

REVENUE AND DEMAND MODELLING AUDIT



SYSTRA

EAST COAST MAIN LINE TRACK ACCESS APPLICATIONS

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1. INTRODUCTION

1.1.1 ORR must decide on the competing applications for access rights on the East Coast Main Line (ECML). The decisions will directly impact the commercial aspirations of the future holder of the East Coast franchise (VTEC) as well as those of existing and potential open access operators (GNER and First Group). The decisions, as well as affecting passengers, may also impact DfT finances and other stakeholders such as rolling stock supply companies and Network Rail.

1.1.2 In making its decisions ORR is following its published criteria and procedures. To support this process it has commissioned CH2M to fulfil three areas of this work related to estimating:

- the demand and revenue implications of the various applications, with particular reference to levels of “abstracted revenue” from other train operators. This helps the ORR to understand the impact of the application on overall industry revenues.
- review the estimates established with input from the applicant(s), potentially affected incumbent operators, funders and any other interested parties; this enables an understanding to be gained by all parties of the forecasts and processes used and provides an opportunity for detailed explanations, and error correction; and
- a “WebTAG-based” economic appraisal of the proposed services, this enables an understanding of the implications of the proposals on the wider UK economy.

1.1.3 Given both the commercial and policy implications of the decisions, the work can be expected to be subject to high profile and detailed legal and technical scrutiny.

1.1.4 CH2M issued a draft report on their modelling work on 29th May 2015, followed by second report on the 5th June, with correction of an error. Further feedback, from stakeholders prior to and during an ORR organised “hearing” on the 12th June 2015, was also gained where a wide number of further issues were raised, covering data, modelling, and appraisal issues. CH2M have undertaken further analysis in responses to these issues raised, and have produced a final round of modelling to assess the access bids, documented in the Phase 2 Final Report dated 7 January 2016 and associated appendices¹.

1.1.5 SYSTRA has been commissioned to review this final round of modelling and analysis carried out by CH2M in order to provide ORR and industry stakeholders assurance that the CH2M analysis robustly calculates the forecast demand, revenues, generation, abstraction, and economic costs and benefits of each application, consistent with its stated methodology.

¹ This report subsequently became the published version titled ‘Assessment of Applications for Track Access on the East Coast Main Line: Phase 2 Final Report’ following minor drafting updates.

2. AUDIT PROCESS

2.1.1 A two-tiered audit approach has been carried out to ensure that a robust modelling framework has been correctly applied to assess the various track access applications. This approach consists of:

- a ‘top-down’ methodology review, of approaches and data used, and
- detailed ‘bottom-up’ analysis of the data and calculations contained within the modelling systems to ensure that this methodology has been implemented correctly and error-free.

2.1.2 The processes adopted within each of these phases of work is discussed in more detail in the following sub-sections.

2.2 Methodology Review

2.2.1 The top down review of methodology was based principally on the report (with Appendices) provided by CH2M. This was supplemented by an examination of the relevant sub models where it was not clear from the report precisely what had been done. In addition, in one area (fares modelling) a small model was developed to be consistent with the report and then checked that it produced the results given in the report; this was necessary as fares are modelled within the overall model and it would have been too cumbersome to explore the behaviour of the fares model within the workings of the overall model.

2.2.2 Three versions of the report were considered:

- Draft (v1.2 of report plus v1 of Appendices A, B, C, D, E, F, G) – 16 October 2015 (some Appendices were provided slightly later); v1.3, which was circulated to applicants, was released shortly after we completed our review of v1.2, but we were informed it had only minor changes and it was not necessary to review this version as well;
- Phase 2 Final Report (First Version) plus Appendices A, B, C, D, E, F, G (Final 1) – 9 December 2015;
- Phase 2 Final Report (Second Version) plus appendices A, B, C, D, E, F, G – 7 January 2016. This report subsequently became the version that was circulated to applicants titled ‘Assessment of Applications for Track Access on the East Coast Main Line: Phase 2 Final Report’ following minor drafting updates.

The review of each version of the report identified a number of issues which were then resolved in the subsequent versions of the modelling and reporting.

2.2.3 In general the review followed the order of tasks in the reports:

- MOIRA analysis
- Fares modelling
- Air competition
- Gravity model
- Crowding model
- Economic evaluation.

- 2.2.4 In some cases the top down review identified errors and these were reported as soon as possible to ORR and CH2M. In other cases, there were potential issues which were passed to those undertaking the bottom up review to look out for and to determine whether they were substantive issues. Some comments made were simply on the documentation: we believed the modelling to be correct, but not as clearly described as it could have been in the documentation (or better evidence could have been provided).
- 2.2.5 As indicated above this was effectively an iterative review, with most issues identified in the first review; on resolution of these in the second report, a further set of issues were identified which were resolved in the final (third report). Our comments on this last version of the report were minor. A further reason for the iteration was that some elements of the model was not available when we undertook our initial review.
- 2.2.6 In addition to the CH2M documentation we have also briefly reviewed the document ‘SDG Economic Appraisal of ECML Track Access Applications’, December 2015, a piece of analysis that SDG have completed for the DfT.

2.3 Model Implementation Audit

2.3.1 The complete Revenue Model Suite that has been developed by CH2M comprises the following:

- MOIRA Demand and Revenue forecasts for each of the options that have been tested, and any documented sensitivity tests.
- A spreadsheet based Revenue Model, operated via the use of macros, which subjects the output MOIRA Revenue and Journey values at station to station level to a series of growth calculations held within separate overlay templates.
- A bespoke Air Abstraction model which calculates uplifts for input to the Revenue Model.
- A bespoke Gravity Model which calculates uplifts for input to the Revenue Model.
- A Crowding Model which calculates constraining factors to apply to unconstrained demand produced by the Revenue Model. These constraining factors are then fed back into the Revenue Model.
- A WebTAG-based appraisal model for each option which used demand, revenue and cost change outputs from the Revenue Model.

2.3.2 Each aspect of the Complete Revenue Model Suite has been subjected to a detailed ‘bottom up’ review to ensure that the model correctly applies the methodology described within the documentation, and this implementation is error-free; this is discussed below for each of the components presented above.

MOIRA Demand and Revenue Forecasts

2.3.3 The demand and revenue forecasts which are input to the Revenue Model are calculated in MOIRA using a series of timetables held within ‘SPG’ files. These SPG files have been formulated by CH2M, and during this process they have been shared with each of the bidders and any comments from the bidders have been considered and updates to the timetables made where necessary. This process has been documented within the final report. Given the level of scrutiny that the timetables inputs have already received we have not sought to review these further as part of the audit.

2.3.4 The SPG files were provided to us, and were input to the MOIRA Northern modelling system to ensure validity. A sample audit of MOIRA model runs has been carried out and the resulting demand and revenue impacts checked against those that have been used within the complete revenue model suite to ensure that we get the same results.

Revenue Model

2.3.5 The Revenue Model is broken down into a series of individual spreadsheets, the audit actions carried out for each of these files is as follows.

2.3.6 The control spreadsheet '**Open_Access_Revenue_Model_(v1)**' dated **05/01/2016 21:57** contains a set of default input values for each of the options tested, and a macro control page which is used to the run the revenue model for each of these options. The input values that have been used for each option have been checked by eye to ensure that they are correct.

- Where they have been documented within the analysis report and appendices the values contained in the model have been cross-checked against the report, on the basis that the methodology contained within this documentation and any subsequent parameter values have been signed off by the top down methodology review.
- Where these inputs have been recommended by industry guidance such as PDFH and WebTAG the values have been cross-referenced against the designated version.
- Finally where these inputs have been produced by a further model within the complete modelling suite the values input to the revenue model have been checked against those output from the donor model.

2.3.7 When the Revenue Model is run from the control sheet a series of overlay spreadsheet templates are applied to the demand and revenue forecasts from MOIRA. This data is effectively fed through each of the templates where the demand and revenue is subjected to a series of growth calculations. The output demand and revenue from each overlay is fed as an input into the next consecutive overlay. A populated version of each of the template sheets is saved for each model run that is complete.

2.3.8 The overlays in order are:

1. Normalisation Overlay NM1 (**NM1_v4 04/12/2015 12:10**) subjects demand and revenue data to normalisation calculations which apply exogenous growth, Peterborough/Stevenage adjustment² and seeds demand and revenue data for any new stations.
2. Normalisation Overlay NM2 (**NM2_v1 30/11/2015 11:55**) combines demand and revenue data for Wednesday, Saturday and Sunday in to full week effect.
3. Fares Overlay FDU (**FDU_v4 18/12/2015 20:09**) applies growth in demand and revenue for all options that compete on fares; this overlay also contains the corresponding competitive response by VTEC.
4. Air Abstraction Overlay AAU (**AAU_v4 27/11/2015 12:48**) applies the effect of competing with the air market to demand and revenue.

² Correction applied to account for other stations being incorporated in the Peterborough and Stevenage zones in MOIRA Northern. See para 3.3.1 for more details.

5. Gravity Model Overlay GMU (**GMU_v3 30/11/2015 14:30**) applies the effect of new and improved service to specific stations, the overall growth at these stations is capped by the growth calculated by the Gravity Model and therefore is only applied if this has not already been achieved by previous overlays.
6. Crowding Impact 1 CD1 (**CD1_v2 04/12/2015 18:03**) preliminary crowding calculations to identify the subset of in-scope demand/revenue to which to apply crowding to, excludes first class and advance.
7. Crowding Impact 2 CD2 (**CD2_v2 07/12/2015 16:39**) applies the crowding suppression factors that have come out of the crowding model.
8. Value of Time Calculations VOT (**VOT_v2 06/12/2015 14:57**) applies WebTAG Values of Time to changes in GJT.
9. Standard Outputs (**SDA_v2 07/12/2015 13:50**) collates demand and revenue data from various stages in the Revenue Model process and analyses the overall change to demand and revenue for each option due to the various growth calculations.

2.3.9 Each of the above templates has been run through the OAK Excel add-in software to establish the location of:

- Hard-coded input cells – we have ensured that these are located within input tabs and through this the provenance of these values has been audited through point 2.3.6 above.
- Calculation cells – and in particular unique calculation formula. Each unique formula (i.e. that which has not been dragged across adjacent cells) has been checked and through this audit we ensure that the calculations are applying the methodology that is detailed within the documentation provided by CH2M, and also that there are no errors held within these calculations.
- Error cells – we have ensured that no error cells exist within the core function of the Revenue Model, and therefore no errors exist in the formulation of the results.

2.3.10 The models and templates stated within paragraphs 2.3.6 and 2.3.8 have then been used to undertake replication runs for each of the options documented in the final report, to ensure that the results documented within the report can be produced by a set of models that have been signed off by the audit process.

Air Abstraction & Gravity Models

2.3.11 Both of these models calculate uplifts that are input to the Revenue Model as hard-coded values. Both models are relatively simple and therefore it has not been deemed necessary to run these model through the OAK add-in software.

2.3.12 Both models are helpfully segmented by input and calculation sheets:

- Inputs: The inputs for these models have been checked and verified as far as is possible. This includes cross-referencing values against the CH2M documentation, industry guidance and MOIRA model outputs.
- Calculations: The calculations have been audited to ensure that the correct methodology has been applied in an error-free way; to achieve this each consecutive calculation has been checked in turn to validate the resulting uplifts

for each of the options. These uplifts have then been checked against the hard-coded inputs that are used in the Revenue Model.

Crowding Model

2.3.13 The crowding model is an established off-the-shelf model that has been developed by GHD. The crowding model has therefore previously been subjected to audit and so our audit focusses on how it has been applied to this particular application.

2.3.14 In order to satisfy ourselves that an appropriate level of crowding modelling has been applied within the CH2M analysis the following has been carried out:

- The calculations within the crowding model have been reviewed to ensure that the methodology that has been described within the CH2M documentation – and ultimately signed off by the top down methodology audit - is that which is applied within the model.
- A sample check of inputs to and outputs from the crowding model has been carried out to ensure the flow of data between the Revenue Model and the Crowding Model has been managed correctly.

Appraisal Model

2.3.15 The appraisal model is the final step in the modelling framework and uses demand and revenue forecasts output from the Revenue Model, along with cost changes to calculate the economic benefits of each of the options. This is a standard WebTAG based appraisal model and indeed we note that CH2M state that this is an established model which has previously been used and audited for similar purposes.

2.3.16 Again since the model is easy to follow we did not deem it necessary to subject the model to the OAK add-in software, and instead followed a similar audit approach as for the Air Abstraction and Gravity models.

2.4 Issues Log

2.4.1 During the audit process an issues log has been kept to keep a reference of any issues that have arisen out of the audit process. These have ranged from discussion points to actual errors in the modelling framework, and this has been indicated through the level of importance attached to each issue raised, which identified whether or not the issue would have a material impact to the results.

2.4.2 Each issue that has been raised has been further investigated by CH2M, with assistance from SYSTRA, and where necessary a discussion has been raised with ORR. A resolution to each of these issues has been sought prior to the conclusion of both CH2M's analysis and our audit process.

2.4.3 The final version of the issues log is submitted to ORR as an appendix to this audit report.

3. AUDIT FINDINGS AND COMMENTARY

3.1.1 Documentation of the findings from the audit process are detailed within this chapter of the report for both the top-down and bottom-up elements of the audit. They are arranged by topic heading, with both the top down and bottom up included under the same heading.

3.2 Overview of CH2M methodology

3.2.1 The overall methodology is very similar to that of more recent previous work to assess Open Access track applications (for example MVA’s analysis of applications for the ECML and for the WCML, published in 2009 and 2011 respectively), with one change: the previous station choice model has been replaced by a gravity model; we discuss this further under the relevant heading (section 3.6).

3.2.2 The overall approach is appropriate. It uses industry standard tools (MOIRA and PDFHv5.1). Where these are not sufficient to address specific issues relating to the applications, then models have been developed to address the issues. These models are consistent with the principles behind PDFH and utilise PDFH concepts and parameter values as far as is possible.

3.3 MOIRA Modelling & Normalisation

3.3.1 We were not asked to review the MOIRA runs in detail. We noted that MOIRA Northern had been used, with an adjustment made to demand changes between Peterborough and London, Stevenage and London, and Peterborough and Stevenage (see Table 4 in Appendix B). This is because these stations in MOIRA Northern include a number of other stations in the vicinity. The need to make this adjustment is clear and the scale of the adjustment looks reasonable, but we do not have the full details of the tests that CH2M carried out in the various versions of MOIRA that have been used to calculate these dampening factors and have not sought to replicate these values.

3.3.2 In the first draft of the analysis the Peterborough/Stevenage dampening factors used within the modelling did not match those stated within the documentation, this was corrected in later versions and we confirm that the correct level of dampening is applied within the modelling framework.

3.3.3 In principle, the MOIRA analysis looked reasonable. However, the top down review highlighted that there were risks around certain points that should be checked in the bottom up review:

- Are the results sensitive to the precise minutes past the hour when a train runs (as opposed to actual journey time)? We note that MOIRA is sensitive to the precise timing of services - as the base demand is segmented in 15 minute intervals, and also the timing of competing services respective to one another. Sensitivity tests 12 and 13 seek to understand this impact of train timings for the VTEC Middlesbrough option, and through this we are content that both CH2M and ORR are aware of a potential impact to the results due to this scheduling of services in MOIRA.

- As a subset of the above, does overtaking have a significant impact on the results? We note that CH2M have performed a series of sensitivity tests to ascertain the sensitivity of the results to the overtaking manoeuvre. These are designated as options 11 through to 15 and are clearly documented within the report. Through this sensitivity testing CH2M make clear to ORR any impact that the overtake has in both VTEC and First Edinburgh proposals, and we are satisfied that this has been considered within the analysis.
- Is sleeper traffic handled appropriately? Since sleeper traffic is not modelled within MOIRA we note that any competition with these services has been excluded from the analysis. Since this has approach is consistent across all options we feel that this is reasonable and confirm that this approach has not implemented any bias.

3.3.4 We have carried out the following MOIRA runs in order to compare the resulting demand and revenue forecasts with those used within the complete Revenue Model suite, we found no issues of replication during these checks:

- IEP Base (Base VTEC 2020 Option)
- Alliance Yorkshire / Cleethorpes (Option 1)
- VTEC Full (Option 8)
- First Edinburgh (Option 7)

3.3.5 The stations Garforth and Headingley are used within the normalisation process as a proxy to the new stations at East Leeds Parkway and Kirkstall Forge respectively in options 1, 10 and 15. CH2M's analysis shows that the opening of these new stations abstracts demand from Leeds at a proportion of 2.3% for East Leeds Parkway and 1.3% for Kirkstall Forge, and the NM1 overlay seeds demand and revenue to these two new stations according to these proportions. This approach is sensible and has been executed correctly, however the since the abstraction proportions have been calculated off-line from the complete Revenue Model suite the formulation of these has not been directly checked.

3.3.6 The MOIRA station to station flows are at times aggregated into flow groups - combining together similar origin to destination movements - to aid the calculations held within the complete Revenue Model, in particular for the application of PDFH elasticity values. The flow groups that have been created are reasonable, the one point we note is that London to Peterborough flows – which is a significant flow on the ECML – is held within flow group 10 which is designated within the PDFH flow category 'London to South East'. CH2M responded by stating 'As part of the London journey to work area with a significant ECML London commuting flow, we felt it appropriate to categorise it as London to South East'. This seems reasonable and we recognize that reclassification would not be material, given that this would be applied within each option.

3.3.7 Some error cells were noted in each of the normalisation overlay templates – NM1 and NM2 – which were further investigated. The two instances are described below:

- Error cells occur in the tabs marked 'contents' and this is due to a mis-match between the tab names stated here and the actual tab names used. This has no bearing on the modelling results and are ignored.

- Error cells exist in the NM1 template which get carried through to the populated versions of the NM1 workbook for options where seeding of new station flows is not required; these occur because input data from a ‘synthetic’ ORCATS MOIRA model run is not provided. These error cells have no bearing on the results in these instances.

3.3.8 The default and input values used within the normalisation modelling for all options have been checked as described in paragraph 2.3.6 and no issues have been found.

3.4 Fares modelling

3.4.1 The fares modelling used ticket type to journey purpose mapping from the National Rail Passenger Survey (NRPS). The alternative would have been to use those in PDFH; however, the PDFH mappings are at a higher level (less disaggregate) than those of NRPS. Both mappings are subject to error, in part because of sample size, in part because respondents do not always know what ticket type they have purchased, in part because such mappings can vary markedly between flows, especially where different TOCs are concerned. Our view is that the mappings used are adequate, there are no better mappings available (without substantial market research), and it is unlikely that the use of different mappings would have led to substantially different results. In particular CH2M have stated that the mappings have been derived from East Coast NRPS data from the latest wave as this most accurately reflects operation on ECML since VTEC took over the franchise – this is reasonable.

3.4.2 The first two versions of the report (Appendix C) appeared to show an illogical position where competitive response by the incumbent actually increased demand for the new entrant. We originally thought this was due to incorrect parameter values. However, ORR and CH2M checked with separate review work being undertaken by Leigh Fisher and found that the spread parameter, although based on old data, appeared still to be appropriate. We then found that the issue was with the fares (average yield) assumptions in Appendix C which were much lower than actual yields. Correcting this resolves the problem.

3.4.3 The inputs and parameter values for the fares overlay have been checked as described in paragraph 2.3.6. Any issues and/or comments are described below, no further issues were found:

- CH2M have used the fares elasticities from PDFHv5.1, whereas WebTAG recommends the use of PDFHv4. There is a debate within the rail industry as to the most appropriate fares elasticities and research is currently being undertaken for the Passenger Demand Forecasting Council into this area. Most rail industry experts consider that PDFHv5.1 elasticities are currently the most appropriate, but DfT guidance still recommends that PDFHv4 elasticities are more appropriate. We prefer the use of PDFHv5.1 elasticities and would normally recommend that a sensitivity test is undertaken to PDFHv4 values; however, for long distance flows to/from London the elasticities are very similar (PDFHv5.1 value is -1.05 for non-seasons; PDFHv4 value ranges from -1.0 to -1.15 depending on distance), we therefore do not consider this necessary.
- The fares elasticity values for the PDFH category ‘Rest of Country > 20 miles’ had been input with the Business and Commute purpose elasticity values transposed.

This has been corrected within the modelling framework, and the values in the final version of the analysis note have been calculated using this corrected version of the modelling framework.

- The fares modelling approach applies the effect of fares competition to a subset of in-scope demand based on available ticket types. A proportion of in-scope demand is hence input to the Revenue Model as a hard-coded value. This approach is reasonable and is clearly described within the documentation, however these calculations have been carried out off-line from the complete Revenue Model suite and have not been independently verified.
- Similarly the open access yields that are used within the fares calculations are well documented and appear reasonable, however the provenance of these fares have not been further verified.
- The complete Revenue Model suite assumes that a level of competitive response from the incumbent will occur for those open access options that compete on fares. This is input to the model as a proportional decrease in incumbent fares. These have been derived off-line from the modelling framework, however CH2M have provided these calculations and they have been checked and verified. This approach seems sensible, and indeed sensitivity tests have been carried out to determine the effect that this modelling has on the results, this is clearly documented within the report.

3.4.4 An error was found in the main body of the calculations held within the fares overlay. This issue double counted some of the demand (and hence revenue) growth as it added scaled in-scope demand to the original demand input to the fares overlay instead of adding the scaled in-scope demand to only the original out-of-scope demand. This has been corrected within the modelling framework and we confirm that the result values presented within the analysis report are calculated using this corrected framework.

3.4.5 As for the NM1 and NM2 overlays, error cells existed in the FDU overlay in the contents tab. This is for the same reason as described in paragraph 3.3.8 and these error cells do not have a bearing on the results forecast.

3.5 Air competition

3.5.1 The methodology utilises the rail/air market share curve in PDFH (Figure B2.1 of PDFHv5.1). However, the first report (and model) did not allow for generation of new demand when rail services were improved; it only considered abstraction from a fixed size total rail+air market. This was corrected in subsequent versions, the formula updates have been verified and the forecasts presented in the analysis report have been derived using this corrected version of the model.

3.5.2 In addition to abstracting from air due to journey time improvements, some applications included an innovative fares policy. PDFH does not provide guidance on how this should be assessed. The methodology used by CH2M of using a Logit mode choice model calibrated to the PDFH market share curve is appropriate.

3.5.3 Further to this we note that the approach to model air abstraction using competition on fares has been derived from existing analysis submitted by First, and therefore some of the input data and the derivation of model parameters to the Logit model is confidential. During the audit we have reviewed these and as stated above we deem the

approach to be appropriate however we have not been able to independently verify the provenance of this source data due to the confidentiality restrictions.

3.5.4 The other inputs used within the Air Abstraction model have been checked as described in paragraph 2.3.6. Any issues and/or comments are described below, no further issues were found:

- The rail journey times used within the Air Abstraction model to generate the abstracted demand have been calculated using MOIRA. We have replicated these values using MOIRA Northern and the timetable SPG files that we were provided with. This process showed that some journey times were out by 1 minute and these have been updated in the latest version of the analysis.
- We note that the CAA data is treated properly and entirely within the model however we have not independently verified its source.
- The rail demand data used to ascertain the rail market size which directly competes with air has been provided by MOIRA. The allocation of the flows that contribute to this market are informed by a list of stations within a catchment area surrounding in-scope airports, this is clearly documented in the report and some spot-checks were carried out to ensure that the allocation of these flows has been carried out correctly.

3.5.5 The uplifts that have been calculated by the Air Abstraction model have been cross-referenced with those input to the Revenue model and we confirm that this transfer of data has been carried out correctly. Furthermore no issues were found in the AAU overlay which applies these uplifts to the demand and revenue forecasts as per the methodology within the documentation states.

3.6 Gravity Model

3.6.1 This model is a new approach for the assessment of track access applications, previous studies having addressed the same issue through a station choice model. CH2M explained that they had chosen the new approach as the data to support a station access model was very old and (they considered) therefore unreliable. We have some sympathy with this view, and have no objection in principle to the use of a gravity model which is mentioned in Chapter B10 of PDFH v5.1 as an appropriate tool in certain circumstances.

3.6.2 The methodology in the first draft version of the report received by SYSTRA was flawed as it resulted in illogical behaviour of the model. This was acknowledged by CH2M and a revised model was presented in CH2M's interim phase 2 report (October 2015) that was issued to stakeholders, and also in its Phase 2 final report and associated analysis. The revised version was simpler and produced a model with sensible parameter values.

3.6.3 We do note, however, that the approach is likely to allocate some demand to generated when it is actually abstracted from other operators at other stations. At the most important locations where this issue occurs of East Leeds Parkway, Middlesbrough and Morpeth further analysis was undertaken to consider this issue; however, this was not done at other locations. We expect the extent of this to be small, but it does mean the generation: abstraction ratio will be marginally over-stated.

3.6.4 We also have some minor concerns with some of the catchment areas which were derived from judgement, in particular that the outer limit of the catchment area for East Leeds Parkway is nearer to Doncaster/York than the new station. We note that abstraction from Leeds, Wakefield and York has been considered within the modelling; however, Doncaster has not been considered. Overall we would not expect the impact of this to be significant.

3.6.5 During the detailed bottom-up audit we found that it was not possible to fully check the calculations in this model due to instances of hard-coded values within calculation formula. This hard coded data is confidential to VTEC, and therefore we have been unable to verify it further. We also note that these calculations are part of some of the more ad hoc analysis that has been carried out to look at potential abstraction, and do not play a part in the formulation of the Gravity model uplifts that are passed through to the Revenue model. However, we have no reason to doubt the calibration of the model, and the resulting demand forecasts seem sensible.

3.6.6 The uplifts that have been calculated by the Gravity model have been cross-referenced with those input to the Revenue model and we confirm that this transfer of data has been carried out correctly. Furthermore no issues were found in the GMU overlay which applies these uplifts to the demand and revenue forecasts as per the methodology within the documentation states.

3.7 Crowding

3.7.1 The crowding model used was one developed for franchise bids. As such it is a very large Excel spreadsheet, but has been previously audited as fit for purpose.

3.7.2 We have not therefore undertaken a full repeat audit of the model, but have examined the principles and made sample checks to ensure it has been correctly applied.

3.7.3 In principle the methodology seems appropriate and treats Advance tickets separately from walk-up, which is important. The initial review identified that the iteration functionality in the model had been turned off to reduce model run times. However, it could not be demonstrated that this had not biased the results (nor could it be demonstrated that it did bias results); as a result it was decided that iteration should be included in subsequent modelling to provide confidence in the results.

3.7.4 The second version of the report and model resolved the principal issue, but there remained a number of lesser points where the report was not precise about what was being done.

3.7.5 The detailed audit of calculations held within the model was limited to assessing whether the functionality of the model adhered to the methodology that was described within CH2M’s report, and assessing the application of that methodology to the case study of the ECML. The following points were raised and discussed with CH2M:

- We questioned the application of the three PDFH crowding curves – regional, intercity or London & South East – to each of the individual flows as they initially appeared to have been applied rather randomly. CH2M responded with the following set of assumptions that they had applied. *‘A regional station is*

designated as any station within a city or town that has a population less than 45,000. Intercity (or inter-urban) stations are therefore any station within a city or town with a population greater than 45,000. South East stations are all located within the South East and are designated a Regional In Vehicle Time Multiplier unless travelling to/from London (which is classified as any station within Zone 6). Station classification is prioritised in the following order: Airport, London, Intercity, South East, Regional (where Airport stations are only classified as Airports if the main patronage of the station is for Airport use. Birmingham International, for example, is not classified an Airport station, as it is believed that more passengers use this station for commuting to the nearby commercial facilities). We consider any flow containing a Regional station as a regional flow for the purposes of allocating the appropriate In Vehicle Time multiplier, however when allocating GJT elasticities, we regard allocate the appropriate elasticity based per the PDFH guidelines which facilitates the identification of flows to/from London separately to the Intercity/Regional classification'. CH2M's response provides reasonable explanation for the allocation of the basis for allocating crowding curves to flows, and in any case the crowding curves are sufficiently similar that applying them on a different basis is unlikely to result in a substantially different result.

- There appeared to be a significant difference between the count data and the MOIRA data in the calibration of the model. This appeared odd as this might be expected to occur within certain time periods but the total across the day might be expected to be similar between the two sources. CH2M's response stated '*The count data provided and mapped to the May 2014 Moira output indicates that Moira's loads are ~15% higher than the count data provided. This is based on the average count at each counted stop on each service on a Wednesday between 21 May and 10 December 2014. Where no count data has been provided we have calculated the ratio between the count and Moira demand on stops prior and following to calculate an approximate new demand figure. Calibration has been undertaken to ensure the loads appropriately reflect the observed passenger counts provided*'. In our view, CH2M's response provides a reasonable explanation for the differences noted.

3.8 Economic Appraisal

- 3.8.1 The review of the economic appraisal was not undertaken until the second version of the report as the detail in the first version was not adequate. A significant issue was found in the way the (dis)benefits of fares changes was modelled. They need to be undertaken using the change in yield at the flow level and then summed, whereas they had been based on overall average yields. This gave erroneous results. The final version has corrected this.
- 3.8.2 It was also unclear as to how the economic impacts of the crowding impact had been modelled and we felt that this was not clearly presented within the documentation. On discussion with CH2M we agree the approach is correct, however this has not been better explained within the documentation.
- 3.8.3 The demand ramp up values that have been used in the modelling and documented in the report are those from PDFHv5, CH2M have confirmed that the Appraisal model applies PDFHv5 methodology rather than PDFHv5.1 which is what the other models in

the Revenue Model Suite use. We don't view this as a material issue as the approach is consistent across all options and is unlikely to introduce bias.

3.8.4 SYSTRA have not been asked to review the operating costs.

3.8.5 The inputs to the Appraisal Model were checked as per paragraph 2.3.6 and some issues were found with the input and use of the PDFHv5 ticket type to journey purpose mappings:

- Firstly we noted that the Appraisal Model uses PDFH based mappings whereas the fares overlay uses mapping from NRPS. It seems odd to us to use two different types of mappings within the modelling framework, however we note that this is unlikely to be a material issue.
- The percentage values held within the ticket type to journey purpose mappings were stated as being from PDFHv5 however cross-reference with this documented showed that the values used were from an earlier – superseded – version of PDFHv5 and not the latest – August 2011 – version. Furthermore the Anytime/Leisure proportion from Table B0.7 has incorrectly been input to the model as 11.6% rather than the 11.1% held in the PDFH document. This has been corrected in the final version of the analysis report and associated modelling framework.
- Finally these mappings are used to calculate a composite cost for full, reduced and season ticket types within the appraisal however these composite costs were then incorrectly applied to the PDFH flow group categories. This has been corrected in the final version of the analysis report and associated modelling framework.

3.9 Appraisal of Options

3.9.1 Replication runs were carried out using the audited version of the Revenue Model to ensure that we could replicate the results that have been documented in the analysis report. The results presented in Chapter 6 of the report are:

- Revenue projections for each of the options considered, segmented by generated and abstracted revenue in order to provide a ratio.
- WebTAG-based appraisal results.

3.9.2 The revenue projections that are presented are calculated using the SDA overlay which is the last step in the Revenue Model process. This overlay template was audited as per the comments in section 2.3 above and no issues were found in the formulation of the results.

3.9.3 The results held within the dashboard tab in the populated version of the SDA overlay for each option were checked against the tables and values stated within the report. This was carried out a number of times in line with the iterative approach of the audit.

3.9.4 We confirm that the revenue projections held within chapter 6 of the final version of the report are those that have been calculated using the audited version of the complete Revenue Model suite.

3.9.5 We also confirm that the appraisal results held within chapter 6 of CH2M’s analysis report are those which are generated by the audited version of the Appraisal Model.

4. CONCLUSIONS

4.1.1 SYSTRA has completed the audit of CH2M’s Complete Revenue Model Suite as described in the previous chapters of this report. Following this audit we conclude that the Complete Revenue Model Suite as provided by CH2M (on the 12th January 2016) is fit for the purpose of assessing the various aspirations for track access on the ECML.

4.1.2 The top down review confirms that the methodology that has been applied in CH2M’s analysis is appropriate to the purpose of assessing the impact of track access applications on the ECML. This methodology is consistent with WebTAG and PDFH where these provide specific guidance, and is consistent with the principles of PDFH where bespoke approaches have been required. We note the following exceptions to this which are further discussed in Chapter 3; these deviations from WebTAG guidance will not have a material impact on the results or indeed introduce any bias.

- CH2M have applied PDFHv5.1 fares elasticities whereas WebTAG recommends that PDFHv4 elasticity values are used.
- CH2M have used PDFHv5 major new service lags within their Appraisal model. WebTAG is not explicit on the use of lags, however it recommends that PDFHv5.1 methodology is applied for modelling GJT impacts.

4.1.3 The bottom-up audit of the models themselves has sought to ensure that the modelling approach correctly applies the methodology as described in CH2M’s documentation – a methodology that has been agreed between ourselves, CH2M and ORR – and that this has been implemented without error. Through this approach we have raised a number of issues with the model developers and these have either been addressed in the final version of the modelling framework, or in small number of cases, a reasonable explanation for not making changes has been provided.

4.1.4 In considering the modelling results, we recommend that ORR bear in mind the following points:

- The results in CH2M’s report are correct for the timetables they have specifically tested, the details of which were agreed with and checked by stakeholders. We recognise that the additional testing of options 11 through to 15 have sought to understand any sensitivity around the timing and/or phasing of certain services and recommend that the results of these tests are taken on board during the review of this piece of analysis.
- CH2M have not modelled the impact of the high density seating layout proposed by First. We believe that the approach undertaken by SDG and documented within the report ‘SDG Economic Appraisal of ECML Track Access Applications’ is sound and suggest that ORR consider conducting a sensitivity test based on applying a 1.1% penalty to First’s in-vehicle time weighting to represent the potential impact of this high density seating. We are making this new recommendation, following completion of CH2M’s work, in the light of our recent review of SDG’s report.

4.1.5 Finally, we confirm that the results from CH2M’s modelling work have been correctly presented in their report.

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