Network Rail and Office of Rail Regulation

AO/016 & AO/021: IIP Tier 0 & 1 Model Audits

Report

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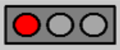
Executive Summary

This report presents the findings of our reviews of Network Rail's 'Tier 0' and 'Tier 1' models that have been used to forecast Network Rail's costs and income during the period from 2014 to 2019 - Control Period 5 (CP5) - and which have been included in the Initial Industry Plan (IIP) of September 2011. The scope of our review has been the computational integrity and data inputs to these models, with the overall aim of gauging the uncertainty in the accuracy of the model outputs. This will help inform the Office of Rail Regulation (ORR) in their advice to Ministers with regards to the IIP.

There are several Tier 1 models, one for each of the main asset groups with several smaller models for other costs or income. In the table below we present our view of uncertainty in each of the model outputs, based on the checks we carried out. Following the table we provide a summary of our findings.

Model	Computational Integrity	Data Inputs
Track (VTISM)	Amber / Green	Green
Track (Renewal & Maintenance)	Green	Amber
Electrical Power	Green	Green
Signalling	Green	Green
Structures	Green	Red
Buildings	Amber	Red
Earthworks	Green	Amber / Green
Telecoms	Green	Amber / Green
Wheeled Plant	Green	Amber
Income	Amber	Amber / Green
EC4T	Green	Amber
Support	Green	Green
Traffic	Green	Green
Other Maintenance	Green	Not reviewed
Operate Costs	Green	Not reviewed
Other Renewals	Green	Not reviewed
Other Maintenance & Asset Management	Green	Not reviewed
Tier 0	Green	Green

Rating	Description
	No errors or small number of superficial errors found
	Minor errors found that have a small but detectable impact on volumes and costs
	Major errors found that have material impact on volumes and costs

General Findings

Given the large number of models reviewed, relatively few computational errors have been identified. However, documentation is generally lacking detail and many of the offline models and data inputs have no documentation. This introduces the risk of different assumptions being made in the chain of models and data.

A common concern that came up several times was the accuracy and coverage of the modelled asset inventory. We found a few models have some significant discrepancies which need to be resolved. Examples include the numbers of bridges in the Structures model and several different types of buildings in the Buildings model.

For the few links between the Tier 1 models we found possible inconsistencies. These links should be checked and strengthened as appropriate.

Track (VTISM)

This is the most advanced model reviewed, in that the volumes of work are estimated in detail. The model is very large with over 100 databases. However, the documentation is incomplete and we were unable to successfully install and run the full model. Our checks were unable to cover all the functionality and the assurance we can provide on the CP5 volumes and costs is therefore limited. That said, we only identified an error in the post-processing of the results prior to input to the Track (Renewals and Maintenance) model. For this complex model we would recommend that Network Rail should improve the documentation and bring in a second member to the modelling team to provide additional resource and cover for absence.

Track (Renewals and Maintenance)

This model summarises the Heavy Maintenance and Renewals outputs from VTISM and also contains the SRS Maintenance model. It is a large and complex spreadsheet model that is reliant on the usage of a large number of Named Ranges and Calculations. It makes extensive use of Visual Basic to coordinate the model runs and produce the outputs. Despite its complexity, the model is well presented and computationally robust. The main concerns are that the Functional Specification is not sufficiently detailed to cover all the functionality, and the large number of data inputs require version control and documentation.

Electrical Power

This model covers a wide variety of assets which helps to explain why it is fragmented. There are many offline models that produce inputs to the model. No computational errors were identified in the Tier 1 model and only one small discrepancy (in the track km) was found in the many input files. The main concern is a lack of documentation and transparency covering all inputs, the process for moving the data from offline models, and the Tier 1 model itself.

Signalling

A well-structured model with no computational errors found. Some minor data input discrepancies were found but these are not used in the calculations within the model and relate to the date the data was extracted from SICA. The output showing signal box closure dates is an input to the Telecoms model, and inconsistencies were found between the two models. It is noted that the CP5 volumes and costs are sensitive to the SEU % activity volumes assumptions which it might be worth reviewing.

Structures

Only one small error was found in the computational checks. But there are major uncertainties concerning the number of bridges included in the model. The model also makes a number of assumptions in its method for estimating bridge renewal volumes which we feel should be reviewed because they may be over-simplistic. It is understood that for the Strategic Business Plan (SBP) the CeCOST model, which is currently under development, will be used as the basis for forecasting volumes of work.

Buildings

Just over half of CP5 expenditure for Buildings is for franchised stations, the volumes of which are derived outside the model. Of the rest, there are major concerns about the assumed number of assets for most types of Building which should be reviewed as a matter of urgency. Some errors have been identified in the calculations for Line-Side Buildings. We were also unable to trace the derivation of route allocations for Light Maintenance Depots.

Earthworks

This is a well presented model with only very minor computational and data input errors identified. The main area of uncertainty is the assumptions made in the simplified methodology since the results are particularly sensitive to them being correct. It would be worth reviewing these for their suitability in developing the SBP.

Telecoms

This model relies on the output from the Telecoms Decision Support Tool to provide asset inventory data and planned renewal intervention dates. Network Rail have indicated that this tool matches the underlying asset register database to within 5% accuracy. Our checks of the Telecoms model have shown that some assets have used the wrong Maintenance Unit Costs and that there is a formatting error for some voice recorder calculations. Together they result in CP5 costs being over-stated by about £3m.

Wheeled Plant

A small calculation error was identified but it does not affect the CP5 volumes or costs. More significantly, some discrepancies were identified in the input workbank volumes.

Income & EC4T

These two models assume different methods for calculating Electric Charge for Traction (EC4T) for freight. One calculates it for income and the other for costs and the two methods provide very different estimates. Whilst freight only makes up a small percentage of the total EC4T charge, it is recommended that these methods should be reviewed and updated for consistency. In addition, the assumed electrification schemes in the EC4T model are out of date and more schemes need to be added.

Support, Property and Non-Controllable Costs

This model is used to generate cost data for a wide range of activities (Human Resources, Finance, Utility costs, etc.) supporting Network Rail's day-to-day operations, but excluding operational assets, in contrast to many of the other Tier 1 models. The computational integrity of the model was successfully verified, as was the consistency of the output data from the currently separate Utilities costs model with the corresponding input data used in the Support model.

Traffic

This model is used to generate traffic data (train km, gross tonnage km etc) for the Income and Track models. The outputs from the model were found to be accurate and consistent with the input to the Income model.

Other Maintenance

This model forecasts indirect maintenance costs for labour, materials, plant and other maintenance not included in the asset models. Only one minor computational error has been identified which will not affect the forecast costs. Network Rail intend to move the 'other maintenance' costs into the relevant asset specific model, to provide a more robust relationship between direct and indirect maintenance.

Operate Costs

This is a well structured model and takes inputs from the Signalling Model. These inputs were checked and found to be accurate and correct. No computational errors were found. The forecasts calculated by the model for CP4 were found to be within 1% of the forecasts presented in the Delivery Plan Update 2011, providing some assurance to the CP5 forecasts.

Other Renewals

The model is used to forecast Network Rail's IT renewal expenditure, Corporate Offices renewals expenditure and Capex related to the Asset Information Strategy, Intelligent Infrastructure and the Engineering Innovation Fund. It is understood that the model inputs are all derived offline and manually entered into the model as input cost profiles starting from year 2014/15 to 2023/24 and control period averages from CP7 to CP11. The offline data source(s) was not checked. The calculations within the model were relatively straightforward and easy to follow and no problems or errors have been identified in the model calculations.

Other Maintenance and Asset Management

This is a spreadsheet model and is not yet documented in the Functional Specification (Document Release 002, October 2011). The model is used to forecast the other maintenance and support costs for National Delivery Service, Engineering, Asset Management Support, Asset Information, Track, SP&C and B&C. The CP5 expenditure forecasts are generally based on end of CP4 spend levels and are directly input into the model as cost profile. The offline data source(s) was not reviewed. No errors have been identified in the model calculations.

Tier 0

This model collates the outputs from all of the Tier 1 models and applies the CP5 efficiencies before presenting the final volume and cost estimates. It was found to do this accurately, although for good housekeeping it is suggested that redundant data is removed.

Unit Costs

Overview

The methodology for deriving the CP4 exit rates, which are vital inputs to the Tier 1 models, has been reviewed for each asset group and summarised below. Some overall concerns are:

- The spread of the unit rates between asset groups is disproportionate to their value. For example, Track at 20% of the total IIP value is based on only 20 out of at total of 300 rates.
- More 'cleaning' of the data underlying the calculation of the rates would be beneficial.
- More benchmarking or market testing would be beneficial.
- There should be greater transparency in the calculation and % uplifts of the rates.

Track
Though this asset contributes the highest amount towards the total CP5 forecast value, the cost model is driven by only 20 Unit Rates. These rates are largely based on historic data which gives confidence regarding the ability to deliver at these rates. However, there are concerns regarding potential overstatement due to potential compounding of such things as uplift and adjustment factors in amalgamating a number of work item rates to arrive at the small number of Unit Cost rates used within the model.

Electrical Power
A very large portion (almost 75%) of the total amount for this asset is not calculated with reference to Unit Cost rates. That said, the methodology used and the data relied on for the calculation of the Unit Costs used within the cost model appears to be of reasonable quality with sufficiently robust coverage for the purpose intended.

Signalling
Rates for resignalling and Modular signalling have been calculated on the “average framework Tender” rate principle. Due to the confidentiality of the data, the reviewer has not had full visibility of the build-up of these rates. Network Rail propose to revert to contracted framework rates once the framework contracts for signalling have been awarded, which is expected to be in time for the SBP. As coverage of the unit of measure is well defined, this proposal would provide significant confidence regarding the ability to deliver works and coverage of the works within the rate. The rate for ERTMS, however, cannot be adjudged as robust as the contracted rate/s. The as-yet-to-be-defined nature of the technology has resulted in estimated rates that cannot at this stage be confirmed as correct or incorrect.

Structures
This asset largely utilizes actual costs to calculate Unit Cost rates. This method therefore provides a high level of confidence with regard to the deliverability of the work at the rates stated, though potentially at ‘soft target’ rates.

Buildings
Good practice has been adopted in calculating the Unit Cost rates for this asset. The coverage and quality of the Unit Cost rates calculated is acceptable. Uplift percentages have been applied taking a blanket approach which needs review but on the whole the Unit Cost rates can be assessed to be of good quality, providing sufficient coverage for the works they represent. However, not all the rates have been used in the Buildings Tier 1 model which raises questions over whether they are consistent with the way that the work has been defined.

Earthworks
The Unit Cost rates for the work items within this asset have been derived via reference to the actual historic cost for similar works. The Unit Cost rates therefore are assessed as providing sufficient coverage for the works they represent and the unique approach adopted in calculating these Unit Cost rates is also considered to be of sufficient quality for the purpose intended. Using historic data provides a high level of confidence with regard to the deliverability of the work at the rates stated, though potentially at ‘soft target’ rates.

Telecoms
The methodology adopted using actual costs as the source data for arriving at the Unit Cost rates for input to the model is easy to follow and understand. The coverage and quality of these rates are therefore deemed satisfactory for this asset. However, an uplift factor is then applied to the Renewal Unit Costs and more work is required to validate these uplifts.

Wheeled Plant
The very specialist nature of the items of work requiring Unit Cost rates within this asset has resulted in a number of approaches being used to arrive at these values. These are deemed to be sufficiently reasonable with regard to the quality and coverage of the Unit Cost rates for the purposes intended when considering the constraints and challenges presented by the unique nature of the asset.

England & Wales / Scotland

All Tier 1 models apportion volumes of work by Operating Route, with Scotland treated as a single Operating Route. However, there are single Unit Costs for each work item with no geographical breakdown. Arguably labour costs might be cheaper in Scotland but some of the work may need to be carried out in more remote locations and so take longer. Without undertaking a detailed review of cost drivers, it is therefore difficult to judge how the adoption of single Unit Costs impacts the uncertainty of renewal and maintenance costs for England & Wales versus Scotland.

Recommendations

The following recommendations are made to improve the modelling. We would also recommend that progress made on them should be reviewed later this year in July or August.

No	Recommendation to NR	Section in Report	NR Champion	Date
IIP.Tier.1	Produce full documentation, including flow diagrams, so that all Tier 1 and associated offline models are covered – such that a new user can understand the functionality.	3	Tier 1 Modelling Team Manager	Oct 2012
IIP.Tier.2	Produce a central Assumptions Register for all Tier 1 models.	3	Tier 1 Modelling Team Manager	Oct 2012
IIP.Tier.3	Provide comments/references to the parts of the data which feed into other Tier 1 models to aid in the updating process.	3	Tier 1 Modelling Team Manager	Oct 2012
IIP.Tier.4	Review progress on recommendations made in this report	Summary	Tier 1 Modelling Team Manager	July 2012
IIP.Track.1	Network Rail to consider training up a second user to spread the knowledge.	4.8.1	Track Modeller	Oct 2012
IIP.Track.2	Improve the file structure, naming conventions and model versioning.	4.8.2	Track Modeller	Oct 2012
IIP.Track.3	Provide documentation on tables and queries contained within the model.	4.8.2	Track Modeller	Oct 2012
IIP.Track (R&M).1	Automate, consolidate and introduce version control for data inputs	5.8	Track (R&M) Modeller	July 2012
IIP.Structures.1	Review and reconcile bridge numbers in the model with confirmed source.	8.5.1	Structures Modeller	July 2012
IIP.Structures.2	Confirm validity of assumptions made for bridge renewals and develop methodology as appropriate.	8.5.2	Structures Modeller	July 2012
IIP.Buildings.1	Review and reconcile asset numbers in model with confirmed source.	9.5.1	Buildings Modeller	July 2012
IIP.Buildings.2	Review and correct as appropriate unit rates and efficiencies in model.	9.8	Buildings Modeller	July 2012
IIP.Buildings.3	Correct computational errors that have been identified in model.	9.8	Buildings Modeller	July 2012
IIP.Buildings.4	Document the method of route allocations for LMDs.	9.8	Buildings Modeller	Oct 2012
IIP.Earthworks.1	Review suitability of modelling assumptions for Strategic Business Plan.	0	Earthworks Modelling Team	July 2012

IIP.Telecoms.1	Correct errors identified in audit.	11.8	Telecoms Modeller	July 2012
IIP.Telecoms.2	Check for consistency with Signalling Tier 1 model for NOS Migration.	11.8	Telecoms Modeller	July 2012
IIP.Wheeled Plant.1	Correct error in calculating first year of overhaul	12.4	Wheeled Plant Modeller	July 2012
IIP.Wheeled Plant.2	Check workbank input data for completeness and accuracy	12.5	Wheeled Plant Modeller	July 2012
IIP.EC4T.1	Reflect the latest assumptions on electrification schemes in each scenario, and update the electric train km accordingly on the affected routes.	14.7	EC4T Modeller	July 2012
IIP.Traffic.1	The documentation of the Traffic model should be improved and expanded.	16.7	Traffic Modeller	Oct 2012
IIP.Other Maintenance.1	NR to develop a plan to improve the modelling of Other Maintenance costs and to update the Functional Specification accordingly.	17.7	Other Maintenance Modeller	Oct 2012
IIP.Tier0.1	The documentation of the Tier 0 model should be improved and expanded, including the provision of comments in the VBA code used in the model.	21.7	Tier 0 Modeller	Oct 2012
IIP.Costs.1	Review if the current approach of using Unit Cost rates for a forecasted workbank can be improved.	22.10	Unit Cost Team	July 2012

Acknowledgements

We would like to thank Network Rail staff for their availability and openness in helping us carry out this review. They have responded to our requests for information and meetings promptly and have volunteered some of the weaknesses in the models.

1 Introduction

1.1 Background

Network Rail, on behalf of the rail industry, published the Initial Industry Plan (IIP) for England & Wales and Scotland in September 2011. This set out the plans of the industry for the five year period 2014 to 2019 - Control Period 5 (CP5) - to deliver a more efficient and better value railway and how the railway can help to deliver sustainable economic growth.

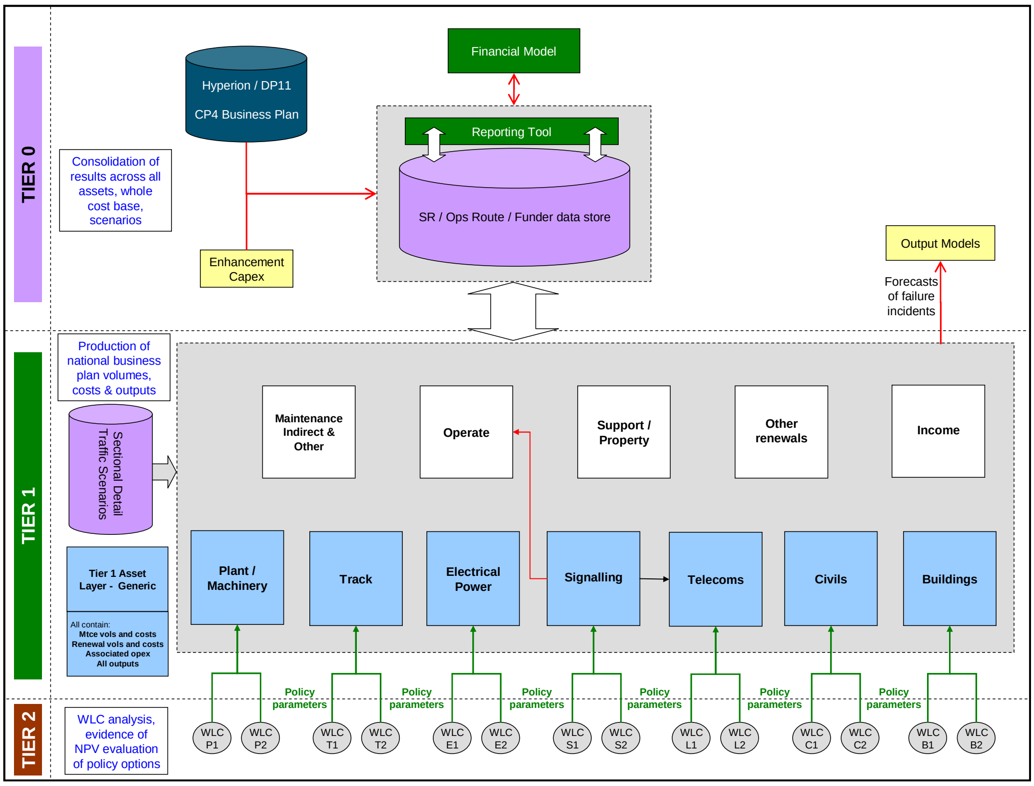
As part of this, the IIP presents a forecast of industry costs and income and the consequent subsidy required from Government. This will inform the Government's High Level Output Specification for the railway in CP5 and Statement of Funds Available to be published in the summer of 2012. The cost and income forecasts have been produced by Network Rail in a series of structured models that have also been used to determine the most reliable, sustainable and efficient asset policies.

Network Rail and the Office of Rail Regulation (ORR) have asked Arup as the Part A Independent Reporter to review the outputs of Network Rail's 'Tier 0', 'Tier 1' and 'Tier 2' models which have fed into the Initial Industry Plan (IIP). A number of different mandates have been issued to review different elements of these, but the overall aim is to bring these reviews together and produce an overall view of uncertainty in the IIP figures, to help inform the ORR advice to Ministers.

1.2 Tier 0, 1 and 2 Models

Network Rail have provided the following chart to show how the various Tier 0, 1 and 2 models fit together.

Figure 1.1: IIP Modelling Structure (Network Rail)



The Tier 2 models are designed to investigate the optimum Whole Life Cost (WLC) renewal and maintenance strategy for each asset. As such, they are detailed and are used to inform asset policy and the modelling principles for Tier 1. Although Figure 1.1 shows a direct connection from Tier 2 to Tier 1, we understand that there are relatively few such direct links so far. Instead, the link to date has been indirect by influencing the policies and hence workbanks that are either calculated by or inputs to the Tier 1 models (depending on the approach taken for that asset). The degree of this influence varies, according to the maturity of the Tier 2 models.

We understand that Network Rail are continuing to develop the Tier 2 models to refine the asset policies in time for their Strategic Business Plan. They are currently being reviewed by Arup in mandate AO/017 and by AMCL.

There are 12 separate Tier 1 models as shown above in Figure 1.1. They vary in size and complexity. All are Excel based with some using Access, and Track includes other packages (e.g. T-SPA and Vampire). Most Tier 1 models are independent although outputs from the Signalling model feed into the Telecoms and Operations models. We understand that it was also intended that there would be a direct link from the Track model to the Wheeled Plant & Machinery model, but that this has not as yet been introduced (although Network Rail advise that National Delivery Services did review the track volume forecasts and took them into account when determining the requirements for numbers of machines).

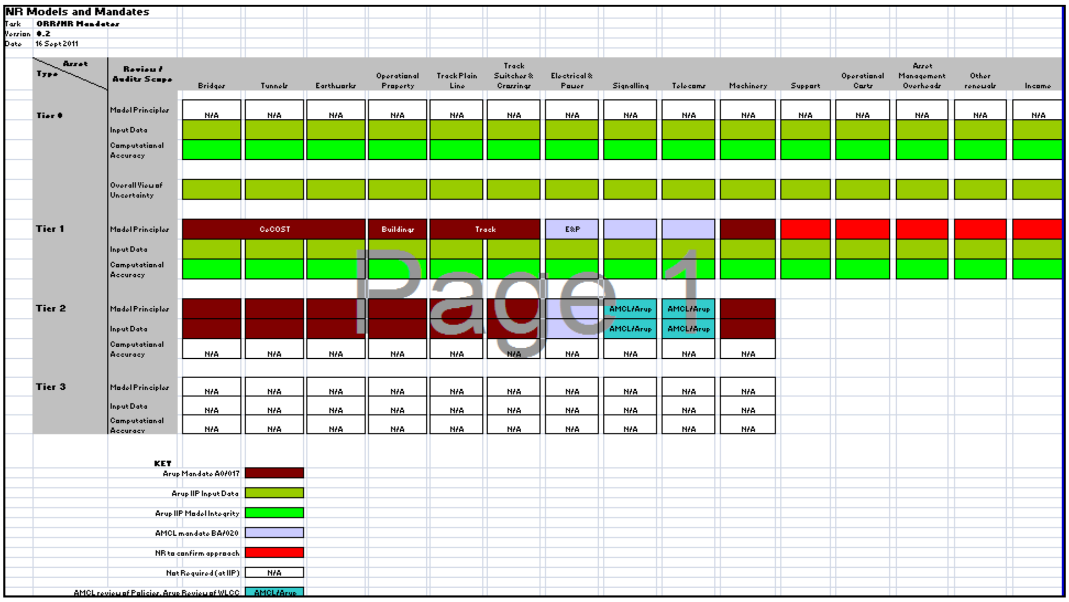
1.3 Relevant Mandates

There is an overlap between several mandates being undertaken by both Arup and AMCL (the Part B Independent Reporter) which cover the review of Tier 0, 1 and 2 models, data inputs and unit cost modelling. These mandates include:

- AO/11: Network Rail Regulatory Accounts Data Assurance;
- AO/13: Review of Renewal Volumes Data;
- AO/15: Audit of the Robustness of the Network Rail Unit Cost Framework;
- AO/17: Initial Industry Plan 2011 Review;
- BA/020: Initial Industry Plan 2011 Review (E&P, Signalling & Telecoms);
- "Review of Phase 1 Asset Information Systems (AIS)";
- AO/016: Prioritised audit of inputs to Network Rail's tier 1 strategic planning models used in support of IIP; and
- AO/021: Audit of integrity of Network Rail's tier 0 and tier 1 strategic planning models used in support of IIP.

The responsibility for the different elements of the model audits is shown in Figure 1.2.

Figure 1.2: Resource Allocation



1.4 This report

This report presents our findings for mandates AO/016 and AO/021 to review the data inputs to the Tier 1 models and the computational integrity of the Tier 0 and 1 models. These mandates are listed in Appendix A. With a review of this size, it would be easy to produce a very long report. To aid the reader, though, we have tried to present our findings as succinctly as possible.

- Section 2 sets out the scope and approach to our review and includes a summary of our initial Scoping Report produced on the 4th November 2011.
- We present our general findings from our reviews in Section 3.
- Sections 4 to 21 in turn present the findings for each model that we have reviewed.
- Part of mandate AO/016 is to review the derivation of the Unit Costs that have been input to the Tier 1 models. This is covered in Section 22 with each of the major assets considered separately.
- Section 23 then presents our conclusions from all the reviews, followed by our recommendations in Section 24 for the further development of the models to inform Network Rail's Strategic Business Plan for CP5 which is due to be published in 2013.

2 Scope and Approach to Review

2.1 Purpose

The overall purpose of the reviews of the IIP being undertaken by Arup and AMCL is set out in mandate AO/016, namely

"The reporter should present its view on the range of uncertainty of the model output due to quality of model input information by:

- *each tier 1 model and for NR's IIP submissions in total;*
- *main building block, including income, support functions, operations, maintenance and renewal uncertainties separately identified; and*
- *England & Wales and Scotland.*

The reporter should also present its view on the overall range of uncertainty of the model output due to:

- *Input data uncertainty, including efficiency evidence uncertainty;*
- *Modelling principles; and*
- *Computational accuracy.*

This should be presented by:

- *each tier 1 model and for NR's IIP submissions in total;*
- *main building block, including income, support functions, operations, maintenance and renewal uncertainties separately identified; and*
- *England & Wales and Scotland."*

2.2 Scope & Scoping Report

In November 2011 we presented an initial Scoping Report that set out our proposed approach and deliverables. In that report we proposed to produce the following for each Tier 1 / Tier 0 model:

- An Assumptions Register;
- A map of inputs – calculations – outputs;
- Record of computational integrity checks carried out and any inaccuracies identified;
- Review of unit costs;
- Record of other data checks carried out and any inaccuracies identified;
- Overall view of confidence in the volume and cost outputs; and
- Suggested improvements to model structure.

As it has turned out, the scale of the work to be carried out in this review has been greater than we had anticipated. There have been a large number of inputs to check and many of the model calculations have not been covered by the Functional Specification and so required considerable time and effort to understand. We have not had time to produce an Assumptions Register or detailed flow maps beyond those presented in the Scoping Report.

2.3 Approach

Given the overlap between the two mandates, each model was reviewed by one person to check both the computational integrity and the data inputs. In most cases our reviewer met with Network Rail modeller(s) at least once, and in some cases several times, in order to understand the model and answer emerging questions.

We also liaised with the Arup and AMCL reviewers of modelling principles to understand the purpose of the model, and whether the calculations and assumptions supported that purpose. The adequacy or otherwise of the principles is outside the scope of this report. We do recognise though that there is an overlap, and so where appropriate we have highlighted the implications of the modelling principles in any assumptions that we believe need to be reviewed and perhaps developed further.

The unit costs input to the Tier 1 models have been developed by a separate Cost team within Network Rail. These represent the rates anticipated by Network Rail at the end of CP4. One of our Cost Management and Quantity Surveyor specialists reviewed the methodology for deriving these costs by sampling a number of items from each major asset.

Network Rail's Cost team also calculated the target efficiencies to be achieved by Network Rail during CP5. These have been input to the Tier 0 model. The method for deriving these efficiencies is covered by a separate mandate being undertaken by SDG. We have therefore restricted out review here to checking that the calculated efficiencies have been input to and applied correctly in the Tier 0 model.

Many of the Tier 1 models receive at least part of the volume of renewal and/or maintenance volumes for CP5 and beyond in the form of a workbank that is generated in offline models or by route engineers. As set out in our Scoping Report, in the time available we have not reviewed these offline models or processes, although we have checked that they have been input correctly to the Tier 1 models. Also we have assumed that this workbank so generated is consistent with the relevant asset policy.

Asset inventory (numbers, age, condition etc) is a key input to most of the Tier 1 models. Where possible, we have checked this against independent records for coverage – to make sure all relevant assets have been included – and accuracy. Sources of such information include Network Rail's 2011 Annual Return and the relevant asset policy.

For all key input files we have requested from Network Rail the immediate source files so that we can check they have been input correctly from a sample of the records. Checking the generation of these source files from, for example, the Asset Register, is beyond the scope of this work in the time available as set out in the Scoping Report.

2.4 Key Documents

The key document reviewed in this work is Network Rail's Functional Specification:

- Network Rail Tier 0/1 Cost Models (the "ICM") Functional Specification, October 2011, Model versions as used for Initial Industry Plan runs, Document release 002.

Model specific supplementary documents were also reviewed as appropriate and are mentioned in the relevant section of this report.

3 General Findings

This section presents our general findings that run through many of our individual model reviews and which are described later in this report.

The modelling for the IIP has been undertaken by a team dedicated to the task within Network Rail. They have a high degree of modelling skills in Excel and Access and this has been demonstrated by the relatively few computational errors that we have found in the models. They have also been very open with us during our reviews and have themselves pointed out weakness in the models.

Producing the cost and income forecasts for the IIP has involved a considerable amount of modelling. As well as the Tier 0 and 1 models, there are many other offline models that have been used to generate the various input files, in particular the workbanks. We were surprised by the number of such models and data sources and the Network Rail team have clearly put a lot of effort into producing these forecasts in time for the IIP.

3.1 Documentation

A consequence of this, though, is that time for documentation may have slipped. We found that the Functional Specification for the Tier 0 and 1 models lacked detail, in particular for some of the calculations. For many of the offline models and processes there was less (and in some cases no) documentation. Whilst understandable, we believe this presents a risk to Network Rail: without full documentation and with different teams contributing inputs to the modelling as well as producing the asset policies themselves, it is possible for different people in the chain to make different assumptions in their models or for generating data. It is also our experience that the process of writing documentation in itself can help the modeller check his or her logic, and so is a good discipline.

3.2 Asset Inventory

3.2.1 Network Rail Internal Audits

Network Rail have reviewed the reliability and accuracy of some of the source asset information, focussing on data deemed to be critical to the IIP. This was a high level review which awarded provisional confidence grades to each source dataset and was reported in 'Overview of Confidence Grading Summary for September 2011 II Submission', dated 17th October 2011.

Separate grades were given to the inventory and condition data for each asset group and are replicated below. They range from B2 to C3/B4. Note that the accuracy score of 2 refers to an accuracy of 95-99%, 3 to 90-95% and 4 to 75-90%.

Table 3.1: Confidence Grades (source: Overview of Confidence Grading Summary for September 2011 IIP Submission, Network Rail)

Asset group	Asset	Inventory	Condition
Track	Plain Line	B3	B2
	Switches and crossings	B3	B2
Signalling	Interlockings	B3	B2
	Point operating mechanisms	B3	B2
	Train detection	B3	B2
	Colour light signals	B3	B2
Telecoms	Station Information and Security Systems (SISS)	B3	B3
Structures	Metal underbridges	C2	C2
	Masonry underbridges	C2	C2
	Tunnels	B2	B2
Earthworks	Embankments	B2	B3
	Soil cuttings	B2	B3
Ops Property	Buildings	B3	B3
Electrical power	OLE	C3	B4
	Conductor rail	C3	B3
	HV switchgear	C3	B4
	Signalling power supplies	C3	B4

We compared the grades awarded to Track with a Network Rail internal audit of GEOGIS ('Track DU Survey Report', 21st January 2011). This reported the findings of a network-wide audit undertaken by Track Maintenance Engineers. It identified errors of asset attributes that were critical to the IIP and were corrected for the modelling. On the evidence of the figures reported, the overall grades of B3 for inventory and B2 for condition shown in the table above appear to be reasonable for the corrected data.

This assessment is a work-in-progress and Network Rail are planning to improve the accuracy of asset information for SBP. The Q3 Monitor from the ORR states the following:

Asset Information
Comprehensive, accurate asset information is vital for effective asset management. Network Rail's own subjective assessment, provided in papers supporting the September IIP, showed its asset data to be considerably behind the requirements of its developing SBP. We will shortly commence an audit to identify what the company needs to do to service our requirements for the PR13 price review. [NR to be given draft mandate Wed 1 Feb]

3.2.2 Asset Information input to the Tier 1 models

We carried out checks that the asset information was input correctly into the models. A common theme that came up several times was the accuracy and coverage of the modelled asset inventory, which concurs with the overall message of Network Rail's own internal audit. Deriving this data often involves downloading information from asset registers and then 'cleaning' it to remove known deficiencies or filling in missing data from alternative sources / assumptions. From checks that we carried out, this is not perfect and there is still more work that could be done to improve this process. For a few models there are some significant discrepancies to be resolved.

3.3 Model Linkages and Assumptions

Most of the Tier 1 models are independent of each other, but a few do overlap. For example, the Signalling model outputs the dates of closure of some signal boxes and these form an input into the Telecoms model. In one or two instances we found or Network Rail mentioned possible inconsistencies.

In other cases there are implicit links – for example the Wheeled Plant fleet needs to be large enough to handle the amount of work (tamping, grinding etc) generated by the Track model. In this instance National Delivery Service (NDS) did review the track volume forecasts and took them into account when determining the requirements for the numbers of machines to be modelled.

We believe it would be worth checking and where appropriate developing these linkages for the Strategic Business Plan. An Assumptions Register would help this process.

4 Track (VTISM)

4.1 Introduction

In our scoping report we identified this model as one of the top priorities for checking. It generates 22% of the total IIP Costs in CP5 as well as being the most complex model. We have therefore covered this model in more detail than the other Tier 0 + 1 models.

The Track Asset Model has been developed to provide Network Rail with an effective Track asset management policy. The model uses the current track characteristics and traffic data as a starting point, with historical maintenance and intervention data to calibrate the model. The model estimates the volumes of work required during CP5 and after for a particular scenario, allowing an assessment of the likely impact on track condition and the associated costs. The Track Asset Model consists of two Tier 1 models:

1. VTISM – Vehicle Track Interaction Strategic Model
2. SRS Maintenance Model

This chapter of the audit covers the modelling undertaken for VTISM. Chapter 5 covers the ICM Tier 1Track Model that contains the SRS Maintenance Model, and also summarises the renewal and Heavy Maintenance outputs from VTISM. VTISM outputs are also required as input to the SRS Maintenance Model.

4.2 Approach to Audit

The model data was obtained over a number of meetings with Network Rail. In addition, several documents were received covering different elements of the model, and these are listed in Appendix B. Despite frequent attempts, it was not possible to obtain the full set of modelling files due to the size and complexity.

A sequence of meetings was undertaken in order to obtain sufficient files to understand the scope of the model, to understand how to run the key processes, and to work through the model's interactions:

Table 4.1: Meetings undertaken and their purpose

Meeting	Date	Purpose
Inception	14/10/2011	To obtain the modelling files to undertake the scoping exercise
Methodology Clarification	07/11/2011	To understand the terminology used in the Implementation report and understand the role of the key processes
Technical Meeting 1	17/11/2011	To review the analysis undertaken so far, to obtain more of the required modelling files and Q&A.
Progress Meeting 1	21/11/2011	Focus on the key databases within the model
Progress Meeting 2	30/11/2011	Understanding model assumptions and discussion on sensitivity testing
Technical Meeting 2	05/12/2011	Running T-SPA sensitivity tests to test model performance
Progress Meeting 3	08/12/2011	Understanding remaining model elements

Initially it had been hoped that it would be possible to follow the modelling process through from start to finish. However due to the complexity of the model, the incomplete set of data and incomplete documentation this was not possible. As a result, a pragmatic approach was required to cover as much of the model's scope as practicable within the timeframe. The approach included the following:

1. To check the most critical components of the model;
2. To check the flow of data through the model for at least one of the five Criticality bands if possible;
3. To undertake sense checks on the linkages between the components and a high level check of the computational integrity, without the detail of a cell by cell (or query by query) analysis;
4. To understand the model post processing and the interface between VTISM and the ICM Tier 1Track Model.

The methodology undertaken attempted to deal with the model's large number of linked databases and excel components using the following methods:

1. Visual Basic Macros to extract the database tables and select queries involved within each query in order to build a picture of the data flow through each database;
2. The database linkages were extracted from the "MSysObjects" hidden table in order to understand and document how the data flows between databases;
3. Advanced Searches within Excel to identify the linkages to other Excel spreadsheets within specific tabs, and to identify where Pivot Tables had come from an external spreadsheet; and
4. Calculation Integrity checks were undertaken where possible, and the flow of data was recreated for samples of data for key sections of the model that were available.

4.3 Model Overview

The definition of what constitutes the VTISM Tier 1 model has a degree of flexibility. Within the VTISM documentation there is frequent reference to a Graphical User Interface (GUI) that has not been used for the purposes of running the assessments for the IIP. As such, it is very difficult to relate the model as documented with the variant of the model that has developed.

The databases that constitute VTISM are consistent with the Policy document; however for the IIP version of the model, they have been manipulated directly rather than using the GUI. Therefore the variant of VTISM used would not be recognisable to a user that was experienced in the standard software. For the purposes of this audit, "IIP VTISM" or "the model" is used to describe the entire Track Model excluding the ICM Tier 1Track Model and the Tier 2 Models.

The IIP VTISM model itself includes approximately sixty databases that are important to produce the Tier 1 outputs for a single set of assessments for a single criticality band. For the entire model, consisting of four sets of assessments each for five criticality bands, there is likely to be in excess of one hundred. This number of databases is in part related to the 2Gb file limit for MS Access. Many of the component databases are approaching this limit, meaning consolidation of the databases is not necessarily straightforward.

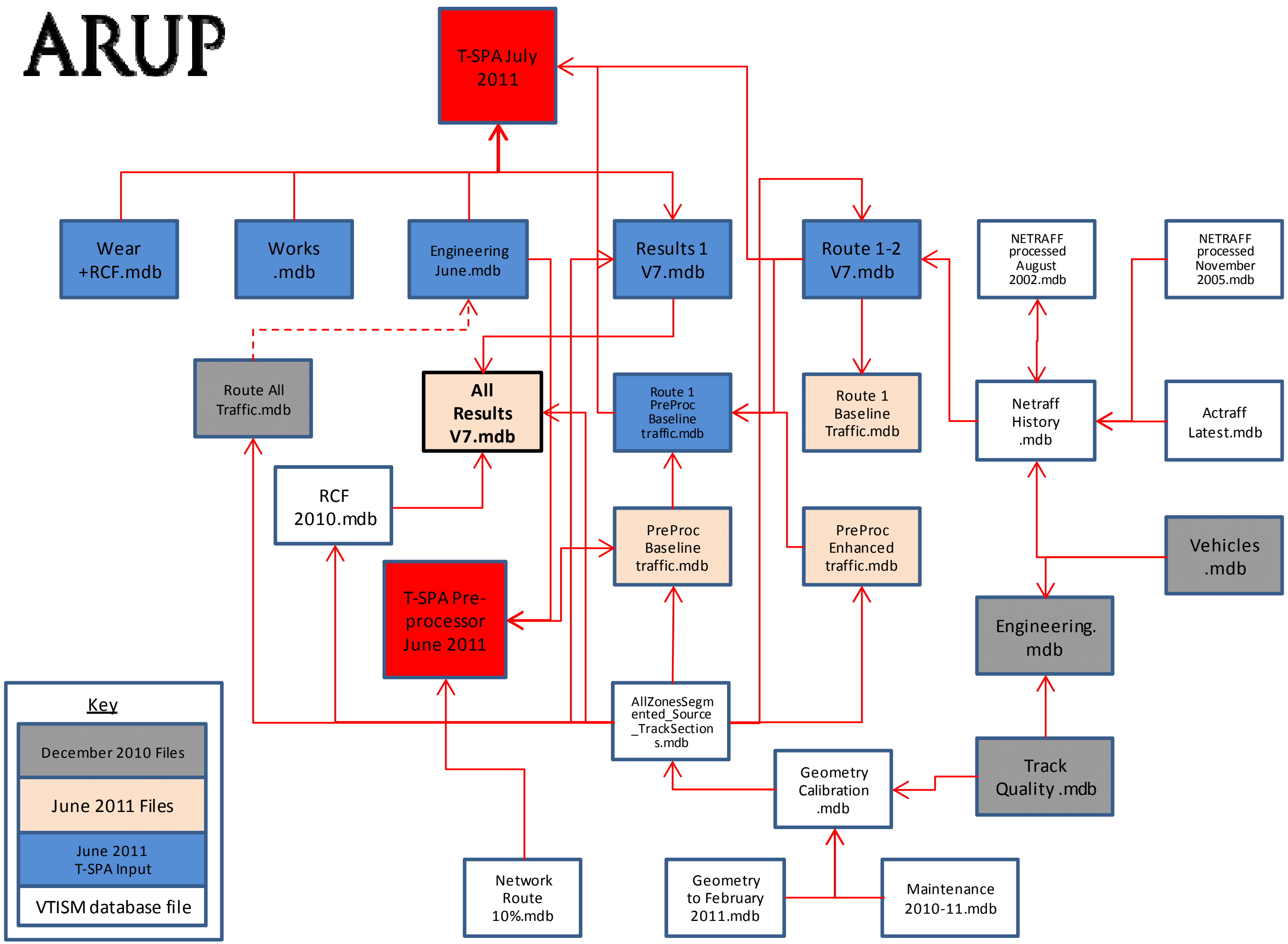
The assessments are chronological developments of the model that have been run at certain dates to reflect the latest stage of the modelling. There are some files that are common between assessments, and there are some files in later assessments that have been derived from the files used in earlier assessments. The assessments that have been undertaken using the model are the following, where only December (2010) and June (2011) have been reviewed to any extent:

1. December 2010: Initial runs to establish the route criticality targets and approximate renewal rates to the end of CP5. The results formed the basis of the first cost estimates;
2. March 2011: Second set of runs, with updated dataset using the same volumes as December 2010;
3. May 2011: Third set of runs, extended to the end of CP11, accounting for increased refurbishment; and
4. June 2011: Final set of runs for IIP, with final policy, engineering parameters and datasets, using an updated version of T-SPA (Track Strategic Planning Application).

The three main components within the model are the Asset Register derived from GEOGIS, the Traffic derived from NETRAFF and ACTRAFF and the Geometry Calibration data that uses historical data to derive curves that determine the localised track deterioration rate. Of these, GEOGIS and NETRAFF are live industry standard databases.

These databases are used as inputs to a variety of pre-processing databases that are then input to the T-SPA programme that is used to simulate the prioritisation of work undertaken, and the impacts of the policy on the long term quality of the track. After the data has been processed using T-SPA, the results are collated for each criticality band in a single database. The post processing involves the conversion of the outputs, from volumes to costs (using the unit costs). This post processing takes the detailed modelling outputs from the Tier 1 model to the high level Tier 0 output. A flow diagram of the key databases is shown on Chart 4.1.

Chart 4.1: Sample of model linkages to produce Criticality Band 1 output.



4.4 Computational Integrity

4.4.1 Model Databases

The significant number of databases within the model created the requirement for some automated processes to produce diagnostics. A Visual Basic code was combined with an SQL extraction process to identify all the table and queries used within each database. This identified a significant number of temporary queries used for a variety of one off calculations, and a number of broken queries where the constituent tables and queries no longer existed. This suggests that a number of updates to the database had modified its functionality, such that either the query is important but no longer functional, or is redundant. Without any appropriate functional specification it is impossible to say which the case is. A final issue was that there are significant numbers of tables within the databases that are neither produced as part of the data processing nor used during the process. The purpose of these tables is largely unknown and it has been assumed that they are remnants from previous work that have not been removed.

The databases we received were checked to ensure they had been set up to avoid inappropriate and accidental manipulation of the core data by queries. As a large number of Append queries are present, it is important to make sure that data is not duplicated (appended more than once). In the sample of cases that were reviewed the database had been set up with Primary keys to stop duplication of data by running the same Append query twice. There are other types of action query such as “Make Table” and “Update” where it is very difficult to be sure that they have been run or not. It would be sensible where there are a significant number of queries to automate the running of them using an Access Macro or VBA so that the manual component of the process is removed and to add some uniformity and reproducibility to the processes.

4.4.2 Data Processing using Excel

The main areas where Excel is used in the model are

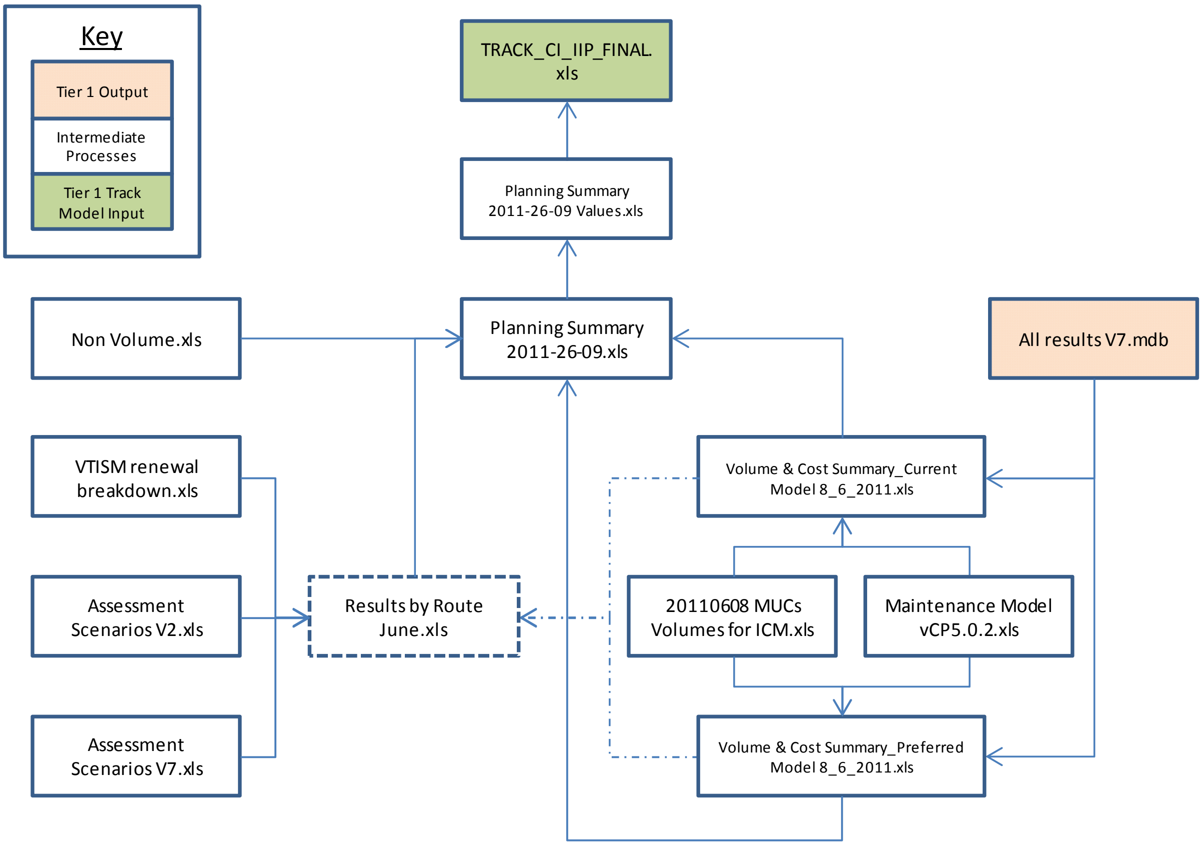
1. Standalone spreadsheets to analyse data in order to determine standard relationships and functions that can be fed back into the modelling; and

2. A series of linked spreadsheets to post process the data from VTISM output to the ICM Tier 1Track Model.

The standalone analysis spreadsheets make use of a variety of techniques including Pivot Tables. The implementation of the calculations is robust, however it is not possible to verify they meet the specification as the precise methodologies are not documented. There are also a few tabs within workbooks that have not been named specifically, retaining the “Sheet1” or “Sheet2” defaults. In addition as data has been extracted from another database using a copy and paste, with only a name of the query (and not the source database or date of extraction), it is very difficult to determine whether the data is current and from an appropriate source.

The linked spreadsheets include a series of processes that manipulate the aggregated outputs for all routes from VTISM for input into the ICM Tier 1Track Model. The data is copied and pasted from the database to the first spreadsheets and Maintenance data is merged in. The spreadsheets are then passed through several intermediates before passing to the Tier 1Track Model where the values are pasted in manually. There are a few issues of concern. Maintenance data is imported via a Pivot Table link. The same Maintenance spreadsheet "Maintenance Model vCP5.0.2.xls" produces the values for both the "preferred" and "current" scenarios. Therefore these values are not stored in a unique spreadsheet, and hence require a degree of knowledge of what the current Maintenance scenario is in the spreadsheet. Ideally there would be a spreadsheet stored for each scenario variant to add a level of clarity to the process. The key spreadsheet in the process is "Results by Route June.xls" which appears to have a few external references that confuse scenarios, a few broken links, formulae errors, and areas that if cleared up would add an element of accuracy and confidence to the process.

Chart 4.2: The flow of data from Tier 1 output to Tier 0 input (where dashed lines indicate checking is required).



4.4.3 Using T-SPA (Track Strategic Planning Application)

T-SPA is Network Rail's Track Strategic Planning Application. It is a decision support tool designed to provide a detailed analysis of a broad range of renewal and maintenance options. In particular the volumes and cost of the work are linked to the condition and performance outputs that would be obtained.

The data processing and manual inputs that are required for the T-SPA Pre-processor and the main T-SPA application are extensive. The pre-processor requires the routes to be broken down into five separate fragments each processed individually for the set of twenty years, and for each of the two scenarios (Current and Preferred/Enhanced). These are all run individually and appended together in an output table “AllPreProcData”. Although these runs are all undertaken manually, they are self-checking, as the use of primary keys ensures that data is not appended more than once. Also, if one of the pre-processing combinations is forgotten there is a failsafe that the main T-SPA run will not work, thus identifying that routes are missing. Hence although this process is largely manual, it is computationally robust provided the operator is sufficiently experienced to understand what is occurring.

It was not possible to replicate the pre-processing as our sample of data did not contain all of the necessary files. However, it was possible to reproduce the June assessment outputs from the main T-SPA application for route (criticality) one. To achieve this, a .mod file that stores all the settings is opened in T-SPA. Then provided the Security files are in the correct location, and the files have the correct path, the data can be loaded in the “Data” tab. Provided this works correctly without any errors the “Scenario” tab can be chosen where the appropriate scenario can be selected using the “+” and right clicking to run.

Once the scenario is completed the “Graphs and Export” tab can be chosen. Right-clicking “Export” to “Dump Asset Data” creates the “Asset Dump” table in the specified results database specified in the setup. The “Asset Dump” is only a temporary set of results that is appended to the “000 All Asset Dump” for permanent storage. For the Route 1 scenarios we were able to compare our temporary results with the results stored in the database and verify that they were identical.

4.4.4 Sensitivity Tests

The scope of the model meant it was too vast to cover the full mechanics of the model comprehensively. A pragmatic approach was adopted to sense check the outputs with the use of sensitivity tests. A single sample Strategic Rail Section (SRS) was prepared for each of the five different criticality bands, each being of similar length of approximately 160km.

The following random selection of routes was made:

Criticality Band	SRS	Route
1	NO3	Stafford to Crewe
2	K15	Swindon to Bristol
3	H07	Hull to Micklefield
4	G17	Stockton to Newcastle
5	I08	Skegness to Grantham

The sensitivity sets were set up by Network Rail using a stripped down set of files derived from the June assessments. This allowed run times to be reduced significantly, and for the results to be meaningful and identifiable as they related to the single SRS in question. For each route, a T-SPA mod file was created each with a core scenario called “Baseline” that contained the standard scenario work volumes that would be the reference point against which the sensitivity results would be compared. In addition to this, an input work volume spreadsheet template was created to allow the sensitivity volumes to be calculated. These were in the correct format that made it easy to paste into the T-SPA scenario.

The process undertaken to run the scenarios was to copy the existing “Baseline” Scenario (in T-SPA) and use the spreadsheet to calculate a ten percent decrease in the volume. This was done by pasting in the update volumes into the scenario set-up and running it to see how they changed the key measures of the quality of track. The following intervention types were undertaken:

1. Renewals Only – Complete Traxcavation, High Output Complete, Steel Sleeper and S&C Renewal;
2. Geometry Only – Tamping and Stoneblowing for both Plain Line and S&C.
3. Refurbishment Only – High & Medium refurbishment for both concrete and other;
4. All Work Volumes – All interventions reduced (renewals, geometry and refurbishment.

In addition to modifying the work volumes, two other sensitivity tests were undertaken. One was to increase the Geometry deterioration parameter by ten percent to reflect the track deteriorating ten percent faster. A sensitivity test on amount of tonnage was also undertaken. This was less straightforward to modify, so volumes from the “preferred” Scenario were used. As this was not a consistent increase (unlike the ten percent in other tests), the tonnage was also output so that the change of Track quality observed could be put into context. Table 4.2 illustrates the sensitivity tests that were undertaken, where the full combination of runs was not necessary based on the differing policy by criticality band. A full set of outputs are included in Appendix B.

Table 4.2: T-SPA Sensitivity Tests undertaken.

Criticality Band	All Work	Renewal Only	Geometry Only	Refurb Only	Deterio-ration	Tonnage
1	☑	☑	☑		☑	☑
2	☑	☑	☑	☑	☑	☑
3	☑	☑	☑	☑	☑	☑
4	☑		☑	☑		
5	☑		☑	☑		

The results of the sensitivity tests showed that for the Good Track Geometry (GTG) indicator, the Criticality Band 3 SRS appeared the most sensitive. For Poor Track Geometry (PTG) the Criticality Band 2 SRS was the most sensitive. These were the most noticeably different results from the full set and are most likely due to specific track characteristics for each of these routes.

Apart from the few route specific subtleties, the majority of the sensitivity test results were in line with expectations and internally consistent. This provides a measure of confidence that the model is performing as expected. However as the sample is only very small, this provides limited assurance on the computational accuracy and quality of the input data.

4.5 Data Inputs and Model Assumptions

The Track Asset Policy Document includes a range of Asset Inventory statistics that have been produced during the model development. These include the breakdown of Plain Line Track assets by type, the total kilometres of each, and other corresponding statistics for items such as Sleeper type. Ideally it would be useful to have an independent source against which to verify the numbers in the model. However due to the difficulty in obtaining these statistics, the model is the only available tool to produce the benchmark numbers.

The key inputs to the model are the following:

- The Asset Register (GEOGIS)
- Historical Traffic Data (ACTRAFF/NETRAFF)
- Geometry Data (8th mile Standard Deviation (SD) record)

The Asset Register, where all the asset data information resides, has been derived from GEOGIS. The Model Implementation Guide states that the GEOGIS database implemented in VTISM was downloaded on 15th October 2010. Following its download, Network Rail have 'cleaned' the data and filled missing gaps to improve its accuracy. This process has been fed back to also improve the main GEOGIS database. This process of improving the data quality is ongoing, but we are not clear if this data input file is formally versioned, which will make it difficult to replicate previous runs of the Track model. In addition, it is not clear if the Track Policy document which records the summary of track inventory has kept pace with the updates made.

The Traffic data comes from two sources; the most recent ACTRAFF data and the 2008 NETRAFF data. These were reconciled together to represent the current traffic on the network. Although there is documentation on the approach for doing this, the precise detail of the exact origin, date and version information of these files is vague. It would be useful to understand the precise source in order to understand the strengths and weaknesses of the datasets. The situation is similar for the Geometry data where the precise dates of origin and source of the data are unclear. The data is stated to be the 8th mile Standard Deviation (SD) records for the last five years, however the start and end dates are not clear.

The model includes a significant number of assumptions. There is no complete assumption register for the model, and due to the volume and complexity of the internal processes, as well as not having access to the full model it has not been possible to fully identify their full extent and impact. To compensate, we consulted Network Rail to understand the key assumptions, which are the following:

- Heavy Refurbishment extends the life of the Asset by 50% and Medium refurbishment by 25%;
- If the Ballast installation date is unknown it is assumed to be the Sleeper Installation date;
- Absolutely choked ballast deteriorates four times faster than absolutely clean ballast, though this is capped so that it is never 2.8 times worse than the theoretical model (based on observed data); and

- PR08 Service life is assumed. The service life determines the expected life based on age and cumulative tonnage. The use of PR08 service life is perhaps conservative.

4.6 Modelled Interventions

The intervention point when options for track renewal are considered is based primarily on the asset component service life, but may be influenced by track geometry deterioration. As stated above, the service lives used in VTISM are based on those used for PR08, which were based on average component ages in each of the 7 track categories and for specific gross tonnage bands at the time of renewal in 2007. The CP5 Track Policy states that service lives are related to the equivalent gross tonnage experienced by the asset and the asset construction type. We consider that using the PR08 table is slightly conservative.

The type of track renewal or refurbishment undertaken at an intervention point in the model is user defined, supported by one of the Whole Life Cycle Cost Tier 2 models which are independent of VTISM and designed to comply with the Track Policy.

Track maintenance intervention points are modelled from two sources. The first for rail is the Whole Life Rail Model which calculates the rail Rolling Contact Fatigue (RCF) damage and side wear rates and the second is the T-SPA pre-processor, which is used to calculate theoretical geometry deterioration rates based on the track characteristics. These are described in more detail in Section 8.5.4 of the Track Policy.

In summary, modelled intervention points for track renewals are consistent with policy as they are based on PR08 track service lives which are gross tonnage dependent. The intervention actions are consistent as they are user defined inputs based on the policy and are not modelled. Track maintenance interventions are based on current practice. For rail and geometry they are supported by bespoke modelling within VTISM. User defined intervention options are supported by independent Tier 2 models.

4.7 Overall View on Uncertainty of Outputs

Overall, we can only provide limited assurance on the outputs as we were unable to receive the full set of modelling files. In many cases we only have a single sample of the multiple sets of databases running parallel processes, so it was impossible to verify that they had all been implemented identically, or in a functionally similar fashion. In many cases the subset of files we received limited the extent to which data could be checked. For example in Access, if a linked table was absent, the design of the subsequent queries in the chain could not be viewed easily, and the data itself could not be viewed. This limited the extent to which the flow of data through the model could be checked, and in particular meant that in a lot of cases the chain of events was broken, meaning that the entire process could not be assessed.

The model has a significant number of elements that require manual input or processing. Some of these are essential, though the rest can be eliminated by improvements in the design. In many cases there was a lack of transparency in how this was done which introduces some uncertainty. In addition, each manual process increases the scope for input errors, in particular the following examples:

1. The inputs to T-SPA require manual inputs to set the particular work volumes (the application of the policy) for the particular scenario;
2. One off manual processes to import text files into databases; and
3. Manual Copy and Pasting from Access to Excel.

Uncertainty is also present due to the lack of precise and specific documentation to accompany the detail of the approach used in each of the key databases. The following documentation was reviewed:

1. *Track Asset Policy* describes a high level outline of the main themes within the Track Model and the broad approach to the modelling.
2. *Model Implementation Guide* that explains the key input files, though lacks documentation of exactly which the key files used in the assessment were, and does not cover the contents and processes within each database in detail.
3. Various other VTISM technical notes that are difficult to relate to the model in its current form (See Appendix B).

The set of VTISM documentation as a whole is no longer fully relevant or representative of the model that has been implemented for the assessments. The VTISM model that is documented has a GUI (Graphical User Interface) to assist with the set up of the model. The model set up to run the IIP no longer uses this interface, and it is uncertain whether the model still functions in an identical way, or has adapted away from the standard functionality. Although the Model Implementation Guide provides some substance in order to understand what some of the key database/spreadsheets are, it is not comprehensive or specific for the assessments, and does not deal with their contents. In several cases an individual database has in excess of one hundred sub components (queries) that do not have any individual explanation. As there is no functional specification to measure the performance against for the majority of these, they function as black boxes, and there is no reference for the inexperienced user to gain an understanding of any of the specific databases used in data processing.

There are several locations where the data has been input manually using a copy and paste rather than a joined Excel table (such as in the Tier 1Track Model input processing) or where temporary processes are used, that are no longer present, to import and process the data (such as in “Wear + RCF.mdb”). This made the task of following the flow of data through the model much more difficult and in some circumstances left uncertainty as to the reliability and reproducibility of the data.

For a typical database in the process the following factors make it difficult to determine the critical path to produce the required output data:

- the significant number or queries and tables;
- the lack of specific documentation;
- the number of temporary outputs and calculation;
- intermediate manual processes; and

- inconsistent and confusing use of naming.

In summary, we can only provide limited assurance on VTISM. Though errors or faults could not be found in the majority of the modelling, it is impossible to draw definitive conclusions given the sample of files provided and the number of manual processes. The model user is highly experienced and able to operate the model extremely effectively. Due to his complete understanding of the model specification and functionality, there is a diminished likelihood of major issues.

It was possible to reproduce the modelled numbers for some of the most important and complex parts. These processes were generally well established; in particular the functionality of T-SPA is well documented and has been rigorously tested. All of the T-SPA model set up information is stored in .mod files, and we were able to use the files provided to reproduce the expected results independently..

In less established areas of the modelling, particularly the post processing from VTISM to the Tier 1Track Model, untidiness and calculation errors are evident, and the model does not have the same level of accuracy and completeness. An example of this is evident in the spreadsheet "Results by Route June.xls". In the "Maintenance Enhanced" tab the wrong spreadsheet is referenced in row 52. The implications of this are that errors will be propagated into the Track Tier 1 Model.

4.8 Suggested Improvements

Overall, we can only provide limited assurance on the outputs as we were unable to receive the full set of modelling files. In many cases we only have a single sample of the multiple sets of databases running parallel processes, so it was impossible to verify that they had all been implemented identically, or in a functionally similar fashion. In many cases the subset of files we received limited the extent to which data could be checked. For example in Access, if a linked table was absent, the design of the subsequent queries in the chain could not be viewed easily, and the data itself could not be viewed. This limited the extent to which the flow of data through the model could be checked, and in particular meant that in a lot of cases the chain of events was broken, meaning that the entire process could not be assessed.

The model has a significant number of elements that require manual input or processing. Some of these are essential, though the rest can be eliminated by improvements in the design. In many cases there was a lack of transparency in how this was done which introduces some uncertainty. In addition, each manual process increases the scope for input errors, in particular the following examples:

4. The inputs to T-SPA require manual inputs to set the particular work volumes (the application of the policy) for the particular scenario;

5. One off manual processes to import text files into databases; and

6. Manual Copy and Pasting from Access to Excel.

Uncertainty is also present due to the lack of precise and specific documentation to accompany the detail of the approach used in each of the key databases. The following documentation was reviewed:

4. *Track Asset Policy* describes a high level outline of the main themes within the Track Model and the broad approach to the modelling.

5. *Model Implementation Guide* that explains the key input files, though lacks documentation of exactly which the key files used in the assessment were, and does not cover the contents and processes within each database in detail.

6. Various other VTISM technical notes that are difficult to relate to the model in its current form (See Appendix B).

The set of VTISM documentation as a whole is no longer fully relevant or representative of the model that has been implemented for the assessments. The VTISM model that is documented has a GUI (Graphical User Interface) to assist with the set up of the model. The model set up to run the IIP no longer uses this interface, and it is uncertain whether the model still functions in an identical way, or has adapted away from the standard functionality. Although the Model Implementation Guide provides some substance in order to understand what some of the key database/spreadsheets are, it is not comprehensive or specific for the assessments, and does not deal with their contents. In several cases an individual database has in excess of one hundred sub components (queries) that do not have any individual explanation. As there is no functional specification to measure the performance against for the majority of these, they function as black boxes, and there is no reference for the inexperienced user to gain an understanding of any of the specific databases used in data processing.

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For a typical database in the process the following factors make it difficult to determine the critical path to produce the required output data:

- the significant number or queries and tables;
- the lack of specific documentation;
- the number of temporary outputs and calculation;
- intermediate manual processes; and
- inconsistent and confusing use of naming.

In summary, we can only provide limited assurance on VTISM. Though errors or faults could not be found in the majority of the modelling, it is impossible to draw definitive conclusions given the sample of files provided and the number of manual processes. The model user is highly experienced and able to operate the model extremely effectively. Due to his complete understanding of the model specification and functionality, there is a diminished likelihood of major issues.

It was possible to reproduce the modelled numbers for some of the most important and complex parts. These processes were generally well established; in particular the functionality of T-SPA is well documented and has been rigorously tested. All of the T-SPA model set up information is stored in .mod files, and we were able to use the files provided to reproduce the expected results independently.

In less established areas of the modelling, particularly the post processing from VTISM to the Tier 1Track Model, untidiness and calculation errors are evident, and the model does not have the same level of accuracy and completeness. An example of this is evident in the spreadsheet “Results by Route June.xls”. In the “Maintenance Enhanced” tab the wrong spreadsheet is referenced in row 52. The implications of this are that errors will be propagated into the Track Tier 1 Model.

4.8.1 Operational

We experienced major difficulties in installing and running VTISM successfully. It is substantial with over 100 databases that only has fragmented and high level documentation. We also note that there is a noticeable lack of cover for the model user’s absence. Given our experience, we consider this a major risk for Network Rail in the continued development of the CP5 volumes and costs for the Strategic Business Plan, and would recommend that Network Rail consider bringing in another team member.

The documentation that accompanies the model needs to be more detailed, relevant, and structured in an organised fashion; ideally it would be located in a single document. The individual processes need to be documented to explain how they apply the policy and how they fit together. In addition, there needs to be a record of assumptions, cross referenced to the model documentation to show where the assumptions are implemented. Flow diagrams would be useful for the inexperienced user to understand where individual components fit within the model.

4.8.2 Technical

It is recommended that the flow of data through the model is reviewed from start to finish, and that the temporary and broken links are re-established and made permanent. As an example, the temporary processes that were created to import data to Access from .csv files should be formalised. The use of copy and pasted values from excel should also be reviewed, as there is no need for static values to be copied and pasted into Excel from Access. The Import External Data->New Database Query can be used to create a dynamic link between Access and Excel. This would allow the data source to be documented (within the dynamic link), and with the manual refresh of data, would allow the user to have control of when the data is updated. For all ranges that require a manual update (in excel) it is recommended that the date of the last refresh and the file name is stored in an adjacent cell as a means of alerting the user to the possible need to update if newer data has been created.

Following on from this it is suggested that “clean” versions of the model are created without the temporary queries that have been created in the live database. This should have a directory structure established that is portable, allowing for the easy transfer between users and without unnecessary files and tables within databases, so that it is as small in size as possible. It is uncertain whether there are duplicate files within the model, as there are several instances of different files with the same name. The structure should remove unnecessary duplication.

Ideally a “relative” file relationship should be employed so that the need for the re-creation of the full original directory structure is not required to avoid the time consuming process of repairing links. As we had difficulty receiving a version of the model that was complete, some thought needs to be given to how to make the model portable, how to ring-fence individual sets of assessments, and also more importantly, how to make regular back-ups easier, and how to store completed sets of assessments. This should perhaps be done using a zipping software and they should be stored separately to avoid any cross-contamination of the data and interference with completed runs. As key files are being updated constantly a specific regular back up of model versions will ensure backward compatibility.

The naming convention for the files should also be changed. The names of the files should reflect their specificity and avoid any generic names such as "Standard Engineering.mdb". This would allow the files to be instantly identified without having to open the database to verify its origin. Ideally the name would have the creation date, a version number and the scenario name (if appropriate). The names of the scenarios should be made uniform to avoid any confusion, so the use of "Preferred" and "Enhanced" should be used consistently throughout the model, to avoid any confusion. Where there is a specific requirement for a particular version of the software used to process the files such as T-SPA version (e.g. 1.6.21), there should be a more transparent way of knowing which version to use. If this is also included in the naming convention of the input file, it may add transparency, though this could be included in the name of the containing folder or using another appropriate method. The terminology that defines what is the model could also use some tightening. The interpretation of what is the "track model" can either include or exclude the SRS Maintenance model.

If possible the manual processes and the sequence of steps to produce the data in the more complicated databases could be automated using macros or VBA. This would eliminate any user errors, and give assurance that all key steps have been included.

Finally, it is recommended that the latest version of Excel be adopted. As it has a larger storage capacity, several of the more complex spreadsheet chains could be coalesced, removing the need for linked spreadsheets. As it has multithreading it also will increase the speed of data processing.

5 Track (Renewals & Maintenance)

5.1 Introduction

The ICM Tier 1 Track Model is used to calculate Renewal and Heavy Maintenance costs derived from volumes imported from VTISM, and to use VTISM track asset volumes to forecast non-heavy maintenance costs (SRS Maintenance Model). The model also receives and stores VTISM track condition outputs, non-volume and off –track renewal expenditure forecasts derived offline.

Table 5.1: Tier 1 Costs for Track with Current Railway plus investments for CP5

Description	Costs (£m)	Percentage Spend
RENEWAL COSTS		
Conventional plain line	1165	22.5%
High output renewal	593	11.5%
Plain line refurbishment	93	1.8%
S&C renewal	733	14.2%
S&C refurbishment	210	4.1%
Non-volume	269	5.2%
Off-track	232	4.5%
MAINTENANCE COSTS		
Maintenance delivery	1473	28.5%
NDS delivery	125	2.4%
Offtrack	276	5.3%
Total Renewal and Maintenance	5169	100.0%

5.2 Approach to Audit

In order to get a full understanding of the model and its underlying assumptions and input data, the following checks were undertaken:

- Audit of spreadsheet formulae and data processing;
- Audit of macro coding;
- Checks on the consistency and appropriateness of the input data with the offline input sources;
- Checks of the calculation methodology against the functional specification; and
- Reproduction of the existing results using the spreadsheet(s) provided.

A flow diagram was created in order to help understand the interaction of the different input and calculation tabs within the spreadsheet. As the model is run using Visual Basic, the code was dissected in order to understand the sequence of data processing.

The following meetings and conversations were held with the NR staff responsible for the model and the input data.

Date/Time/Venue	Agenda
13/10/2011 09:30 – 11:00 Arup offices at 13 Fitzroy St	High level walkthrough of Track Tier 1 model
27/01/2012 16:15 – 16:45 Telephone Conversation with Network Rail Modeller	Discussion on the functional specification, resolution of queries and request for offline data inputs.

5.3 Model Overview

The Track Tier 1 model reviewed is an Excel spreadsheet model (named TRACK_CI_IIP_FINAL.xls). The model functions by using offline inputs pasted into yellow cell ranges before the model is executed. Calculations are either applied to large ranges using a Visual Basic subroutine named "Purple_cell" which copies formulae from purple named ranges to values in larger ranges, or the calculations are dynamically refreshed in the relevant tab when the inputs have changed. The entire model is run by the click of a button which calls the required calculations to be sequenced in turn. Overviews of the processes that are undertaken are documented in the Functional Specification (Document Release 002, October 2011) in Section 4.

The model consists of 38 tabs, 19 Visual Basic sub-routines and 215 named ranges. 14 tabs are used primarily for input, 5 for calculation, 17 are calculated using Visual Basic, with 1 main output sheet (Dashboard) and an output to Tier 0 models. The list of worksheets in the model and their primary purpose are identified in the table below.

Tab Name	Type
MD_NetGeog	Input
MD_Scen	Input
Scenario	Input
Tier 0 codes	Input
Dashboard	Output
Settings	Calculation
Scenarios	Input
Time	Input
NetGeog	Input
VTISM work types	Input
VTISM inventory outputs	Input

Normalisers	Visual Basic
MNTs	Calculation
Calculate volumes	Visual Basic
Consolidate current MNT	Visual Basic
Volume consolidation	Visual Basic
Activity Overlays	Calculation
RAM 1112	Input
Policy & RAM adjust	Visual Basic
Veg - drainage - inspection	Calculation
Adjust for veg drain inspect	Visual Basic
MNT Unit Rates	Input
MNT Costs by SRS	Visual Basic
SRS Route Mapping	Input
MNT vols by route	Visual Basic
MNT costs by route	Visual Basic
Ren and heavy maint unit costs	Input
VTISM heavy maint volumes	Visual Basic
Heavy maintenance vols by route	Visual Basic
Heavy maintenance cost by route	Visual Basic
S&C grinding	Calculation
PWAY other	Visual Basic
Consol and adjust Scotland	Visual Basic
Renewals vols	Visual Basic
Renewals costs	Visual Basic
Non-volume and off-track	Input
Condition outputs	Visual Basic
Tier 0	Visual Basic/Output

In contrast to the other Tier1 models, the Track Tier1 model does not have the inbuilt functionality to model the three standard scenarios listed below:

- CR - Current Railway;
- CI - Current Railway plus investments to reduce costs; and
- PP - Preferred Plan.

It has been confirmed by NR that the spreadsheet provided only models the "CI" scenario, with two other separate spreadsheets used to model the remaining scenarios. These spreadsheets have not been provided or reviewed for the purpose of this audit, and are assumed to differ only on the inputs inserted into the model. Although the "Scenario" tab within the spreadsheet has a dropdown box where the scenario can be changed it does not result in the switching between scenarios.

The key inputs to the Tier 1 Track Model are renewals and heavy maintenance volumes, track construction type, category and condition forecasts from VTISM. Track renewal volumes are adjusted offline to take account of the CP4 workbank and High Output plan, although these adjustments do not change the network total of the volumes. For non-heavy maintenance NR Track Asset management have provided offline inputs relating to the 2013/14 delivery plan volumes, and actual 2011/12 RAM volumes (by SRS) for the modelled volumes to be calibrated against.

The renewal and heavy maintenance data is processed by aggregation of the data from SRS to Operating Route using a standard mapping. These are then multiplied by a set of Unit Costs to provide the total renewal and heavy maintenance costs by Operating Route.

The non-heavy maintenance calculations are undertaken by choosing a normaliser metric for each maintenance type. These normalisers are used to calculate an "activity volume per unit of normaliser" factor which when multiplied by the normaliser volume calculates the level of maintenance activity. These activity values are then calibrated to the actual observed values from the RAM 2011/12 volumes and policy driven changes. The volume of activity is also adjusted by the change in value of the normaliser, as predicted by VTISM.

5.4 Computational Integrity

The implementation of the model within the spreadsheet is largely consistent with the Functional Specification, though there are some additional subtleties within the spreadsheet that are not documented fully.

A Visual Basic process was used to isolate each of the spreadsheet's 7822 formula cells with reference to their tab and cell of origin. These were condensed into ranges of common formulae that identified where there were differences in formulae between adjacent cells. An example of where this is noticeable is in the tab "MNT vols by route" where the formulae in the cells L6 and M6 are inconsistent. As this is neither explained in the Functional Specification nor the spreadsheet itself, the validity is unclear. Due to the significant number of calculations it is difficult to document, however it is suggested that ranges with consistent formulae be coloured similarly to highlight such subtle differences.

The three main purposes of the spreadsheet are to calculate the following costs:

- Renewals;
- Heavy Maintenance; and
- Non-Heavy maintenance.

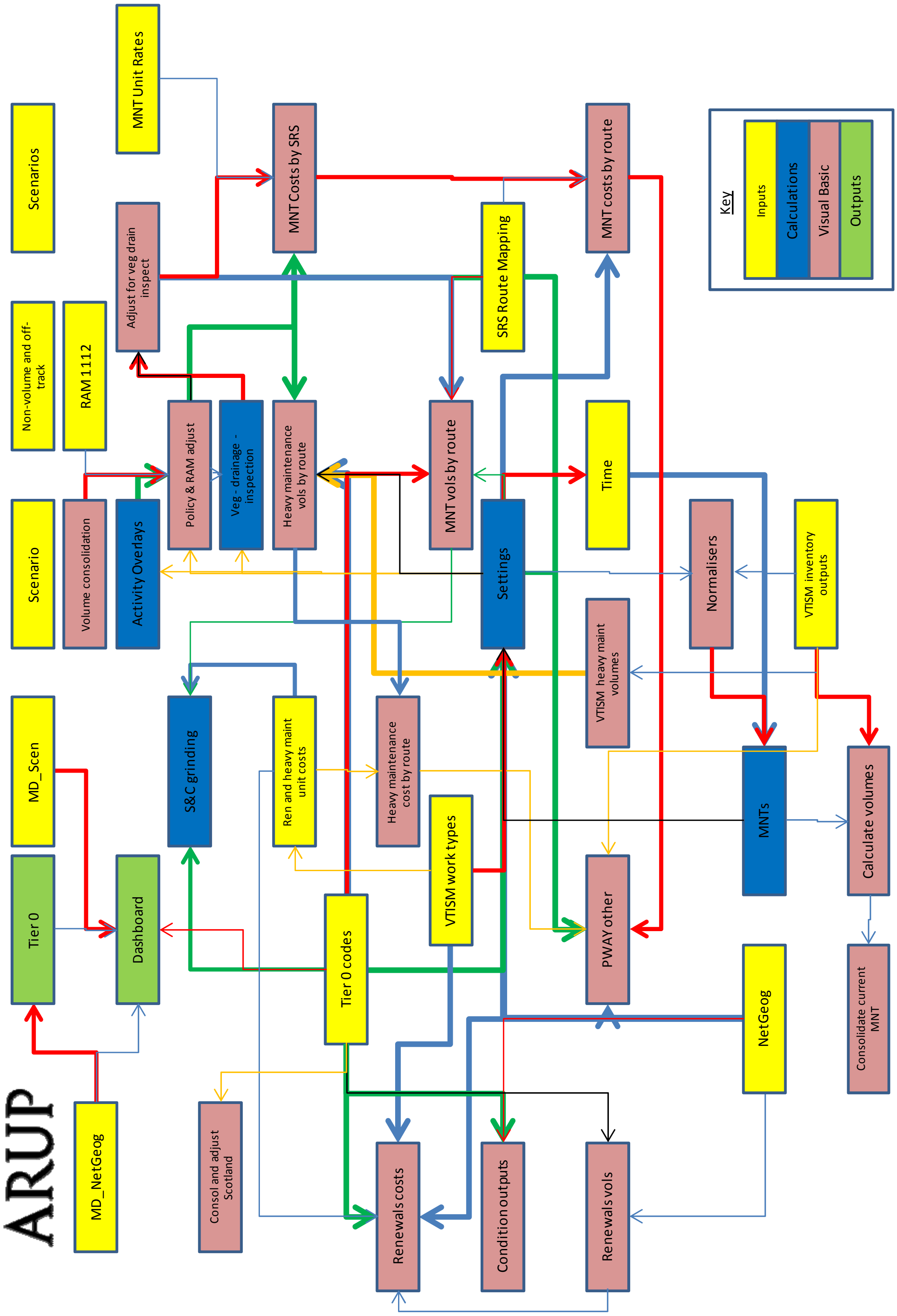
For renewals and heavy maintenance the functional specification does not mention that the volumes are aggregated from SRS to Operating Route as an intermediate step. The calculations for non-heavy maintenance are consistent with the functional specification however there are several subsequent processes that are not documented in particular the following (with the tab where the calculations occur in brackets):

- Implementation of S&C grinding (S&C grinding);
- Adjustment of Scotland's share of maintenance (Consul and adjust Scotland) ; and
- Implementation of the maintenance type PWAY other (PWAY other).

A significant part of the model's functionality is implemented using Visual Basic. This process was dissected line by line with all the Named Ranges checked and the ordering of the processes compared against the Functional Specification. The process is deemed robust in its implementation.

Chart 5.1 illustrates the flow of data through the model. With the exception of the tabs called "Scenario" and "Scenarios", which appear redundant, every component shows a clear purpose and has an integral part in the model.

Chart 5.1 Flowchart illustrating the linkages between tabs within the Tier 1 Track Model (TRACK_CI_IIP_FINAL.xls).



5.5 Data Inputs and Model Assumptions

The data inputs to the Tier 1Track model were reviewed to verify that the correct data sources had been used. Table 5.2 illustrates the key input sheets in the model and the source of information. The tabs in bold font are those which differ for each of the three scenarios (CI, CR and PP) as mentioned in Chapter 5.3. Each of these inputs is derived from VTISM outputs that have been post-processed into intermediate excel spreadsheets. The remaining inputs are static for each of the 3 scenario variants of the spreadsheet. The majority of this data has been input directly by the Asset Management function, and as such no input source files could be obtained to verify against.

The Maintenance unit costs (MUCs) however could be verified against a spreadsheet ("111017 Consolidated unit cost workbook.xls") containing the most up to date unit costs provided by NR. A comparison of the MUCs revealed that the majority were different for both Heavy and non heavy maintenance types. NR advise however that the specified MUCs are wrong and the model is correct.

Table 5.2: The key input sheets and the source of the data

Input Tab	Source	Detail
VTISM inventory outputs	VTISM data reformatted v2.xls	Reformatted VTISM output
MNTs	Provided by Asset Management	
Activity Overlays	Provided by Asset Management	
RAM 1112	Provided by Asset Management	Route Asset Managers
Veg – drainage -inspection	Provided by Asset Management	
MNT Unit Rates	MUCs provided by Maintenance	MUC inconsistency
Ren and heavy maint unit costs	Renewal UCs from Policy, MUCs provided by Maintenance	MUC inconsistency
VTISM heavy maint volumes	Maintenance by SRS.xls	Processed VTISM output
Renewals vols	Planning Summary 2011-20-09.xls	Processed VTISM output
Non-volume and off-track	Provided by Asset Management	
Condition outputs	Planning Summary 2011-20-09.xls	Processed VTISM output

The key assumption in the model that is not mentioned in the Functional Specification is the treatment of MNT022 – PWAY Other. This Maintenance type is forecast differently from the other MNTs and is assumed to be a fixed percentage (8.5% as standard in the model) of a selection of other related MNTs.

5.6 Consistency with Policy

Please refer to section 4.6.

5.7 Overall View on Uncertainty of Outputs

No major concerns were raised by the data and computational checks. However as there are areas where the Functional Specification does not fully document the calculations and processes within the model, there is some inherent uncertainty with what has been implemented and the assumptions made.

There are errors in “Planning Summary 2011-26-09Values.xls” that propagate from intermediate files used to process the data processing (as discussed in section 5.1). As this spreadsheet provides the core inputs to the model from VTISM, it is likely that these errors will propagate through to the Track Tier 1 Model.

5.8 Areas for Improvement (in model)

The Functional Specification could be expanded to cover the calculations and processes that occur in the spreadsheet that are not documented. This will allow the implementation to be checked and put into context. As the spreadsheet is large in size (38 tabs and 7822 calculations), it would be helpful if the Functional Specification and Spreadsheet were aligned so that the areas where calculations are performed could be identified. This could be done using a naming/numbering convention for named ranges that is consistent with the Functional Specification and also including more annotations in the spreadsheet that use standardised terminology.

The use of Visual Basic could be expanded to make the process of auditing the spreadsheet easier and reducing the need for manual input of data into the yellow ranges. Visual Basic could be used to import the input data in an automated fashion, using an input tab, where the names of the input files could be specified. As there are a significant number of manual imports, this would ensure that they are all updated as necessary and using the appropriate source files.

The use of offset functions in the named ranges could also be replaced with static ranges that are calculated in Visual Basic at the start of the model run macro. This would make the named ranges are easier to interpret and mean that they could be navigated by using the dropdown list rather than needing to access them using Name Manager.

It is also suggested that either the functionality be added to switch between scenarios or the tab should be removed altogether to avoid confusion.

6 Electrification Power & Fixed Plant

6.1 Introduction

The Electrical Power and Fixed Plant Tier1 Model is used to forecast activity volumes and costs for Electrical Power and Fixed Plant assets from CP5 onwards. The model dashboard presents the forecast maintenance and renewals costs and volumes by year starting at 2014/15 to 2023/24, totals for CP5 and CP6, and then control period averages for CP7 to CP11.

We understand that all financial output is in 2011/12 prices, stated at CP4 exit efficiency. Many of the renewal and all of the maintenance activities are input as cost profiles with these efficiencies applied outside of the Tier 1 model.

6.2 Approach to Audit

In order to get a full understanding of the model, input data and underlying assumptions, the following checks were carried out:

- Audit of macro coding,
- Audit of spreadsheet and database based data manipulation, and
- Audit of data from input to output to confirm that correct data are being accessed, correct calculations are being applied and model outputs are correctly collated and presented (including link between tier 1 and tier 0 models).

The following meetings were held with the NR staff responsible for the model and the input data.

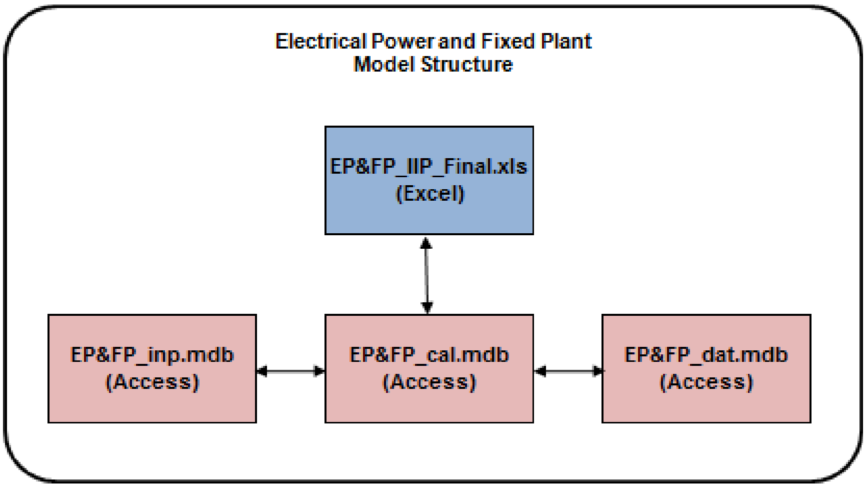
Date/Time/Venue	Agenda
27/10/2011 15:00 – 16:30 at Kings Place	General walkthrough of model
02/11/2011 10:00 – 11:30 at Ryedale House	High level walkthrough of model input data
11/11/2011 09:30 – 11:00 at Arup	Walkthrough of model calculations
16/11/2011 16:00 – 17:30 at Ryedale House	Model inputs and unit costs
21/11/2011 10:30 – 12:00 at Ryedale House	Follow up session on data inputs
28/11/2011 10:30 – 11:30 at Ryedale House	Data Inputs and clarifications

The data and information provided during and subsequent to the initial meetings were reviewed following which further meetings were arranged to review initial queries. All information and data presented, together with the clarifications received at and following the review meetings were referenced in the preparation of this report.

6.3 Model Overview

The model is built using Excel 2003 spreadsheet and Access 2003 database. Excel being the frontend and Access is the calculation engine as shown in **Figure 6.1**.

Figure 6.1: Electrical Power & Fixed Plant Model Overview



The model consists of three MS Access databases with various table and queries within it and one excel spreadsheet. The spreadsheet consists of 21 worksheets, 3 VBA components and 97 named ranges. There are 16 input sheets, 4 calculation sheets and 1 output sheet. The output to Tier 0 model is created within Access which is then manually copied and pasted in to the Tier 0 model.

The model workbank is made up of data from a number of inputs derived from offline sources. A high level documentation of the model structure and input data can be found in the Functional Specification (Document Release 002, October 2011) in Section 9. However, this documentation lacked detail in terms of how the inputs were derived and the model calculations. The latter is important because all the calculations are in Access which makes them more difficult to follow.

Different assets have different methods for generating the workbanks. Some are outside the Tier 1 model and others are in the model.

The model uses five bands of route criticality. The Criticality levels identify the nominal life of the asset. Each of the Strategic Route Sections is assigned a 1-5 criticality grade and this defines the frequency of renewal.

Scenarios Modelled

The three scenarios modelled are as below:

- CR - Current Railway;
- CI - Current Railway plus investments to reduce costs; and
- PP - Preferred Plan.

The 'Current Railway plus Investments to Reduce Costs' and 'Preferred Plan' scenarios include the following inputs which are not included in the 'Current Railway' scenario:

- Energy efficiency – £5m per annum 2014/15 onwards
- Crossrail signalling resilience - £12m in 2014/15 and £8m in 2015/16 (split 50/50 between Anglia and Western)
- SCADA network management - £5m per annum from 2014/15 – 2016/17

Consequently, the results for CI and PP scenarios were found to be the identical.

6.4 Computational Integrity

Checks were carried out to ensure that the tables within Access databases refer to the correct dataset in the Excel spreadsheets. The databases were checked to ensure they had been set up to avoid inappropriate and accidental manipulation of the core data by queries. As a large number of 'Append' queries are present, it is important to make sure that data is not duplicated. Macros within the spreadsheet model and in the access database were checked to ascertain their function. A manual check of the formulae in Excel and queries in Access was performed to understand the modelling methodologies used and to confirm the suitability of the results. The calculations were also run on a small sample of dataset to check they are correct.

The significant number of tables and queries within the 'EP&FP_calc.mdb' database created the requirement for some automated process to produce diagnostics. A Visual Basic code was used to identify all the table and queries used within this database in order to understand the calculations within the model.

No errors have been identified in the model calculations itself. However, the structure of the model is comparatively complex and includes several 'linked tables' which need to be specified in accordance with the computer being used. The sequence of queries used in calculations is not particularly clear to an inexperienced user, and therefore, it is difficult to replicate the results without prior hands-on experience.

The process of the audit would have significantly benefited if the model was accompanied with a technical note detailing the modelling methodology and a flow chart to illustrate the calculations within.

The four types of modelling methodologies used in the EP & FP Tier1 model are as follows:

- Cost Profile
- Volume profile
- Age Profile
- Life cycle

Cost Profile - The assets modelled using cost profile methodology accounts for 62% of the total estimated cost for CP5 (maintenance - 26% and renewals - 36%). The forecasts for Cost profile modelling are based on previous patterns of expenditure, expert judgement or from a set of assumptions and calculations carried out offline. These costs are directly input in to the model (i.e. without volumes or unit rates). The Tier 1 model simply distributes them by SRS allocation and adds them up.

Volume Profile, Age Profile and **Life cycle -** are all volume based calculations.

The Volume profile calculations obtain volumes determined from offline models and bottom up work banks and multiply them by the unit rates.

In Age Profile and Lifecycle methods, the renewal volumes for CP5 are modelled within the Tier1 model, which are then multiplied by a unit rate also to give an overall cost (e.g. OLE, HV switchgear renewals, LV DC switchgear, transformers/rectifiers renewals).

The Age Profile calculations are based on an assumed average asset service life, defined in years. Age of the asset is treated as a proxy for its condition and the ageing process is a proxy for the degradation mechanism. When calculating the renewal date of an asset, the model looks up which Criticality band the SRS is assigned and applies the asset technical life corresponding to that Criticality band.

The life cycle modelling methodology is similar to age profile but allows for a number of predefined series of timed interventions at specified points in an asset's life before it is completely renewed. This methodology is used for some OLE interventions only.

The delivery period for renewing each asset is assumed to be five years, with the cost split evenly across them (ie 20% per year). **Table 6.1** below shows the resulting CP5 and CP6 costs by each type of modelling methodology (more details can be found in Appendix C).

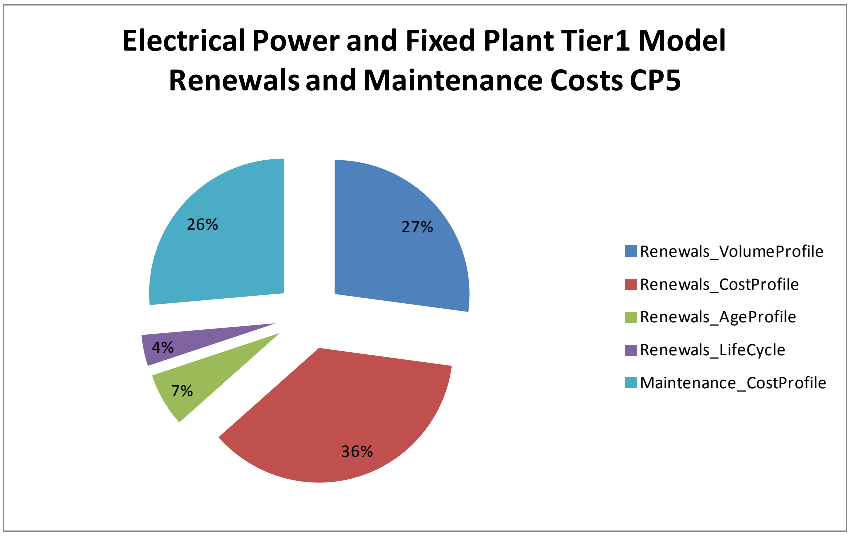
Table 6.1: CP5/CP6 costs associated with the four modelling methodologies in EP & FP Tier 1 Model

Maintenance Costs (£m)	**14/15**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**20/21**	**21/22**	**22/23**	**23/24**	**CP5**	**CP6**
Cost Profile	63	64	65	66	66	66	66	66	66	66	**324**	331
Renewals Costs (£m)	**14/15**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**20/21**	**21/22**	**22/23**	**23/24**	**CP5**	**CP6**
Cost Profile	114	80	88	83	79	72	70	70	70	70	**445**	352
Volume Profile	81	68	67	65	52	40	42	44	38	34	**333**	198
Age Profile	8	11	16	20	25	17	26	25	25	27	**79**	120
Life cycle	0	8	8	15	15	15	24	25	25	25	**46**	114
Total	266	230	245	248	237	211	229	229	224	222	**1,227**	1,115

The CP5 total cost (Tier 1 before applying the efficiencies in Tier 0) of £1,227m is made up of:

- 'Cost profile' Maintenance = £324m (estimated off line)
- 'Cost profile' Renewals = £445m (based on historic spend or GRIP estimates of projects)
- Renewals modelled by Tier 1 = £458m

The split of CP5 costs is shown diagrammatically in the following pie chart.



It was observed that the model received a wide array of inputs from various offline sources and the data in the workbank is fragmented.

No problems or errors have been identified in the model calculations itself. The logic of the model appears to make sense and the formulae have been applied consistently. However, the process of the audit would have significantly benefited if the model was accompanied with a technical note detailing the modelling methodology and with a flow chart to summarise the calculations.

6.5 Data Inputs and Model Assumptions

The model receives a workbank as a key input. It is understood that the workbank was manually compiled from various other data sources and offline models. Due to the large asset base and highly fragmented input sources, it was a significantly complex process to check the data in the workbank and compare it with the data from the input sources.

Therefore, in the time available, a sample of records that have considerable impact on the overall forecast expenditure for CP5, were checked against their sources. However, we recommend that it would be a useful exercise to check all the offline models and other input data sources to ascertain their integrity.

Asset Inventory: The workbank is based on a download from Ellipse for all national assets in autumn 2010 which was subsequently cleaned of errors and then changed to take into account the committed schemes. Spot checks were carried out on HV switchgears to check that the model covers all assets on the network and it was observed that they are closely inline.

Activity Volumes and Unit Costs: All the maintenance costs are derived in an off line model and input into the Tier1 model as cost profile. It includes both planned maintenance and reactive maintenance, with the latter based on historic analysis. CP5 costs are lower once the forecast efficiencies are taken into account. All the renewals are modelled as ‘full’ i.e. no partial renewals.

Almost half of the renewals are input to the model as cost profile (ie without volumes or unit rates). These have been derived off line from a number of sources and the Tier 1 model simply distributes them by SRS and adds them up. They cover a very wide portfolio of assets. Some of the costs are outside the control of NR – for example, Grid Supply assets. Cable theft is an estimate based on judgement. The GE electrification is based on the cost estimate at GRIP Stage 1. The majority of the rest is based on historic spending. For renewals within the model for age profile assets (OLE), the model defines what new asset replaces each old asset.

Maintenance Costs - The maintenance cost profile data from the workbank in the Tier1 model was checked against the source data that was supplied by NR and discrepancies were found. NR have explained that the Maintenance costs derived from the offline models were adjusted to calibrate the data to the observed CP4 spend levels. The purpose of the exercise was to calibrate the split between Scotland and England & Wales to match that budgeted for at the end of CP4 while leaving the National total the same. The original values were checked to compare against these calibrated values and the calibrated values matched with the data in the workbank. This step is not documented in the Functional Specification document and which was acknowledged during the process of the audit. This is an area for improvement with better documentation on why the values have been adjusted and their implications.

A minor discrepancy (24 track km) was observed on comparing the total electrified track km value used to calibrate the maintenance cost data for Conductor Rail to the observed CP4 spend levels, to that in the Annual Return 2011. However, it is concluded that this is unlikely to have a significant impact on the overall forecast CP5 expenditure.

6.6 Modelled Interventions

The Electrical Power (EP) comprises of a large asset base and therefore the model includes input from various sources including some offline models. A sample of checks was conducted against the CP5 policies and these checks show consistency between the policy and the modelled interventions.

- The lifecycle phases modelled in ICM for the OLE asset is consistent with Table 10.4 in the Electrical Power asset policy document.
- Cable theft – the policy assumes that cable theft will remain at the same level during CP5 as CP4, and this is reflected in the model.
- CP5 policy states that HV switchgear shall be programmed for refurbishment or renewal based on condition score (asset health index). Assets shall be prioritised using route criticality banding. This policy has been correctly applied in the model.

6.7 Overall View on Uncertainty of Outputs

No major concerns are raised by the computational and data input checks. However, it is noted that the model depends on several offline analyses and asset management assumptions, and the outputs consequently depend on the accuracy and reliability of these sources.

Our review of the various input data sources suggested that the current process of collating the data for the workbank from various offline sources seems to be too complicated. It is recommended that the process be automated and better documented for transparency.

6.8 Suggested Improvements

The following improvements are suggested.

- An area for improvement would be to streamline the number of tables and queries within the 'ElectricalPower_CAL.mdb' database to simplify some of the calculation processes.
- Also some of the calculations (for example: Cost profile and Volume profile calculations) can be readily computed within the Excel spreadsheet which is the front end of the model.
- The functional specification to include a description of the scenarios modelled and the difference between them in terms of data inputs and assumptions (for example, enhancement schemes modelled). This will provide better clarity in interpreting the model results.
- The output should include the name of the scenario tested to avoid confusion.
- The offline models supplied were neither documented and nor self-explanatory and hence necessitated a few meetings with the asset managers to understand the process of how the data from these models was adjusted (where necessary) and compiled into the workbank.

7 Signalling

7.1 Introduction

The Signalling Infrastructure Cost Model consists of a spreadsheet based model with a number of inputs derived from offline sources. The model is contained in the Signalling_IIP_Final.xls Excel spreadsheet and is built in Excel 2003. The model is documented in the Functional Specification (Document Release 002, October 2011) in Section 5.

The model is used to indicate the renewals element of the selected policy when applied to the population of interlockings utilising a workbank built in accordance with the rules and decision criteria derived from the Tier 2 model for the selected policy (and relevant local factors).

Currently the Infrastructure Cost Model (ICM) utilises a manually created workbank based on a combination of Signalling Infrastructure Condition Assessment (SICA) information, the rules in the asset policy developed from the Whole Life Cycle Cost (WLCC) model analysis, expert judgement and resource and access constraints. For each defined intervention, the costs and effects on the asset base are quantified, and the model changes the technology type of each interlocking based on chosen interventions.

The main outputs are an evaluation of the cost of implementing the scenario, the likely change in maintenance workload, the predicted change in asset performance, any change in the cost to operate the interlockings and the quantity of project work resource required. The workbank and the outputs cover a number of control periods and more than one cycle of major intervention for many interlockings.

The model outputs require accurate unit costs for each work type, and assessments of predicted maintenance and performance. The model currently provides results relating to signal box closure dates to the Tier 1 Telecoms model and provides an estimate of the signalling staff cost savings to the Tier 1 Operate Cost model. These are required due to the Network Operating Strategy (NOS) seeking to progressively reduce the frontline operations workforce by migrating operational management of signal boxes from over 800 locations to a target of 14 modern operating centres.

7.2 Approach to Audit

The approach to the audit has been to check the workings of the macros contained within the model, a check on the calculations and a check on the development of the inputs into the model including the various workbanks. Various people at Network Rail have been spoken to regarding the inputs and the structure of the model.

The following meeting were held with Network Rail to discuss the Signalling Model and the workbanks contained within it.

Date	Meeting
24th October 2011	Signalling Model Overview
16th November 2011	Signalling Model Specific Questions
23rd November 2011	Signalling Model Workbank Overview
30th November 2011	Signalling Model Calculations Overview
5th December 2011	Signalling Model Workbank Inputs

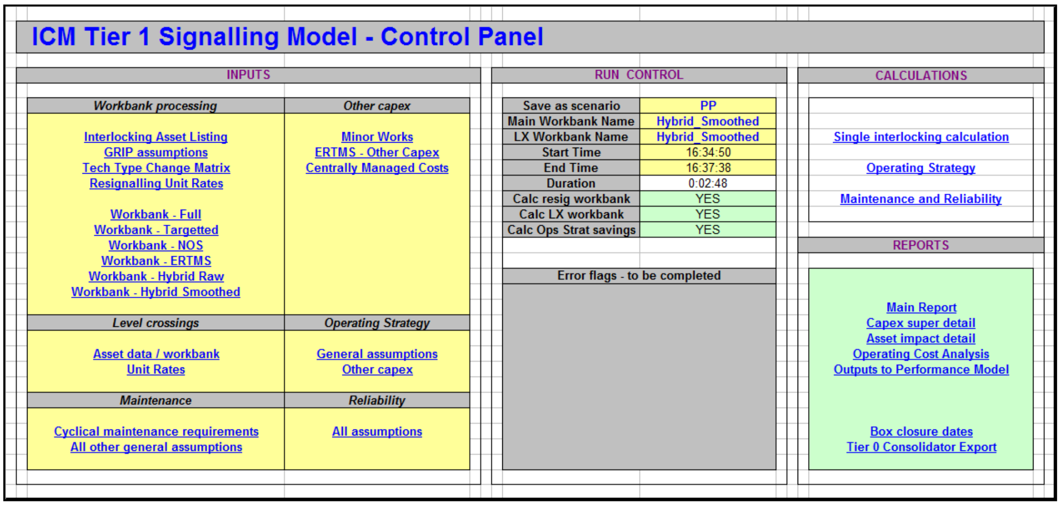
7.3 Model Overview

The model consists of 36 visible worksheets and 2 hidden worksheets. The names of the worksheets and their visibility are shown in the table below.

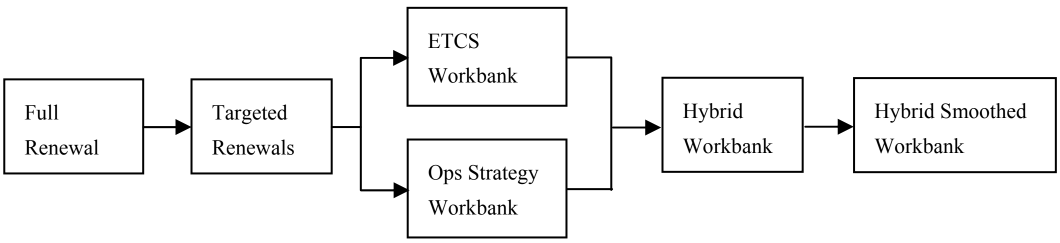
Sheet name	Visible
Change_Control_Log	Hidden
Range thing	Hidden
SYSLL	Visible
000_ControlPanel	Visible
100_I_SICA	Visible
101_I_IXLass	Visible
102_I_GRIP	Visible
103_I_TTchanges	Visible
104_I_IXLunitRates	Visible
105_I_ERTMSotherCapex	Visible
110_I_IXLwbk_FULL	Visible
111_I_IXLwbk_TARG	Visible
112_I_IXLwbk_NOS	Visible
113_I_IXLwbk_ERTMS	Visible
114_I_IXLwbk_HYBR	Visible
115_I_IXLwbk_HYBS	Visible
201_I_LX	Visible
202_I_LX_All	Visible
301_I_MinorWorks	Visible
401_I_SIGBOXass	Visible
402_I_OS	Visible
403_I_OpsStrat_OtherCapex	Visible
501_I_NAT	Visible
601_I_MNT	Visible
602_I_MNT2	Visible
701_I_PER	Visible
801_C_LiveIXLwbk	Visible
802_C_IXL	Visible

803_C_OS	Visible
804_C_MF	Visible
900_ERROR_CHECKS	Visible
901_O_MAIN_REPORT	Visible
902_O_CapexDetail	Visible
903_O_AssetDetail	Visible
904_O_Operate	Visible
905_O_SigBoxLives	Visible
906_O_PM_output	Visible
TIER 0	Visible

The model has the following Control Panel which assists in the categorisation and areas of the various aspects of the model.



The model consists of six signalling workbanks which have been developed to give the preferred plan. The development of the workbanks can be seen in the flow chart below:



A level crossing workbank is also included in the model.

In addition to these workbanks, a number of other inputs are included which help derive the timescales for the signalling renewals.

The model does not directly take inputs from SICA (although SICA is used in the development of the workbanks). In addition, route criticality is not used in the model although Network Rail have advised that they are currently building the process of route criticality into the model to allow for different maintenance policies to be applied.

7.4 Computational Integrity

The main calculations in the model are contained within the following three worksheets:

- 802_C_IXL (Interlocking Calculations);
- 803_C_OS (Ops Strategy Workstation Calculations); and
- 804_C_MF (Cyclical Maintenance & Reliability Calculations).

Looking at these in turn, the calculations in sheet 802 calculate how the costs will be allocated to financial years for the various work types over the life of the project. This allows the costs by GRIP stage to be calculated for each financial year.

Sheet 803 contains the Operating strategy calculations whilst sheet 804 undertakes the cyclical maintenance and reliability calculations.

All the calculations in the model are run from a number of macros. These have been checked and correctly undertake the process they have been written to do. The calculations have also been checked manually in the spreadsheet by replicating what the macros undertake and the same results have been produced.

7.5 Data Inputs and Model Assumptions

The model has a number of data inputs and assumptions contained within it. These are referenced in the Functional Specification document, with many of the inputs and assumptions being derived from the Signalling Asset Management Team.

The Direct Labour Full Employment Costs initially come from the Maintenance Function but have been adjusted to calibrate the model to the observed CP4 spend levels. This is documented in the Functional Specification document. However, the original values have not been checked to compare against these calibrated values. This is an area for improvement with better documentation on why the values have been adjusted and what the ramifications of this are.

Data inputs from the workbanks have been checked against the raw data and appear to have been correctly applied in the model. The following inputs have been checked against the source data:

- Various control points (from SICA reports e.g. PSICA_AN_Acle_30-NOV-2005.xls & PSICA-LNW(N)-Preston-20052010.xls);
- All workbanks in the model (CP5 Signalling Base Plan Workbanks (Anglia.xls);
- The Number of level crossing types (Asset Lists 29-11-11.xls);
- Cyclical Maintenance assumptions (Maintenance Performance Relay Calcs for ICM (25-05-11.xls);

- Annual failure incidents per SEU (Maintenance Performance Relay Calcs for ICM (25-05-11.xls);
- The Planned Maintenance hours per SEU (Maintenance Performance Relay Calcs for ICM (25-05-11.xls); and
- The final control centre opening dates (still to be checked).

The above source data has been checked against what is in the model and most of the data has been accurately input into the model. However, there is a difference in the SICA values for Preston in the model compared to the Preston SICA output (as shown in Table 10 of the Model03 worksheet). On discussion with Network Rail, this is related to the assessment date in the model showing 19/04/05 and the SICA report received being from 20/05/10 so the model does not contain the latest SICA values. . Network Rail has advised that these values do not affect the model calculations.

Checks with the team responsible for the development of the workbank and the inputs were also undertaken and their knowledge and understanding of the inputs is excellent. A presentation has been passed to Arup showing the development of the workbanks (as shown in Section 7.3) from the Full Renewals to the Hybrid Smooth Workbank. This document has been included in Appendix D. It is understood that when renewals are undertaken, the maintenance costs in the following period reflect the type of renewal undertaken and thus are adjusted.

The unit costs in the model have been checked and appear to have been correctly used compared to the independently provided cost units.

For this audit, the accuracy and coverage of the asset databases has not been checked. A number of the data inputs in the model have been checked against the source data but the source data has not been audited any further than that.

The Signalling model has a count of 1654 interlocking areas which is comparable to the approximate number of 1637 interlocking areas shown in Table 1.3 of the ORR-#427988-v1-20110930_NR_PR13_CP5_Signalling_Asset_Policy_for_IIP.PDF document.

7.6 Modelled Interventions

A check has been made of the Asset Policy Document (20110930_NR_PR13_CP5_Signalling_Asset_Policy_for_IIP.PDF) against the model to check that the model follows what is indicated in the policy. At present, the model does not use route criticality in its calculations. The policy states that this would be segmented by strategic route section to allow the most critical parts of the routes to be identified along with the interlockings. As discussed earlier, this is being incorporated into the latest edition of the model.

The workbanks contained within the model reflect current and/or proposed policy, including the European Rail Traffic Management System (ERTMS) and the Network Operating Strategy (NOS) scenarios. The workbanks appear to be consistent in the way they have been developed to that described in the policy. Section 10 of the policy covers the ‘Policy Selection for CP5’ and discusses how the workbanks will best fit with national signalling strategies for ERTMS and NOS and looks at the five scenarios used in the model and explains the reasoning behind them including the maintenance and renewal expenditure.

7.7 Overall View on Uncertainty of Outputs

The model currently provides results relating to signal box closure dates to the Tier 1 Telecoms model and provides an estimate of the signalling staff cost savings to the Tier 1 Operate Cost model. The operating cost calculations within the signalling model have been checked. The consistency of the interface between the Signalling model and the Telecoms and Operate Cost Tier 1 models has been checked as Data Inputs as part of the audits of these two models (see sections 11.5 and 18.5 of this report respectively).

A sensitivity test was undertaken on the 10% assumption for SEU % activity volumes. This is the assumed possible scope efficiency (reduction in the size of the interlocking asset for future capex and opex calculations) for the first time a full resignalling work type is applied to the interlocking. It reflects the ability to remove functionality / routes / layout no longer required from the design going forward, and because it requires redesign rather than just renewal of components, can only be assumed in the case of a full resignalling. This value is a Signalling Asset Management assumption and so a test was carried out to see how sensitive this is to the model and to give an indication of the change in costs if this efficiency was doubled.

Hence, this value was increased to 20%, with the result that the Full conventional and modular resignalling reduced by £82 million and £21 million respectively for CP5. This indicates the sensitivity of the CP5 outputs to this assumption and suggests that the important assumptions should be checked for suitability.

7.8 Suggested Improvements

Overall, the model is well structured and relatively easy to follow in what it is doing. The data input errors that have been identified should be corrected. In addition, the number of assumptions contained within the model may need to be reviewed on a regular basis although it is understood that the inputs are constantly being revised in line with various workstreams.

The documentation should be improved. A useful addition to help show how the model operates would be a diagram showing the principle behind the 802 calculations (GRIP spread across financial years). This is relatively easy to understand with the aid of a diagram. The greatest area for improvement would be to streamline the amount of formulae in the model to simplify some of the processes. The Functional Specification document requires section 5.1.1 (asset description) to be completed and reference made to which worksheet the tables are relating to in the model would be beneficial. Some commentary on the outputs would also be useful as it is not clear if the model is producing SICA outputs (assumed it does not at this stage).

In terms of the workbanks, these are built outside of the model so some documentation on the development of these and reference to the inputs used would provide further clarity on how these are constructed and where the data comes from.

Apart from that, the essence of the model is relatively simple in what it is doing and although not very user friendly for someone new to it, is well understood by the people in Network Rail who develop and use it.

8 Civils Structures

8.1 Introduction

This is an Excel spreadsheet model (Structures_IIP_Final.xls). Section 6 of the Functional Specification (Document Release 002, October 2011) describes the model.

The model estimates Network Rail's expenditure for the following assets:

- Underbridges;
- Overbridges;
- Major Structures;
- Tunnels; and
- Minor Assets.

Table 8.1 summarises the CP5 expenditure as estimated in the Structures Tier 1 model. Underbridges account for the highest expenditure in CP5 as seen below. The modelling methods adopted by each Structures asset vary and several inputs and model assumptions are used to produce the expenditure for future control periods.

Table 8.1: Structures Tier 1- CP5 Expenditure Estimate

Structures	CP5 Expenditure Estimate (£m)
Underbridges	1, 024
Overbridges	152
Major Structures	146
Tunnels	107
Minor Assets	198
Other	75
Total Renewal Cost	**1, 703**
Exams & Assessments	222
Total Maintenance Cost	**222**

It should be noted that the model also reports Earthworks and Drainage expenditures which are forecast in the separate Earthwork Tier 1 model (Section 10). The output from the Earthworks Tier 1 model is a direct input in the Structures model. **Table 8.2** below summarises the estimated CP5 expenditure for Earthworks.

Table 8.2: Structures Tier 1 - Earthworks CP5 Expenditure Estimate

Earthworks & Drainage	CP5 Expenditure Estimate (£m)
Earthworks Total Renewal Cost	425
Drainage Total Renewal Cost	17
Earthworks Total Maintenance Cost	13

8.2 Approach to Input Data Audit

For the purpose of this audit, two meetings were held as shown in **Table 8.3**. The purpose of these meetings was to obtain a general overview of the model, clarify any issues identified and enhance our understanding of the model functionality. The Arup Reviewer of the Asset Policy Review was also involved to check how well the model conformed to the policy.

The structure of the model was mapped out in a flow diagram to aid our understanding. The main data inputs and model assumptions were identified and added to a log of requests for supporting information which was sent to Network Rail to respond. In addition, any queries on model calculations were also included for clarification.

Table 8.3: Structures Tier 1 - Meetings

Date/Time/Venue	Agenda
2nd Nov 2011 9:30-11:30 Ryedale House	General walkthrough of model
15th Nov 2011 14:30-18:00 Ryedale House	Walkthrough of Offline models

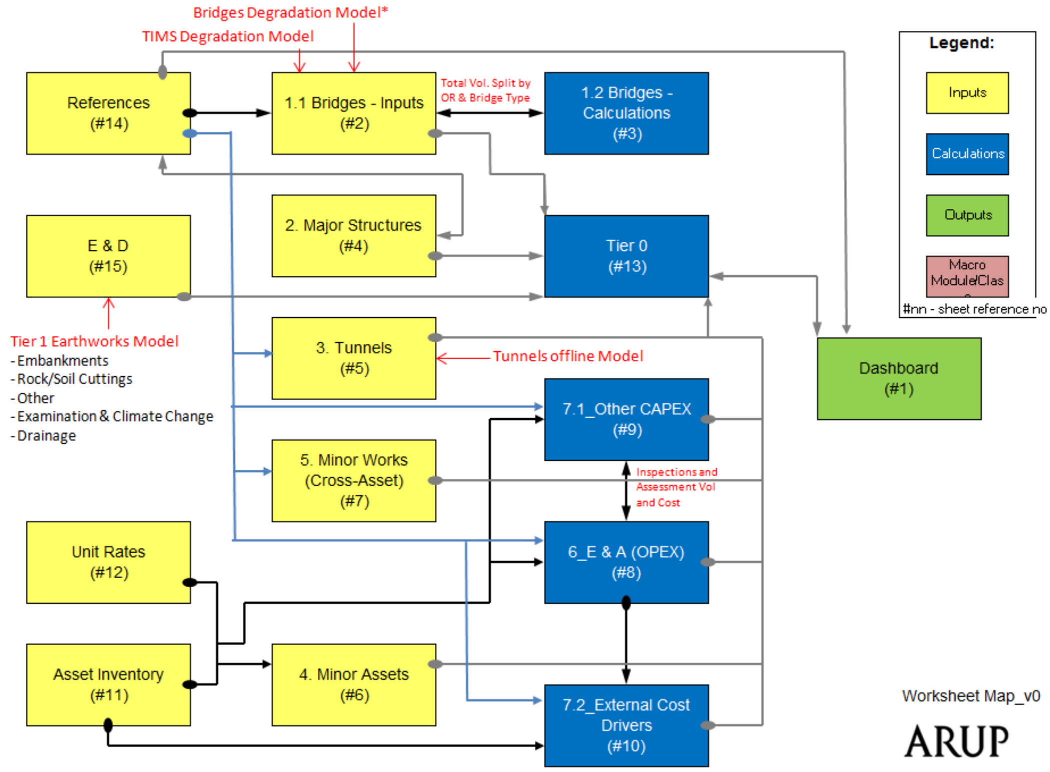
8.3 Model Overview

Based on an analysis that we carried out by using a VBA Macro, **Table 8.4** below summarises the characteristics of the spreadsheet model audited, and **Figure 8.1** illustrates the architecture of the model. Note that 'Tier 0' shown in the diagram refers to the worksheet with that name in the model rather than the separate Tier 0 database reviewed in a later section of this report.

Table 8.4: Structures Tier 1 - Spreadsheet Characteristics

Structures_IIP_Final.xls	
No. of worksheets	15
VBA components	0
No. of named ranges	615
No. of Input Sheets	9
No. of Calculation Sheets	5
No. of Output Sheets	1

Figure 8.1: Structures Tier 1 - Worksheet Map



The model uses several offline models to generate inputs for the Structures model.

- Bridges degradation rates were calculated offline for eight family groups and input to the Tier 1 model. Another offline model was used to generate the uplift to condition as a result of Minor Works carried out on each family group of bridges to the end of CP4 (“Total CP4 BCMI uplift from MW’s repeat exam bridges only”).
- Major Structures are modelled on the basis of a bottom-up workbank and priced accordingly.
- Tunnels uses a combination of condition based top-down modelling (uplifted to include those tunnels that have no condition data) and bottom-up route generated workbanks for CP5 volumes. There is also a check to remove any overlaps between the two methods.
- The CP5 volumes for Minor Works across all structures are derived offline and are based on the volumes of works reported from 2006 to March 2011. They are not reported separately but are allocated between each of the main asset groups.

The model also predicts expenditure on:

- Minor Assets (based on rolling forward CP4 projected volumes);
- Examination & Assessment costs (based on input Cost Profile);
- Other CAPEX (based on input Volume and Cost Profile); and
- External Cost Drivers (based on input Cost Profile).

8.4 Computational Integrity

The formulae in each of the worksheets have been checked and found to be consistent with the Functional Specification. Only one error has been identified in a formula as shown in **Table 8.5** below. The impact of this error is negligible. A full list of the computational integrity checks performed can be found in Appendix E.

Table 8.5: Structures Tier 1 - Computational Integrity discrepancies

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
2. Major Structures	Additional Risk Sum	Z24 : Z306	×	"SDI207.63 = £150" (Cell AJ49) not picked up by lookup. Correction required. Cell AJ49 should state 'SDI1207.63' not 'SDI207.63'.

8.5 Data Inputs and Model Assumptions

8.5.1 Asset Inventory

Table 8.6 shows the asset inventory used in the model. The purpose of this table is to check that all relevant assets are included in the model.

Each of the asset worksheets (bridges, tunnels etc) has its own inputs of asset inventory which is used in the calculation of costs and volumes. In addition, there is a separate 'Asset Inventory' worksheet which shows the numbers of all assets from an alternative source. Finally the Functional Specification provides a count of the assets.

Table 8.6: Structures Tier 1 - Asset Inventory comparison

	Model Input for each Asset Calculation	'Asset Inventory' Worksheet	Functional Specification (Section 6)
Bridges			
Overbridges			
Brick	2, 948	3760	4, 364
Concrete	2, 281	1817	1, 964
Metallic	2, 392	257	2, 815
Other	907	146	311
Total	**8, 528**	**5, 980**	**9, 454**
Underbridges			
Brick	6, 982	9514	9, 689
Concrete	2, 014	2624	2, 647
Metallic	5, 058	7188	7, 288
Other	279	211	453
Total	**14, 333**	**19, 537**	**20, 077**
Major Structures			
Total	**283**	**-**	**283**
Tunnels			
Bores	810	-	810
Total	**810**		**810**
Minor Assets			
Culverts	-	22, 019	22, 019
Footbridges	-	1, 367	1, 367
Coastal, River, and Estuarine Defences	-	558	558
Retaining Walls	-	21, 145	21, 145
Total		**45, 089**	**45, 089**

Network Rail have advised that the discrepancies for bridges in the above table can be accounted for the following reasons:

- The "Asset Inventory" numbers includes Major Structures whereas the numbers used in the bridge model are exclusive of Major Structures. This makes sense since Major Structures are treated separately in the model.
- The "Asset Inventory" numbers include assets with the following operational status which the asset numbers for the bridge model excludes: In Development, Part-removed, Proposed, Blanks, Unlocated, Unknown, part-infilled, operational. This suggests to us that the bridge model under-states the true number of bridges.
- The asset numbers used in the bridges model excludes all data not matched to the new operating routes. The "Asset Inventory" counts assume that the matched distribution is representative of that unmatched to the new operating

routes and so includes them. Again this suggests to us that the bridge model under-states the true number of bridges.

Given the wide range in discrepancies in the bridge numbers, a reconciliation should be undertaken as a matter of urgency.

In addition to the assets shown in the table above, the 'Asset Inventory' worksheet contains details on numbers of Pipe Bridges and Side of Line Bridges which are shown in **Table 8.7**. A Pipe Bridge carries pipes over a railway line and we believe that a Side of Line Bridge is a structure lying parallel to the railway line. Neither are mentioned in the asset policy. Network Rail advise they are included in the Tier 1 model (although this is not made explicit in the model).

Table 8.7: Structures Tier 1 - Pipe bridges & Side of line bridges inventory

	Pipe Bridges	Side of Line Bridges
Brick and Masonry	175	604
Concrete	23	147
Metallic	100	237
Other	242	165
Total	**540**	**1153**

8.5.2 Bridge Assumptions

The method for estimating volumes and costs of renewals in the model for CP5 (and beyond) makes a number of assumptions. These are not specified in detail in the Functional Specification so, given the bridge renewal costs total almost £1.2bn for CP5, we highlight some below.

- Minor Works – their impact on improving the condition of bridges is based on a comparison of condition scores from inspections carried out before and after Minor Works that have been undertaken during CP4. The average impact is then applied to all bridges for CP5. This assumes that all bridges will receive Minor Works during CP5.
- CP4 Renewal volumes – the model assumes that the total projected volumes of renewals for over-bridges and under-bridges will be delivered. However, the relative proportions between the different bridges are assumed to remain the same as those delivered to date which can produce very different volumes from those planned for individual bridge types. For example, if the planned volume for brick under-bridges is assumed instead, then their cost of renewals during CP5 falls by £150m. Network Rail advise that a different methodology will be employed in the CeCOST model which is in development and will be used to inform the Strategic Business Plan (SBP). CP4 Renewals impact – the model assumes that the projected volumes during CP4 will sustain the overall condition of bridges so that the average scores are the same at the end the end of CP4 as they are at the start. As an example of the impact of this assumption, if only 90% of the degradation of brick under-bridges is addressed during CP4, then the CP5 renewal cost increases by £21m.

As a sense check to the method and assumptions, we have compared the implied cost and impact of Minor Works and Renewals. This is shown in **Table 8.8** below for brick under-bridges. It suggests that Minor Works cost 6 times more than renewals to deliver the same BCMI impact for this type of bridge.

Table 8.8: Comparison of costs and impact of Minor Works v Renewals (Brick Under-bridges)

	Impact on BCMI condition score (average per bridge)	CP5 cost	Ratio of impact:cost
Minor Works	+0.4	£180m	1:450
Renewals	+6.1	£450m	1:74

These assumptions might be valid, but given the large costs involved we would suggest that Network Rail should review these assumptions with a view to validating them and/or developing the methodology. Indeed, Network Rail advise that following publication of the IIP, they have undertaken analysis to validate the benefits of Minor Works and major interventions which will in turn be used in the models in development for the SBP.

8.5.3 Other Data Inputs and Assumptions

Appendix E provides the list of data inputs and assumptions that we checked with Network Rail. Of these, those shown in **Table 8.9** were found to be discrepancies against the source data.

We also noted several instances of numbers of assets that were non-integers in the model which should clearly be integers. However, the impact of correcting these will be small.

Table 8.9: Structures Tier 1 - Assumptions & Inputs discrepancies

Structures Model Tier 1, Final Version		Versus	Input Source		Comment
Worksheet	**Description**		**Source Details**	**Description**	
1.1 Bridges - Inputs	Bridge Degradation - *"CP4 BCMI change/day under 'do nothing' scenario"* value for Scotland/Underbridges/Other Cell E67	✗	Deg Rate Transformation Calcs.xls, Sheet *DRs RN Model* Cell S33	Daily Degradation Rate	Degradation rate used for Scotland/Underbridges/Other is different to source. Correction required.
	Total CP4 BCMI uplift from MW's (repeat exam bridges only)	✗	Compressed_Calculations__REPAIRED_v4_Compressed_Calculations__Streamer_Engine_v1.24_-_Bridge_Model_based_on_DB_output_v6_Links_removed.xlsm	TIMS CP4 degradation model	Total CP4 BCMI uplift from Minor Works (repeat exam bridges only) - All values different from source except: Anglia-BB0-B Kent-BBO-O Kent-BBU-O LNE-BBO-O East Midlands-BBO-B Scotland-BBO-O Sussex-BBU-C Sussex-BBU-O Western-BBO-O Western-BBU-O

	Total number of bridges	×	Compressed_Calculations__REPAIRED_v4_Compressed_Calculations__Streamer_Engine_v1.24_-_Bridge_Model_based_on_DB_output_v6_Links_removed.xlsm	TIMS CP4 degradation model	Total number of bridges - counts for the following are all zero in the source file. The values in brackets were instead used in the model: LNE-BBU-O (13) East Midlands-BBO-O (14) East Midlands-BBU-O (6) Wales-BBU-O (24) Wessex-BBO-O (4) Wessex-BBU-O (2) Total No. of Bridges: Bridge Totals (by bridge type/Material Type) different to those in "Asset Inventory" tab.
E&D	Earthworks & Drainage, Expenditure per CP for: - Soil cuttings - Rock Cuttings - Embankments - Examination & Climate Change - Other - Drainage	×	Tier 1 Earthworks Model, Version 6	Inputs fed from Worksheet "Tier 0"	CP year values pasted in E&D are different from the Earthwork's Tier 0 tab. However, totals do add up on Dashboard. This will need to be updated.

8.6 Modelled Interventions

A comparison of the Structures Asset Policy document and the Tier 1 Structures model is presented and discussed in detail in Arup's report 'Part A Reporter Mandate AO/017: Initial Industry Plan (IIP) 2011Review - Summary Report - Observations and Conclusions', dated 16th December 2011 (see section 7.4).

In brief, the policy describes different interventions for each of the five Route Criticality bands. The current Tier 1 model does not include Route Criticality. We have been advised by Network Rail, however, that this will be included in later versions of the model if the current model continues to be used and not replaced by CeCOST.

The degradation rates within the Structures model are consistent with data provided in the policy. The volumes of work calculated by the model are also generally consistent although there is no direct linkage with the Policy.

8.7 Overall View on Uncertainty of Outputs

Only one computational has been found in the model which has negligible impact on the estimated costs and volumes. However, we have serious concerns about the assumed number of bridges that have been modelled. Given the cost of renewing bridges is £1.2bn out of the total structures renewals of £1.7bn, we view this as a major uncertainty.

8.8 Suggested Improvements

The suggestions for improvement are made:

- Lack of documentation for the Structures Tier 1 model and associated offline models impeded the auditing process. It is proposed that thorough documentation of the model is prepared, including guides to the model itself, to assist the user to operate the model.
- Review the assumptions (and method) for estimating renewals volumes for bridges. As well as those described above, it was noted that the degradation rate for "Other" bridge material (for every 10 operating routes) was estimated by taking the average of Masonry, Metal and Concrete degradation rates for that particular operating route. The validity of this assumption should be reviewed by Network Rail.
- Since a considerable number of "lookup" formulae have been used in the model, it is easy to miss values that have been entered under a different name (refer to error in section 8.4). To avoid this, use of the "Data validation" on Excel could be used to restrict invalid input data. Alternatively, a simple check on the totals could be included to check if all values have been picked up by the "lookup" formulae.

9 Buildings

9.1 Introduction

The Buildings Tier 1 model is split by Franchised Stations and Managed Stations and consists of three spreadsheets as represented below. It is documented in the Functional Specification (Document Release 002, October 2011) in Section 8.

The expenditure for Franchised Stations is also reported in the Managed Stations model, that is, spreadsheet *BUILDINGS_ OTH_IIP_FINAL.xls*.

Table 9.1: Breakdown of Buildings Tier 1 Model

Franchised Stations	Buildings, Platforms, Canopies, Train Sheds, Footbridges, Minor Works, Lifts & Escalators, Mechanical & Electrical, Other Fabric, Planned Preventative Maintenance, Inspections.
BUILDINGS_OTH_IIP_FINAL.xls	
Managed Stations	• **Franchised Stations:** (As above) • **Managed Stations:** Buildings, Canopies, Footbridges, Inspections, Lifts & Escalators, M&E Other, Other, Platforms, Train Sheds. • **Light Maintenance Depot:** Fabric, M&E, Inspections. • **Depot Plant** • **Lineside Buildings:** Fabric, M&E, Inspections. • **MDU Buildings** • **NDS Depots** • **Capital Overheads (Bonuses and Pensions)**

Table 9.2 below summarises the CP5 expenditure as predicted in the Buildings Tier 1 model. As can be seen Franchised Stations generate the highest CP5 expenditure at over 55% of the total. The profile of work for Managed Stations (17.4% of total expenditure) is produced outside of the model (the process of which has not been checked during this review) and input to the model as a workbank. The other assets within the Buildings model adopt varying modelling approaches to forecast renewal expenditure.

Table 9.2: Buildings CP5 Expenditure

Buildings	**CP5 Expenditure (£m)**
Managed Stations	207
Franchised Stations	651
Light Maintenance Depots	68
Depot Plant	59
Lineside Buildings	90
MDU Buildings	51
NDS Depots	36
Capital Overheads (Bonuses and Pensions)	18
Total Renewal Cost	**1, 189**

9.2 Approach to Audit

For the purpose of this audit, two meetings were held as shown in **Table 9.3**. The purpose of these meetings was to obtain a general overview of the model, clarify any issues identified and enhance our understanding of the model functionality. Hugh Fenwick was involved in Asset Policy Review, which consisted of checking how well the model conformed to the policy. Besides, several other issues were clarified via email correspondence.

Table 9.3: Buildings Tier 1 - Meetings

Date/Time/Venue	Agenda
30th Nov 2011 11:30-13:30 Arup No.13	General walkthrough of Buildings pre-processor and Franchised stations model
07th Dec 2011 11:00 – 13:00 Arup No. 13	General walkthrough of Managed stations model

9.3 Model Overview

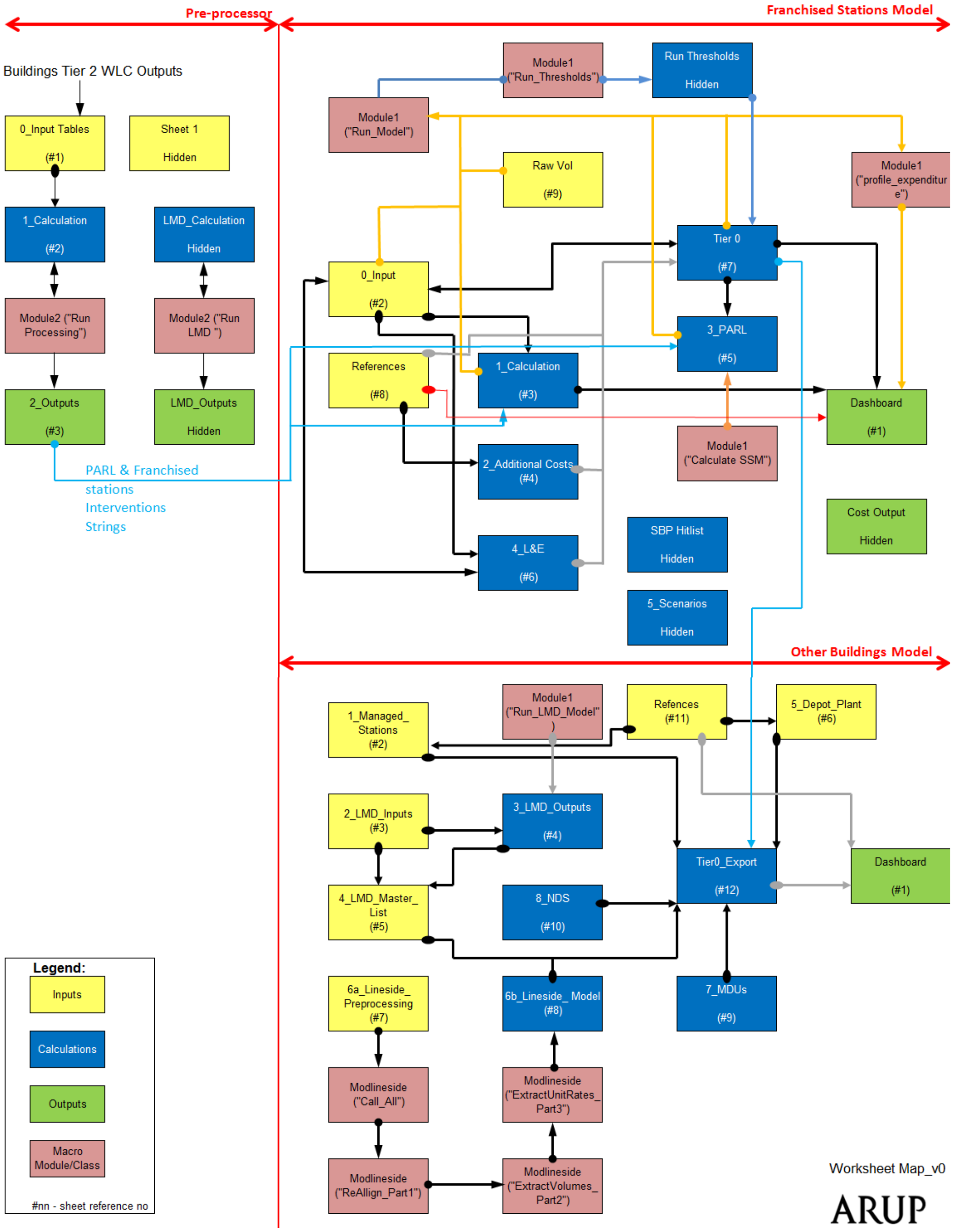
The Buildings Tier 1 model comprises of three spreadsheet models. **Table 9.4** below summarises the characteristics of the spreadsheet model audited and **Figure 9.1** illustrates the architecture of the buildings model.

Table 9.4: Buildings Tier 1 - Spreadsheets Characteristics

	BUILDINGS_FS_IIP_FINAL (Pre-processor).xls	BUILDINGS_FS_IIP_FINAL.xls	BUILDINGS_OTH_IIP_FINAL.xls
No. of worksheets	6	13	12
VBA components	2	1	4
No. of named ranges	29	250	490
No. of Input Sheets	2 (1 hidden)	4 (1 Hidden)	6
No. of Calculation Sheets	2 (1 hidden)	7 (1 Hidden)	5
No. of Output Sheets	2 (1 hidden)	2 (1 Hidden)	1

Note that the hidden worksheets in two of the spreadsheet models were not relevant to IIP models and should have been omitted as advised in the meeting of 30/11/2011. As such these worksheets were not checked for the purpose of this exercise.

Figure 9.1: Buildings Tier 1 - Worksheet Map



The pre-processing model essentially calculates Asset Risk Score (ARS) and Percentage Asset Remaining Life (PARL) by block from features granularity for Franchised Stations. It also determines the optimal interventions and associated condition based on starting PARL, and creates Intervention Strings by block.

In the Franchised Stations spreadsheet model, these intervention strings are amended if 'forced renewal' is required. The associated intervention costs are then compiled with respect to the updated Intervention Strings and reported in the Tier 0 worksheet. Cost uplifts are applied as required which account for Low-Cost components, Stations not surveyed and heritage factor of 35%. The associated additional costs (Mechanical & Electrical, Inspection, Other Fabric, Minor Works, PPM), renewal and maintenance costs for Lift and Escalators are also calculated in this spreadsheet. Expenditure is reported under one scenario only, that is, Current Railway. The Dashboard reports Costs, Volumes and Average PARL for each Control Period, the latter being an indicator of sustainability.

The Managed Stations spreadsheet model forecasts the expenditure for managed stations based on an offline workbank. Other assets that are modelled within this spreadsheet are Light Maintenance Depots (LMDs), Depot Plants, Line-side Buildings, National Delivery Services (NDS) Depots and Maintenance Delivery Units (MDUs). The modelling methods implemented vary depending on the asset type. The Franchised Stations expenditure is also reported on the Dashboard. Expenditures are reported under all three scenarios, that is, Current Railway, Current Railway plus investment to reduce costs and Preferred Plan.

Table 9.5 below summarises the modelling approaches implemented for each asset category for the Buildings Tier 1 model as documented in the Functional Specification.

Table 9.5: Buildings Tier 1 - Renewals Modelling Method

Asset	Renewal Modelling method
Managed Stations	Workbank
Franchised Stations	
Buildings; Platforms; Canopies; Train Sheds; Footbridges	Condition Profile
Other Fabric; Lift & Escalators Maintenance; Mechanical & Electrical; Minor Works; Planned Preventative Maintenance	Cost Profile
Lift & Escalators Renewals	Workbank
Inspections	Volume Profile
Light Maintenance Depots	
Fabric	Condition Profile
Mechanical & Electrical; Inspections	Cost Profile
Depot Plant	Life Cycle
Line-side Buildings	
Fabric	Condition Profile
Mechanical & Electrical; Inspections	Cost Profile
Maintenance Delivery Units	Bespoke
National Delivery Services Depots (Fabric)	Workbank and Cost Profile
NDS Depots (Plant)	Life Cycle
Capitalised Overheads	Cost Profile

Each of the modelling methods uses a considerable number of data inputs and model assumptions which have been checked as detailed in the following sections.

9.4 Computational Integrity

The formulae in each of the worksheets have been checked and found to be consistent with the Functional Specification. The computational errors are identified in **Table 9.6**. A full list of the computational integrity checks performed can be found in Appendix F.

Table 9.6: Computational Integrity Discrepancies

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
BUILDINGS_FS_IIP_FINAL (Pre-processor).xls				
				None
BUILDINGS_FS_IIP_FINAL.xls				
				None
BUILDINGS_FS_OTH_IIP_FINAL.xls				
6b_Lineside Model	Input Data	AR5 : BS9508	×	Correction Required: Cell AJ49, no intervention seem to be needed (columns AR-AU) but there is a cost for it (Column BR) For the majority of Roof Drainage, the volume/cost of work is not being calculated as stated in Assumptions (worksheet 6a, cell J20). e.g. row 106. For intervention C2 it says volume is 29.0764, but it should be 7.25528 according to the assumptions in worksheet 6a.

It was found that the assumed volumes calculation for Line side buildings were not being calculated as stated in the "6a_Lineside_Preprocessing" worksheet. This was mainly an occurrence for Roof Drainage where it is believed that the volume is not being calculated as specified in the "6a_Lineside_Preprocessing" worksheet, that is, *2*SQRT (Area) + 2 * Height*. As such, there is a potential that the model is overestimating the cost for Line-side Buildings by circa £1.2M.

The macro also seems to generate costs where no intervention is required (one count only with a cost of £1,000). Either the assumptions described in the spreadsheet should be corrected or the macro performing the calculation should be updated accordingly.

9.5 Data Inputs and Model Assumptions

9.5.1 Asset Inventory

Table 9.7 shows the asset inventory used in the model and compares it to that given in the Functional Specification.

Table 9.7: Buildings Tier 1 - Asset Inventory Comparison

	BUILDINGS_FS_IIP_FINAL.xls	BUILDINGS_OTH_IIP_FINAL.xls	**Functional Specification (Figure 8-1)**
Stations			
Franchised Stations	2, 506	-	2, 507
NR Managed Stations	-	18	18
Closed Stations	-	-	179
Total	**2, 506**	**18**	**2, 704**
Light Maintenance Depots			
Depot Access Conditions (DAC) Leased	-	74 (References)	71
Total		**74**	**71**
Maintenance Delivery Unit			
Network Rail Managed	-	643 (MDU)	489
Total		**643**	**489**
National Delivery Services			
Network Rail Managed	-	32 (References)	32
Total		**32**	**32**
Line-side Buildings			
Critical	-	-	4226
Redundant	-	-	1099
GSMR/FTN	-	-	3262
Non-critical	-	-	4995
Total		**9,342**	**13,582**

The main concern here is that there is a difference of 4,240 between the number of Line-side buildings modelled and the number specified in the Functional Specification. Network Rail advise that the model excludes about 3,000 Telecoms GMSR Buildings. However, it is understood that this has no impact on expenditure as the numbers of Line-side buildings are used solely for route allocation.

Moreover, there is a deficiency in the number of franchised stations modelled. The Functional Specification states that there are a total of 2,507 franchised stations as opposed to 2,506 which has been used throughout the model. This is potentially underestimating the expenditure by £260k per Control Period (a minor concern).

A total of 74 LMDs are being modelled as opposed to 71 as stated in the Functional Specification, potentially overestimating renewal costs by £2.8m per Control Period.

Finally there is a discrepancy of 154 MDUs between those being modelled and the number stated in the Specification. However, this discrepancy has no impact on the expenditure as the numbers are used solely for route allocation and volumes are based on bottom up assumptions from the routes.

These discrepancies that affect the expenditure forecast should be investigated. Note that the number of Depot Plants is not included in the Functional Specification and should also be investigated.

9.5.2 Other Inputs and Assumptions

Table 9.8 below summarises the errors identified for all data inputs and assumptions in the Buildings Tier 1 model. A full list of checks performed can be found in Appendix F.

Table 9.8: Buildings Tier 1 – Data Inputs & Model Assumptions Discrepancies

Model		Comment
Worksheet	**Description**	
BUILDINGS_FS_IIP_FINAL (Pre processor).xls		
		None
BUILDINGS_FS_IIP_FINAL.xls		
0_Inputs	Uplift for stations not surveyed	1 No. Station missed. Correction required.
2_Additional Costs	Total No. Of Stations (by TOC)	Total No. of Stations should be 2507.
	Annual other costs (by TOC)	Total No. of Stations should be 2507.
4_L&E	Allocation by TOC (by No. Of Stations)	Total No. of Stations should be 2507.
BUILDINGS_OTH_IIP_FINAL.xls		
2_LMD_Inputs	Total No. of LMDs	The model uses 74 No. LMDs as opposed to 71 No. as in Functional Specification
	Unit Costs	Slightly different from the unit rates workbank. Update required.
MDU's	MDU counts by OR	Total adds up to only 643 as opposed to only 489 in Functional Specification. (TBC)

Note that we are waiting for Network Rail to confirm the reasons for some of these discrepancies.

LMD's seem to be using the wrong unit costs and assumed volumes. It was also noted that the modelling method used for LMD was slightly different to that specified in the Functional Specification which was pointed out in our meeting of 07/12/2011.

The assumed efficiencies to produce CP4 exit rates differ to what is specified in the Unit Costs Workbook and Network Rail's efficiency paper ('The PERIODIC REVIEW 2013, Progressive Assurance Process Network Rail's Efficiency Assumptions in IIP'). Both these documents specify a 5% efficiency to apply to all Buildings rates. However, in the model 5% has been applied to the Quantity Surveyor rates and 10% to all other rates. It is understood that the model is correct and reflects the expected continued efficiency to be gained by the end of CP4 for costs derived bottom up against other. The Unit Costs Workbook should be updated accordingly.

9.6 Modelled Interventions

A check on the Asset Policy Document against the Building models was undertaken to verify if the models follow what is stated in the policy. The main concern that was presented in Arup's report on the policy is the adoption of hybrid or typical asset groups in the model.

Taking footbridges as an example, the policy sets out different interventions for different types of footbridge (concrete, metal etc). However, in the model a "typical" footbridge has been devised to simplify the modelling. The "typical" footbridge has been developed using OPAS data. Footbridge volume data was analysed to find the most common average characteristics of Network Rail station footbridges per Station category. The model then assumes every footbridge is of this type and computes the outputs accordingly. It is difficult to judge the extent of the approximation made in this way.

9.7 Overall View on Uncertainty of Outputs

Some of the data inputs for LMDs, NDS Depots and MDUs are out of date, and in some cases wrong (e.g. assumed volume for activities for LMDs). There are also serious doubts over the assumed number of buildings for all but Managed Stations and NDS Depots.

The volumes being generated for Line-side buildings (Roof Drainage mainly) are not being calculated according to the volume calculation assumptions as stated in 6a_Lineside_Preprocessing worksheet. Its impact on the cost is potentially being overestimated by £1.2m.

There is a discrepancy between the number of MDU's modelled and the number stated in the Functional Specification although they are only used for route allocation and do not affect the CP5 expenditure.The model uses approximated dimensions for every MDU asset feature (by operating route) and it might be worth reviewing whether they need to be estimated more accurately and/or in more detail.

9.8 Suggested Improvements

The following are proposed towards improving accuracy and reliability of the model:

- Review asset numbers and update model accordingly (make it easier in the model to see the assumed asset numbers as well).
- Review unit rates and efficiencies and update accordingly.

- Address computational errors that have been identified.
- There are examples of copy and paste with no explanation as to how numbers were generated. For example, the way that the route allocation percentages have been generated for LMDs - Sussex has no LMDs and has been set manually to zero. The others have been adjusted somehow (with no formulae in cells) to represent the total and the method implemented needs to be documented.
- Update the method for LMDs to be in line with the Functional Specification or update the Functional Specification itself.
- Since a significant amount of calculations are run by macros, it would be useful to document the process (for example, flowcharts) so that any user can make amendments more easily as required.

10 Earthworks

10.1 Introduction

This is an Excel spreadsheet model (Earthworks Tier 1 - Version 6.xls). It is documented in Section 7 of the Functional Specification (Document Release 002, October 2011).The earthworks model estimates expenditure for:

- Embankments,
- Rock Cuttings,
- Soil Cuttings,
- Other (Minor Works, Monitoring/Alarms, Mineworkings) and
- Drainage.

Table 10.1 summarises the CP5 expenditure as forecast in the earthworks model. Note that Drainage expenditure is an input to the model and is derived from a separate offline analysis.

Table10.1: Earthworks Tier 1 - CP5 Expenditure Estimate

Earthwork	CP5 Expenditure Estimate (£m)
Embankments	151
Rock Cuttings	101
Soil Cuttings	96
Other	77
Drainage (Offline Analysis)	17
Total Renewal Costs	**442**
Examination & Climate Change	13
Total Maintenance Costs	**13**

As can be seen, embankments incur the highest renewal expenditure in CP5 and drainage the lowest. Each asset implements different modelling approaches, inputs and assumptions which are in turn used to derive the expenditure for future Control Periods.

10.2 Approach to Audit

The approach for the earthworks audit was to check the inputs of the model, the calculations and any assumptions made. Network Rail was asked to provide supporting evidence (where possible) for the inputs and assumptions made and these were checked for consistency.

Since macros were not used in this model, simple manual checks were performed to ensure that the calculations in the model were correct. Where the calculations relied on data found in different worksheets, the formulae were checked to make sure that the right cell/range was being referred to.

Since the model was relatively simple, all queries and issues were clarified through email correspondence and as such no meetings with Network Rail were required.

10.3 Model Overview

The overall architecture of the Earthworks spreadsheet model is shown in **Figure 10.1**.

Figure 10.1: Earthworks Tier 1 - Worksheet Map

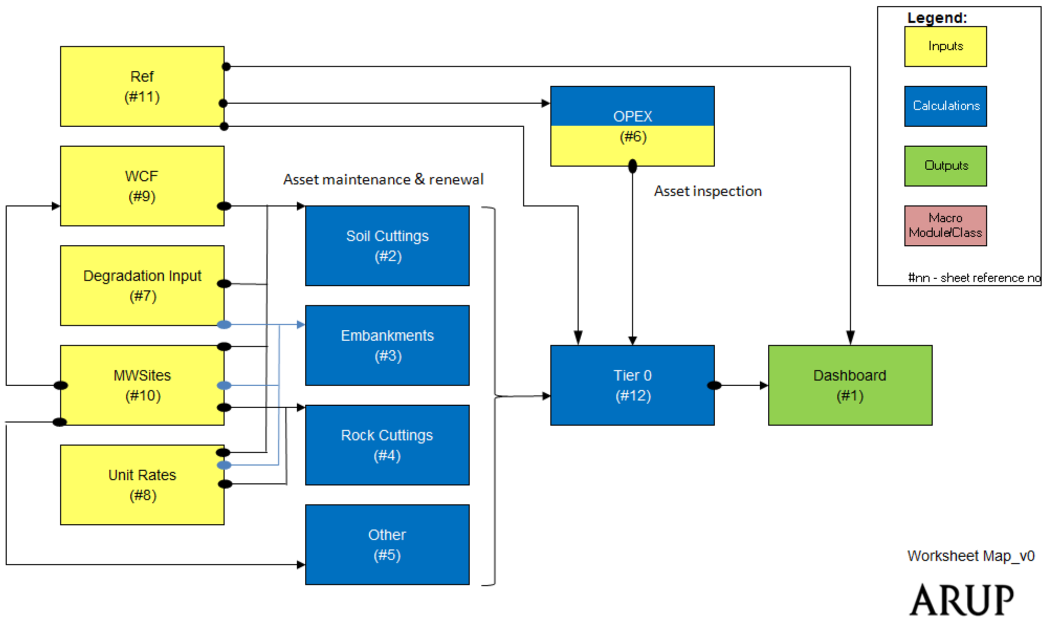


Table 10.2 below summarises the characteristics of the spreadsheet model audited. The relatively few elements of the model are consistent with the model being simpler than those for other assets.

Table 10.2: Earthworks Tier 1 - Spreadsheet Characteristics

Earthworks Tier 1 - Version 6.xls	
No. of worksheets	12
VBA components	1
No. of named ranges	6
No. of Input Sheets	6
No. of Calculation Sheets	5
No. of Output Sheets	1

Table 10.3 shows the modelling methods used for each asset sub-group for Earthworks. Renewals for the three main groups (Embankments, Soil Cuttings and Rock Cuttings) are modelled within the spreadsheet based on their condition. Other renewals and all maintenance volumes have been put together outside of the model and are input as costs profiles.

Table 10.3: Earthworks Tier 1 - Modelling Methods

Asset	Modelling Method	
	Renewal	**Maintenance**
Embankments	Condition Based Bespoke	Cost Profile Based on Expert assumptions
Soil Cuttings	Condition Based Bespoke **Water Concentration Features (WCF):** Volume Profile	Cost Profile based on Expert Assumptions
Rock Cuttings	Condition Based Bespoke	Cost Profile based on Expert Assumptions
Other	**Minor works & Monitoring/Alarms:** Cost Profile based on Expert Assumptions **Mineworkings:** Cost Profile	

Overall the model is well presented and easy to follow. A key point is that the model relies on a significant number of assumptions for the Embankments, Soil Cuttings and Rock Cuttings. For example, for Embankments it is assumed that renewal costs will reduce by 20% during CP5 due to increased maintenance.

10.4 Computational Integrity

The formulae in each of the worksheets have been checked and found to be consistent with the Functional Specification.

Table 10.4 below summarises the two issues that Network Rail have themselves identified within the model. Both are of minor concern, and do not materially impact the CP5 volumes and costs.

A full listing of the computational integrity check performed for the earthworks model can be found in Appendix G.

Table 10.4: Earthworks Tier 1 - Computational Integrity discrepancies

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
Soil Cuttings	# of sites forecast to move from 'Marginal' to 'Poor' over CP4		×	As Identified in "Degradation Input" worksheet, formula should refer to cell I14 and not K14
Soil Cuttings	CP5 required volume (m2 of earthwork remediated)		×	As Identified within model: Number used erroneously in submission. Should be =E16*(1+E13) = 56133224.35 Small error

10.5 Data Inputs and Model Assumptions

A check on the data inputs and model assumptions was performed. No major issues were identified in the data input and the full list of data inputs and model assumptions checks can be found in Appendix G. Table 10.5 below shows only one minor issue with the inputs.

Table 10.5: Earthworks Tier 1 - Data Inputs & Model Assumptions Discrepancies

Inputs	Worksheet	Comments	Source / evidence?
National 5ch	WCF	Correction required to avoid confusion (Minor concern).	The actual number should be 4289. The 4290 value appears in one cell due to some rounding differences but is not used in any calculation.

10.6 Modelled Interventions

A check on the Asset Policy Document against the Earthworks model was undertaken to verify if the model follows what is stated in the policy.

Whilst we understand that the ICM Tier 1 Model has been qualitatively influenced by the Earthwork Policy (for example increased maintenance, drainage work etc. is planned) we have not seen any evidence that the Asset Policies are directly linked to the proposed volumes and costs. More details on the links between the Policy and modelling can be found in section 8.4.14 of Arup's report 'Part A Reporter Mandate AO/017: Initial Industry Plan (IIP) 2011Review - Summary Report - Observations and Conclusions', dated 16th December 2011.

10.7 Overall View on Uncertainty of Outputs

No major concerns are raised by the computational and data input checks.

As noted in our Report for Mandate AO/017:-

- In principle the ICM Tier 1 spreadsheet model does not seem to be an unreasonable way of obtaining an initial 'top down' view as to the required future volumes and costs.
- We understand from the Earthworks Asset Policy that NR are developing their CeCOST model to provide an improved forecast of work volumes, outputs and expenditures for the Strategic Business Plan (SBP) submission. However at the time of writing (November 2011), we understand that the CeCOST model is still under development and the volumes and costs for the IIP have been derived solely from the ICM Tier 1 Model.

The Tier 1 model is relatively simple and the estimated CP5 renewal and maintenance volumes and costs are sensitive to a number of assumptions. Developing the model detail would provide a more robust estimate.

Suggested Improvements

We highlight the following assumptions that would be worth reviewing.

- The Embankment and Soil Cutting analysis is modelled based on a single deterioration profile irrespective of material type. The results are sensitive to this rate, for example if the rate of marginal Embankments degrading to Poor status is 10% worse than assumed, then the cost of Embankment renewals in CP5 increases from £151m to £178m. Since failure of these assets is dependent on the material properties it is suggested that Network Rail should consider the implications of this assumption.
- The estimates for Rock Cuttings are based on the assumption that CP5 work volumes will be the same as CP4.
- The Water Concentration Feature (WCF) cost is highly dependent on the unit rates and work proportion for Drainage Renewal and Ditch Clearing (unit rates of £212/m and £4.3/m respectively). The current assumed split between the two work activities is 50% and this has a significant impact on the WCF cost due to the large difference between the unit rates.

11 Telecoms

11.1 Introduction

The model forecasts Network Rail's expenditure for the assets on Network Rail's telecommunications network. This asset contributes £630 million towards the IIP total value.

Table 11.1 summarises the forecast CP5 expenditure in the Telecoms Tier 1 model.

Table 11.1 : Telecoms - CP5 Forecast Expenditure

Telecoms Systems	CP5 Expenditure (£m)	Percentage
Operational communications	38	15%
Network	10	4%
Station Information and Surveillance Systems (SISS)	1	0%
Response	59	24%
Telecoms Support	38	16%
Recoveries	-41	-17%
Management & Indirect	15	6%
Telecoms Contracts	125	51%
Total Maintenance Costs	**244**	**100%**
Projects & Other	116	30%
Operational communications	51	13%
Network	53	14%
Station Information and Surveillance Systems (SISS)	165	43%
Total Renewals Costs	**386**	**100%**

Telecoms contracts is the maximum spend item under maintenance costs, accounting for just over half of £244m forecast expenditure in CP5.

Station information and surveillance systems are the maximum spend assets under Renewals with a forecast expenditure of £165m out of total £386 forecast renewals expenditure in CP5.

11.2 Approach to Audit

In order to get a full understanding of the model, input data and underlying assumptions, the following checks were carried out:

- Audit of spreadsheet based data manipulation;
- Audit of macro coding; and

- Audit of data from input to output to confirm that correct data are being accessed, correct calculations are being applied and model outputs are correctly collated and presented.

A manual check of the formulae in the model was performed to understand the modelling methodologies used and to confirm the suitability of the results. The calculations were also run on a small sample of dataset to check they are correct.

The following meeting was held with the NR staff responsible for the model and the input data.

Date/Time/Venue	Agenda
06/12/2011 10:00 – 12:30 Arup	Walkthrough of model and input data

11.3 Model Overview

This is a spreadsheet model (Telecoms_IIP_Final.xls). It is documented in the Functional Specification (Document Release 002, October 2011) in Section 10.

The output from the model is divided into three main parts:

- Renewals volumes and costs;
- Maintenance volumes and costs; and
- Reliability and other asset outputs.

Scenarios Modelled

The model consists of three scenarios as listed below:

- CR - Current Railway;
- CI - Current Railway plus investments to reduce costs; and
- PP - Preferred Plan.

The ‘Current Railway’ and ‘Current Railway plus Investments to Reduce Costs’ scenarios are identical.

The model calculates renewal volumes based upon condition driven planned first renewal dates derived offline in the Telecoms Decision Support Tool (DST) and calculates subsequent renewals using ‘Age Profile’ methodology. The model has the ability to model partial interventions and allows for the change of asset type at first intervention.

11.4 Computational Integrity

The main calculations in the model are contained within the following worksheets:

- Calc_Volumes

- Concentrator_Volumes
- Unit_Cost_Spreader
- Calc_Costs
- Mtce_Cost_Output
- NOS_14_Renewals_Costs_&_Volumes
- NOS_Service_Migration_Costs
- NOS_14_Future_Line_Volumes

The calculations in the model are run from a number of Visual Basic macros. These have been checked along with the formulae in each of the worksheets and found to be consistent.

Renewals Volumes and Costs

The Telecoms Tier1 model takes input from the Tier 1 Signalling model relating to Network Operating Strategy (NOS) signal box closure dates and NOS migration path.

The 'Preferred, signal box closure dates were checked against the output from the Signalling Tier 1 model and discrepancies were found. However, the impact on the overall renewal costs, resulting from these discrepancies, was found to be negligible (an underreporting of £0.21m) and an over-reporting of £0.59m for CP6 as shown in the Table below.

Description	**CP5 (£m)**	**CP6 (£m)**
Renewals Cost Reported in Telecoms Tier1 model	385.84	467.57
Renewals Cost using the preferred closure dates from the Signalling Tier1 model	386.05	466.98
Difference	**0.21**	**-0.59**

Similarly minor discrepancies were also found in the 'Targeted' box closure dates as compared to the output from the Signalling Tier 1 model.

Some formatting errors were found in the input data relating to the 'Nice' voice recorders. Network Rail advise that this was caused by updates made to the DST being out of line with the way that the Tier 1 model was designed to identify these voice recorders, and that they will correct this in future runs of the model. The impact of this error is of small magnitude and is reported in the Table below.

Description	**Renewals Cost (£m)**
Total Renewals Cost Forecast in Tier1 Model	386
Corrected input data formatting for 'Nice' voice recorders	385
Difference	**1**

Maintenance Volumes and Costs

The forecast number of maintenance services and the number of failure incidents requiring maintenance attendance are derived offline and input into the Tier1 model. The model applies Maintenance Unit Costs (MUC) to the maintenance volumes to calculate the planned maintenance costs per annum. Our checks have indicated that CP4 exit rates have not been used in the Telecoms Tier1 model resulting in an overestimation of £2m in the total Maintenance cost for CP5 as shown in the Table below. However, correct RUCs are applied to the failure volumes to calculate the rapid response costs per annum.

Description	**Maintenance Cost (£m)**
Total Maintenance Cost Forecast in Telecoms Tier1 Model	244
Maintenance Cost using CP4 exit rates	242
Difference	**2**

In summary, the renewals costs for CP5 are over-reported by £1.21m and the overall maintenance costs are over-reported by approximately £2m in the Telecoms Tier 1 model.

11.5 Data Inputs and Model Assumptions

Data Inputs

As identified in the functional specification document, the key inputs into the model and their respective sources are as listed in the two tables below.

Telecoms Tier1 Model - Renewals Inputs

Input type	***Description***	***Source***
Asset inventory	Asset volume (or quantity)	Telecoms Asset Management Decision Support Tool (DST)
Interventions	Planned first renewal date	DST as above
	First intervention <Renewal Type>, i.e. (Full or Partial)	DST as above
	List of the <Asset Type> that are maintainer renewed	Telecoms Asset Management Assumption
	NOS box closure dates	Signalling Tier 1 model
	NOS migration path list – i.e. end <Asset Location> for each starting <Asset Location>	Signalling Tier 1 model
	Life extension allowances for NOS affected <Asset Type>	Telecoms Asset Management Assumption

Input type	**Description**	*Source*
	Asset replacement policy – i.e. what replaces what at renewal, e.g. Electro-mechanical concentrator to Processor Controlled Concentrator.	Telecoms Asset Management Assumption
	Concentrator line reduction % at 1st renewal	Telecoms Asset Management Assumption
	Nominal asset life	Telecoms Asset Management Assumption
Delivery	GRIP stage spend profile over delivery years	Delivery function planning assumption
Unit cost	End CP4 efficient cost (including line migration cost)	Delivery function forecast

The Telecoms Decision Support Tool (DST) is a system level inventory of all renewable telecoms assets. This tool is used to capture condition assessments and calculate the subsequent renewal dates based on asset condition. This is an offline tool. The output from DST serves as the key input for the renewal volumes and costs calculations within the model.

Telecoms Tier1 Model - Maintenance Inputs

Input type	**Description**	*Source*
Intervention	Forecast of planned maintenance volumes (Services per annum)	Maintenance delivery function assumption (derived offline)
	Forecast of response volumes (failures per annum)	Maintenance delivery function assumption (derived offline using FMS data)
	Bespoke Operating Route allocation metrics (%)	Maintenance delivery function planning assumption
Unit Cost	Maintenance Unit Cost (£11/12)	Maintenance delivery function forecast

The forecast Maintenance volumes are directly input into the model from offline sources. The forecast number of failure incidents requiring maintenance activities is also derived offline and input into the model. The model applies Maintenance Unit Costs (MUC) to maintenance and failure volumes and accordingly calculates the forecast maintenance and response costs from CP5 onwards. Our checks have identified that the CP4 exit rates are not used for MUCs.

Key Assumptions

The model uses the following assumptions:

- Concentrator line reduction percentage at 1st renewal – 45%.
- Sweat Factor (Life extension allowances for NOS affected asset type. This allows assets to be 'life extended' where renewal date falls within a certain proximity of the box closure date) – 3 years.
- For Processor Controlled Concentrators, the line quantity per unit is assumed to be 22.4.
- Default DST '0' quantities are converted to '1' to ensure all the assets are included in the calculations.

11.6 Modelled Interventions

A review of the Telecoms Asset Policy Document (dated September 2011) against the Telecoms Tier1 model was undertaken to verify if the interventions modelled in Tier1 adhere to the asset policy.

The Telecoms Asset Policy document states that the ICM is able to model Telecoms service levels using Asset and Route Criticalities. Service criticality is defined using asset criticality (for all assets) combined with route criticality for Railway Operational Services, Station category for Customer Services and an overall high criticality for Network Services. Our checks have indicated that although the model includes this functionality, it is not used in the calculation of the renewals and maintenance costs/volumes for CP5.

The following checks show consistency between the asset policy and the modelled interventions:

- For Concentrators including Electro-Mechanical, Processor Controlled and PABX, the asset policy states that the renewal shall be deferred if signal box closure proposed is within three years of recommended renewal date. This policy has been correctly applied in the model.
- The model allows for asset type changes at First Intervention. For example: electro-mechanical concentrators are replaced by processor controlled systems.
- The critical asset nominal lives used in the Tier 1 Telecoms model are consistent with those listed in the asset policy document (In Section 8.3.2 of Telecoms Asset Policy Document).
- As stated in the asset policy, first Intervention are modelled as either 'Full' or 'Partial', based on an identifier in the DST. Subsequent renewals are all modelled as 'Full' to reflect the potential requirement for whole system renewal.
- The preferred plan scenario in ICM is based on NOS. This is in line with the CP5 policy - CP5 will see a move from traditional renewal of individual concentrator systems to a regional approach based around control centres.

11.7 Overall View on Uncertainty of Outputs

This model relies on the output from the Telecoms Decision Support Tool to provide asset inventory data and planned renewal intervention dates. Network Rail have indicated that this tool matches the underlying asset register database (ELLIPSE) to within 5% accuracy.

Our checks of the Telecoms model have shown that there is a formatting error for some voice recorder calculations. CP4 exit rates are not used while calculating the Maintenance costs for CP5. Together they result in CP5 costs being over-stated by about £3m.

11.8 Suggested Improvements

As identified in the function specification document, it is recommended that the asset and/or route criticalities are incorporated in the calculations to help identify how investment should be focussed across the asset inventory and also to defer or turn off renewals based on assigned criticalities.

In addition to the above, the following is recommended:

- Checks to ensure consistency in the formatting of the input data to minimise errors.
- Verify consistency with the asset inventory from ELLIPSE asset database
- Checks to ensure consistency with the output from Tier 1 Signalling model relating to Network Operating Strategy (NOS) signal box closure dates and NOS migration path. Although, the impact on CP5 costs was observed to be negligible (£0.21m).

12 Wheeled Plant

12.1 Introduction

The Wheeled Plant and Machinery (WPM) Tier1 Model is used to forecast the cost of renewals and overhauls for Network Rail-owned Traction and Rolling Stock Fleets, On-Track Machines and Plant with rail wheels. The model also covers Network Rail's fleet of road vehicles (cars and vans). The capital expenditure (renewals and overhauls costs) is calculated from CP5 onwards.

Table 12.1 below summarises the output from the WPM Tier 1 model and the percentage spend forecast for each of the asset group. High Output ballast cleaners, Interventions fleet and Road vehicles are the maximum spend items.

Table 12.1: Tier 1 Costs for Wheeled Plant & Machinery

Description	**Renewals + Overhauls Costs (£m)**	**Percentage Spend**
High Output	21.5	23%
Infrastructure Monitoring	2.6	3%
Intervention	27.2	29%
Incident Response	0.6	1%
Locomotives	1.2	1%
Materials Delivery	2.4	2%
On Track Plant	3.1	3%
S&C Delivery	0.5	1%
Seasonal	12.1	13%
Road Vehicles	22.9	24%
Fleet Support Plant	0.8	1%
Total Renewal + Overhaul Costs	94.7	100%

12.2 Approach to Audit

In order to get a full understanding of the model, input data and underlying assumptions, the following checks were carried out:

- Audit of spreadsheet based data manipulation;
- Audit of macro coding; and
- Audit of data from input to output to confirm that correct data are being accessed, correct calculations are being applied and model outputs are correctly collated and presented.

A manual check of the formulae in the model was performed to understand the modelling methodologies used and to confirm the suitability of the results. The calculations were also run on a small sample of dataset to check they are correct.

The following meetings were held with the NR staff responsible for the model and the input data.

Date/Time/Venue	Agenda
21/10/2011 09:30 – 11:00 NR's offices at Kings Place	High level walkthrough of WPM Tier 1 model
01/11/2011 14:00 – 15:30 Arup	Walkthrough of workbank and offline input data

12.3 Model Overview

This is a static spreadsheet model and is contained wholly within Excel (Wheeled Plant_IIP_Final.xls). It is documented in the Functional Specification (Document Release 002, October 2011) in Section 11. The model consists of 15 worksheets, 2 VBA components and 76 named ranges. There are 7 input sheets, 6 calculation sheets and 1 output sheet plus an output to Tier 0 models. The list of worksheets in the model and their purpose are identified in the table below.

Worksheet Name	Type
Settings	Input
Lists	Input
MD_NetGeog	Input
MD_Scen	Input
Years	Input
Geography	Input
Hierarchy and interventions	Input
Lifecycle	Input/Calculation
Renewals calcs	Calculation
Full ren allocation	Calculation
Overhauls calcs	Calculation
Overhauls workbank	Input/Calculation
Overhaul allocation	Calculation
Cost Tier 0	Output
Dashboard	Output

It is understood that the Tier 1 Wheeled Plant and Machinery model currently takes no inputs from any other formally defined Tier 1 or Tier 2 models. At present there is no link between the Wheeled Plant and Track Tier 1 models.

Full Renewal costs are calculated in the model using the Age Profile method. The model has the ability to override the first renewal year.

Overhauls costs are mostly derived from a workbank. However, a small number of overhauls are modelled using the Life Cycle method and the model has the ability to override the first overhaul year.

The model applies the appropriate unit costs against the volumes and spreads costs and volumes across a specified number of years.

Similar to the other Tier1 models, the WPM Tier1 model has the inbuilt functionality to model the three standard scenarios listed below:

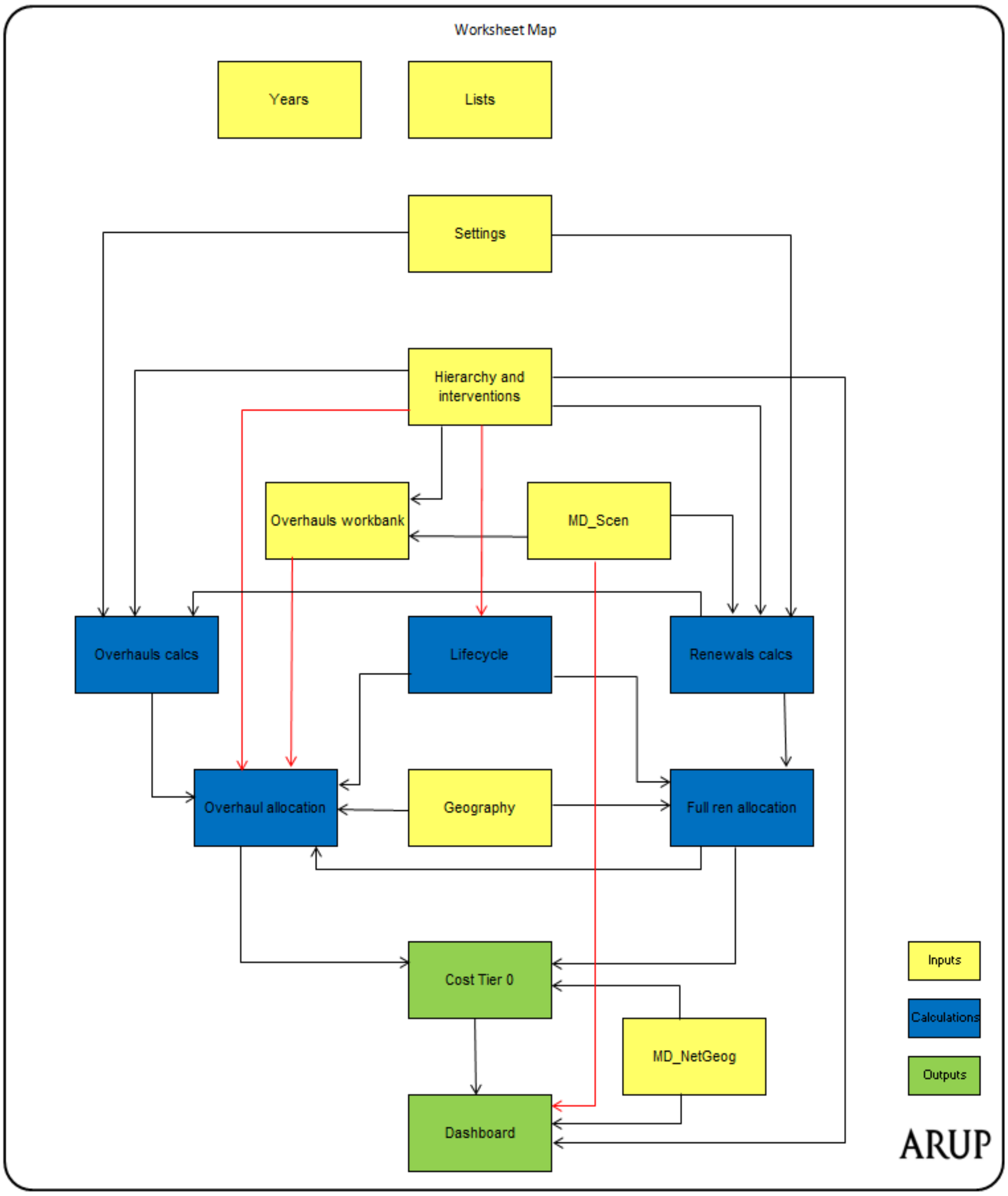
- CR - Current Railway;
- CI - Current Railway plus investments to reduce costs; and
- PP - Preferred Plan.

However, we understand that all the three scenarios are identical and have the same inputs and outputs in the WPM Tier1 model.

12.4 Computational Integrity

Figure 12.1 illustrates the architecture of the model.

Figure 12.1: Flowchart of Wheeled Plant and Machinery Tier1 Model



The logic of the model appears to make sense and the formulae have been applied consistently. However, there seems to have been an error in calculating the first overhaul year for some of the assets. The consequence of this is that the calculated first overhaul year is same as the most recent renewal year of the asset. However, this only affects the output for CP4 and doesn't impact on the results presented for CP5. It is recommended that the formula to calculate the first overhaul year is corrected in the future revision to the model.

12.5 Data Inputs and Model Assumptions

Data Input

The model workbank includes volumes of renewals based on condition driven planned first renewal dates that are derived offline.

Data from the renewals workbank in the Tier 1 model was randomly checked against the raw data supplied by NR. Our checks show that the asset inventory in the Tier 1 model does not entirely match with the asset inventory in the raw data. For some assets, the 'Built Year' in the raw data (T&RS Inventory.Arup.20111202.xls) supplied by NR did not match with the 'Last Year Replaced' data in the model as shown in the tables below. Consequently, the calculated first renewal year for these assets are incorrect. The discrepancies are illustrated in **Table 12.2** and **Table 12.3** below. For example, in the Tier 1 model, four PL Stoneblowers have their 'Last year replaced' as 2000. Whereas in the inventory data supplied by NR, there are only two PL Stoneblowers with their 'Built Year' in 2000.

Table 12.2: Inventory for Stoneblowers - WPM Tier 1 model

Inventory (Source: WheeledPlant_IIP_Final.xls)			
Asset	**Last year replaced**	**Number**	**Renewal Year**
Stoneblower Plain Line	1999	3	
Stoneblower Plain Line	2000	2	2015
Stoneblower Plain Line	2000	2	
Stoneblower Plain Line	2004	4	2019
Stoneblower Plain Line	2005	1	2019
Stoneblower Multipurpose	2006	1	
Stoneblower Multipurpose	2008	1	
Stoneblower Multipurpose	2007	1	

Table 12.3: Inventory for Stoneblowers - Inventory data supplied by NR

Inventory (Source: T&RS Inventory.Arup.20111202.xls)		
Asset	**Built Year**	**Number**
Stoneblower - plain line	1962	1
Stoneblower - plain line	1998	2
Stoneblower - plain line	1999	2
Stoneblower - plain line	2000	2
Stoneblower - plain line	2004	5
Stoneblower - plain line - Stored Inoperable	1996	1
Stoneblower - plain line - Stored Inoperable	1998	1
Stoneblower - plain line - Stored Operable	1997	1
Stoneblower - plain line - Stored Operable	1998	3
Stoneblower, Multi-Purpose YZA-A	2006	1
Stoneblower, Multi-Purpose YZA-A	2007	1
Stoneblower, Multi-Purpose YZA-A	2008	1

Discrepancies were also found in the input data for Trailer, Trolleys and Trainborne Monitoring equipment when compared with the workbank in the WPM Tier1 model, as shown in the **Table 12.4**.

Table 12.4: Renewal Volumes in CP5

Fleet 2	**WPM Tier1 Model workbank**	**Input Data supplied by NR**	**Difference**
Cars	1115	1115	-
Fleet Support Plant	24	24	-
High Output System 1	1	1	-
Lorry	9	9	-
Mobile Elevated Work Platform	30	30	-
MPV Master and Slave	32	32	-
OTP MPV	8	8	-
Rail Grinders	5	5	-
Rail Mounted Portable Plant	20	20	-
Regulator	1	1	-
Severn Tunnel Recovery Fleet	3	3	-
Trailer	20	19	1
Trainborne Monitoring Equipment	2	1	1
Trolley	14	15	-1
Vans	6441	6441	-

We consider that there is some uncertainty with regard to the accuracy of the input data and it is recommended that further detailed checks are carried out to ensure the completeness and accuracy of the model workbank.

The WPM Tier 1 model currently uses a workbank to cost overhauls. We have checked a sample of data from the workbank with the input data supplied by NR and found to be consistent.

Key Assumptions

NR have identified the following overarching assumptions that apply to the model / workbank:

- Track access patterns remain as CP4.
- Organisation structure remains stable.
- Routes will not require to have dedicated fleet.
- Volumes of Intervention fleet assets are based on modelled Track demand, it is assumed that this based on a National Fleet and a National plan, smoothed across seasons, and across a full weekday and weekend shift pattern. This is critical for grinder and Stoneblower volumes.
- Asset population for materials delivery fleets can only be calculated in response to a delivery plan, not gross tonnages. This is not yet available and Fleet size is assumed to remain at CP4 exit rates.
- All new vehicles will be designed for standardisation and for multipurpose (Plain Line and Switches & Crossings) use.

12.6 Modelled Interventions

A review of the Fleet Asset Policy document (dated 27th May 2011) for Wheeled Plant and Machinery was undertaken to verify if the interventions modelled in Tier1 adhere to the asset policy.

Our checks have shown that the workbank in the Tier 1 model is consistent in the way it has been developed to that written in the policy (Table 1.2: Application of Renewal Options by Fleet).

12.7 Overall View on Uncertainty of Outputs

NR have acknowledged that they have made assumptions about the geographical spread of work, and the weekend/weeknight/peak demand spread, and that the WPM fleet size to meet CP5 demand is reasonable but not generous.

There is a risk of one additional (new) multi-purpose stoneblower machine or the reintroduction of one or more of the stored-operable plain line machines at up to £750,000 each (overhaul plus recruitment and training of crew) until they receive more granular data.

12.8 Suggested Improvements

We support the future developments as listed in the functional specification document. In addition, we recommend that Network Rail carry out detailed checks against asset inventory since our checks in the given time have revealed some discrepancies.

As for other Tier 1 models we suggest improved documentation including flow diagrams, a detailed definition of each scenario modelled and the derivation of the model inputs.

13 Income

13.1 Introduction

This is a spreadsheet model (Freight_OpenAccess_Income_v07.xls). It is not yet documented in the Functional Specification (Document Release 002, October 2011).

The model forecasts Network Rail's income from a number of sources as shown in the table below with figures taken from the Tier 0 model output for the current railway.

Table 13.1: Current Railway Revenues forecast by Income Model (Tier 0 output)

Income Source	CP5 Income (Current Railway)
Rail freight	£312m
Open Access Operators	£116m
CTRL	£29m
Crossrail	£488m
Station and depot facility charges	£125m
Other facility charges	£94m
TOC Insurance Premia	£15m
Total	**£1,179m**

Most of the model calculations focus on the first two of these sources.

Rail freight income is calculated on the basis of the expected growth in demand. The resulting income is then calculated for Variable Track Access (VTAC) by multiplying the forecast tonnage km by a unit rate based on an analysis of 2010/11 income. Similarly, the Capacity Charge and EC4T incomes are calculated from the forecast train km and electric train km respectively. Other revenue and performance penalties are assumed to be the same as for 2009/10.

Income from Open Access operators is calculated in a similar way. It is based on historic incomes for the years 2009/10 and 2010/11, updated according to forecasts for each of the operators.

13.2 Approach to Audit

In the absence of a Functional Specification, the workings of the spreadsheet were discussed with the Network Rail modeller by phone. The calculations were then checked including that they had been applied consistently throughout the spreadsheet. Assumptions and data inputs were listed and then sent to Network Rail with a request for supporting evidence.

13.3 Model Overview

Given this is not modelling a particular asset, there are no relevant policies to review.

Generally speaking, we consider that the approach taken to model income from rail freight and open access operators is reasonable. Income from Crossrail, which is the largest source, has been derived outside the model and is an input. The other sources are similarly input into the model and are generally assumed to remain constant or similar to CP4 values.

13.4 Computational Integrity

The formulae in each of the worksheets have been checked and make sense. The individual elements of the freight and Open Access incomes have been tested and found to add up correctly to the total respective incomes.

It is noted that there seems to have been an error in inputting the electric train km for Heathrow Express, London Underground and the Island Line. They have all been input as zeros when in fact they are operated by electric trains. The consequence of this is that the income from Electric Current for Traction (EC4T) has been calculated on the basis of their input train km (not electric train km). However, we believe this is reasonable and is not a concern.

13.5 Data Inputs and Model Assumptions

We have identified the following issues for consideration in the next version of the model.

13.5.1 Growth in Freight Traffic

The model has effectively smoothed the increase in freight traffic so that it is more conservative than the demand forecasts. This method was chosen after discussions within Network Rail and reflects a compromise between high and low forecasts. The final demand at the end of CP5 is the same as the high forecast, however the growth is backloaded towards the end of the control period.

The impact of this smoothing is relatively small, reducing the income to Network Rail from £326m to £312m for the current railway scenario.

13.5.2 Freight Train Km

The freight train km in the model for 2010/11 show a total of 46.752 million km compared with 35.045 million km shown in the 2011 Annual Return. The difference is explained by the fact that the Annual Return excludes locomotives running as ‘light’ and non-commercial traffic (such as engineering haulage trains).

Income from the capacity charge is based on train km. In total, this is budgeted at £3.8m for 2011/12. The model predicts 48.26 million km and so calculates a charge of 7.6p per train km for England & Wales and 10.7p per train km for Scotland in 2011/12.

Our assumption is that non-commercial train km should be excluded from this calculation. On the basis of the above figures for 2010/11, about 36.56 million km should be charged resulting in rates of 10.9p and 14.2p per train km for England & Wales and Scotland respectively per train km. However, because these rates are applied to forecasts of commercial + non-commercial freight train km in the model, the lower rates calculated are applicable and the estimates of the capacity charge are correct. Explaining this in the spreadsheet or the Functional Specification would be helpful.

13.5.3 EC4T Rate

The model calculates an EC4T rate per train km for freight from the 2011/12 budget figures. This rate is then assumed to be constant throughout the remainder of CP4 and CP5. The budget for such income in 2011/12 is £5.8m.

The open access operators do not use EC4T rates because of missing electric train km information, but effectively the calculations assume a rate based on the average of the 2009/10 and 2010/11 years. Again this is assumed to remain constant through CP4 and CP5, which amounted to £2.9m in 2010/11.

However, the separate EC4T model which is used to calculate the costs (as opposed to the income) for all passenger and freight trains assumes an increase in the tariff in 2014/15 of 32.9% and 41.1% for England & Wales and Scotland respectively. This results in significantly higher costs for CP5. For example, under the ‘Current Railway’ the Income model calculates income from EC4T for freight trains at £37m, whereas the EC4T model methodology estimates these costs at £91m. The two values should be the same.

13.5.4 VTAC Calibration Factors

The calculated 2011/12 VTAC rates are multiplied by a calibration factor of 1.011 for England and Wales, and 1.349 for Scotland. The purpose of these factors is unclear, and Network Rail have acknowledged that the geographical difference warrants further review.

13.5.5 Crossrail

It is noted that the Crossrail income for CP4 (shown in the Income model) is not shown separately in the outputs from the Tier 0 model. Network Rail advise that this is included in the ‘Other Facilities Charges’ line in Tier 0 for CP4, but will be separated out for the Strategic Business plan as it already is for CP5.

13.5.6 CTRL

Responsibility for the HS1 infrastructure is currently concessioned to Network Rail (CTRL) Ltd, for which they receive an income of £13.92m in 2011/12. Network Rail advise that the expiry date of the current agreement is 31 December 2047. HS1 do, however, have a ‘one-off’ opportunity (subject to three years’ notice) to break the current agreement at the beginning of its next control period. The next opportunity when it could invoke this clause is 1 April 2015, when its second control period begins. At this stage there is no assurance that Network Rail CTRL Ltd will continue to maintain the HS1 infrastructure beyond 31 March 2015. The forecasts have therefore been developed on this basis.

The trigger date for invoking the clause is 31 March 2012, at which point Network Rail will review the validity of the current assumption and update accordingly. The residual income after 2015 (£3.5m per year) in the current forecast is from stations, which operate under a concessions agreement with no break clauses before 2086.

It would be worth checking that the same assumption has been made on the cost side for the various assets.

13.5.7 Performance

The model assumes that performance penalties will remain constant at the level of the 2010/11 budget during the remainder of CP4 and throughout CP5, at a rate of £6.9m per year.

However, the actual performance payments in 2010/11 were significantly higher at £12.3m (source: 2010/11 Regulatory Accounts). During that year, freight trains suffered an average of 4.29 minutes per 100 freight train km (source: 2011 Annual Return). This would suggest that there is a risk of the forecast performance penalties being too low.

That said, in section 9.5.2 of the IIP, it is forecast that the performance of freight trains will improve from 2.96 minutes per 100 freight train km in 2014/15 to 2.64 minutes per 100 train km by the end of CP5 in 2018/19 (for the current railway). This is significantly better than the delays experienced in 2010/11, and if they are delivered they should deliver fewer penalties than forecast in the model.

We would suggest that the performance penalties should be set at the budget for the end of CP4, and then progressively reduced in line with the performance improvements during CP5.

13.6 Overall View on Uncertainty of Outputs

In the absence of a Functional Specification, the logic of the model appears to make sense and the formulae have been applied consistently. However, a source of uncertainty is the method for calculating EC4T income which is inconsistent with the EC4T cost model.

The freight income for Scotland is less certain than for England and Wales because of its significantly higher VTAC Calibration Factor which Network Rail want to review.

13.7 Suggested Improvements

The EC4T methodology should be reviewed for consistency with that in the EC4T cost model.

As suggested by Network Rail, the geographical difference in VTAC Calibration Factors should be reviewed.

The Functional Specification for this model should be documented.

We would also suggest that the income from performance penalties should be reviewed so that assumptions made are consistent with the IIP plans. (More generally, it would also be worth reviewing Schedule 8 payments in the same light.)

14 EC4T

14.1 Introduction

This spreadsheet model (EC4T CP5 June 11 - v13.xls) calculates the Electric Current for Traction (EC4T) costs for CP5 and beyond. This is based on the forecast traffic, rolling stock consumption rates and electricity tariff rate. Separate calculations are made for:

- Franchised passenger services
- Freight
- Open access
- NR own traction
- Non traction

14.2 Approach to Audit

The model was reviewed against the Functional Specification and a number of queries were listed relating to the assumptions and data inputs. These are sent to Network Rail for comment.

14.3 Model Overview

The current consumption rates per train km for each TOC have been estimated from the 2009/10 outturn cost and consumptions figures. The annual forecast increases in traffic have then been applied through to CP5 and beyond, along with expected changes to rolling stock and electrification schemes.

The EC4T tariff has been forecast for each year based on the current hedging policy ending and the future market forecast. This results in a significant annual increase in the forecast tariff for the first year of CP5 (33% for England and Wales and 41% for Scotland).

This approach to calculating the EC4T cost for freight and Open Access Operators differs to the approach taken to forecast the income for EC4T from freight and Open Access Operators (see the section above on the Income model). This is described further below.

14.4 Computational Integrity

No problems or errors have been identified in the model calculations.

14.5 Data Inputs and Model Assumptions

The only concern that we identified relates to the forecast electric train km in the worksheet “201_C_MainConCostCalc”. Changes are made (in pink) to reflect the impact of electrification schemes and the consequent switch from diesel to electric trains on the affected routes. These changes were based on the assumptions available at the time the model was run.

- In the Current Railway scenario, electrification schemes for Northern and North Transpennine were included, but not GWML and Edinburgh – Glasgow.
- In the Preferred Plan scenario, none of the additional schemes were included (for example, Midland Mainline, Gospel Oak - Barking, Scotland Phase 2 and Cardiff Valleys).

Given the Northern and North Transpennine schemes add £4m and £4.9m per year respectively by 2016/17 in the model, including the missing schemes will have a detectable impact on the overall EC4T costs.

These assumptions should be reviewed for the Strategic Business Plan, in both the EC4T and Income models.

14.6 Overall View on Uncertainty of Outputs

No errors have been identified in the model calculations.

Some electrification schemes have not been assessed resulting in some missing EC4T costs.

It is noted that as expected, the EC4T costs are directly dependent on the assumed tariffs. So if the actual tariff in CP5 turns out to be double that currently forecast, the total EC4T cost will double. In the case of the Current Railway, this would double the cost in CP5 from £1.2 billion to £2.4 billion.

14.7 Suggested Improvements

Reflect the latest assumptions on electrification schemes in each scenario, and update the electric train km accordingly on the affected routes.

15 Support, Property and Non-Controllable Costs

15.1 Introduction

The Support, Property and Non-Controllable Costs model covers a wide range of miscellaneous costs in five major categories, as set out in the Tier 0/1 Cost Models Functional Specification (Release 002, October 2011):

- Human Resources, Finance, Government and Corporate Affairs, Information Management, Planning and Development, Commercial Property and Other Corporate functions, which includes Strategic Sourcing, Legal and Inquiry, Board, Safety and Compliance, Transformation Team, Westwood;
- Insurance costs;
- Utilities costs;
- Support costs in non-Maintenance Asset Management functions; and
- Non-controllable costs excluding EC4T (i.e. Electric Current for Traction).

It presents these costs by operating scenario at various levels of network geography for the individual years 2009/10 – 2023/24 and by Control Period (CP) average for CPs 7-11. Controllable costs are disaggregated by function and cost category, and income and non-controllable costs are presented separately on the model dashboard.

15.2 Approach to Audit

The spreadsheet comprising the model was reviewed for formula consistency and to check that a sample of the model outputs correctly reflect the corresponding inputs for a range of cost categories, scenarios and network geographies.

15.3 Model Overview

The model takes the form of a single spreadsheet: the file 'SUPPORT_IIP_FINAL.xls' was the version provided for the purposes of the audit. The model contains a Dashboard worksheet, several worksheets containing parameters for hierarchies, efficiencies, network coding and other metrics, input worksheets for each of the cost categories covered by the model, and, finally, a Collated Results worksheet providing the data that are shown in summary form in the Dashboard, and that also form the input to the Tier 0 model. The hierarchies used in this model differ from those in the other, asset-related Tier 1 models, reflecting the fact that this model covers costs related to support functions, such as Human Resources and Information Management (IM), rather than the operation, maintenance and renewal of physical assets. The model also includes income from property and other sources, which is handled as a 'negative cost'.

Some very limited input control/error prevention facilities are performed by a VBA macro contained in Module 1 of the model, while Modules 2 and 3 contain additional VBA code that was used during model development but is now redundant (these modules should be removed, to avoid potential confusion). Most of the costs data are held within the model, but Utilities costs are obtained from an offline model, although we understand that there are aspirations within Network

Rail to incorporate this functionality within the Support, Property and Non-Controllable Costs model.

15.4 Computational Integrity

Routine checks were conducted for spreadsheet errors (i.e. inconsistent formulae, etc.) within the 'Dashboard' and 'CollatedResults_ORAllocate' worksheets, where the bulk of the model's calculations are performed; no errors were found.

Computation checks were also conducted on a sample of Dashboard outputs, using various parameter combinations. We understand that the three different Scenarios used in other models are identical as far as the Support model is concerned, and this was verified during the review process by means of visual checks. Since there are no Information Management costs associated with Property (or most other MOPS categories), the initially-selected check (second set of parameters in the table below) was not particularly meaningful, and was augmented by a check on the Commercial Property costs associated with the Property MOPs category. The combinations used, and the results obtained, are summarised in **Table 15.1**; the checks indicated that all the model outputs were correct.

While the checks indicated that the model is functioning as intended, the checking process was made more difficult by the extensive use of the OFFSET( ) and INDIRECT( ) functions in Excel; while we understand that these functions are powerful and flexible, and assist with model development, they do potentially make the review and maintenance of models more difficult and time-consuming, and their use should be avoided where possible. This view is confirmed by the DfT spreadsheet modelling best practice guidelines in the recently-issued ITT for the InterCity West Coast Franchise, for example – see pp84-85 of http://assets.dft.gov.uk/publications/intercity-west-coast-franchise-itt/invitation-to-tender-main-document.pdf. This is not really an issue for the current set of models, but should be borne in mind for future model development.

Table 15.1: Summary of Computational Integrity Checks

Geography	Year/ Control Period	Cost by Function or Category	Input Price Change Overlay	Overlay Efficiency?	Apply Stretch?	MOPS	Outputs	
							Model	Check
Network Total	15/16	HR	Global	Yes	No	Maintenance	0.2	OK
England and Wales	18/19	Information Management	Staff Costs Only	No	Yes	Property	0	OK
England and Wales	18/19	Commercial Property	Staff Costs Only	No	Yes	Property	2.3	OK
Scotland	21/22	Group Insurance	Utilities Costs Only	Yes	No	Support	7.3	OK
LNE	CP8	Staff Costs	Staff and Utilities Costs Only	No	Yes	Total	4.5	OK
Wessex	CP11	Other Operating Income	None	Yes	No	Total	-0.2	OK

15.5 Data Inputs and Model Assumptions

We understand that most of the data inputs to the model are simply copied and pasted from other, typically Accounting and Finance, sources, the data being supplied in the appropriate format for pasting directly into the model. There is inevitably a degree of risk of human error in any copying and pasting process, but the fact that the data are supplied in a 'paste-ready' format reduces this, and we understand that simple cross-checks of data totals, etc., are conducted to ensure consistency between the supplied inputs and the data that have been pasted into the model.

As noted above, Utilities costs are the exception, being calculated offline in another model, although there are plans to incorporate this process directly within the Support, Property and Non-Controllable Costs model. For the purposes of the input data checks, we compared the 'Utilities spend' data with 'Application of efficiency overlay' in the 'Final Output' worksheet of the Utilities model (the spreadsheet 'Utilities module v2.3 (sent to Arup v2).xls') with the data shown in the CP5 modelled, post-efficient input to the 'Utilities' worksheet of the Support model. The two sets of data were found to be identical.

15.6 Overall View on Uncertainty of Outputs

Based on the checks described above, the Support model is computationally accurate, and the data outputs from the standalone Utilities model are consistent with the inputs to the Support model.

15.7 Suggested Improvements

The model is not particularly complex, but in common with many of its counterparts, the provision of enhanced documentation would be helpful for users, maintainers and developers, since the Functional Specification provides only a very limited overview of the scope of its cost base, its functionality (there is no explanation of which elements of the model perform the various functions, for example), and data links and proposed future developments. This documentation should take the form of a written guide and process description, and also the addition of explanatory comments to the VBA code (the code is limited in its extent and complexity, but the provision of comments is nonetheless helpful and is good development practice).

16 Traffic

16.1 Introduction

The Traffic model is neither a Tier 1 nor a Tier 2 model, but its outputs provide input to the Tier 1 Track and Income models, in the form of data including train km, electric train km and gross tonne km.

16.2 Approach to Audit

The traffic model was not reviewed in detail, but its outputs for both the ‘Current Railway’ and ‘Preferred Plan’ scenarios were compared with the inputs to the Income model, and checked for equivalence.

16.3 Model Overview

The Traffic model comprises six Microsoft Access databases, which contain a range of infrastructure and traffic inputs, queries for processing the data, and a single database containing the outputs for franchised and Open Access passenger, and freight traffic.

16.4 Computational Integrity

The comparisons of the two datasets indicated that the Traffic model outputs and the Income model inputs are in agreement to within +/- 0.01% for Open Access operators, and within +/- 0.00% (and typically much less) for the Freight Operators.

16.5 Data Inputs and Model Assumptions

The data inputs and assumptions underlying the model were not reviewed.

16.6 Overall View on Uncertainty of Outputs

Based on the computational checks conducted, the outputs from the Traffic model are accurate and replicable. However, the structure of the Traffic model is comparatively complex: for example, it includes several ‘linked tables’, which need to be specified in accordance with the computer being used, and the database names do not clearly indicate their respective roles and positions within the process and sequence. The sequence of queries used to produce the model outputs is not particularly clear to an inexperienced user, either, and the results are therefore difficult to replicate without prior hands-on experience. This inevitably has implications for the model’s reliability in the event of unplanned staff absences, for example.

16.7 Suggested Improvements

The model itself is accurate, as noted above, but its structure and workings are not particularly transparent, and the key to dealing with these issues is the preparation of improved documentation, describing the purpose, structure and functionality (i.e. the inputs to, the queries used and their sequence) and the outputs from the model. This would provide valuable information and guidance to new and inexperienced users and reviewers of the model, and also to model maintainers and developers.

17 Other Maintenance

17.1 Introduction

This is an Excel spreadsheet model (Maintenance ISBP Indirect model - 20110913 - v10.xls). It is documented in Section 13 of the Functional Specification (Document Release 002, October 2011). This model predicts the CP5 expenditure for:

- Maintenance Indirect Labour costs;
- Maintenance Indirect Material costs;
- Maintenance Indirect Plant costs;
- Maintenance Indirect Other costs; and
- Other Maintenance related costs not included in other models.

It is understood that the 'Other Maintenance' model is not fed by any other Tier 1 or Tier 2 model. The modelling method for End CP4 Indirect Labour costs is based on "volume profile" (headcount in this case) whereas Materials, Plant and Other indirect related costs are modelled as percentage uplifts of the labour costs (using 2010/11 actual financial data).

Other maintenance costs are all derived offline and manually entered into the model as input cost profiles. Table 17.1 below summarises the CP5 expenditure as forecast in the model.

Table 17.1: Other Maintenance Tier 1 - CP5 Expenditure Estimate (Tier 1)

Maintenance Indirect Costs	CP5 Expenditure Estimate (£m)
Maintenance HQ	191
Route HQ	96
Delivery Unit HQ	216
Signals	130
Telecoms	55
Track	326
E&P	3
Exceptionals	154
Other	1
Group	201
Total Maintenance Indirect Costs	**1,373**

17.2 Approach to Audit

Since Network Rail are aware that this model requires improvement, we were advised to focus effort on checking the computational accuracy. Accordingly, the inputs and assumptions used in this model were not verified.

Simple manual checks were performed to ensure that the calculations in the model were correct. Where the calculations relied on data found in other worksheets, the formulae were checked to make sure that the right cell/range was being referenced. For the purpose of this audit, no meetings were held with Network Rail.

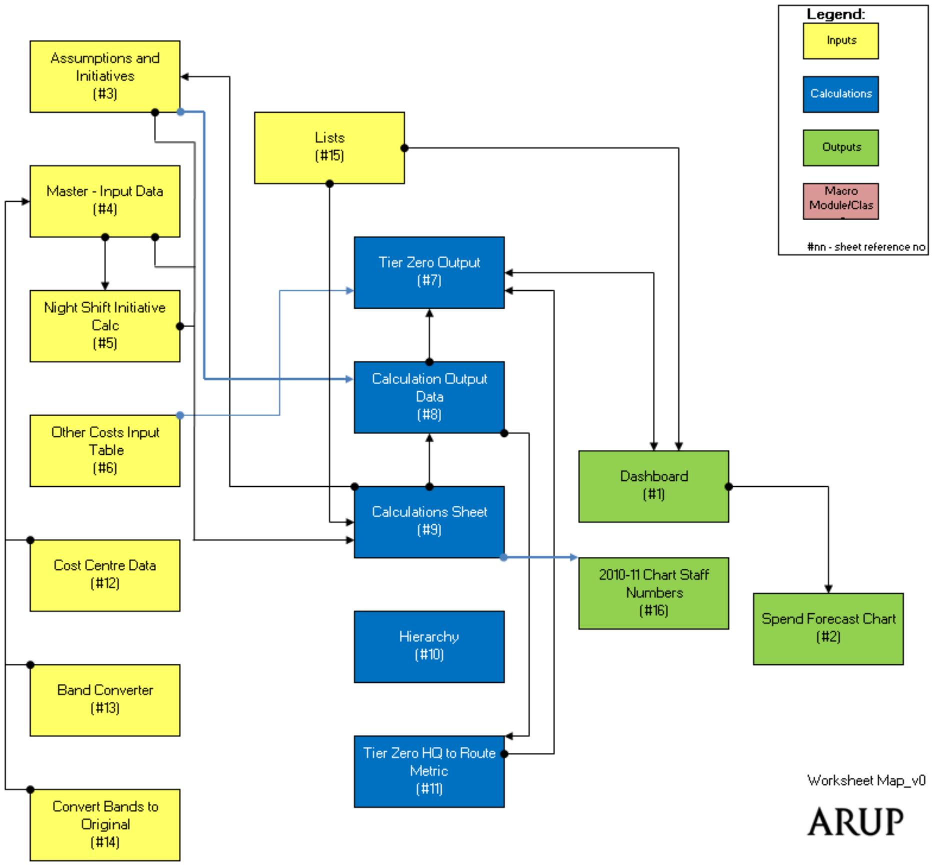
17.3 Model Overview

Table 17.2 below summarises the characteristics of the spreadsheet model audited based on an analysis that we carried out by using a VBA macro. As can be seen, there are no macros used in this spreadsheet model. The overall architecture of the Maintenance ISBP Indirect model is shown in **Figure 17.1**.

Table 17.2: Other Maintenance Tier 1 – Spreadsheet Characteristics

Maintenance ISBP Indirect model - 20110913 - v10.xls	
No. of worksheets	16
VBA components	0
No. of named ranges	47
No. of Input Sheets	8
No. of Calculation Sheets	5
No. of Output Sheets	3

Figure 17.1: Other Maintenance Tier 1 – Worksheet Map



17.4 Computational Integrity

A check on the computational integrity of the model was carried out and the formulae in each worksheets have been checked. A full list of computational checks performed can be found in Appendix H.

Only one computational error was found within the model, which we consider of minor concern as it does not affect the calculation in this instance. Table 17.3 below summarises the computational error.

Table 17.3: Other Maintenance Tier 1 - Computational Integrity discrepancies

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
Tier Zero HQ to route metric	£	D3 :D12	×	Sum range is not fixed (However, values are consistent in this case). Update required

17.5 Data Inputs and Model Assumptions

Since Network Rail is aware that further improvement is needed to this model, it was advised that no checks on the inputs and model assumptions were necessary for this model.

17.6 Overall View on Uncertainty of Outputs

Only one computational error has been found in this model which is of marginal concern as it has no impact on the estimated costs.

17.7 Suggested Improvements

As identified by Network Rail, this model requires a considerable amount of improvement and it is envisaged that 'other maintenance' costs will be included and modelled in the relevant asset specific model as stated in the Functional Specification.

18 Operate Costs Model

18.1 Introduction

The Operate Costs model is used to forecast the future costs of the function formally known as Network Rail's 'Operations and Customer Services', and is structured around a number of groupings for staff and or cost type. These groupings and the estimated costs for CP5 in the model are shown in Table 18.1 below:

Table 18.1: Business Analysis Grouping and CP5 Estimate of costs (Tier 1)

Business Analysis Grouping	CP5 Expenditure Estimate (£m)
Signaller/LX Keeper	956.7
Shift Signalling Managers	24.3
Local Operations Managers / Operations Managers	66.1
Operations Control	111.7
Electrical Control Room Operators	28.1
Mobile Operations Managers	137.6
Performance	49.4
Route Enhancement Managers	0
Managed Stations	197.4
Customer Relationship Executives	33.5
Other Route Staff	79.1
O&CS Maintenance Costs	45.9
Other Operating Income	-101.6
Operations Services (HQ)	35.7
Planning and Performance (HQ)	41.0
Stations and Customer Services (HQ)	7.4
Other HQ Costs	10.9
Weather related specific costs	86.4
Total	**1809.7**

The model receives from the Tier 1 Signalling model an estimate of the signaller/Level Crossing keeper headcount profile and employment costs consistent with the delivery of the operating strategy. It uses calculation rules to derive an estimate of the headcount and cost associated with the Shift Signalling Managers, Local Operations Managers/Operation Managers and Operations Control to be consistent with the planned reductions in signaller headcount. In addition, it captures the assumed future headcount and cost profiles on all other staff/cost types as manual inputs.

18.2 Approach to Audit

This model has been audited with a lighter touch than other models after talks with Network Rail confirmed this to be acceptable. The model has been checked for consistency on the inputs received from the Signalling model and the calculations have been checked. A discussion with the Network Rail modeller indicated that a review of the inputs would be difficult to undertake and so it was agreed that the model outputs would be compared to the values found in the appendices of the Control Period 4 Delivery Plan update 2011. No meetings have been held with regard to this model although a telecom was held on the 16th January to discuss the model and the audit.

18.3 Model Overview

The model consists of 25 visible worksheets and 2 hidden worksheets. The names of the worksheets and their visibility are shown in the table below.

Sheet name	Visible
List Library	Visible
PreProcFeed	Visible
Headcount Data	Visible
200809	Hidden
NOS	Hidden
CP5 Ops Strategy Inputs	Visible
1 - SIG	Visible
2 - SSM	Visible
3 - LOM	Visible
4 - CON	Visible
5 - ECR	Visible
6 - MOM	Visible
7 - PER	Visible
8 - REM	Visible
9 - MAN	Visible
10 - CRE	Visible
11 - OTH	Visible
12 - MNT	Visible
13 - OOI	Visible
14 - HOS	Visible
15 - HPP	Visible
16 - HSC	Visible
17 - HOT	Visible
18 - WEA	Visible
SUPER SUMMARY REPORT	Visible
Error Checks	Visible
TIER 0	Visible

The model is contained solely within Excel and has no macros associated with it.

18.4 Computational Integrity

The workbook contains a number of calculations within each of the worksheets numbered 1 – 18 as well as the Super Summary Report and TIER 0 worksheets.

A random selection of the calculations were checked to make sure they were looking at the correct inputs and the calculations were also checked outside of the worksheet using the values. These were all deemed acceptable.

The inputs received from the Signalling Model were checked and found to be accurate and consistent with the values found within the Signalling Model.

The model is well structured and easy to follow with relatively simple calculations.

The documentation which accompanies the model is useful and gives an insight into what the model does and the inputs and calculations contained in it.

18.5 Data Inputs and Model Assumptions

The model contains a number of data inputs and model assumptions. However, as agreed with Network Rail, these have not been checked (other than the inputs from the Signalling Model) within this review. The model does contain a number of assumptions from O&CS, Ops Finance systems and Operating Strategy, as indicated in the Functional Specification document.

18.6 Overall View on Uncertainty of Outputs

The outputs from the model for CP4 have been checked against the values to be found in appendices 14 (network), 32 (England and Wales) and 36 (Scotland) of the Control Period 4 Delivery Plan Update 2011. These values and the relevant model values are shown in the table below.

Operating Expenditure	**Delivery Plan Forecasts** **(£m, 2011/12 prices)**	**Model Values**	**Percentage Difference**
Network Operations	2,093	2,112.9	+1%
England and Wales	1,902	1,921.7	+1%
Scotland	192	191.2	0%

The results in the table show that the modelled values are within 1% of the forecast values in the Delivery Plan and indicate that the model produces outputs which are consistent with these. This provides confidence in the accuracy of the model for CP4 which provides the basis for the CP5 forecasts.

18.7 Suggested Improvements

The model is relatively small and has reasonable documentation to accompany it. Although not examined in detail in this review, the area where improvement could be made is the audit trail of inputs, to clarify data sources and assumptions made. Apart from this, the model performs well and is understood by the Network Rail modellers in ownership of it.

19 Other Renewals

19.1 Introduction

This is a spreadsheet model (Other_Renewals_IIP_Final.xls). A very brief overview of the model along with the list of inputs can be found in Chapter 12 of the Functional Specification (Document Release 002, October 2011).

The model is used to forecast Network Rail's IT renewal expenditure, Corporate Offices renewals expenditure and Capex related to the Asset Information Strategy, Intelligent Infrastructure and the Engineering Innovation Fund.

19.2 Approach to Audit

The spreadsheet comprising the model was reviewed for formula consistency. A sample of the model's outputs was checked to ensure that they correctly reflect the corresponding inputs for a range of cost categories, scenarios and network geographies.

19.3 Model Overview

The 'Other Renewals' model is built using Excel 2003 and has no macros associated with it. All costs are derived offline and manually input and there is no documentation on the approach for doing this.

The formulae within the model allocate these costs to the Network Rail Operating Routes. Apart from this there are no other calculations in this model. The model does not include a dashboard. The output to Tier 0 model is created in the form of a table which is then manually copied and pasted into the Tier 0 model.

19.4 Computational Integrity

A check on the computational integrity of the model was carried out and the formulae in each of the worksheets were checked. The calculations within the model were relatively straightforward and easy to follow and no problems or errors have been identified in the model calculations.

19.5 Data Inputs and Model Assumptions

Other renewals costs are all derived offline and manually entered into the model as input cost profiles starting from year 2014/15 to 2023/24 and control period averages from CP7 to CP11. **Table 19.1** below summarises the CP5 expenditure as forecast in the model for the three scenarios. It was observed that the scenarios 'Current Railway plus investments to reduce cost' and' Preferred Plan' have identical inputs. The calculations within the model were checked for consistency and accuracy. However, the data inputs and assumptions within the model were not reviewed.

Table 19.1: Other Renewals Tier 1 Model - Input/Output Costs

Other Renewals Tier 1 Model - Input/Output Data				
L4 Description	**L5 Description**	**Current Railway (£m)**	**Current Railway plus investments to reduce cost (£m)**	**Preferred Plan (£m)**
IT	IT	0.0	164.2	164.2
Signalling	Points	0.8	0.8	0.8
	Track Circuits	1.1	28.8	28.8
	Level Crossings	0.0	2.1	2.1
	SSI Interlockings	0.0	2.7	2.7
	Axle Counters	0.0	1.1	1.1
Electrification and Fixed Plant	Points Heaters	0.8	0.8	0.8
	ELDs	0.3	0.3	0.3
	PSP Generators	0.0	1.5	1.5
	Electrification and Fixed Plant	0.0	3.5	3.5
Civils	Wire Rock Fall	0.0	0.4	0.4
	Earthworks	0.0	0.6	0.6
	Buildings	0.0	7.5	7.5
Telecoms	Telecoms	0.0	4.2	4.2
Track	Track	0.0	5.0	5.0
IT	IT	0.5	14.7	14.7
Project Management & Engineering	Project Management & Engineering	0.0	28.7	28.7
IM Renewals	IM Renewals	0.0	0.0	0.0
Strategic Capex	Strategic Capex	103.6	103.6	103.6
Business Improvement	Business Improvement	72.1	72.1	72.1
Maintains an Operational Capability	Maintains an Operational Capability	85.2	85.2	85.2
Traffic Management Systems	Traffic Management Systems	0.0	0.0	0.0
Renewals to our property portfolio	Renewals to our property portfolio	60.6	60.6	60.6
Enhancements to MDUs/Office estate	Enhancements to MDUs/Office estate	30.5	30.5	30.5
Engineering Innovation Fund	Engineering Innovation Fund	5.0	5.0	5.0
TOTAL		**360.5**	**623.8**	**623.8**

19.6 Overall View on Uncertainty of Outputs

No errors have been identified in the model calculations and the outputs matched with the inputs for the relevant scenarios. However, it would be useful to understand the precise source of data inputs in order to ascertain the credibility of the model outputs.

19.7 Suggested Improvements

As for other Tier 1 models we suggest improved documentation including flow diagrams where possible, a detailed definition of each scenario modelled and a description detailing the derivation of the model inputs.

20 Other Maintenance and Asset Management

20.1 Introduction

'Other Maintenance and Asset Management' is a spreadsheet model. It is not yet documented in the Functional Specification (Document Release 002, October 2011).

The model is used to forecast the other maintenance and support costs for the following:

- National Delivery Service
- Engineering
- Asset Management Support
- Asset Information
- Track
- SP&C
- B&C

20.2 Approach to Audit

The spreadsheets comprising the two models were reviewed for formula consistency. A sample of the model's outputs was checked to ensure that they correctly reflect the corresponding inputs for a range of cost categories and network geographies.

20.3 Model Overview

This spreadsheet model forecasts Network Rail's expenditure for CP5 and beyond.

Scenarios CR and CI are modelled using two separate models as listed below:

- Other_AM_CR_IIP_Final.xls - Current Railway (CR); and
- Other_AM_CI_IIP_Final.xls - Current Railway plus investments to reduce costs (CI).

Table 20.1 below summarises the CP5 expenditure for the two scenarios as forecast in the model. The outputs for 'Current Railway' and 'Current Railway plus investment to reduce costs' scenarios were compared and the difference in the total forecast expenditure was attributed to the additional salary costs (support) of £22.8m within 'Asset Information' category in CP5 for 'Current Railway plus investment to reduce cost' scenario.

Table 20.1: CP5 Forecast Expenditure - Other Maintenance and Asset Management Tier 1 Model

CP5 Forecast Expenditure (£m)	CR	CI	Difference (CI less CR)
Maintenance Costs			
NDS Material Costs	104.6	104.6	0.0
NDS Other Maintenance of Strategic Plant	56.9	56.9	0.0
NDS Other	48.5	48.5	0.0
Engineering	5.2	5.2	0.0
Asset Management Support	0.0	0.0	0.0
Asset Information	35.3	35.3	0.0
Track	0.0	0.0	0.0
SP&C	0.0	0.0	0.0
B&C	0.0	0.0	0.0
Support Costs			
NDS	70.0	70.0	0.0
Engineering	115.8	115.8	0.0
Asset Management Support	4.2	4.2	0.0
Asset Information	57.5	80.3	22.8
Track	18.4	18.4	0.0
SP&C	29.9	29.9	0.0
B&C	19.6	19.6	0.0
Grand Total	**565.8**	**588.6**	**22.8**

20.4 Computational Integrity

A check on the computational integrity of the model was carried out and the formulae in each of the worksheets were checked. No errors have been identified in the model calculations.

20.5 Data Inputs and Model Assumptions

The CP5 expenditure forecasts are based on end of CP4 spend levels and are directly input into the model as cost profile. For the items listed in **Table 20.2**, the estimated additional costs for CP5 have been overlaid.

Table 20.2: CP5 overlay

	CP5 overlay (£m)				
Description	**14/15**	**15/16**	**16/17**	**17/18**	**18/19**
NDS					
NDS Income	5.99	5.99	5.99	5.99	5.99
Stoneblower	0.15	0.15	0.15	0.15	0.15
Tamper	0.14	0.14	0.14	0.14	0.14
SandC Rail Grinding	0.85	0.85	0.85	0.85	0.85
Private Party Costs - Stoneblower Maintenance	1.51	1.51	1.51	1.51	1.51
Asset Information					
Salary Costs	4.57	4.57	4.57	4.57	4.57

20.6 Overall View on Uncertainty of Outputs

No errors have been identified in the model calculations itself. However, as the model did not accompany any documentation, it was difficult to understand what the model is supposed to do and how it is supposed to do it, and therefore whether the input data, assumptions made and outputs it is generating are correct.

20.7 Suggested Improvements

The Functional Specification for this model should be documented.

Any redundant data in the model inputs should be removed to improve the clarity of the modelling process and reduce the potential for uncertainty and confusion.

21 Tier 0

21.1 Introduction

The Tier 0 model accepts the outputs from the Tier 1 models as input, applies efficiencies as appropriate, and aggregates the data by future network scenario, network geography (for overall costs and work volumes), and also by cost hierarchy (i.e. controllable and non-controllable operating expenses, renewals and enhancements costs, and income). Through its various dashboards, it enables the filtering and presentation of overall and disaggregate results in various ways, providing summaries by scenario, asset type, geography and year.

21.2 Approach to Audit

In recognition of the audit timescales, the large number of database queries and macros, and the extent of the underlying VBA code, a high-level review process was adopted, comprising spot checks of the input data and the computation process, including the application of efficiencies.

Because of the structure of the model, relying as it does on the extensive use of databases and queries, such an 'inductive approach' is suitable, since the operations applied to a subset of the overall data will reflect those applied to the dataset as a whole.

21.3 Model Overview

The model comprises a spreadsheet 'front end'(Tier0_vLIVE.xls), containing the Tier 0 dashboards, and three underlying databases (ComDim.mdb (common to several of the Tier 0 and Tier 1 models), Tier0_Dat.mdb and Tier0_Cal.mdb), which are used to store and process reference data and the inputs from the Tier 1 models. As well as providing the model 'front end', the spreadsheet allows the final data to be filtered in a range of different ways, by various categories.

21.4 Computational Integrity

The Tier 0 outputs produced by the Tier 1 model for Wheeled Machinery and Plant were selected for a computational check. This was done by conducting a 'parallel calculation' of the Tier 0 Cost outputs for the High output sub-category of Wheeled Machinery and Plant for the 'Current Railway' scenario. This was done using spreadsheet-based calculations and data manipulations to replicate the algorithms and processes used in the Tier 0 model, including the application of efficiencies (i.e. Efficiency Profile 5, 7.5% in total, for the category under review).

The parallel calculations exactly replicated the results shown in the dashboard of the Tier 0 model front end spreadsheet, i.e. worksheet '910_O_ModDash'), and we therefore conclude, on the basis of the sample checks conducted, that the Tier 0 modelling process is computationally correct.

21.5 Data Inputs and Model Assumptions

Checks were conducted on the efficiency values used in the model, and on the consistency of the Tier 0 model inputs with the outputs from the Tier 1 models.

The Tier 0 model was checked for consistency between the Efficiency inputs (as specified in the front end spreadsheet worksheets '201_C_EfficiencyProfiles' and '211_C_EfficiencyChoices') and the planned efficiencies as set out in the Network Rail document *PERIODIC REVIEW 2013 Progressive Assurance Process: Network Rail's Efficiency Assumptions in IIP*, in which the efficiency values are set out in the table in section 6, *Core efficiency assumptions*. The correspondence is not immediately obvious from either the model or the document, but the relationship and correspondences were explained by Network Rail, and we are satisfied that the efficiency values are incorporated correctly in the Tier 0 model inputs, as shown both. The efficiency values used in the Tier0_Cal.mdb database were also checked, and found to be consistent with the values shown in the front end spreadsheet and in the efficiency documentation.

The Tier 0 output from the Tier 1 Signalling Model for the 'Preferred Plan' scenario was compared with the corresponding values in the dashboard on the '910_O_ModDash' worksheet of the Tier 0 model, with no efficiencies applied. The results were found to be broadly consistent, but two anomalies were identified:

1. The Tier 0 file contains some 'ERTMS Other' costs with no corresponding 'LxCode' values (approximately £5m for 2014/15 and £8.8m for 2023/24) which are not included in the Tier 0 model; however, we understand that these values are redundant and no longer used, and are awaiting removal from the modelling process.
2. The Tier 0 model includes Indirect Maintenance Costs for Signalling (£26m for each year) which are not shown in the Tier 1 Signalling model outputs. We understand that these costs are derived from the Maintenance Indirect Costs (MIN) model, as indicated in the MC_SIG_IND… records of the Dim_CostHierarchy table in the ComDim.mdb database.

Similarly, the Tier 0 output from the Tier 1 Telecoms Model for the 'Preferred Plan' scenario was compared with the corresponding values in the dashboard on the '910_O_ModDash' worksheet of the Tier 0 model, with no efficiencies applied (the 'Preferred Plan' was the scenario modelled in the version of the Telecoms model originally supplied by Network Rail, and it was considered best not to make any adjustments to the model). The values for the total Maintenance Costs for each year were compared, together with a sample of Maintenance Volumes for Concentrators (2014/15), Cables and route (2018/19), CCTV (2020/21) and Power (2023/24), Renewals Costs for Network and for Minor works (2014/15 – 2023/24), Renewal Volumes for Partial PA (2014/15 – 2023/24), and Outputs for Total Failures (2014/15 – 2023/24). All values were found to be consistent.

Finally, the Tier 0 output from the Tier 1 Civils Model for the 'Current Railway' scenario was compared with the corresponding values in the dashboard on the '910_O_ModDash' worksheet of the Tier 0 model, again with no efficiencies applied. All the Tier 1 outputs were compared with the Tier 0 dashboard, and were found to be consistent. None of the CP4 or Outputs values shown in the Tier

0 dashboard were found in the Tier 1 model; we understand that none of the Tier 1 models contain CP4 data, and that these are held in a separate pre-processing file (Tier 0 CP4 Pre-Process v3.xls), but the source of the Tier 0 Outputs values is unclear.

21.6 Overall View on Uncertainty of Outputs

As in the case of the Tier 1 models, the model documentation is restricted to a very high-level overview in the Functional Specification, and this introduces an inherent degree of uncertainty with regard to the model outputs, since it is difficult to understand what the model is supposed to do and how it is supposed to do it, and therefore whether the outputs it is generating are correct.

Despite the shortcomings of the documentation, the sample checks conducted on the computational integrity, data inputs and model assumptions indicate that the model is accurate, although some tidying up and removal of redundant data is required.

21.7 Suggested Improvements

Although the functionality of the Tier 0 model is limited, in that it collates, aggregates, filters and presents the combined results from the Tier 1 models, it is thus completely central to the IIP and SBP modelling process. It is also quite complex in its operation, 'slicing and dicing' the data in various ways, and containing a large number of database queries, in addition to VBA code. The provision of user (and developer and maintainer) documentation is therefore of particular importance, both in the form of a written user guide and process description, and also in the form of commenting of the VBA code.

Any redundant data in the Tier 1 model outputs should be removed, to improve the clarity of the modelling process and reduce the potential for uncertainty and confusion.

It is understood that further enhancement and automation of the Tier 0 processes is planned, and we endorse this approach, since the less user intervention that is required, the lower the likelihood of simple and understandable errors (for example through the process of copying and pasting data) on the part of users.

22 Unit Costs

22.1 Introduction & Approach to Audit

The Unit Costs are used within each of the asset cost models as base values which price up the total volume of works expected to be delivered as renewal activities and maintenance activities within the control period.

The Unit Costs (particularly those derived via the Cost Analysis Framework) have previously undergone review as part of the Network Rail Regulatory Accounts Data Assurance process and were given a Unit Rate Confidence Gradings of B3 and C2 respectively for the reliability and accuracy of the renewal unit costs and the maintenance unit costs.

The Unit cost review exercise in this report is aimed at assessing the methodology adopted in calculating the Unit Costs rates (*i.e.* CP4 exit rates) for each of the assets for the IIP submission, to provide a qualitative view on the robustness of the approach adopted and comment on the quality and coverage of the unit costs used in Network Rail's tier 1 models.

A detailed mathematical analysis of the individual Unit Rates themselves to comment on the acceptability of the value thereof (to include any review of forecasted efficiencies to arrive at the CP4 exit rate) has not been carried out as part of this Unit Cost review exercise at this stage. This Unit Cost review also excludes assessing the workmix of the previous Control Period (CP4) against the workmix forecasted for the next Control Period (CP5) to determine if these workmixes are consistent with each other, as a difference in these will impact on the appropriateness of use of historical data to calculate a Unit Cost rate for any work undertaken during the next Control Period (CP5).

Based on the above, the steps anticipated as required for the review of this data for each of the assets were as follows.

1. Select a sample of Unit Cost rates for each asset for detailed review of the methodology.
   (This sample to be based on the total value of the workbank for the period and the contribution of each Unit Cost rate towards the total asset value, such that the Unit Cost rates which are most heavily relied on within the overall modelling for each asset category were chosen.)
2. For each asset model, select between 3 and 6 Unit Rates such that these Unit Rates represented the pricing of a significant portion of the total contribution from that particular asset towards the IIP value
3. Arrange meetings with the Unit Cost development team within Network Rail to enable a detailed review of the Unit Cost rates.
4. The review to include the build up of the Unit Cost rates, challenging the logic, review any assumptions and appropriateness / reasonableness of such assumptions, any exclusions, any factoring utilised in the calculation thereof and to find out if any market testing/ benchmarking exercises had been performed to further validate the Unit Rates which were used within the asset cost models.
5. Report on the outcome of this exercise on an asset by asset basis.

Based on the above steps, the data and information provided was reviewed after which meetings with each asset team (Asset Managers & Unit Cost developers, where available) were arranged to review initial queries. These meetings were followed up with queries on data and information presented for review. All information and data presented, together with the clarifications received at and following the review meetings were utilised in the preparation of this report.

22.2 Track

The Track asset contributes the largest overall value to the IIP valuation. This value is made up of items of renewal works and maintenance works. The options for these works are as tabulated below.

Work Item	Current	Current with investment	Enhanced traffic	No traffic increase
Complete PL renewal	1918	1082	1119	1018
PL refurbishments	385	769	799	730
S&C renewal	703	700	723	659
S&C refurbishments	171	242	250	224
Track non-volume	205	205	205	205
Off track	232	232	232	232
Heavy maintenance	400	389	405	383
Other maintenance	1487	1487	1514	1449
Total	**5500**	**5106**	**5247**	**4900**

Amounts in £ millions

Within above options, the maintenance work elements have been priced with reference to Maintenance Unit Rates (MUCs) and the Renewal works with reference to Renewal Unit Cost rates.

The two elements of renewals and maintenance use similar but slightly different techniques to arrive at the Unit Cost rates for the works.

As the techniques are non work item specific, the Unit Cost review for this asset did not concentrate on looking at individual work item Unit Cost rates but was carried out instead as a review of the two methods for calculating the Unit Cost rates for the renewals works and the maintenance works.

22.2.1 Method/s used for calculating Unit Costs

The renewal Unit Cost rates have been taken as the rates for the work items as given in the Network Rail Business Plan. These have been calculated with reference to the actual historical costs on a route by route basis using the contracted rates to carry out the works.

For the Maintenance Unit Costs (MUCs), the actual activity hours expended as recorded have been extracted from the Ellipse database and the percentage split for labour, plant & material has been determined and the labour element has been calculated via reference to cost per unit of labour. Thereafter, the plant and material costs have been determined as a ratio to the labour costs to arrive at final rates. As the Ellipse system does not account for non productive hours, an adjustment has been made to take cognisance of this factor.

Both renewal Unit Cost rates and Maintenance Unit Cost rates have been calculated for composite items of work.

22.2.2 Overall View

The use of historical and contracted data to calculate Unit Cost rates provides a reasonable level of confidence in the ability to deliver the works for the Unit Cost rates declared as these Unit Costs represent the actual incurred and contracted values. The ability to deliver the works at the stated Unit Costs gives some credence to the methodology utilised to arrive at the Unit Cost rates. This said, it also needs to be noted that this asset is a complex one to deliver and therefore this simplistic approach which uses twenty Unit Cost rates to price a value in the region of £5billion needs review for appropriateness and not only on the ability for delivery.

Furthermore, the aggregated approach adopted of calculating Unit Cost rates for large and complex composite items of work does not provide clear visibility of the resource levels expended for the work items or validity of same thus giving rise to the possibility that the most economical and efficient way to deliver the works may not be the one that Unit Cost rates have been calculated for. This approach also carries significant potential for cumulative and/or compounded factoring of such things as productivity (*i.e.* the lack thereof) levels as the limited number of items effectively means that composite work items have been priced thus allowing the opportunity for such errors to occur within the pricing.

For Maintenance Unit Costs, a productivity factor has been applied to the calculated Activity Hours. The activity hours appear to be based on historical actual hours and not quantum based and validated perhaps via a time motion study which would take note of the most efficient and effective way of executing the task. In addition, the productivity uplift percentage applied to the value so derived to take cognisance of the non productive time does not appear to be validated. This therefore has the potential to compound any effect of inaccuracies within the calculated activity hours leading to the potential of an impact to the calculated MUC rate. Therefore, while the Unit Cost rates calculated for MUCs have credence with regard to the ability to deliver the works to and within the stated Unit Cost rates, as the base resource levels used to build the MUC Unit Cost rates have not been validated there is the potential that the rate may be a soft rate which may be easily bettered.

22.2.3 Areas for Improvement (in Unit Cost calculation)

The level of resources included for within the activities for which Unit Cost rates have been calculated have not been validated. It is worth considering carrying out a validation of these as such would significantly enhance the reasonableness and acceptability of the calculated Unit Cost rates.

For Maintenance Unit Costs, the productivity factor applied has not been validated. However, there appears to be potential for this factor to be refined with reference to the difference in hours recorded between the Oracle Time recording system and the Ellipse system for works as one system has been advised to record all time with the other recording actual time on work activity. This adjustment is worthy of consideration.

The number of Unit Cost items is considered too few when considered against the complexity of the asset being priced. A disaggregation of the work items so that the number of composite items is reduced and the number of Unit Cost items is increased is likely to provide a better output. Also worth serious consideration is adopting a method which prices Unit Cost items at base rates and then adjusts this with reference to a cost driver index (which will need to be developed) which takes note of the cost driving factors for this asset.

22.3 Electrification Power & Fixed Plant

This asset contributes £1.227 billion towards the IIP total value. The work type and valuation profile of the total contribution from this asset is as identified within the table below.

Work Type	Cost Profile	Life Cycle	Age Profile	Volume Profile	Total
Electrical power maintenance	£ 324m				£ 324m
Electrical power renewals	£ 445m	£ 46m	£ 79m	£ 333m	£ 903m
Total	**£ 769m**	**£ 46m**	**£ 79m**	**£ 333m**	**£ 1227m**

Amounts in £ millions at 2011/12 prices

Of these values, the highest contribution is from the value stated within the column titled Cost Profile. This is made up of a maintenance element and a renewals element. The maintenance element of the value has been calculated as a cumulative number of manhours to carry out the maintenance workbank priced at standard maintenance hourly rates and therefore has not been based on a Unit Cost rate. The details of the renewal element of the Cost Prifile values were not made available but Network Rail advised that these were largely made up of values such as estimates, project costs based on historical values and some values calculated with reference to Unit Cost rates. However, further detail of this was not available for review.

The values within the column titled Volume Profile contribute about 25% towards the total value and have been based on Unit Cost rates. Therefore, two items within this category were selected for further review on the basis of their high contribution towards the total volume profiled workbank. These items were:

- DC electrification systems - Distribution - HV cables
- Non-traction power supplies - Signalling power distribution Cables

Each of the above items contain two sub categories which have Unit Cost rates attached thereto and in total contribute 41% towards the Volume profile costs. Based on this high contribution, these four (04) Unit Costs were decided as the most appropriate to delve deeper into within this Unit Cost review exercise.

22.3.1 Method/s used for calculating Unit Costs

Unit Cost rates for the work items within this asset have been calculated using four (04) methods. These are:

- Bottom up estimating – Built from historic data with labour calculations as advised by delivery teams at generic labour rates
- Framework estimates – Composite rates using exsiting framework rates for scope detailed in the workbook
- Historic costs – Where there are historic projects that are similar to the scope detailed in the workbook
- Live projects – Data from current ongoing projects excluding anomalies and abnormals

The Unit Cost rates calculations for the DC Electrification systems for distribution (HV Cables) have been calculated by utilising a bottom up estimating approach by pricing two work items each to take note of a high and low quantity level which have then been averaged to arrive at a base average estimated value for each. Input rates for the bottom up estimates have been based on framework, historic costs and live project data as stated above. These base value have been uplifted for Network Rail costs and for Contractor overheads and profits using internally agreed uplift factors. These values have then been uplifted to 2011/12 rates and discounted to take cognisance of the balance efficincy to be delivered between the date of the estimate and the CP4 exit point.

The Unit Cost rates calculation for the Non traction power supplies (Signalling power distribution cables) has followed the same method as the one for HV cables except that in this instance the Contractor profit and overhead component has not been included for as the work is being delivered through inhouse resources.

The Unit Cost rates so calculated are the ones which have then been input to the model which forecasts the total for IIP purposes.

22.3.2 Overall View

The Unit Cost rates calculation and the use of these within the asset cost model were not clear at the outset of the review process and required further consultation with Network Rail team to clarify. However, upon receipt of clarifiction the view is that the method adopted appears reasonable and appropriate for the purpose intended.

This lack of clarity was found to be partially due to the model itself as this model departed from the other assets in being created outside of MS Excel thus giving it less flexibility and a lower level of user friendliness to allow easy access for review.

22.3.3 Areas for Improvement (in Unit Cost calculation)

The use of an approach consistent with the approach adopted by the other asset models would enhance the userfriendly nature of the model and thus help support an easier review.

The Unit Cost rates have not been subjected to a benchmarking or any market testing to validate same. Carrying out such would further validate and enhance the quality of the Unit Cost rates.

Percentage uplifts have been used within the process of calculating Unit Cost rates and while these percentages have been shown to be in keeping within the levels for same as dictated by the corporate estimating function, there has been no demonstration of how these percentages have been validated. Hence an exercise to validate these standard & generic uplift factors would be worth considering.

22.4 Signalling

The total value of signalling for CP5 is £3.073 Billion. Three elements were selected for the review process displayed in the table below. The three rates have a combined value of £1.284 billion or 41.79% of the total value for the signalling apportion of CP5. These three elements have been highlighted as contributing a significant percentage to the overall value and therefore any sensitivity would make a significant difference.

Item	**Unit**	**Total (£ millions)**	**% of total**
1. Resignalling (not major structures)	SEU	772,563	25.14
2. Modular signalling	SEU	212,976	6.93
3.Planned (cyclical maintenance)	K Hours (1000 Hrs)	298,559	9.72

22.4.1 Method/s used for calculating unit cost

Network Rail have used three methods to obtain unit rates, estimated, 'historic' project data and average tender framework rates.

22.4.1.1 Average tender Framework Rate:

During the review process it became evident that the rates for resignalling (not major structures) and Modular signalling have been calculated on the "average framework Tender" rate principle. Arup requested a breakdown of these rates and how they were calculated. The following response was received from Network Rail:

'Since the signalling frameworks have yet to be awarded and ARUP is one of the tenderer's chosen design partners I regret that the information cannot at this stage be promulgated outside of Network Rail. When the Frameworks are awarded we may be able to review this decision.

The ORR should be made aware of the sensitivity of this information, which is covered by the Utilities Directive, and in particular the reasons why it cannot be released at this stage either to them or their contractor'.

The estimated rates used are indicative but Network Rail state they are robust and therefore are appropriate to supersede the historical data. The two rates still offer an efficiency saving on the CP4 exit rate; this may indicate that the appropriateness of these rates is not unreasonable. It is not possible to comment further without having access to additional data.

Arup was further advised that in terms of the application of framework unit rate data, the intention is to move from 'average tender' data to 'actual awarded framework contract' unit rate data once the framework procurement process has been finalised (expected to be in time for the SBP). This substitution confirms the ability to deliver the works at the rate used and is a welcome development, subject to a future review of the process and resulting rate.

22.4.1.2 Historic Project Data Rate:

Network Rail have utilised their internal scorecard system to track Signalling Equivalent Units (SEUs) unit costs against actuals for individual projects/ routes. These scorecards also highlight the percentage split between the SEUs rates and abnormal rates.

Using the data gathered from the scorecards the CP4 SEU rates have been aligned with the CP5 SEU rates. These CP4 exit rates have been subjected to the efficiency reductions and then applied to CP5. Where possible actual costs have been favoured over estimated costs but on work types with few schemes, estimated costs have been used in conjunction with the actual costs. These rates have been updated, "normalised", to the 2012 rate and a multiple score card mean average has been generated to provide a single SEU rate for the individual work types.

The SEU rates presented in CP5 are an amalgamation of the historical data for SEU rates and abnormal rates. Furthermore the historical SEU rates are an amalgamation of the scorecard data and in some circumstances estimated data. Considering these potential inconsistencies in datasets, greater visibility of this amalgamation process may lead to greater confidence in the elemental SEU rates.

In the document provided by Network Rail "Definition of Signalling Equivalent Units (SEU) and Volume Reporting" it is stated in section 3.2 that the SEU volume is recounted on average around 3-4 times throughout the lifecycle of the project. Insufficient data has been provided to determine the impact, if any, of this recounting, but further visibility of this process and how a realignment of these remeasured volumes impacts on the forecast, may lead to greater confidence in the Unit Cost rates.

Essentially it would seem the SEUs have been calculated as mean averages formed from a variety of datasets which may result in irregularities when amalgamated, as these different datasets may not be comparable.

22.4.1.3 Estimated Rates:

Network Rail have estimated rates for new work types from CP4 to CP5. It may be that these new work types are the amalgamation and/or the splitting of previous work types from the previous CP periods and therefore only limited historical data is available.

Accordingly Network Rail has prepared peer reviewed estimates to determine these SEUs based on exit rates from CP4. Visibility of how these CP4 rates have been estimated would enhance the confidence in this method.

22.4.1.4 ERTMS:

The rates for the ERTMS have been calculated using all three types of unit rates.

Once rates had been determined by amalgamating and adjusting all existing data, these were peer reviewed by a senior panel of named individuals within Network Rail. The panel selected the rates they considered to be most appropriate and had these reviewed externally, through Ansaldo UK.

Due to the insufficient quantity of historical data this may not be an unreasonable method to employ.

22.4.2 Overall view

The methods selected by Network Rail may not be unreasonable, confidence in the methods may be increased, subject to further interrogation into the mechanics of these methods.

Historic project data rates have been calculated using the mean average of SEUs from a variety of data sets, increased explanation of the measures taken to mitigate any potential inconsistencies that may occur from this method may further improve the confidence in the outputs.

22.4.3 Areas for improvement (in Unit Cost calculation)

Average Framework tender rate: Network Rail's proposal to move to using 'actual awarded framework contract' unit rate is welcome in principle and should improve the accuracy of the rates.

Historic project data: The amalgamated rates would benefit from having greater clarity in how they have been put together so that the build up is easier to follow. A benchmarking of these rates would further enhance their validity and as such it is worth exploring a benchmarking exercise.

Estimated rates: The validity of the estimated rates may improve by being subjected to an external benchmarking exercise. An example of which may be for the ERTMS SEUs to be benchmarked in line with the UIC- ERTMS benchmark results, although Network Rail point out that no European scheme has to date installed a UK version of ERTMS and that design is still theoretical and not proven. Alternative benchmarks worth considering are mature cab-signalling systems (like LZB or TVM430) by comparing the differences with ERTMS to try to 'translate' the costs to ERTMS (for instance, look at incremental GSM R costs and take out coded track circuits).

22.5 Civil Structures

The overall total contribution from the Civil Structures asset towards the IIP value is £1,703million of Renewals Costs and £222million of Maintenance Costs.

An initial review of the Asset Cost Model Dashboard revealed that a few specific items as the major contributors to the total value. These Unit Cost rates are tabled below and were concentrated upon during the Unit Cost review process.

Item of Work	Contribution (Value)	Contribution (%)
Underbridges – Exc. Minor Works	£ 844 million	43.83%
Minor Works – Underbridges	£ 180 million	9.37%
Overbridges – Exc. Minor Works	£ 76 million	3.94%
Minor Assets Retaining Walls	£ 73 million	3.77%

The above items that were selected for further review represent slightly over 60% of the total value of work reviewed. A further two (02) items of work, Major Structure and Examination of Structures, contribute a further 16% towards the total. However, as the value for Major Structures was based on the cumulative estimated value for the workbank (on an individual project basis and not a Unit Cost rate approach) for the period, and the Examination of Structures is based on a current contracted rates, these items were not reviewed in detail during the Unit Cost review exercise.

22.5.1 Method/s used for calculating Unit Costs

The primary source for data to produce the Unit Cost rates for the various items of work has been historical data from Network Rail records taken from CAF, MONITOR and the CP4 Business Plan. This historical information has then been used to derive Unit Cost rates via calculating composite rates for the work items as defined by the Repeatable Work Item (RWI) categorisation.

22.5.2 Overall View

As the actual costs have been accumulated within the various cost collection databases for the defined work items, and this has then been divided by the recorded number of instances for each type of defined work where the work has been a combination of ongoing and completed projects, the methodology adopted for deriving the Unit Costs for the various work items under this asset appears to give a reasonable Unit Cost rate at which the works may be delivered.

The large number of instances of each type of work taking place and the reference to a defined coverage as specified within the Network Rail RWI categorisations acts as a double edged sword, as it gives both confidence towards the credibility of this approach as well as some level of concern. The confidence comes from the use of actual costs which provides validity of the ability to carry out the works for the Unit Cost rate stated. But this same method gives rise to concern as it also allows the possibility of the level of resources allowed for within the Unit Cost rate being over generous. This is more so as work is being carried out primarily via internal resources which may not exert the same pressures of an external operator who will strive to minimise resource usage (if activities are priced and paid for on an activity basis and not on resources expended basis only) to maximise the profit margin.

Therefore, the Unit Cost stated has the potential of being a soft target rate to achieve during delivery and thus may be open to challenge on value for money grounds. This also carries with it the potential of real efficiencies gained for instance through application of the learning curve principle not becoming visible until a longer period has elapsed.

22.5.3 Areas for Improvement (in Unit Cost calculation)

The performance of some external review of the Unit Cost rates via either a benchmarking exercise or a market testing of the rates to validate these values would further enhance the robustness and credibility of the rates.

Uplift percentages have been applied to the base Unit Cost rates to arrive at final values and there is no visibility of the provenance of these percentages. A validation of these uplift percentages to confirm the appropriateness of applying them on all base rates as a blanket approach is worth considering.

22.6 Buildings

The Building asset contains 88 Unit Cost rates and contributes £1.189 million towards the total IIP value.

The building cost model lacks user friendliness and this presented a challenge to easily distinguish the most heavily relied upon rates therein. This meant that the identification of Unit Cost rates for further review for the building asset had to be done via an informed selection of six items to investigate further. The items so selected were:

- External Joinery (Windows and doors generally) – Redecorate;
- Platform Surfaces (Tarmacadam) – Minor Repair;
- Platform Copers (PCC Slabs) – Lift, clean, rebed & repoint;
- Footbridge Structure (Parapets, cladding, etc) – Redecorate;
- Trainshed (Close boarded and felt covered) – Replace roof covering; and
- Canopy Steel Structure(Structural beams) – Replace at life end

22.6.1 Method used for calculating Unit Costs

The approach taken by the Building asset Unit Cost team within Network Rail has been to outsource the development of Unit Costs to an external cost consultancy specialising in estimating for the units of work within this asset category.

The details of the process adopted by this external cost consultant has been provided and this describes a detailed process of estimating for each work activity at resource levels which have then been validated through benchmarking and market testing of the rates so derived.

The base Unit Cost rates so derived have been uplifted for implementation and Network Rail costs through the application of blanket uplift percentages to arrive at final Unit Cost rates for the items of work.

22.6.2 Overall View

While the Unit Cost rates have been calculated in line with what may be expected as reasonable good practice for such, a high majority of these Unit Cost rates appear to not feature within the asset cost model.

However, the calculation of a Unit Cost rate for an item implies that the item is recognised as a specifically identifiable element/unit of work. Therefore, by not having a volume of such priced with reference to the Unit Cost rate for same would appear to indicate that this item of work is not being carried out within the Control Period. However, as there appears to be a large number of Unit Cost rates seemingly not being used within the cost model, it raises the query if all the work for the Control Period has been priced in within the overall value submitted or if it is possible that the work may believed to have been priced in through some other composite rate used within the model. Such could lead to either a gap or an overstatement of the total final value, both instances leading to loss of confidence of the modelled value.

As the model is not a particularly user friendly tool, it is not easily visible which of the above may be taking place therein. However, either of these aspects if intrinsic within the model will give rise to concerns about the value it predicts as a total for the asset for the Control Period.

Therefore, while the Unit Cost rates for the asset may be considered as reasonable, the usage made of these is unclear and hence the output stated is questioned.

22.6.3 Areas for Improvement (in Unit Cost calculation)

Implementation costs have been applied as a 48% uplift to each base Unit Cost calculated. This application of a blanket rate which includes for incidental fees and possession management would be worth a further review to validate the applicability of such a uniform uplift as each item of work is unlikely to attract the same type and level of implementation costs. For example, replacing platform copers and painting a window facing a ticket hall are likely to be significantly different, sinces one activity is likely to require possession working while the other may be carried out during a midweek morning shift in essentially a high street environment. The application of such blanket uplift percentages to all base Unit Costs without differentiation may benefit from some refinement.

22.7 Earthworks

The total value for the Earthworks asset is made up of only three (03) workitems hence the Unit Cost rates for all three items were further reviewed. These three work items were;

1. Embankments
2. Rock Cuttings
3. Soil Cuttings

22.7.1 Method used for calculating Unit Costs

The method used for each work item has been to produce individual cost curves for historical project data based on volume of work and unit cost for the individual projects and then to recalculate the cost based on the unit cost for the volume of each project and determine a correction factor based on the difference of the total value as actual and as recalculated via the cost curve. Thereafter, the value for the future workbank has been calculated to which the previously calculated correction factor has been applied such that a total value for the future workbank has been assessed. The Unit Cost rate has then been calculated as total estimated value for the workbank divided by the total quantity.

22.7.2 Overall View

The method utilised for the derivation of Unit Cost rates for the work items is based on historical data and hence carries the same positive aspects as well as the concerns detailed within the Civil Structures section above.

The correction factor applied has mathematical logic but does not take the approach of analysing project cost drivers.

The coefficient of correlation has been calculated for each of the cost curves (Embankments – 0.39, Rock cuttings – 0.57 and Soil cuttings – 0.36) and these show a low correlation between the costs and volumes. This does raise concerns but as the workbank for Control Period 5 has been advised to be very similar to the historical workbank these concerns are somewhat alleviated.

22.7.3 Areas for Improvement (in Unit Cost calculation)

The low number of work items within this asset category which are carried out using significantly different methodologies depending on such things as location factors and constraints suggests that a cost driver analysis approach which identifies the unique cost drivers and attributes costs against such as a potentially more appropriate method to derive Unit Costs in the future.

Such a method may also allow elimination of a very low correlation between the volume and rates as seen within the current methodology.

There also does not appear to be any benchmarking or market testing of the rates derived via this method to validate same. Such an exercise is worth considering for the future.

22.8 Telecoms

The overall total contribution from the Telecomms asset towards the IIP value is £244million of Maintenance Costs and £386million Renewals Costs.

For the Maintenance component, a very significant portion (51.22%) of the value is attributed to maintenance contracts already let to Global Crossings, BT and other support contracts with a further 15.65% of costs allocated against the Network Rail Telecom Support Centres located in Stoke and Doncaster. These values are non Unit Cost driven and are at contracted values or estimated rates based on resource usage (headcount & operational costs) of the support centres. A further 24.17% is made up of work done as Rapid Response to Telecomm Faults and 6.39% is attributable to the maintenance of Power for Operational Communications. These two items of Maintenance were therefore reviewed with regard to their Unit Costs.

For the Renewals component, the three largest contributors were SISS (CIS) – 14.33%, SISS (CCTV) – 13.43% and Network (Cables & Routes) – 10.26%. A further 25 Unit items made up the balance ~66% with no single item contributing more than 8% individually towards the total. Therefore, the three items of Renewals work identified above were reviewed with regard to their Unit Costs.

22.8.1 Method used for calculating Unit Costs

Unit Costs for Maintenance Items:

The Rapid Response to Telecom Faults is made up of 11 different types of faults each of which have individual modelled Unit Cost Rates ranging from £339.56 (faults for the SISS – CIS) to £1,381.01 (cable faults). The review of the build up of these rates revealed that these rates have been derived with reference to records of actual resource quantities of labour, plant & material for each fault taken from Network Rail's Oracle Time & Labour database and the number of faults taken from Network Rail's Fault Management System records.

The Unit Cost for the maintenance of Power for Operational Communications has been derived via reference to the total such service visits within the system as recorded within Network Rail's Ellipse database which are then assessed for value via resourcing the work at norm resource levels (for labour) and actual for material with an attribution for plant and an adjustment made for labour productivity levels.

Unit Costs for Renewal Items:

The Unit Costs for the reneval of the SISS(CIS & CCTV) items have been calculated utilising first principle estimating methods. This method then allows percentage uplifts for Network Rail costs, Preliminaries, Overheads and the like. The percentages used for these uplits appear to be assumed and unvalidated.

For the item of Network (Cables & Routes) Unit Cost rates have not been developed and the amount for this has been based around what can be delivered on a route basis.

22.8.2 Overall View

Unit Costs for Maintenance Items:

The methodology of using the total actual costs divided by the large number of recorded actual instances of each maintenance type/activity together to derive the Unit Cost rates for the maintenance work items appear to be reasonable for the purpose intended.

Unit Costs for Renewal Items:

The methodology of using first principle estimating for calculating Unit Cost rates can be considered as appropriate for the works. However, when these base amounts are then uplifted using uplift percentages for all Unit Cost items the appropriateness of these uplift percentages has to be validated. The data made available for this Unit Cost review exercise does not include any substantiation of these uplift values applied for the various Renewal Unit Cost rates. Therefore, while the method adopted in arriving at the Unit Cost rates for Telecomms Renewal items is considered appropriate for the purpose intended, a further exercise which validates the uplifts applied seems necessary to provide a high degree of confidence regarding the suitability of the actual value of the Unit Cost rates.

22.8.3 Areas for Improvement (in Unit Cost calculation)

More visibility and transparency of the application of a productivity factor for labour resource norms would be recommended as would be a subsequent check to confirm that the total hours for labour as calculated after this adjustment matched up with the actual hours of labour on record as such would support the validity of the productivity factor applied.

For the Renewals Unit Cost rates, a validation of the percentage uplift factors used would enhance the reliability and robustness of the outcome. It is also worth investigating the appropriateness of using the same blanket percentage uplift for each factor considered for all items of work.

The Unit Rates derived do not appear to be market tested or benchmarked to validate the reasonableness of same.

These actions are worth considering for the future.

22.9 Wheeled Plant & Machinery

The overall total contribution from the Wheeled Plant & Machinery asset towards the IIP value is £473.66 million.

The major contributors towards this total value were identified as follows.

Unit of Work	Contribution (Value)	Contribution (%)
High Output Overhaul Programme	£ 107.47 million	22.69%
Vans	£ 97.95 million	20.68%
Rail Grinders	£ 69.58 million	14.69%
Stoneblowers	£ 49.58 million	10.47%
MPV Master & Slave	£ 48.00 million	10.13%

A further 37 Unit items made up the balance ~25% with no single item contributing more than 3.5% individually towards the total. Therefore, the five items of work identified above were reviewed with regard to their Unit Costs.

22.9.1 Method/s used for calculating Unit Costs

The Unit Cost review for this asset identified that the overhaul element of the costs for each of the items reviewed had been addressed as dictated by by the Vehicle Maintenence Instructions issued by the manufacturers and priced at the contract rates for 2011/12 whereas the renewal element of the cost for each of the items had been addressed differently within the Unit Cost calculation exercise to suite the specific constraints of that individual piece of kit.

Renewal element costing:

The renewal Unit Cost of the High Output Overhaul Programme is a placeholder value only. This is for renewing the system and the value herein is based on the historic purchase cost with view of refining same in early 2012 prior to the production of the Strategic Business Plan.

The vans which is the second largest contributor to the asset total was costed on the basis of fleet rates with the view of refining and bettering via taking this function in house at a later date.

Some of the Rail Grinders (32 stone) are still being designed and the renewal costs are based on a 30% uplift to CP4 rail grinder procurement prices on the premise that the current machine is expected to be 30% larger than that procured previously.

For the Stoneblowers, the original purchase price of the machines has been indexed taking account of the small order sizes and additional factors for design changes and in-line condition monitoring to improve reliability and facilitate investigation in to predictive maintenance.

The Multi Purpose Vehicles have been based on a market rate obtained prior to the supplier leaving the market and as such has become a placeholder only to be finalised once the strategy for replacement has been finalised as part of the production of the Strategic Business Plan.

22.9.2 Overall View

In is observed that the very specialist nature of some of the large plant being renewed which are also only manufactured by a limited number of specialist global suppliers has significantly constrained the approaches available to adopt for the calculating the cost for the various items within this asset for IIP purposes. It therefore appears that the process adopted might be considered as the most viable methodology for the individual elements priced for within this asset taking cognisance of the best available information and the challenges presented to the Unit Cost team.

22.9.3 Areas for Improvement (in Unit Cost calculation)

Though the specialist nature of the renewal cost might be challenging for deriving Unit Costs, there is potential for improving on the Unit Cost for the overhaul functions for the maintenance of these items of plant. An approach worth investigating would be potentially joining up or establishing an international benchmarking group of railway operators who are also users of this same or similar technology to monitor self performance against a peer group towards achieving and bettering the benchmark set by the group with reference to international practice and lessons learnt by other operators using similar technology within their railway networks.

22.10 Overall Conclusion of the Unit Cost Review

The methods for the build up of the unit rates for each asset model have been broadly determined and addressed on an asset by asset basis.

In general the methods adopted could be considered as potentially the easiest way to arrive at Unit Cost rates. This is because most assets have adopted an approach of using readily available data in the form of historic cost and contract rates to arrive at Unit Cost rates based on simple average methods.

However, these assets are significantly complex and the valuation of an overall workbank spanning a five year control period needs to take cognisance of a significant number of variables if a single point rate is to represent a work item.

Furthermore, the complexity also gives rise to the query regarding the sufficiency of the number of Unit Cost rates for any given asset. In total, there are under 300 Unit Cost rates within the Unit Cost rate workbook and of these some 30% are for the Buildings asset which contributes about 5% towards the total IIP value. Conversely, the Track asset which is a more complex asset and which makes up almost 20% of the total IIP value is calculated based on twenty Unit Cost rates. This therefore raises concerns regarding the adequacy and reasonableness of the Unit Cost approach as currently done for IIP valuation.

A further aspect of the Unit Cost rate approach as currently carried out relates to the appropriateness or the validity of the data used for calculating Unit Cost rates. In each asset section this has been addressed in more detail but the potential absence of confidence lies in the principle use of the data. The data appears to have been collated and used at face value and no real detail of a thorough data cleansing exercise prior to use of the data has been visible. Furthermore, the majority of Unit Cost rates do not appear to have been subjected to benchmarking or market testing (with the exception of buildings which has been outsourced to an external cost consultancy) to validate their use within the models produced by Network Rail.

This apparent lack of visibility or execution of benchmarking is a facet of all of the assets that could be improved. A further element for possible improvement, which has been suggested in several of the assets, is greater clarity and transparency in some of the broad percentage uplifts applied to rates. A particular example of this can be extracted from the Buildings asset section (16.6.3) where it is highlighted that the uplift percentages have been applied to the base Unit Cost rates to arrive at the final values but there is no visibility of the provenance of these percentages and their applicability on a blanket basis. This could be improved by a validation of these uplift percentages to confirm the appropriateness of applying them to all base rates. Such an exercise will also allow understanding if a blanket approach is appropriate.

Greater clarity, visibility and transparency could also be applied to the mechanics of how some of the unit rates have been created and subsequently used within the various asset cost models. Some of the amalgamated datasets have been unified and aligned which may result in a unit rate being skewed or not representative of the dataset. This amalgamation for creating composite Unit Cost rates also allows the potential for duplication or multiple factoring for productivity levels to creep into the Unit Cost rates which may result in inflated rates being calculated.

In light of the complexity of the assets being priced, an alternative approach we recommend Network Rail should consider is adopting a base rate with a cost driver index such that the various complexities within the assets are accounted for.

23 Conclusions

Network Rail have carried out an extensive amount of modelling to estimate the volumes and costs of renewals and maintenance activities for the main asset types. The approaches taken have varied between assets. Not surprisingly, Track which contributes about 20% to the overall CP5 costs, is the most developed model and estimates the volume of work in detail. Other assets have simpler approaches, in some cases surprisingly so given the size of the estimated costs. We understand that Network Rail are seeking to develop the Tier 1 models further for the Strategic Business Plan and to incorporate outputs from the more detailed Tier 2 models. We would endorse this development.

The computational integrity of most models is high with relatively few errors found. However, more discrepancies were found in the data inputs. Most worrying is discrepancies in asset inventory information that we found in the Structures and Buildings models, and this needs to be addressed as a matter of urgency.

The method for deriving the unit costs to be used in these models makes use of readily available data. In some cases this can limit the accuracy of the rates and we note that the volumes estimated in detail by the Track model are then multiplied by a limited range of unit rates. More sophisticated methods, along with benchmarking or market testing, might be more appropriate in many cases.

Model documentation is incomplete. In many cases the Functional Specification does not set out all of the steps in calculations and we therefore had to spend a lot of time and effort understanding how the formulae worked. In addition, documentation for the data inputs and offline models was generally missing. In many cases this made it hard to trace the source of the inputs. We recommend that documentation is improved.

Many of the Tier 1 models receive at least some of their renewal and/or maintenance workbanks as inputs. These have been generated elsewhere. As we set out in our Scoping Report, we have only checked that these workbanks have been input correctly and have not reviewed the process of generating them. We consider it worthwhile to review these processes which we anticipate will happen alongside the development of the Tier 2 models.

There are a number of smaller Tier 1 models alongside the larger asset models. The documentation is particularly thin for most of these, and in some cases the modelling appears to be on the simplistic side. We would suggest that more attention should be paid to this group of models.

The IIP presents costs for England & Wales and separately for Scotland. All Tier 1 models apportion volumes by Operating Route, with Scotland treated as a single Operating Route. In some cases this apportionment is on the basis of dividing the total work by the proportion of assets on each route (for example, Earthworks) which is not unreasonable. In more cases, though, the input workbanks already specify the work by individual asset which is then summed up by Operating Route (for example, signalling and telecoms), and would be expected to be more accurate.

However, unit costs are not disaggregated by Operating Route. Without undertaking a detailed review of the underlying data, it is difficult to judge how using a single Unit Cost introduces uncertainty on the accuracy of the England & Wales costs versus the Scotland costs. Arguably labour costs could be cheaper in Scotland but some of the work may need to be carried out in more remote locations and so take longer.

We are therefore not in a position to judge if there is more uncertainty with the England & Wales or Scotland costs.

24 Recommendations

Table 24.1: Recommendations

No	Recommendation to NR	Section in Report	NR Champion	Date
IIP.Tier.1	Produce full documentation, including flow diagrams, so that all Tier 1 and associated offline models are covered – such that a new user can understand the functionality.	3	Tier 1 Modelling Team Manager	Oct 2012
IIP.Tier.2	Produce a central Assumptions Register for all Tier 1 models.	3	Tier 1 Modelling Team Manager	Oct 2012
IIP.Tier.3	Provide comments/references to the parts of the data which feed into other Tier 1 models to aid in the updating process.	3	Tier 1 Modelling Team Manager	Oct 2012
IIP.Tier.4	Review progress on recommendations made in this report	Summary	Tier 1 Modelling Team Manager	July 2012
IIP.Track.1	Network Rail to consider training up a second user to spread the knowledge.	4.8.1	Track Modeller	Oct 2012
IIP.Track.2	Improve the file structure, naming conventions and model versioning.	4.8.2	Track Modeller	Oct 2012
IIP.Track.3	Provide documentation on tables and queries contained within the model.	4.8.2	Track Modeller	Oct 2012
IIP.Track (R&M).1	Automate, consolidate and introduce version control for data inputs	5.8	Track (R&M) Modeller	July 2012
IIP.Structures.1	Review and reconcile bridge numbers in the model with confirmed source.	8.5.1	Structures Modeller	July 2012
IIP.Structures.2	Confirm validity of assumptions made for bridge renewals and develop methodology as appropriate.	8.5.2	Structures Modeller	July 2012
IIP.Buildings.1	Review and reconcile asset numbers in model with confirmed source.	9.5.1	Buildings Modeller	July 2012
IIP.Buildings.2	Review and correct as appropriate unit rates and efficiencies in model.	9.8	Buildings Modeller	July 2012
IIP.Buildings.3	Correct computational errors that have been identified in model.	9.8	Buildings Modeller	July 2012
IIP.Buildings.4	Document the method of route allocations for LMDs.	9.8	Buildings Modeller	Oct 2012

IIP.Earthworks.1	Review suitability of modelling assumptions for Strategic Business Plan.	0	Earthworks Modelling Team	July 2012
IIP.Telecoms.1	Correct errors identified in audit.	11.8	Telecoms Modeller	July 2012
IIP.Telecoms.2	Check for consistency with Signalling Tier 1 model for NOS Migration.	11.8	Telecoms Modeller	July 2012
IIP.Wheeled Plant.1	Correct error in calculating first year of overhaul	12.4	Wheeled Plant Modeller	July 2012
IIP.Wheeled Plant.2	Check workbank input data for completeness and accuracy	12.5	Wheeled Plant Modeller	July 2012
IIP.EC4T.1	Reflect the latest assumptions on electrification schemes in each scenario, and update the electric train km accordingly on the affected routes.	14.7	EC4T Modeller	July 2012
IIP.Traffic.1	The documentation of the Traffic model should be improved and expanded.	16.7	Traffic Modeller	Oct 2012
IIP.Other Maintenance.1	NR to develop a plan to improve the modelling of Other Maintenance costs and to update the Functional Specification accordingly.	17.7	Other Maintenance Modeller	Oct 2012
IIP.Tier0.1	The documentation of the Tier 0 model should be improved and expanded, including the provision of comments in the VBA code used in the model.	21.7	Tier 0 Modeller	Oct 2012
IIP.Costs.1	Review if the current approach of using Unit Cost rates for a forecasted workbank can be improved.	22.10	Unit Cost Team	July 2012

Appendix A

Mandates

Mandate for Independent Report (Part A)

Audit Title:	Prioritised audit of inputs to Network Rail's tier 1 strategic planning models used in support of IIP
Mandate Ref:	AO/016
Document version:	Draft A
Date:	September 2011
Draft prepared by:	
Remit prepared by:	
Network Rail reviewer:	

Authorisation to proceed

ORR		
Network Rail		
Independent Reporter		

1 Background

Network Rail has developed a suite of models to help build up its plans for PR13. "Tier 1" models are strategic planning models which forecast work volumes, outputs and expenditure for a portfolio of network assets. There are separate tier 1 models for the following main asset categories: machinery, track, electrical power, signalling, telecoms, civils and buildings. There are also tier 1 models for support and operational costs. The "Tier 0" model draws on the outputs of the tier 1 models to present a "dashboard" overview of NR's plans. This mandate covers inputs to all tier 0 and tier 1 models.

Network Rail has used the outputs of its tier 1 and tier 0 models in developing its contribution to the Initial Industry Plan (IIP). The quality of the outputs of these models depends on:

- The modelling principles, i.e. how policy has been modelled;
- The input data; and
- The computational accuracy of the models.

This mandate covers the audit of input data. The independent reporter will audit the accuracy and reliability of the inputs on a prioritised basis to inform our advice to ministers. This work will also form part of progressive assurance leading towards the assessment of efficient costs for CP5. This mandate does not cover inputs to tier 2 models which will be addressed through the mandate "Initial Industry Plan 2011 Review".

The modelling principles are to be covered separately by the mandate "Initial Industry Plan 2011 Review" which focuses on asset policy. Understanding the effect of proposed asset policy requires a view of the policy's projected total volumes, costs and outputs over the long term and an engineering assessment of how this has been modelled. A separate note is being written to clarify the content of the Initial Industry Plan 2011 Review.

The computational accuracy of the models is also to be covered separately by the mandate "Audit of integrity of Network Rail's tier 0 and tier 1 strategic planning models used in support of IIP".

This mandate also has interfaces with other pieces of reporter work, and in particular "NR Bottom-up Benchmarking Programme Audit".

Although written as separate mandates they all address different aspects of robustness of NR's IIP. Co-ordination is required to avoid overlaps and to ensure that the overall review of IIP does not inadvertently omit vital areas of assessment. This mandate should draw on previous audits where possible to avoid duplication of work.

This mandate also covers the need to produce an overall view of uncertainty in the IIP figures by drawing on all evidence.

Network Rail has carried out an internal audit of asset data quality and developed target milestones. The quality and findings of this work will be considered as part of the mandate scope.

2 Scope

The reporter will audit the inputs to the tier 1 models including unit costs, asset data, intervention options (alignment with asset policies) and the inputs to non-volume costs. The reporter will also audit the inputs to the tier 0 model including the outputs of tier 1 models, and historical expenditure and business plans. The audit will be prioritised as detailed below. It will consider all scenarios considered. The audit will assess the quality of the inputs in terms of reliability, accuracy and coverage.

Unit costs

The reporter will audit the quality and coverage of the unit costs used in Network Rail's tier 1 models. In particular, the reporter will consider:

- Previous audits of actual unit cost capture and unit cost quality, including the regulatory accounts audit, the 2009/10 annual return audit and Arup's "Audit of the Robustness of the NR Unit Cost Framework", May 2010.
- The audit trail between Network Rail's actual unit costs (RUCs, MUCs and CAFs as appropriate) and the unit costs used in the models.
- Assumptions used in deriving unit costs for planning purposes and the effect of these on data quality.

Asset data

The reporter will review Network Rail's internal audit of asset data to assess:

- The data covered and their coverage of tier 1 model inputs
- The data quality evaluation criteria and process
- The quality of the results obtained, i.e. does the reporter consider that the results of NR's internal audit are a true representation of the reliability, accuracy and coverage of the data?

Following the review of NR's internal audit the reporter will develop and implement a method for prioritising the audit of input asset data based on the materiality of its effect on planned expenditure. This data may include population (inventory), type, condition, age, criticality, performance and degradation trends. The reporter will assess the quality of those data in the prioritised list, taking account of NR's internal audit where relevant. Stage 1 of the review (see "Methodology", below) will scope the asset data review.

The reporter will draw on any relevant findings from Arup's "Audit of Renewals Volume Data" and AMCL's "Review of Phase 1 AIS".

Non-volume costs

The reporter will develop and implement a method for prioritising the audit of the inputs to non-volume costs in the IIP, aligned with the methodology proposed for prioritised audit of asset data. The reporter will audit the reliability, accuracy and coverage of the data.

Interventions

The reporter will establish whether the interventions modelled are consistent with those identified in the asset policies.

Efficiencies

Network Rail's evidence and assumptions on efficiency are also expected to be inputs to the tier 1 models. The audit of Network Rail's efficiency evidence and assumptions is partly covered by Arup's reporter mandate "NR Bottom-Up Benchmarking Programme Audit".

Tier 0 model

The reporter will check that the tier 0 model:

- draws on the correct outputs of the tier 1 models;
- draws on historical data and forecast plans for CP4 correctly;
- correctly interfaces with output models.

Overview

The reporter should present its view on the range of uncertainty of the model output due to quality of model input information by:

- each tier 1 model and for NR's IIP submissions in total;
- main building block, including income, support functions, operations, maintenance and renewal uncertainties separately identified; and
- England & Wales and Scotland.

The reporter should also present its view on the overall range of uncertainty of the model output due to:

- Input data uncertainty, including efficiency evidence uncertainty;
- Modelling principles; and
- Computational accuracy.

This should be presented by:

- each tier 1 model and for NR's IIP submissions in total;
- main building block, including income, support functions, operations, maintenance and renewal uncertainties separately identified; and
- England & Wales and Scotland.

3 Methodology

The reporter will deliver the scope of work described above through:

- review of the tier 0 and tier 1 models that feed into IIP
- close working with NR modelling team, workshops and meetings as required
- review of tier 0 and tier 1 supporting documentation
- review of NR's asset data audit documentation
- review of previous reporter studies
- review of asset policies
- prioritised audit of tier 1 input information
- audit of tier 0 input information
- co-ordination with other reporter mandates

The reporter will conduct the audit of input information in two stages:

Stage 1 – Detailed scoping: The reporter will review the models, documentation and scope of previous and parallel audits and produce an interim report giving the proposed detailed scope of this audit. The detailed scope is to include:

- a proposal for the prioritised audit of input data;
- a methodology for conducting the audit, including level of sampling to be employed and confidence in the level of uncertainty – the reporter to consider presenting uncertainty at the 95% confidence limit; and
- a proposed method for reporting uncertainties due to input data.

The interim scoping report will be reviewed and agreed by ORR and NR before proceeding.

Stage 2 – Audit: The reporter will carry out the audit and produce its draft and final reports based on the agreed detailed scoping report.

The reporter will produce a short separate report giving its view on overall tier 1 modelling uncertainty for IIP.

4 Deliverables

- Interim scoping report detailing proposed prioritised list of inputs for audit and proposed sampling methodology - late October 2011
- Draft reports 9 December 2011
- Final reports mid January 2012

Governance process for issuing Independent Reporter reports is included in Appendix A.

5 Timescales

- Kick-off meeting late September 2011
- Model workshops with ORR and NR, early October
- Fortnightly progress reports
- Interim scoping report detailing proposed prioritised list of inputs for audit and proposed sampling methodology - late October 2011, three weeks following provision of input information by NR
- Draft reports 9 December 2011
- Final reports mid January 2012

6 Independent Reporter remit proposal

Arup shall prepare a proposal for review and approval by the ORR and Network Rail on the basis of this mandate. The approved proposal will form part of the mandate and shall be attached to this document.

The proposal will detail tasks, programme, deliverables, resources and costs.

Appendix A
Governance process for issuing Independent Reporter reports

Revision	Purpose	Outcome
Draft	Review for factual correctness and comments	First drafts of the report should be issued to ORR and Network Rail, who have fourteen days to review the contents before a tri-partite session is arranged at which feedback is provided to the reporter. Network Rail may choose to provide Director level input at this stage.
Final draft	Review	The Reporter will issue a final draft report to both ORR and NR within five working days of the tri-partite meeting All three parties agree contents and recommendations as far as possible via correspondence or meetings as appropriate. Further comments shall be provided within five working days.
Final report		The Reporter will issue its final report to both the ORR and NR. If agreement over its contents has not been reached the report will contain the Reporter's independent assessment together with opinions from ORR and NR to document their positions ORR will publish the report on their website It is anticipated that the issue of the final report (i.e. version 1) would take no longer than 1 working week after receiving the final report.

Mandate for Independent Report (Part A)

Audit Title:	Audit of integrity of Network Rail's tier 0 and tier 1 strategic planning models used in support of IIP
Mandate Ref:	AO/021
Document version:	Draft A
Date:	September 2011
Draft prepared by:	
Remit prepared by:	
Network Rail reviewer:	

Authorisation to proceed

ORR		
Network Rail		
Independent Reporter		

1 Background

Network Rail has developed a suite of models to help build up its M&R plans for PR13. "Tier 1" models are strategic planning models which forecast work volumes, outputs and expenditure for a portfolio of network assets. The tier 0 model draws on the outputs of the tier 1 models to present a "dashboard" overview of NR's plans.

Network Rail has used the outputs of its tier 1 and tier 0 models in developing its contribution to the Initial Industry Plan (IIP). The quality of the outputs of these models depends on:

- The modelling principles, i.e. how policy has been modelled;
- The input data; and
- The computational accuracy of the models.

There is a need for ORR, Network Rail and its key stakeholders to be satisfied that the overall modelling process is robust, that any specific errors are identified and that any other key weaknesses are recognised. This mandate covers the audit of the computational accuracy of the models. The independent reporter will audit the integrity of the modelling to inform our advice to ministers. This work will also form part of progressive assurance leading towards the assessment of efficient costs for CP5.

The modelling principles are to be covered separately by the mandate "Initial Industry Plan 2011 Review" which focuses on asset policy. Understanding the effect of proposed asset policy requires a view of the policy's projected total volumes, costs and outputs over the long term and an engineering assessment of how this has been modelled. A separate note is being written to clarify the content of the Initial Industry Plan 2011 Review.

The audit of input data is to be covered separately by the mandate "Prioritised audit of inputs to Network Rail's tier 1 strategic planning models used in support of IIP" and co-ordinated with the mandate "NR Bottom-up Benchmarking Programme Audit".

Although written as separate mandates they all address different aspects of robustness of NR's IIP. Co-ordination is required to avoid overlaps and to ensure that the overall review of IIP does not inadvertently omit vital areas of assessment. This mandate should draw on previous audits where possible to avoid duplication of work.

2 Scope

The reporter will audit the tier 0 and tier 1 models for computational integrity, auditing the accuracy of the macro coding and formulae that model application of policy. The key objective of this review is to perform a detailed "forensic" audit of the formulae and macros that constitute tier 0 and tier 1 modelling in order to be able to confirm that they correctly carry out the calculations described in their functional specifications and to identify any computational errors. The reporter should also comment on the robustness of the functional specifications.

All tier 0 and tier 1 models are to be audited including:

- Tier 0 – main dashboard
- Tier 1 – all asset modules, including machinery, track, electrical power, signalling, telecoms, civils and buildings
- Tier 1 – all other modules, including asset management overheads, operations, support/property, other renewals and income.

The audit will include:

- Audit of macro coding
- Audit of spreadsheet based data manipulation
- Audit of data from input to output to confirm that correct data are being accessed, correct calculations are being applied and model outputs are correctly collated and presented (including link between tier 1 and tier 0 models)
- Audit of output calculation and interface with output models (e.g. Operational Performance Model)
- Audit of robustness of modelling by tier 1 model, tier 0 model, regional disaggregation if appropriate.
- Assessment of effectiveness and efficiency of coding, with a focus on effectiveness (production of accurate outputs) in assessing model output uncertainty. Advice on efficiency of coding is secondary and will be addressed through recommendations.

Performing the audit to the standard required will require team members to have a very good working knowledge of:

- Microsoft Excel – including use of the visual basic macro language
- Microsoft Access – including the use of "action queries", macros and visual basic code

Experience of detailed audit of complex models is also essential.

The reporter will present a view of the range of uncertainty for the model outputs and therefore IIP due to the integrity of the modelling.

3 Methodology

The reporter will deliver the scope of work described above through:

- Audit of tier 0 and tier 1 models
- Review of all supporting documentation, including functional specifications
- Coordination with other reporter studies, including policy / IIP review and prioritised audit of tier 1 input information
- Close working with the model development team on the structure and workings of the model, workshops and meetings as required

4 Deliverables

The main deliverable of this project is:

- An audit report on the computational accuracy of the model, identifying any areas where the Reporter believes that the model does not correctly complete the calculations defined in the detailed functional specification, and quantify the effect of these errors on the numbers reported in the tier 0 model, tier 1 models and IIP.

The report should describe the audit methodology adopted and the analysis carried out. The Reporter should provide interim and final reports, with presentations to Network Rail and ORR at each stage.

- Draft report 9 December 2011
- Final report mid January 2012

Governance process for issuing Independent Reporter reports is included in Appendix A.

5 Timescales

- Kick-off meeting late September 2011
- Model workshops with ORR and NR, early October
- Fortnightly progress reports
- Draft report 9 December 2011
- Final report mid January 2012

6 Independent Reporter remit proposal

Arup shall prepare a proposal for review and approval by the ORR and Network Rail on the basis of this mandate. The approved proposal will form part of the mandate and shall be attached to this document.

The proposal will detail tasks, programme, deliverables, resources and costs.

Appendix A
Governance process for issuing Independent Reporter reports

Revision	Purpose	Outcome
Draft	Review for factual correctness and comments	First drafts of the report should be issued to ORR and Network Rail, who have fourteen days to review the contents before a tri-partite session is arranged at which feedback is provided to the reporter. Network Rail may choose to provide Director level input at this stage.
Final draft	Review	The Reporter will issue a final draft report to both ORR and NR within five working days of the tri-partite meeting All three parties agree contents and recommendations as far as possible via correspondence or meetings as appropriate. Further comments shall be provided within five working days.
Final report		The Reporter will issue its final report to both the ORR and NR. If agreement over its contents has not been reached the report will contain the Reporter's independent assessment together with opinions from ORR and NR to document their positions ORR will publish the report on their website It is anticipated that the issue of the final report (i.e. version 1) would take no longer than 1 working week after receiving the final report.

Appendix B

Track

Table B.1 illustrates the total combination of sensitivity tests undertaken for the Track Asset Model. Four of these tests were undertaken using a template spreadsheet created by Network Rail to modify input work volumes by 10%. The tests using this approach were the following:

1. Renewals Only – Complete Traxcavation, High Output Complete, Steel Sleeper and S&C Renewal;
2. Geometry Only – Tamping and Stoneblowing for both Plain Line and S&C.
3. Refurbishment Only – High & Medium refurbishment for both concrete and other;
4. All Work Volumes – All interventions types reduced (Renewals, Geometry and Refurbishment).

In addition to these tests which were input directly into T-SPA, two other tests were devised to test the model sensitivity using the model database inputs. The Deterioration sensitivity test was undertaken by directly modifying the geometry characteristics. This test would effectively mean that the deterioration of the track was 10% faster.

The tonnage sensitivity test did not involve a 10% change. Instead the change in tonnage was reflected in the increase in traffic from the “Baseline” scenarios to the “Enhanced”. This created a differential in tonnage for which it would be possible to see the resulting impact on track quality. As the change in tonnage was not a fixed amount the total tonnage was output from the model for each of the two scenarios, so that it could be related to its effect.

Table B.1: T-SPA Sensitivity Tests undertaken.

Criticality Band	All Work	Renewal Only	Geometry Only	Refurb Only	Deterio-ration	Tonnage
1	☑	☑	☑		☑	☑
2	☑	☑	☑	☑	☑	☑
3	☑	☑	☑	☑	☑	☑
4	☑		☑	☑		
5	☑		☑	☑		

The outputs produced compared each result against a central baseline model run a single Strategic Route Sections (SRS) for each if the five Criticality Bands as shown in Table B.2:

Table B.1: The Strategic Route Sections (SRS) chosen for the sensitivity tests.

Criticality Band	SRS	Route
1	NO3	Stafford to Crewe
2	K15	Swindon to Bristol

3	H07	Hull to Micklefield
4	G17	Stockton to Newcastle
5	I08	Skegness to Grantham

The comparisons against the baseline were undertaken for each of the tests using the following standard indicators used to assess track quality:

1. Good Track Geometry (GTG);
2. Poor Track Geometry (PTG);
3. Serious Defects;
4. Sleeper Life;
5. Rail Life;
6. Ballast Fouling Index; and
7. Switch Life.

Tonnage Comparison (Baseline vs Enhanced)

Criticality 1

Baseline [1]

Start Year	EGT
2011	25349512
2012	26326835
2013	29003934
2014	29623129
2015	30231197
2016	30803606
2017	31339770
2018	31887135
2019	33613817
2020	33613817
2021	33613817
2022	33613817
2023	33613817
2024	35837128
2025	35837128
2026	35837128
2027	35837128
2028	35837128
2029	38026064
2030	38026064
2031	38026064
2032	38026064
2033	38026064

Enhanced [2] [2] vs [1]

Start Year	EGT	% Change
2011	25349512	0%
2012	26326835	0%
2013	29003934	0%
2014	30298426	2%
2015	31627946	5%
2016	32940294	7%
2017	34219344	9%
2018	35571555	12%
2019	37658969	12%
2020	37658969	12%
2021	37658969	12%
2022	37658969	12%
2023	37658969	12%
2024	40309985	12%
2025	40309985	12%
2026	40309985	12%
2027	40309985	12%
2028	40309985	12%
2029	42912630	13%
2030	42912630	13%
2031	42912630	13%
2032	42912630	13%
2033	42912630	13%

Criticality 2

Baseline [3]

Start Year	EGT
2011	9944626
2012	9997479
2013	10060233
2014	10089941
2015	10119058
2016	10145945
2017	10171241
2018	10197437
2019	10333954
2020	10333954
2021	10333954
2022	10333954
2023	10333954
2024	10601310
2025	10601310
2026	10601310
2027	10601310
2028	10601310
2029	10887090
2030	10887090
2031	10887090
2032	10887090
2033	10887090

Enhanced [4] [4] vs [3]

Start Year	EGT	% Change
2011	9944626	0%
2012	9997479	0%
2013	10060233	0%
2014	10147430	1%
2015	10236542	1%
2016	10324452	2%
2017	10410830	2%
2018	10501243	3%
2019	10656398	3%
2020	10656398	3%
2021	10656398	3%
2022	10656398	3%
2023	10656398	3%
2024	10947890	3%
2025	10947890	3%
2026	10947890	3%
2027	10947890	3%
2028	10947890	3%
2029	11259532	3%
2030	11259532	3%
2031	11259532	3%
2032	11259532	3%
2033	11259532	3%

Criticality 3

Baseline [5]

Start Year	EGT
2011	5892295
2012	5926828
2013	5954122
2014	5963179
2015	5970417
2016	6080833
2017	6083884
2018	6085358
2019	6445005
2020	6445005
2021	6445005
2022	6445005
2023	6445005
2024	7284081
2025	7284081
2026	7284081
2027	7284081
2028	7284081
2029	7898249
2030	7898249
2031	7898249
2032	7898249
2033	7898249

Enhanced [6] [6] vs [5]

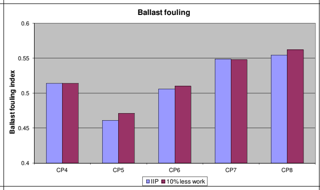
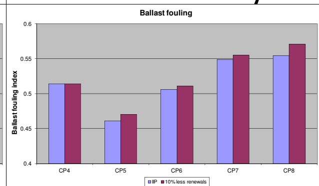
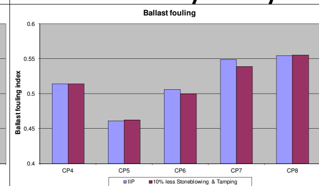
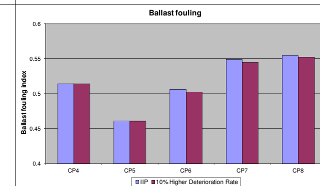
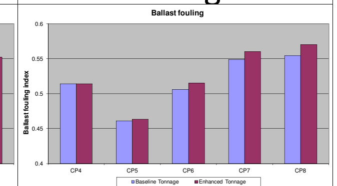
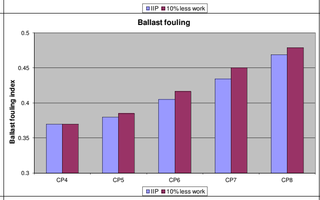
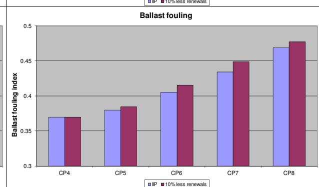
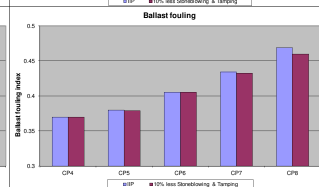
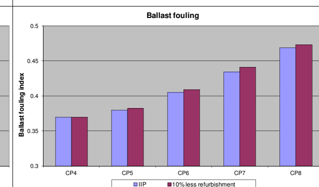
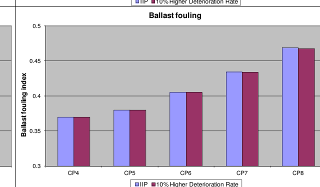
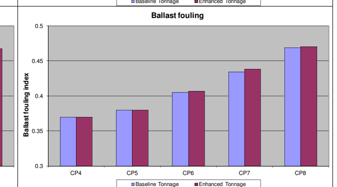
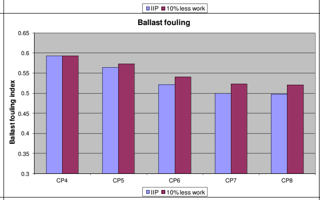
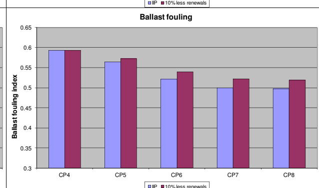
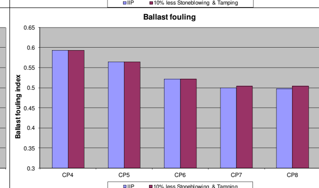
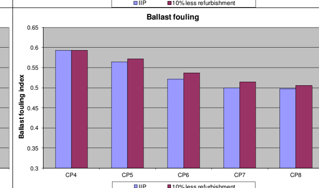
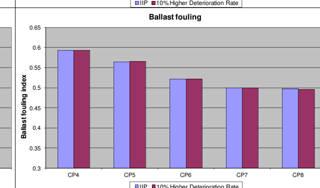
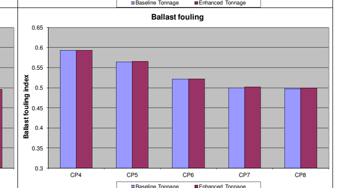
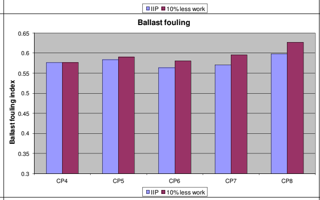
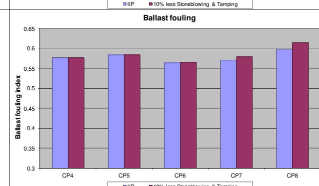
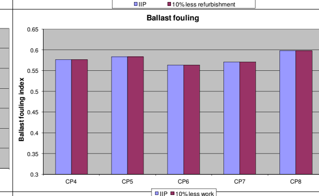
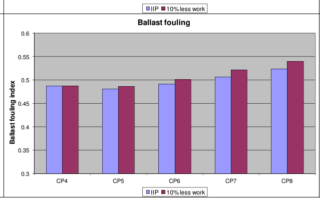
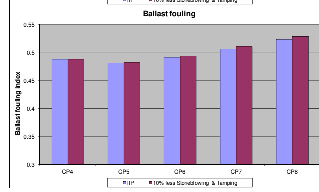
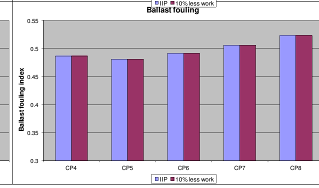
Start Year	EGT	% Change
2011	5892295	0%
2012	5926828	0%
2013	5954122	0%
2014	5988124	0%
2015	6020079	1%
2016	6154900	1%
2017	6180771	2%
2018	6204975	2%
2019	6568821	2%
2020	6568821	2%
2021	6568821	2%
2022	6568821	2%
2023	6568821	2%
2024	7418274	2%
2025	7418274	2%
2026	7418274	2%
2027	7418274	2%
2028	7418274	2%
2029	8040302	2%
2030	8040302	2%
2031	8040302	2%
2032	8040302	2%
2033	8040302	2%

Sleeper Life comparison between Baseline (Violet) and Sensitivity Test (Dark Magenta) for Criticality Band 1-5

- N03 - Band 1
- K15 - Band 2
- H07 - Band 3
- G17 - Band 4
- I08 - Band 5

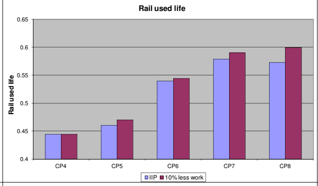
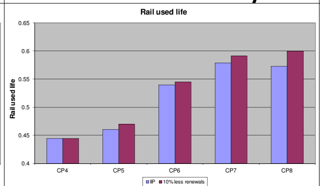
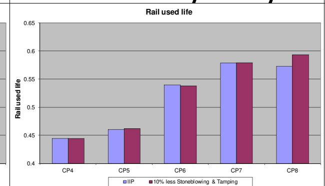
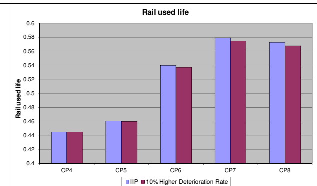
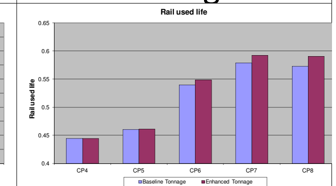
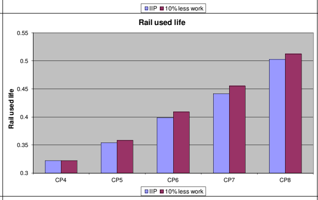
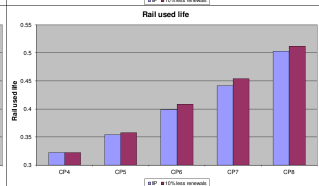
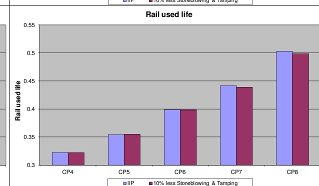
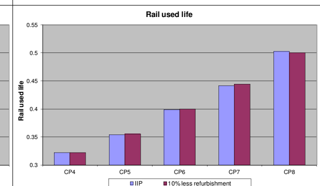
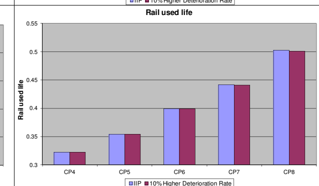
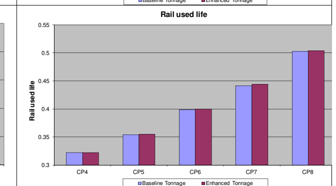
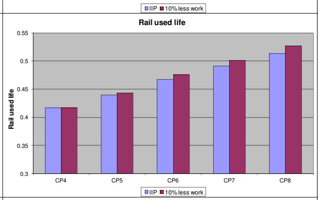
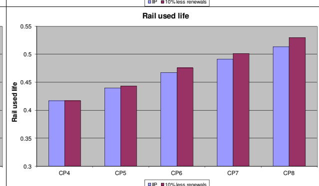
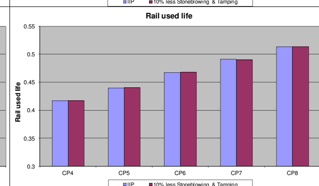
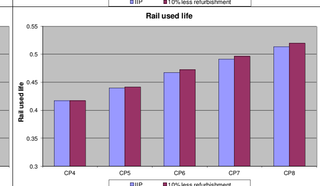
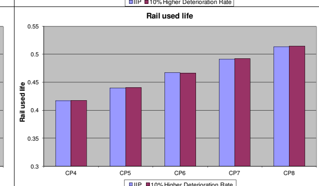
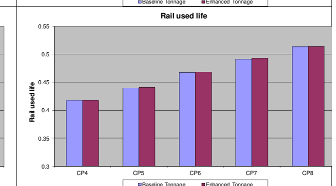
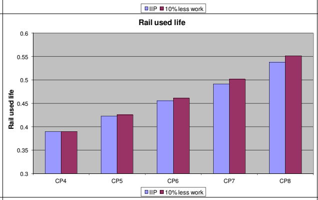
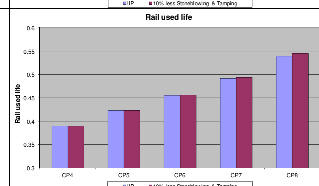
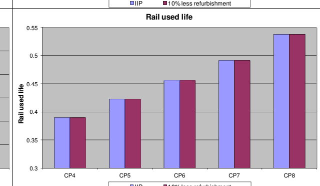
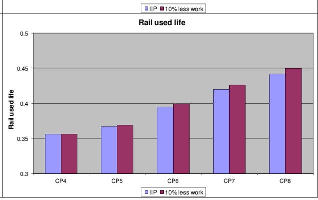
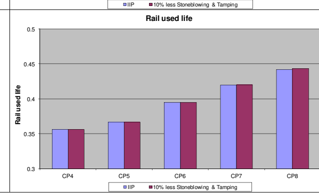
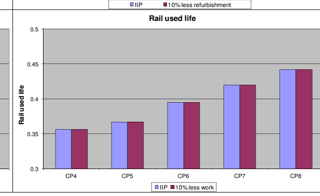
Ballast Fouling Index comparison between Baseline (Violet) and Sensitivity Test (Dark Magenta) for Criticality Band 1-5

- N03 - Band 1
- K15 - Band 2
- H07 - Band 3
- G17 - Band 4
- I08 - Band 5

	All Work volumes	Renewal Only	Geometry Only	Refurbishment Only	Deterioration	Tonnage
1						
2						
3						
4						
5						

Rail Life comparison between Baseline (Violet) and Sensitivity Test (Dark Magenta) for Criticality Band 1-5

- N03 - Band 1
- K15 - Band 2
- H07 - Band 3
- G17 - Band 4
- I08 - Band 5

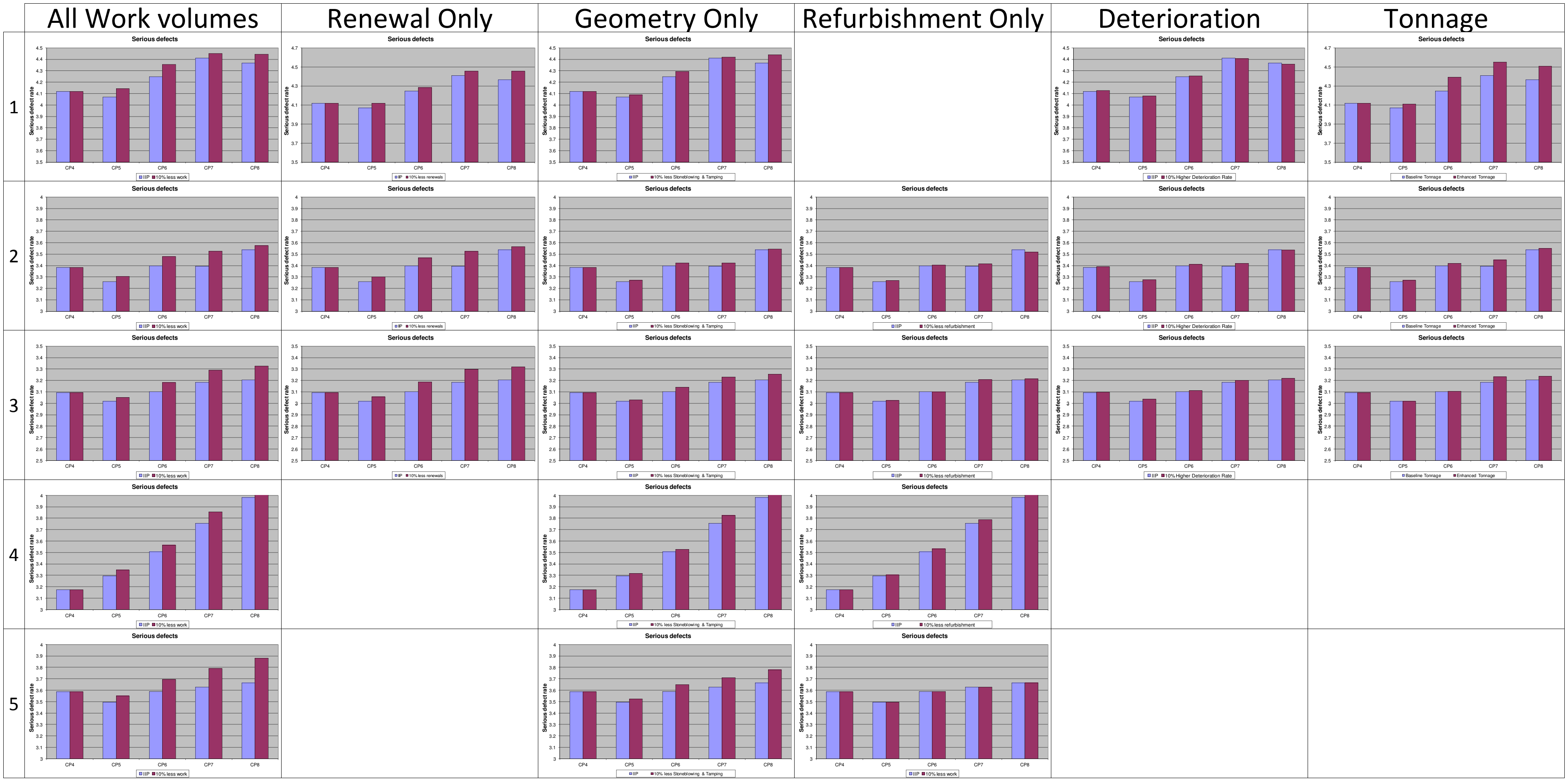
	All Work volumes	Renewal Only	Geometry Only	Refurbishment Only	Deterioration	Tonnage
1						
2						
3						
4						
5						

Sleeper Life comparison between Baseline (Violet) and Sensitivity Test (Dark Magenta) for Criticality Band 1-5

- N03 - Band 1
- K15 - Band 2
- H07 - Band 3
- G17 - Band 4
- I08 - Band 5

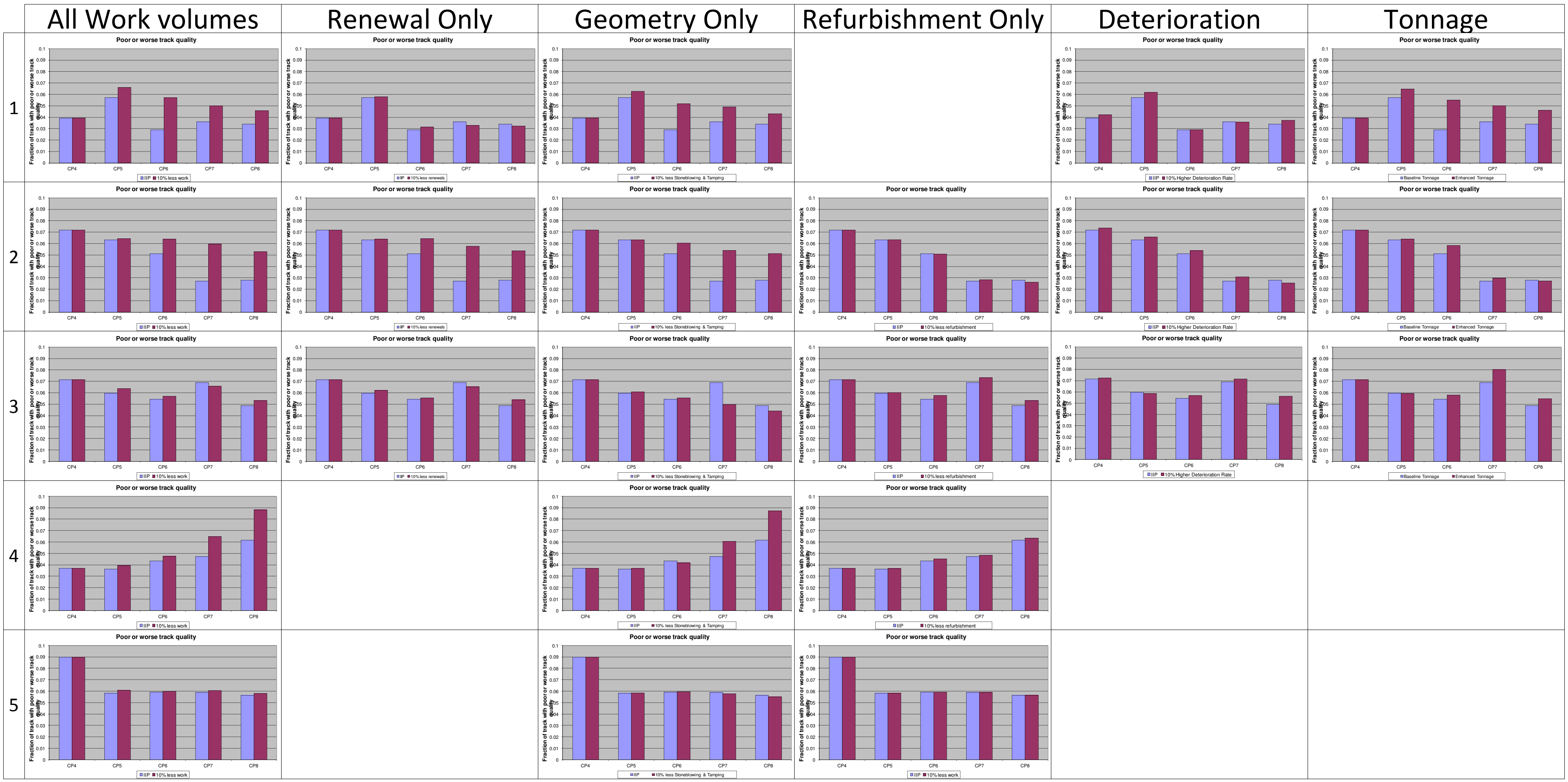
Serious Defect comparison between Baseline (Violet) and Sensitivity Test (Dark Magenta) for Criticality Band 1-5

- N03 - Band 1
- K15 - Band 2
- H07 - Band 3
- G17 - Band 4
- I08 - Band 5



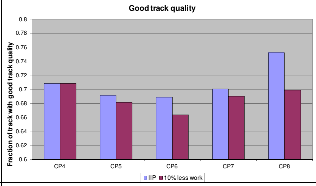
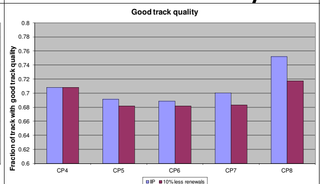
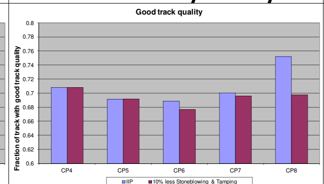
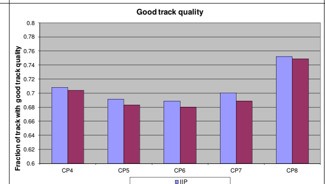
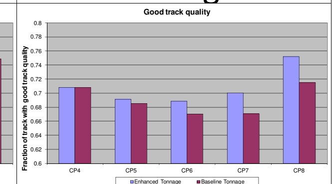
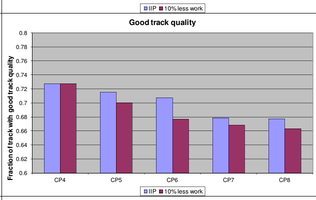
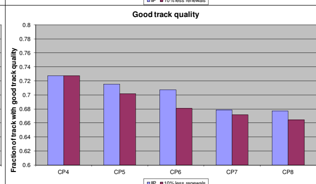
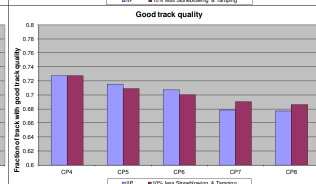
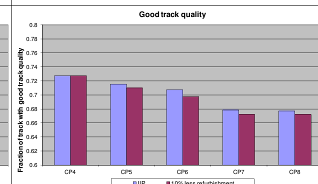
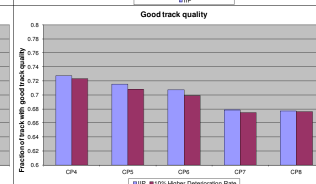
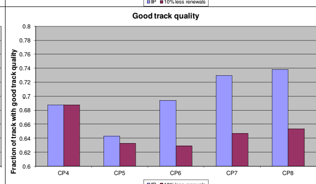
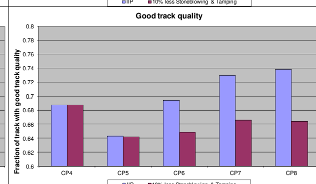
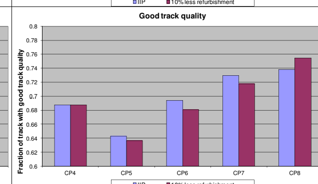
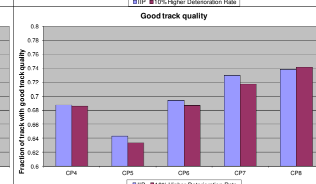
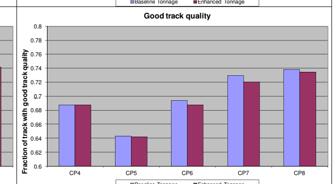
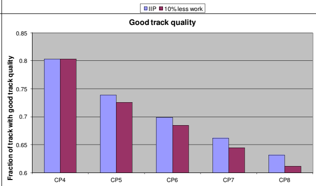
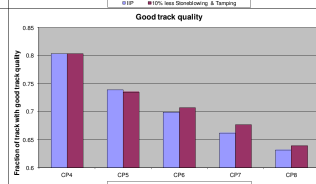
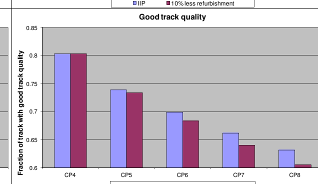
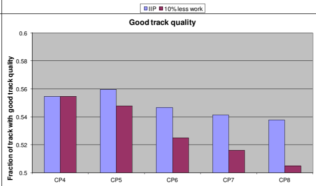
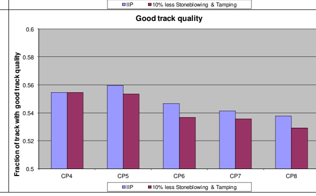
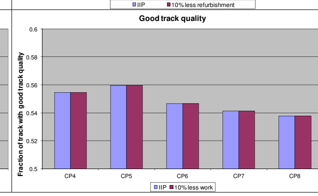
Poor Track Geometry (PTG) comparison between Baseline (Violet) and Sensitivity Test (Dark Magenta) for Criticality Band 1-5

- N03 - Band 1
- K15 - Band 2
- H07 - Band 3
- G17 - Band 4
- I08 - Band 5



Good Track Geometry (GTG) comparison between Baseline (Violet) and Sensitivity Test (Dark Magenta) for Criticality Band 1-5

- N03 - Band 1
- K15 - Band 2
- H07 - Band 3
- G17 - Band 4
- I08 - Band 5

	All Work volumes	Renewal Only	Geometry Only	Refurbishment Only	Deterioration	Tonnage
1						
2						
3						
4						
5						

Appendix C

Electrical Power and Fixed Plant

Appendix A: Electrical Power and Fixed Plant

CP5 Expenditure associated with the four modelling methodologies used in Tier1 Model
Network geography level

£m 2011/12

Maintenance	CP5 Total					CP6 Total				
	CostProfile	LifeCycle	AgeProfile	VolumeProfile	Total	CostProfile	LifeCycle	AgeProfile	VolumeProfile	Total
Electrical power maintenance	324				324	331				331
AC electrification systems	127				127	133				133
Distribution	4				4	5				5
OLE	121				121	127				127
Other	1				1	1				1
DC electrification systems	41				41	41				41
Distribution	16				16	16				16
Electrical traction equipment	24				24	24				24
Other	1				1	1				1
Non-traction power supplies	63				63	63				63
Points heating	20				20	20				20
Signalling power supplies	42				42	42				42
Other	1				1	1				1
Fixed plant	24				24	24				24
Sudbrook Pumping Station	5				5	5				5
Other fixed plant	19				19	19				19
Indirects	69				69	70				70
Labour	62				62	63				63
Plant	4				4	4				4
Materials	1				1	1				1
Other	2				2	3				3

Renewals	CP5 Total					CP6 Total				
	CostProfile	LifeCycle	AgeProfile	VolumeProfile	Total	CostProfile	LifeCycle	AgeProfile	VolumeProfile	Total
Electrical power renewals	445	46	79	333	903	352	114	120	198	784
AC electrification systems	99	46	12	65	222	66	114	46	12	238
Grid supply points	8				8	15				15
Switchgear						4				4
Transformer	5				5	8				8
Cable	2				2	4				4
Distribution	7		12	3	22	3		46	3	52
HV switchgear			12		12	0		46		46
Substation ancillary equipment	4				4	1				1
HV cable	3				3	2				2
Transformers				3	3				3	3
OLE	79	46		52	177	30	114		7	151
GE project	41				41					
Campaign A										
Contact/catenary wire	8				8					
Mid-life refurbishment		46			46		114			114
Emerging campaign changes	10				10	5				5
Full renewal										
Structures				36	36	20				20
Component change	14			16	30	5			7	12
Climate change adaptation	6				6					
Protection and control	5			10	15	18			2	20
Protection				5	5	5			2	7
RTUs	5			6	11	13				13
System capability/capacity										
Faster isolations										
Security of supplies										
DC electrification systems	111		67	133	311	82		74	91	247
Grid supply points	5				5	15				15
Switchgear	3				3	4				4
Transformer	3				3	8				8
Cable						4				4
Distribution	40		67	63	170	19		74	56	150
HV switchgear	20		19		39	12		33		46
Substation ancillary equipment	17			8	25	3				3
HV cable	4			55	58	4			56	60
Transformers/rectifiers			14		14			6		6
LV DC switchgear			34		34			35		35
Electrical traction equipment	35			43	78	20			33	53
Conductor rail	15			24	39	15			14	29
LV cable	10			19	29	5			19	24
Hook switch legislation	10				10					
Protection and control	3			27	30	28			2	30
Protection	3			10	13	6			2	7
RTUs				17	17	22				22
System capability/capacity	28				28					
Faster isolations										
Security of supplies	28				28					
SCADA	18				18					
National SCADA system	18				18					
Network management										
Non-traction power supplies	46			113	159	50			84	134
Points heating	21				21	18				18
Renewal	18				18	18				18
Climate change adaptation	3				3					
Signalling power supplies	20			109	129	28			84	111
Principal supply points				24	24	8			9	16
Signalling power distribution				85	85				75	75
650V distribution reconfiguration										
650V cable legislation	20				20	20				20
HV distribution	4			4	8	4			1	5
Plant	102			21	124	88			10	98
Lighting	1			21	22	16			10	26
Auxiliary supplies	12				12	13				13
Fixed plant	18				18	9				9
Other fixed plant	15				15	9				9
Climate change adaptation	3				3					
Small plant										
Energy										
Energy efficiency										
Reduction in losses										
Other	69				69	67				67
Cable/copper theft	10				10	10				10
Traction	5				5	5				5
Non-traction	5				5	5				5
Asset condition assessment	6				6	3				3
Overheads and abnormals	50				50	50				50
Reactive minor works	4				4	4				4
West Coast Route Modernisation										

Appendix D

Signalling

NetworkRail

ARUP Review

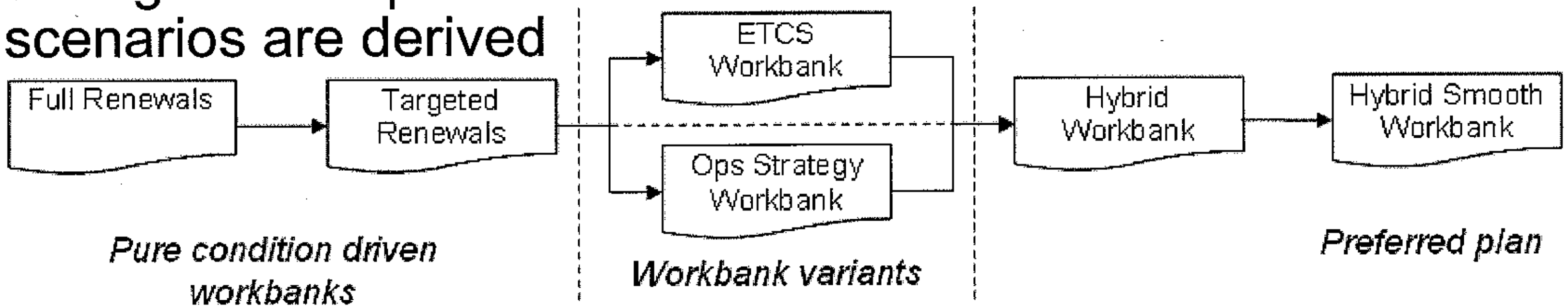
NetworkRail

Signalling IIP

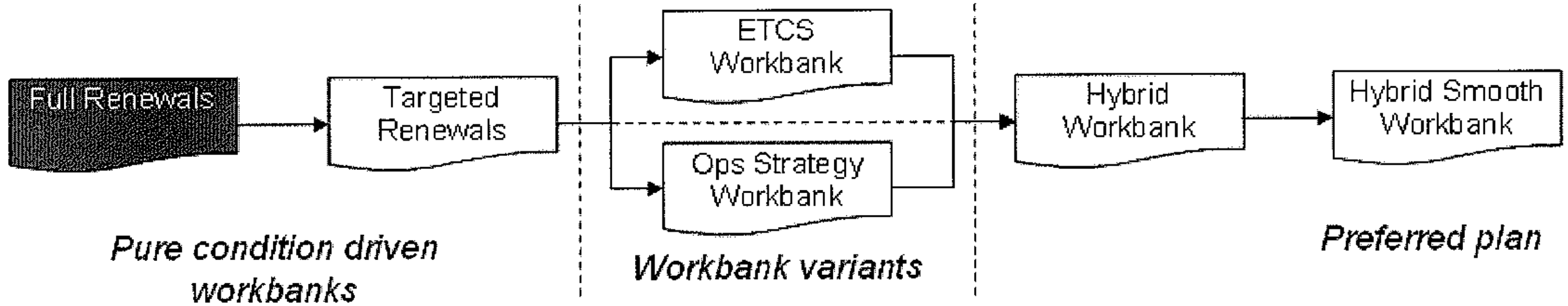
- The IIP is presented as three scenarios. For signalling scenario 2 and 3 are the same

Scenario	IIP Submission (£M) Pre-Efficient	Supporting Workbank
1. Current Railway	2,627	Targeted
2. Current Railway plus Investments	3,510	Hybrid Smooth
3. Preferred Plan	3,510	Hybrid Smooth

- Each scenario is support by a workbank which informs the forecast of costs and volumes. The following flowchart is used throughout the presentation to outline how the forecast for the scenarios are derived



The signalling workbank aims to reduce operating costs and deliver lowest whole life, whole system cost



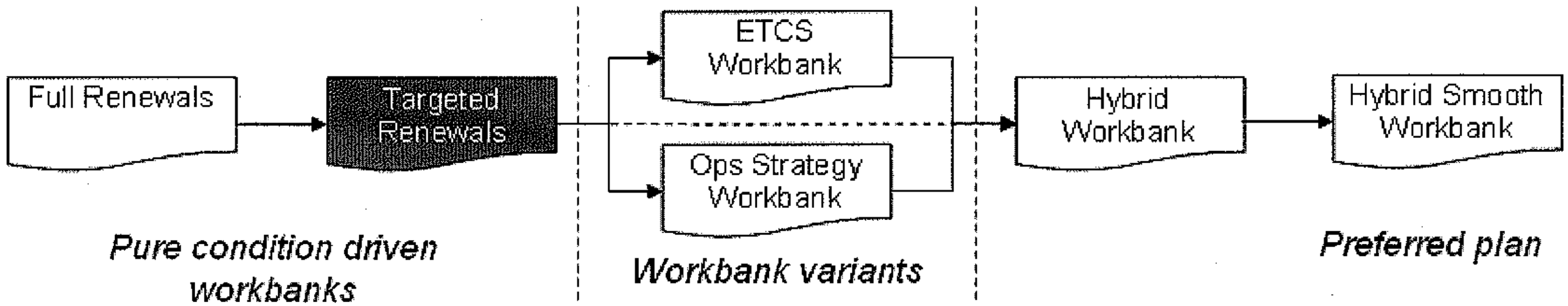
Development of the Full Renewals workbank

- Conventional renewals regime with baseline ETCS
- All assets will be monitored for condition / age to ensure that renewals or upgrades are planned in a timely manner. SICA and other tools will be used to identify the condition (and rate of change in condition) of assets and interlockings, and to establish when a decision on renewal or replacement needs to be taken.
- At the "intervention decision point" arising from SICA reviews of the assets, an assessment shall be made as to the most appropriate intervention. The decision will take account of other interventions required in a similar timescale to identify opportunities for configuration change.
- The Signalling Infrastructure Condition Assessment (SICA) process provides a comprehensive measure for monitoring long-term asset sustainability. The measure is compiled from an assessment of a sample of assets, taking account of their physical condition, environment, reliability and maintainability. The output from the assessment is a remaining system life for the assets within an interlocking area or level crossing.

Rules for Full Renewals workbank

Starting Technology	First Intervention WT To be Used	Intervention Date	Subsequent Interventions WT
Mechanical Interlocking	15 – Mechanical Refurbishment	35 Years	15 – Mechanical Refurbishment
Relay / Electronic Interlocking	16 – Modular Full Renewal	35 Years	16 – Modular Full Renewal
Relay / Electronic Interlocking	1- Full Resignalling	35 Years	1- Full Resignalling
Relay / Electronic Interlocking	20 – ERTMS L2 – Full Renewal	35 Years	

The signalling workbank aims to reduce operating costs and deliver lowest whole life, whole system cost



Development of the Targeted Renewals workbank

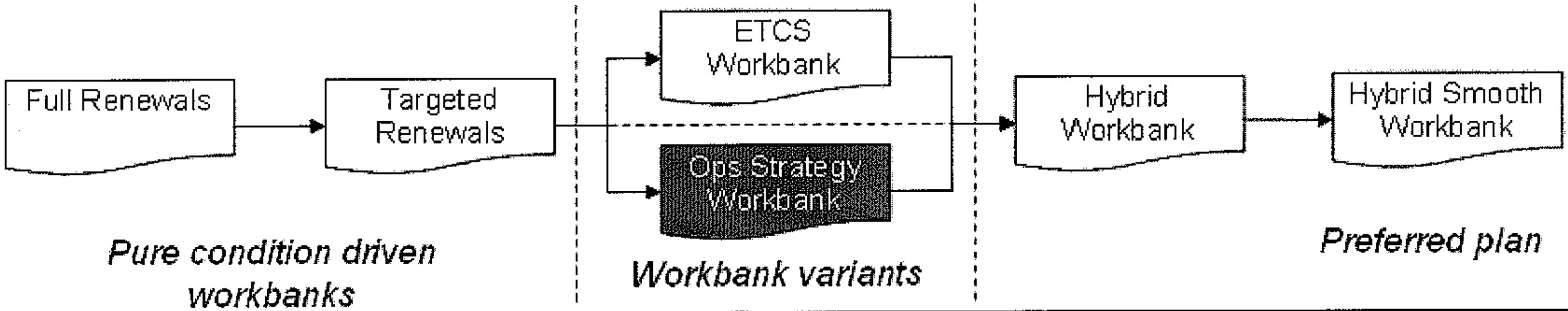
- Targeted renewals regime with baseline ETCS
- All assets will be monitored for condition / age to ensure that renewals or upgrades are planned in a timely manner. SICA and other tools will be used to identify the condition (and rate of change in condition) of assets and interlockings, and to establish when a decision on renewal or replacement needs to be taken.
- At the "intervention decision point" arising from SICA reviews of the assets, an assessment shall be made as to the most appropriate intervention. The decision will take account of other interventions required in a similar timescale to identify opportunities for configuration change.
- The Signalling Infrastructure Condition Assessment (SICA) process provides a comprehensive measure for monitoring long-term asset sustainability. The measure is compiled from an assessment of a sample of assets, taking account of their physical condition, environment, reliability and maintainability. The output from the assessment is a remaining system life for the assets within an interlocking area or level crossing.

Rules for Targeted Renewals workbank

Starting Technology	Componen t	First Intervention Work Type To be Used	Subsequent Interventions Work Type
Mechanical	All	15 – Mechanical Refurbishment16 – Modular Full Renewal	15
SSIRelay / SSI	All	3– Interfaced SSI; or 10 – Relay interlocking	16
SSIRelay / SSI	Interlocking	7 – SSI interlocking	If 1st=10; 3 or 10 If 1st=3; 7
SSIRelay / SSI	Sig Interface	12 – Signallers Interface Renewal / Re-control	7
SSIRelay / SSI	Outside Eqpt	51 & 52 – OutsideEquipment Renewal over 20 / 30 yrs	12

NetworkRail

The signalling workbank aims to reduce operating costs and deliver lowest whole life, whole system cost

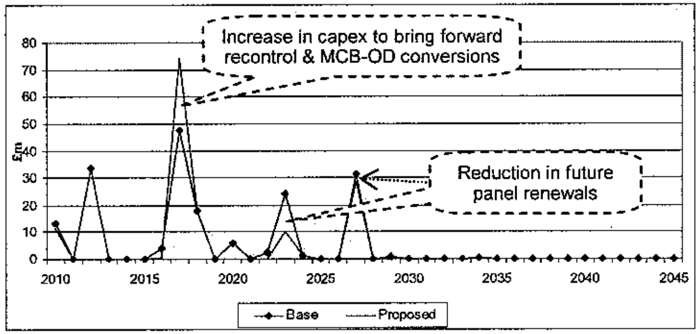


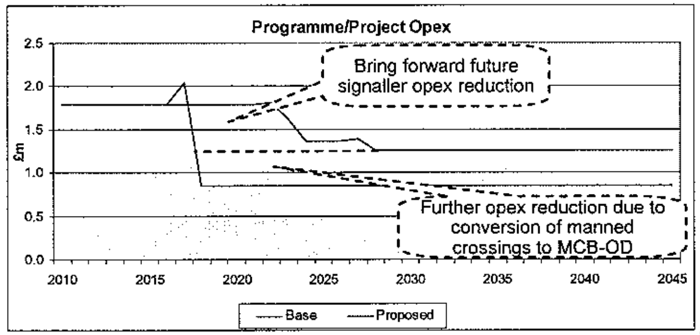
Development of the Ops Strategy (opex driven) workbank

- The Ops Strategy workbank was developed from the Targeted Renewals workbank
- In a workshop, Route Asset Management & Operations packaged lines of route together to create proposed changes to the workbank to reduce operating costs
- This was an iterative process driven by asset knowledge, operating knowledge and a business case to come up with a logical package of work
- A business case was assessed for each package of work & a Benefit to Cost Ratio (BCR) of 1.5 was required to decide whether a proposed change to the workbank should be included
- The BCR was based on:
  - change in capex profile against targeted renewals (Costs). This includes the cost of bringing future spend forwards as well as the cost of any additional work which otherwise wouldn't have been spent under a targeted renewals approach (eg the incremental cost of modular signalling above mechanical life extension)
  - change in opex profile (Benefits). Where a targeted renewals plan would naturally deliver opex savings at a future point in time, the business case only assess the incremental savings delivered through bringing the signalling recontrol forward.

Example: Opportunity to recontrol Cambridge prior to condition driven date

- Opportunity to recontrol Cambridge ahead of its condition driven date





- Positive business case to bring forward recontrols from 2023 and 2027 to 2017
  - **BCR of 3.1**
- Includes savings from 2 manned crossing locations converting to MCB-OD
  - If these weren't included the business case would still be positive with a reduced BCR of 1.9

NetworkRail

Signaller opex is calculated at workstation level and is driven by the allocation of interlockings to workstations

Current workstation opex

- Actual signaller / crossing keeper headcount
  - Relief signaller headcounts are pro rata spread across relevant locations
- Actual opex costs by grade
  - calculated at network level
  - takes overtime, etc into account
- Each signalling interlocking is associated to a current workstation as well as a future workstation at a ROC

Over time, the signalling control of each interlocking is transferred to new workstations
- triggered in the workbank & ICM by specific worktypes (eg 2, 12, 16)

What does this mean?

	Current	end CP5	end CP11	*Aspiration*
• Signaller headcount	4,846	3,154	1,389	*<1,000*
• Annual signaller opex	£231m	£167m	£78m	*£60m*
• Number of workstations	903	663	341	*230*
– *Mech*	*457*	*274*	*40*	-
– *RRI*	*294*	*134*	*11*	-
– *Elec*	*152*	*255*	*290*	*230*
• Avg SEUs per Workstation	71	95	172	*250*

- The above aspirations will be achieved through:
  - improving the migration plan to further accelerate migration in CPs 6 & 7
  - improved workstation sizings to further improve signaller efficiencies

Future opex is made up of :
- existing workstations yet to be recontrolled/resignalled
- new (ROC) workstations

Existing workstation opex

- As long as any SEUs are still controlled from an existing workstation, we assume the current headcount & grade is maintained for that particular workstation

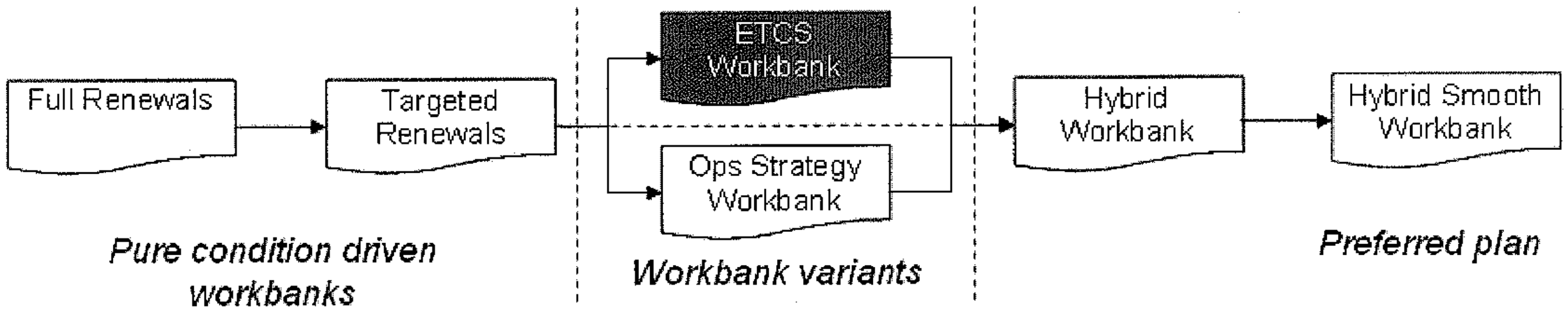
New (ROC) workstation opex

- As soon as any SEUs are controlled from a new workstation, it immediately triggers the requirement to be fully populated
  - even if its full potential allocation of signalling control has not been achieved
- New workstation assumptions:
  - 5.5 heads per Traffic Management workstation
  - 6.3 heads per workstation where TM has not been deployed
  - £60k per head (equivalent to signaller grade 8)
- It is assumed that all MCB & CCTV crossings will be converted to MCB-OD and so will not incur any opex
  - In reality, not ALL crossings will be suitable for MCB-OD but the future workstation sizings have allowed capacity for this

Overhead (OM/LOM) management opex

- Headcount assumed to reduce in number at a rate of 1 head for every 30 signallers
  - current ratio is actually closer to 1:12 but 1:30 has been selected to allow for partial migrations in management areas and future management requirements

The signalling workbank aims to reduce operating costs and deliver lowest whole life, whole system cost



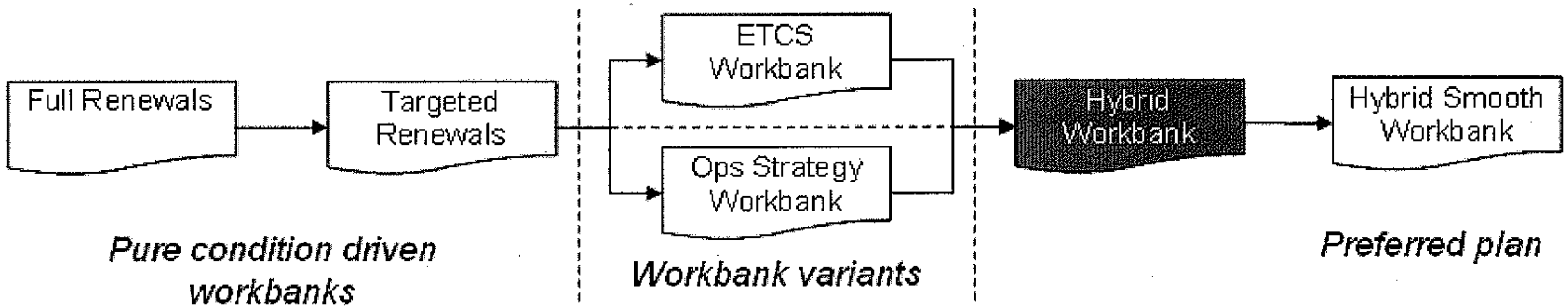
Development of the ETCS workbank

- Network Rail directed the inclusion of 3 core routes within the base plan. (GW L2 overlay, and both EC (South) and MML (South) L2 no signals
- The aim of developing the "ETCS workbank" was to deliver a National ETCS L2 Railway integrating infra and train plans
- The ETCS workbank was therefore developed from the Targeted Renewals (+3 core routes) workbank independent of Ops Strategy
- In a set of workshops, Route Asset Management & the ETCS Programme Team (including an ATOC rep for train fitment plan) proposed changes to the Targeted Renewals (+3 core routes) workbank
- ETCS at Level 2 was thus introduced which;
- Aligned with natural significant signalling renewal interventions whilst developing a train fitment programme that aligned with the ETCS infrastructure dates, reflecting:
  - New trains entering service as ETCS fitted
  - A minimised retro fitment with assumptions around:
    - Proposals to cascade fleets
    - Aligning major proposals for fleets against franchise changes

Rules for ETCS within the ETCS workbank

- The Workbank assumed ETCS L2 fitment at a cost of 62.8% of a resignalling Work Type 2.
- The ETCS cost utilised in the long term workbank did not take account of the reduction in cost of ERTMS L3 and the renewal from 1st cycle ETCS to 2nd cycle ETCS
- For clarity a set of Rules for development of the ETCS specific workbank were introduced :
  - E1: Introduce ETCS at next major intervention if the intervention is after or within 2 years of the majority (95%) of trains that cross the route are fitted with ETCS [Timing of decision]
  - E2: Where interventions are less than 100 SEU's AND cover less than 35mile, then group with adjacent areas [Line of route/minimising transitions decision]
  - E3: Small (<100SEU's OR<35 miles) island of conventional signalling should not be left unconverted surrounded by areas of ETCS

The signalling workbank aims to reduce operating costs and deliver lowest whole life, whole system cost



Development of the Hybrid workbank

Hybrid Aim

- The aim of the "Hybrid" Workbank is to achieve the following without adding additional risk to the train fitment plan:
- Accelerate business case justified ops efficiency schemes
- Deliver a national ERTMS railway aligning delivery with significant renewal interventions

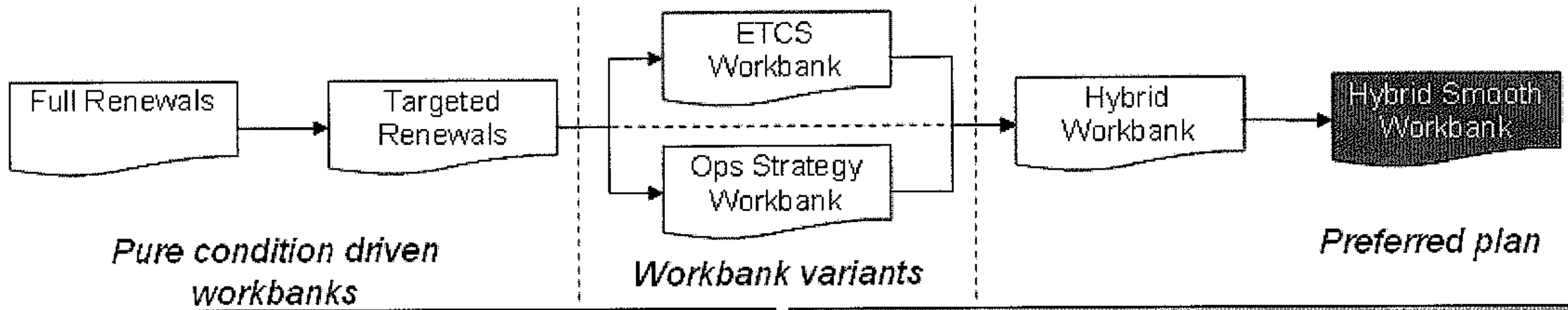
- The Hybrid Workbank was developed through a subsequent set of workshops with the routes once the standalone ETCS and Ops Strategy workbank had been developed

Rules for ETCS within the Hybrid workbank

- Assumptions on cost and ETCS WT assumed for ETCS Workbank also apply for Hybrid Workbank
- If there is a conflict between the Ops Strategy and the ETMS workbank then the following rules should be applied
  - H1: Ops Strategy workbank is given precedence unless ETCS technology can be utilised with no additional risk introduced from amending the train fitment programme
  - H2: Where train fitment permits and where ETCS rules allow then accelerate the ETCS scheme to the dates proposed ops efficiency schemes
  - H3: Where H2 cannot be achieved for the proposed Ops Strategy date BUT can be achieved within 2 years of the date then accelerate the ETCS scheme to a date within 2 years of the proposed ops efficiency scheme
  - H4: Where the ETCS workbank cannot be accelerated to achieve the ops efficiency then Ops Strategy 1st cycle date applies and 2nd cycle ETCS date follows

NetworkRail

The signalling workbank aims to reduce operating costs and deliver lowest whole life, whole system cost



Development of the Hybrid Smooth workbank

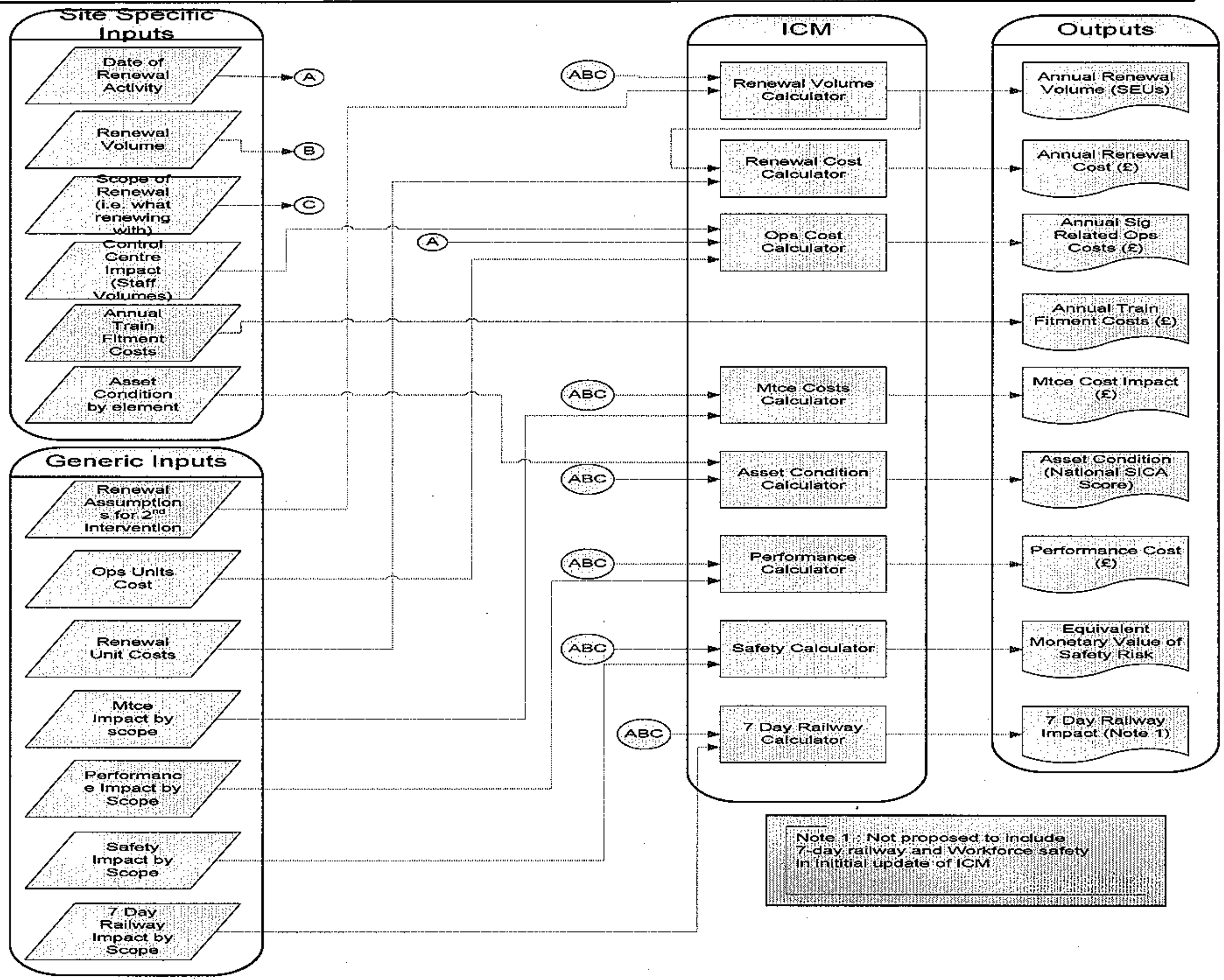
- Following deliverability review of the Hybrid Workbank to create a Hybrid (smoothed) another mini iteration was required to asses infrastructure date movements impacting upon train fitment plans.
- Integrated plan is now under change control process.

Rules for the Hybrid Smooth workbank

- Dates Amended to achieve a smooth delivery profile
- Condition led dates restricted to a maximum 2 year increase in date

Infrastructure Cost Model (ICM)

- The ICM is to be a tool that models key signalling outputs given a proposed signalling Workbank. it costs a multi cycle interlocking level resignalling Workbank
- The criteria for selecting the optimum scenario are twofold:
- The lowest whole life cost, taking account of maintenance and renewal expenditure, safety risk and the cost of service failures
- The best fit with national signalling strategies for ERTMS and NOS.
- The ICM profiles the cost of each intervention over the GRIP stages and years around the commissioning date; and simulates the impact of that Workbank on the mix of interlocking predominant technology types and the control points from where signalling operations are carried out. This ensures that the Workbank directly influences future operating and maintenance costs, and also future reliability forecasts.



Appendix E

Structures

E1 Data Inputs and Model Assumptions

Structures Model Tier 1, Final Version		Versus	Input Source		Comment
Worksheet	**Description**		**Source Details**	**Description**	
1.1 Bridges - Inputs	Bridge Degradation - *"CP4 BCMI change/day under 'do nothing' scenario*" value for Scotland/Underbridges/Other Cell E67	✗	Deg Rate Transformation Calcs.xls, Sheet *DRs RN Model* Cell S33	Daily Degradation Rate	Degradation rate used for Scotland/Underbridges/Other is different to source. Correction required.
	Impact of MW's on SCMI Multiplier = 2	✓			
	BCMI Targets	✓	Section 5.6 of the 'Structures Asset Policy, September 2011	Report	
	Average End of CP4 BCMI without Intervention	✓	Compressed_Calculations__REPAIRED_v4_Compressed_Calculations__Streamer_Engine_v1.24_-_Bridge_Model_based_on_DB_output_v6_Links_removed.xlsm	TIMS CP4 degradation model	
	Number of bridges with repeat exams included in calculations	✓	Compressed_Calculations__REPAIRED_v4_Compressed_Calculations__Streamer_Engine_v1.24_-_Bridge_Model_based_on_DB_output_v6_Links_removed.xlsm	TIMS CP4 degradation model	

Structures Model Tier 1, Final Version		Versus	Input Source		Comment
Worksheet	**Description**		**Source Details**	**Description**	
	Total CP4 BCMI uplift from MW's (repeat exam bridges only)	×	Compressed_Calculations__REPAIRED_v4_Compressed_Calculations__Streamer_Engine_v1.24_-_Bridge_Model_based_on_DB_output_v6_Links_removed.xlsm	TIMS CP4 degradation model	Total CP4 BCMI uplift from MW's (repeat exam bridges only) - All values different from source except: Anglia-BB0-B Kent-BBO-O Kent-BBU-O LNE-BBO-O East Midlands-BBO-B Scotland-BBO-O Sussex-BBU-C Sussex-BBU-O Western-BBO-O Western-BBU-O
	Total number of bridges	×	Compressed_Calculations__REPAIRED_v4_Compressed_Calculations__Streamer_Engine_v1.24_-_Bridge_Model_based_on_DB_output_v6_Links_removed.xlsm	TIMS CP4 degradation model	Total number of bridges - counts for the following are all zero in the source file. The values in brackets were instead used in the model: LNE-BBU-O (13) East Midlands-BBO-O (14) East Midlands-BBU-O (6) Wales-BBU-O (24) Wessex-BBO-O (4) Wessex-BBU-O (2) Total No. of Bridges: Bridge Totals (by bridge type/Material Type) different to those in "Asset Inventory" tab.
	Weighted Average CAF Unit Rates	✓			
	Calibration Factor	✓			
	Live B&C Business Plan Volumes	✓			
	Volumes 2: Business Plan Volumes (actual to date)	✓			

Structures Model Tier 1, Final Version		**Versus**	**Input Source**		Comment
Worksheet	**Description**		**Source Details**	**Description**	
1.2 Bridges - Calculations	Additional Volume to achieve capability targets, CP5 to CP8	✓			
2. Major Structures	Overlay for painting of Forth Bridge	✓			
	IP Estimated Cost (£k)	✓			
	Central Business Plan Overheads (%)	✓	*Section 4.4 of 'Structures Unit Rate Commentary*		
	Additional Steelwork Cost (Additional Risk Sum)	✓			
3. Tunnels	Standard Interventions & Unit Rates	✓			
	Activity Volumes Generated by matching defects to standard interventions in TCMI Model	✓			
	No. of TCMI Reports excluding repeats = 414	✓			
	Total no. bores (CARRS) = 810	✓	23112011 Tunnel Asset Count Filtering Flow Chart		
	CP5 Tunnels Workbank	✓			
	2. CP5 'Model' - Based on TCMI Snapshot	✓			
4. Minor Assets	Total CP4 Projected Volumes (m^2)	✓			
	Uplift factors to represent anticipated increase in activity	✓			

Structures Model Tier 1, Final Version		**Versus**	**Input Source**		Comment
Worksheet	**Description**		**Source Details**	**Description**	
	in CP5 from CP4				
5. Minor Works (Cross-Asset)	CP5 Unit Rates	✓	Structures Unit Rate Commentary, Network Rail Control Period 5 Planning, Rev 01, 30th September 2011		PM Services - 5.26% NR HQ - 0.90% IP Central Costs - 0.80% Asset Management - 1.50% Possession Management - 1.20%
	CP5 Volume	✓			
	Minor Work Activity Split by Asset Type	✓			
	Asset Type Split by Operating Route	✓			
6_E & A (OPEX)	Bridges Examination Build-up (Detailed & Visual)	✗	20110524 Bridge DE Volumes v1.0xls		Profiled DE in CP5: Non Integer Profiled Visual in CP5: Non Integer
	Tunnels Examination Build-up (Detailed & Visual)	✗	20110520 Tunnels Exam Volumes_v1.0.xls		Profiled DE in CP5: Non Integer Profiled Visual in CP5: Non Integer
	Culverts Examination Build-up (Detailed & Visual)	✗	20110511 Culverts v1.0.xls		Profiled DE in CP5: Non Integer Profiled Visual in CP5: Non Integer
	Asset Count: Bridges Underwater UTGRA Retaining Walls Sea Defences Ancillaries Large & Unique Tenanted Arch Reconnaissance	✗	TBC		Bridges Underwater: Non Integer Retaining Walls (Visuals): Non Integer
	Bridge Strikes Annual Number / year	✓	TBC		

Structures Model Tier 1, Final Version		Versus	Input Source		Comment
Worksheet	Description		Source Details	Description	
	Bridge Strikes - CEFA 2009/10 Final Account Numbers per route	✓	TBC		
	By Route: Bridge Count Tenanted Arches Count (Estimate) Retaining Wall Count Coastal.. Count UTGRA Estimate Underbridges Count (For Underwater)	×	TBC		Bridge Count: Non Integer Tenanted Arches Count (Estimate): Integer Retaining Wall Count: Non Integer Coastal… Count: Non Integer UTGRA Estimate: Non Integer Underbridges Count (For Underwater): Non Integer
	2009/10 P13 National Bridges Strike Report Breakdown		TBC		
	Rapid Response - Non Bridge Strikes	×	TBC		Proposed Total (per OR): Non Integer Total per CP: Non Integer
	Additional Examination - Cyclic Additional Examination - One off (Volume per OR)	✓	TBC		
	Additional Examination - Cyclic Additional Examination - One off (Rate per Examination)	✓	TBC		
	Scour: Initial Assessment Detailed Assessment Proving Foundations	×	TBC		No. Assets/year: Non Integer
	Assessment Unit Rate = 1000	✓	TBC		
	Scour & NBSI Vol	×	TBC		Volume calculated using Non Integer values

Structures Model Tier 1, Final Version		Versus	Input Source		Comment
Worksheet	Description		Source Details	Description	
7.1_Other CAPEX	Other CAPEX Costs: BG3 Mitigation Bridge Marking & Plating Hazard Management Hidden Shafts HQ Programmes	✓	TBC		
	Hidden Critical Elements	✓	TBC		
	Scour Proving Foundation	×	TBC		No. assets/yr: Non Integer
	Other CAPEX Costs	×	TBC		Tunnel Bore Count: Non Integer
7.2_External Cost Drivers	CP5 Forecast (per Route)	✓	TBC		
	External Cost Drivers: Reduced Possession Access Traffic Growth; "End-CP4" to "Current Railway" Traffic Climate Change Adaptation	✓	TBC		
Asset Inventory	Asset Count by Material Type	×	TBC		Asset Count: Non Integer
	Minor Assets Count - Level 4 Reporting Tool	×	TBC		Asset Count: Non Integer
	Minor Assets OR Proportions	✓	TBC		
			TBC		
Unit Rates	Structures Average Unit Rates: Average Unit Rate incl PM Services (£/m2) Central Business Plan Overheads (%)	✓	'Structures Unit Rate Commentary, Network Rail Control Period 5 Planning, Rev 01, 30th September 2011'		

Structures Model Tier 1, Final Version		Versus	Input Source		Comment
Worksheet	Description		Source Details	Description	
	Structures - Minor Works Unit Rates: Average Monitor Rate (£) Central Business Plan Overheads (%)	✓	'Structures Unit Rate Commentary, Network Rail Control Period 5 Planning, Rev 01, 30th September 2011'		
	Structures - Unit Rates for CEFA Products: CEFA Contract Equivalent Unit Rate £	✓	'Structures Unit Rate Commentary, Network Rail Control Period 5 Planning, Rev 01, 30th September 2011'		NR Project Management Costs 7%
Tier 0	N/A				
References	N/A				
E&D	Earthworks & Drainage, Expenditure per CP for: - Soil cuttings - Rock Cuttings - Embankments - Examination & Climate Change - Other - Drainage	✗	Tier 1 Earthworks Model, Version 6	Inputs fed from Worksheet "Tier 0"	CP year values pasted in E&D are different from the Earthwork's Tier 0 tab. However, totals do add up on Dashboard.

E2 Formulae consistency

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
Dashboard			✓	
1.1 Bridges-Inputs	'do nothing' Total CP4 BCMI degradation (with duplicate exams)	K20 : K99	✓	Formula consistent for all 80 families
	Total BCMI uplift due to MW's in CP4	L20 : L99	✓	
	do nothing' BCMI totals at end of CP4	M20 : M99	✓	
	Volume weightings for route split	O20 : O99	✓	
	Route Level Volumes (CP5 - CP8)	Q20 : T99	✓	
	Route Level Calcs (£m) (CP5 - CP8)	V20 : Y99	✓	
	Total No. of Bridges by Bridge Tye & Material Type	I101 : I108	✓	Total no of bridges do not add up to totals as in "Asset Inventory" (inclu. Counts by Material/OR)
	Live B&C Business Plan Volumes	D155 : K166	✓	
	Volumes 1: Final CP4 Projected Volumes	D138 : K149	✓	
	CP5 All Inclusive Unit Rate (£/m^2)	J119 : J130	✓	NOTE: Average of the OB/UB preventative, repair, replace and strengthen unit rates has been used as a sensible approximation for waterproofing
	CP4 Unit Rates (UB& OB)	D112 : D113	✓	
1.2 Bridges - Calculation	Total Number of Bridges	D8 : K8	✓	
	Total Number of Bridges (with duplicate exams)	D9 : K9	✓	
	Total BCMI uplift due to MW's in CP4	D10 : K10	✓	
	CP4 Volume (actual to date)	D11 : K11	✓	
	Volume uplift to reflect CP4 business plan total	D12 : K12	✓	
	Forecast CP4 Volume (m2)	D13 : K13	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	'do nothing' Total CP4 BCMI degradation (with duplicate exams)	D14 : K14	✓	
	Average CP4 BCMI degradation/ bridge/ day	D15 : K15	✓	
	Total CP4 BCMI degradation	D16 : K16	✓	NOTE: Multiplied by 365.25 days where the 0.25 accounts for leap years
	'do nothing' BCMI totals at end of CP4	D17 : K17	✓	
	'do nothing' End-CP4 average BCMI	D18 : K18	✓	
	Implied Start of CP4 BCMI	D19 : K19	✓	
	End of CP4 Avg BCMI (with intervention)	D20 : K20	✓	
	End CP BCMI Target	D22 :K22 D30 : K30 D38 : K38 D46 : K46	✓	
	End CP BCMI Target (- Minor Work's impact)	D23 :K23 D31 : K31 D39 : K39 D47 : K47	✓	
	End CP BCMI - No Intervention	D24 :K24 D32 : K32 D40 : K40 D48 : K48	✓	
	BCMI uplift required to meet target (- Minor Work's impact)	D25 :K25 D33 : K33 D41 : K41 D49 : K49	✓	
	CP4 volume adjustment ratio	D26 :K26 D34 : K34 D42 : K42 D50 : K50	✓	
	Total volume required over CP (m2)	D28 :K28 D36 : K36 D44 : K44 D52 : K52	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
2. Major Structures	Additional Risk Sum	Z24 : Z306	✗	"SDI207.63 = £150" (Cell AJ49) not picked up by lookup. Correction required. Cell AJ49 should state 'SDI1207.63' not 'SDI207.63'.
	Total Central Business Plan Overheads (%)	AE24 : AE306	✓	
	PM Services @ 5.8%	AF24 : AF306	✓	
	Total IP Estimated Cost Incl, Overheads (£k)	AG24 : AG306	✓	
	Total Expenditure by OR (£m)	E5 : S14	✓	Note: Scotland expenditure accounts for expenditure for "Overlay for painting of Forth Bridge" (Cells E19 : S19)
3. Tunnels	2. CP5 'Model' - Based on TCMI Snapshot - Volumes	X196 : AP981	✓	
	Manual Assessment of CP5 overlap	AQ196 : AW981	✓	
	Final Volumes	AX196 : AX981	✓	
	Final Cost	AY196 : AY981	✓	
	Result Summary	F988 : T1027	✓	
4. Minor Assets	Total CP5 Forecasted Volume By Operating Route	K28 : AA147	✓	
	Total CP5 Forecasted Spend By Operating Route (£m)	J53 : Y277	✓	
5. Minor Works (Cross-Asset)	Monitor Rate + PM Services (£)	H5 : H13	✓	
	CP5 Average Rate (£)	M5 : M13	✓	
	Total Cost (£)	H45 : V676	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
6_E & A (OPEX)	Total Forecasted Spend By OR	E8 : T28	✓	
	Total Volume Forecast By OR	E36 : T56	✓	
	CP5 Total forecast	J157 : J167	✓	
	Uplift* by 1.1465 Factor	E174 : E178	✓	
	Capex Funded	H172 : AT182	✓	
	Scour CP5 Spend	F247 : F250	✓	
	Assessment (Volumes and Cost)	D257 : W265	✓	
	Scour (Assessment and Scour - Cost and Volumes)	D274 : Q283	✓	
7.1_Other CAPEX	Other CAPEX Costs	F108 : N118	✓	
	Assessments	F95 : L105	✓	
	Inspections	O95 : S105	✓	
	Scour Proving Foundation - CP5 Spend	H92	✓	
	Total CP5 Volume Forecast By OR	G50 : V72	✓	
	Total CP5 Forecasted Spend By OR	G12 : V45	✓	
7.2_External Cost Drivers	Total External Cost Drivers Cost	F33: R42	✓	
	Total CP5 Forecasted Spend By OR	H12 : V22	✓	
Asset Inventory	N/A			
Unit Rates	CP5 All Inclusive Unit Rate (£/m2)	M8 : M34	✓	
	CP5 Average	L41 : L49	✓	
	Structures - Unit Rates for CEFA Products	J53 : J 86	✓	
Tier 0	Cost	B3 : X292	✓	
Reference	N/A			
E &D	N/A			

Appendix F

Buildings

F1 Input Data and model Assumption

Model		Input Source		Comment
Worksheet	Description	Source Details	Description	
BUILDINGS_FS_IIP_FINAL (Pre processor).xls				
0_Input Tables	Intervention for Buildings, Platforms, Canopy, Train Sheds & Fotbridges for each PARL Band starting condition (225 No)	Buildings Tier 2 model		
	PARL (145 Nos)			
1_Calculation	Asset Inventory (feature level)	Buildings Tier 2 model		
BUILDINGS_FS_IIP_FINAL.xls				
Dashboard	PARL Threshold (Building, Canopy, Footbridge, Platform, Train Shed)	AM Assumption		
	ARS Threshold (Building, Canopy, Footbridge, Platform, Train Shed)	AM Assumption		
0_Inputs	% Efficiency to end CP4 (Other)	AM Assumption		
	Intervention types including volumes by station category type			
	Asset Inventory by OR			
	RPI Conversion Table	Planning and Regulation RPI guidance		
	Do Nothing Degradation Curves			
	Average Block Curves (to output PARL after a full renewal)			
	Interventions performed at full renewal date	Tier 2 Model		
	Optimal Interventions performed after forced full renewal			
	Return to X% Parl			

Model		Input Source		Comment
Worksheet	Description	Source Details	Description	
	following a full renewal			
	Year to Period Conversion Table			
	Uplift for interventions on low-cost components			
	Uplift for stations not surveyed			1 No. Station missed. Correction required
	Heritage Factor Uplift			
	HF Pro-rata split			
2_Additional Costs	Cost by OR (Minor Works, PPM, M&E, Other Fabric)			
	Proportion of Planned, Urgent and PPM work (by material type: M&E, Masonry, Timber)			
	Inspection Frequency			Additional Examinations a non integer.
	Total Operational FS Stations			Should be 2507
	Unit cost of inspection	Total 2010/11 Cost. Tom Kirkham CP4 CEFA workbank		
	Current Plan Value			
	Total Annual Inspection Allocation			
3_PARL	N/A			
4_L&E	Renewals workbank			
	Maintenance			
	No of Lifts & Escalators by route			
	No of Lifts & Escalators by TOC			
Tier 0	Expenditure Profile			

Model		Input Source		Comment
Worksheet	**Description**	**Source Details**	**Description**	
References	N/A			
Raw Vol	N/A			
BUILDINGS_OTH_IIP_FINAL.xls				
1_Managed_Stations	Managed Stations - Offline Workbank	Offline workbank		
	Efficiency = 10%			
	Scenarios (To change Scenario figures, change here)	Allocation for an approved programme.		Protect key assets against the treat of terrorism
	IP Annual Pensions Cost (incl. Route proportion)			
	CP5 Total Figures (BG445 : BN446)			No formulae in cells.
2_LMD_Inputs	ARS Threshold	AM Assumption		
	PARL Renewal Threshold	AM Assumption		
	Depot Shed Average			Offline Analysis
	LMD Building median			Not used in model.
	LMD Building average			Not used in model.
	Do Nothing MLE	Offline analysis		
	Returns to (% PARL)			Buildings AM assumption
	Unit Costs			Slightly Different from the unit rates workbank. Update required.
	Cat A station building values (from FS model)	From FS Model		
	Cat F station building values			Average Volumes for a Category F Franchised Station Building used in an old version of the Franchised Stations model
	LMD Inventory (Incl. Avg of ARL, Avg of PARL,			

Model		Input Source		Comment
Worksheet	Description	Source Details	Description	
	Avg of F3, Avg of F4, ARL)			
	Interventions for buildings	Paste from FS Model		
	Do Nothing from Franchised Stations	FS Model		
	Annual Change - Buildings (Row 550)			
3_LMD_Outputs	N/A			
4_LMD_Master List	No. Of LMD's (Total 2010/11 Cost)			
	Total Inspection Cost (£m)			Old CP4 Business Plan.
	Cost of MW, PPM, Other M&E, Other Fabric (by OR)	Source Plan Analysis workbook on 24/05/2011 (£k)		
	Adjustment to include costs for Wales (£M)			No Formulae in cells. Total costs have been allocated to routes based on number of LMD's (see sheet 'References' Range J17:L27)
	Adjusted to split MW and PPM in Fabric and M&E			
	Efficiency (Fabric, M&E, Inspections)			
5_Depot_Plant	Depot Plant Asset Population & Value	Depot Plant Cost Prediction		Edd Davison
6a_Lineside_Preprocessing	% Volume worked on B1, B2, C1 & C2 (for each element: Roof Pitched, Roof Flat, Roof Drainage, Walls, Cladding, Windows, Doors, Stairs & steps, Shutters, Lighting,			Based on surveys completed by Route Managing Directors

Model		Input Source		Comment
Worksheet	Description	Source Details	Description	
	Circuits)			
	Unit Rates: B1, B2, C1 & C2 (for each element: Roof Pitched, Roof Flat, Roof Drainage, Walls, Cladding, Windows, Doors, Stairs & steps, Shutters, Lighting, Circuits)	Franklin & Andrews base rates were taken for full renewal of each element. Buildings asset management overlaid some assumptions in order to derive rates for B2, C1, C2 interventions		Chris Cox
	Volume Calculation by element	Assumptions		
6b_Lineside Model	Demolised/Redundant Costs (CP5)			
	Domestic Wiring Equipment - Total Cost over CP5			
	1b. Lineside Master Data List (by route and Status (Critical Lineside, Non Critical Lineside))			
	Annual MAINTENANCE Cost breakdown by Route - FTN Summary document	FTN Summary Document		
	Annual Renewal Costs			
	Total Inspection Costs			
	M & E Costs by year (CP5)			
	PPM Costs by year (CP5)			
	Reactive Costs by year			

Model		Input Source		Comment
Worksheet	Description	Source Details	Description	
	(CP5)			
	9. Demolition and Decommining iof Signal Boxes in CP6 and CP7			
	End CP4 Efficiency	Assumptions		
MDU's	Approx. Dimensions (Area - m2) by OR & Asset feature			TBC
	Volume percentage by renewal Policy, Maintenance (by OR and Asset Feature)			
	Rates for B1, B2, C1, C2 (by Asset Feature)			
	NR Uplift Rate (excluding 7% Possession)			
	Rates for B1, B2, C1, C2 (by Asset Feature)			
	Unit Rates - B1 Rates, B2 Rates, C1 Rates, C2 Rates			
	Implementation Costs (48%)			
	Corporate Costs (4.40%)			
	Contingency (5%)			
	MDU buildings			
	Efficiency (10%)			
	Reactive Cost in CP5 (£826410.34)			
	MDU counts by OR			Total adds up to only 643 as opposed to only 489 in Spec.
NDS	10/11 Costs (Reactive Maintenance, PPM, MEW, CEFA Inspections, Fabric Element of MEW)			No formulae in cells. Update required
	Renewals £15.67 broke down into			
	NDS - Depot Plant (offline workbank)			

Model		Input Source		Comment
Worksheet	Description	Source Details	Description	
	NDS - Buildings - Allocation by Route			No formulae in cells
	NDS Total Costs			No formulae in cells
References	Operating Route Infrastructure Metrics			
	RPI conversion			
Tier 0 Export	N/A			

F2 Formula Consistency

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
BUILDINGS_FS_IIP_FINAL (Pre-processor).xls				
1_Calculation	Various		✓	
BUILDINGS_FS_IIP_FINAL.xls				
0_Inputs	Asset Inventory Proportion	Y20 : AG30	✓	
	IP/ Maintenance?	P7 : P51	✓	
	New # of Stations	AA8 :AA17	✓	
	Total Uplift (Building, Canopy, Footbridge, Platform, Train Shed)	J92 : J96	✓	
	Cost to allocate by route/year	J122 : N131	✓	
	Volume Uplift to allocate by route/year	T122 : AF131	✓	
	Cost to allocate by TOC/year	J135 : N154	✓	
	Volume Uplift to allocate by TOC/year	T135 : AF154	✓	
	Annual Cost (£m) 2010/11 (by asset type)	F168 : F172	×	NOTE: total adds up to 2506 (should be 2507)
	# of operational station by route	G166 : P166	✓	
	Cost split by route and asset type	G168 : P172	✓	
	# of operational station by TOC	G175 : Z175	✓	
	Cost split by TOC and asset type	G177 : Z181	✓	
	Cost overlay consolidation	H186 : V335	✓	
	Volume overlay consolidation	H340 : V729	✓	L&E volumes picked from L&E worksheet

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
			☐	
1_Calculation	Station/Block Type Id		✓	
	Block ID		✓	
	Station Name		✓	
	A-F Category		✓	
	Block Title		✓	
	Block Type		✓	
	Average PARL		✓	
	Average ARS		✓	
	Initial State		✓	
	Intervention String		✓	
	Percentage Asset Remaining Life (by CP)		✓	
	Renewal Overide Period? (by CP)		✓	
	Additional String for forced renewal		✓	
2_Additional Costs	Total No. Of Stations (by TOC)	T4 : AM4	✗	Note: 2506 No. stations carried over
	% of Stations (by TOC)	T5 : AM5	✓	
	Expenditure (by spend sub-category, asset material, route)	J17 : Y346	✓	
	Inspections		✓	
	Summary of annual other costs (by route)	H381 : Q385	✓	
	Annual other costs (by TOC)	H391 : AA395	✗	Note: 2506 used in calculation
3_PARL	PARL calculatoin	A3 : W11818	✓	
4_L&E	Maintenance cost allocated by route	K79 : K88	✓	
	Cost Allocated by route	E102 : S111	✓	
	Allocation by TOC (by No. Of Stations)	E114 : S133	✗	Note: 2506 No. Of stations being used in calculation

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
Tier 0	Model Overlay and Additional Costs Consolidatoin Table			
References	N/A			
Raw Vol				Optional (from dashboard) - run from macro
BUILDINGS_FS_OTH_IIP_FINAL.xls				
1_Managed Stations	Cost by OR and cost type (Buildings, Canopies,Inspections, etc...)	I447 : W526	✓	
	Managed Stations Costs (by OR, cost type) with 10 % efficiency and RPI ratio	AN447 : BB536	✓	
	Cost by OR, Cost Type, Scenario (including IP Annual Pensio Costs)	AM540 : BA 819	✓	
	Total Volumes	BK461 : BK468	✓	
2_LMD Inputs	Convert PARL to ARL and Round	L21 : L120	✓	
	Calc Type	M21 : M120	✓	
	Renewal Triggers	Q21 : AY120	✓	
	ARL Minus 1	Q122 : AY221	✓	
	Convert to ARL	Q224 : AY323	✓	
	Convert to PARL	S326 : AY425		
	Cap at 100	Q428 : AY527		
LMD_Masterlist				
	Adjusted to include costs for wales (£m)	AD96 : AH105	✓	No formulae in cells

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Adjusted to split MW and PPM in Fabric and M&E	AL96 : AN105	✓	
	LMD Costs	W127 : AK156	✓	
	LMD Cost by Scenario including Cost allowande for terrorism treats	X162 : AL251	✓	
5_Depot Plant	Anticipated Renewal year	L5 : L538	✓	
	Control Period Renewal	M5 : M538	✓	excludes rows 125, 168, 193, 248, 398, 463, 464, 500, 501, 528
	1 Est Total Renewal Cost (M)	O5 : O538	✓	
	2nd Renewal Year	P5 :P538	✓	Rows 26, 170, 259, 271, 272, 319, 340, 361, 362 (N/A)
	2nd Control Period Renewal	Q5 :Q538	✓	
	2nd Control Period Renewal Cost (M)	R5 :R538	✓	
	Periodicity	T5 : T538	✓	
	Anticipated Next Event	U5 : U538	✓	
	Projected Overhaul Year	V5 : V538	✓	Formula doesn't apply to all rows
	Total Cost	Y5 : Y538	✓	
	1st Est Overhaul Cost	Z5 : Z538	✓	Formula doesn't apply to all rows
	2nd Overhaul Year	AA5 : AA538	✓	Formula doesn't apply to all rows
	2nd Control Period Overhaul	AB5 : AB538	✓	Formula doesn't apply to all rows
	2nd Total Overhaul Cost (M)	AC5 : AC538	✓	Formula doesn't apply to all rows
	Renewals Totals (by CP)	I544 : W553	✓	
	Overhaul Totals (by CP)	I556 :I565	✓	
	Totals (by CP)	I568 : I577	✓	
	Depot Plant Costs (£m)	I585 : W592	✓	
	CP Total Figues	Y583 : AE592	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Cost by Scenario (inclu Terrorism threat costs)	I597 : W656	✓	
6a_Lineside Preprocessing	Macro			
6b_Lineside Model	Input Data	AR5 : BS9508	✗	Correction Requred: Cell AJ49, no intervention seem to be needed (columns AR-AU) but there is a cost for it (Column BR) For the majority of Roof Drainage, the volume/cost of work is not being calculated as stated in Assumptions (worksheet 6a, cell J20). e.g. row 106. For intervention C2 it says volume is 29.0764, but it should be 7.25528 according to the assumptions in worksheet 6a.
	Sum of Volume & Costs by each route in Line side Survey data	D4 : S13	✓	
	Uplift Volumes & Costs	D40 : S57	✓	
	Sum of critival and non critival Volumes & Costs	D64 : AG72	✓	
	Western Route Figures as Average of other 8 routes	D79 : AG87	✓	
	Final Costs (Sum of Intervention Costs + All other Costs)	D93 : R107	✓	
	Final Costs by each route	F118 : T147	✓	
7_MDUs	Intervention Type - Cost Totals	K14 : R68	✓	Heading Change required - Volume Totals
	B1, B2, C1, C2 Volume intervention totals	F72 : I81	✓	
	New Unit Rates updated by Tim Stringer	L91 : R97	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Intervention Unit Rates	B118 : H153	✓	
	Intervention Frequency	L129 : P138	✓	
	Total MDU Costs (£m) (Including Efficiency and RPI)	Y114 : AM123	✓	
	Total Cost (by CP & Scenario)	Y133 :AM162	✓	Terrorism allocation applies to Managed Stations only
8_NDS	Anticipated Renewal Year	L24 : L143	✓	
	Control Period Renewal	N24 : N143	✓	
	1 Est Total Renewal Cost	P24 : P143	✓	
	2nd Renewal Year	Q24 : Q143	✓	
	2nd Control Period Renewal	R24 : R143	✓	
	2nd Est Total Renewal Cost (m)	S24 : S143	✓	
	Periodicity (years)	U24 : U143	✓	
	Anticipated Next Event	V24 : V143	✓	
	1st Control Period Overhaul	X24 : X143	✓	
	1st Est Total Overhaul Cost (M)	AA24 : AA143	✓	
	2nd Overhaul Year	AB24 : AB143	✓	
	2nd Control Period Overhaul	AC24 : AC143	✓	
	2nd Est Total Overhaul Cost (M)	AD24 : AD143	✓	
	NDS Renewal Cost	H163 : V172	✓	
	NDS Overhaul Cost	H177 : V186	✓	
	NDS Total Costs (£m)	H191 : V200	✗	No Formulae in cell. Update Required
	NDS Total Costs (including allocation	K211 : Y240	✓	Terrorism allocation applies to Managed Stations only

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	for Terrorism Threat)			

Appendix G

Earthworks

G1 Data Inputs & Model Assumptions

Data Assumptions & Inputs			
Inputs	**Worksheet**	**Comments**	**Source / evidence?**
Annual average # of sites remediated to a 'Serviceable' condition in CP4	Soil Cuttings		Asset Management Assumption based on CP4 Business Plan
% of these sites starting in 'Poor' condition			Asset Management Assumption based on CP4 Business Plan
Annual # of 'Poor' condition sites treated via emergency response in CP4			Asset Management Assumption based on CP4 Business Plan
CP4 Business Plan volume (m2 of earthwork remediated)			10/11 P07 Business Plan
Reduction in cost due to increased maintenance			Asset Management Assumption
Assumed years to treat all sites (programme length)			
Assumed average size of site (m) (100m ~ 5ch)			
Climate Change allocation (£k)			Reference 'Impact of Climate Change on Geotech and Drainage CP5.doc'
Additional expenditure in CP6 and CP7			Reference 'Impact of Climate Change on Geotech and Drainage CP5.doc'
Annual average # of sites remediated to a 'Serviceable' condition in CP4	Embankments		Asset Management Assumption based on CP4 Business Plan
% of these sites starting in 'Poor' condition			Asset Management Assumption based on CP4 Business Plan
Annual # of 'Poor' condition sites treated via emergency response in CP4			Asset Management Assumption based on CP4 Business Plan
CP4 Business Plan volume (m2 of earthwork remediated)			10/11 P07 Business Plan

Data Assumptions & Inputs			
Inputs	**Worksheet**	**Comments**	**Source / evidence?**
Reduction in cost due to increased maintenance			Asset Management Assumption
Additional expenditure in CP7 to CP11			Reference 'Impact of Climate Change on Geotech and Drainage CP5.doc'
CP4 Business Plan volume (m2 of earthwork remediated)	Rock Cuttings		10/11 P07 Business Plan
Reduction in cost due to increased maintenance			Asset Management Assumption
Vegetation Clearance (£k/year)	Other		Asset Management Assumption
Existing Programme of Minor Works - # of sites fixed per year			Asset Management Assumption based on CP4 Business Plan
Current levels of ground investigation (£k/year)			Asset Management Assumption
Rock Fall Alarms - new sites for rock fall alarms (# 5ch/year)			Asset Management Assumption
Rock Fall Alarms - Cost per 5ch (£k)			Asset Management Assumption
Mineworkings - Desk studies CP5 Total (£k)			Assumes activity as per CP4: Desk Studies £0.887M (148 studies) Investigation £5.512M (55 sites), & Treatment £4.537M (10 sites). Information provided by NR Mining team in CP5 Mining bottom up review presentation dated 11/3/2011.
Mineworkings - Investigation CP5 Total (£k)			
Mineworkings - Treatment CP5 Total (£k)			
Number of Earthworks Examinations - 10 Year Prediction	OPEX		JBA Earthworks Examinations database

Data Assumptions & Inputs			
Inputs	**Worksheet**	**Comments**	**Source / evidence?**
% Soil Cuttings			JBA Earthworks Examinations database 05/05/11
Unit Rate (£/exam) per territory			CEFA Contract
Project Management (PM) uplift			CEFA Project Team
Climate Change Annual Allocation (£k)			(Reference 'Impact of Climate Change on Geotech and Drainage CP5.doc')
CP6 to CP11 Addition (£m/year)			(Climate change cost increasing - reference 'Impact of Climate Change on Geotech and Drainage CP5.doc')
Cuttings - % Moving from condition A to condition B in a 5 year period	Degradation Input		(Network Rail derived)
Embankments - % Moving from condition A to condition B in a 5 year period			Mouchel Derived
Baseline Condition Information of the Earthworks Assets used in Modelling 05/05/11 - Embankment, Soil Cutting, Rock Cutting			JBA database
Total Volume of projects (m^2) - Embankments, Cutting Soil, Cuttings Rock	Unit Rates		Master_ Combined CP5 Input Spreadsheet v1_20110527 2ndCut.xls
Total Budget for projects (£k) - Embankments, Cutting Soil, Cuttings Rock			Master_ Combined CP5 Input Spreadsheet v1_20110527 2ndCut.xls
route miles for NR	WCF		Analysis Lancs and Cumbria Del. Unit
route miles for LNW			Analysis Lancs and Cumbria Del. Unit
number of sites LNW			Analysis Lancs and Cumbria Del. Unit

Data Assumptions & Inputs			
Inputs	**Worksheet**	**Comments**	**Source / evidence?**
Percentage of Ditch Clearing and Drainage Renewal			Asset Management Assumption
National 5ch		Correction required to avoid confusion (Minor concern).	The actual number should be 4289. The 4290 value appears in one cell due to some rounding differences but is not used in any calculation.
1: ROCK CUTTING SCALING (BY ABSEILERS)	MW Sites		avg, of 4 contractor prices
2: ROCK CUTTING SCALING (BY ROAD-RAIL PLANT)			avg, of 4 contractor prices
3: RENEW DRAINAGE			avg, of 4 contractor prices
4: CLEAR DITCHES			avg, of 4 contractor prices
5: CLEAR WOODY VEGETATION (ASSSUME BOTH SIDES)			avg, of 4 contractor prices
Typical' maintenance site is (from CAF 08/09 to 10/11)			CAF 08/09 to 10/11
Assumed number of earthworks maintenance sites in CP5			
Assumed split/ sites in CP5			
# of 'Poor' 5 Chains	Ref		Data from JBA website 05/05/11
Total # of 5 Chains			Data from JBA website 05/05/11
Drainage	Tier 0		Offline Analysis

G2 Formulae consistency

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
Soil Cuttings	Annual average # of 'Poor' condition sites remediated in CP4	E6	✓	
	Total number of 'Poor' condition sites treated in CP4	E8	✓	
	# of sites forecast to move from 'Marginal' to 'Poor' over CP4	E9	×	As Identified in "Degradation Input" worksheet, formula should refer to cell I14 and not K14
	Shortfall of sites addressed in CP4	E10	✓	
	% volume uplift required in CP5 to return to Start CP4 condition	E13	✓	
	CP5 required volume (m2 of earthwork remediated)		×	As Identified within model: Number used erroneously in submission. Should be =E16*(1+E13) = 56133224.35 Small error
	Average Unit Rate (£K/m2)	E20	✓	
	Total CP5 Cost (£k)	E22	✓	
	# of vulnerable sites identified in LNW study	E25	✓	
	Route Miles in LNW	E26	✓	
	National Route Miles	E27	✓	
	Implied national total number of sites	E28	✓	
	Total number of sites to treat in CP5	E30	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Unit Rate - Drainage Renewal (£/m)	E34	✓	
	Unit Rate - Ditch Clearing (£/m)	E35	✓	
	Assumed % Split Drainage Rewenal (vs. Ditch Clearing)	E36	✓	
	Total CP5 Cost (£k)	E37	✓	
	# of sites fixed (total embankments & cuttings)	E40	✓	
	Unit rate (£k per earthwork maintenance site)	E41	✓	
	% of sites fixed which are Soil Cuttings (by £total cost)	E42	✓	
	Total CP5 Cost (£k)	E43	✓	
	TOTAL CP5 COST (£m)	E47	✓	
Embankments	Annual average # of 'Poor' condition sites remediated in CP4	E6	✓	
	Total number of 'Poor' condition sites treated in CP4	E8	✓	
	# of sites forecast to move from 'Marginal' to 'Poor' over CP4	E9	✓	
	Shortfall of sites addressed in CP4	E10	✓	
	% volume uplift required in CP5 to return to Start CP4 condition	E13	✓	Same as for soil cuttings,
	CP5 required volume (m2 of earthwork remediated)	E17	✓	
	Average Unit Rate (£K/m2)	E20	✓	
	Total CP5 Cost (£k)	E22	✓	
	# of sites fixed (total embankments & cuttings)	E25	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Unit rate (£k per earthwork maintenance site)	E26	✓	
	% of sites fixed which are Embankments (by £total cost)	E27	✓	
	Total CP5 Cost (£k)	E28	✓	
	TOTAL CP5 COST (£m)	E30	✓	
Rock Cuttings	CP5 required volume (m2 of earthwork remediated)	E5	✓	
	Average Unit Rate (£K/m2)	E8	✓	
	Total CP5 Cost (£k)	E10	✓	
	# of sites fixed (total embankments & cuttings)	E13	✓	
	Unit rate (£k per earthwork maintenance site)	E14	✓	
	% of sites fixed which are Rock Cuttings (by £total cost)	E15	✓	
	Total CP5 Cost (£k)	E16	✓	
	TOTAL CP5 COST (£m)	E18	✓	
Other	Average cost per site fixed (£k)	C8	✓	
	Total Cost (£k/year)	C9	✓	
	CP5 TOTAL Minor Works (£k)	C10	✓	
	Total Cost (£k/year)	C17	✓	
	CP5 TOTAL Monitoring/Alarms (£k)	C19	✓	
	CP5 TOTAL Mineworkings CP5 (£k)	C24	✓	
	Total CP5 Cost (£m)	C26	✓	
			□	
OPEX	CP5 Total	Q7 : Q11	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Volume Split by Cutting Type and Territory	D14 :M23	✓	
	Examination Cost (£k)	D28 : M37	✓	
	CP5 annual average (national) (£k)	F39	✓	
	CP5 annual average (national, incl. PM) (£k)	F42	✓	
	% of network nationally	G47 : G56	✓	
	% of national exams CP5	H47 : H56	✓	
	£k for CP5 Exams	I47 : I56	✓	
	Climate Change (£k in CP5)	J47 : J56	✓	
	TOTAL CP5 (£k)	K47 : K56	✓	
Degradation Inputs	Soil Cuttings condition profile	K7 : M9	✓	
	Numbers moved from Marginal to Poor during a control period	I14	✓	
	Embankments condition profile	G28 : I30	✓	
	Embankment Total	D45 : I45	✓	
	Soil Cutting Total	D54 : I54	✓	
	Rock Cutting Total	D63 : I53	✓	
Unit Rates	Average Unit Rates (Embankments, Soil Cuttings, Rock Cuttings)	D34, F34, H34	✓	
WCF	number of sites nationally	B18	✓	
	Unit Rates (Ditch Clearing & Drainage Renewal)	C25, D25	✓	
	Total/year/territory (Ditch Clearing & Drainage Renewal)	C26, D26	✓	
	Total Cost	C28	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Total per CP	C29	✓	Note: Divided by 25 to account for 5 Network rail territories and 5 years in the control period
MW Sites	Typical Maintenance Site dimensions	D11, F11	✓	
	Site size	B20 : B24	✓	
	Cost to fix a site	C20 : C24	✓	
	Assumed split of sites	E20 : E24	✓	
	Cost to fix CP5 sites	F20 : F24	✓	
	CP5 Costs (£)	H20 : J24	✓	
	Total Volume fixed	C27	✓	
	Total 5 chains fixed (5ch ~ 100m)	C28	✓	
	Overall average cost per maintenance site	C30	✓	

Appendix H

Other Maintenance

H1 Formulae consistency

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
Dashboard	Various	-	✓	All formulae consistent
Spend Forecast Chart	-	C6 : G6	✓	
Assumtions and Initiatives	Efficiencies achieved through initiatives	C13	✓	
	Cumulative Stretch overlay multiplier	E15 : J15	✓	
	Initiative Lookup	I58 : I111	✓	
Master - Input Data	-	P3 : Y5096	✓	
Night Shift Initiative Calc	Count	D3 :D273	✓	
	% of DU work type applicable	K3 : K11	✓	
	Net uplift Salary	L3 : L11	✓	
Other Costs Input Table	-	-	-	
Tier Zero Output	CP costs	M3 : AA512	✓	
Calculation Output Data	CP costs	G3 : O442	✓	
Calculations Sheet	Total to be modelled (10/11 Posts)	G4 : G219	✓	
	Start Headcount split by route	I4 : R219	✓	
	Wales Split	T4 : V219	✓	

Worksheet	Process	Range Applicable	Formulae Consistency	Comments
	Headcount Reduction	X4 : AF219	✓	
	2010/11 Headcount split by route	AH4 : AR219	✓	
	2011/12 - 2019/19 Headcount split by route	AT4 : EJ219	✓	
	Unit Rates	J224 : Q439	✓	
	2010/11 - 2018/19 Cost split by route	AH224 : EJ439	✓	
	Initiative driven Total Cost by year	AA224 : AA439 AF224 : AF439	✓	
Hierarchy	-	-	-	
Tier Zero HQ to route metric	£	D3 :D12	✗	Sum range is not fixed (However, values are consistent in this case). Update required
	E&W	G3 : G12	✓	
Cost Centre Data	-	-	-	
Band Converter	Result	F4 : F57	✓	
Convert Bands to Original	-	-	-	
Lists	-	-	-	
2010-11 Chart Staff Numners	-	-	-	