calculated speeds (as limited by braking performance) suggest a linespeed limit of 60 mph. Despite the greater speed reduction than the Northbound direction, modelling resulted in no timing impact as geography constraints (the effect of gravity) limited the modelled train to speeds under 60 mph.

While stopping distances have been calculated with a conservative assumption of 3 through-piped (unbraked) wagons in a consist for this project, the impact of removing that assumption was considered for this case study. As only one signaling block necessitated the 60 mph restriction, calculations with all wagons braked resulted in a 65 mph limit throughout the case study.

Table 26 Basingstoke – Reading Oxford Road Junction timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs (Cl. 66, 1600t)	21.5	-
T1302	20.5	-1
T1348 ('enhanced' speeds)	20.5	-1
T1348, with Class 70	19.5	-2

End-to-end timings could be reduced by 1-minute due to an overly pessimistic SRT between Bramley and Basingstoke (this SRT could be matched by travelling at 37 mph). An additional 1-minute time reduction would be possible through improved acceleration if operating with a Class 70 locomotive.

The presentation time of southbound freight services at Basingstoke is generally dependent on the gaps between passenger trains available to freight on the two-track section between Oxford and Didcot. Most freight trains running towards Southampton must wait between 3 and 10 minutes on the approach to Basingstoke to allow South Western Railway services to run towards Southampton first.

The reduction in journey time on the section between Southcote Junction and Basingstoke is insufficient to allow the freight trains to avoid this wait and clear the two-track section between Worting Junction and Shawford Down Junction ahead of the South Western service. This means the reduction in journey time can only be translated into a potential performance improvement for freight services, as they would become more likely to present themselves on time at Basingstoke.

8.3 South and West London Lines

8.3.1 Introduction

The South London Line is a very busy passenger railway with various Southeastern and London Overground services interacting with the freight trains operating on this section. The off-peak West London Line timetable foresees four London Overground services running between Clapham Junction (Platform 0) and Stratford, as well as an hourly Southern service running between East Croydon, Clapham Junction (Platforms 16/17), and Watford Junction. All five services stop at all stations along the West London Line.

There is a QJ (reserved) path in the May 2025 timetable for an hourly London Overground shuttle running between Shepherd's Bush and Clapham Junction (Platform 17). As this is not currently operating, it has been disregarded for the purpose of this analysis.

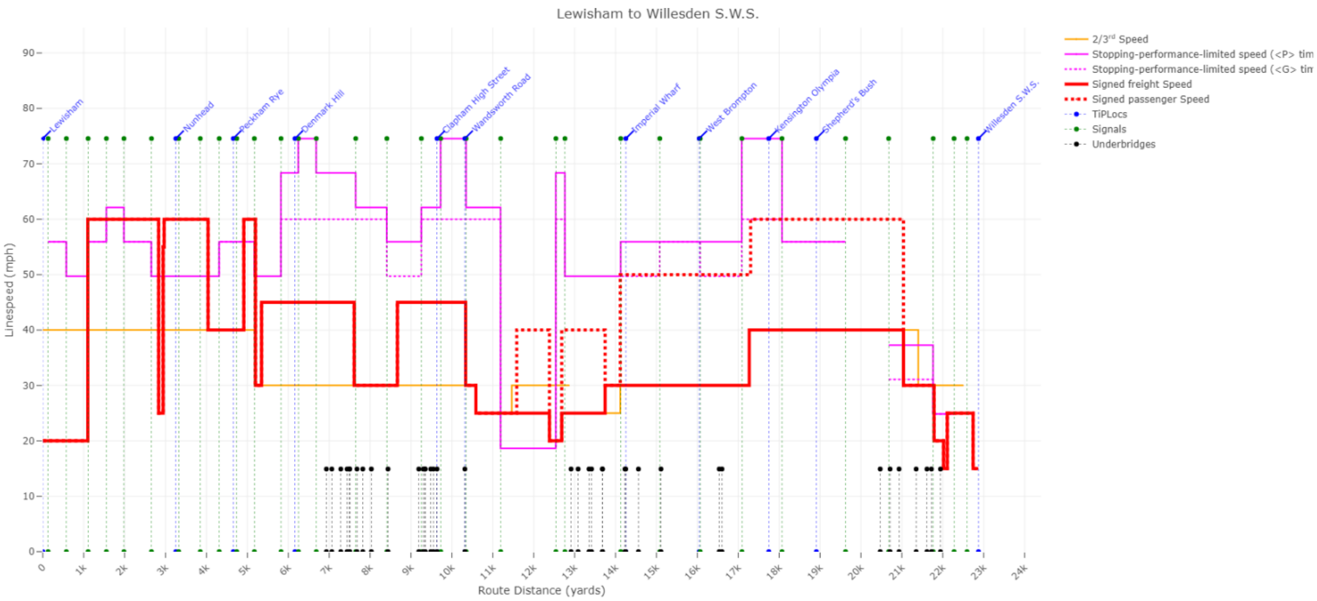
8.3.2 Analysis

The key capacity constraint in this area is the availability of paths on the West London Line. The headway for stopping and freight services on the route is 4 minutes—meaning that with a broadly 15-minute frequency of the Overground services it is possible to fit two freight paths in each gap between these trains, except when the Southern service operates. The run times of these freight services are effectively determined by the run times of the stopping passenger services, which are generally slower than the run times of even heavy freight trains across this section. They are also determined by the alignment of gaps between passenger services on the South and West London Lines in relation to one another. As these routes are generally timetabled independently, these gaps do not align, with freight trains transferring from the South to the West London Lines and vice-versa having to wait for a gap between passenger services at Latchmere or Longhedge Junctions.

This multitude of constraints means that freight services that run through this area during the hours of operation of passenger services are unable to capitalise on the modelled reduction in running times in terms of reducing their end-to-end journey times. The modelled reduction in run times does, however, offer the opportunity for freight trains to improve their on-time performance through the area.

8.3.3 Lewisham – Willesden S.W.S.

Figure 38 EF opportunities between Lewisham and Willesden



Three pairs of opportunities to raise freight speeds on this route are shown in Figure 38. The most significant opportunity exists between Imperial Wharf and North Pole Junction where the linespeed could be raised from 30/40 mph to 50/55 mph. Smaller opportunities exist around Nunhead, where the Two Thirds Rule limits Class 6 trains to 40 mph, and between Denmark Hill and Wandsworth Road, where the Two Thirds Rule limit is 30 mph.

In practice, there is no benefit around Nunhead as the preceding 20 mph limit from Lewisham and the 25 mph limit at Nunhead Junction prevent a loaded freight train achieving 40 mph in this location. Benefits are quantified in Section 7.

The modelled baseline for this route is a net 30 seconds faster than the existing SRTs. Table 27 shows modelling with enhanced freight speeds results in end-to-end timings 3 minutes faster than the modelled baseline.

Table 27 Lewisham – Willesden S.W.S. timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs (Cl. 66, 2000t)	33	-
T1302	32.5	-0.5
T1348 ('enhanced' speeds)	29.5	-3.5
T1348, with Class 70	29	-4

Table 28 shows the variation in section delays along the route.

Table 28 Section times for Lewisham – Willesden S.W.S.

Route section	Current SRT	Modelled IRT	Delay
LEWISHM - LEWIVLJ	1	1.07	0.07
LEWIVLJ - NUNHEDJ	3.5	3.83	0.33
NUNHEDJ - NUNHEAD	1	0.42	-0.58
NUNHEAD - CFTNRJUNCTION	2	2.00	0.00
CFTNRJUNCTION - DENMRKH	1	0.98	-0.02
DENMRKH - VOLTRDJ	4.5	4.20	-0.30
VOLTRDJ - FACTRYJ	1	0.52	-0.48
FACTRYJ - LNGHDGJ	1.5	1.22	-0.28
LNGHDGJ - LTCHMRJ	2.5	2.20	-0.30
LTCHMRJ - WBRMPTN	4	3.98	-0.02
WBRMPTN - KENOLYM	3	1.30	-1.70
KENOLYM - SHPDSB	1.5	0.82	-0.68
SHPDSB - NPOLEJ	1.5	2.17	0.67
NPOLEJ - MTRBDGJ	2	0.68	-1.32
MTRBDGJ - WLSDSWS	3	3.20	0.20

Denmark Hill to Voltaire Road Junction offers a small timing reduction with enhanced freight speeds; however, the primary opportunity is in the four sections between West Brompton and Mitre Bridge Junction. These sections do not all offer a net reduction from existing SRTs: the current section timing before North Pole Junction is pessimistic. Furthermore, the modelled baseline offers timing decreases between West Brompton and Kensington Olympia, North Pole Junction and Mitre Bridge Junction.

As explored in the T1301 project, current WLL timings are unrealistic, on some sections of route the timings are too fast and on other sections of route too slow. This project additionally identifies a possible net timing reduction for the northern part of the WLL. The increased momentum would be advantageous on the climb to Mitre Bridge Junction to mitigate this.

8.3.4 Willesden S.W.S. – Lewisham

In the South/East direction the benefit of enhanced speeds is smaller, 2 minutes, shown in Table 299.

Table 29 Willesden S.W.S. – Lewisham timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs (Cl. 66, 2000t)	32	-
T1302	31	-1
T1348 ('enhanced' speeds)	29	-3
T1348, with Class 70	28.5	-3.5

The section delays, shown in Table 30Table 30, are similarly variable to the reverse direction. A reduction from SRTs to the modelled baseline is possible between Kensington Olympia and West Brompton with further reduction possible with increased freight speeds, shown below.

Table 30 Section times for Lewisham – Willesden S.W.S.

Route section	Current SRT	Modelled IRT	Delay
WLSDSWS - MTRBDGJ	3.5	3.18	-0.32
MTRBDGJ - NPOLEJ	1.5	1.30	-0.20
NPOLEJ - SHPDSB	1.5	1.98	0.48
SHPDSB - KENOLYM	1	0.78	-0.22
KENOLYM - WBRMPTN	3	1.17	-1.83
WBRMPTN - LTCHMRJ	3.5	2.82	-0.68
LTCHMRJ - LNGHDGJ	2.5	2.02	-0.48
LNGHDGJ - FACTRYJ	1	1.37	0.37
FACTRYJ - VOLTRDJ	1	1.08	0.08
VOLTRDJ - DENMRKH	5	5.07	0.07
DENMRKH - CFTNRJUNCTION	1	0.73	-0.27
CFTNRJUNCTION - NUNHEAD	2	2.45	0.45
NUNHEAD - LEWIVLJ	4.5	3.48	-1.02
LEWIVLJ - LEWISHM	1	1.05	0.05

ThisTable 29 does not account for a 1minute TPR adjustment between Crofton Road Junction and Nunhead (made necessary because of a 30 mph linespeed limit on crossovers). The modelled performance indicates this adjustment could be reduced.

Modelling over this route accounts for linespeed adjustments between Nunhead and Lewisham set to come into effect in December 2025, following resignalling. In particular, a 20 mph restriction is set to be increased to 25 mph.

8.4 Brighton Main Line

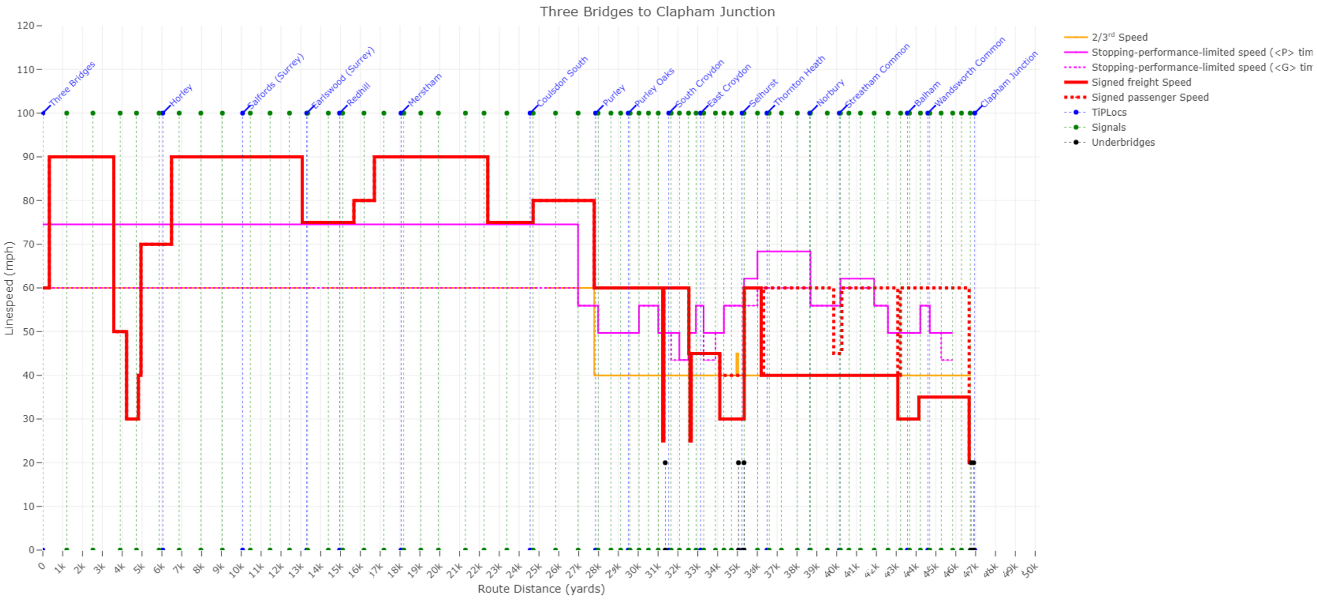
8.4.1 Introduction

The Brighton Main Line is one of the busiest passenger railway lines in Great Britain, hosting frequent services from London and from the Thameslink route towards Gatwick Airport, Brighton, and other towns in Sussex and on the South Coast. It also hosts frequent suburban services operating through South London.

8.4.2 Northbound

Figure 39 shows locations where reassessment of the braking performance of freight trains would permit running at higher speeds than the current linespeed restrictions. Firstly, speeds could be increased above the current two thirds limit of 40 mph after Purley. Secondly, the current linespeed of 40 mph around Streatham Common could be raised. Finally, linespeeds could be increased between Balham and Clapham Junction.

Figure 39 EF opportunities between Three Bridges and Clapham Junction



The current Gatwick Airport – Salfords SRT does not take into account the platform 1 speed limits, inducing a delay of over 1.7 minutes in the model within that section. This is somewhat offset by a pessimistic SRT between Redhill and Stoats Nest Junction. Overall, the modelled baseline (following the T1302 methodology) produces timings 30 seconds slower than the current SRTs.

The adjustments required to existing SRTs are shown in Table 31, along with the timing benefits possible with enhanced freight speeds. There is over 2 minutes of benefit available in the dense traffic sections between Purley and Streatham Common. An additional 1-minute time reduction is possible in the final section between Balham and Clapham Junction if allowable freight speeds are increased.

Table 31 Section times for Three Bridges – Clapham Junction

Route section	Current SRT	Modelled IRT	Delay
THBDGS - GTWK	3	3.12	0.12
GTWK - SALFDS	3	4.72	1.72
SALFDS - EARLSWD	2.5	2.57	0.07
EARLSWD - REDHILL	2	1.88	-0.12
REDHILL - SNSTJUNCTION	11.5	10.08	-1.42
SNSTJUNCTION - PURLEY	1	1.05	0.05
PURLEY - SCROYDN	3.5	2.53	-0.97
SCROYDN - ECROYDN	1.5	1.15	-0.35
ECROYDN - WNDMLBJ	1	0.65	-0.35
WNDMLBJ - SELHRST	1.5	1.07	-0.43
SELHRST - STRHCOM	4.5	3.65	-0.85
STRHCOM - STRENJUNCTION	1	0.63	-0.37
STRENJUNCTION - BALHAM	2	1.92	-0.08
BALHAM - CLPHMJC	3.5	2.60	-0.90

The modelled speeds provide a decrease in modelled timings of 4 minutes (compared to baseline modelling) with the enhanced speeds. This is shown in Table 32.

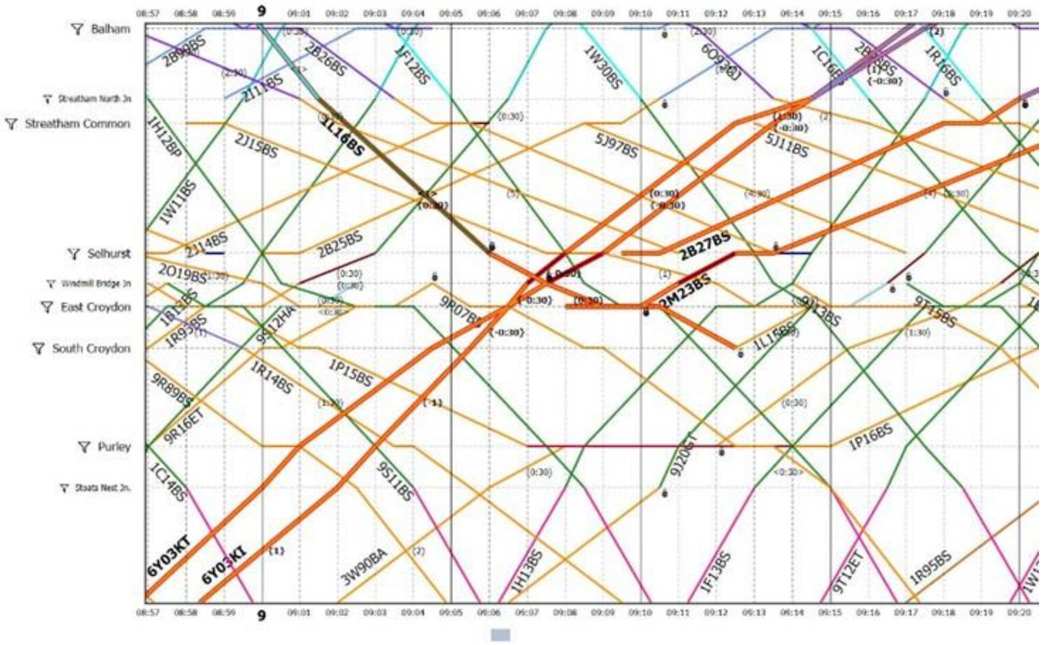
Table 32 Three Bridges - Clapham Junction timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs (Cl. 66, 1600t)	41.5	-
T1302	42	0.5
T1348 (‘enhanced’ speeds)	38	-3.5
T1348, with Class 70	37.5	-4

There are generally two gaps in each off-peak hour between passenger trains. One of these is typically used by freight trains, whereas the other is often filled by long-distance Empty Coaching Stock (ECS) moves between depots, as well as departmental trains (measurement, railhead-treatment, and more). Northbound paths originate at a number of terminals in Sussex and South London (Newhaven, Crawley, Purley) or come from Kent (via the Tonbridge – Redhill line) and then run towards the West London line via East Croydon, Streatham Common and Clapham Junction (Platforms 16/17).

Using existing timings, it is not always possible to run a 1800t freight path between South Croydon and Selhurst due to the alignment of passenger paths adjacent to the gap provided for freight. The modelled IRTs are significantly faster through this area and would allow for these freight trains to operate, albeit with minor retimings to adjacent passenger trains. These retimings mostly require shifting pathing time that is already contained within the path between different points and would have no bearing on the end-to-end journey times of passenger services.

Figure 40 Time-distance graph showing path towards Balham

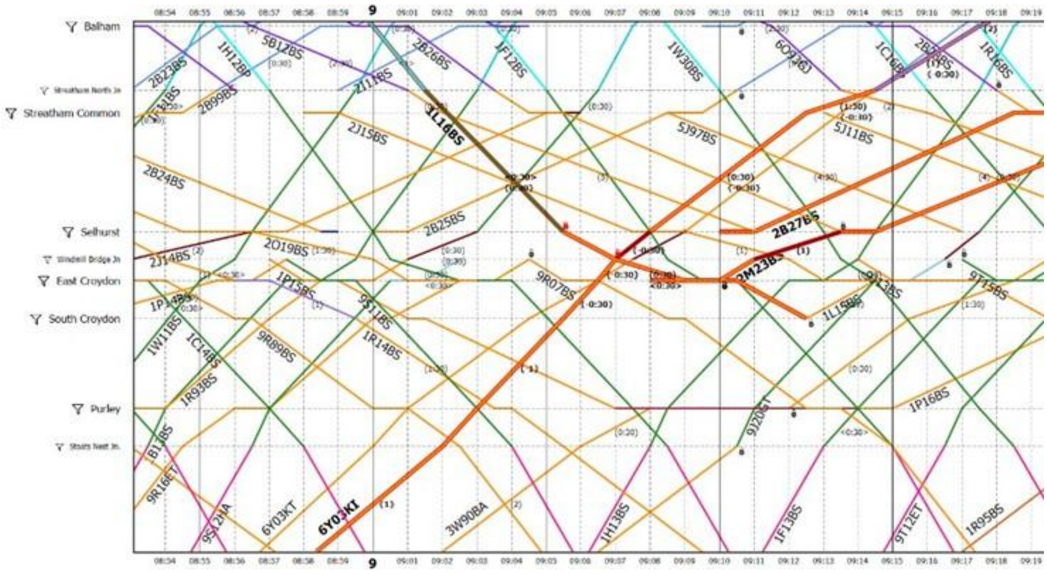


This snapshot of the train graph shows the conflicts generated by running one of the hourly freight paths through the South Croydon – Selhurst area. It also shows the difference in running time between existing SRTs and the modelled IRTs.

When using the existing SRTs, the conflicts between the freight path and adjacent passenger paths cannot be resolved by simple redistribution of pathing time within the passenger paths.

This can, however, be done if the modelled IRTs are used. This is illustrated on the graph in Figure 41 below.

Figure 41 Time-distance graph showing path towards Balham



The modelled IRTs also allow for the path to be re-routed via Crystal Palace and Streatham Hill (bearing in mind gauge restrictions on that route) – this would, however, require the train to run through East Croydon and Windmill Bridge Junction using the fast line rather than the slow line as is customary. While this routeing is slower than the routeing via Streatham Common, it may improve reliability.

8.4.3 Southbound

South Croydon to Purley currently requires a 1.5-minute TPR adjustment, due to typical routing through platform 5. Model times are just over 1 minute slower than the existing SRT (within the TPR allowance).

Less benefit can be observed between Balham and South Croydon in this direction as the uphill gradient acts as a limiting factor on performance.

The unrounded section times (with recommended enhanced speeds and calculated with the T1302 timing methodology) are displayed in Table 33.

Table 33 Section times for Clapham Junction – Three Bridges

Route section	Current SRT	Modelled IRT	Delay
CLPHMJC - BALHAM	6	5.17	-0.83
BALHAM - STRENJUNCTION	2	2.55	0.55
STRENJUNCTION - STRHCOM	1	0.63	-0.37
STRHCOM - SELHRST	4.5	3.93	-0.57
SELHRST - WNDMLBJ	1.5	1.02	-0.48
WNDMLBJ - ECROYDN	1	0.85	-0.15
ECROYDN - SCROYDN	1.5	1.37	-0.13
SCROYDN - PURLEY	3.5	4.60	1.10
PURLEY - SNSTJUNCTION	1.5	1.48	-0.02
SNSTJUNCTION - REDHILL	9	7.98	-1.02
REDHILL - EARLSWD	1.5	0.95	-0.55
EARLSWD - SALFDS	2	1.83	-0.17
SALFDS - GTWK	3	3.12	0.12
GTWK - THBDGS	4.5	3.15	-1.35

There is no net benefit of enhanced speeds after rounding timings, as Table 34 shows. The modelled timings provide a decrease of 3.5 minutes from existing SRTs (before adding the TPR adjustment to SRTs). A Class 70 would bring an additional 1minute benefit in this direction as its greater power is more impactful with the challenging geography.

Table 34 Clapham Junction – Three Bridges timings summary

Methodology	Time (mins)	Difference from SRTs (mins)
SRTs	42.5	-
T1302	40	-2.5
T1348 (enhanced speeds)	40	-2.5
T1348, with Class 70	39	-3.5

This allows for the potential of an improved reliability of services, and longer/heavier trains on the route.

There is generally one path per hour available for freight trains on the Brighton Main Line in the southbound direction. This path requires some trains to recess at South Croydon (Platform 4) for a period of 15-30 minutes. This is necessary if the trains are running to locations south of Three Bridges, as the gap in the passenger timetable used by freight north of the Croydon area does not align with gaps across the junction at Three Bridges or through Balcombe Tunnel. Trains heading for locations north of Three Bridges (Purley, Crawley, Redhill or towards Kent) do not need to stop at South Croydon, as the gap between passenger trains is sufficient for them to run as far as Gatwick Airport and Crawley New Yard.

Despite the modelled IRTs being faster than the existing SRTs, they are not sufficiently fast to allow freight trains to take advantage of any other gaps in the passenger timetable anywhere on the Brighton Main Line. They may, however, permit routeing trains via Crystal Palace, which may enhance their performance due to fewer passenger trains operating on that route.

8.4.4 General Commentary

With the Brighton Main Line hosting a very large number of passenger trains, it is not generally possible to find sufficient spare capacity for additional opportunities to operate freight trains. The modelled IRTs do, however, offer the opportunity for freight trains to run faster and more reliably – possibly by utilising the fast lines where capacity and other conditions permit. There are also two locations where particular attention should be paid when routeing freight trains:

- Gatwick Airport: Platform 1 at Gatwick Airport is located on a loop with a 25 mph turnout on the approach. Most Up (Northbound) passenger trains are routed via Platform 1 – this does not impede their progress in any way, as all passenger trains passing through Gatwick Airport call at the station. Platform 2 is used to terminate Great Western services from Reading – doing so generates fewer timetable conflicts, as terminating trains do not have to cross the path of northbound services. However, that also means that Platform 2 is occupied at the same time as a possible gap for freight trains that could otherwise pass that platform. If they are forced to use Platform 1 instead it takes a long time for freight trains to accelerate from the 25 mph speed restriction, while Platform 2 does not feature any speed restrictions. It is therefore suggested that Great Western services should use Platform 1 at Gatwick Airport when northbound freight trains have to pass through the station.
- South Croydon: The junction at the southern end has a 20 mph speed restriction for trains running on the Down Slow through Platform 5 towards Purley. This restriction does not exist on the Slow Reversible (Platform 4). It is therefore recommended that all freight is routed via Platform 4, particularly those trains that do not have to stop at South Croydon to let passenger trains pass.

9 Summary of potential speed changes

9.1 Deriving differentials

Table 35 summarises the current maximum speeds as set out in the Sectional Appendix, the corresponding Two Thirds Rule speed, the proposed speeds calculated in this project and the improvement relative to current speeds. An explanation of how to interpret the table is given below.

The first group of two columns are taken from the Sectional Appendix and show the 'Maximum Permissible speed as shown in Table A' (in blue), and the 'Maximum Permissible speed of Class 6, 7, 8 freight trains' (in red). The latter is derived by calculating 2/3rds of the permissible speed of line (column 1) and rounding down to the nearest 5 mph. The rounding down frequently results in limits lower than 2/3rds of the permissible speed of line.

The next set of three columns under 'Recommended maximum speed' show the recommended speed for Class 4, Class 6 <P> and Class 6 <G> categories based on work in this project, derived from the braking model, geographic model and case studies.

The third set of three columns under 'Recommended speed differential' express the recommended speeds as a differential relative to the lower of the permissible speed of the line or the relevant maximum train speed.

The final set of three columns, under 'Improvement vs either current max permitted speed or max train speed', shows the relative improvement against current speeds as dictated by the Two Thirds Rule with positive numbers representing an increase from the current speed and negative a decrease.

For sections of line with maximum permissible speeds at or below 50 mph the recommended freight speeds (for all Class 4, Class 6 <P> and Class 6 <G> are the same as the maximum permissible speed—there is no differential. The Two Thirds Rule can be retired in these circumstances.

Reductions to the current allowable Class 4 speeds are highlighted in the third group of columns. These are necessary due to the increased length of Class 4 trains since the initial deployment of the Two Thirds Rule (from which Class 4 traffic is exempt). The greater length of Class 4 trains increases the propagation time for pressure in the brake pipe, and hence the stopping time.

Note: this is only an issue when the line speed is 75 or 80 mph; in most circumstances the 'main line' line speed is greater than this. This issue is also locomotive specific, see section 9.2.

Table 35 Recommended differentials and their impact

Current permissible speed (mph) From Sectional Appendix Table A		Recommended maximum speed (mph)			Recommended speed differential (mph)			Improvement vs either current max permitted speed or max train speed (mph)		
Maximum permissible speed (‘signalling design speed’)	For Class 6, 7 and 8 freight trains (Two Thirds Rule)	Class 4	Class 6 <P>	Class 6 <G>	Class 4	Class 6 <P>	Class 6 <G>	Class 4	Class 6 <P>	Class 6 <G>
90	60	75	60	60	0*	0*	0*	0	0	0
85	55	75	60	60	0*	0*	0*	0	+5	+5
80	50	70	60	60	-5	0*	0*	-5	+10	+10
75	50	65	60	60	-10	0*	0*	-10	+10	+10
70	45	60	60	60	-10	0*	0*	-10	+15	+15
60	40	55	55	50	-5	-5	-10	-5	+15	+10
55	35	50	50	50	-5	-5	-5	-5	+15	+15
50	30	50	50	50	0	0	0	0	+20	+20
45	30	45	45	45	0	0	0	0	+15	+15
40	**25**	40	40	40	0	0	0	0	+15	+15
35	**20**	35	35	35	0	0	0	0	+15	+15
30	30	30	30	30	0	0	0	0	0	0

0* Speed limited by Class 4 or Class 6 maximum train speeds rather than stopping performance

Speeds for stopping distance calculations are currently specified in 10 kmh increments as set out in the braking standards. The recommended maximum speeds derived by the project team for Class 4, Class 6 <P> and Class 6 <G> were therefore calculated in 10 kmh increments, then converted to mph and then rounded down to the nearest 5 mph increment to match standard speed signage. This conversion and rounding-down process introduces significant unevenness in the differentials at higher speeds, resulting in three 10 mph differentials compared to the usual 5 mph differential at maximum permissible speeds above 50 mph (in the second group of columns), shown in Table 35.

A potential improvement would be to introduce 5 kmh increments for the stopping distance calculations as this speed increment is smaller than 5 mph so, after rounding, will align better with 5 mph spaced speed limit. Table 36 shows how multiples of 10 (in kmh) convert to signed speeds in mph. The potential reduction in impact from moving to 5 kmh increment of stopping distance is shown in Table 37. This is a recommendation of this project and is also applicable to minimising impacts from ETCS roll out.

Table 36 Impact of stopping calculation in 10 kmh increments being converted to mph and rounded down

Rounded SPL speed (kmh)	Signed speed (mph)
120	70
110	65
100	60
90	55
80	45
70	40
60	35
50	30
40	20
30	15

Table 37 When determining route-specific EF speeds a value of 50 mph was recommended when the stopping distance was larger than the stopping distance for a standard consist at 80 kmh. 80 kmh converts to 49.7 mph hence the unrounded SPL speed is highly likely to exceed 50 mph. Impact of stopping calculation in 5 kmh increments being converted to mph and rounded down

Rounded SPL speed (kmh)	Signed speed (mph)	Increase from using 10 kmh rounding
120	70	0
115	70	5
110	65	0
105	65	5
100	60	0
95	55	0
90	55	0
85	50	5
80	45	0
75	45	5
70	40	0
65	40	5
60	35	0
55	30	0
50	30	0
45	25	5
40	20	0
35	20	5
30	15	0

Most SPL speeds that do not round to a multiple of 10 (multiple of 5 kmh) usually translate to a signed speed 5 mph higher than if they were rounded down a further 5 kmh.

9.2 Recommended differentials

It was deemed impractical for more than one variation from passenger linespeed to be communicated to freight drivers through signage or other means. The recommended freight speeds in Table 35 have been consolidated into a single freight speed in Table 38. Above 60 mph, the Class 6 maximum train speed, the recommend signed freight speed is the calculated maximum Class 4 speed. At 60 mph, the lower of the 3 calculated freight speeds must be adopted.

There is only one meaningful conflict, when the maximum speed of a route is 60 mph. Section 9.1 recommends constraining Class 4 trains and Class 6 trains in <P> brake setting to 55 mph. As we take the lowest common denominator approach, the limit for Class 6 trains in <G> brake setting of 50 mph should be followed (this recommendation is highlighted in yellow in the table).

Table 38 Recommended differentials and their impact

Current maximum permissible speed (mph)		Potential realistic speed differential (mph)			Improvement vs either current max permitted speed or max train speed (mph)	
From Sectional Appendix Table A 'signalling design speed'	For Class 6, 7 and 8 freight trains (excluding MPVs, OTMs & parcels)	Potential practical single freight speed to be used on signage	Class 4 differential	Class 6 differential (mph)	Class 4 improvement over existing	Class 6 improvement over existing
90	60	75	0*	0*	0	0
85	55	75	0*	0*	0	+5
80	50	70	-5	0*	-5	+10
75	50	65	-10	0*	-10	+10
70	45	60	-10	0*	-10	+15
60	40	50	-10	-10	-10	+10
55	35	50	-5	-5	-5	+15
50	30	50	0	0	0	+20
45	30	45	0	0	0	+15
40	**25**	40	0	0	0	+15
35	**20**	35	0	0	0	+15
30	30	30	0	0	0	0

0* Speed limited by Class 4 or Class 6 maximum train speeds rather than stopping performance

The calculated speeds in this project are based on Class 66 operation. More modern locomotives (Class 68, Class 70, Class 88, Class 93, and Class 99) have better stopping performance and as locomotives are the first vehicles to apply the brakes. Better locomotive stopping performance can have a useful positive impact on overall train stopping performance which could lead to smaller differentials being required for more modern locomotives. However, as Class 66 locomotives are the most prevalent locomotives on the GB network (and are likely to remain so for some considerable time), recommendations are based on their capabilities.

In a similar way, much better stopping performance is possible with use of an EOTD. It is likely no differential between freight and passenger speeds would be required where freight trains fitted with an EOTD. As adoption of EOTDs is not widespread within GB (and is unlikely to be before significant ETCS use on freight services), detailed consideration of their impact is beyond the scope of this project.

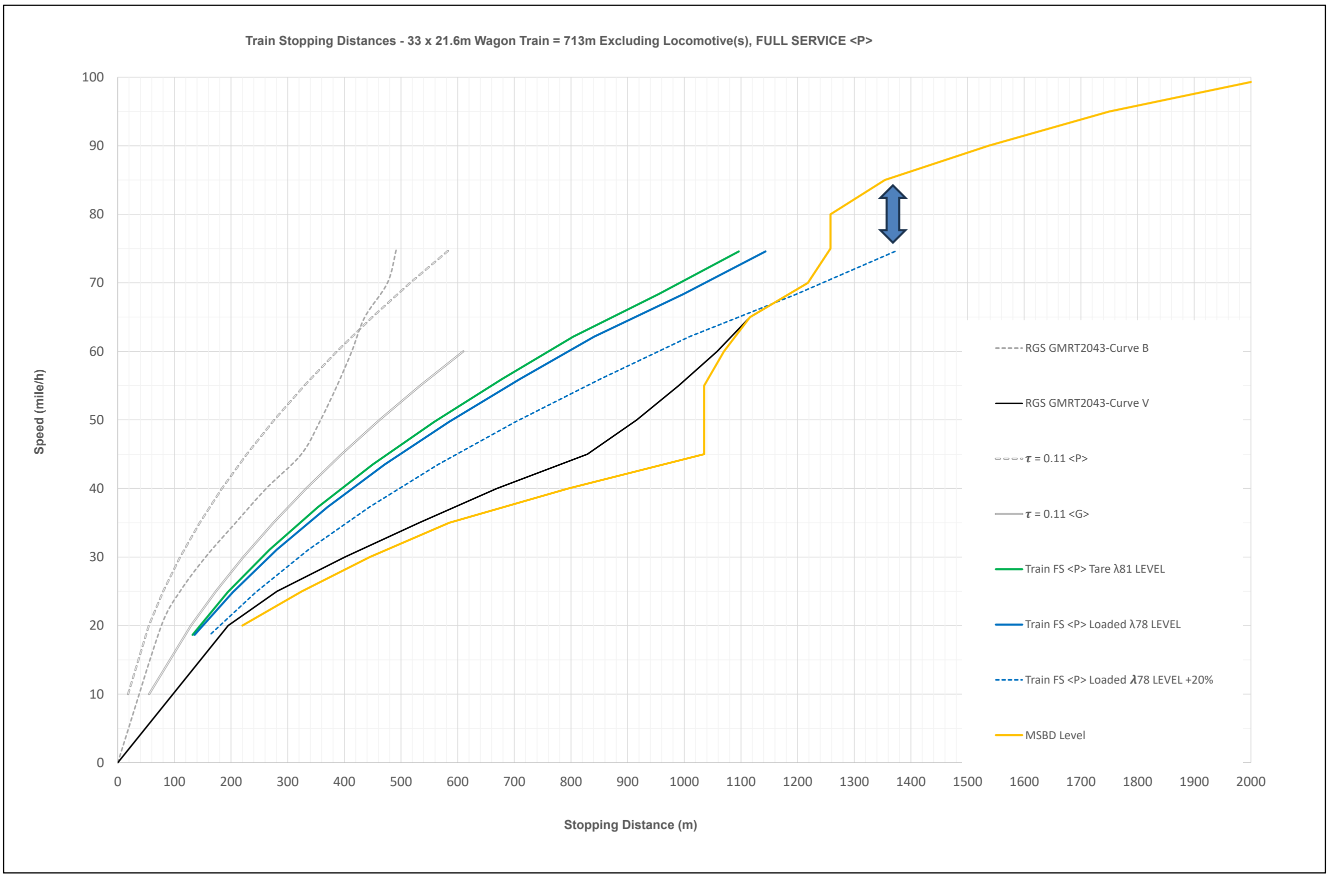
9.3 Practical differentials

The reduction in Class 4 speeds recommended in Table 38 covers five maximum permissible speeds. However, analysis of the Kent, Sussex and Wessex regions indicate that the Basingstoke – Southcote Junction section considered in Section 8 is the affected section with highest Class 4 freight traffic. This case study also shows the impact typically affects a small number of miles and results in a small timing impact. The appendix contains tables showing the different maximum permissible design speeds across the Southern Network.

No Class 4 restrictions are necessary where the design speed of a route is 85 mph or greater. Despite the train stopping distance curve being to the right of the MSBD curve at these speeds, the stopping distance should be calculated for the maximum train speed (75 mph). This value is lower than the MSBD distance for all speeds 85 mph and above (illustrated with a blue double arrow in Figure 42). Hence, no restrictions on Class 4 speeds (above the existing 75 mph limit) are necessary when the signalling design speed is 85 mph or above.

A reassessment would be required if freight trains were to be run above 75 mph.

Figure 42 Class 4 stopping distance, determined by braking model



10 Implementation

10.1 Approach

The implementation of the opportunities for reducing the freight differential were discussed at the two stakeholder meetings held in August 2025. These discussions centred around two questions:

- What is the process for making changes?
- Who can be champion or Project Manager for these changes, who ‘own’ implementation after this project is completed?

10.2 Process

It was agreed that if changes are to be made it should be Network Rail as the national infrastructure manager who leads them. Therefore, it would be best if the process adopted to make that change was linked to existing processes already managed by Network Rail.

The point was made that the revision of lineside speeds is usually linked to changes in the signalling and outside of this there is no formal process. After discussion it was felt that the Network Change process could be used, with the additional benefit that the revisions could help close out some unagreed historic Network Change requests.

10.3 Championing change

The workshops were not designed to identify an individual to act as a champion, this decision has to be made within Network Rail. It was felt that the champion should probably be within the Network Operations Team in the Southern Region, supported by the Southern Freight team.

Appendix A: Table A maximum permissible speeds by route section

The table below contains the maximum permissible speed for each route section (specified by LOR and sub divided where needed) at the time the project was undertaken.

Three Tables, one for each of the Kent, Sussex and Wessex Network Rail subregions.

Key for the following Tables:

Key:

Case Study Coverage
Transferable learning from case studies
No Transferrable learnings from case studies e.g. for 85mph - the routes have no Class 4
Two Third rule is not applicable due to low route permissible speed (20, 25 or 30mph) or local exemption

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Table 39 Kent subregion table:

LOR														Notes
	Max. Permissible speed from Table A (mph)	**90**	**85**	**80**	**75**	**70**	**60**	**50**	**45**	**40**	**30**	**25**	**20**	
	Two Third Rule Speed (mph)	**60**	55	**50**	**50**	**45**	**40**	**30**	**30**	**25**	30	25	20	
	Potential Practical Class 4 Speed (mph)	**75**	75	**70**	65	**60**	**55**	**50**	**45**	**40**	30	25	20	
	Potential Practical Class6 <P> speed (mph)	**60**	60	**60**	60	**60**	**55**	**50**	**45**	**40**	30	25	20	
	Potential Practical Class 6 <G> speed (mph)	**60**	60	**60**	60	**60**	**50**	**50**	**45**	**40**	30	25	20	
LOR	**Recommended Freight Speed for Signage (mph)**	**75**	**75**	**70**	**65**	**60**	**50**	**50**	**45**	**40**	**30**	**25**	**20**	**Notes**
SO110	Victoria to Ramsgate (via Herne Hill and Chatham)	St Mary Cray - Ramsgate					Victoria - St Mary Cray (NOT atlantic lines)		Victoria - St Mary Cray (Atlantic lines)					
SO130	Charing Cross/Cannon Street to Dover Priory/Eurotunnel (via Tonbridge)	Orpington - Folkstone		Petts Wood Jn - Orpington	Folkestone - Dover Priory	Hither Green - Petts Wood Jn	Charing Cross - Hither Green							
SO140	Swanley to Ashford			All										
SO150	Sittingbourne (Eastern Jn.) to Sheerness-On-Sea					All								
SO160	Faversham to Dover Priory	all												
SO170	Tonbridge to Bo Peep Jn	Strawberry Hill Tunnel - Bo Peep Jn					Tonbridge - Strawberry Hill Tunnel							
SO180	Paddock Wood to Maidstone West					All								
SO210	Appledore to Lydd town (Goods Line)												All	
SO220	Ashford to Ramsgate (via Canterbury West)				All									
SO240	Buckland Jn to Minster East Jn					All								
SO250	Battersea Pier Jn to Willesden West London Jn.						Kensington Olympia - North Pole Jn	Kensington Olympia - north side of River Thames		Longhedge Jn - north side of River Thames	North Pole Jn - Mitre Bridge Jn	Battersea Pier Jn - Longhedge Jn		Special 40mph for tunnel traffic for lower permissbale speed area on SO250
SO260	Brixton Jn to Shortlands Jn						"Catford Loop"							
SO280	Farringdon to Herne Hill						Blackfriars - Herne Hill				Farringdon - Blackfriars			
SO290	North Kent East Jn to Dartford Jn (via Greenwich)						All							
SO300	Lewisham to Crayford Creek Jn (via Bexleyheath)						All							
SO310	Hither Green to Maidstone West (via Dartford)					All								
SO320	Hoo Jn. to Grain (Goods Line)									All but n/a				n/a = Local Exemption from 2/3rd rule already existed
SO330	Nunhead to Hayes						All							
SO350	Grove Park to Bromley North									All				

Table 40 Sussex Subregion Table

LOR	Max. Permissible speed from Table A (mph)	90	85	80	75	70	60	50	45	40	30	25	20	Notes
	Two Third Rule Speed (mph)	60	55	50	50	45	40	30	30	25	30	25	20	
	Potential Practical Class 4 Speed (mph)	75	75	70	65	60	55	50	45	40	30	25	20	
	Potential Practical Class6 <P> speed (mph)	60	60	60	60	60	55	50	45	40	30	25	20	
	Potential Practical Class 6 <G> speed (mph)	60	60	60	60	60	50	50	45	40	30	25	20	
LOR	**Recommended Freight Speed for Signage (mph)**	**75**	**75**	**70**	**65**	**60**	**50**	**50**	**45**	**40**	**30**	**25**	**20**	**Notes**
SO500	Victoria to Brighton	Purley - Brighton				Fast lines only: Wandsworth Common - Selhurst	Victoria - Purley		Battersea Park - Factory Jn					
SO510	London Bridge to Epsom Downs					New Cross Gate - Windmill Bridge (Fast lines)	London Bridge - New Cross Gate; New Cross Gate - Windmill Bridge Jn (slow lines); Norwood Fork Jn - Epsom Downs							
SO520	Three Bridges to Portsmouth Harbour		Three Bridges- Horsham; Havant - Portsmouth		Horsham- Havant									
SO530	South Croydon to East Grinstead		Hurst Green Jn - East Grinstead - DOWN line only			Woldingham - Hurst Green Jn; East Grinstead - Hurst Green Jn - UP line only								
SO540	Hurst Green Jn to Uckfield					All								
SO550	Redhill to tonbridge		All											
SO560	Redhill to Guildford	Guildford - Shalford Jn				Shalford Jn - Redhill *Special*								Shalford Jn - Redhill, special local rule: 35mph local rule = "50% rule" due to cyclic top from non-bogie aggregate wagons during M25 construction
SO590	Keymer Jn to Eastbourne													
SO600	Willingdon Jn to Ashford					west of Hastings	Hastings - Ashford							
SO620	Brighton to Seaford					All								
SO630	Brighton to Littlehampton					All								
SO640	Barnham to Bognor Regis					All								
SO645	Battersea Park to Peckham Rye (Atlantic Lines)								Atlantic Lines					
SO650	Balham Jn to Beckenham Jn						All							All signed now post resignalling so "n/a"
SO660	Purley to Caterham						All							
SO680	South Bermondsey Jn to Horsham				Leatherhead - Horsham		South Bermondsey - Leatherhead							
SO700	Streatham South Jn to Sutton (via Wimbledon)						All							

Table 41 Wessex Subregion Table

LOR	Max. Permissible speed from Table A (mph)	90	85	80	75	70	60	50	45	40	30	25	20	Notes
	Two Third Rule Speed (mph)	60	55	50	50	45	40	30	30	25	30	25	20	
	Potential Practical Class 4 Speed (mph)	75	75	70	65	60	55	50	45	40	30	25	20	
	Potential Practical Class6 <P> speed (mph)	60	60	60	60	60	55	50	45	40	30	25	20	
	Potential Practical Class 6 <G> speed (mph)	60	60	60	60	60	50	50	45	40	30	25	20	
LOR	Recommended Freight Speed for Signage (mph)	75	75	70	65	60	50	50	45	40	30	25	20	Notes
SW100	Waterloo to Clapham Junction						All							
SW105	Clapham Junction to Weymouth	New Malden - Bournemouth	Bournemouth - Weymouth		Clapham Junction - New Malden									
SW110	Woking Junction to Portsmouth Harbour	Woking Jn - Rowlands Castle	Rowlands Castle - Portsmouth Harbour											
SW115	Worting Junction to Exeter St. Davids	Andover - Salisbury Tunnel Jn	Worting Jn - Andover; Salisbury Tunnel Jn - Exmouth Jn			Exmouth Jn - Exter St. Davids								
SW120	Pirbright Jn to Alton					All								
SW125	Southcote Junction to Basingstoke				All									** local route two-Third rule exemption**
SW130	Eastleigh to Romsey													
SW135	Eastleigh to Fareham				All									
SW140	St. Denys to Portcreek Junction				All									
SW145	Northam Junction to Canute Road										All			(Southampton Eastern Dock access)
SW150	Redbridge to Salisbury Tunnel Junction			All										
SW155	Totton to Fawley (Goods Line)										All			
SW160	Brockenhurst to Lymington Pier						All							
SW165	Hamworthy to Hamworthy Goods (Goods Line)												All	
SW170	Westbury to Wilton Junction				All									
SW175	Castle Cary to Dorchester Junction				All									
SW180	Raynes Park to Horsham				Leatherhead - Horsham		Raynes Park - Leatherhead							
SW185	Motspur Park to Chessington South						All							
SW190	New Malden to Shepperton						All							
SW195	Hampton Court Junction to Hampton Court								Down line	Up line				
SW200	Hampton Court Junction to Guildford (Via Cobham)					All								
SW205	Leatherhead to Effingham Junction					All								
SW210	Clapham Junction to Southcote Junction (Via Reading)					Feltham - Reading	Clapham Junction - Feltham							
SW220	Latchmere Junction to Kensington Olympia							Kensington Olympia - north side of River Thames		Latchmere Jn - north side of River Thames				See Kent region SO250
SW225	Point Pleasant Junction to Wimbledon								Wimbledon - East Putney (now special local signage)				East Putney - Point Pleasant	Now signed as "30 / LU45" on the shared section i.e. no action needed as all NR is 30mph
SW230	Barnes to Feltham Junction (Via Hounslow)						All							** All dual signed**
SW240	Kew East Junction to Old Kew Junction						n/a							** All Signed **
SW245	Twickenham to Shacklegate Junction						All							
SW250	Staines to Windsor And Eton Riverside						All							
SW255	Virginia Water to Weybridge					All								
SW260	Ascot to Ash Vale Junction						All							
SW265	Guildford to Wokingham					All								
SW300	Gomshall to Shalford Junction					Shalford Jn - Redhill *Special*								Special: 35mph local rule = "50% rule" due to cyclic top from non bogie aggregate wagons during M25 construction

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