

28 April 2017

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## **Audit of the development of PLANET Framework Model version 7.1**

Dear Andrew,

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) and the latest version of the model is version 7.1 (v7.1).

The aim of the audit was to provide independent verification to HS2 Ltd that the model processes and inputs of PFM version 7.1 met the specification for the PFM that was developed and agreed between HS2 Ltd and the model developers Mott MacDonald and Systra.

Our audit has been undertaken with the degree of skill and care to be expected from a competent professional consultant experienced in undertaken such services. From the information we have reviewed, we confirm that users of the model and its results can be confident that the implementation of model updates leading to PFM v7.1 correctly reflect the documented methodology. During our audit, we noted a number of specific issues which are detailed 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, 2015 and 2016 and provided individual sign-off letters for these.

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

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The subject of this letter is the audit of model development resulting in PFM version 7.1 (v7.1) which builds on the previous release version of PFM version 6.1 (v6.1) via a number of interim releases that have also been audited and are described below.

We have only audited elements of the model that have changed in the new model version (rather than re-auditing the whole PFM) and this letter relates to the changes from v6.1 to v7.1 only. The audit criteria for each element to be audited have been discussed with the model developers beforehand. In addition to auditing the individual model update items, we have also reviewed the implemented version of PFM v7.1 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 note for each interim 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 added to the Development Opportunity Log<sup>2</sup> (DOL) held centrally by HS2 Ltd. 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 v6.1 and v7.1 are described in the documentation drafted by SYSTRA on behalf of HS2 Ltd which accompanies the model version release. These updates are explained in outline below, followed by a description of the audit process and audit results.

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<sup>2</sup> The Development Opportunity Log is a register of model issues that could be addressed in future model development. The log is maintained by HS2 Ltd. Items are added to the log if they have been agreed as development.

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## Summary of Model Updates

The focus of the updates in v7.1 was the implementation of updated economic forecasts, the move to the latest software platform, some updates to service coding and the move of the second forecast year to 2037/38. In particular, the changes described in the table below were implemented.

Model version	Model Update Change	Corresponding Section(s)
PFMv6.2	Minor updates to line coding and rail preloads to address known issues in v6.1.	1. PFMv6.2: NT TPE re-audit 2. PFMv6.2: Red Checks
PFMv6.2.1	Updated assumptions following release of the WebTAG databook update containing revised Vehicle Operating Cost (VOC) parameters as well as revised Vehicle Occupancy parameters.	3. PFMv6.2.1: revised car cost and occupancy
PFMv6.3	Update of the second model forecast year from 2036/37 to 2037/38 in order that the 20-year appraisal forecast horizon used for economic appraisal can be maintained when the model is used during 2017. Other updates include the incorporation of automated checking on the regional models, as well as a more simplified folder structure for model inputs to improve usability and updates to the standard outputs.	4. PFMv6.3: Second Forecast Year 5. PFMv6.3: Standard Model output updates 6. PFMv6.3: Timetable Database
PFMv6.4	New demand matrices derived from revised demand driver generators (DDGs) that have been supplied by the DfT following the OBR's November economic forecasts.	7. PFMv6.4: Rail Trip Matrices
PFMv6.5	Move to EMME version 4.2.9 and updates to TSS coding.	8. PFMv6.5: TSS LM and GA updates 9. PFMv6.5: New EMME version
PFMv6.6	Service Coding Updates - Not audited as changes were subsumed in PFMv6.7.	None
PFMv6.7	Updates to service coding for HS2 and a number of classic rail lines. Further TSS updates.	10. PFMv6.7: TSS Reference Case Updates 11. PFMv6.7: Service Coding Updates
PFMv6.9	Update to WebTAG, new demand forecasts, further updated HS2 services.	12. PFMv6.9: WebTAG updates 13. PFMv6.9: HSS TSS and WebTAG updates
PFMv7	Update to the new demand matrices from further revised DDGs. Minor changes to LM transit lines and updates to appraisal spreadsheets.	14. PFMv7: PFMv7b Demand Forecasts 15. PFMv7: Final Model Run
PFMv7.1	Update to WCML	16. PFMv7.1: WCML Updates

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## Model Audit details

Our audit process and findings under each of these headings are discussed in the following sections.

### 1. PFMv6.2: NT TPE re-audit

#### Description of the Model Updates

Updated Northern Trains (NT) and TransPennine Express (TPE) service coding DM and DS coding.

#### Audit Process

The first stage in the audit process was to check that the Do Minimum (DM) updates were applied correctly. Using the DM Specification Changes Note supplied by Mott MacDonald, the auditors were able to establish whether the changes were successfully applied. This stage involved the use of an Excel spreadsheet with additional calculations to aid the auditing process. This stage was applied to both Planet Long Distance (PLD) and Planet North (PN) models.

The second and final stage involved auditing of the changes applied to the Do Something (DS) scenarios. The basis for this was again supplied by Mott MacDonald in the document Changes Summary. As with the first stage, comparison software was used along with spreadsheet tools to facilitate with the auditing process.

#### Audit Results

All of the line coding was compared to the changes note. Any issues found were reported back to the model developers and clarified or corrected. Two minor items were added to the DOL.

### 2. PFMv6.2: Red Checks

#### Description of the Model Updates

Following “red checks”<sup>3</sup> by the model developers of the Planet Framework Model (PFM v6.1) a small number of changes were made relating to transit line coding for Great Western (GW), Cross Country (XC) and London Midland (LM).

Further changes contained in PFMv6.2 relate to updates of the preloads spreadsheet to reflect the service changes described above. In addition, the appraisal spreadsheet was updated with the latest set of annualisation factors.

#### Audit Process

The first stage in the audit process was to check that the red check changes have been correctly applied. The preloads spreadsheets which had been updated as outlined in the release note and check log spreadsheet were also checked for Planet South (PS), PLD, Planet

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<sup>3</sup> The red check is the final check in the model developers' own quality assurance process.

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Midlands (PM) and PN for D, C and Y networks<sup>4</sup>. The updated annualisation factors in the appraisal spreadsheet were checked too.

## **Audit Results**

No issues were found in the transit line coding, preload spreadsheets or the appraisal spreadsheet.

## **3. PFMv6.2.1: revised car cost and occupancy**

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

Revised figures have been provided by HS2 Ltd for the vehicle operating costs and vehicle occupancy parameters used in the vehicle costs and occupancy factor calculations of PFM. The changes to vehicle occupancy are based on the updates in WebTAG “TAG data book Summer 2016 FC (v1.6 beta) with revised FC for RWE.xls” as supplied by HS2 Ltd.

### **Audit Process**

The PFMv6.2.1 model was used in the checking process for the update of the vehicle operating costs and vehicle occupancy parameters calculated using the “TAG data book Summer 2016 FC (v1.6 beta) with revised FC for RWE.xls” spreadsheet supplied by HS2 Ltd.

We checked and verified the updates to figures as outlined in “20160921\_Model\_PFMv621\_Release\_Note\_v1.1.docx”.

### **Audit Results**

The updates to the vehicle operating costs and vehicle occupancy parameters have been checked and verified to ensure the correct values have been used in the input files:

- mf751.311;
- mf752.311;
- mf753.311;
- voc.mac; and
- Heathrow\_Demand.xls.

No erroneous values were observed. The workings of the calculations undertaken to obtain the parameters used in the files have been checked against the WebTAG databook.

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<sup>4</sup> The D, C and Y networks refer to Phase 1 (London to the West Midlands), Phase 2a (West Midlands to Crewe) and Phase 2b (Full Network) respectively.

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## 4. PFMv6.3: Second Forecast Year

### Description of the Model Updates

The PFMv6.3 is an update version of the PFM v6.2.1 that includes mainly updates to the second forecast year from 2036/37 to 2037/38.

### Audit Process

Initially, the new folder structure of the updated model input has been reviewed. A separate spreadsheet, "*High level checks on PLD and regional matrix totals 03112016.xlsx*" has been created to include the PLD and the Regional Demand matrices derived from the PFMv63\_C37\_RUN.zip.

The matrix totals were then compared with the ones stated in the Model Release Notes, PLANET Framework Model version 6.3 "*Model\_Release\_Notes\_PFMv6.3\_v1.0\_DRAFT.docx*". An additional review was made where the PFMv6.3 were compared to the ones from the PFMv6.1c.

### Audit Results

High level checks on the new Rail, Air and Highway demand matrices have been done. A summary table has been created to compare the previous stated with the audited matrix totals. The demand totals and percentage increases match what was given in the Model Release notes. Finally, the new folder structure and macro changes were checked. No errors were found.

## 5. PFMv6.3: Standard Model output updates

### Description of the Model Updates

As part of an on-going set of enhancements to the model outputs some changes were made to the HS2 demand outputs. This was done in numerous different stages:

- Demand Output changes;
- Standard Outputs Refresh Card 1;
- Standard Outputs Refresh Card 2;
- Standard Outputs Refresh Card 3;
- Standard Outputs Refresh Card 4; and
- GJT Demand Templates.

### Audit Process

The updated standard outputs template was compared against the previous version each time, with the first compared against PFMv6.3. Any changes to the spreadsheets were checked against expected changes stated by the model developers. Updated macros and batch files were also compared to the previous versions. The process was re-run to attempt to replicate the expected results.

### Audit Results

All changes matched to what was expected. The process was tested and run completely without errors.

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## 6. PFMv6.3: Timetable Database

### Description of the Model Updates

The model developers updated the process of allocating transit vehicle types to transit lines to remove redundant vehicle types, streamline the vehicle definition files and to better aid the conversion from SPG<sup>5</sup> to EMME<sup>6</sup> coding.

### Audit Process

The audit of vehicle types was done in two stages. Firstly, the previous vehicle list, as used in PFMv6.2, was listed with all duplicates removed. This list was compared to that provided by Mott McDonald. No differences were found between these lists.

This list was then checked against the new list of vehicle types, to see if all unique vehicle types had been carried forward. A check was also done to identify which vehicle types were used in the lines coding. The vehicle types from the New VehTypeFile + Lookup sheet has been checked for consistency in description. Several vehicle types were found to have duplicated descriptions but different seated/total capacity. Following a response from Mott MacDonald the second instance of each vehicle type was changed.

### Audit Results

No issues remain following correction of some vehicle type definitions.

## 7. PFMv6.4: Rail Trip Matrices

### Description of the Model Updates

The Demand Driver Generator (DDG) forecasts released by the Department for Transport (DfT) for the post-Brexit period have been implemented in the Exogenous Demand Growth Estimator (EDGE)<sup>7</sup> forecasting framework to produce updated future rail demand matrices.

### Audit Process

The aim of this audit is to verify that the new demand totals and values described in the technical note are found in the data (spreadsheets, txt files) provided. It should be noted that only the changes to input demand have been checked as not enough data was included to check rail impacts.

Following the initial audit which focused on the integrity of the process and its reporting, we have additionally looked at the plausibility of the results following concerns about the significant changes in demand resulting from the new inputs.

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<sup>5</sup> SPG Files are output files from the MOIRA rail industry model that contain rail service specifications.

<sup>6</sup> EMME is the proprietary software in which the PLD is set up.

<sup>7</sup> The EDGE database provides a mechanism for forecasting the growth in rail demand on a geographical basis.

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## **Audit Results**

The checks for the changes in the DDG forecasts and their impact on the future year rail demand forecasts indicate that all of the input values and calculations described in the technical note - *December 2016 Demand Drivers: Impact to PFM Rail Forecasts* are correct.

Regarding the matrix results we note that these can be explained by the input parameters.

## **8. PFMv6.5: TSS LM and GA updates**

### **Description of Model Updates**

Updated Train Service Specification (TSS) Do Minimum data was provided by the DfT. This was passed through the Timetable Database (TTDB) to produce new DM and DS coding for LM and Greater Anglia (GA).

### **Audit Process**

A summary of the expected changes was provided by the model developers. This was used to check that the new service coding produced by the TTDB matched expectations.

Further checks were done to compare the change from PFMv6.2 to see what the level of change is.

### **Audit Results**

The results matched what was expected when comparing the PLD services. For LM we found a large increase in the level of service in PN. This was reported to the model developers and found to be an expected result of a change in methodology for creating the regional networks. The previous LM services had not been updated recently to match this change in methodology therefore we were happy with the change. These services were subsequently superseded in PFMv6.6.

## **9. PFMv6.5: New EMME version**

### **Description of Model Updates**

As a result of moving to a new version of EMME, the batch files, macros and Standard Output template spreadsheets were updated to function in EMME4.2.9. This work is a part of rolling updates requested by HS2 Ltd as part of checklist of enhanced model outputs and the migration from EMME3 to EMME4.

### **Audit Process**

The updated *PFMv65\_Red\_Y37* model files (.mac and .bat files) include the following changes compared against the *PFMv62\_Red\_Y36* version of the model. Both models function in EMME4.2.9. Further to the previous checks we compared the standard outputs templates of the two models.

The *PFMv65\_Y37\_UNRUN* version of the model was used to test the forecast year model (2037). A full model run was replicated to audit the process (i.e. all .bat files and macros run without any errors in EMME4.2.9) and to compare the output files (*Standard outputs.xlsx*) against the ones included in the RUN version provided (populated versions).



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## **Audit Results**

A full model run (PFMv6.5) has been successfully replicated. The updates to batch files/macros compared against the PFMv6.2 version have been recorded and the entire process runs completely with no errors. The output files are identical to the ones included in the RUN version provided.

We found a few discrepancies in the standard outputs for these versions of PFM and what we have previously audited. Those found in the PFMv6.2 are not important as this version was only used by Mott MacDonald to test EMME4.2.9.

## **10. PFMv6.7: TSS Reference Case Updates**

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

For the HS2 service, journey times were updated over the examined phases: 1, 2a, and 2b (i.e. D, C and Y). The updates are based on the new assumptions proposed by HS2 Ltd. This work is a part of rolling updates requested by HS2 Ltd as part of checklist of enhanced model outputs.

### **Audit Process**

Initially the updated transit line coding was imported into an Excel spreadsheet and calculations were made to identify and highlight the calling points and journey times between consecutive stations. The results were then checked against the specification table provided by Systra; cross checks were made to audit the service coding, stopping patterns and journey times for each phase (1, 2a and 2b).

### **Audit Results**

A small number of minor discrepancies between specified and coded journey times were identified and communicated to the model developers. The issues were corrected in updated coding.

## **11. PFMv6.7: Service Coding Updates**

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

PFMv6.7 is a new model version with updated LM and GA transit lines and updated demand forecasts.

### **Audit Process**

Checks and updates carried out on:

- TOC coding, specifically LM and GA services;
- London U/D (up and down) services code updates;
- Updated peak-period factors; and
- Standard output template checks.

### **Audit Results**

All of the input values and calculations are accurate and appear reasonable. Any issues found were addressed by the model developers and were included in PFMv6.9.

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## **12. PFMv6.9: WebTAG updates**

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

Updates to the model input files to take account of the new TAG data book January 2017.

### **Audit Process**

The model inputs were compared to PFMv6.7 and checked that the expected changes were in place. This included looking at various model input files including the Heathrow demand spreadsheet, model output templates and the appraisal spreadsheet.

### **Audit Results**

All of the input values and calculations were found to be accurate and appear reasonable given the updates to WebTAG.

## **13. PFMv6.9: HSS TSS and WebTAG updates**

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

PFMv6.9 is a further update to the model version to include any changes found from the Ref Check review, include another HSS TSS update and WebTAG updates.

### **Audit Process**

The model inputs were compare to PFMv6.7 and checked that the expected changes were in place. The new HSS services were compared to the specification provided by HS2 Ltd – a similar audit to previous done. The WebTAG changes previously audited were check to confirm inclusion in the model runs. A replication run was not performed as we were expecting PFMv7.

### **Audit Results**

All the inputs were as expected and no errors were found. The peak period factors were updated as expected, all the new standard outputs were included and the WebTAG updates have also been included in the model runs.

## **14. PFMv7: PFMv7b Demand Forecasts**

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

A further update to the demand forecasts was calculated by the model developers in-line with further discussion with DfT. These forecasts will be input to the updated PFMv7 model. PFMv7b in this context relates only to the demand inputs and was not a version of PFM produced. Following the initial audit which focused on the integrity of the process and its reporting, we have additionally looked at the plausibility of the results following concerns about the significant changes in demand resulting from the new inputs. The forecasting approach was updated and re-based from a forecasting base year of 2014 to 2016. To reflect the real growth in rail demand from 2014 to 2016, an uplift of 6% was applied to the original 2014 base to uplift to 2016 before the DDG growth was applied from 2016/17.

### **Audit Process**

High level checks were carried out on uplifted 2016 and future year matrix totals for PLD, PN, PM and PS for both 2026 and 2037.

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## **Audit Results**

The totals for the 6% increase are correct across all regional models. The resultant future year demand totals show increases from the previous DDG update but remain lower than those in PFMv6. This is as expected with new DDGs.

## **15. PFMv7: Final Model Run**

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

PFMv7 was supplied by the model developers for audit. This was compared against PFMv6.9. The expected changes included minor further changes to LM transit line coding, inclusion of the PFMv7b DDG and minor updates to some of the standard output spreadsheets. An updated appraisal spreadsheet was also provided.

### **Audit Process**

A comparison of all the files was carried out against PFMv6.9. Any changes were documented and compared to what was expected from details provided by the model developers. The updates to the appraisal spreadsheets were checked against the updated changes provided by the model developers.

### **Audit Results**

All changes were as expected. A model replication run was carried out and the results match exactly what was produced by Systra. The appraisal spreadsheet was updated as specified.

## **16. PFMv7.1: WCML Updates**

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

The model was updated with some West Coast Main Line (WCML) services in the Do Minimum using 9-car Pendolinos instead of 11-car.

### **Audit Process**

A comparison of all the files was carried out against PFMv7. Any changes were documented and compared to what was expected. The changes to the Do Minimum lines coding were looked at in detail and compared against a note provided by Systra.

### **Audit Results**

A single minor discrepancy was found. This was reported to Systra and corrected. There were no other changes to the model except for the Do Minimum lines coding.



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## Summary and Conclusion

Our audit has been undertaken with the degree of skill and care to be expected from a competent professional consultant experienced in undertaken such services. From the information we have reviewed, we confirm that users of the model and its results can be confident that the implementation of model updates leading to PFM v7.1 correctly reflect the documented methodology. During our audit, we noted a number of specific issues which are detailed in this letter. We do not judge any of these to have a material impact on the case for HS2.

Yours sincerely

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