

14 September 2016

Andrew Rees  
Economic and Commercial Analysis  
High Speed Two Limited  
One Canada Square  
Canary Wharf  
London E14 5AD

Dear Andrew,

## **Audit of the development of PLANET Framework Model version 6.1**

Jacobs has audited the transport demand modelling framework developed on behalf of High Speed Two Limited (HS2 Ltd) for the demand forecasting and business case work for the High Speed Two project. This is known as the PLANET Framework Model (PFM).

The aim of the audit was to provide independent verification to HS2 Ltd that the model processes and inputs of PFM version 6.1 met the specification for the PFM that was developed and agreed between HS2 Ltd and the model developers Mott MacDonald and Systra.

From the information that we have reviewed and in exercising the degree of skill and care to be expected from a competent professional consultant experienced in undertaking such services, we confirm that users of the model and its results can be confident that the implementation of the model updates leading to PFM v6.1 correctly reflect the documented methodology subject to the revision/rectification of the specific details raised in this letter. We do not judge any of these to have a material impact on the case for HS2.

The remainder of this letter provides background information on our audit, outlines model updates for the current version, describes our main audit processes and summarises our audit results.

## **Background**

Our initial audit report<sup>1</sup> was published in October 2013, relating to PFM version 4.3. Since then, further development of the PFM has taken place and we have audited each interim version during 2014 and 2015 and provided individual sign-off letters for these.

The subject of this letter is the audit of model development resulting in PFM version 6.1 (v6.1) which builds on the previous release version of PFM version 5.2 (v5.2) via a number of interim releases that have also been audited but have not been the subject of a formal audit letter.

We have only audited elements of the model that have changed in the new model version (as described to us by the model developers), rather than re-auditing the whole PFM and this letter relates to the changes from v5.2 to v6.1 only. However, in addition to auditing the individual

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<sup>1</sup> PLANET Framework Model Audit Report, Model Implementation and Standard Case Forecast, October 2013

model update items, we have also reviewed the implemented version of PFM v6.1 to ensure that all the individual updates have been included.

At each stage of the model update and audit process, we produced detailed technical notes of our findings that were summarised in an audit letter for each completed model version. Where differences between the model and its documented methodology could not be addressed in time for the release of a model version, the issues identified were recorded for future updates of PFM. Often these issues were then resolved in subsequent release versions of the model.

As with the main audit, our audit methodology was focussed on reviewing the implementation of the specified methodology rather than a review of the methodology itself.

The updates undertaken by the model developers between v5.2 and v6.1 are explained in outline below followed by a description of the audit process and audit results.

The updates in v6.1 were concerned with a wide range of areas covering service coding and trip matrices within the model as well as output routines and appraisal modules. The base year for the model has also been updated to 2014/15.

## Lines File Updates

### Description of the Model Updates

With regard to service coding, the following service groups were updated:

- East Coast Main Line;
- East Midlands;
- Chiltern;
- London Midland;
- Northern Trains;
- Trans Pennine;
- Open Access services; and
- HS2 services in the do-something networks.

The updates included both the do-minimum and do-something networks and covered (where appropriate) all four of the constituent models PLANET Long Distance (PLD), PLANET South (PS), PLANET Midlands (PM) and PLANET North (PN). In addition, a new 2014/15 base year network was created by splicing the existing 2010/11 base year (BY) and the 2026/27 do-minimum (DM) network files for train operating companies where these years were already representative of the 2014/15 network.

### Audit Process

For each of the updated lines files, our audit covered:

- The model developers' interpretation of present day timetables and timetable information provided by the Department for Transport (DfT) for the future year coding; and
- The accuracy of the lines file coding against the model developers' specification.

Within the network coding, we reviewed:

- Train frequencies;
- Stopping patterns; and
- Train capacities.

In addition, we looked at the consistency between the constituent models making up the PFM, PLD, PN, PM and PS.

Our audit methodology focussed on reviewing the implementation of the specified methodology rather than a review of the methodology itself.

The audit procedure for these was as follows.

- Lines file imported into Excel spreadsheet;
- Visual check of headway where amended in specification;
- Additional calculation added to spreadsheet to identify and highlight calling points and enable easy validations of amendments to section times and calling points in specification;
- Summary audit log spreadsheets completed showing checks by transit line number by file;
- Potential errors and mismatches were checked back with the model developers and specification or transit lines were amended as necessary; and
- Final audit check of amended transit lines.

Following the audit of lines files for individual Train Operating Companies (TOCs), we undertook a sample audit of the updates to the preload<sup>2</sup> spreadsheets required to reflect these service updates, focussing on the service update to East Midlands (EM) and East Coast (EC) only.

The preload spreadsheet includes a line matching tab which provides a correspondence between the PLD and regional model services and their packet codes. Services are grouped by packet code based on which PLANET region, the TOC, package code (based on route and stopping pattern) and direction of travel.

However, given the number of preload spreadsheets, their complex nature and the small impacts of errors, it was agreed with HS2 Ltd that a targeted sample preload check would be undertaken.

## **Audit Results**

The process to specify and code updates to the lines files was particularly lengthy, which allowed us to use the embedded approach to auditing to greatest effect. During this audit we were in close contact with the model developers who provided individual elements of their work for audit before completion of the full lines file coding. As a result, we were able to feed back

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<sup>2</sup> Preloads are the transfer of passenger flows for services that operate in both the PLANET Long Distance (PLD) and Regional models (PS, PM, and PN). This only applies to longer distance morning peak services that cross the regional model boundaries and preloads are used in the calculation of crowding.

any issues quickly and updates or corrections could then be issued for re-review. This interactive iterative process led to a final coding that contained very few additional issues to be noted for future updates of PFM.

## Base Rail Trip Matrices and Demand Drivers

### Description of the Model Updates

Updates to the rail trip matrices included the creation of new 2015 rail matrices from LENNON<sup>3</sup> data, with additional use of data from the Transport for London's Rolling Origin-Destination survey (TfL RODS) and from the Office for Road and Rail (ORR) for PS, and the derivation of new growth factors based on a re-run of the DfT's EDGE<sup>4</sup> rail demand forecasting framework.

### Audit Process

The audit of the base year trip matrix creation included a review of the SQL<sup>5</sup> database used to process the data.

The audit process of the growth drivers involved a review of the updated inputs to EDGE, reviewing the log files and changes made and a comparison of the original PLD matrices with the updated matrices. This included checks of the ticket type to journey purpose mapping, sense checks on the top 30 Origin-Destination pairs, and comparisons of trip totals and growth rates.

### Audit Results

During the audit of the 2014/15 rail trip matrices, a small number of counterintuitive origin-destination flows were identified in PLD and PM and were discussed with the model developers. In most cases these could be traced back to issues in the input Lennon data, where processing methodology, including the use of Oyster data had changed between 2011 and 2015. As these issues relate to input data, there was no immediate fix or processing error by the model developers; it has, however, been agreed that further investigation is required and this has been noted for future updates of PFM. In general, we found that the updated 2015 rail demand matrices were sensible and so was the growth from 2011.

## Station Choice Model updates

### Description of the Model Updates

In addition, some updates were made to the Station Choice Model (SCM) to cater for new movements in the updated rail matrices that were not previously recorded.

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<sup>3</sup> "LENNON" is the rail industry's central ticketing system. It provides information on the vast majority of national rail tickets purchased in Great Britain and is used to allocate the revenue from ticket sales between train operating companies.

<sup>4</sup> "Exogenous Demand Growth Estimator", a DfT tool for forecasting rail passenger demand.

<sup>5</sup> "Structured Query Language", a special-purpose programming language designed for managing data held in a relational database management system.

## **Audit Process**

A series of sample outputs from the SQL database for both PM and PN were provided by the model developers for us to review and perform high level checks on. These checks included comparing totals before and after the SCM and that the code was written logically. In addition, a member of our team spent a day with the model developers at their office, during which the SCM input update was explained. Finally, a document was provided which detailed the various SQL procedures that are used.

## **Audit Results**

Our overall conclusion following our review of the SQL component of the SCM input update was that the process was sound and logical without any serious issues.

## **Highway Networks**

### **Description of the Model Updates**

In parallel with the rail network coding, highway networks were updated to create a new 2015 network and to ensure that all future networks include the DfT RIS1 committed schemes.

### **Audit Process**

The audit involved a review of the log of changes spreadsheet provided by the model developers and the actual networks. The model update log file was checked to verify all the schemes had been approved by DfT. The proposed action comments in the 'model check log' spreadsheet were then checked against the corresponding scheme descriptions provided by DfT and the network files were all checked to ensure that the proposed actions had been implemented correctly. These included checks of all the changes on PLD links including link type, length and number of lanes.

As part of the highway preload process audit, we checked that traffic counts were correctly assigned to model links and that directionality was correct, that traffic count data and model flows were commensurate to the PLD model time period and the screenline validation was against WebTAG guidance.

### **Audit Results**

We concluded from our review that all the schemes approved by DfT had been coded correctly in the Do Minimum demand network files for 2026 and 2037. However, we noted that the methodology for deriving the preload adjustments, which looks at the difference between total traffic counts and model flow, sets the adjustment to zero if the calculation returns a negative value. This means that only positive adjustments can be made, so in situations where the model flow is higher than the observed count, the preload adjustment will not reduce the model flow in line with the count. The highway model's primary purpose is to provide long distance high level highway costs to inform the mode share between rail, highway and air modes. The highway network is therefore very coarse and difficult to validate even with the use of preload factors. Although the screenline validation is below WebTAG validation criteria it is important that it is seen in this context. The overall contribution of the highway module to the overall HS2 demand forecasts is minor. There is an intention to improve the level of highway validation in upcoming versions of PFM and this task has been noted for future updates of PFM.

## Highway trip matrices

### Description of the Model Updates

Highway trip matrices were updated using new TEMPRO<sup>6</sup> growth factors.

### Audit Process

The main purpose of the audit of the updated highway trip matrices was to confirm the integrity and robustness of the macros, internal calculations and layout of the Excel spreadsheets that create the highway matrices including checking the TEMPRO factors and growth. Our overall audit process comprised three main stages:

- General issue identification;
- Input to output sample calculation tests; and
- Model stress testing.

As well as looking at the function and form of the spreadsheets the inputs from TEMPRO were recreated (directly from TEMPRO) and checked against the growth factors in the spreadsheet.

### Audit Results

Our review of the process to create highway trip matrices concluded that the model is clearly set out. We were able to replicate and verify the TEMPRO growth process. The operation of macros was clearly set out and compliance with the DfT Best Practice guidelines was generally good, though some housekeeping was recommended to provide further clarity and transparency on the process used to create the updated highway trip matrices.

## Air trip matrices

### Description of the Model Updates

Air trip matrices were updated using air passenger demand growth from the DfT's National Air Passenger Allocation Model (NAPAM).

### Audit Process

The audit of the air trip matrices included a sense check of the growth in the matrix totals between 2014/15 and future years as described in the documentation, a review of the demand growth between forecast years and a check that the air matrix totals were logical, comparing previous and updated forecasts. Finally, we looked at all individual origin-destination pairs to check that the changes were sensible and to identify any unexplained outliers.

### Audit Results

The audit of the air trip matrices identified a small number of anomalies in some individual origin-destination pairs. These were noted for future updates of PFM but were judged to have minimal impact on model results.

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<sup>6</sup> "Trip End Model Presentation Program", software used to extract trip ends and growth factors from the DfT's National Trip End Model (NTEM).

## Updates to address previously noted issues

### Description of the Model Updates

An interim model version (v5.4) was created to address a number of issues identified in previous model versions.

### Audit Process

The audit involved a review of the services and network changes in this version of the model. In particular, we checked changes to service frequencies, vehicle classes, service descriptions, service patterns, link lengths and node coordinates in files for PLD, PN, PM and PS, as well as preload files and the network coding of walk links around Birmingham New Street station.

### Audit Results

In our review of these updates we identified a small number of coding issues in transit line files which were corrected in an updated version.

## Appraisal

### Description of the Model Updates

The model output routines and appraisal spreadsheet were updated to facilitate use of new values of time by distance band. Our audit covered several versions of the PFM Appraisal Spreadsheet, culminating in the review of v6.

### Audit Process

Updates to the model output routines and appraisal spreadsheet were reviewed to check separately the distance-banding facility implemented in the EMME macros that calculate and output appraisal values from PLD, PS, PM and PN, and the updates to the appraisal spreadsheet to receive the modified outputs.

The audit involved detailed line-by-line checking of the model code by an experienced EMME modeller. The review of the appraisal spreadsheet was aimed at verifying the implementation of the modifications and a more general review of compliance with guidance where appropriate.

### Audit Results

Following the audit of the output routines for appraisal we confirmed that the process was implemented as intended. We noted that the calculation for non-fuel cost savings differed for business compared with commuting and leisure and for the latter two purposes the calculation led to results of the opposite sign to business. This is a known inconsistency that is corrected for by the way the appraisal spreadsheet accepts and uses these results.

During our audit of the appraisal spreadsheet, we noted some minor issues of clarity and redundancy that have been recorded for future updates of the appraisal spreadsheet. These include a simplification of value of time updates by taking the values directly from the WebTAG databook, the adoption of consistent terminology for journey purposes and the use of consistent file naming nomenclature that allows distinction between different versions of the workbook.

## Version 6.1 Forecast Model Run

### Description of the Model Updates

Following the updates made to individual parts of the modelling suite as described above, a model version 6.1 forecast run was undertaken.

### Audit Process

The aim of the audit was to check whether all the updates to individual model elements that had been audited in isolation had been successfully implemented in the v6.1 forecast model run. This included the following checks:

- All the files were provided as per the checklist;
- Latest updated base matrices were correctly read in;
- Latest base networks were being read in;
- Latest lines file and preloads file were being read into the model run;
- Latest rail fares were being used;
- Latest air and highway matrices were being read in;
- The Heathrow model had been updated; and
- Any changes to macros and batch files had been correctly implemented.

### Audit Results

The audit found no issues.

### Summary and Conclusion

From the information that we have reviewed and in exercising the degree of skill and care to be expected from a competent professional consultant experienced in undertaking such services, we confirm that users of the model and its results can be confident the implementation of the model updates leading to the re-issue of PFM v6.1 correctly reflects the documented methodology subject to the revision/rectification of the specific details raised in this letter.

We do not judge any of these to have a material impact on the case for HS2.

Yours sincerely



**Hermann Maier**  
Technical Director  
020 7939 6280  
hermann.maier@jacobs.com