Review of Possessions Cost Compensation
Stage 2: Final Report

A Report to Network Rail, ORR and ATOC.
30th November 2007

Prepared by:	Approved by: .....
Rich Fisher	Tim Smith
Principal Consultant	Regional Director

Review of Possessions Cost Compensation

Rev No	Comments	Date

Marlborough House, Upper Marlborough Road, St Albans, Hertfordshire, AL1 3UT
Telephone: 020 8784 5784 Fax: 020 8784 5700 Website: http://www.fabermaunsell.com

Job No	Reference	Date Created
54689TSAT	Review of Possession Cost Compensation	30th November 2007

Table of Contents

1. Introduction

1 Introduction

1.1 Background

1.1.1 This report is about the direct costs incurred by train operators when Network Rail take possession of the rail network to undertake maintenance, renewal or enhancement of the network. Currently, Network Rail compensates Train Operators for possessions through two separate channels, using similar processes but each according to slightly different criteria:

- Schedule 4, contained in most passenger Track Access Agreements, contains the provision to claim back 'direct costs' for possessions that qualify as being Significant Restrictions of Use (SRoU)[1]. Train Operators receive no compensation for costs incurred under normal Schedule 4 disruption (known from this point on as a RoU) which does not meet the SRoU thresholds.
- Alternatively, if the possession is associated with a 'Network Change' project (Part G), operators can claim their costs in all cases where they can demonstrate that such have been incurred. Whilst general principles and practices have been developed, the cost categories allowed are not stipulated contractually.

1.1.2 The Office of Rail Regulation (ORR) decided to review the compensation mechanisms as part of Periodic Review 2008. ORR asked the Industry Steering Group (ISG) to review the current arrangements and to propose revised ones for consultation with the industry no later than September 2007 (see http://www.rail-reg.gov.uk/upload/pdf/pr08-toc_comp.pdf).

1.1.3 Faber Maunsell was commissioned by ISG to undertake a review of the compensation paid to Train Operators for the additional costs associated with possessions. During Stage 1 of the work (July to September 2007) six Train Operators provided information as to the costs they experienced as a result of possessions. Cost data for a total of 80 possessions was collated and analysed. As a result of this work it was concluded that:

- Bus replacement costs form the highest proportion of costs (around 90%);
- None of the simple measures of disruption, such as possession duration, train miles affected, or Schedule 4 revenue compensation, provide an adequate direct driver of costs that could be used alone to devise a sensible mechanism for cost compensation;
- The concept of Estimated Bus Miles (EBMs) was developed as an alternative metric. This reflects the impact of the possession on the train service that would normally operate, and the level of rail replacement bus provision required, which depends on the availability of an alternative diversionary route, or the presence of an alternative parallel operator such as LUL;
- Analysis of the relationship between EBMs and rail replacement bus costs show a reasonably good linear relationship. It was therefore proposed that EBMs form the basis of a compensation mechanism for the industry; and
- In addition, it was proposed that compensation should be provided for the costs, or savings, of train mileage based on the net train miles operated. These cost changes are already taken into account in the current compensation mechanism. However, to reduce transaction costs it was proposed that the rate applied per train mile should be calculated as an average at Service Group or Train Operator level.

[1] A SRoU is defined as being a Restriction of Use (RoU) that is longer than 60 hours (not including any hours of Public Holiday days), or associated with a Major Project Notice. The contract stipulates the cost categories which might be claimed as Direct Costs, for example rail replacement services, publicity, additional train planning. Claims under this mechanism are subject to a £10,000 minimum.

1.1.4 ISG supported the principle of the proposed formulae to calculate rail replacement bus costs based on Estimated Bus Miles (EBMs) and to incorporate costs or savings resulting from changed train mileage. The proposed mechanism was included in the proposed changes to possession compensation which were published for industry consultation in September 2007.

1.1.5 Before a decision can be made about implementation, additional work is required to test and refine the mechanism, and to give the industry confidence about the robustness of the proposals. Faber Maunsell was commissioned by ISG on 19th October 2007 to carry out further work during November 2007 to establish (and if possible improve) the robustness of the Stage 1 compensation formula; and to make provisional estimates of the timescale for implementing the system, and the staff resources that the industry would need to allocate to implement it. This Report contains the conclusions of this work, henceforth referred to as 'Stage 2'.

1.2 Scope of Work

1.2.2 In order to test the proposed mechanism we collected further possession cost data from five Train Operators (see Section 2).

1.2.3 The Stage 2 data was used to test the existing Estimated Bus Miles model, and to produce a new equivalent model. This has tested whether the proposed mechanism is robust by examining whether the new data leads to significantly different results compared with the original analysis.

1.2.4 During Stage 1 we observed a range of unit rates (£ per EBM) within the group of London & South East (LSE) operators, and variance between different types of Train Operator, for example LSE, Intercity and Regional. The data has also been used to test whether these differences are statistically significant, and hence whether different rates might be justified in the proposed compensation mechanism (see Section 3).

1.2.5 We have also considered how the proposed mechanism would be implemented (see Section 4 and Appendix A). At the end of Stage 1, we recommended that the proposed mechanism could be implemented through the use of lookup tables. To validate the feasibility of the mechanism and to assess the effort involved, we supported the data preparation exercise for one Train Operator, London Midland.

1.2.6 We have also considered the practical issues of implementation, particularly the feasibility of incorporating the proposed compensation process within Schedule 4 Compensation System (S4CS) and the resource and cost implications of operating the mechanism. Alongside this we have developed a prototype system in Microsoft Access for calculating compensation.

1.2.7 In October, we hosted an industry workshop on behalf of ISG to explain our proposals and to support the consultation process. The issues highlighted by the industry representatives at the workshop are contained in Appendix B.

1.2.8 Finally, we have set out an outline of proposed steps and associated timescales for the longer-term implementation of the proposed mechanisms, in line with the timescales for the 2008 Periodic Review (see Section 5).

2. Stage 2 Cost Data Collection

2 Stage 2 Cost Data Collection

2.1 Information from Train Operators

2.1.1 Information was collected from five Train Operators who had agreed to participate in the study. Two of the operators were involved in Stage 1; these were joined by three 'new' participants who were London and South East (LSE) operators.

2.1.2 The involvement of LSE operators was particularly important, given that in Stage 1 we observed a range of unit rates (£ per EBM) within possessions classed as LSE. Variance was also observed between different types of Train Operator, for example LSE, Intercity and Regional. It should also be noted that in Stage 1 of the work, we only had access to cost data for one LSE Train Operator.

2.1.3 The brief for Stage 2 was more tightly focussed hence the contact with the Train Operators was more concentrated on data collection. We met with each operator (both 'old' and 'new') to discuss the data they could provide. This also allowed them to raise any issues, such as 'special cases' where they thought that the proposed mechanism might break-down. The key themes and issues that emerged from our discussions were:

- General disagreement over whether a lower cut-off should be applied, and at what level. Possessions shorter than this cut-off would not be compensated. Whilst some operators agreed there would be too much administration involved in compensating for every possession, others said that by setting a limit Network Rail might start to plan possessions to come in at just under this limit to avoid making compensation payments.
- Bus costs were generally considered as being the major cost of possessions, but responses did vary from virtually all costs being buses due to staff and posters being generic and so difficult to tie to a single possession, to 'other costs' being very significant across one operator in particular.
- Buses were always procured from a single bus operator as part of an ongoing contract, although some operators had one single unit charge whilst others were charged varying rates based on the specification of each possession.
- Train Operators pointed out the need to ensure that the list of possessions was representative, and did not simply include the larger cases. Repeated similar closures or very long possessions involved significant degradation of the service such that the demand for the route had been reduced and so the replacements costs were not proportional to a 'normal' possession.
- All LSE Train Operators stated that they were charged by London Buses for whenever their passengers were transferred to their services, but that they were not charged by LUL. One operator highlighted a potential risk that LUL may start charging.
- There was variation in the systems in place for charging other mainline rail operators for running buses to cater for their passengers as well. There was an agreement that in the vast majority of cases one 'set' of replacement buses will run, but this varied from one operator not charging its neighbours for taking their passengers as well (and vice versa), to a system where charging was in place between operators to cater for their passengers too. There was also one example where one bus company will run all of the replacement buses on a route, and then invoice each operator separately based on estimates of passengers on each operator's services.
- Train Operators serving airports all agreed that in the majority of cases bus replacements will run for the entire length of a journey to avoid people having to transfer their luggage a number of times.

- All operators pointed out a number of examples where a train is not just replaced by a single bus to replace it. This was due to; running 'fast' and 'slow' buses; some stations not being accessible by large buses, so minibuses were run; poor roads in rural areas causing long journey times, and so several buses shuttling backwards and forwards; and busy trains simply having more passengers than a single bus can accommodate. There were also examples of bus costs being higher due to buses not necessarily just running between the stations where the possession occurs. This was predominant late at night, where buses cannot make the connections and so run through to the final destination of trains, as well as the train running beyond a possession, often over long distances.
- Train Operators also pointed out the costs incurred if Network Rail cancelled a possession after the buses had been booked. It was suggested that the proposed mechanism should make some allowance for this.
- For one SE operator, the normal response if one London termini is blocked is to use an alternative station. Passengers are transferred between stations on LUL. However, occasionally key LUL lines are also subject to engineering work at the same time. In this case a significant bus operation is needed to transfer passengers. This suggests that an over-ride facility might be needed to enable the proposed mechanism to cope with material changes outside the scope of the railway itself.

2.1.4 Each Train Operator was invited to review and suggest amendments to our proposed list of example possessions. We also emphasised the importance of clear guidance as to the pattern of bus deployment and service impact in each case, to enable us to become fully informed regarding the services provided and able to calculate the EBMs accurately. Train Operators were asked to 'sign-off' these assumptions in order to prevent any interpretative bias on our behalf. However, in some cases due to the tight timescales and level of record-keeping, it was necessary for us to make some assumptions.

2.1.5 As before, Train Operators generally indicated that rail replacement buses were the most significant costs. Our analysis of the Stage 2 cost data is shown below in Table 2.1.

Table 2.1 – Analysis of Sample Possessions by Type of Cost.

Type of Costs	% of Total Costs			
	RoUs	SRoUs	Part G	Total
Rail replacement buses	98%	94%	93%	95%
Other	2%	6%	7%	5%

2.1.6 Thus the Stage 2 cost data confirms our conclusion from Stage 1 that rail replacement bus costs are the most significant costs to Train Operators. However, this figure may be an over-estimate of the proportion of rail replacement bus costs because of the difficulty in identifying all of the other costs, particularly for RoUs which are currently not compensated.

2.2 Representative Sample Possessions

2.2.1 As a result of the Stage 2 data collection exercise a sample set of 76 further possessions was collected (i.e. additional to the 80 possessions analysed in Stage 1). This sample covered the full range of duration, mileage, days and scales of disruption. Below, Figure 2.1 shows the histogram of the Stage 2 sample possessions distributed by the total costs to Train Operators. Figure 2.2 shows the distribution by duration of possession.

Figure 2.1 – Histogram of Stage 2 Sample by Cost to Train Operator.

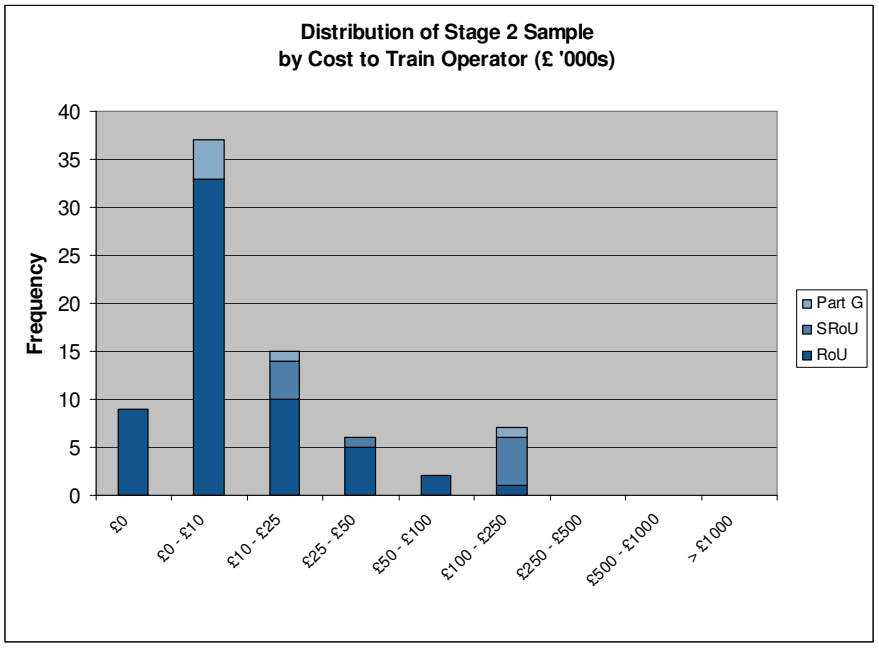
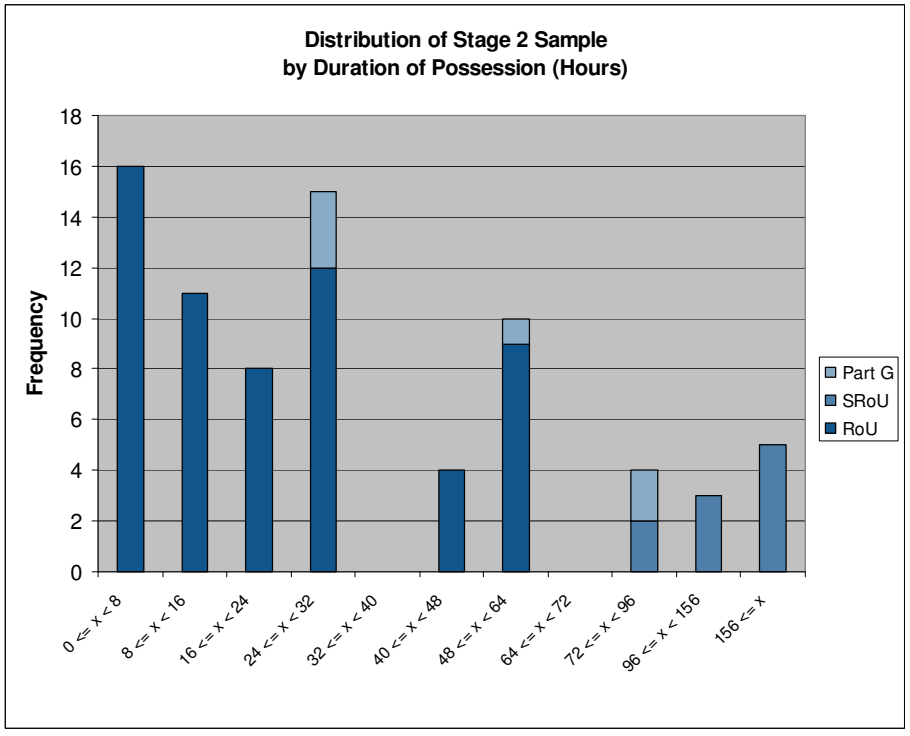


Figure 2.2 – Histogram of Stage 2 Sample by Duration of Possession.



2.2.2 For comparison Figure 2.3 shows the histogram of the complete sample (Stage 1 and Stage 2 combined) distributed by the total costs to Train Operators. Figure 2.4[2] shows the distribution by duration of possession. Figure 2.5 shows the equivalent duration histogram for the possessions on the national network during the financial year 2006/07.

Figure 2.3 – Histogram of Stages 1 and 2 Sample by Cost to Train Operator.

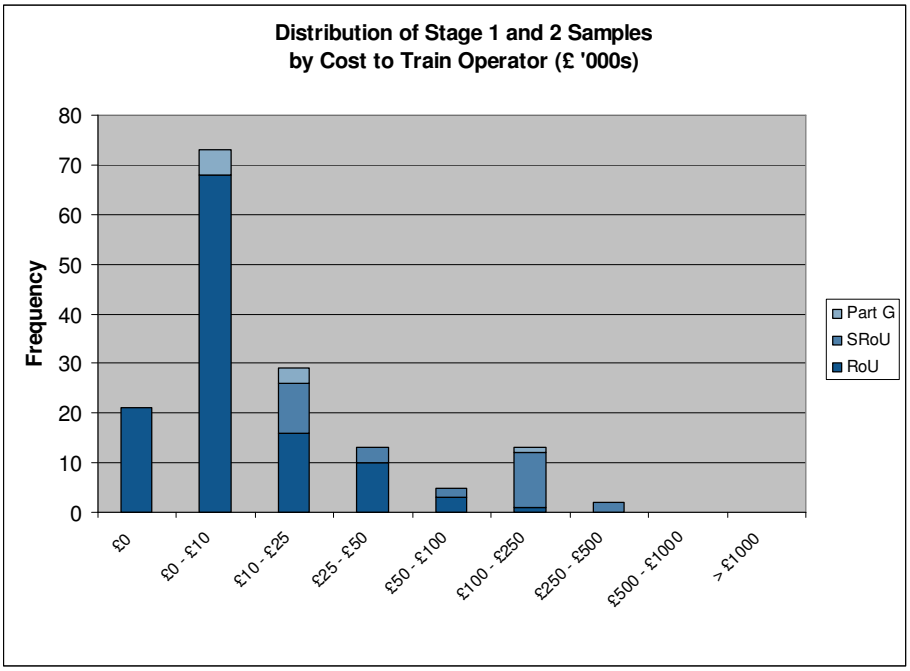
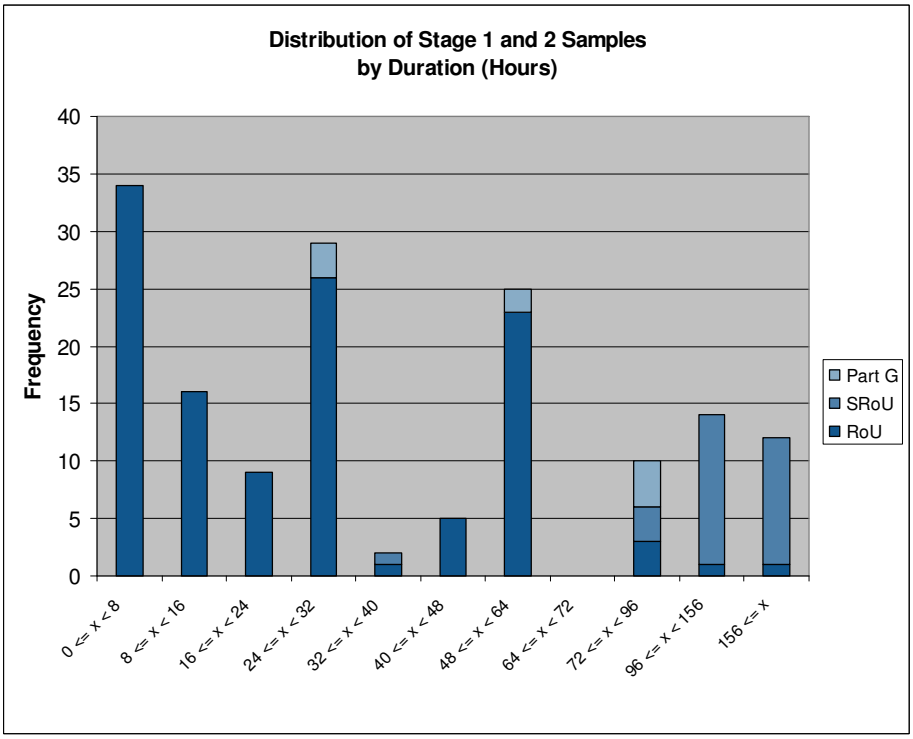
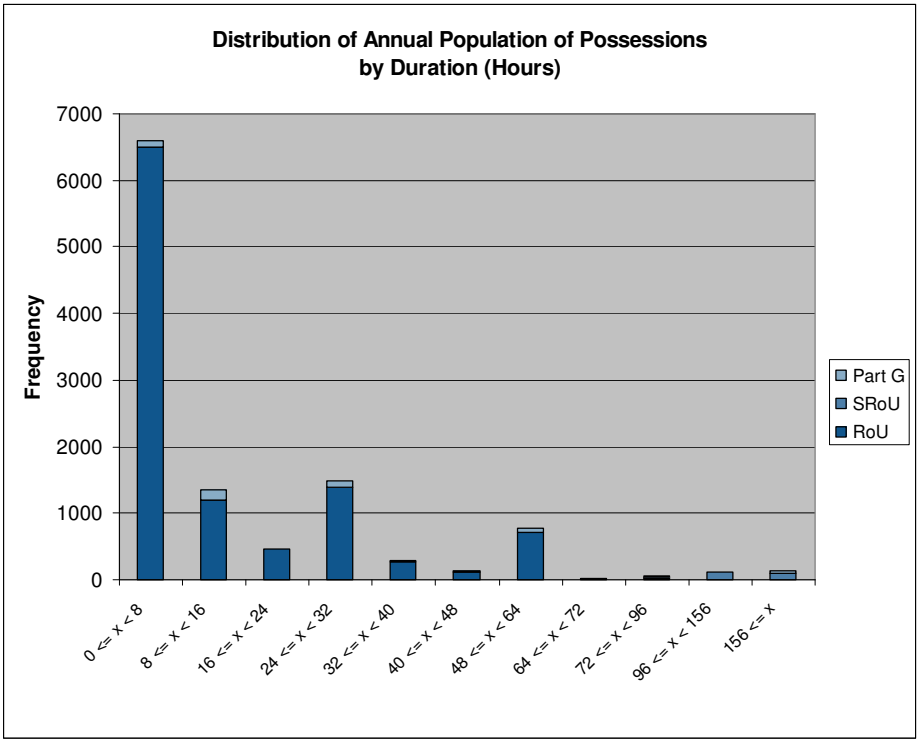


Figure 2.4 – Histogram of Stages 1 and 2 Sample by Duration of Possession.



[2] The histogram shows that the sample contains one possession that is 136 hours long, but is classed as a RoU since it has zero cost due to the availability of a diversionary route. One SRoU of 36 hours is also shown – this relates to WCRM and thus was subject to compensation.

Figure 2.5 – Histogram of Annual Population of Possessions by Duration.



2.2.3 As stated in the Stage 1 report, the annual possession population was taken as the 11,432 individual possessions recorded in Network Rail's Schedule 4 Compensation System (S4CS) for the financial year 2006/07. This total is calculated on the basis that every possession is counted once per Train Operator affected. Table 2.2 below compares the sample possessions collected in Stage 1 and Stage 2 against this population.

Table 2.2 – Analysis of Sample Size vs. Population.

	Number of Sample Possessions Collected	% of Annual Possession Population (of 11,432)
Stage 1	80	0.7%
Stage 2	76	0.7%
Total	156	1.4%

3. Testing the EBM Relationship

3 Testing the EBM Relationship

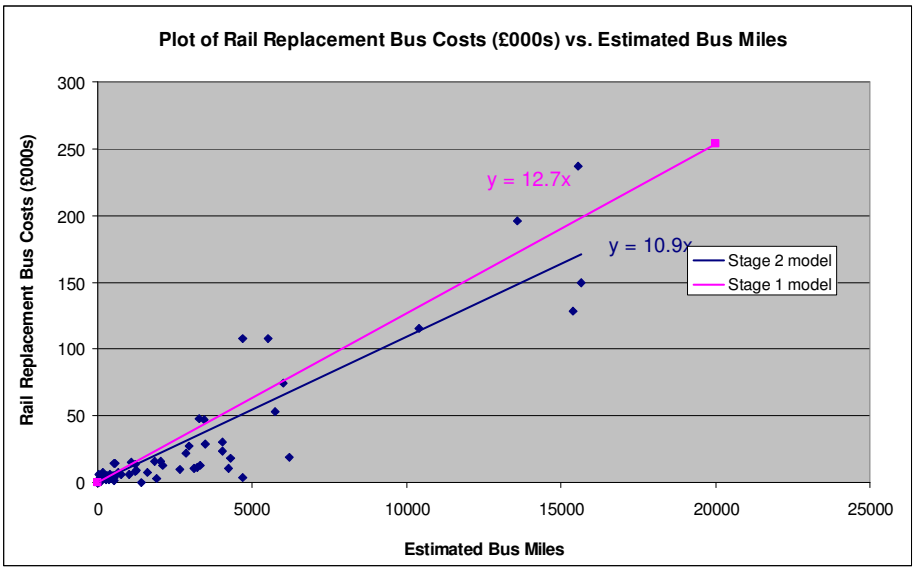
3.1.1 During Stage 1, the relationship between EBMs and rail replacement bus costs showed a reasonably good linear relationship. From the sample of data available, a single value per EBM was derived which provided reasonable compensation across the Train Operators. We therefore proposed that EBMs form the basis of a compensation mechanism for the industry.

3.1.2 The objectives of the Stage 2 analysis were to test the robustness of the relationship used in the proposed compensation mechanism, and also to conclude whether the best outcome is a single rate, or whether there should be differentiation, for example, between London and South East (LSE) operators and 'Other' operators. In working towards these objectives we have balanced the need for reasonable accuracy with the requirement for simplicity and practicality. Our analysis is reported here, with further detail provided in Appendix D.

3.1.3 The Stage 2 possession cost data was used to test the model derived during Stage 1 by applying the model to the Stage 2 data. The Stage 2 data was also used to produce a new equivalent model. The purpose was to test whether the proposed mechanism was robust by examining whether the Stage 2 data leads to significantly different results compared with the original analysis.

3.1.4 Figure 3.1 shows the plot of Rail Replacement Bus Costs against EBMs, with the model derived from the Stage 1 sample data compared with the model derived from the Stage 2 data.

Figure 3.1 - Rail Replacement Bus Costs against EBMs.



3.1.5 There appears to be a reasonable linear relationship between EBMs and costs in the Stage 2 data (an R-Squared of 0.87). However, the slopes of the models derived from the two sets of data are different. Table 3.1 shows the confidence intervals on the slope of the lines.

Table 3.1 - 95% Confidence Intervals for Both Models.

Model Derived From	95% Confidence Interval on m (slope of line)	
Stage 1 data	11.70	13.68
Stage 2 data	9.92	11.89

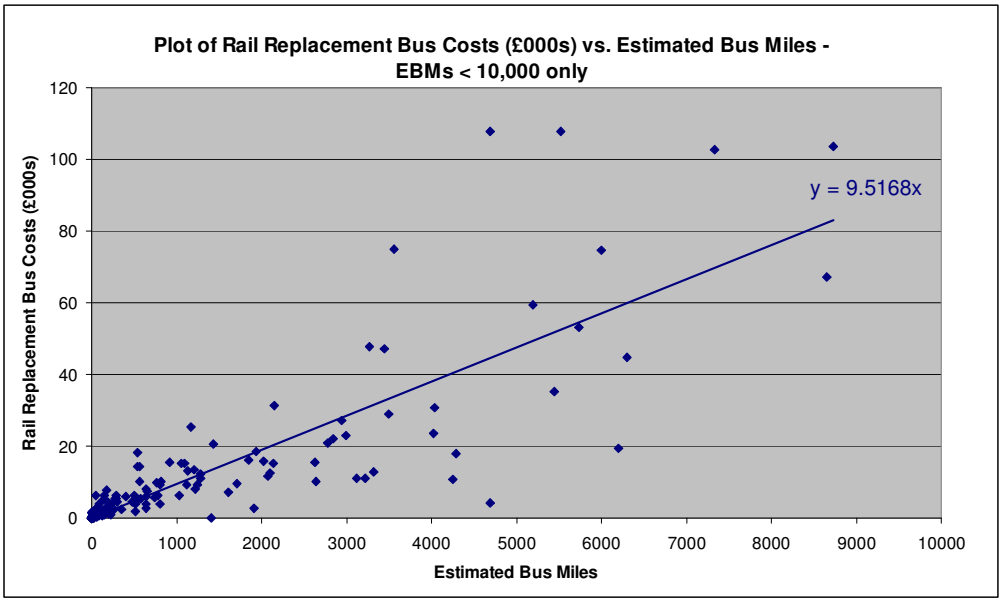
3.1.6 Since the 95% confidence intervals barely overlap, we concluded there is a significant difference between the fit of the EBM relationship to the two sets of data[3]. This could be because EBMs relationship is not robust and that the fit of the model during Stage 1 was a one-off. Alternatively, it might be caused by differences in the data that the model is currently not reflecting, for example, a change in the mix of operators.

3.1.7 The data is broadly representative of the pattern of possession on the network[4], which means it is not evenly spread. We have some concerns that a small number of high values are influencing the slope of the model[5] and resulting in a misleadingly high R-Squared value.

3.1.8 We tried taking logarithms to get a more evenly spread dataset. However, the resulting model significantly under-estimated compensation for the larger possessions. Our conclusion was that neither the linear model nor the log model handled the large-value possessions well. In the linear model they influence the results too strongly, and in the log model they are significantly under-estimated. Given that the log model does not seem to produce a significantly better model, we concluded that for the sake of simplicity we should continue with a linear model.

3.1.9 To remove the influence of the high value points we excluded points with more than 10,000 EBMs from our analysis. We would prefer our model to fit better at the low end where most of the points are, rather than at the high end where there are few points which could be addressed by special negotiation anyway. Figure 3.2 shows the resulting plot for only the small possessions in the combined dataset of Stage 1 and Stage 2 data.

Figure 3.2 - Rail Replacement Bus Costs against EBMs (Stage 1 and Stage 2 data).



3.1.10 As a result of excluding these points, the slope changes from 11.88 to 9.52, and the R-Squared value reduces from 0.88 to 0.77.

3.1.11 With the larger points excluded, the confidence intervals on the slope of the Stage 1 and Stage 2 models increase, (as shown in Table 3.2).

Table 3.2 - 95% Confidence Intervals for Both Models with Larger Points Excluded.

Model derived from	95% Confidence Interval		Slope
Stage 1 data	9.42	11.11	10.26
Stage 2 data	7.26	10.27	8.26

[3] A T-Test on the estimates of the slope from the two sets of data gave a probability of 0.012 that they were not statistically different (see Appendix D).
[4] The data contains a small number of quite large possessions, and then many small possessions.
[5] We have tested the influence of these points by removing each point in turn from the data and calculating the impact on the slope of the fitted line. However, unless we have an 'a priori' reason we cannot exclude these points arbitrarily.

3.1.12 Thus, removing the larger data points did not resolve the differences between the two datasets. So we then examined whether secondary variables should be included to help explain this variation between the relationships observed in the two datasets.

3.1.13 During Stage 1 we observed a range of unit rates (£ per EBM) within the group of London & South East (LSE) operators, and variance between different types of Train Operator, for example LSE, Intercity and Regional. We also noted possible differences between the SRoU vs. RoU split, and the weekend vs. weekday split. The combined dataset (both Stage 1 and Stage 2 data) has been used to test whether these differences are statistically significant, and hence whether different rates might be justified in the proposed compensation mechanism.

3.1.14 Table 3.3 shows the regression results from looking at three secondary variables: SRoU and RoUs; Weekend and Weekday possessions; by Train Operator type (LSE and Other).

Table 3.3 – Results of Models Including Secondary Variables (Smaller Possessions)

Secondary Variable Included	Slope	Lower 95% CI	Upper 95% CI	T-Test[6]	R^2
None	9.52	8.66	10.37	0.081	77%
RoU	11.57	8.78	14.37	0.000	80%
SRoU	7.65	7.00	8.30		82%
Weekday	7.89	6.53	9.25	0.013	75%
Weekend	10.15	9.09	11.21		79%
LSE	12.38	10.99	13.77	0.000	82%
Other	8.33	7.31	9.35		78%

3.1.15 We concluded that 'SRoU / RoU' and 'LSE / Other' are both candidates for inclusion as a secondary variable. However, it is more intuitive that 'LSE / Other' should be included because of the high costs of hiring buses in the South East of England, and greater road congestion will lead to longer journey times for equivalent journey lengths.

3.1.16 Including 'LSE / Other' as a secondary variable has not resolved the differences between the two datasets. This is shown below in Table 3.4 which shows the regression slopes derived when the data is segmented by Train Operator and stage of the study, e.g. for Regional operators there is a large difference between the slope derived from the Stage 1 and Stage 2 data.

Table 3.4 - Regression Slopes Derived from Segmented Data.

Train Operator Type	Stage 1 Data Regression Slope	Stage 2 Data Regression Slope
LSE	10.49	12.43
Regional	10.95	3.81
Intercity	7.85	-

[6] T-Test on the difference between the estimates of the slopes at the 5% level.

3.1.17 We concluded:

- There appears to be a reasonable linear relationship between EBMs and costs that can be derived from the Stage 2 data;
- The Stage 2 data and the Stage 1 data do not independently give the same model, and we have not identified any single factor which explains this difference;
- There is an issue with the data for high-value possessions, which has not been resolved by transforming the data using logarithms. Since these possessions are having an undue influence on the results we have excluded those with > 10,000 EBMs from the data;
- There is some evidence for having a 'RoU / SRoU' split or a 'LSE / Other' split. However, neither secondary variable helps fully explain the variation between the datasets; and
- It is more intuitive that 'LSE / Other' should be included.

3.1.18 The realistic solutions that could be implemented are:

- A simple linear model with a rate of £11.88 per EBM;
- A simple linear model with a rate of £9.52 per EBM, and provision for Train Operators to negotiate above 10,000 EBMs; or
- A simple linear model with a rate of £12.38 per EBM for LSE operators, and a rate of £8.32 per EBM for 'Other' operators, and a provision for Train Operators to negotiate above 10,000 Estimated Bus Miles.

3.1.19 We would recommend implementing the third of these options, given the good reasons to believe that costs in the South East of England are higher. If this analysis is not sufficient in to give confidence in setting the actual rates per EBMs, then we recommend requiring Train Operators to collect further possession cost data, in advance of CP4. This would provide a much larger dataset from which to draw conclusions, and possibly even to set individual rates per Train Operator.

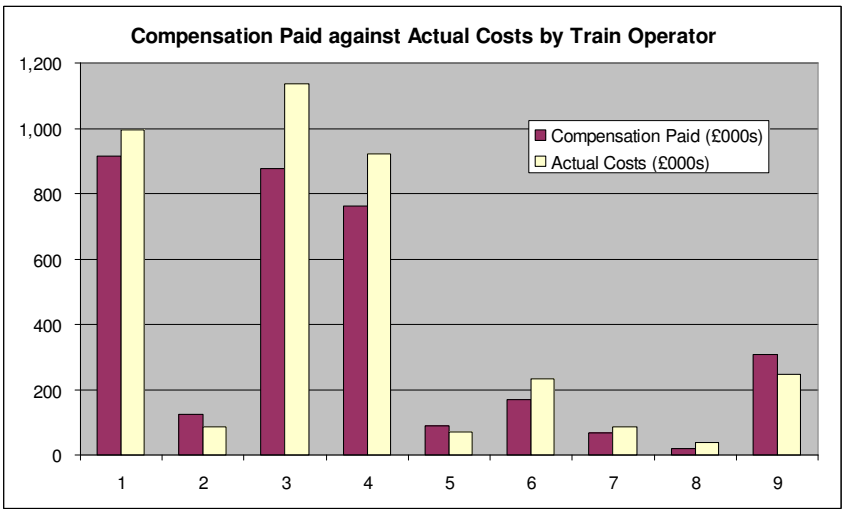
3.1.20 We have applied the third of these options to the combined sample data to test whether the mechanism provides fair compensation across the Train Operators. Table 3.5 shows the calculated compensation against actual costs for each Train Operator. Figure 3.3 shows the same results graphically. These suggest that on average, fair compensation is provided across the Train Operators.

3.1.21 Note, the data for which compensation is calculated is the same data that the model is based on. Therefore, the calculated compensation can only be taken as indicative of the likely size of error (if the model is applied to all possessions) if the sample is truly representative of the possession population. The results of the revised model would best be tested on a fresh (independent) dataset.

Table 3.5 – Calculated Rail Replacement Bus Compensation by Train Operator.

Train Operator	Actual Costs (£000s)	Estimated Costs (£000s)	% Difference
1	996	915	-8%
2	86	126	47%
3	1136	878	-23%
4	920	763	-17%
5	69	91	32%
6	233	169	-28%
7	85	69	-20%
8	40	19	-53%
9	247	306	24%
Total	**3812**	**3334**	**-13%**

Figure 3.3 – Calculated Rail Replacement Bus Compensation by Train Operator.



4. Practical Implementation

4 Practical Implementation

4.1 Outline of Principles

4.1.1 At the end of Stage 1, we recommended that the proposed compensation mechanism could be implemented through the use of lookup tables. The fundamental purpose of such tables would be to turn information that is already known about a possession into the parameters needed to calculate EBMs and thus the compensation payable.

4.1.2 When a possession is being planned, the following facts are known:

- The section of network that will be subject to engineering activity;
- The start and finish times for the possession; and
- The service groups that are affected.

4.1.3 The information required to calculate EBMs is:

- The number of trains affected (which can be derived from the timetable);
- The distances between stations on the network (fixed and invariable); and
- The impact on the train service (and thus the bus replacement required), i.e. the response by the Train Operator to the possession.

4.1.4 It is the last piece of the information that is not currently known, and which the lookup table is designed to supply. This will be done by recording the expected response of an individual Train Operator to a possession on a particular route section. This combined with the information on the trains affected and the distances would enable the compensation to be calculated in a repeatable and efficient manner.

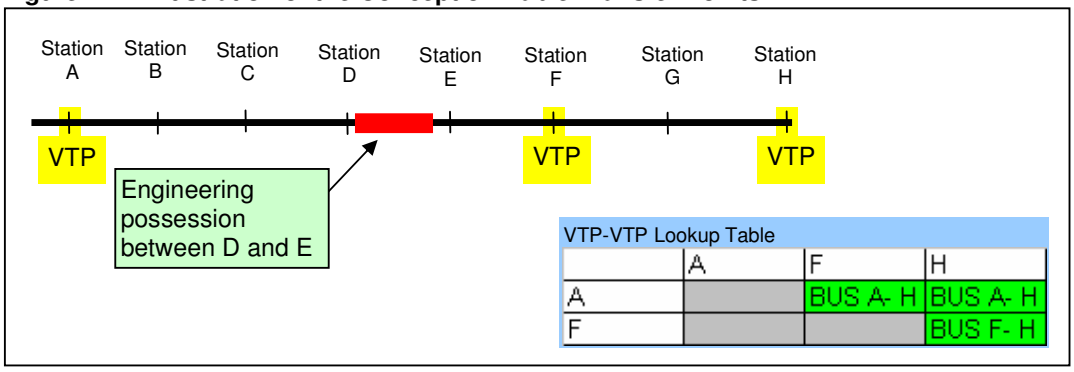
4.1.5 We developed the concept of a 'Viable Transfer Point' (VTP) which are stations where trains can be turned back short of the possession and passengers can be transferred conveniently between trains and buses / other trains / LUL, or represent points between which trains can be diverted around the possession. This concept provides the intermediate link between the section of network that will be subject to engineering activity and the distances over which trains and/or buses will operate as a result of the possession. Thus, any population of a lookup table for a Train Operator needs to begin by agreeing a list of the relevant VTPs.

4.1.6 For each pair of VTPs served by a Train Operator, a unique possession response can be defined and recorded. This is done in a 'road atlas distance table' format, henceforth known as a 'VTP-VTP Lookup Table'. To identify the agreed response to a particular possession, it is necessary to find the closest two VTPs that sit either side of the site of the possession.

4.1.7 The application of a VTP-VTP Lookup Table is illustrated in Figure 4.1. The section of network between stations D and E will be subject to engineering activity. The closest two VTPs that sit either side of the site of the possession are A and F. The response to this planned possession is looked up in the table.

4.1.8 The VTP-VTP Lookup Table shows that for a possession between A and F the agreed response is for trains to terminate at A from the west, and for buses to run between A and H. (Note, station H is the end of the line).

Figure 4.1 – Illustration of the Concept of Viable Transfer Points.



4.1.9 In this example, it would be possible to operate buses between A and F and restart trains between F and H. However, generally it is undesirable for trains to operate isolated from the rest of the network (and therefore crew and maintenance facilities). Hence, buses are operated between A and H. This example illustrates that the recorded response between two VTPs may (for such practical reasons) cover more than the section of network between these two points.

4.1.10 The VTP-VTP Lookup Tables will need to be populated at Service Group level, though in many cases all services for an individual Train Operator can be treated in the same way. However, the possibility of disaggregating the response to possessions is particularly important for Train Operators with less homogenous service patterns. These operators tend to run different levels of bus replacement due to the different needs of their passenger markets and the ability of the rolling stock to stop at particular stations.

4.1.11 Populating the VTP-VTP Lookup Tables will mean Train Operators and Network Rail agreeing for each entry in the table whether buses would run, a diversionary route would be used, or a combination of the two. Any debate about the rules and specific cases would be addressed as part of the process of populating the table, in other words in an 'off-line' debate.

4.1.12 We see preparation of the data for each Train Operator would involve two stages of work:

1. Identifying the relevant Viable Transfer Points which would be highlighted on a VTP Network Map – a different map may be required for each Service Group; and
2. Populating the VTP-VTP Lookup Table for each Service Group, that is for each pair of VTPs a unique possession response would be agreed and recorded.

4.1.13 Following this exercise, each individual possession response (i.e. each entry in the VTP-VTP Lookup Table) needs to be converted into a form that can feed into the calculation of EBMs. This mapping data would be created in a data population exercise and would be stored in the compensation system database as described in Section 4.3.

4.2 Preparation of Data for London Midland

4.2.1 In order to understand the effort required to complete the task of preparing the data for all operators, we were commissioned to trial this process for London Midland. We hosted two workshops for representatives of London Midland and Network Rail. In advance of these sessions we undertook some preparatory work to support the process. This included identifying information that could be used to assist the running of the workshop.

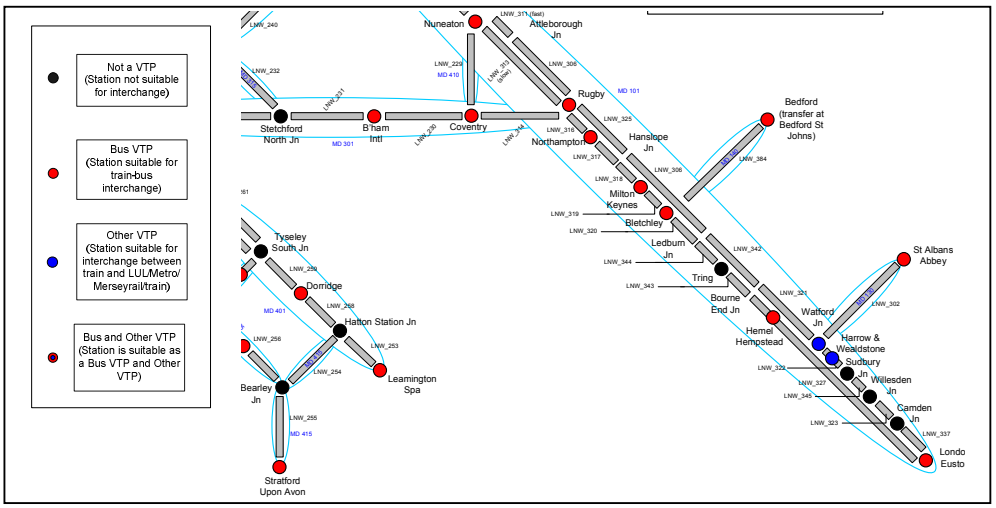
4.2.2 At the workshop the following issues emerged:

- There were some differences in the response on a Sunday compared to other days of the week. These differences are due to more capacity becoming available on a Sunday, enabling diversions to occur over alternative routes (which are otherwise congested). An example of this is where possessions on the Bromsgrove line can result in diversions on the Kidderminster line on a Sunday, but not otherwise due to lack of capacity on this route.
- There were examples where the length (distance) of a possession would affect the response, i.e. the response depends on whether adjacent sections were blocked. An example was the section from The Hawthorns to Birmingham Snow Hill. If the adjacent section (Smethwick to The Hawthorns) was unaffected, then trains would run to The Hawthorns and passengers use the Metro from there to travel to Birmingham Snow Hill. However, if Smethwick to The Hawthorns was also affected then bus replacement was required from Smethwick to Birmingham Snow Hill.
- The 'spokes' of the network were affected by whether there was access to stabling and train crew facilities at the end of the spoke. There is a general dislike of running train services that are isolated from these facilities by a disruptive possession. Thus, if a possession occurs at the start of a spoke, bus replacement tends to occur all the way to the outer end of the spoke (unless these facilities are available at this extremity). An example would be the route between Birmingham and Lichfield.
- The availability of road access was also a significant factor in determining where bus replacement would occur. For example, whilst Wellington on the Shrewsbury route had better facilities for turning trains around, in practice Telford was used to run bus operations because of the improved access to fast roads.
- In a number of cases bus replacement services are operated to stations on an adjacent line, rather than along 'line of route'. For example, when WCML is blocked south of Northampton, most replacement bus services operate to Wellingborough where passengers from Birmingham transfer to Midland Mainline services to London. In these cases, FULL bus replacement is assumed, with train miles being counted along the 'line of route'. This will tend to result in an over-estimate of compensation. However, it was agreed that as long as the mechanism was fair, 'winning' in these cases would be counteracted by 'losing' in other cases.
- Market location was also significant in determining the response to a possession. For example, a possession between Leamington Spa and Dorridge affecting London Midland services into Birmingham. Passengers from Leamington to Birmingham can use other services to travel via Coventry to Birmingham New Street. However, many of the passengers on these trains will be to or from intermediate stations (otherwise they would already be using fast trains). Thus the diversion does not provide a workable alternative for most passengers. Thus, in this case full bus replacement should be assumed between Leamington and Dorridge.
- There are additional costs due to the need for temporary bus transfer facilities if large volumes of passengers are to be handled at certain locations, for example, Birmingham New Street and Milton Keynes. This is discussed below in more detail.
- A number of stations were identified as being potential points from which to run bus services, but which are currently unsuitable to act as VTPs, due to the size of the bus stands or other safety concerns. Since under the proposals compensation is related to the location of VTPs, in the future it would be possible to assess the impact on the compensation bill of investing in

the creation of further VTPs at strategic locations on the network. This could help provide a business case for such investment, which would help reduce whole industry costs.

4.2.3 We began the actual data population process by identifying the VTPs which were recorded on a network map shown below in Figure 4.2. The complete map is shown in Appendix A.

Figure 4.2 – VTP Network Map of London Midland Routes.



4.2.4 We then moved on to populate the VTP-VTP Lookup Table for London Midland, differentiating between Service Groups where necessary. Figure 4.3 shows the VTP-VTP Lookup Table for the route between Wolverhampton and Shrewsbury. Further examples are shown in Appendix A.

Figure 4.3 – VTP-VTP Lookup Table for Birmingham to Stafford via Walsall.

LM03 Birmingham to Stafford via Walsall		Viable Transfer Points - To					
		Rugeley Trent Valley	Hensford	Walsall	Tame Bridge Parkway	Birmingham New Street	Wolverhampton
Viable Transfer Points - From	Stafford	FULL BUS: Stafford - Rugeley Trent Valley	FULL BUS: Stafford - Hensford	FULL BUS: Stafford - Walsall	FULL BUS: Stafford - Tame Bridge Parkway	FULL BUS: Stafford - BNS	n/a
	Rugeley Trent Valley		FULL BUS: Hensford - Rugeley Trent Valley	FULL BUS: Walsall - Rugeley Trent Valley	FULL BUS: Tame Bridge Parkway - Rugeley Trent Valley	FULL BUS: BNS - Rugeley Trent Valley	n/a
	Hensford			FULL BUS: Hensford - Rugeley Trent Valley	FULL BUS: Hensford - Tame Bridge Parkway	FULL BUS: Hensford - BNS	n/a
	Walsall				If Pleck Junction to Tame Bridge only Stafford services: DIVERT via Wolverhampton, PARTIAL BUS: Tame Bridge Parkway - BNS Walsall services: FULL BUS: Tame Bridge Parkway - Walsall	If Pleck Junction to Soho / Proof House only DIVERT via Wolverhampton, PARTIAL BUS: BNS - Walsall	FULL BUS: Walsall - Wolverhampton
					FULL BUS: Walsall - Tame Bridge Parkway	Else FULL BUS: BNS - Walsall	
	Tame Bridge Parkway					If via Soho and Perry Barr DIVERT via Aston, NO BUS	n/a
						If via Aston and Perry Barr DIVERT via Soho, PARTIAL BUS: BNS - Tame Bridge Parkway	
						Else DIVERT via Wolverhampton, PARTIAL BUS: BNS - Walsall	

4.2.5 Through this process we gained an understanding of the cost, time and resource required to develop the tables across all Train Operators. Table 4.1 shows an estimate of the breakdown required by each party to undertake this work for London Midland.

4.2.6 This process has provided an indication of the work required to create the two key sets of documentation (the VTP Network Map and the VTP-VTP Lookup Table). However, it is likely that in practice two further stages of work would be needed before the compensation process could begin operation:

- Conversion of each individual possession response (i.e. each entry in the VTP-VTP Lookup Table) into a form that can feed into the calculation of EBMs; and
- Wider review of the decisions recorded in the VTP-VTP Lookup Table by others in Network Rail and the Train Operator.

4.2.7 The data population exercise to create the two key sets of documentation has been trailed with London Midland. The effort involved in this task has been estimated below in Table 4.1. A considerable proportion of the time was spent discussing the best approach and refining the process and structure, something that would be avoided once the process was rolled out. However, the population was not completed by the end of the second session, and would probably require a further session to ensure that both Network Rail and the Train Operator were satisfied with the results. Therefore the time requirements for this stage are probably a reasonable indication of the average time needed per Train Operator.

4.2.8 Following this two other tasks are required before the process could begin operation. These have not been undertaken, but have been estimated in Table 4.1. Note, the task of converting each individual possession response so they can be used to calculate EBMs, could be undertaken either by Network Rail or by external support.

Table 4.1 - Effort to Populate London Midland Lookup Table.

Stage of Work	Effort Required (Days)		
	Train Operator	Network Rail	External Support
Preparation of VTP Network Map and VTP-VTP Lookup Table			
Preparation for Workshop			1
Workshop	2	2	6
Write-up			1
Other Tasks			
Wider Review	1	1	
Conversion of Possession Response			3
Total	**3**	**3**	**11**

4.2.9 At the workshop we were provided with an example of an Engineering Planning Guide produced by Network Rail. Unfortunately this Guide (for Aberdeen to Birmingham) covers a very limited part of the London Midland network[7]. However, it was an illustration of the information that may already be available, that could be used by the industry to prepare the lookup tables. We would suggest that further effort should be made to identify other such useful documents.

4.2.10 The purpose of the Guide is stated as *"to facilitate the planning of engineering work on the railway by establishing viable service alternatives for trains affected by engineering work. This guide shows in pictorial form the diversionary route arrangements to be implemented"*. Figure 4.4 shows an excerpt from the Guide.

[7] Whilst this Guide is currently the only one in print, we were told that others are being prepared.

Figure 4.4 – Excerpt from Engineering Planning Guide for Low Fell Jn – Ferry Hill.

Ferryhill – Darlington (LN600)

VXC

Divert via Norton West Jn (Stillington route) and/or bus replacement.

Start/terminate some services at Darlington/York to/from the south.

West Coast Main Line to be available north of Preston and with both routes to Manchester open via Bolton and Wigan and both routes Manchester – Birmingham via Crewe and Stoke.

GNER

Divert via Norton West Jn (Stillington route).

Services start/terminate at York. HST service 1 tph between York and Newcastle/Scotland.

Northern

Bus replacement and/or divert via Sunderland (Durham Coast Route).

TPE

Bus replacement and/or divert via Sunderland (Durham Coast Route).

Freight

Divert via Norton West Jn (Stillington route).

NB: Special arrangements for W9 traffic/containers.

4.3 Temporary Bus Facilities

4.3.1 At the London Midland and Network Rail workshop, it emerged that at some locations additional costs are incurred if large volumes of passengers are transferred to buses. Due to safety concerns at Birmingham New Street and Milton Keynes, if the number of passengers transferring to buses exceeds a certain level then this operation must be moved outside the station area to create more space and increase safety.

4.3.2 This incurs costs due to the requirement for traffic orders, road signage, barriers and police supervision. The costs of such temporary facilities are not included in the calculation of the proposed EBMs compensation rate, which is based on the costs (provided by Train Operators) of procuring vehicles and staff.

4.3.3 Where a possession breaches the proposed safety net of either single possession >60 hours (excluding public holidays) or a series of possessions, there will be an opportunity to recover these costs where they can be shown to breach £10,000. Where the Train Operator as Station Facility Owner (SFO) procures these temporarily facilities in many cases these costs will be recovered.

4.3.4 The situation is less clear where Network Rail is the SFO, for example at Birmingham New Street. In this case, if they can be confident of recovering the costs from Network Rail (as happens under the current Part G mechanism), one Train Operator might carry out the procurement on behalf of all the operators.

4.3.5 However, if Network Rail procures these facilities on behalf of the Train Operators, the additional cost would be shared between all of the affected operators. Thus there is some risk that the cost would not breach the proposed safety net of £10,000 and thus could not be recovered from the engineering project (via the proposed compensation arrangements). In this case there is the risk that either the cost is charged to the Network Rail Route, or Train Operators refuse to co-operate.

4.3.6 This issue could be handled in two ways:

- Network Rail could agree that at the limited number of locations where such problems exist, they will procure the facilities and charge the costs internally to engineering projects; or
- Each VTP could be given a capacity limit, which when breached would mean that calculation of compensation for each Train Operator could be based on the next VTP along (i.e. over a longer distance). The Train Operators would receive more compensation, which they would be expected to use to fund the required temporary facilities. However, they would also be free to instead operate buses from the next VTP station, if this were cheaper.

4.4 Operational Processes

4.4.1 As well as trialling the offline data collection exercise with London Midland, we also examined how the process might operate in practice. This has involved:

- Understanding Network Rail's possession planning process and how the S4CS revenue compensation system currently operates within this process;
- Developing a proposal for how cost compensation might be incorporated into the possession planning process; and
- Prototyping the compensation calculations in Microsoft Access, so that the resource and cost implications can be assessed.

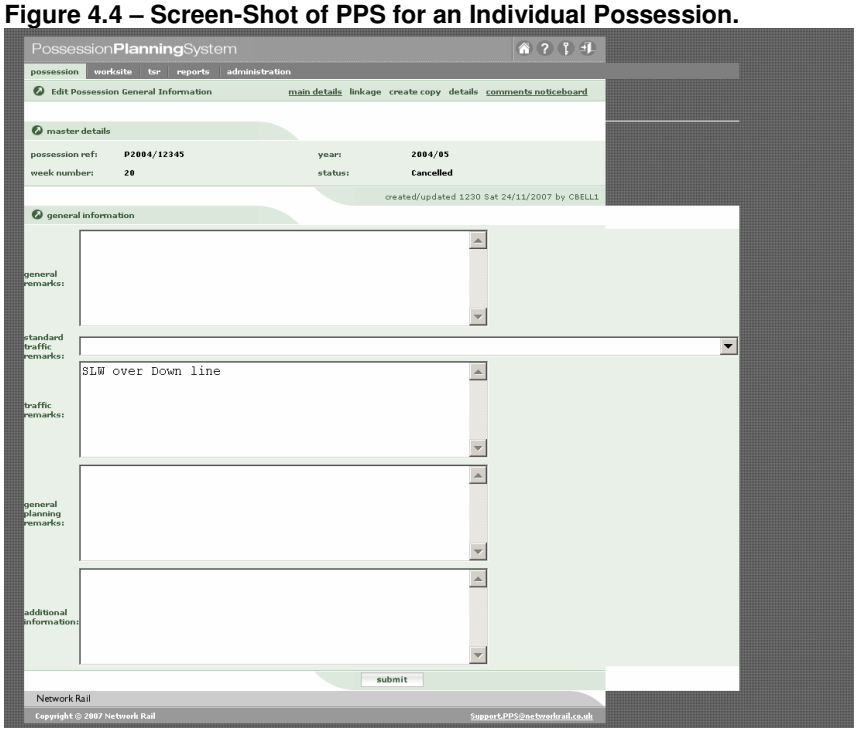
4.4.2 To help understand the possession planning process, we met a number of Network Rail personnel who support either the Schedule 4 revenue compensation system (S4CS) or the Possession Planning System (PPS). Their names are listed below in Table 4.2.

Table 4.2 – List of Network Rail Stakeholders.

Name	Role
Neil Raw	Schedule 4 Support Manager
Jo Bridge	Schedule 4 Support Assistant
Gordon Dudman	S4CS Developer
Chris Bell	PPS Support Technical Clerk

4.4.3 At the start of the possession planning process, Network Rail planners enter the details of a possession into the PPS system. During this process a free text field is used to make a suggestion to the Train Operator(s) affected as to what the appropriate response should be in terms of bus replacement / diversions etc. (Train Operators are free to accept or disregard this advice). Figure 4.4 illustrates that the response to a particular possession (as recorded in PPS) is to commence Single Line Working on the Down line.

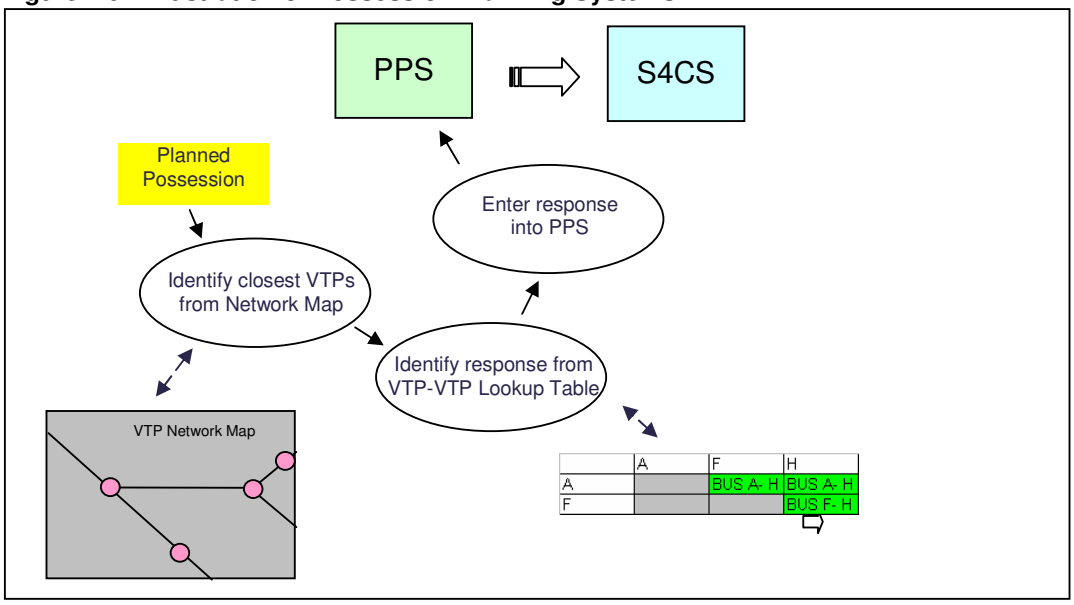
Figure 4.4 – Screen-Shot of PPS for an Individual Possession.



4.4.4 We propose that the planning process is adapted so that planners are asked to identify the relevant record(s) from the VTP-VTP Lookup Table for each possession. This information would then be entered into PPS, alongside other information. The code identifying the record in the table could be entered into an existing free text field (in an agreed format), or into a new text field or drop-down box. An advantage of using PPS to record this information is the robust

audit trail PPS provides, so that changes are recorded and can be tracked. This process is illustrated below in Figure 4.6.

Figure 4.6 – Illustration of Possession Planning Systems.



4.4.5 There is an existing interface between PPS and S4CS which is used to transfer the information used to calculate revenue compensation. This interface would need to be adapted to pass through the code identifying the record in the VTP-VTP Lookup Table (alongside the other information used in S4CS). In addition, there may be a need to modify the P3E system, which is used by Network Rail to plan possessions at a Territory level. P3E then interfaces with PPS, to transfer data. Modifying, P3E in addition to PPS would allow Territory planners to consider the impact on Train Operators (in terms of the possession response).

4.4.6 S4CS would be adapted to calculate the EBMs for the possession, and thus the compensation due to Train Operators. The unique code identifying the record in the VTP-VTP Lookup Table would be used to access data on the response from a stored database of responses[8]. These would be stored in terms of EBM weights for each of the Constant Traffic Sections[9] (CTS) that are affected by the response. Such a format of storing possession responses is illustrated below in Figure 4.7.

Figure 4.7 – Illustration of Format of Possession Response Data.

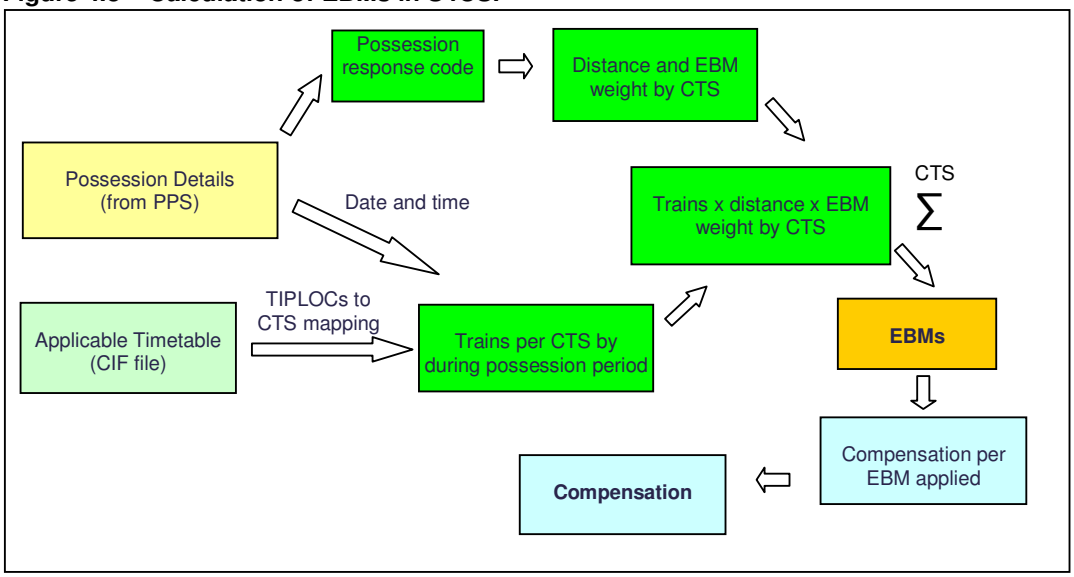
Possession Response	Service Group	CTS	% FULL BUS	% NO BUS	% SOME BUS	Intermediate Stop	From	To	Distance (KM)	RoR Section Name
LM01.01	ALL	LNW_337		100%			London Euston	Camden Jn	2.4	MD 101 Euston to Madeley (exclusive)
LM01.01	ALL	LNW_323		100%			Camden Jn	Willesden Jn	6.0	MD 101 Euston to Madeley (exclusive)
LM01.01	ALL	LNW_345		100%			Willesden Jn / Harlsd	Sudbury Jn	3.2	MD 101 Euston to Madeley (exclusive)
LM01.01	ALL	LNW_322		41%			Sudbury Jn	Watford Jn	16.6	MD 101 Euston to Madeley (exclusive)
LM01.02	ALL	LNW_337		100%			London Euston	Camden Jn	2.4	MD 101 Euston to Madeley (exclusive)
LM01.02	ALL	LNW_323		100%			Camden Jn	Willesden Jn	6.0	MD 101 Euston to Madeley (exclusive)
LM01.02	ALL	LNW_345		100%			Willesden Jn / Harlsd	Sudbury Jn	3.2	MD 101 Euston to Madeley (exclusive)
LM01.02	ALL	LNW_322		100%			Sudbury Jn	Watford Jn	16.6	MD 101 Euston to Madeley (exclusive)
LM01.03	ALL	LNW_337	100%				London Euston	Camden Jn	2.4	MD 101 Euston to Madeley (exclusive)
LM01.03	ALL	LNW_323	100%				Camden Jn	Willesden Jn	6.0	MD 101 Euston to Madeley (exclusive)
LM01.03	ALL	LNW_345	100%				Willesden Jn / Harlsd	Sudbury Jn	3.2	MD 101 Euston to Madeley (exclusive)
LM01.03	ALL	LNW_322	100%				Sudbury Jn	Watford Jn	16.6	MD 101 Euston to Madeley (exclusive)
LM01.03	ALL	LNW_321	87%				Watford Jn	Bourne End Jn	13.0	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_337	100%				London Euston	Camden Jn	2.4	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_323	100%				Camden Jn	Willesden Jn	6.0	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_345	100%				Willesden Jn / Harlsd	Sudbury Jn	3.2	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_322	100%				Sudbury Jn	Watford Jn	16.6	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_321	100%				Watford Jn	Bourne End Jn	13.0	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_343	100%				Bourne End Jn	Tring	9.7	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_344	100%				Tring	Ledburn	10.7	MD 101 Euston to Madeley (exclusive)
LM01.04	ALL	LNW_320	100%				Ledburn	Bletchley	13.7	MD 101 Euston to Madeley (exclusive)
LM01.05	ALL	LNW_337	100%				London Euston	Camden Jn	2.4	MD 101 Euston to Madeley (exclusive)

[8] This information is purely for system purposes and would be visible to those responsible for maintaining and supporting the system.

[9] CTS boundaries relate to where significant changes in traffic occur; thus they represent the most likely place for trains affected by a possession to terminate / re-start or to be diverted. Thus they provide a convenient way to summarise the possession response in terms of the factors that feed into the EBMs calculation.

4.4.7 The calculation of EBMs would then proceed as illustrated in Figure 4.8.

Figure 4.8 – Calculation of EBMs in S4CS.



4.4.8 CIF files (representing the Applicable Timetable) would be analysed by S4CS to count the number of trains running over each CTS for each time period. This would require a mapping between pairs of TIPLOCs and CTSs (which was provided to us by Network Rail). The date/time of the possession (taken from PPS) would then be used to count those trains on each CTS during the period of the possession.

4.4.9 The unique possession response would provide the EBM weight and distance for the CTSs affected. Thus this information can be combined with the numbers of trains from the timetable analysis above to calculate the EBMs, and thus the compensation paid to the Train Operator. As explained in Section 4.1 we are proposing that these calculations would occur at Service Group level.

4.4.10 The process we have proposed for calculating compensation would work equally smoothly whether it is finally decided to adopt a secondary variable or not. If multiple rates were incorporated, the appropriate rate would simply be selected from a table of rates.

4.4.11 To test the feasibility of this process, we have developed a prototype tool in Microsoft Access. The tool performs the calculation of EBMs when a possession is identified to a possession response. We have based this tool on a subset of the London Midland area, given that the VTP-VTP Lookup Table is already available for this Train Operator. Appendix E contains an outline of the design of this tool.

4.4.12 We have not investigated in detail the process required to calculate changes in train mileages. S4CS already carries out comparison of the timetables in order to calculate the revenue compensation that is due to Train Operators. Therefore, we believe that the changes needed to enable the system to calculate the change in train mileage by Service Group should be relatively simple. However, some manual intervention may be necessary to adjust this figure to take account of circumstances such as:

- Where a Service Group is affected by more than one possession and therefore the costs need to be allocated between them; and
- Where there are changes in train mileages that are not due to a possession, for example, driver training or movements for maintenance purposes.

4.4.13 It is likely that this intervention will need to be carried out in consultation with Train Operators who will have a clear view as to why particular train movements have been planned.

4.4.14 As a result of our research and development, we have concluded that if the possession planning process can be adapted as described above, a fairly automated process can be developed with minimal transaction costs. Table 4.3 lists the key dependencies that these changes would entail.

Table 4.3 – Key Dependencies to Incorporating Calculation of Cost Compensation.

Dependency	Required	Likely Cost
Amendments made to instructions for possession planning.	Yes	Small
New field added to PPS (and P3E).	No	Significant
Training of users to use VTP-VTP Lookup Table.	Yes	Small
Modification to PPS-S4CS Interface.	Yes	Significant
Modifications to S4CS.	Yes	Significant

4.4.15 S4CS calculates compensation after a possession has occurred, with a 'ready-reckoner' tool being used by some Network Rail Territories to assess the costs of disruptive access to the infrastructure. We believe that a similar tool should be created to estimate the cost compensation which would result from a proposed possession.

4.4.16 This 'ready-reckoner' would work in the same way as the live tool, but use a CIF file from a previous version of the timetable. Such a tool would enable Network Rail to take account of the costs of a possession as part of the engineering planning process (perhaps at T-60).

5. Conclusions and Recommendations

5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 In Stage 2 we have collected and analysed a further set of costs for 76 sample possessions. We have concluded:

- There appears to be a reasonable linear relationship between EBMs and costs in the Stage 2 data. However, the Stage 2 data and the Stage 1 data do not independently give the same model, and we have not identified any single factor which explains this difference;
- There is an issue with the data for high-value possessions, so those with > 10,000 EBMs have been excluded;
- There is some evidence for having a RoU / SRoU split or an LSE / Other split. It is more intuitive to include LSE / Other as a secondary variable. However, neither secondary variable helps explain the variation between the relationships observed in the two datasets;
- Applying a simple linear model with separate rates for LSE operators and Other operators to the combined dataset provides reasonable compensation to each Train Operator; and
- Given, the objective of simplicity, the data suggests that the proposed mechanism continues to provide a workable means of compensating Train Operators.

5.1.2 Therefore we recommend that:

- The proposed mechanism is taken forward, with the inclusion of LSE / Other as a secondary variable to the model;
- An additional threshold is incorporated to allow costs to be negotiated where EBMs are more than 10,000. These possessions have been excluded from the analysis, and there was some evidence for increased variability in costs at this level. Those possessions of this size that were included in the sample did not seem to fit the model derived from the smaller possessions; and
- If this analysis is not sufficient in to give confidence in setting the actual rates per EBMs, then we recommend requiring Train Operators to collect further possession cost data, in advance of CP4.

5.1.3 At the end of Stage 1, we recommended that the proposed compensation mechanism could be implemented by using lookup tables. As a result of trialling the preparation of data for London Midland, and considering some of the system issues, we have refined our proposals for how the mechanism would operate:

- The concept of a 'Viable Transfer Point' (VTP) has been developed – these are stations where trains can be turned back short of the possession and passengers can be transferred conveniently between trains and buses / other trains / LUL, or points between which trains can be diverted around the possession;
- In advance of operation, for each Train Operator, the relevant VTPs need to be identified on a VTP Network Map, and then a road-atlas style VTP-VTP Lookup Table populated to record the expected response to a possession. In addition, each entry in the VTP-VTP Lookup Table would need to be converted into a form that can feed into the calculation of EBMs;
- During operation, possession planners would use the VTP Network Map to identify the closest two VTPs that sit either side of the site of the possession. The VTP-VTP Lookup Table would be used to identify the agreed response between the two VTPs, which would be entered into the PPS free text field;
- The calculation of EBMs could then be incorporated into S4CS by finding the trains affected from analysis of the relevant CIF files and the date/time of the possession from PPS, and the

EBM weights and distances from the identified possession response (which would select the relevant record from a stored list);

- The process we have proposed for calculating compensation would work equally smoothly whether it is finally decided to adopt a secondary variable or not; and
- Under these proposals, compensation is related to the location of VTPs. Therefore, it will be possible to assess the impact on the compensation bill of investing in the creation of further VTPs at strategic locations on the network. This could help provide a business case for such investment, which would help reduce whole industry costs.

5.1.4 As a result of the data preparation sessions with London Midland, we reached the following conclusions about what could be expected as the process was rolled out to other Train Operators:

- Those involved were fully engaged and understood the concepts and objectives of the exercise. As the sessions progressed, the Faber Maunsell team began to adopt a more 'hands-off' approach; however, it was still necessary to keep reminding participants of the central concepts and objectives. We also dealt with a number of complex cases, where it was necessary for us to clarify how the process was applied (see Appendix C);
- Some reduction in external support could be expected as the process was rolled out to other Train Operators and becomes more familiar;
- However, the people who need to be involved in the process from the Train Operators (e.g. Track Access Managers, Forward Timetable Planning Managers) and Network Rail (e.g. Customer Relationship Executives) have limited available time. Thus, workshop sessions cannot afford to lose their way, by getting bogged down in details. Much of the role undertaken by the Faber Maunsell team was to keep the discussion 'on track' and to ensure that by the end of the sessions the key objective had been achieved;
- Preparatory work was found to be valuable in order to make best use of the working sessions, and the industry resources may not exist to undertake this in advance; and
- While the process may become more familiar to Network Rail as it is rolled-out, it would be fresh to each new Train Operator involved, who may require some support to understand the process.

5.1.5 We have also considered the practical issues of implementation, particularly the feasibility of incorporating the proposed compensation process within S4CS and the resource and cost implications of operating the mechanism. We have met with Network Rail employees who manage, support and operate S4CS and PPS. We have developed a practical process for operating the proposed compensation system.

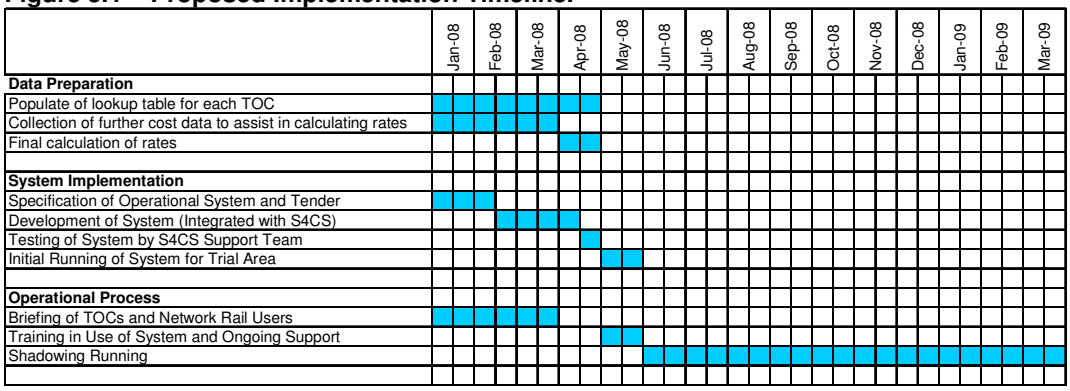
5.1.6 A number of outstanding policy decisions need to be taken by the industry:

- *Should a lower threshold be applied, below which costs are not compensated?* We believe that the proposals we have made regarding implementation could work with low transaction costs, suggesting that either a very low threshold or no threshold could be adopted;
- *Should the compensation rates be uplifted each year?* The default position would be to increase the rates annually by RPI. Analysis of the cost data from Train Operators might suggest efficiencies that could be expected during the Control Period, and thus the profile of rates that could incentivise this behaviour by Train Operators; and
- *At which date in the planning process should the cost compensation calculation be deemed to be frozen, and not subject to other variation, even if other factors change subsequently?* A strong argument can be made that calculations should be based on T-12, accepting that payment would be due for a possession in the T-12 plan, even if it subsequently does not go ahead.

5.2 Outline Timetable for Implementation

5.2.1 Below, as illustrated in Figure 5.1, we set out an outline of proposed steps and associated timescales for the longer-term implementation of the proposed mechanisms, in line with the timescales for the 2008 Periodic Review.

Figure 5.1 – Proposed Implementation Timeline.



5.2.2 One of the key activities is the population of a VTP-VTP Lookup Table for each of the 18 franchised Train Operators. This would include reviewing the London Midland table. Table 5.1 below shows our provisional estimate of the total industry effort to complete this process.

Table 5.1 – Industry Effort to Populate Lookup Tables.

Stage of Work	Person-Days Required		
	Train Operator	Network Rail	External Support
Per Train Operator	3	3	7
Total	**54**	**54**	**126**

5.2.3 We have assumed that the need for external support is significantly reduced as the process becomes more established. We also believe that this work could occur at the rate of three to four Train Operators per month, which would lead to completion by the end of April 2008.

5.2.4 The actual compensation rates will also need to be derived. This could involve further cost data for specific possessions from a wider group of Train Operators. We recommend that Train Operators are involved immediately so that, at the very least, accurate data can be collected for possessions occurring over the next few months.

5.2.5 A related issue is the need to ensure the rates used in the mechanism reflect the efficient costs to Train Operators of procuring bus services. Work undertaken during Stage 1 showed that proportionately higher costs were observed in the sample dataset for SRoUs compared to RoUs. This could be caused by a number of factors, one of which is that RoU possessions are currently uncompensated. Thus the RoU data points may represent more efficient costs of procuring bus services, since they are a direct cost to the Train Operator. However, the costs of RoUs may be under-estimated because Train Operators keep limited records of them. We suggest that further benchmarking should occur, perhaps using data sources from outside the industry.

5.2.6 Further work is needed to refine the rates per train mile for Train Mileage Costs, which should be derived from the annual variable access charge paid by each Train Operator, and the train miles run by that operator. In particular, further work may be needed to derive an accurate fuel costs for diesel trains, perhaps involving the use of benchmark fuel costs per train mile.

5.2.7 The development of a prototype compensation system leads us to believe that 14 weeks should provide sufficient time for tendering and developing the system changes needed to incorporate the process within S4CS. This would be followed by a short period of acceptance testing by Network Rail's S4CS Support Team. We would then propose a month of initial trial running for

a small part of the network. This would lead to an operational system, with full shadow-running commencing from the beginning of June 2008.

5.2.8 Training and support will also be needed for Network Rail and Train Operator staff. This would need to occur at a number of levels:

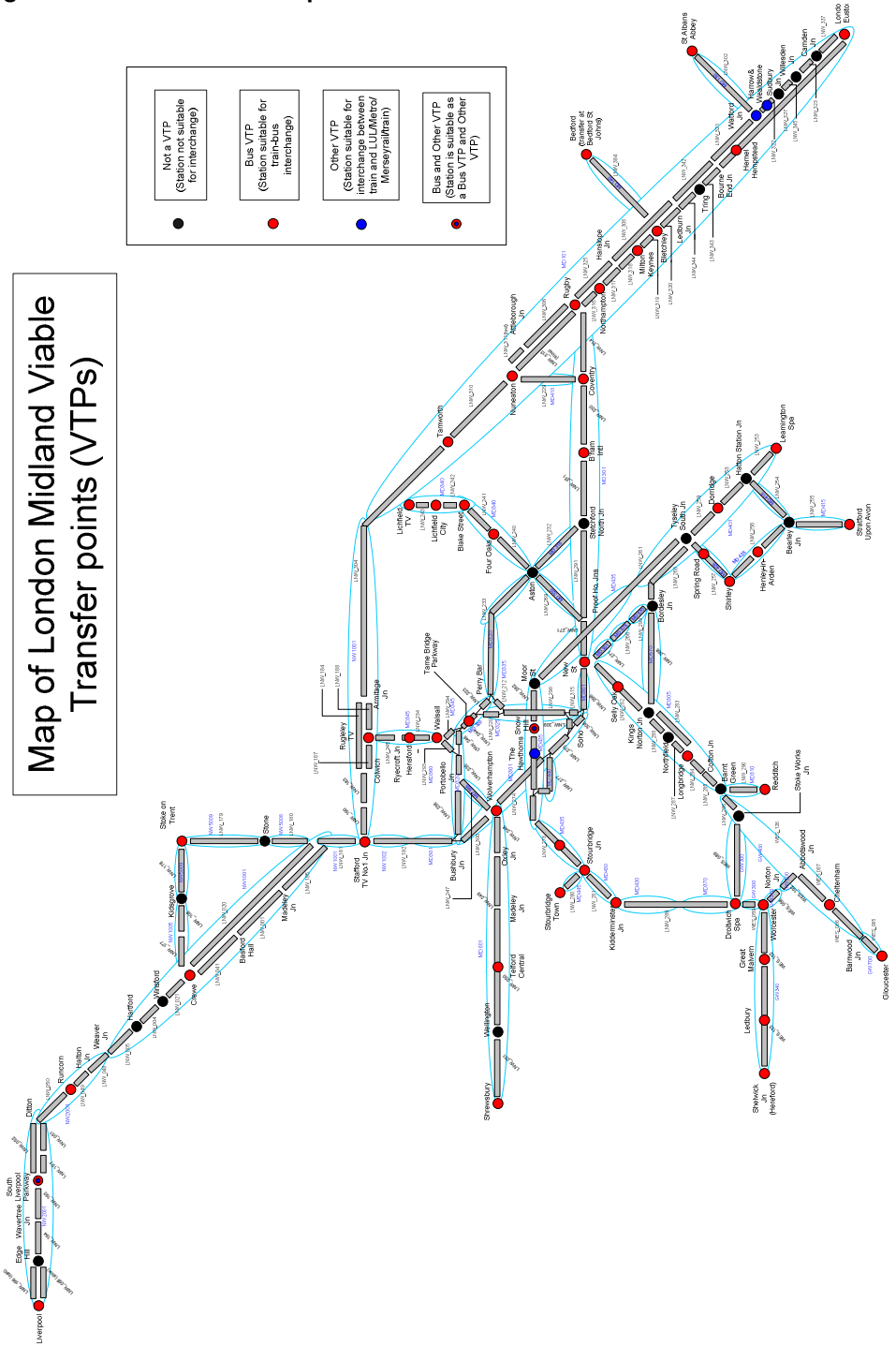
- Briefing sessions at a relatively senior level, and would involve an explanation of the proposed mechanism;
- Training and support of Network Rail possession planning teams to enable them to use the new system; and
- Support for Train Operator staff to enable them to verify the compensation calculated by Network Rail.

Appendix A: London Midland Data

Appendix A: London Midland Data

Figure A.1 shows a map of the London Midland network that was developed during the workshops, showing the applicable Viable Transfer Points.

Figure A.1 – VTP Network Map of London Midland Routes.



Figures A.2 – A.7 show the VTP-VTP Lookup Table for some of the London Midland routes.

Figure A.2 – VTP-VTP Lookup Table for Liverpool - Stafford - Nuneaton.

LM02 Liverpool - Stafford - Nuneaton		Viable Transfer Points - To							
		Liverpool South Parkway (LSP)	**Runcorn**	**Crewe**	**Stoke-on-Trent**	**Stafford**	**Rugeley Trent Vallay**	**Tamworth**	**Nuneaton**
Viable Transfer Points - From	**Liverpool Lime Street (LLS)**	If Mersey Rail operating and access to Allerton Jn TRANSFER: LLS - LSP, NO BUS Else If Allerton Jn available FULL BUS LLS - LSP Else FULL BUS: LLS - Runcorn	If Dition Xover available FULL BUS: LLS - Runcorn Else FULL BUS: LLS - Crewe	FULL BUS: LLS - Crewe	FULL BUS: LLS - Stoke-on-Trent	FULL BUS: LLS - Stafford	n/a	n/a	n/a
	Liverpool South Parkway (LSP)		If Dition Xover available FULL BUS: LLS - Runcorn Else FULL BUS: LLS - Crewe	FULL BUS: LLS - Crewe	FULL BUS: LLS - Stoke-on-Trent	FULL BUS: LLS - Stafford	n/a	n/a	n/a
	Runcorn			FULL BUS: LLS - Crewe	If Crewe station only affected DIVERT around Crewe, PARTIAL BUS: Runcorn - Stoke-on-Trent Else FULL BUS: LLS - Stoke-on-Trent	If Crewe station only affected DIVERT around Crewe, PARTIAL BUS: Runcorn - Stafford Else FULL BUS: LLS - Stafford	n/a	n/a	n/a
	Crewe				If E Midlands services running Crewe - Stoke TRANSFER: Crewe - Stoke Else FULL BUS: Crewe - Stoke	DIVERT: via Stoke-on-Trent Crewe - Stafford, NO BUS	n/a	n/a	n/a
	Stoke-on-Trent					If E Midlands services running Crewe - Stoke DIVERT: via WCML Crewe - Stafford, FULL BUS: Stoke - Stafford TRANSFER: Crewe - Stoke *(market to Crewe is weak)* Else DIVERT: via WCML Crewe - Stafford, FULL BUS: Crewe - Stoke - Stafford	tbc	tbc	tbc
	Stafford						FULL BUS: Stafford - Rugeley Trent Valley	tbc	tbc
	Rugeley Trent Vallay							tbc	tbc
	Tamworth								tbc

Figure A.3 – VTP-VTP Lookup Table for Euston to Stafford / Shrewsbury via Birmingham.

LM01 Euston to Stafford / Shrewsbury via Birmingham

Viable Transfer Points - To (columns) / Viable Transfer Points - From (rows)

From \ To	Harrow & Wealdstone	Watford	Hemel Hempstead	Bletchley	Milton Keynes	Northampton	Rugby	Coventry	Birmingham International	Birmingham New Street	Wolverhampton	Stafford	Telford	Shrewsbury
Euston	If Wembley North Junction available Transfer to LUL: Euston - Harrow & Wealdstone [LM01.01] ElseIf DC line operating: Transfer to DC line to Euston to Watford [LM01.02] Else FULL BUS: Euston - Hemel Hempstead [LM01.03]	If DC line operating: Transfer to DC line to Euston to Watford [LM01.02] Else FULL BUS: Euston - Hemel Hempstead [LM01.03]	FULL BUS: Euston - Hemel Hempstead [LM01.03]	FULL BUS: Euston - Bletchley [LM01.04]	FULL BUS: Euston - Milton Keynes [LM01.05]	FULL BUS: Euston - Northampton [LM01.06]	FULL BUS: Euston - Rugby [LM01.07]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Harrow & Wealdstone		FULL BUS: Euston - Watford [LM01.08]	FULL BUS: Euston - Hemel Hempstead [LM01.03]	FULL BUS: Euston - Bletchley [LM01.04]	FULL BUS: Euston - Milton Keynes [LM01.05]	FULL BUS: Euston - Northampton [LM01.06]	FULL BUS: Euston - Rugby [LM01.07]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Watford			FULL BUS: Euston - Hemel Hempstead [LM01.03]	FULL BUS: Euston - Bletchley [LM01.04]	FULL BUS: Euston - Milton Keynes [LM01.05]	FULL BUS: Euston - Northampton [LM01.06]	FULL BUS: Euston - Rugby [LM01.07]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hemel Hempstead				FULL BUS: Hemel Hempstead - Bletchley [LM01.08]	FULL BUS: Hemel Hempstead - Milton Keynes [LM01.09]	FULL BUS: Hemel Hempstead - Northampton [LM01.10]	FULL BUS: Hemel Hempstead - Rugby [LM01.11]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bletchley					FULL BUS: Bletchley - Milton Keynes [LM01.12]	FULL BUS: Bletchley - Northampton [LM01.13]	FULL BUS: Bletchley - Rugby [LM01.14]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Milton Keynes						FULL BUS: Milton Keynes - Northampton [LM01.15]	FULL BUS: Milton Keynes - Rugby [LM01.16]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Northampton							FULL BUS: Northampton - Rugby [LM01.17]	FULL BUS: Northampton - Coventry	n/a	n/a	n/a	n/a	n/a	n/a
Rugby								FULL BUS: Coventry - Rugby	FULL BUS: Birmingham International - Rugby	FULL BUS: BNS - Rugby	n/a	n/a	n/a	n/a
Coventry									FULL BUS: Birmingham International - Coventry	FULL BUS: BNS - Coventry	n/a	n/a	n/a	n/a
Birmingham International										Stechford to Proof House only Fast trains = DIVERT via Aston, NO BUS Local trains = DIVERT via Aston, PARTIAL BUS (Adderley Park) Else FULL BUS: BNS - Birmingham International	Stechford to Crane Street Jn only Liverpool & Shrewsbury trains = DIVERT via Aston & Tame Bridge Parkway, NO BUS Local trains = FULL BUS: Wolverhampton - Birmingham International Else Liverpool trains = FULL BUS: Stafford - Birmingham International Shrewsbury trains = FULL BUS: Shrewsbury - Birmingham International Local trains = FULL BUS: Wolverhampton - Birmingham International	n/a	n/a	n/a
Birmingham New Street											If only Soho to Crane Street Jn blocked Liverpool & Shrewsbury trains = DIVERT via Tame Bridge Parkway, NO BUS Local trains= FULL BUS: BNS - Wolverhampton [LM02.02] Else Liverpool & Shrewsbury trains = DIVERT via Aston and Tame Bridge Parkway, NO BUS Local trains= FULL BUS to Wolverhampton [LM02.03]	If only Soho to Bushbury blocked Liverpool & Shrewsbury trains = DIVERT via Tame Bridge Parkway PARTIAL BUS: Wolverhampton Local trains= FULL BUS: BNS - Wolverhampton [LM02.02] If only New Street to Bushbury blocked Liverpool & Shrewsbury trains = DIVERT via Aston and Tame Bridge Parkway PARTIAL BUS: Wolverhampton Local trains= FULL BUS to Wolverhampton [LM02.03] Else Liverpool trains = FULL BUS: BNS - Stafford Shrewsbury trains = FULL BUS: BNS - Shrewsbury Local trains = FULL BUS: BNS - Wolverhampton [LM02.04]	Shrewsbury trains = FULL BUS: BNS - Shrewsbury Liverpool trains = DIVERT via Tame Bridge Parkway PARTIAL BUS: Wolverhampton Local trains = FULL BUS: BNS - Wolverhampton	Shrewsbury trains = FULL BUS: BNS - Shrewsbury Liverpool trains = DIVERT via Tame Bridge Parkway PARTIAL BUS: Wolverhampton Local trains = FULL BUS: BNS - Wolverhampton
Wolverhampton												FULL BUS: Stafford - Wolverhampton	FULL BUS - Wolverhampton - Shrewsbury	FULL BUS - Wolverhampton - Shrewsbury
Telford														FULL BUS - Telford - Shrewsbury

Figure A.4 – VTP-VTP Lookup Table for Birmingham to Stafford via Walsall.

LM03 Birmingham to Stafford via Walsall		Viable Transfer Points - To					
		Rugeley Trent Valley	Hensford	Walsall	Tame Bridge Parkway	Birmingham New Street	Wolverhampton
Viable Transfer Points - From	Stafford	FULL BUS: Stafford - Rugeley Trent Valley	FULL BUS: Stafford - Hensford	FULL BUS: Stafford - Walsall	FULL BUS: Stafford - Tame Bridge Parkway	FULL BUS: Stafford - BNS	n/a
	Rugeley Trent Valley		FULL BUS: Hensford - Rugeley Trent Valley	FULL BUS: Walsall - Rugeley Trent Valley	FULL BUS: Tame Bridge Parkway - Rugeley Trent Valley	FULL BUS: BNS - Rugeley Trent Valley	n/a
	Hensford			FULL BUS: Hensford - Rugeley Trent Valley	FULL BUS: Hensford - Tame Bridge Parkway	FULL BUS: Hensford - BNS	n/a
	Walsall				If Pleck Junction to Tame Bridge only Stafford services: DIVERT via Wolverhampton, PARTIAL BUS: Tame Bridge Parkway - BNS Walsall services: FULL BUS: Tame Bridge Parkway - Walsall	If Pleck Junction to Soho / Proof House only DIVERT via Wolverhampton, PARTIAL BUS: BNS - Walsall	FULL BUS: Walsall - Wolverhampton
					FULL BUS: Walsall - Tame Bridge Parkway	Else FULL BUS: BNS - Walsall	
	Tame Bridge Parkway					If via Soho and Perry Barr DIVERT via Aston, NO BUS	n/a
						If via Aston and Perry Barr DIVERT via Soho, PARTIAL BUS: BNS - Tame Bridge Parkway	
						Else DIVERT via Wolverhampton, PARTIAL BUS: BNS - Walsall	

Figure A.5 – VTP-VTP Lookup Table for Birmingham - Leamington / Stratford.

LM04 Birmingham - Leamington / Stratford		Viable Transfer Points - To					
		Dorridge	**Leamington Spa**	**Spring Road**	**Shirley**	**Henley-in-Arden**	**Stratford Upon Avon**
Viable Transfer Points - From	**Birmingham Snow Hill (BSH)**	Leamington = FULL BUS: BSH - Leamington Stratford trains = FULL BUS: BSH - Stratford Upon Avon	Leamington = FULL BUS: BSH - Leamington Stratford trains = FULL BUS: BSH - Stratford Upon Avon	If Spring Road to sidings available Leamington trains = FULL BUS: BSH - Leamington Stratford trains = FULL BUS: BSH to Spring Road. Else Leamington = FULL BUS: BSH - Leamington Stratford trains = FULL BUS: BSH - Stratford Upon Avon	Leamington = FULL BUS: BSH - Leamington Stratford trains = FULL BUS: BSH - Stratford Upon Avon	Leamington = FULL BUS: BSH - Leamington Stratford trains = FULL BUS: BSH - Stratford Upon Avon	Leamington = FULL BUS: BSH - Leamington Stratford trains = FULL BUS: BSH - Stratford Upon Avon
	Dorridge		Leamington trains = FULL BUS: Dorridge - Leamington Spa Stratford trains = FULL BUS: Dorridge - Stratford Upon Avon	n/a	n/a	n/a	Leamington trains = FULL BUS: Dorridge - Leamington Spa Stratford trains = FULL BUS: Dorridge - Stratford Upon Avon
	Spring Road				DIVERT: via Hatton, PARTIAL BUS: Dorridge to Stratford Upon Avon	DIVERT: via Hatton, PARTIAL BUS: Dorridge to Stratford Upon Avon	FULL BUS - Dorridge to Stratford Upon Avon
	Shirley					DIVERT: via Hatton, PARTIAL BUS: Shirley to Stratford Upon Avon	FULL BUS - Shirley to Stratford Upon Avon FULL BUS - Dorridge to Stratford Upon Avon
	Henley-in-Arden						FULL BUS: Henley-in-Arden to Stratford Upon Avon FULL BUS: Dorridge to Stratford Upon Avon

Figure A.6 – VTP-VTP Lookup Table for Birmingham - Lichfield Trent Valley.

LM05 Birmingham - Lichfield Trent Valley		Viable Transfer Points - To			
		Aston	Four Oaks	Blake Street	Lichfield TV
Viable Transfer Points - From	Birmingham New Street	FULL BUS - Birmingham New Street - Lichfield TV	FULL BUS - Birmingham New Street - Lichfield TV	FULL BUS - Birmingham New Street - Lichfield TV	FULL BUS - Birmingham New Street - Lichfield TV
	Aston		FULL BUS - Birmingham New Street - Lichfield TV	FULL BUS - Birmingham New Street - Lichfield TV	FULL BUS - Birmingham New Street - Lichfield TV
	Four Oaks			FULL BUS - Four Oaks - Lichfield TV	FULL BUS - Four Oaks - Lichfield TV
	Blake Street				FULL BUS - Blake Street - Lichfield TV

Figure A.7 – VTP-VTP Lookup Table for Birmingham - Kidderminster/Redditch/Hereford.

LM06 Birmingham - Kidderminster / Redditch /

Viable Transfer Points - To

Viable Transfer Points - From

	The Hawthorns	Rowley Regis	Stourbridge Junction	Kidderminster	Selly Oak	Longbridge	Redditch	Droitwich Spa	Worcester Shrub Hill	Cheltenham Spa	Great Malvern	Ledbury	Hereford
Birmingham Snow Hill (BSH)	If Metro is available TRANSFER Metro - The Hawthorns BSH, NO BUS Else FULL BUS: BSH - Rowley Regis	FULL BUS: BSH - Rowley Regis	FULL BUS: BSH - Stourbridge Junction	If BSH - to Bescot only (on turnaround at Kidderminster) FULL BUS: BSH - Kidderminster Else FULL BUS: BSH - Droitwich Spa	n/a	n/a	n/a	FULL BUS: BSH - Droitwich Spa	FULL BUS: BSH - Worcester Shrub Hill	n/a	n/a	n/a	n/a
The Hawthorns	If No Hawthorns to Bescot only (on turnaround at Kidderminster) FULL BUS: BSH - Kidderminster Else FULL BUS: BSH - Droitwich Spa	FULL BUS: BSH - Rowley Regis	FULL BUS: BSH - Stourbridge Junction	If No Hawthorns to Bescot only (on turnaround at Kidderminster) FULL BUS: BSH - Kidderminster Else FULL BUS: BSH - Droitwich Spa	n/a	n/a	n/a	FULL BUS: BSH - Droitwich Spa	FULL BUS: BSH - Worcester Shrub Hill	n/a	n/a	n/a	n/a
Rowley Regis	If Rowley Regis to Bescot only (on turnaround at Kidderminster) FULL BUS: Rowley Regis - Kidderminster Else FULL BUS: Rowley Regis - Droitwich Spa		FULL BUS: Rowley Regis - Stourbridge		n/a	n/a	n/a	FULL BUS: Rowley Regis - Droitwich Spa	FULL BUS: Rowley Regis - Worcester Shrub Hill	n/a	n/a	n/a	n/a
Stourbridge Junction	If Stourbridge Junction to Bescot only (on turnaround at Kidderminster) FULL BUS: Stourbridge - Kidderminster Else FULL BUS: Stourbridge - Droitwich Spa				n/a	n/a	n/a	FULL BUS: Stourbridge - Droitwich Spa	FULL BUS: Stourbridge - Worcester Shrub Hill	n/a	n/a	n/a	n/a
Kidderminster					n/a	n/a	n/a	FULL BUS: Kidderminster - Droitwich Spa	FULL BUS: Kidderminster - Worcester Shrub Hill	n/a	n/a	n/a	n/a
Birmingham New Street (BNS)					Redditch trains = FULL BUS: BNS - Redditch Hereford trains = DIVERT: via Camphill NO BUS	If BNS - Kings Norton only Redditch trains = FULL BUS: BNS - Redditch Else if Sun Redditch trains = FULL BUS: BNS - Redditch Mon-Sat Redditch trains = FULL BUS: BNS - Redditch Hereford trains = FULL BUS: BNS - Worcester SH	If Sun Redditch trains = FULL BUS: BNS - Redditch Mon-Sat Redditch trains = FULL BUS: BNS - Redditch Hereford trains = FULL BUS: BNS - Worcester SH	If Sun Redditch trains = FULL BUS: BNS - Redditch Mon-Sat Redditch trains = FULL BUS: BNS - Redditch Hereford trains = FULL BUS: BNS - Worcester SH	n/a	n/a	n/a	n/a
Selly Oak						If Selly Oak - Kings Norton only Redditch trains = FULL BUS: BNS - Redditch Hereford trains = DIVERT: via Camphill, NO BUS Else if Sun Redditch trains = FULL BUS: BNS - Redditch Hereford trains = DIVERT: via Stourbridge Junction Mon-Sat Redditch trains = FULL BUS: BNS - Redditch Hereford trains = FULL BUS: Worcester SH	If Sun Redditch trains = FULL BUS: Selly Oak - Redditch Hereford trains = DIVERT: via Stourbridge Junction Mon-Sat Redditch trains = FULL BUS: Selly Oak - Redditch Hereford trains = FULL BUS: BNS - Worcester SH	If Sun Redditch trains = FULL BUS: Selly Oak - Redditch Hereford trains = DIVERT: via Stourbridge Junction Mon-Sat Redditch trains = FULL BUS: Selly Oak - Redditch Hereford trains = FULL BUS: BNS - Worcester SH	n/a	n/a	n/a	n/a
Longbridge							If Sun Redditch trains = FULL BUS: Longbridge - Redditch Hereford trains = DIVERT: via Stourbridge Junction Mon-Sat Redditch trains = FULL BUS: Longbridge - Redditch Hereford trains = FULL BUS: Worcester SH	If Sun Redditch trains = FULL BUS: Longbridge - Redditch Hereford trains = DIVERT: via Stourbridge Junction Mon-Sat Redditch trains = FULL BUS: Longbridge - Redditch Hereford trains = FULL BUS: Worcester SH	n/a	n/a	n/a	n/a	n/a
Droitwich Spa									Hereford trains = FULL BUS: Droitwich Spa - Worcester SH Local trains = FULL BUS: Droitwich Spa - Great Malvern	n/a	Hereford trains = FULL BUS: Droitwich Spa - Hereford Local trains = FULL BUS: Droitwich Spa - Great Malvern	n/a	n/a
Worcester Shrub Hill										FULL BUS: Worcester SH - Cheltenham Spa	FULL BUS: Worcester SH - Hereford	FULL BUS: Worcester SH - Hereford	FULL BUS: Worcester SH - Hereford
Great Malvern												FULL BUS: Great Malvern - Hereford	FULL BUS: Great Malvern - Hereford
Ledbury													FULL BUS: Ledbury - Hereford

Appendix B: Notes of Workshop Discussion

Appendix B: Notes of Workshop Discussion

In September, we hosted an industry workshop on behalf of ISG to explain our proposals and to support the consultation process. The issues highlighted by the industry representatives at the workshop are listed below:

- The issue of whether a Train Operator would charge other Train Operators for carrying their passengers during a possession. This can depend on whether the possession has fed into ORCATS, and thus the carrying Train Operator gets a revenue boost.
- Joint bus plans are a common feature – would this mechanism encourage or discourage more efficient working?
- The impact of train and flow size on the volume of buses required. Surely this would affect bus costs and should be reflected in the mechanism?
- The issue of thresholds and the impact on behaviour. For example, a lower threshold might lead to Network Rail planning possessions to come in at just under this limit to avoid making compensation payments.
- The compensation for changes in train mileage does not take into account additional staff and maintenance costs.
- Calculating an average rate per train mile at Train Operator level could lead to significant inaccuracies, given the difference between vehicle miles and train miles. Doing this at service group level might help resolve this issue.

Appendix C: Clarification of EBM Principles

Appendix C: Clarification of EBM Principles

During the data collection exercise we observed how the proposed mechanism coped with potential 'special cases'. We were also presented by Train Operators with some hypothetical 'what-ifs', as they asked how the mechanism would cope with potential possessions.

As a result of this process we developed some clarifying principles to ensure that a consistent approach to interpreting each possession was applied across the sample dataset, and across the different Train Operators. If the proposed mechanism were implemented by the industry it is likely that these 'case law' principles would develop further, and would become a useful aid to creating the proposed lookup table for each Train Operator. Table C.1 outlines the principles below.

Table C.1 – 'Case Law' Principles for Calculating EBMs.

Situation	Principles for Calculating EBMs
A diversionary route allows trains to operate around a possession. However, limited capacity on the diversionary route means that only a subset of services can be diverted.	50% or more of services can be diverted = NO or PARTIAL bus replacement. Less than 50% of services can be diverted = FULL bus replacement.
A parallel route is available (e.g. LUL) but there is limited capacity to carry the number of passengers on the disrupted service.	Passengers on 50% or more of services can be diverted then either NO or PARTIAL bus replacement. Less than 50% of services can be diverted then FULL bus replacement assumed.
A diversionary or parallel route is available. However, the alternative does not feed into the 'key' stations for the service group, which actually lies within the scope of the possession.	The location of the 'key' destination / origin of passengers should be taken into account. In this case FULL bus replacement should be assumed.
Most replacement bus services are operated to stations on an adjacent line, rather than along 'line of route'. This could be termed as having an available parallel route, but which lies some distance from one of the ends of a possession.	Assumed as FULL bus replacement, with train miles being counted along the 'line of route'. This will tend to result in an over-estimate of compensation. However, most examples of this are in LSE which may be under-compensated in other cases.
A diversionary route allows trains to operate around a possession. However, limited capacity on the diversionary route means that trains on the diversionary route are removed to enable the long-distance services to be diverted.	Compensation for the long-distance diverted services and the removed services on the diversionary route are calculated separately.
Trains in different service groups are treated differently on the same route, because of different stopping patterns and demand.	EBMs are calculated at service group level.
Trains are diverted around a possession, but partial bus replacement is required for intermediate stations. The number of trains calling at these intermediate stations varies by station.	Calculation of EBMs for partial bus replacement is based on the maximum % of trains stopping at any intermediate station.
Due to a possession at the start of a route, trains originate from a different station and then join the original route part-way through their journey.	EBMs are calculated based on the distance from the normal origin station to the first station that is common between the normal and diverted routes.
All stations within Zone 1 of the Travelcard area are treated as being accessible by LUL or bus.	EBM weight of 0.0 applied to diversions to alternative London termini.

Appendix D: Statistical Analysis

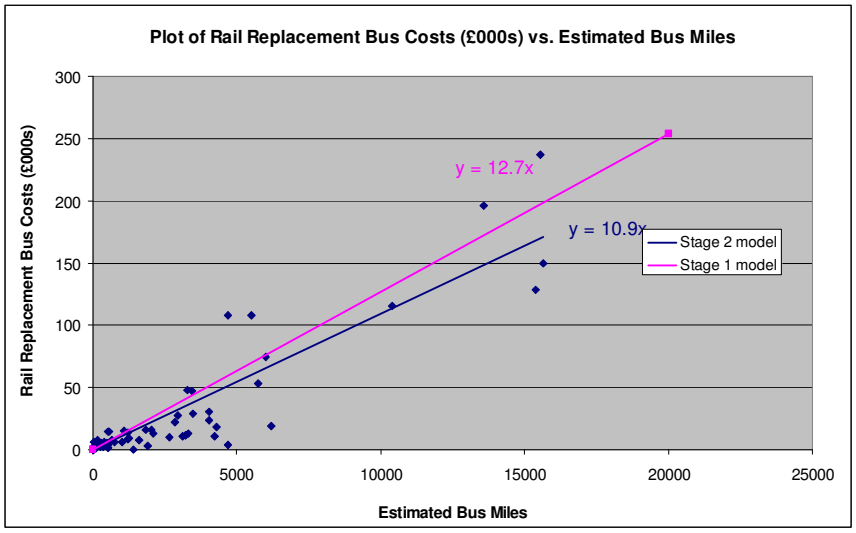
Appendix D: Statistical Analysis

Testing the Stage1 Model

The Stage 2 possession cost data was used to test the model derived during Stage 1 by applying the model to the Stage 2 data. The Stage 2 data was also used to produce a new equivalent model. The purpose was to test whether the proposed mechanism was robust by examining whether the Stage 2 data leads to significantly different results compared with the original analysis.

Figure D.1 shows the plot of Rail Replacement Bus Costs against EBMs, with the model derived from the Stage 1 sample data compared with the model derived from the Stage 2 data.

Figure D.1 - Rail Replacement Bus Costs against EBMs.



There appears to be a reasonable linear relationship between EBMs and costs in the Stage 2 data (an R-Squared of 0.87). However, the slopes of the models derived from the two sets of data are different. Table D.1 shows the confidence intervals on the slope of the lines.

Table D.1 - 95% Confidence Intervals for Both Models.

Model Derived From	95% Confidence Interval on m (slope of line)	
Stage 1 data	11.70	13.68
Stage 2 data	9.92	11.89

We performed a T-Test to test the Null Hypothesis that the estimates of the slope from the two sets of data are not statistically different. The T-Test gave a probability of 0.012 at the 5% level, from which we concluded that there was a significant difference between the fit of the EBM relationship to the two sets of data. This could be because EBMs relationship is not robust and that the fit of the model during Stage 1 was a one-off. Alternatively, it might be caused by differences in the data that the model is currently not reflecting, for example, a change in the mix of operators.

In Table D.2 below, the actual costs for the Stage 2 sample possessions are compared against the compensation paid under the Stage 1 and Stage 2 models. This shows that the application of the Stage 2 model over-estimates costs considerably.

Table D.2 – Application of Stage 1 and Stage 2 Models to Stage 2 Possessions.

Train Operator	Actual Costs (£000s)	Stage1 Model Compensation (£000s)	% Difference	Stage 2 Model Compensation (£000s)	% Difference
1	996	939	-6%	806	-19%
2	86	129	50%	111	29%
3	483	807	67%	693	44%
4	69	93	36%	80	16%
5	95	231	142%	198	108%
Total	1,729	2,199	27%	1,888	9%

In the above table, the data for which compensation is calculated is the same data that the Stage 2 model is based on. Therefore, the compensation under the Stage 2 model can only be taken as indicative of the likely size of error (if the model is applied to all possessions) if the sample is truly representative of the possession population. As discussed below, there are a number of reasons why the Stage 2 sample may not be fully representative.

There could be a number of underlying reasons for differences in the relationships seen in the Stage 1 data compared with the Stage 2 data. During Stage 1 we observed variation between different types of Train Operator. Hence, the change in the mix of operators could have a significant impact on this relationship. Table D.3 shows the mix of Train Operators who provided data for each stage of the study.

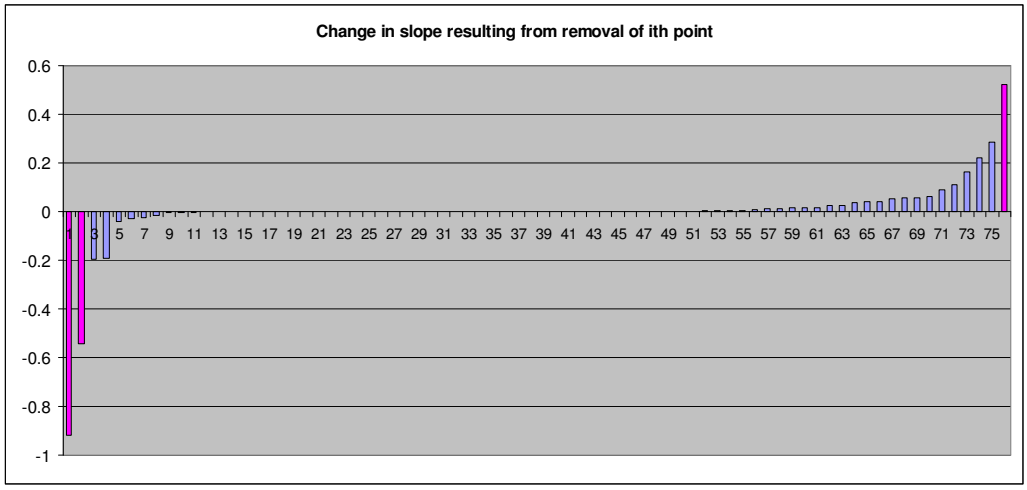
Table D.3 - Train Operators Providing Data for the Study.

Type of Train Operator	Stage 1	Stage 2
LSE	1	3
Regional	3	2
Intercity	2	0

Although the Stage 2 data does appear to show a reasonable linear relationship, Figure D.1 shows that the data consists of a large proportion of small value points which are generally over-estimated, and a small number of high value points which look to be driving the slope of the line. This merits further investigation, as we would prefer our model to fit better at the low end where most of the points are, rather than at the high end where there are few points which could be addressed by special negotiation anyway.

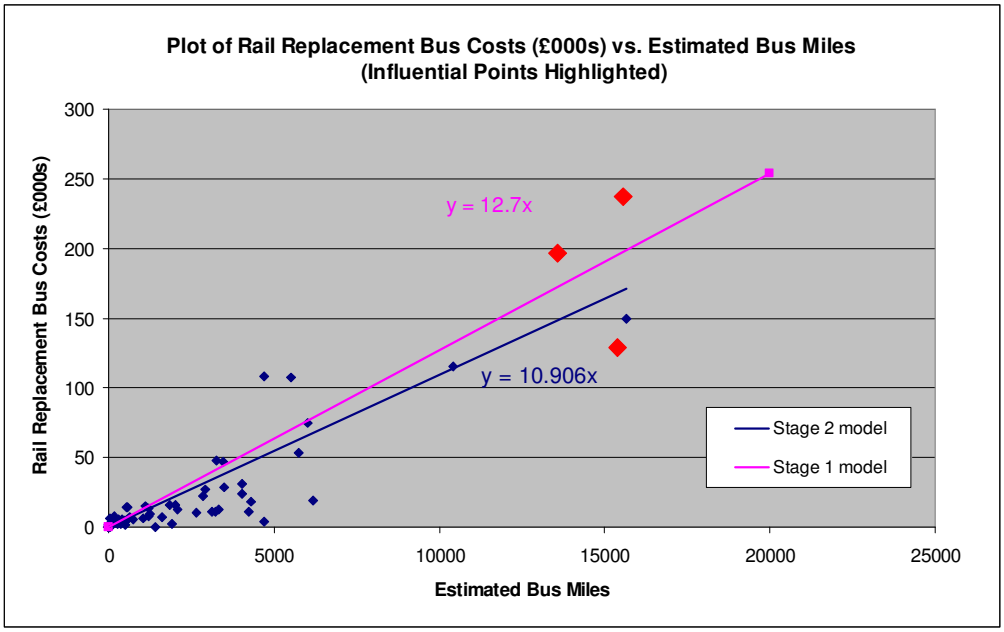
To assess how influential these high value points are, we have recalculated the slope removing each point in turn. The more the removal of the point changes the slope, the greater the influence of that individual point. Figure D.2 shows the impact of removing each data point on the resulting regression slope.

Figure D.2 - Impact Of Removing Each Data Point On The Resulting Regression Slope.



There are three points with particularly high influence, and these are three of the highest value points (as indicated in Figure D.3).

Figure D.3 - Rail Replacement Bus Costs against EBMs (Points of Influence Shown).



We concluded from the Stage 2 data that there was a linear relationship between EBMs and costs, although it was different to the Stage 1 relationship. However, there were problems with the distribution of the data points and the fit of the model at the low end versus the high end. Therefore we decided to combine the data from Stages 1 and 2 into one dataset and examine whether these problems still existed in the full dataset.

Creating a Model based on All Data

Figure D.4 suggests that the same problems are found with the combined dataset as the Stage 2 data – i.e. a large number of small value points that are over-estimated and a few high value points which appear to be quite influential in determining the slope of the line.

Figure D.4- Rail Replacement Bus Costs against EBMs using All Data.

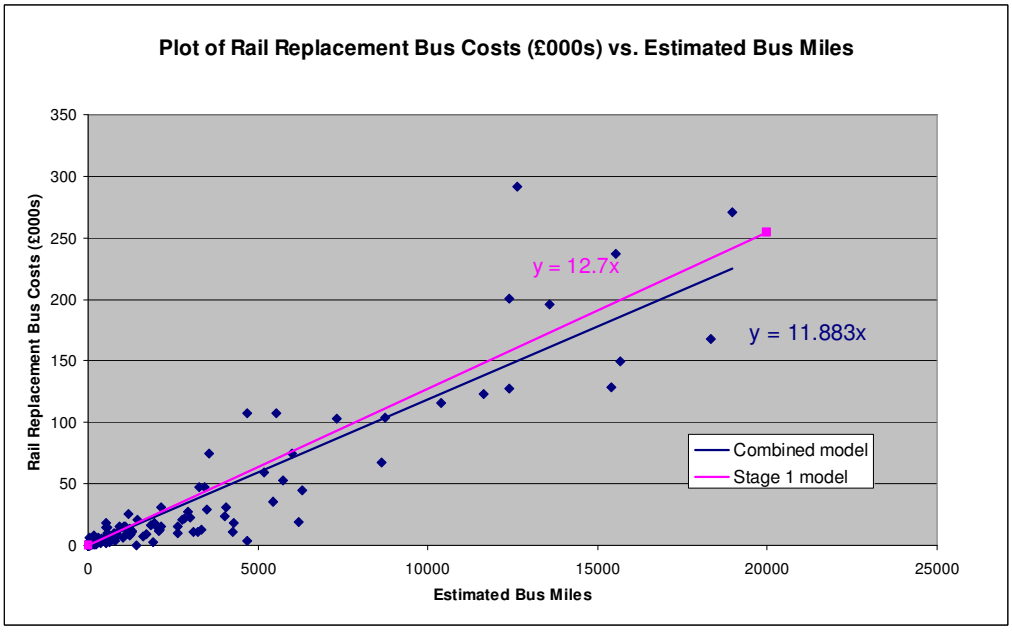
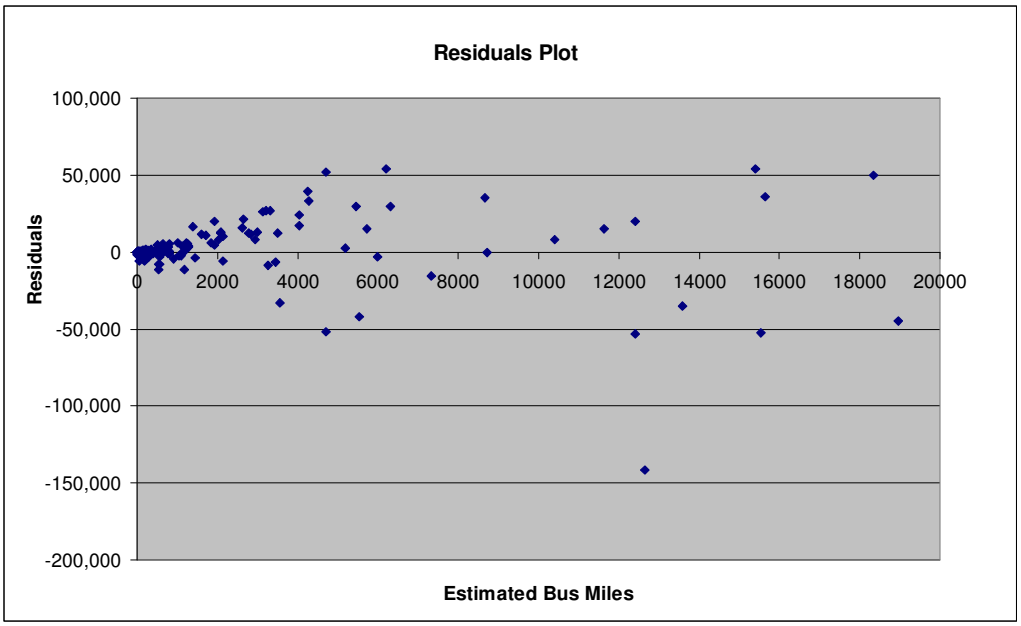


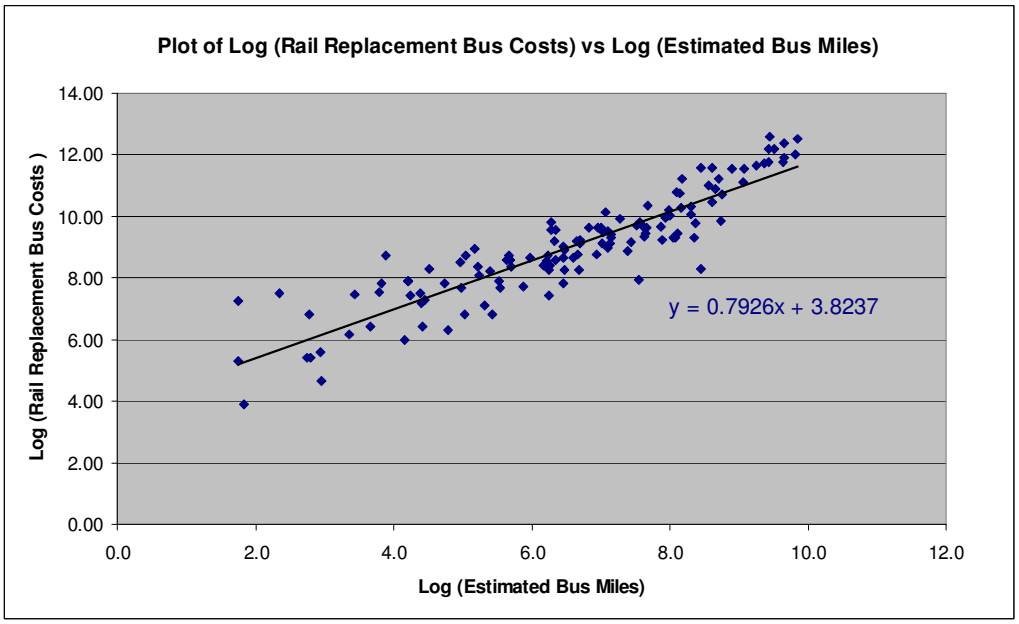
Figure D.5 shows a plot of the residuals for the combined model, which confirms that the same problems are found with this dataset. For possessions with a lower number of EBMs (say from 2000 to 6000 EBMs), there are more positive residuals than negative. The spread of the residuals increases as EBMs increase.

Figure D.5- Residuals Plot of Combined Data Model.



The data is broadly representative of the pattern of possession on the network[10], which means it is not evenly spread across the range of EBMs. Therefore we have tried to take logs in order to get a more evenly spread dataset (Figure D.6).

Figure D.6- Log Rail Replacement Bus Costs against Log EBMs.



Superficially this alternative model looks like an improved fit against the data, but note that the model consistently under-estimates compensation for the larger possessions.

[10] The data contains a small number of quite large possessions, and then many small possessions.

Figure D.7 compares the log model and the linear model when both are applied to the original (untransformed) data. Once the log model is transformed, the problem with the high-value possessions is exacerbated.

Figure D.7- Log Rail Replacement Bus Costs against Log EBMs.

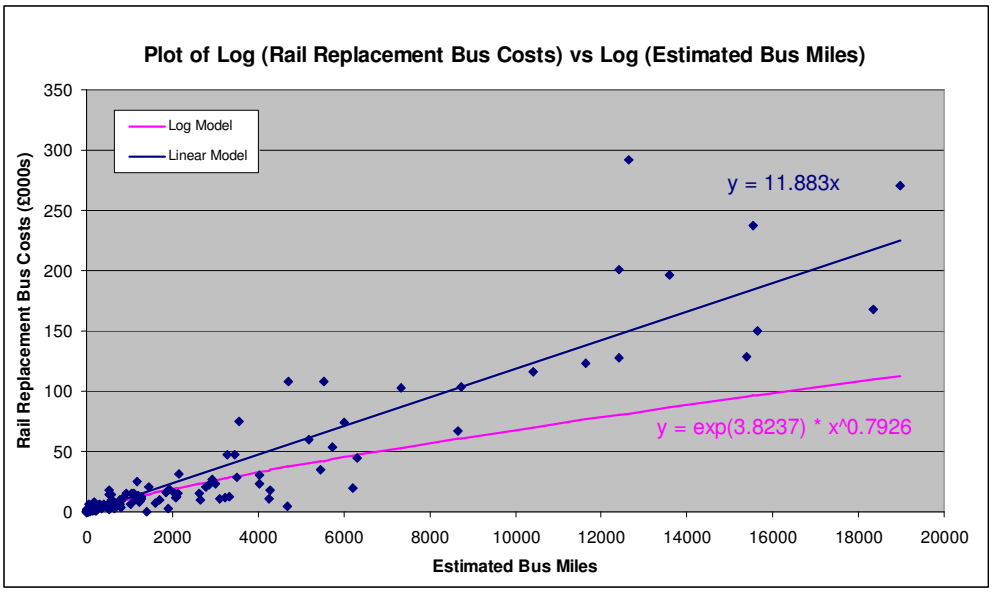


Table D.4 shows the sum of the residuals squared for the two models. The residuals for the log model have been calculated on the model applied to the untransformed data, as shown in Figure D.7.

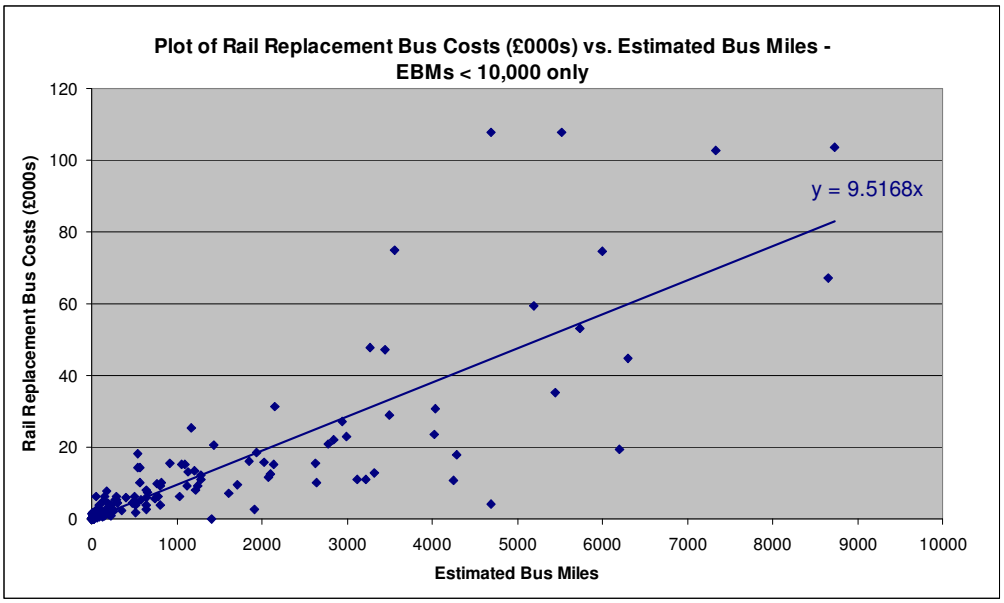
Table D.4 – Sum of Residuals Squared.

	$\Sigma(R_i)^2$
Linear Model	60,538,287,935
Log Model	152,318,071,173

Our conclusion was that neither the linear model nor the log model handled the large-value possessions well. In the linear model they influence the results too strongly, and in the log model they are significantly under-estimated. It would seem that we cannot find a model that accurately predicts both the small-value and the large-value possessions simultaneously. Given that the log model does not seem to produce a significantly better model, we concluded that for the sake of simplicity we should continue with a linear model.

In order to better examine the small-value data points, we removed all high value points from the linear model at a cut-off of EBM > 10,000. The resulting data and model are shown in Figure D.8.

Figure D.8 - Rail Replacement Bus Costs against EBMs (Small Possessions only).



As a result of removing the high value points, the slope of the linear model changes from 11.88 to 9.52, and the R-squared drops from 0.88 to 0.77. It is a characteristic of the way R-Squared is calculated that a small number of observations which have high (or low) values, compared to the mean of the sample, can result in a misleadingly high R-Squared. When the high values are removed, we see what appears to be better straight line for these points, even though the R-squared is smaller.

Removing high-value possessions has not resolved the issue of the models based on Stage 1 and Stage 2 data separately giving different results. When the Stage 1 and Stage 2 are plotted separately and regressed, the confidence intervals for the derived models increase (as shown in Table D.5). A T-test on the difference between the two slopes gives a probability of 8.1% that the estimates of the slope from the two sets of data are not statistically different.

Table D.5 - 95% Confidence Intervals for Both Models with Larger Points Excluded.

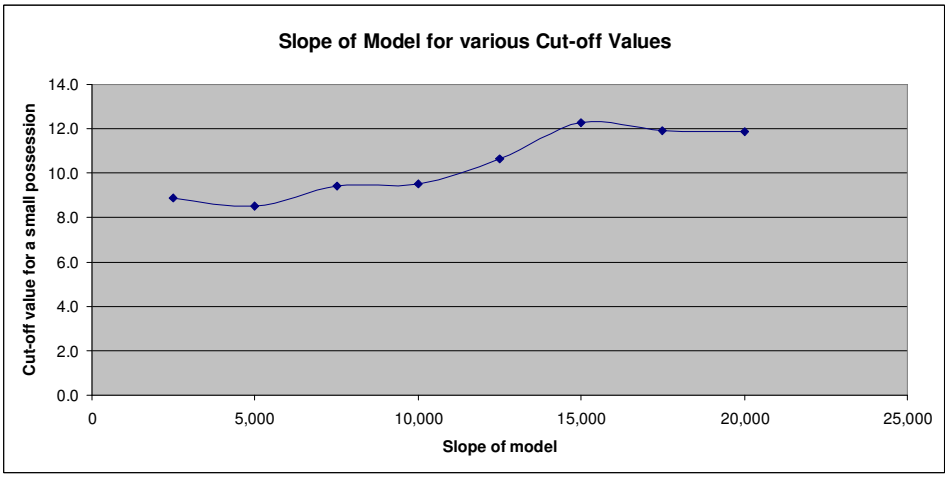
Model derived from	95% Confidence Interval		Slope
Stage 1 data	9.42	11.11	10.26
Stage 2 data	7.26	10.27	8.26

Our definition of small possessions (EBM <= 10,000) is entirely arbitrary. We have tested the impact of various different cut-off values on the slope of the model for the remaining small possessions. The results are below in Table D.6 and Figure D.9. There is some evidence that once points above 10,000 EBMs are included, the slope starts to change more significantly.

Table D.6 – Slope of the Model for Various Cut-Off Values.

Cut-off (>EBMs)	Slope of Model			Number of data points
	Estimate of m	95% Confidence Interval		
2,500	8.9	7.9	9.8	116
5,000	8.5	7.4	9.6	135
7,500	9.2	8.4	10.1	144
10,000	9.5	8.7	10.4	145
12,500	10.6	9.9	11.4	149
15,000	12.3	11.4	13.2	151
17,500	11.9	11.1	12.7	154
20,000	11.9	11.2	12.6	156

Figure D.9 – Slope of the Model for Various Cut-Off Values.



To summarise thus far: We have identified a problem with the large-value possessions, and have removed them in order to focus on the smaller-values ones, which there is a greater need to predict more accurately. However, the linear model on the smaller possessions has a lower R-Squared than for the data overall.

With the larger points excluded, the confidence intervals on the slope of the Stage 1 and Stage 2 models increase, (as shown in Table D.7).

Table D.7 - 95% Confidence Intervals for Both Models with Larger Points Excluded.

Model derived from	95% Confidence Interval		Slope
Stage 1 data	9.42	11.11	10.26
Stage 2 data	7.26	10.27	8.26

Thus, removing the larger data points has not resolved the differences between the two datasets. So we now examined whether secondary variables should be included to help explain this variation between the relationships observed in the two datasets.

Exploring Secondary Variables

During Stage 1 we observed a range of unit rates (£ per EBM) within the group of London & South East (LSE) operators, and variance between different types of Train Operator, for example LSE, Intercity and Regional. We also noted possible differences between the SRoU vs. RoU split, and the weekend vs. weekday split. The combined dataset (both Stage 1 and Stage 2 data) has been used to test whether these differences are statistically significant, and hence whether different rates might be justified in the proposed compensation mechanism.

Figure D.10 shows the data split between possessions that qualify as SRoU and those that are RoUs. Note, due to the small number of Part G possessions these have been allocated to the relevant category.

Figure D.10 - Bus Costs against EBMs (SRoUs vs. RoUs).

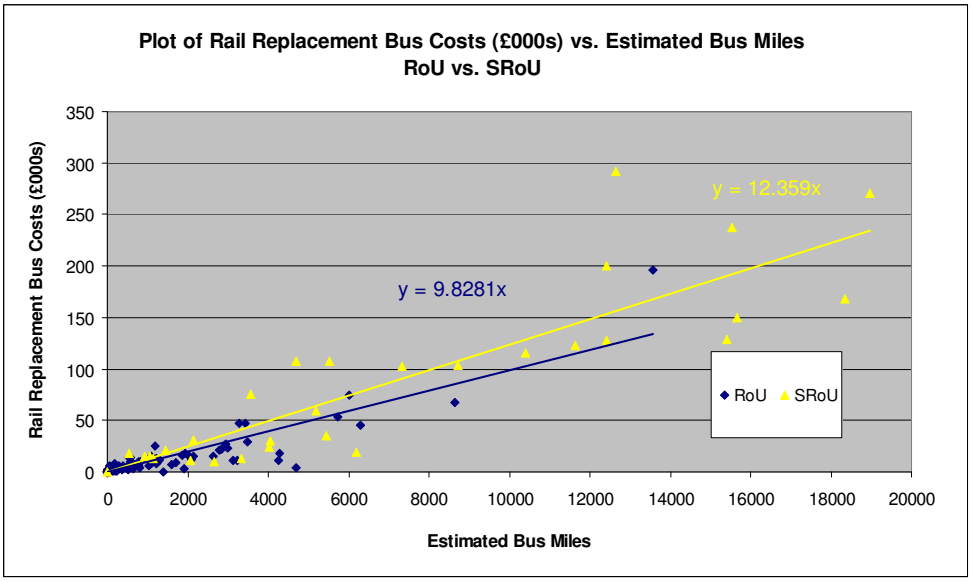
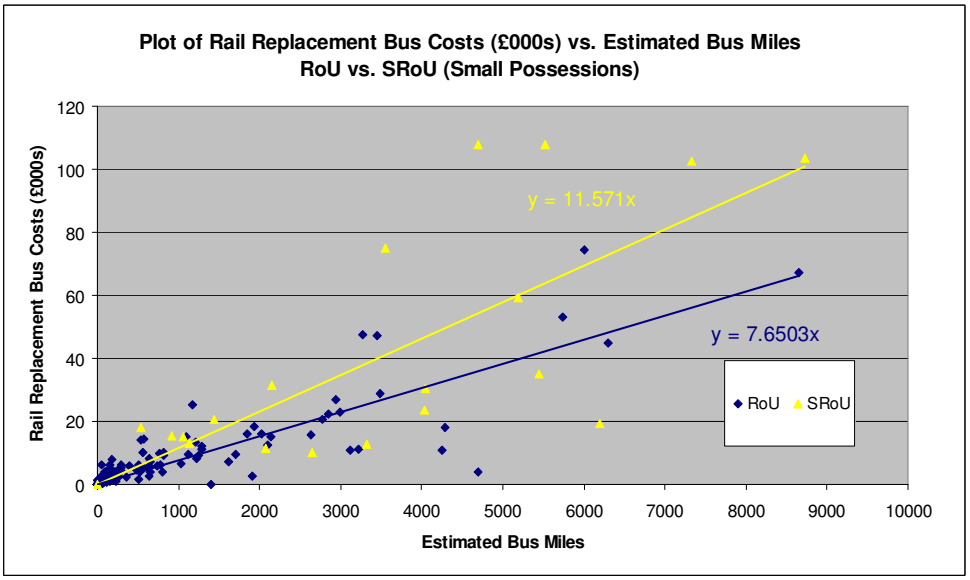


Figure D.11 shows the same plot, but with the larger possessions excluded. The slopes become more different from each other.

Figure D.11 - Bus Costs against EBMs (SRoUs vs. RoUs) – Small Possessions.



A similar pattern is found between Weekend vs. Weekday possessions. This is not surprising given that the two variables are related to a degree – by definition there are no SRoUs that are

Weekend only. We carried out a correlation test between RoU vs. SRoU and Weekday vs. Weekend, and calculated the correlation co-efficient as 0.3253.

Figure D.12 shows the data split by type of Train Operator (LSE vs. Other). With the full data the slopes are very similar.

Figure D.12 - Bus Costs against EBMs (LSE vs. Other).

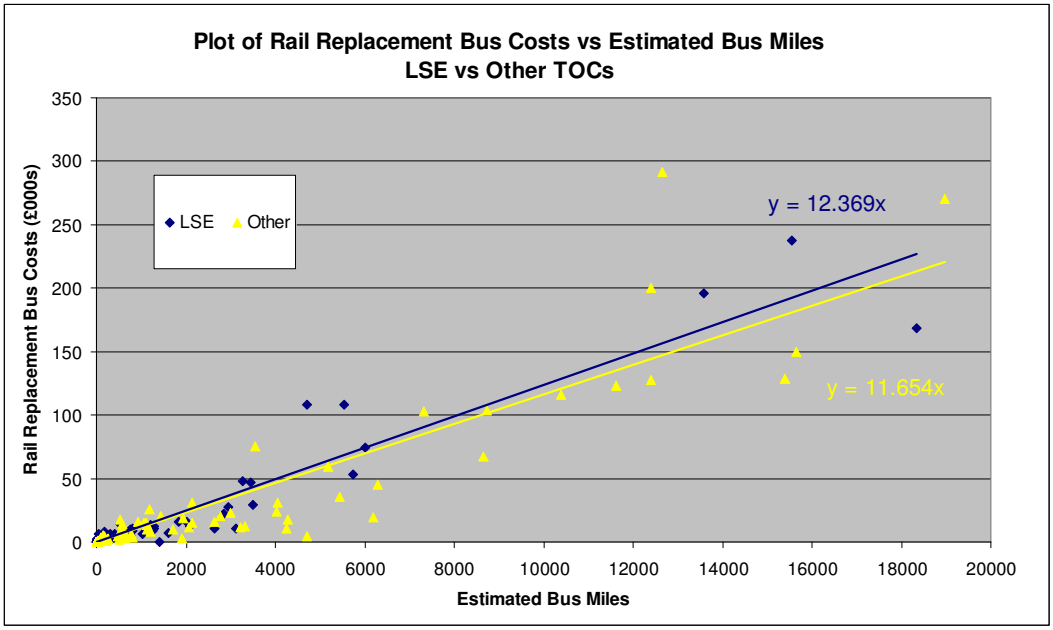
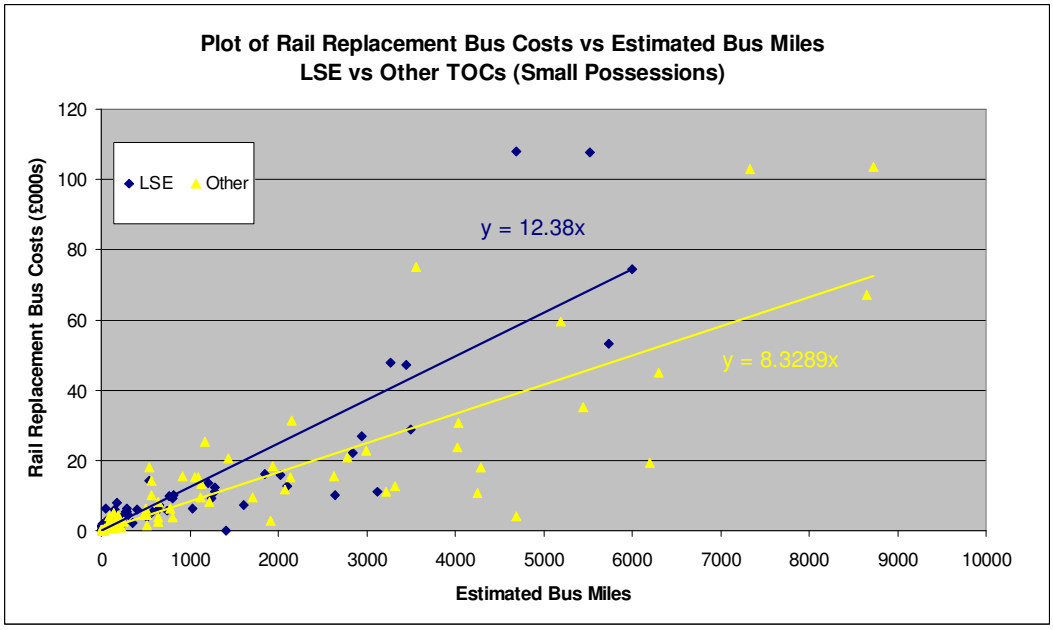


Figure D.13 shows the same plot, but with the larger possessions excluded.

Figure D.13 - Bus Costs against EBMs (LSE vs. Other) – Small Possessions.



Tables D.8 and D.9 summarise the results of testing these secondary variables. We have not looked at the combined effect of these variables, as a model with many factors would become too complex to be useful, and probably could not be supported by the data anyway. In addition, the correlation between some of the proposed secondary variables makes them unsuitable to use as independent variables in a regression.

Table D.8 – Results of Models Including Secondary Variables (All Data)

Secondary Variable Included	Slope	Lower 95% CI	Upper 95% CI	T-Test[11]	R^2
None	11.88	11.18	12.59	0.012	88%
RoU	12.36	10.72	14.00	0.005	89%
SRoU	9.83	9.06	10.60		84%
Weekday	10.96	9.59	12.33	0.176	85%
Weekend	12.02	11.18	12.86		88%
LSE	12.37	11.49	13.25	0.305	92%
Other	11.65	10.62	12.69		86%

Table D.9 – Results of Models Including Secondary Variables (Smaller Possessions)

Secondary Variable Included	Slope	Lower 95% CI	Upper 95% CI	T-Test	R^2
None	9.52	8.66	10.37	0.081	77%
RoU	11.57	8.78	14.37	0.000	80%
SRoU	7.65	7.00	8.30		82%
Weekday	7.89	6.53	9.25	0.013	75%
Weekend	10.15	9.09	11.21		79%
LSE	12.38	10.99	13.77	0.000	82%
Other	8.33	7.31	9.35		78%

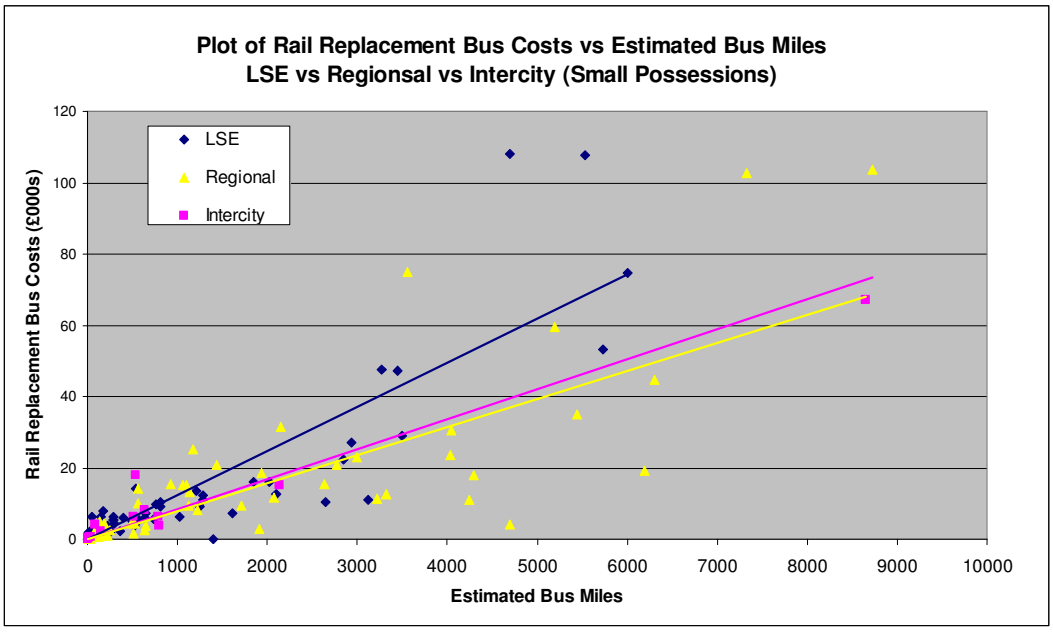
For the smaller possessions only, including the RoU / SRoU split or the LSE / Other split in the model gives a better R-Squared result than the simple EBMs model. The T-Test result confirms that there is a significant difference in the relationships seen in the data for these two splits. If the large possessions are included then the LSE / Other split no longer gives two clearly different slopes. Again the T-Test confirms this conclusion.

Therefore, SRoU / RoU and LSE / Other are both candidates for inclusion as a secondary variable. However, it is more intuitive that LSE / Other should be included because of the high costs of hiring buses in the South East of England, and greater road congestion that will to lead to longer journey times for equivalent journey lengths, and this poorer utilisation of buses.

In principle, we could split the non-LSE operators into Regional and Intercity. However, we only have 15 possessions for Intercity operators, and as Figure D.14 shows, these points on their own would have a slope very similar to that of the Regional operators.

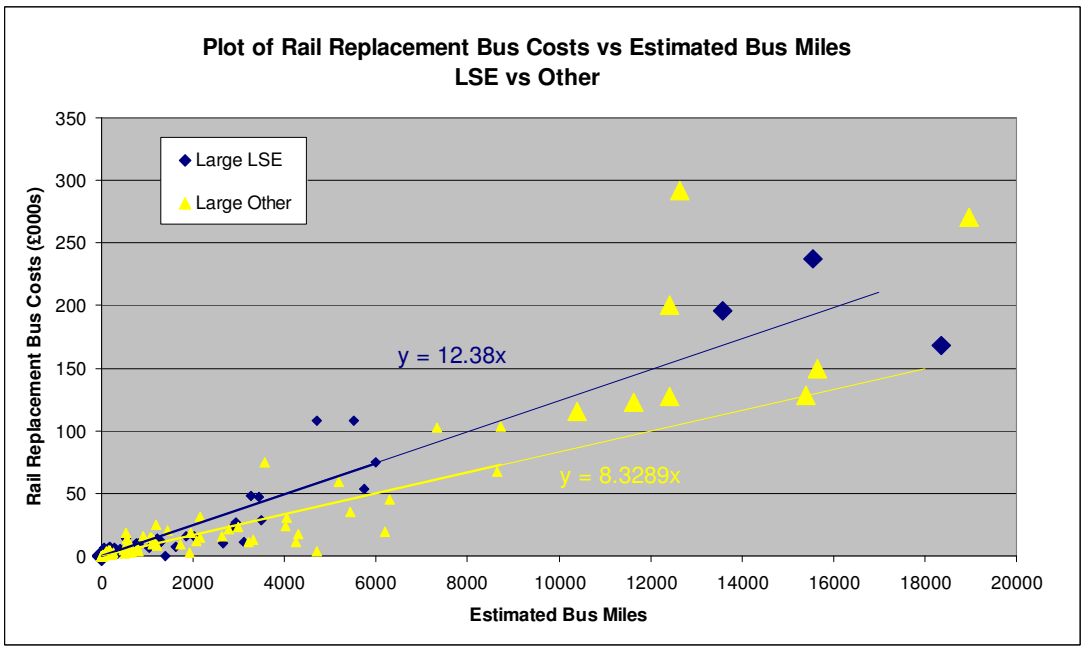
[11] T-Test on the difference between the estimates of the slopes at the 5% level.

Figure D.14 - Bus Costs against EBMs (LSE, Regional and Intercity) – Small Possessions.



As a final test, if the model were to be based on the results from small possessions only, split by LSE and Other operators, then Figure D.15 shows how this would apply to the large possessions.

Figure D.15 - Bus Costs against EBMs – All Data, Model Based on Small Possessions



There are only three large LSE possessions, so it difficult to come to any conclusions about these. However, for the non-LSE large possessions, the data has no discernable pattern, and will certainly not fit small possessions model. Given the spread of the data and how few points there are, it is also hard to conclude anything about these. We feel that we are unable to determine any robust relationship for large possessions.

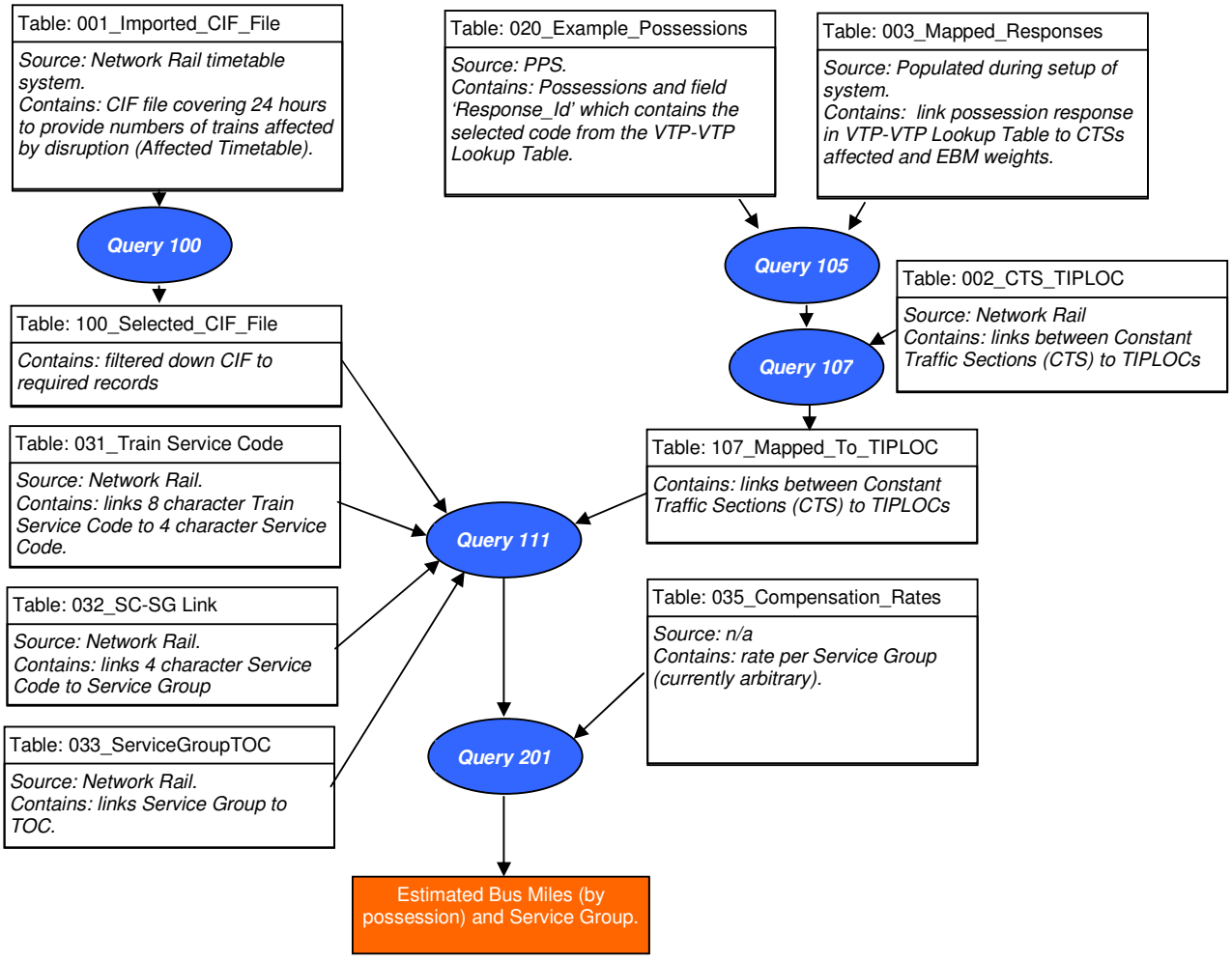
FABER MAUNSELL | AECOM

Appendix E: Design of Prototype System

Appendix E: Design of Prototype System

To test the feasibility of this compensation process, we have developed a prototype tool in Microsoft Access. Figure E.1 shows an outline of the design of this tool.

Figure E.1 – Design of Prototype System in Microsoft Access.



We recommend a review and update of all the mapping datasets before operation begins. This is particularly the case with Table 002_CTS_TIPLOC which currently contains some spurious data. We recommend a thorough review to ensure the TIPLOCs correspond to the mandatory timing points for each relevant service code. Unless this data is reviewed there is a danger than trains might be excluded from the count of affected trains, and thus the calculation of EBMs would be an under-estimate.

The tool contains four macros which carry out the following actions:

- 0 Clear CIF File – delete all records from Table 001, and compact and repair the database;
- 1 Import CIF File – import a selected CIF file;
- 2 Process CIF File - extract and process the relevant data from the CIF file; and
- 3 Calculate Compensation – calculate compensation for the possessions in Table 020.