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Audit of the development of PLANET Framework Model version 9

Dear Jack,

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 9 (v9).

The aim of the audit was to provide independent verification to HS2 Ltd that the model processes and inputs of PFMv9 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 PFMv9 correctly reflect the documented methodology. During our audit, we noted some specific issues which are detailed in this letter. We do not judge any of these to have a material impact on the results of PFMv9.

During the replication runs for PFMv9, which used the same inputs and model versions as the model developers, some minor inconsistencies were found in the initial runs undertaken by Jacobs. These were subsequently found to relate to the specific set-up of the modelling machine used by Jacobs. Therefore, while we have confidence that the model runs set up by the model developers can be replicated, some caution is advisable when running PFMv9 in a different IT environment from that used originally.

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 from 2014 to 2019 and provided individual sign-off letters for these.

The subject of this letter is the audit of model development resulting in PFMv9 which builds on the previous release version of PFM version 7.1 (v7.1) 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 v7.1 to v9 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 PFMv9 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 v7.1 and v9 are described in 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.

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

Summary of Model Updates

The focus of the updates in v9 was split into two parts:

Updated for PFMv7.1 to PFMv8:

- Updated highway demand matrices;
- April 2018 Demand Driver Generators (DDGs);
- WebTAG updates;
- Conventional rail and HS2 TSS updates; and
- Enhanced standard outputs templates.

Updated for PFMv8 to PFMv9:

- New reliability methodology;
- Further train service specification (TSS) updates; and
- New PFM core model, which incorporates a new file structure of the model has been implemented in this version.

In particular, the changes described in the table below were implemented.

Model version	Model Update Change	Corresponding Section(s)
PFMv7.2	Update to the Appraisal Spreadsheet to allow any cap year to be set beyond the final forecast year.	1. PFMv7.2: Updated Appraisal Spreadsheet
PFMv7.3	Implementation of Do Minimum Demand Response only for PLD. This process allows the PFM to respond to changes in costs between the base year and forecast modelled years. It also results in a well converged Do Minimum scenario.	2. PFMv7.3: Do Minimum Demand Response for PLD 3. PFMv7.3: Line-line transfer outputs and the HS/Conventional demand updates 4. PFMv7.3: Standard Model output updates
PFMv7.4	Implementation of Do Minimum Demand Response extended to regional models. Same updates to PFMv7.3 but extending it to regional models.	5. PFMv7.4: Do Minimum Demand Response extended to regional models 6. PFMv7.4: HS PN Vehicle Capacity Correction
PFMv7.5	PFMv7.5 is the converted version of PFMv7.4 to EMMEv4.3.3 and has incorporated enhanced standard outputs updates.	7. PFMv7.5: Update to EMME 4.3.3 8. PFMv7.5: Yellow and Orange Checks Templates 9. PFMv7.5: HS2Select.mac update 10. PFMv7.5: Sector Benefits 3 Appraisal Updates 11. PFMv7.5: Preloads VBA Simplification 12. PFMv7.5: HS2 Model Splitting Services

PFMv7.6	Incorporates a range of smaller model updates: Standard Outputs updates, addition of Regional OD and Sectoral Benefits Outputs, Preload VBA simplification, update of rail network distances and minor coding corrections.	13. PFMv7.6: Model Preparation 14. PFMv7.6: Economic Appraisal Updates 15. PFMv7.6: Standard Model output updates 16. PFMv7.6: WebTAG Updates 17. PFMv7.6: DfT VBA Standards Updates
PFMv7.7a	Improves the pivoting process built from the previous version. PFMv7.7 was converted to PFM7.7a to include changes to standard outputs template that crashes during the pivot run.	18. PFM7.7a: Standard Model Run Audit 19. PFM7.7a: Pivot Tests Audit (PFMv77a_DN_37_UNRUN) 20. PFMv7.7a: Pivot Tests Audit (PFMv77a_DM_37_UNRUN_PIVOT) 21. PFMv7.7a: Pivot Tests Audit (PFMv77a_P2b_37_UNRUN_PIVOT)
PFMv7.8	Embeds pivot proofed further outputs and applies split service methodology. This enables Do Minimum outputs to be sourced from the "Pivot" databanks imported to the Step 3 model from a converged Step 2 (converged Do Minimum) model run. The batch files, macros and other outputs were updated to implement the new processes	22. PFMv7.8: Pivot Proofing Outputs Audit 23. PFMv7.8: Economic Appraisal Spreadsheet Audit
PFMv7.9	This version of PFM incorporates Highway Demand matrices update & rebuild. New base year matrices were built using Highways England five regional highway models.	24. PFMv7.9: Highway Demand Matrices Rebuild Card123 Audit 25. PFMv7.9: Highway Demand Matrices Rebuild Card 4 Audit 26. PFMv7.9: Highway Demand Matrices Rebuild Card 5 Audit 27. PFMv7.9: Standard Model Test Audit
PFMv7.10	This version includes initial DDG updates and expanding the model to three forecast years with the addition of 2048.	28 PFMv7.10: Standard Model Test Audit

PFMv7.10a	Includes April 2018 DDGs updates following more recent information and economic forecasts and modifications in the standard output spreadsheet, batch files and macros to ensure that these works properly when used with splitting services.	29. PFMv7.10a: Audit of EDGE Inputs Spreadsheet – PDFHv6 30. PFMv7.10a: Standard Outputs and Splitting Services Audit 31. PFMv7.10a: Update of Dataset C for Splitting Services. 32. PFMv7.10a: Economic Appraisal Spreadsheet Update WebTAG 33. PFMv7.10a: Standard Model Test Audit 34. PFMv7.10a: Pivot Model Test Audit 35. PFMv7.10a Demand Forecast Review
PFMv7.11	Includes WebTAG updates, SCM catchment and PFM consistency review.	36. PFMv7.11: Standard Model Test Audit
PFMv7.12	Includes conventional rail and HS2 TSS updates. This includes updates to Do Minimum and Do Something coding, splitting services and addition of HS Eastern leg coding in Planet North.	37. PFMv7.12: Standard Model Test Audit
PFMv8	Red check version of PFMv8.	38. PFMv8 Standard Model Test Audit 39. PFMv8 Pivot Tests Audit DN 40. PFMv8 Pivot Tests Audit DM 41. PFMv8 Pivot Tests Audit DS
PFMv8.1	EMME macros updated to produce outputs from PFMv8 for use in GIS.	42. PFMv8.1: Update of Output Files for GIS
PFMv8.1	The Standard Outputs Template Time of Day inputs updated to include the additional scenario Phase 1a.	43. PFMv8.1: Standard Outputs Template Update – Time of Day
PFMv8.1	The batch file procedure to produce the list of transit lines on base network and used to compare the Do Minimum and Do Something files and other parameters (transit lines, vehicles per hour, capacity).	44. PFMv8.1: Prestore Checks

PFMv8.1	The reliability ratios of long-distance rail services using Network Rail's PEARS database have been analysed. Delay minutes caused by each Train Operating Company (TOC) or by Network Rail are recorded for each Service Flow in PEARS. The reliability ratio is used as an input to the PFM and is calculated as total delays per operator divided by train kilometres.	45. PFMv8.1: PEARS Data Analysis
PFMv8.1	A pivot model set has been developed to address all previously identified items for improvements from PFMv8 of the model except HS2 TSS and East Coast TSS.	46. PFMv8.1: Pivot Tests
PFMv8.3	The development of a new PFM "core" model which then will become the building block upon which further model development will take place.	47. PFMv8.3: File Consistency Review
PFMv8.4	The reliability and performance demand model updates to allow the modelling of new guidance on demand uplifts due to change in reliability.	48. PFMv8.4: Reliability and Performance Demand Update
PFMv8.4	The PFMv8 TOC-TOC update to include the regional models in outputs and to also produce outputs for the Do-Minimum scenario.	49. PFMv8.4: TOC-TOC Transfer Enhancements
PFMv8.4	Additional updates on the TOC-TOC outputs as a standalone process.	50. PFMv8.4: TOC-TOC Transfer Enhancements Standalone Process
PFMv8.4	The Prestore Checks updates to include additional checks at the start of the model run reducing input driven errors in the model runs.	51. PFMv8.4: Prestore Checks - Final Card
PFMv8.4	May 2019 WebTAG databook metrics, new forecast years and demand and minor TSS corrections.	52. PFMv8.4: Model Audit
PFMv8.5	Updates to the Reliability Methodology	53. PFMv8.5: Model Audit
PFMv9	TSS updates	54. PFMv9: Model Audit
PFMv9	Forecast Year 2049	55. PFMv9: 2049 Audit
PFMv9	6 Trains Per Hour Scenario	56. PFMv9: 6tph Audit

Model Audit details

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

1. PFMv7.2: Updated Appraisal Spreadsheet

Description of the Model Updates

Updated appraisal spreadsheet (v7.2) to allow any cap year to be set beyond the final forecast year.

Audit Process

The updated appraisal spreadsheet has been compared against the previous version (v7.1) supplied as part of the PFMv7.1 audit. A brief overall comparison has been made but only detailed checks have been carried out where SYSTRA noted changes had been made. These changes were:

- "RunInputs" – a new drop-down box to enable the user to set the cap year;
- "OtherAssumptions" – updates to the rows that calculate factors (185:186); and
- Updates to the macros to deal with different cell references on the "RunInputs" sheet.

The above changes were checked and confirmed to be correct. It should be noted that as part of this audit some checks were carried out on formulas and cell highlighting. Generally, throughout the input sheets yellow cells are input cells. This is not always consistent. Best practice would be to have a consistent highlighting of cells throughout the spreadsheet.

Following the initial audit these points were highlighted and communicated to the model developers.

Audit Results

The Appraisal Spreadsheet has been updated as expected and is able to execute calculations accurately. There are some minor housekeeping issues but nothing that impacts the workings of the spreadsheet.

2. PFMv7.3: Do Minimum Demand Response for PLD

Description of the Model Updates

Updated batch files and macros for the implementation of Do Minimum Response for PLANET long Distance (PLD). This update was undertaken to improve model convergence and demand responses within the model framework.

Audit Process

The updated model files (.mac and .bat files) have been compared against PFMv71_Y37_UNRUN and reviewed against the table of changes provided by the model developers.

The Run_Tests.bat file has been tested for each switch combination, in order to verify that the user is prompted with the correct message. All checks have run correctly and correspond with the expected response.

Audit Results

The changes to input files defined by the model developers have been confirmed to be correct and as expected. The model stress test behaved correctly in all instances and results for each test run were verified against the model developer results.

3. PFMv7.3: Line-line transfer outputs and the HS/Conventional demand updates

Description of the Model Updates

Updated batch files, macros and spreadsheets for changes to line-line transfer outputs and the HS/Conventional demand updates. The aim of this update is to implement the line-line transfer process and reduce the negative classic rail values in the sector-sector sheets of the standard output spreadsheet. This was previously inconsistent with the HS demand, produced at a station zone level, while total rail sector demand was produced in PLD zoning.

Audit Process

The updated model files (.mac and .bat files) have been compared against PFMv71_Y37_UNRUN and reviewed against the comments provided by the model developers.

Audit Results

The updates found in each file appear in line with comments from the model developers, however there hasn't been sufficient commentary to highlight these changes, information such as author, date and description of updates is not given. This is important when tracking progression of file updates. Each of the model processes will also need testing to confirm outputs are produced as expected.

A new version of the line-line transfer tool has been created in the PFMv8 version of the model providing more description and commentaries. These have been tested and the outputs are produced as expected.

4. PFMv7.3: 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 two stages:

a) Model Outputs Correcting Known Issues Card 1
b) Model Outputs Correcting Known Issues Card 2

Audit Process

The audit process consisted of a comparison between PFMv71_Y37 and Line to Line Transfer updates and review of HS/Conventional Demand Calculations.

The model run process has not been tested as part of this audit, due to software changes by INRO. Emme 4.3.2 has been superseded by version 4.3.3. The new files were tested as part of PFMv7.5.

Audit Results

All the changes were consistent with the model developers' comments, with the exception of the variable change in Standard_Out_Template.xlsm. This was found to have no impact on the VBA script or have any impact of the model processes or results.

5. PFMv7.4: Do Minimum Demand Response extended to regional models

Description of the Model Updates

Updated and added batch files, input files, macros and standard outputs files to improve the model convergence and demand response within the model framework.

Audit Process

This audited process consisted of a comparison between the folders PFMv73_Y37_UNRUN and PFMv74_Y37_UNRUN.

Audit Results

Most of the updates were clearly outlined by the model developer, but some minor ones were only discovered through comparing files in this stage of the audit process. These are renamed files which are necessary when updating PFM model versions and do not have any impact on the model processes and results.

6. PFMv7.4: HS PN Vehicle Capacity Correction

Description of the Model Updates

Incremental updates to PFMv7.1 which examines the changes applied as part of HS PN Vehicle Capacity Correction.

Audit Process

This audit process consisted of a folder comparison between PFMv71_PN and Y PN Transit Lines.

Audit Results

No issues have been identified. The findings are consistent with the comments we received from the model developers and were the only alteration between the files.

7. PFMv7.5: Update to EMME 4.3.3

Description of the Model Updates

PFMv75_Y37_UNRUN is the converted version of PFMv74_Y37_UNRUN to EMME4.3.3 and has incorporated new standard outputs updates and corrections.

Audit Process

This audited process consisted of a comparison between the folders PFMv74_Y37_UNRUN and PFMv75_Y37_UNRUN. Files relating to the Base Year model were received alongside with the forecast model. However, we have not done the Base year model comparison as part of this work but the changes will be noted when a new base model is produced.

Audit Results

Most of the updates were clearly outlined by the model developer, however, some minor ones were only discovered through comparing files in this stage of the audit process. These are renamed files which are necessary when updating PFM model versions and do not have any impacts on the model processes and results.

8. PFMv7.5: Yellow and Orange Checks Templates

Description of Model Updates

Updated Yellow and Orange Checks templates to incorporate more checks of results.

Audit Process

The audit process consisted of a comparison between the updated files and its previous versions. A high-level review was also undertaken to check the validity of the checks and whether anything else could be included.

Audit Results

Most of the updates were clearly outlined by the model developer however, some minor ones were only discovered during the audit process. These changes were related to the organization of the spreadsheet and additional key indicators.

Following the high-level review both checks are detailed and thorough enough to give a good highlight of what has changed. Adding Seated KM could provide some additional benefit.

9. PFMv7.5: HS2Select.mac update

Description of Model Updates

Updated EMME model macro named HS2Select.mac. The updates were done to enable the select link assignment to be done using existing strategy file rather than doing an assignment for each cordon link.

Audit Process

The audit process consisted of a comparison between the above file from PFMv75_Y37 and the previous versions from PFMv74_Y37, PFMv73_Y37, PFMv72_Y37, PFMv71_Y37, PFMv69_Y37, PFMv67_Y37 and PFMv63_Y37.

The files from PFMv67_Y37 to PFMv74_37 are identical; hence, comparisons are done for PFMv74_Y37 and PFMv63_Y37.

Audit Results

All the changes to the macro file defined by the model developers have been confirmed to be correct and as expected.

10. PFMv7.5: Sector Benefits 3 Appraisal Updates

Description of the Model Updates

Updated Sector Benefits 3 (SB3) Appraisal, which involves two additional templates to calculate total Sector/Origin-Destination (Sec/OD) benefits across all four PFM models (PLD, PM, PN and PS) and taking the existing regional Sec/OD benefits developed for the Distributional Analysis and embedding them within the model structure as Standard Outputs.

Audit Process

This audited process consisted of a comparison between the updated files from folders PFMv75_Y37_UNRUN and PFMv71_Y37_UNRUN.

Audit Results

All the changes to the files defined by the model developers have been confirmed to be correct and as expected.

11. PFMv7.5: Preloads VBA Simplification

Description of the Model Updates

Updated preload VBA codes and making it all consistent in all preload spreadsheets.

Audit Process

This audited process consisted of a comparison between the updated files from folder PFMv75 phases D, C and Y and its original version.

Audit Results

All the changes to the files defined by the model developers have been confirmed to be correct and as expected. The VBA codes in the Preload Spreadsheets were also checked against the latest DfT VBA Coding Standards. All the code follows the guidelines except for line continuation. This is noted and should be updated when the next version of the model is created but has no impact on the results.

12. PFMv7.5: HS2 Model Splitting Services

Description of the Model Updates

Updates to the model input files to reflect a new approach to the modelling of the HS2 splitting services through the use of dummy nodes at the split intersections.

Audit Process

The files provided to the Auditors were compared against their respective previous versions in the folder PFMv75_Y37_UNRUN.

Audit Results

Most of the changes observed are consistent with the provided changes documentation - 20171018_HS2_Revised_HS_Split_Service_Coding_FINAL_with_Appraisal, with the following exceptions:

- Changes to HS2Select.mac;
- Changes to the model link (_lin.in) files;
- Changes to the model node (_net.in) files;
- Changes to the Preload spreadsheets,

for files contained in both folders Crewe_Hub_Test_SC6_Updated_Files and SPLIT3_Updated_Files. Unlike the other text files provided, updates to these files were not explicitly referred to in the changes documentation but the nature of the changes is similar to that observed across the other macros.

The Splitting services were checked again in PFMv7.10a which included them in a main model run. No issues were found.

13. PFMv7.6: Model Preparation

Description of the Model Updates

This is the first step in the development of PFMv7.6 and aims to gather and incorporate updates to the model files that have already been developed.

Audit Process

This audited process consisted of a comparison between the updated files from folder PFMv76 phases D, C and Y and its previous version PFMv75.

Audit Results

All the changes to the files defined by the model developers have been confirmed to be correct and as expected

14. PFMv7.6: Economic Appraisal Updates

Description of the Model Updates

Updated economic appraisal spreadsheet template.

Audit Process

The audit process consisted of a comparison between the updated file and its previous version.

Audit Results

Most of the updates were clearly outlined by the model developer, however, one minor change was only discovered through comparing files in this stage of the audit process. This was rows inserted in YrBreakdown sheets for 'REVENUE GROWTH INDEX (REAL) - NO FARE Cap' which has no impact on the model process or results.

15. PFMv7.6: 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 several stages:

a) Orange Checks Template Update - Card 2
b) Line to Line Comparison Tool
c) Model Outputs: Correcting Known Issues – Card 4
d) Model Outputs– Card 7 Rationalise Coding

Audit Process

This audited process consisted of a comparison between the original and updated files.

Audit Results

Orange Checks Template Update – Most of the updates were stated in the changelog, however, some minor ones were only discovered through comparing files in the audit process. One change was related to a change already being incorporated in the old version of the file. The others were changes in the text values and headings of the tables and do not impact the model processes or results.

Line to Line Comparison Tool - A rerun was done using the tool for both line transfer files and an identical output as to what the model developer provided was produced. Hence, the comparison tool and output defined by the model developers have been confirmed to be correct.

Model Outputs: Correcting Known Issues – Card 4 – Some of the updates were clearly outlined by the model developer, however, some minor ones were only discovered through comparing files in the audit process. These changes relate to text changes, row updates related to expected

station name updates and path reference corrections. None of these have an impact of the model process or results.

Mode Outputs -Card 7 Rationalise Coding - Most of the updates were clearly outlined by the model developer except for the three updates to the 2014_Base.bat file. These are updates on the main folder name, introduction of demand response option (set as OFF) and calling of Outputs_TA_Comm_base.bat file. The changes do not have any impact on the model results.

16. PFMv7.6: WebTAG Updates

Description of the Model Updates

Updated model files to incorporate the DfT's latest WebTAG data book (July 2017). These updates have been assigned to PFMv7.1 model version to assess the impact before incorporating it to PFMv7.6. These are then compared to the original version of PFMv7.1.

Audit Process

This audited process consisted of a comparison between the original and updated files.

Audit Results

Most of the updates were stated in the changelog, however, some minor ones were only discovered through comparing files in the audit process. The majority of these changes refer to expected changes in line with the WebTAG updates and changes to 2037 forecast year which were not included in the changelog. These changes have been confirmed by the model developer as expected to change.

17. PFMv7.6: DfT VBA Standards Updates

Description of the Model Updates

Reviewed and updated VBA codes in the standard output spreadsheets and making it consistent with DfT standards.

Audit Process

The audit consisted of two parts: (1) a comparison of the updated files with their previous versions; and (2) an assessment of any updated VBA coding against the DfT VBA Coding Standards.

Audit Results

A number of changes were observed across the provided model files. In most cases, the changes were only to the VBA coding (which was assessed in the second part of the audit), and the updating of Filepaths and input/output file names.

In general, the updated VBA coding is compliant with the DfT VBA Coding Standards. Two areas that the Model Developer could consider reviewing are the additional use of line continuation

and more in-line comments for greater code usability. Although these have no impact on results.

18. PFMv7.7a: Standard Model Run Audit

Description of the Model Updates

Updated the model and standard output files to improve the pivoting process built from previous version.

Audit Process

This audited process consisted of a comparison between PFMv7.7a and PFMv7.6 for all model phases. A full model run using PFMv7.7a_P2b_27 version of the model has also been replicated.

Audit Results

The updates found in each of the model phases have been confirmed to be consistent with list of changes provided by the model developers. A full model run for the standard test have been successfully replicated with no errors identified. In line with this, updates on the VBA codes have been confirmed to be working. The HS2 model splitting services that was tested previously was not incorporated in this version of the model.

19. PFMv7.7a: Pivot Tests Audit (PFMv77a_DN_37_UNRUN)

Description of the Model Updates

Pivoting has been implemented to address issues with regard to poor convergence, demand response due to crowding and scheme coding in the Do Minimum. Pivoting allows the model to pivot from the output of another model. This audit focuses on the Do Nothing scenario with future year costs and run through to convergence (PFMv77a_DN_37_UNRUN).

Audit Process

This audited process consisted of full model run and standard outputs comparison against the ones provided by the model developers. Manual comparison of the files was not included in this audit as this was already done in the standard model test.

Audit Results

A full model run has been successfully replicated with no errors identified. The minor differences (decimal points) observed in some of the standard outputs are considered acceptable since convergence outputs are identical.

20. PFMv7.7a: Pivot Tests Audit (PFMv77a_DM_37_UNRUN_PIVOT)

Description of the Model Updates

Pivoting has been implemented to address issues with regard to poor convergence, demand response due to crowding and scheme coding in the Do Minimum. Pivoting allows the model to pivot from the output of another model. This audit focuses on the Do Minimum converged demand response (PFMv77a_DM_37_UNRUN_PIVOT).

Audit Process

This audited process consisted of full model run and standard outputs comparison against the ones provided by the model developers. Manual comparison of the files was not included in this audit as this was already done in the standard model test.

Audit Results

A full model run has been successfully replicated with no errors identified. The minor differences (decimal points) observed in some of the standard outputs are considered acceptable since convergence outputs are identical.

21. PFMv7.7a: Pivot Tests Audit (PFMv77a_P2b_37_UNRUN_PIVOT)

Description of the Model Updates

Pivoting has been implemented to address issues with regard to poor convergence, demand response due to crowding and scheme coding in the Do Minimum. Pivoting allows the model to pivot from the output of another model. This audit focuses on the converged Do Something (PFMv77a_P2b_37_UNRUN_PIVOT) pivoted from the costs and demand in the converged Do Minimum run.

Audit Process

This audited process consisted of full model run and standard outputs comparison against the ones provided by the model developers. Manual comparison of the files was not included in this audit as this was already done in the standard model test.

Audit Results

A full model run has been successfully replicated with no errors identified. The minor differences (decimal points) observed in some of the standard outputs are considered acceptable since convergence outputs are identical.

22. PFMv7.8: Pivot Proofing Outputs

Description of the Model Updates

Updated the new pivoting standard output processes. This enables Do Minimum outputs to be sourced from the “Pivot” databanks imported to the Step 3 model from a converged Step 2 (converged Do Minimum) model run

Audit Process

This audited process consisted of comparison of the updated batch files and macros and their previous version in PFMv77a_P2b_37_RUN_PIVOT_CD.

Audit Results

The updates found in each of the files have been confirmed to be consistent with the updated standard output processes provided by the model developers. However, it is noted that there hasn't been sufficient commentary in some of the newly added files to highlight changes on the information such as author, date and description of updates. This information is important when tracking progression of the file updates but does not impact the running of the model.

23. PFMv7.8: Expand Economic Appraisal Template

Description of the Model Updates

A new version of the economic appraisal spreadsheet has been updated to expand the template to six phases to accommodate any future phases testing.

Audit Process

The audit process consisted of a comparison between the files Economic_Appraisal_Spreadsheet_v761_Template_-_FINAL_-_QES.xlsm and Economic Appraisal Spreadsheet v762 Template - QES.xlsm.

Audit Results

The comparison concludes that the changes made to the spreadsheet were entirely consistent with comments made by the developer with regards to changes made to individual sheets.

24. PFMv7.9: Audit of Highway Matrices Rebuild using SQL – Cards 1, 2 and 3

Description of the Model Updates

New base year highway matrices were built using Highways England five regional highway models using procedures set up in Microsoft SQL Server (SQL).

Audit Process

The main part of the audit of the Highway Rebuild Matrices SQL database was reviewed by the Jacobs auditor in attendance of the Systra model developers. In addition, checks of the matrix totals were carried out and compared to those provided by the model developers.

Audit Results

The auditor determines the Systra model developers were able to demonstrate the proposed methodology for Highway Demand Matrices development was successfully implemented in SQL. The additional processes were added as expected with the matrix totals as per an email from the Model Developers.

Detailed documentation of this was subsequently produced by the model developers. This has checked and review to ensure enough detail of the processes and changes were documented.

25. PFMv7.9: Audit of Highway Matrices Rebuild Card 4

Description of the Model Updates

Updates to the network links, nodes and preloads in relation to the highway demand matrices rebuild.

Audit Process

The audit process consisted of a comparison between the files in PFMv6_Base14_v17f that correspond to the files provided in Highway network update_audit03052018.

Audit Results

While most of the observed differences on files are consistent with the updates noted by the model developers, two network links have been removed and were not noted. Model developers confirmed that these links are expected to be removed and included in the updates.

26. PFMv7.9: Audit of Highway Matrices Rebuild Card 5

Description of the Model Updates

Updated the future year matrices in relation to the highway demand matrices rebuild.

Audit Process

The audit process consisted of a comparison between the updated matrices (mf21, mf22 and mf23) and their previous versions from PFMv7.7a.

Audit Results

While most of the updates on the matrices are consistent with the documentation provided by the model developers, the figures for the new 2026 matrix for commute have been found to be inconsistent. The model developers confirmed that the figures in the actual matrices which were sent to the auditors are correct. The figures in the documentation have been updated to reflect this.

27. PFMv7.9: Standard Model Test Audit

Description of the Model Updates

Updated the model and standard output files to incorporate the changes in the highway demand matrices.

Audit Process

This audited process consisted of a comparison between the following pairs of folders:

- PFMv79_P1_26_UNRUN and PFMv77a_P1_26_UNRUN
- PFMv79_P1_37_UNRUN and PFMv77a_P1_37_UNRUN

- PFMv79_P2a_26_UNRUN and PFMv77a_P2a_26_UNRUN_C
- PFMv79_P2a_37_UNRUN and PFMv77a_P2a _37_UNRUN_C

- PFMv79_P2b_26_UNRUN and PFMv77a_P2b _26_UNRUN_Y
- PFMv79_P2b_26_UNRUN and PFMv77a_P2b_37_UNRUN_Y

Audit Results

Most of the updates found in each of the six folders have been confirmed to be consistent with list of changes provided by the model developers. However, there were a number of files highlighted in this audit that were not included in the list of changes. The model developers confirmed that these are working files and will not impact the model run. We recommend for these files to be reviewed, whether these are needed or can be removed in the PFM model structure. Subsequent model versions have also contained these working files and model replication has been successful, confirming that they do not impact the model run.

28. PFMv7.10: Standard Model Test Audit

Description of the Model Updates

Review of PFMv7.10 model set. This incorporates the correction to the Northampton-Rugby inputs to Transfer.exe.

Audit Process

This audited process consisted of a comparison between PFMv7.9 and PFMv7.10 and a model replication run of PFMv7.10_P2b_38.

Audit Results

The updates found in each of the nine folders have been confirmed to be consistent with the list of changes provided by the model developers. Full model run for the standard test have been successfully replicated with no errors identified. It is also worth noting that PFMv7.9 does not have the equivalent of the 2048 model sets in PFMv7.10, these files were compared against the 2037 model sets in PFMv7.9.

Furthermore, a few observations were noted that may need updating in the future versions of the model because it causes the model run to crash.

- All standard output templates were saved with the calculation options set to manual. This doesn't allow the file directories to be updated automatically.
- HS2_select_line_sector_matrix_conversion.xlsm – File reference was copied as values. It will be good to set a macro that sets the directory automatically.

29. PFMv7.10a: Audit of EDGE Inputs Spreadsheet – PDFHv6

Description of the Model Updates

Updated the EDGE inputs spreadsheet, which translates elasticities from PDFH v6 into detailed inputs to EDGE.

Audit Process

This audited process consisted of reviewing the computed EDGE inputs for the relevant worksheets in the spreadsheet.

Audit Results

The values in the spreadsheet are mostly as expected. A few comments were made during the audit about differences from what PDFH recommended. These were confirmed by the model developer to be as expected, as they had followed DfT's approach/recommendations. Therefore, we can confirm that the correct values and approach has been implemented.

30. PFMv7.10a: Standard Outputs and Splitting Services Audit

Description of the Model Updates

Updated the standard output and time of day analysis files. These include modifications in the standard output spreadsheet, batch files and macros to ensure that these works properly when used with splitting services.

Audit Process

This audited process consisted process consisted of a comparison between the folders PFM77a_P2b_37_UNRUN and Splitting services updates to standard outputs to auditors.

Audit Results

The comparison concludes that the changes made to all the files were entirely consistent with comments made by the model developers.

31. PFMv7.10a: Update of Dataset C for Splitting Services

Description of the Model Updates

The updates include the procedure to copy station to station outputs to the dataset C for splitting services folder. Macros have been rationalised to incorporate these changes.

Audit Process

This audited process consisted of a comparison between the files provided by the model developer and their previous versions from the PFMv7.8: Pivot Proofing Outputs audit.

Audit Results

The updates found in each of the macros have been confirmed to be consistent with the description provided by the model developers.

32. PFMv7.10a: Economic Appraisal Spreadsheet Update WebTAG

Description of the Model Updates

Review of economic appraisal spreadsheet versions 762 and 761 in relation to WebTAG parameter updates.

Audit Process

This audited process consisted of a comparison between economic appraisal spreadsheet versions 762 and 761.

Audit Results

Most of the updates found in the folder have been confirmed to be consistent with list of changes provided by the model developers. For the other updates highlighted in this audit, the changes observed are related to the general updates in the spreadsheet, hence, expected to be in this version of the file.

33. PFMv7.10a: Standard Model Test Audit

Description of the Model Updates

Review of PFMv7.10a model set. This incorporates the correction to the Northampton-Rugby inputs to Transfer.exe.

Audit Process

This audited process consisted of a comparison between PFMv7.10 and PFMv7.10a and a model replication run of PFMv7.10a_P2b_38.

Audit Results

The updates found in each of the nine folders have been confirmed to be consistent with the list of changes provided by the model developers. Full model run for the standard test have been successfully replicated with no errors identified.

Furthermore, a few observations were noted that may need updating in the future versions of the model because it causes the model run to crash.

- All standard output templates were saved with the calculation options set to manual. This doesn't allow the file directories to be updated automatically.
- HS2_select_line_sector_matrix_conversion.xlsm – File reference was copied as values. It will be good to set a macro that sets the directory automatically.

34. PFMv7.10a: Pivot Model Test Audit

Description of the Model Updates

Review of PFMv7.10a pivot model set. Pivoting has been implemented to address issues with regard to poor convergence, demand response due to crowding and scheme coding in the Do Minimum. Pivoting allows the model to pivot from the output of another model.

Audit Process

This audited process consisted of two parts, the first one was the review of inputs files for each of the three steps in setting up the pivot tests and the second was a full model replication run using PFMv7.10a_P2b_38_PIVOT_CD.

Audit Results

Most of the parameters set up for the pivot tests were consistent to the guidance note. For the other highlighted changes, the model developers confirmed that these are expected in this version of the model. However, we recommend that these should be reviewed and referenced in the pivot test guidance note for consistency.

A full model run for the pivot test PFMv7.10a_P2b_38_PIVOT_CD has been successfully replicated with no errors identified.

Furthermore, a few observations were noted that may need updating in the future versions of the model because it causes the model run to crash. The model developers confirmed to update the release note to incorporate these in the guidelines when running the model

- All standard output templates were saved with the calculation options set to manual. This doesn't allow the file directories to be updated automatically.
- HS2_select_line_sector_matrix_conversion.xlsm – File reference was copied as values. It will be good to set a macro that sets the directory automatically.

35. PFMv7.10a: Demand Forecast Review

Description of the Model Updates

The main objective of this task is to review the growth factors used in the demand forecasting process.

Audit Process

The audit process consisted of manual calculation of the forecast demand for PLANET Long Distance (PLD) for model year 2038, Phase 2b based on the following steps.

a. Identified key travel movements to be used for checking the growth factors.
b. Summarized the 2014/15 base demand per journey purpose for each of the key travel movements.
c. Applied the global factor (1.069) from the ORR website to convert the 2014/15 base demand to 2016/17.

d. Applied the growth factors from EDGE to forecast year 2038.
e. Adjusted the proportions of Car Available to Non Car Available based on change in car availability from the Car Availability DDG from DfT.
f. Compared the 2038 forecast demand to the ones provided by the model developers.

Audit Results

The EDGE and car available to non-car available factors used in calculating the demand forecasts were provided by the model developers and not included as part of this audit. The origin-destination pairs used for this audit were found to be representatives of key travel movements in the model.

The comparison shows that the growth factors used in the demand forecasting process have been applied as expected based on the documentation provided by the model developers.

36. PFMv7.11: Standard Model Test Audit

Description of the Model Updates

Review of PFMv7.11 standard model set. This incorporates updates on WebTAG, station choice model, air demand and standard output templates.

Audit Process

The audit process consisted of two parts. First is the model comparison where we checked each of the model files and compared it against its previous version. The second part is the model replication where we created a run version of the model and compared the standard outputs provided by model developers.

Audit Results

Most of the updates found in each of the nine models have been confirmed to be consistent with the list of changes provided by the model developers. For the other updates highlighted in this audit, the model developers confirmed that these are expected in this version of the model.

Full model run for the standard test have been successfully replicated with no errors identified.

Furthermore, a few observations were noted that may need updating in the future versions of the model because it causes the model run to crash.

- All standard output templates were saved with the calculation options set to manual. This doesn't allow the file directories to be updated automatically.
- HS2_select_line_sector_matrix_conversion.xlsm – File reference was copied as values. It will be good to set a macro that sets the directory automatically.

37. PFMv7.12: Standard Model Test Audit

Description of the Model Updates

Review of PFMv7.12 standard model set. The changes to this model include updates to conventional rail and HS2 TSS.

Audit Process

The audit process consisted of a comparison between PFMv7.11 and PFMv7.12.

Audit Results

All updates noted by the model developers were found during the audit. However, a number of files related to EMME, old legacy files and issue with the prebuild check run were not included in the list of changes provided. The model developers confirmed that they are aware about these files, they do not impact the model results and will be amended in PFMv8.

38. PFMv8: Standard Model Test Audit

Description of the Model Updates

Review of PFMv8 standard model set. The changes to this model include updates to highway demand matrices, DDGs, WebTAG and conventional rail and HS2 TSS. This is the red check version of PFMv7.12

Audit Process

The audit process consisted of a comparison between PFMv7.11 and PFMv8. A full model run using the PFMv8_P2b_39 version of the model has been replicated; the model run successfully and no errors were recorded.

Audit Results

Most of the updates found in each of the nine models have been confirmed to be consistent with the list of changes provided by the model developers. For all but one of the differences the model developers confirmed that these are expected in this version of the model.

The exception to this is an update to the Air Supply in PLD_d_DM_lin.in. The 2039 updated values were incorrectly applied to 2026. This issue has been added to the DOL and will be fixed in the next version of the model. A sensitivity test run by the Model Developers confirmed the impacts on Total Benefits to be less than 0.05% and on Revenue to be less than 0.3%.

Full model run for the standard test have been successfully replicated with no errors identified.

39. PFMv8: Pivot Tests Audit DN

Description of the Model Updates

Pivoting has been implemented to address issues with regard to poor convergence, demand response due to crowding and scheme coding in the Do Minimum. Pivoting allows the model to pivot from the output of another model. This audit focuses on the Do Nothing scenario with future year costs and run through to convergence (PFMv8_DN_39_UNRUN).

Audit Process

This audited process consisted of full model run and standard outputs comparison against the ones provided by the model developers. Manual comparison of the files was not included in this audit as this was already done in the standard model test.

Audit Results

A full model run has been successfully replicated with no errors identified. The minor differences (decimal points) observed in some of the standard outputs are considered acceptable since convergence outputs are identical.

40. PFMv8: Pivot Tests Audit DM

Description of the Model Updates

Pivoting has been implemented to address issues with regard to poor convergence, demand response due to crowding and scheme coding in the Do Minimum. Pivoting allows the model to pivot from the output of another model. This audit focuses on the Do Minimum converged demand response (PFMv8_DM_39_UNRUN_PIVOT).

Audit Process

This audited process consisted of full model run and standard outputs comparison against the ones provided by the model developers. Manual comparison of the files was not included in this audit as this was already done in the standard model test.

Audit Results

A full model run has been successfully replicated with no errors identified. The minor differences (decimal points) observed in some of the standard outputs are considered acceptable since convergence outputs are identical.

41. PFMv8: Pivot Tests Audit DS

Description of the Model Updates

Pivoting has been implemented to address issues with regard to poor convergence, demand response due to crowding and scheme coding in the Do Minimum. Pivoting allows the model to pivot from the output of another model. This audit focuses on the converged Do Something (PFMv8_P2b_39_UNRUN_PIVOT) pivoted from the costs and demand in the converged Do Minimum run.

Audit Process

This audited process consisted of full model run and standard outputs comparison against the ones provided by the model developers. Manual comparison of the files was not included in this audit as this was already done in the standard model test.

Audit Results

A full model run has been successfully replicated with no errors identified. The minor differences (decimal points) observed in some of the standard outputs are considered acceptable since convergence outputs are identical.

42. PFMv8.1: Update of Output Files for GIS

Description of the Model Updates

EMME macros updated to produce outputs from PFMv8 for use in GIS. These included information relating to total link capacity, service preload volumes, total uncrowded and crowded in-vehicle time and service boardings and alightings by node.

Audit Process

The execution of the macros was tested by updating the source macro script files, undertaking a full macro run and checking output files. The model run was complete using the PFMv8_P2b_39_UNRUN. The macro used for the Long Distance and regional models were checked. The output files were compared to results obtained from model developers ensuring attributes on link capacity, service preload volumes, total uncrowded and crowded in-vehicle time and service boardings and alightings by node were replicated.

Audit Results

The updated macros have been successfully tested using PFMv8_P2b_39_UNRUN with no errors identified. Expected list of outputs have been produced at the end of the model run in the correct folder and are identical to the version sent by the model developers.

43. PFMv8.1: Standard Outputs Template Update - Time of Day

Description of the Model Updates

The Standard Outputs Template was adjusted to include the additional scenario Phase 1a. The ToD Inputs (Time of Day) sheet was modified with additional cell formatting included.

Audit Process

This audited process consisted of a comparison between the updated Standard_Out_Template.xlsm and its previous version in PFMv8. The differences between the Excel file versions were recorded after a cell by cell cross check was completed.

Audit Results

All the updates found during the audit pertaining to the Time of Day analysis. Formulae updates and updates to calculated values as well as cell formatting have been confirmed to be consistent with changes described by the model developers.

44. PFMv8.1: Prestore Checks

Description of the Model Updates

The batch file procedure used in the model set up of PFMv8 and the setup of the input files was verified. The batch file procedure was developed to produce the list of transit lines on base network and used to compare the Do Minimum and Do Something files and other parameters like the number of lines, vehicle per hour, capacity.

Audit Process

This Prebuild process was checked on an UNRUN version of a selected model. The batch file PrestoreCheck.bat, which runs the prebuild checking process, was tested using the PFMv8_P2b_39_UNRUN version of the model.

Audit Results

The batch file PrestoreCheck.bat has been successfully tested using PFMv8_P2b_39_UNRUN with no errors identified. Expected outputs have been produced at the end of the batch file run.

45. PFMv8.1: PEARS Data Analysis

Description of the Model Updates

The reliability ratios of long-distance rail services using Network Rail's PEARS database have been analysed. Delay minutes caused by each Train Operating Company (TOC) or by Network Rail are recorded for each Service Flow in PEARS. The reliability ratio is used as an input to the PFM and is calculated as total delays per operator divided by train kilometres.

Audit Process

Following a review of the documentation, our audit consisted of a sheet-by-sheet examination of the spreadsheets provided. Our review focussed on the structure of the databook, input data and functionality. We spot-checked some of the calculations and undertook some stress testing

Audit Results

The documentation provided was clear. The Excel workbook well-structured and largely conforms with best practice. As part of our audit we identified a number of issues, none of these affect the results obtained from the spreadsheet with current data inputs but one inconsistency in the formulae (in sheet 'Delays (Peak+Offpeak)') had the potential to generate errors with different data inputs. The model developers addressed the audit results and provided an updated spreadsheet 'train delays per km spreadsheet_afteraudit.xlsx' incorporating the suggested changes.

46. PFMv8.1: Pivot Tests

Description of the Model Updates

A pivot model set has been developed to addresses all previously identified items for improvements from the previous PFMv8 of the model except HS2 TSS and East Coast TSS.

Audit Process

The development of the PFMv8.1 pivot model was checked against the guidance documentation. The parameter setup as outlined in the Pivot Guidance documentation was verified. A series of runs for the different scenario years and options have been undertaken. In addition, the file comparison exercise has been carried out to verify the model enhancements and updates from PFMv8 to PFMv8.1 as recorded in the DOL.

Audit Results

The parameters set up for the pivot tests were broadly consistent to the Pivot Guidance Note. A couple of items were found to be inconsistent as follows:

- Incorrect input files on the \HS2\Inputs\Pivot\ PLD\SCM folder for all model phases for year 2026.
- Folder names under \HS2\Inputs\Pivot\PLD, \HS2\Inputs\Pivot\PM, \HS2\Inputs\Pivot\PN and \HS2\Inputs\Pivot\PS are inconsistent to the Pivot Guidance Note – from AssignPivot to Databank_Assign folder.

Most of the updates found in the files during the comparison to PFMv8 have been confirmed to be consistent with the PFMv81 Release Note. A set of files were found to be included when they should not have been updated and some files that were updated were missing from the note. The model developer has confirmed that the changes we have seen are the expected changes.

These inconsistencies were raised with model developers who confirmed corrections were to be picked up in PFMv8.4.

In auditing PFMv8.4 we can confirm that the inconsistencies were addressed.

47. PFMv8.3: File Consistency Review

Description of the Model Updates

The PFM directory had significant discrepancies between the number of batch files and Emme macros in each model phase of the UNRUN folder. This led to an investigation focussing on identifying and removing redundant files from the PFM directory and checking the consistency in coding between files identified as essential to the standard or pivot model run processes. This resulted in the development of a new PFM “core” model which then will become the building block upon which further model development will take place.

Audit Process

The new PFM “core” model has been used to set up PFMv8_P1a_26, PFMv8_P2b_39 and PFMv8_P2a_49. This was done by copying all the emmemats and emmebanks from the current PFMv8 structure to the new PFM “core” model. This check was done to ensure that the new core model provides identical results to the current PFM model.

Full model runs of PFMv8_P1a_26, PFMv8_P2b_39 and PFMv8_P2a_49 have been replicated; the models run successfully and no errors were recorded. The standard outputs were then compared against the version using the current PFM structure.

Audit Results

Full model runs using the new PFM “core” model have been successfully replicated with no errors identified. All standard outputs were checked and confirmed to be consistent with the outputs produced using the current PFM structure.

48. PFMv8.4: Reliability and Performance Demand Update

Description of the Model Updates

The reliability and performance demand model updates incorporated updates to the file management processes to allow the modelling of new guidance on demand uplifts due to change in reliability.

Audit Process

The audit process consisted of the review of the updated and new files for the reliability and performance task. These files are then compared to their previous version in PFMv8.

Audit Results

Most of newly added and updated files were consistent to the notes provided by the model developers. Where differences were found, the model developers confirmed that these are expected in this version of the model.

49. PFMv8.4: TOC-TOC Transfer Enhancements

Description of the Model Updates

The PFMv8 TOC-TOC process produces outputs using the PLD and only for the Do-Something scenario. An update was made to include the regional models in outputs and to also produce outputs for the Do-Minimum scenario. However, a Do-Minimum Pivot model crash was observed during the PLD 03 test assign stage. The TOC-TOC process files were updated to address this issue.

Audit Process

Jacobs has been commissioned by HS2 Ltd to undertake an audit of the TOC-TOC Transfer Enhancements. As a result of further investigations, the following files were updated to enable all PFM models to run successfully.

The audit process consisted of the review of the updated files including the following:

- DS.bat
- Line_Transfers.py
- Line_Transfers_Batch.bat
- mark.xlsm
- Rassignsetup.mac

A comparison of between the PFMv8 TOC-TOC process files and those updated for PFMv8.1 was undertaken. The changes identified were checked against a changes log provided by model developers.

Audit Results

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

50. PFMv8.4: TOC-TOC Transfer Enhancements Standalone Process

Description of the Model Updates

Additional updates on the TOC-TOC outputs as a standalone process was undertaken to further improve model runs reducing the chance of a model crash. This update also addressed long run times with the introduction of the regional models and Do Minimum scenario. To implement this, relevant macros, batch files and spreadsheets have been updated and removed.

Audit Process

The audit process consisted of the review of the updated files, checked against the list of changes documented in HS2_MD_TOC-TOC_Standalone_SummaryNote_v0.4.docx. A test was carried out on the 2039 Phase 2b model, comparing the file set up between the previous version PFMv8 and the updated version PFMv8.4.

Audit Results

The file updates have been confirmed to be consistent with the changes recorded in the HS2_MD_TOC-TOC_Standalone_SummaryNote_v0.4.docx document. It was recommended that the file set for the TOC -TOC Transfer process was checked once again with the PFMv8.5.

This process was checked in PFMv8.5 which was included as part of the main model run. No issues were found.

51. PFMv8.4: Prestore Checks - Final Card

Description of the Model Updates

The Prestore Check were incorporate to add an additional layer of sense checks at the beginning of a model run to reduce input driven errors in the model runs.

Audit Process

The audit process consisted of the review of the updates to files as recorded list of changes documented in PrestoreComparison18-37-45.xlsx and PreStoreChecks_TechNote_v2.1.docx.

Audit Results

The differences identified in the updated files were mostly consistent with those recorded in the change log provided by model developers. Some differences and updates not described in the change log documents were also picked up during the audit. The changes have been communicated to the model developers who agree that these changes were intentional and necessary.

These updates were also checked and confirmed in the PFMv9.

52. PFMv8.4: Model Audit

Description of the Model Updates

The PFMv8.4 includes the May 2019 WebTAG databook metrics, new forecast years and demand and minor TSS corrections.

Audit Process

The audit process consisted of the review of the updated files to identify and check the changes as recorded in PfMv84_FileChanges.xlsx . These files were compared against their previous version in PFMv8.3.

Audit Results

The updates found in the files have been confirmed to be consistent with the list of changes documented in PfMv84_FileChanges.xlsx, except for one input file called PLD_d_DM_net.in. This file is not expected to change but updates were observed when compared to its previous version.

The file PFM_d_DM_net.in in scenario DN 2039 was confirmed to be corrected in PFMv9.

53. PFMv8.5: Model Audit

Description of the Model Updates

The PFMv8.5 includes the updates to the reliability methodology. This audit includes review of PFMv8.5 model years 2029 and 2039 only.

Audit Process

The audit process consisted of a review of the updated files between PFMv8.5 and PFMv8.4. The general update into this version is the incorporation of the updated reliability methodology and Prestore check.

Audit Results

All file updates found during the audit have been confirmed to be consistent with the updated reliability methodology and Prestore check updates.

54. PFMv9: Model Audit

Description of the Model Updates

The PFMv9 includes TSS updates. This audit includes review of PFMv9 model years 2029 and 2039 only. The model year 2049 was excluded as it was not ready for review during the time of audit.

Audit Process

The first step in the audit process is to review PFMv9 and compare it to PFMv8.5. The general update into this version is the incorporation of the updated TSS.

The second step of the audit process consisted of the review of input files for the Do Minimum and Do Something pivot scenarios.

Full model runs of PFMv9_DN_29 (standard run), PFMv9_P1a_29 (standard run), PFMv9_DM_29 (pivot run), PFMv9_P1a_29 (pivot run), PFMv9_DN_39 (standard run), PFMv9_P1a_39 (standard run) and PFMv9_DM_39 (pivot run) have been replicated; the models run successfully and no errors were recorded. The standard outputs were then compared against the outputs produced by the model developers.

Audit Results

All file updates found during the audit have been confirmed to be consistent with the TSS updates. The inputs to pivot have also been reviewed and confirmed to be consistent with the Pivot Guidance Note. Full model run for PFMv9_DN_29 (standard run), PFMv9_P1a_29 (standard run), PFMv9_DM_29 (pivot run), PFMv9_P1a_29 (pivot run), PFMv9_DN_39 (standard run), PFMv9_P1a_39 (standard run) and PFMv9_DM_39 (pivot run) have been successfully replicated with no errors identified. The comparison of standard outputs summarized in the table above shows minor differences in values (decimal points) but identical convergence outputs.

We did have some model crashes during the running of the replication runs. These were due to the VBA codes in the preloads spreadsheet and are a known issue. They can be resolved by restarting the machine and running the model again. The model developers are aware of this and confirmed the plan of converting this procedure to Python in a future PFM version.

During the replication runs for PFMv9, which used the same inputs and model versions as the model developers, we had some runs that were inconsistent with the results produced by the model developers. Subsequently, either Jacobs or SYSTRA have re-run these runs, using identical inputs, and were able to replicate the results. It has been confirmed that Mott MacDonald have been able to replicate all the model runs used for this PFMv9 release therefore we have confidence in the model results for PFMv9. Some minor inconsistencies were found in earlier re-runs by Jacobs which related to the specific set-up of the modelling machine used by Jacobs. Therefore, while we have confidence that the model runs set up by the model developers can be replicated, some caution is advisable when running PFMv9 in a different IT environment from that used originally.

During the Red Check carried out by the model developers it was discovered that some of the changes related to the air/highway supply (PLD_d) input files stated in PfMv85_PfMv9_CORE_Comparison.csv were not correct. The model developers informed that the changes in supply has a minimal impact on results.

It was subsequently found by the model developers that there was an issue in the Phase 2a model where HS2 services in P2a did not use a direct HS2 link between Birmingham International – Crewe. Although the journey times were correct it applied the wrong (and less reliably) West Coast delay per km values. The model developers have run sensitivity rests on this had the following impact:

- Phase 2a – Benefits +1%
- Phase 2b - - Benefits +0.8%

These will be updated by the model developers and audited in PFMv9.1.

55. PFMv9: 2049 Audit

Description of the Model Updates

This version includes the audit of the third forecast year assignment in PFMv9 which is 2049.

Audit Process

The first step in the audit process is to review the updated files between the two PFM versions (with and without forecast year 2049) to check if all updated files were consistent to the list of changes provided by the model developers.

Full model runs of PFMv9_DN_49 (standard run) and PFMv9_P1a_49 (standard run) have been replicated; the models run successfully and no errors were recorded. The standard outputs were then compared against the outputs produced by the model developers.

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. Full model run for the PFMv9_DN_49 (standard run) and PFMv9_P1a_49 (standard run) have been successfully replicated with no errors identified. The comparison of standard outputs summarized in the table above shows minor differences in values (decimal points) but identical convergence outputs.

The PFMv9_DM_49 pivot run was not successfully replicated. This is related to the model replication issue caused by Jacobs modelling machine discussed above and now resolved. However, Systra managed to replicate the PFMv9 DM 2049 pivot run using the PFMv9 DN 2049 and PFMv9 P1a 2049 standard runs that Jacobs set-up which provides confidence in the model results for PFMv9 2049.

56. PFMv9: 6 Trains Per Hour Audit

Description of the Model Updates

This version includes the audit of the PFMv9 6 trains per hour (tph) scenarios. It includes new scenarios in the PFM model named P1bi and P2ai. And within these, the line files were updated to reflect the changes.

Audit Process

The first step in the audit process is to review the updated files between the two PFM versions (with and without 6tph scenarios) to check if all updated files were consistent to the list of changes provided by the model developers.

Full model runs of PFMv9_P1bi_29 have been replicated; the models run successfully and no errors were recorded. The standard outputs were then compared against the outputs produced by the model developers.

Audit Results

All file updates found during the audit have been confirmed to be consistent with the list of updated files provided by the model developers. Full model run for the PFMv9_P1bi_29 has been successfully replicated with no errors identified. The comparison of standard outputs summarized in the table above shows minor differences in values (decimal points) but identical convergence outputs.

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 PFMv9 correctly reflect the documented methodology. During our audit, we noted some specific issues which are detailed in this letter. We do not judge any of these to have a material impact on the results of PFMv9.

During the replication runs for PFMv9, which used the same inputs and model versions as the model developers, some minor inconsistencies were found in the initial runs undertaken by Jacobs. These were subsequently found to relate to the specific set-up of the modelling machine used by Jacobs. Therefore, while we have confidence that the model runs set up by the model developers can be replicated, some caution is advisable when running PFMv9 in a different IT environment from that used originally.

Yours sincerely

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