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Jack Grigg
Economic and Commercial Analysis
High Speed Two Limited
The Podium
1 Eversholt Street
London
NW1 2DN

Audit of the development of PLANET Framework Model version 10a

Dear Jack,

We at Jacobs have 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 10a (v10a).

The aim of the audit was to provide independent verification to HS2 Ltd that the model processes and inputs of PFMv10a 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 undertaking 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 PFMv10a correctly reflect the documented methodology. During our audit, we noted some specific issues which are detailed in this letter. These issues have already been addressed and we do not judge any of these to have a material impact on the results of PFMv10a. The rail fares calculation which was based on the previous methodology needs a wider review and discussion between HS2 Ltd and model developers post PFMv10a. We do not judge the comments raised in the audit to have a material impact.

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[1] 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, 2016, 2017, and 2020 providing individual sign-off letters for these.

The subject of this letter is the audit of model development resulting in PFMv10a which builds on the previous release version of PFM version 9 (v9) via a number of interim updates 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 v9 to v10a 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 PFMv10a to ensure that all the individual updates have been included.

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 v9 and v10a are described in other documentation produced by SYSTRA on behalf of HS2 Ltd. These updates are explained in outline below, followed by a description of the audit process and audit results.

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[1] PLANET Framework Model Audit Report, Model Implementation and Standard Case Forecast, October 2013

Summary of Model Updates

The focus of the updates in v10a was the inclusion of the rebasing updates in the rail demand for PLANET Long Distance (PLD), PLANET Midlands (PM), PLANET North (PN) and PLANET South (PS) from 2014/15 to 2018/19, a new Python preload process, pivot process simplification and updated Station Choice Model (SCM) access costs. Furthermore, this version includes the recalibration work which incorporates the data from the recent National Travel Survey (NTS).
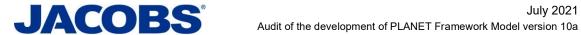
Model Version	Model Update Change	Corresponding Section(s)
PFMv9.1	This version includes pre-store check and reliability updates, 2039 air supply correction and standalone TOC-TOC process.	1. PFMv9.1
PFMv9.1	This update replaces the current Excel based preload process with a process in Python.	2. PFMv9.1: Python Preload
PFMv9.1	The deannualisation factors have been updated from PFMv6 for PM PN and PLD. The journey purpose splits have been updated for PM and PN. This is to allow for the use of MOIRA demand matrices as a starting point, rather than LENNON ticket sales	3. PFMv9.1: Deannualisation Factors and Journey Purpose Split
PFMv9.3	This version incorporates the new Economic Appraisal Spreadsheet (EAS) tool, updates to python preloads, removal of Heathrow, pivot simplification and the use of Excel 2016	4. PFMv9.3
PFMv9.3	PM PN Matrix Development 2014/15 Updates involves the use of MOIRA 2015 as new input demand and steps to convert it to 2015 zone to zone demand.	5. PFMv9.3 PM PN Matrix Development 2014/15
PFMv9.3	PM PN Matrix Development 2018/19	6. PFMv9.3: PM PN Matrix Development 2018/19

	Updates involves the use of MOIRA 2018 as new input demand and steps to convert it to 2018 zone to zone demand.	
PFMv9.3	PLD Matrix Development 14/15

Updates involves the use of MOIRA 2015 as new input demand and steps to convert it to 2015 zone to zone demand | 7. PFMv9.3: PLD Matrix Development 14/15 |
| PFMv9.3 | PLD Matrix Development 2018/19

Updates involves the use of MOIRA 2018 as new input demand and steps to convert it to 2018 zone to zone demand. | 8. PFMv9.3: PLD Matrix Development 2018/19 |
| PFMv9.3 | PLD Fare Matrices 2018/19

Update includes the new set of rail fares matrices development for the PLD rail model. | 9. PFMv9.3: PLD Fare Matrices 2018/19 |
| PFMv9.3 | PS Rebasing

Matrix development process for Planet South (PS) matrices based on the 2016 RailPlan (RRP). | 10. PFMv9.3: PS Rebasing |
PFMv9.4	This version incorporates the updates to the SCM access costs.	11: PFMv9.4
PFMv9.5	This version incorporates the 2018/19 rebased models.	12: PFMv9.5
PFMv9.5	Rebasing from 2014 to 2018	13. PFMv10 Base 18 Test D vs PFMv6 Base14
PFMv9.6 and v9.6a	PFMv9.6 incorporates updates to forecast year demand using March 2020 Office for Budget	14. PFMv9.6 and v9.6a

	Responsibility (OBR) growth forecasts and WebTAG inputs using the Sensitivity Databook released in July 2020. PFMv9.6a includes updates to WebTAG inputs using the standard May 2020 Databook. This version was only used for comparison to PFMv96 and was not used in future model versions.	
PFMv9.6	This part of the model build adjusts the Planet South (PS) output from the Timetable Database (TTDB) to take it from the Proxy network and adjust it to the real PS network. It does this using a series of Python scripts to make incremental changes.	15. PFMv9.6: TTDB PS Network
PFMv9.6	This includes updates to the batch files and spreadsheets that help to automate the production of various vehicle and passengers kilometre outputs from the PFM models.	16. PFMv9.6: Vehicle Kilometre Outputs Automation
PFMv9.7	-	This version was not audited. The updates in this version were reviewed as part of the PFMv9.8 audit.
PFMv9.8	This version includes updates to the carbon output process, base year standard output data, PS matrix size, database C output process and prestore checks. In addition, this incorporates the updates to the Train Service Specifications (TSS) which were implemented in PFMv9.7.	17. PFMv9.8
PFMv9.9a	The update to this version is the inclusion of the December 2020	18. PFMv9.9a

	Demand Driver Generators (DDGs).	
PFMv9.9b	This version includes the February 2021 WebTAG Databook internal update.	19. PFMv9.9b
PFMv9.9c	This version includes new parameters from the recalibration demand work.	20. PFMv9.9c
PFMv10	This version was taken from PFMv9.9c with some adjustments to the parameters related to recalibration work.	21. PFMv10
PFMv10a	This version incorporates updates to the Values of Time (VoT).	22. PFMv10a

Model Audit details

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

1. PFMv9.1

Description of the Model Updates

This version includes pre-store check and reliability updates, 2039 air supply correction and standalone TOC-TOC process.

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- o PFMv9_PXX_YY vs PFMv9.1_PXX_YY

Audit Results

Most of the file updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. However, there were files that have been updated and added but were not included in the change log. The model developers confirmed that these changes were expected in this version of the model.

2. PFMv9.1 - Python Preload

Description of the Model Updates

This update replaced the previous Excel based preload process with a process in python. As part of the update, the data from the Excel spreadsheets has been extracted into CSV for use in Python.

Audit Process

The audit process consisted of a comparison between the updated batch files, a review of the new preload inputs and a replicate run using the new python preload process. It was found during the development of the python preloads that PFMv9 Do Nothing had a problem with certain GW links having zero preloads where the j-node is 6 digits. In addition, PS to PLD preloads were rounded to the nearest whole number. Therefore, in order to have a meaningful comparison, revised versions of PFMv9 were run with DN fixed and with Excel preload spreadsheets rounded to 2 decimal places for all models.

Audit Results

All the file updates found were expected and matched previous inputs where necessary. Full model run for the PFMv9_DN_39 (standard run) have been successfully replicated with no errors identified. The comparison of standard outputs shows minor differences in values (decimal points) but identical convergence outputs. This is expected from running on different machines and given the convergence is identical, the replication run is acceptable.

3. PFMv9.1 - Deannualisation Factors and Journey Purpose Split

Description of the Model Updates

The deannualisation factors have been updated from PFMv6 for PM PN and PLD. The journey purpose splits have been updated for PM and PN. This is to allow for the use of MOIRA demand matrices as a starting point, rather than LENNON ticket sales.

Audit Process

The audit process consisted of checking the working of the individual spreadsheets, ensuring consistency across the different models and comparing the workings to the provided scoping. The spreadsheets have been audited with a view to check the inputs, assumptions, and calculations.

Throughout the workbook, there are instances of calculations changing across continuous columns, or down subsequent rows. This would typically be flagged as not aligning to modelling best practices, but we have not reported all instances of this as we believe HS2 is content with the current layout. This does not have a material impact on the workbook, and users need to be aware that they should not assume they can drag calculations across/down an entire block of cells.

Audit Results

The deannualisation factors derived for PM, PN and PLD are appropriate for MOIRA and consistent with the factors derived for PFMv6. The journey purpose splits derived for PM and PN are appropriate for MOIRA and consistent with approach used for the deannualisation factors. The workings of all the spreadsheet match the expected scope and no errors were found.

4. PFMv9.3

Description of the Model Updates

This version incorporates the new EAS tool, updates to python preloads, removal of Heathrow, pivot simplification and the use of Excel 2016.

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- PFMv9.1_PXX_YY vs PFMv9.3_PXX_YY

It was noted that comparison to PFMv9.1 seemed to be more appropriate as PFMv9.2 was an interim test. PFMv9.2 includes both the removal of Heathrow and pivot simplification and the changes in this version were reviewed in PFMv9.3.

Audit Results

All file updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers for this version of the model.

5. PFMv9.3 - PM PN Matrix Development 14/15

Description of the Model Updates

This audit concerned checks of spreadsheets and SQL queries used in the PM and PN matrix development step within PFM for 2014/15. These checks focused on accuracy and correctness throughout the steps. The steps are:

1. Proportion split data

2. Deannualisation and User Class Factors

3. Moira Pre-Processing

4. SCM Restrictions

5. Other Database Inputs

6. Database Processing to create Z2Z Demand

7. Database processing to create SCM Input Files

8. Amendments and Further Information

Audit Process

The audit process for this task is summarized below.

In step 1, the data provided in the files is already split by the distance bands and their source cannot be checked at the auditor's side as it is stored on the model developer's system. However, there are checks within spreadsheets that compare used values with source values and these are correct. They prepare input datasets for the SQL process later. The final output datasets contain proportions by groups of stations weighted by ORR demand for each station.

In step 2, the formulas and calculations for the deannualisation factors and user class split proportions have been checked. step 3,the script for Moira dataset works as expected and was reproduced.

In step, the spreadsheet "AccessToSplit_v2.xlsx" has been checked. In step 5, there is no information on how the files have been produced but checks have been done if the files have been uploaded correctly to the SQL database.

In step 6, the SQL script which converts the MOIRA data to Zone to Zone demand, as well as creates a mapping from Z2Z to nearby stations has been checked.

In step 7, the scripts which are used for all the Z2Z movements that appear in either NCA or CAV data and the script to retrieve the proportion mappings for all the Z2Z movements have been checked.

And lastly, in step 8, the script from step 6 that was missing has been sent from the developers and has been checked.

Audit Results

Below is the summary of audit results and recommendations.

In step 1, the input table "PM_PM_O_D_Proportions_v5" is constructed by pasting together data from 3 different files. This is not explicitly written out which tables are part of this input table. This

has been addressed by the model developers and information were provided on how the file was made.

The spreadsheets and table inputs in step 2 are correct. In step 3, the pre-processing script works correctly and was reproducible.

In step 4, there is an extra row in the SQL table, which is not in the input file and this needs to be investigated. This has been addressed by the model developers and that the extra row was added manually to avoid errors in the SCM code. In step 5, files have been correctly uploaded in the SQL database

In step 6, there is no mention of the multiplication factor 1.2 for the distances, which needs to be justified or explained. There is also different table naming in the scripts compared to the document. These have been addressed by the model developers and confirmed that the 1.2 factor was adopted from the previous methodology from the previous base work which uses crow-fly distances for the rail network distances. Information was also provided on the different table naming in the scripts as opposed to the document, that the renumbering was because it was run in later part of the code and for consistency.

The remaining parts of the code in step 6 have been coded correctly.

The scripts in step 7 are coded correctly.

Step 8 summarizes the updates to the files that require changes as highlighted in the previous steps and additional clarifications from the model developers.

6. PFMv9.3 - PM PN Matrix Development 18/19

Description of the Model Updates

This was an audit of the matrix development for PFM Planet Midlands (PM) and Planet North (PN). The matrix updates included:

- Using 2018/19 Moira data

- Adjusting the car availability splits based on 2018/19 TEMPro Data

- Renaming and changing the references in the calculations and code to cover 2018/19 instead of 2014/15

Audit Process

This audit included the checks of spreadsheets and SQL queries used in the matrix development step within PFM for 2018/19 in comparison to the 2014/15. The audit consisted of a review of the files and documents provided by the model developers. Files refer to data processing inputs, Z2Z demand database inputs and SCM inputs.

High level checks were carried out to see if TEMPro growth factors calculated for CAV/NCA for 2018/19 follow the same methodology in PM and PN. The calculations are correct, and formulas point to correct cells. The growth rates were correctly applied to the data. Moreover, all the scripts have been checked in order to see if they create the same outputs with the correct names.

Audit Results

Overall, the process for 2018/19 uses the same scripts as 2014/15 with adjusted table and file names for the new data and the method and processing steps in these scripts were checked in the 2014/15 PM PN matrix development audit.

7. PFMv9.3 - PLD Matrix Development 14/15

Description of the Model Updates

In this task, an audit of the matrix development for PLD (Planet Long Distance) was undertaken. The updates included PFM rebasing to 2014/15 by using MOIRA as the source for rail journeys and revenue data.

Audit Process

This audit outlines the checks of spreadsheets and SQL queries used in the PLD matrix development step within PFM for 2014/15. These checks focus on accuracy and correctness throughout the steps. In the input tables, the review has focussed on the district and zoning system, deannualisation factors, station reference, London split, journey purpose and car availability proportions. In the SQL process, checks have been done in the transpose step, aggregation to PLD zones and output spreadsheet. The full SQL process was also replicated, and results were compared to those provided by the model developers.

In each of the steps mentioned above, the following checks have been done:

- The formulas are correct, consistent and link to the right cells.

- The SQL code is constructed correctly, and the tables are created correctly within SQL.

- The SQL queries have been correctly copied from the spreadsheets into scripts.

Audit Results

Overall, the queries have been constructed correctly and any spelling mistakes in declaring variables, table names, column names have been taken into account in the later stages of the process.

However, in the step related to "station reference", we would recommend some changes if this work was to be reproduced as currently it would require manual changes to the code as it will crash. The Station Reference code is not easily reproducible since there are some problems within the syntax. There is also incorrect column naming in that process which can be removed since the column naming does not have an impact later and not used.

8. PFMv9.3 - PLD Matrix Development 18/19

Description of the Model Updates

The updates include PFM rebasing to 2018/19 by using MOIRA as the source for rail journeys and revenue data. The updates and changes were outlined by the developers and are the following:

1. Year to MAR 2019.csv – main input table with MOIRA 2018-2019 data

2. PLD_Matrices_Outputs_1819.xlsb – the spreadsheet with final outputs

3. 1.Transpose step.sql – MOIRA 2018-2019 dataset comes only with station codes, an extra step was added in the beginning of this query to allocate MOIRA station names to their codes (but the rest of the code stays the same).

4. 20200514_Generic_London_District_Map.xlsb – this input table was updated with TEMPRO growth for 2018/19 matrices, updated input values from sheet "London_Split" were used.

5. 20200410 PLD Rebase Calcs_201819.xlsx – updated TEMPRO growth was added as values from sheet "SQL" was used."

Audit Process

This audit consisted of checks of spreadsheets and SQL queries used in the PLD Matrix development step within PFM for 2018/19. Since this process is very similar to the matrix development for the 14/15 year, only the updated inputs and scripts have been checked. These checks focussed on accuracy and correctness throughout the steps.

Specifically, the new input tables have been checked regarding the formulas in the spreadsheet and if they were linked in the right cells. Moreover, we checked whether the SQL codes have been constructed correctly and whether the tables in SQL are created correctly.

Audit Results

Overall, apart from a small required change in the SQL code (name change for a table, which was subsequently rectified by the model developers) the process for the 2018-2019 PLD matrix development were implemented correctly.

9. PFMv9.3 - PLD Fare Development 18/19

Description of the Model Updates

This task is about the new set of rail fares matrices development for PLDl. This audit was concerned with checks of an Excel spreadsheet and a Word document. These checks focussed on correctness of formulas and logic throughout the steps. This audit was made on the files provided by the model developers. The Excel spreadsheet used for this audit was "20200722_Fare_Matrix_Evaluation_201819.xlsb" and the Word document provided for this audit was "20200722 PFM Rebase PLD – Fares.docx".

Audit Process

The spreadsheet contains seven sheets which are listed below in the same order as they appear in the workbook:

1) Versions,
2) 201819,
3) PLD_Outputs,
4) Conversion_Tables_PDFH_mapping,
5) PDFH_mapping,
6) Mask, and
7) Labels

The audit included a review on the methodology, the content, the calculations, the assumptions which have been considered to establish the trip origin/destination (O/D) fares, the Excel formulas and the logic for the calculation of the average yield per journey and the average yield per kilometre.

Audit Results

Overall, the logic and the formulation used for the development of the PLD fares matrices model spreadsheet have been constructed correctly. A summary of the most relevant recommendations to be considered are shown below:

- Reordering the sheets in the spreadsheet in sequence of their use for a clearer understanding of the procedure.

- Introducing a list of abbreviations used in the spreadsheet reflecting the full term in-text followed by the acronym in parentheses.

- Using the same terminology consistently throughout the spreadsheet and document.

- The formula used to calculate the "Fare Flag" for business, commute and leisure refers only to the totals in the "Flow Type" and not to the ranges for the individual purposes. The model developers will be reviewing this approach post PFMv9.7.

Update: Any changes would be part of the wider review of the rail fares methodology post PFMv10a. We do not judge the comments above to have a material impact.

10. PFMv9.3 - PS Rebasing

Description of the Model Updates

This task was concerned with a review of the SQL queries and spreadsheets used in the Planet South (PS) matrix development. These checks focussed on accuracy and correctness throughout the steps. An audit of the steps against the provided documentation was also undertaken.

Audit Process

The first step in the audit process was to check the SQL queries. There are 3 sets of SQL scripts within the SQL database, set A, B and C. The A set extracts and processes the RRP data, the B set extracts and processes the PS data and the C set combines the outputs from A and B to rezone and use MOIRA to uplift the data. We have analysed each script to ensure we understand

the process it is performing; executed sections of the SQL and checked results; ran SQL select statements; ran the checks already in place within the script and ran the entire SQL script where possible.

The second part of the audit was to check the spreadsheets. Each spreadsheet contains a contents list on the BMS sheet that describes the purpose of each sheet. We have used this content list as a template. To audit the spreadsheets, we have checked that the description of each sheet matches what is described in the contents and related the conclusions and comments in the document to various sheets as well as checking the validity of the process described.

Audit Results

We have reviewed the spreadsheets, the SQL code and the documentation relating to the PS matrix development project. We have also run the SQL code to check it performs as required as well as performing spot checks by running our own SQL statements where we considered it necessary. We have found no major issues.

11. PFMv9.4

Description of the Model Updates

This version incorporates the updates to the SCM access costs.

Audit Process

The audit process consisted of the review of the updated files. These files were compared against their previous version in PFMv9.3 (PFMv93_PXX_YY).

Audit Results

All but one of the file updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. There is one change highlighted which was not included in the note. The model developers confirmed that updates to this file is expected.

12. PFMv9.5

Description of the Model Updates

This version incorporates the 18/19 rebased models.

Audit Process

The first part of the audit process consisted of the review of the updated files. These files were compared against their previous version in PFMv94 (PFMv94_PXX_YY).

Full model run of PFMv95_P2b_29 (pivot run) have been replicated successfully. The standard outputs were then compared against the outputs produced by the model developers.

Audit Results

All but three of the file updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. The model developers confirmed that the updates to these three files are expected and should be included in the change log.

The comparison of standard outputs shows minor differences in values (decimal points) but identical convergence outputs. This is expected from running on different machines but as previously agreed, the convergence is identical therefore the replication is acceptable.

Furthermore, during the model replication, the model stopped running when it reached the Dataset A process. This occurred at the very end of the assignment and the model developers confirmed that this does not impact the standard outputs and will be investigated post PFMv9.7.

Update: This has been resolved in PFMv10 and no issues were found when running the assignment.

13. PFMv95 Base18 Test D vs PFMv6 Base14

Description of the Model Updates

An audit of the PFM Base model (PFMv10 Base18 Test D) has been undertaken. This version incorporates the rebasing from 2014 to 2018. The updated and added batch files, input files, macros and standard outputs files are then compared against its previous model version PFMv6 Base14.

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- o PFMv6 Base14 vs PFMv10 Base18

Audit Results

Most of the updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. However, there were files that were updated but were not included in the change log. The model developers confirmed that the updates to these files are expected and should be included in the change log.

14. PFMv96 and v96a

Description of the Model Updates

PFMv9.6 incorporates updates to forecast year demand using March 2020 OBR growth forecasts and TAG inputs using the Sensitivity Databook released in July 2020 while PFMv96a includes updates to TAG inputs using the standard May 2020 Databook. The updated and added batch files, input files, macros and standard outputs files were compared against its previous model version PFMv9.5.

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- o   PFMv95_PXX_YY vs PFMv96_PXX_YY

- o   PFMv95_PXX_YY vs PFMv96a_PXX_YY

Audit Results

Most of the updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. The changes highlighted were not included in the note but are expected to change as part of the update. However, values incorporated in the file voc.mac were incorrect and need to be updated. The model developers acknowledged this and confirmed that the impact of this in the model assignment is quite small. This will be corrected in PFMv9.8 and will be reviewed again.

Update: The issue found in the file voc.mac has been corrected in PFMv9.9c. Also, PFMv9.6 was taken as the final version based on the confirmation that TAG would adopt the sensitivity version.

15. PFMv96 TTDB PS Network

Description of the Model Updates

This audit was about the Timetable Database (TTDB) in Planet South (PS). The model incorporates updates to a python script which automate different elements of the model. The following are changes to the script:

- Replaces nodes pairs and node triples (where the triple is a combo of 2 node pairs) to new node IDs

- Selects unused lines and delete them

- East Midland lines to and from St Pancras are adjusted

- Greater Anglia and Cross Rail lines to and from Liverpool Street are adjusted

- Manual changes are made to SE to align it on HS1, and a SW line to remove a double backing issue

Audit Process

This audit reviewed the process that develops the creation of transit lines in PS. For each procedure, a brief summary of the step, list of the files used, comments on the outcome of the processes and any recommendations for future similar work were discussed.

Audit Results

The script correctly returns all the changes that are referred in the model updates.

16. PFMv96 Vehicle Kilometre Outputs Automation

Description of the Model Updates

In this task, model updates refer to the batch files and spreadsheets that help to automate the production of various vehicle and passengers kilometre outputs from the PFM models and a spreadsheet that compiles various scenarios.

Audit Process

For this audit, a model replication run has been undertaken to ensure that this procedure will not have any impacts to the standard outputs. A full model run of PFMv9_P1b_39 (with Vehicle KilometreK Outputs Automation) has been successfully replicated. The standard outputs were then compared against the outputs without the automation.

Audit Results

The model PFMv9_P1b_39 (with Vehicle KilometreK Outputs Automation) has been successfully replicated. All standard outputs and PFMv9_P1b_39_CarbonOutputs.xlsm matches to the results of the model without the automation.

17. PFMv9.8

Description of the Model Updates

This version includes updates to the carbon output process, base year standard output data, PS matrix size, database C output process and prestore checks. In addition, this incorporates the updates to the Train Service Specifications (TSS) which were implemented in PFMv97 (which was not audited on its own).

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- o PFMv96_PXX_YY vs PFMv98_PXX_YY (this was added to follow the changes based on the last version of the model we audited)

- o PFMv97_PXX_YY vs PFMv98_PXX_YY

Audit Results

Most of the updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. However, there were file changes that were not included in the change log including those that were related to running the assignment. We did not review these as part of the audit, but these will be reviewed again when we do the model replication in PFMv10.

Update: These have been reviewed and included as part of the model replication in PFMv10.

18. PFMv9.9a

Description of the Model Updates

The update to this version is the inclusion of the December 2020 Demand Driver Generators (DDGs).

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- o PFMv98_PXX_YY vs PFMv99a_PXX_YY

Audit Results

All the updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers.

It was later noted that an updated version of PFMv99a (February 2021 version) was run by the model developers. This included rerunning of 2041 and 2051 matrices and updates to the files in *PfMv99a_PXX_YY\HS2\Inputs\PhaseSpecificInputs\02_Year\Demand\2041 & 2051*.

These changes were confirmed during the PFMv99b audit.

19. PFMv9.9b

Description of the Model Updates

This version includes updates to the TAG Databook February 2021 internal update.

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- o PFMv99a_PXX_YY (January 2021 version) vs PFMv99b_PXX_YY

Audit Results

Most of the updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. However, there were files in the change log that were listed in different folder locations. These are related to the typo error in the change log and have been confirmed with the model developers. In addition, during the audit we were made aware that a newer version of PFMv99a was run (February 2021 version). The input files for 2041 and 2051 demand were updated as part of this February version and therefore no change was found in these files between PFMv99a and PFMv99b.

20. PFMv9.9c

Description of the Model Updates

This version includes new parameters from the recalibration demand work.

Audit Process

The audit process consisted of comparison between the following PFM model versions.

- o   PFMv99b_PXX_YY vs PFMv99c_PXX_YY

Audit Results

Most of the updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. However, the *voc.mac* file under the folder *PfMv99c_PXX_YY\HS2\01PLD\Macros\Assign* was not included in the list of changes but is expected to change. This has been confirmed with the model developers.

21. PFMv10

Description of the Model Updates

This version includes further updates from the recalibration demand work. In addition, this incorporates updates to values of time, new phase s3i and s4i, revised HS2 journey times and operating costs.

Audit Process

The audit process consisted of comparison between the following PFM model versions and full model run for PFMv10_DN_29, PFMv10_DM_29 and PFMv10_S3_29.

- o   PFMv99c_PXX_YY vs PFMv10_PXX_YY

Audit Results

Most of the updates found during the audit have been confirmed to be consistent with the list of changes provided by the model developers. However, there were changes that were not included in the note but are expected to change as part of the update. These were confirmed by the model developers.

Full model run for PFMv10_DN_29, PFMv10_DM_29 and PFMv10_S3_29 have been successfully replicated with no errors identified. The comparison of standard outputs summarized in the tables above show minor differences in values (decimal points) but identical convergence outputs. This is expected from running on different machines but as previously agreed, the convergence is identical therefore the replication is acceptable.

22. PFMv10a

Description of the Model Updates

This version includes updates to Values of Time (VoT).

Audit Process

The audit process consisted of comparison between the following PFM model versions and full model run for PFMv10a_DN_29, PFMv10a_DM_29 and PFMv10a_S3_29.

- o PFMv10_PXX_YY vs PFMv10a_RefCase_PXX_YY

Audit Results

All updates found during the audit have been confirmed to be consistent with the changes described by the model developers.

Full model run for PFMv10a_DN_29, PFMv10a_DM_29 and PFMv10a_S3_29 have been successfully replicated with no errors identified. The comparison of standard outputs summarized in the tables above show minor differences in values (decimal points) but identical convergence outputs.

Filename: HS2_PFMv10a_Audit_Letter_v5_final.docx

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 undertaking 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 PFMv10a correctly reflect the documented methodology. During our audit, we noted some specific issues which are detailed in this letter. These issues have already been addressed and we do not judge any of these to have a material impact on the results of PFMv10a. The rail fares calculation which was based on the previous methodology needs a wider review and discussion between HS2 Ltd and model developers post PFMv10a. We do not judge the comments raised in the audit to have a material impact.

Yours sincerely

Hermann Maier

Senior Associate Director
Hermann.Maier@Jacobs.com