AUDIT OF TRACK ACCESS CHARGING MODEL
For HS1 Limited
Initial Report, 15 May 2019

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Glossary

Acronym	Meaning
AMS	Asset Management Strategy
CIR	Commission Implementing Regulation
CP	Control Period (CP2 – 2014-20; CP3- 2020-2025)
DFT	Department for Transport
EU	European Union
FCP	First Class Partnerships Ltd
IAC	Infrastructure Access Charge
IRC	Investment Recovery Charge
LCR	Life Cycle Report
LTC	Long Term Charge
NRHS	Network Rail High Speed
NRIL	Network Rail Infrastructure Limited
OMR	Operations, maintenance & renewals
ORR	Office of Road and Rail
PR19	Periodic Review 19
PWC	Price Waterhouse Coopers
SoS	Secretary of State (for Transport)
WACC	Weighted Average Cost of Capital

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1 Executive Summary

1.1 HS1 CP3 Pricing Model Audit

We have conducted an audit of the CP3 Pricing Model through three paths of enquiry:

Regulatory Compliance

We have reviewed the relevant pieces of legislation that are used to determine an Infrastructure Access Charges for HS1. In some cases, the legislation has changed since the previous pricing model was used (CP2). We have reviewed the legislation alongside management's interpretation of the impact of the changes to the model. We confirm our agreement with HS1's views.

Our review has included reviewing the charging structure within the model, and we have concluded that it is consistent with the Railway Regulations.

Model Audit Work

We received an initial version of the Pricing Model (v19b), which we then reviewed the internal workings through (a) a review of formulae, reporting and cross-sheet use of data, and (b) by constructing a simpler parallel model to validate the initial model's models outputs. Following our first review we made a number of comments (see Comment Log – Appendix B 1.2) which were dealt with, resulting in an updated model version (v.21a). We were able to review the changes and use the parallel model to check changes through to pricing outputs.

We have found that the CP3 HS1 Pricing Models (version 21a) works in a way consistent with the rules and assumptions that have been explained to us by management and our regulatory review. The model allocates costs to operators and services in consistent way for each charging category.

Other Audit Matters

In addition to the specific regulatory and methodology audits of the model, the team considered other related matters that could be considered by HS1. These were:

- Noting the substantial amount of hard-coded input data from external sources (not part of this audit scope) we draw your attention to the potential audit limitations from not validating input data effectively,

- Noting the model's age, complexity and version control we make recommendations around improving the quality & durability of the HS1 Pricing Models

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2 Introduction

2.1 Background

In 2010 HS1 Ltd was awarded a 30-year concession agreement by the Secretary of State (SoS) for Transport to operate and maintain the high-speed route (infrastructure and stations) from St Pancras International in London to the Channel Tunnel boundary (108km).

The Office of Rail and Road (ORR) regulates the track and infrastructure on the route whilst the Government's Representative within the DfT regulates the stations. Regulation involves approving the costs and charges for long-term renewals by reviewing HS1's Asset Management Strategy (AMS) and Life Cycle Reports (LCRs). International train operators and domestic train operators pay a long-term charge (LTC) to use the infrastructure to cover the costs of renewals over a 40-year period. These charges are determined every five years as part of a Control Period review.

The next control period CP3 commences from 1 April 2020, following the periodic review concluding in 2019 (PR19).

As part of the regulatory review process HS1 have updated their previous regulatory charging model for CP3 and now wish to commission an audit of it in advance of their final PR19 submission at the end of May. This report is the output from that audit.

2.2 FCP's Scope of Work

1. Audit the revised charging model to confirm it meets all regulatory requirements. This will incorporate:

- Reviewing and confirming understanding of the specific requirements of the ORR Regulatory Framework for HS1. (We note that there have been changes to the regulatory requirements since CP2 and that the model needs to meet these requirements).
- Reviewing any reports, highlighting concerns and recommending changes from previous audits.
- Reviewing and documenting (high-level) workings of the current model ie inputs, calculations, macros, outputs.
- Highlighting noted changes to the model and reviewing change control history
- Confirmation that documented workings of the current model will comply with ORR regulatory framework (including changes to date).
- Confirmation that internal workings and computations of the model are as expected
- Confirmation that outputs and reports reflect the computational outputs of the model
- Identification of any errors in the model and suggest changes to rectify these
- Considering the efficiency and effectiveness of the model and recommending any improvements that could be made
- Considering and advising on the use of proprietary assurance software on model

- Confirming that the model complies with the Railways Access and Management Regulations 2016 and EU CIR of 2015 on the modalities of calculating track access charges

2. Provide additional advice, if appropriate, to:

- Improve the model's structure and functionality
- Realise further efficiencies in the cost categories and their associated business activities

2.3 Structure of this report

This report has been structured in line with the instructions set out above as follows;

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- Regulatory Compliance (section 3)

    o Reviewing and confirming understanding of the specific requirements of the ORR Regulatory Framework for HS1. (We note that there have been changes to the regulatory requirements since CP2 and that the model needs to meet these requirements).

    o Reviewing any reports, highlighting concerns and recommending changes from previous audits.
    o Considering and advising on the use of proprietary assurance software on model
    o Confirming that the model complies with the Railways Access and Management Regulations 2016 and EU CIR of 2015 on the modalities of calculating track access charges

- Model Audit Work (Section 4)

    o Reviewing and documenting (high-level) workings of the current model ie inputs, calculations, macros, outputs.
    o Highlighting noted changes to the model and reviewing change control history
    o Confirmation that documented workings of the current model will comply with ORR regulatory framework (including changes to date).
    o Confirmation that internal workings and computations of the model are as expected
    o Confirmation that outputs and reports reflect the computational outputs of the model
    o Identification of any errors in the model and suggest changes to rectify these

- Other Audit Considerations (Section 5)

    o Considering the efficiency and effectiveness of the model and recommending any improvements that could be made

    o Considering and advising on the use of proprietary assurance software on model

2.4 Disclaimer and limitations

This report has been prepared for HS1 limited and must not be disclosed to any third parties without the prior written permission of HS1 Limited. In carrying out our work and preparing our report we have worked in accordance with the terms of our contract of engagement.

Accordingly, we assume no responsibility or liability whatsoever to any third parties who are shown or gain access to our report in relation to the report's contents and any use such third parties may choose to make of our report is entirely at their own risk.

This report has been drafted based on the information and reports provided to FCP shown in Appendix A. It should also be noted that this report comprises 26 pages including Appendices.

2.5 Document approval and release

This report has been prepared and reviewed using suitably qualified and experienced specialists, and subject to FCP quality assurance prior to release.

Insert any other quality sign-off requirements from the client or proposal.

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3   Regulatory compliance

3.1   Introduction

In this section we define the legislative requirements which HS1 must adhere to when completing their track access charging model. We then offer a commentary about the model's compliance with these requirements.

3.2   Requirements

The regulatory requirements for HS1's track access charging model are defined in the following documents:
- Schedule 4 of HS1's Concession Agreement with the SoS
- EU CIR 2015/909, modalities for the calculation of IAC
- Railway Infrastructure (Access and Management) Regulations 2016

Schedule 4 of HS1's Concession Agreement has a two-page section dealing with access charges and a one-page section dealing with price indexation. The access charging schedule states that the principles of HS1's charging regime shall comply with the requirements of the 'Railways 'Regulations', which are defined elsewhere as the Railway Infrastructure (Access and Management) Regulations 2016. Both parties to the contract also acknowledge that the charging regime is intended to operate in a manner consistent with the 'Railways Regulations'.

Schedule 10 of HS1's Concession Agreement defines the process for asset stewardship and the Periodic Review, and the related responsibilities within this process for HS1 and the ORR.
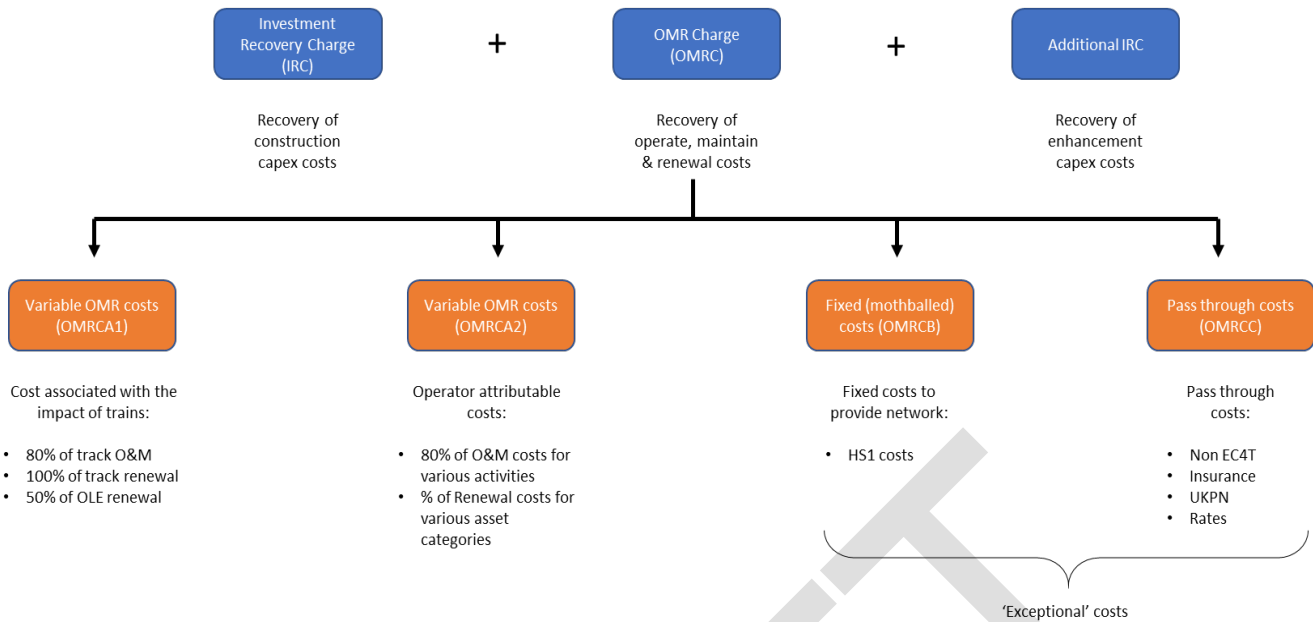
Section 3.1 of the schedule outlines a charging regime consisting of an Investment Recovery Charge (IRC), an additional IRC and an OMR charge, which is reflected in the actual structure of HS1's charging regime (see section 3.3).

The Concession Agreement gives primacy to the Railway Infrastructure (Access and Management) Regulations 2016 in defining the structure and contents of the charging model. This wide-ranging piece of legislation establishes the structure of the UK rail industry and the respective roles of the Regulator, Infrastructure Managers such as HS1 and Network Rail, and the various Railway Undertakings which use the nation's rail infrastructure.

Section 4 of the Regulations deal with access charging. The principles of the regime are around cost recovery through a framework agreed by the Rail Regulator and in accordance to include operational costs and renewal costs based upon an asset management register.

3.3   HS1's charging structure

The figure below shows HS1's charging structure:

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Investment Recovery Charge (IRC)	+	OMR Charge (OMRC)	+	Additional IRC
Recovery of construction capex costs		Recovery of operate, maintain & renewal costs		Recovery of enhancement capex costs

Variable OMR costs (OMRCA1)	Variable OMR costs (OMRCA2)	Fixed (mothballed) costs (OMRCB)	Pass through costs (OMRCC)
Cost associated with the impact of trains: • 80% of track O&M • 100% of track renewal • 50% of OLE renewal	Operator attributable costs: • 80% of O&M costs for various activities • % of Renewal costs for various asset categories	Fixed costs to provide network: • HS1 costs	Pass through costs: • Non EC4T • Insurance • UKPN • Rates

'Exceptional' costs

It can be seen that this model is consistent with the structure laid out in section 3.2 of the report. The OMR (Operate, Maintain and Renew) charge is split into several sub costs in a manner agreed previously by the Rail Regulator.

3.4 Findings/Commentary

3.4.1 Impact of new Regulations

The Railways Regulations 2016 supported by the Commission Implementing Regulation 2015/909 (CIR) have both come into effect since current charges were set and impact the charging framework for CP3. As part of our audit we have considered the implication of the new regulations and how the pricing model should be revised and have discussed this with HS1. The original model we reviewed did not reflect the new regulations but was revised during the audit process. The final model adopted by HS1 (version 21a) includes a number of changes to reflect the impact of the new regulations. Our audit findings support these changes as noted below.

The new regulations consider two broad categories of cost, directly incurred and common or fixed costs:

- **Directly Incurred Costs.** The main impact of the new regulations is to provide greater definition and clarity on what operation, maintenance and renewal (OMR) costs should be classed as directly incurred by train services on the network. These cover the wear and tear cost caused by traffic and are often referred to as short run marginal costs. Previously in its network statement and the price setting model, HS1 had included a category called direct avoidable costs. The new regulations make it clear that this category should not be classed as a directly incurred cost, but instead is mainly a fixed cost (see next category). We recommend that the terminology in the model and the network statement is amended. The classification "avoidable" is still useful however as it is used in the model to allocate some fixed costs to specific types of train service, namely: freight, international and domestic.

- **Common or Fixed Costs**. In order to recover HS1's full costs the regulations allow for HS1 to recover the long term OMR costs that are incurred regardless of the level of usage of the network. These are often referred to as fixed or common costs.

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This categorisation into two classes of cost is consistent with the HS1 Concession Agreement (Schedule 10, section 2, clause 7) that says OMR costs approved or determined by ORR for calculating track access charges shall comprise 2 elements, namely:

1. charges in respect of costs directly incurred as a result of operating train services, and;
2. charges in respect of fixed and common costs payable to HS1 irrespective of the level of HS1 usage.

We now consider each of these two elements in the following sections.

3.4.2   Directly incurred costs

Non-Eligible as direct costs. Article 4 of the CIR sets out a list of costs that are not eligible to include as direct costs for the calculation of charges and as a result the following changes for CP3 are required:

Cost item	Change for CP3
Network Rail High Speed (NRHS) payroll costs	All NRHS payroll costs that had previously been coded as directly avoidable are no longer eligible as a direct cost and should move from avoidable to common cost category
NRHS payroll recoveries on project costs	These costs are not direct and so should move from the previous category of directly avoidable to common costs.
NRHS contribution to national NRIL costs	Most of these costs are not direct and so should move to common cost category. HS1 estimate that 15% are avoidable costs as they relate to timetabling, standards and engineering assurance activities.
NRHS track recording costs	These were previously coded as directly avoidable but should now move to common costs as they relate to the whole network
NRHS security	These were previously coded as directly avoidable but should now move to common costs as they relate to the whole network
NRHS other costs and professional fees	These relate to overheads and are therefore not direct costs. They should move from avoidable to the common cost category
NRHS management fee and risk premium	These are not direct costs and so should move to the common cost category
NRHS enhanced maintenance	These were previously coded as directly avoidable but should now move to common costs as they relate to the whole network
HS1 financing costs on negative escrow accounts for track renewals and overhead line	Previously all track renewal and 50% of overhead line renewal costs were treated as directly incurred costs, but now the financing element must be removed and categorised as common costs
HS1 financing costs on negative escrow accounts for all other renewals	Previously financing costs for all other renewals were included in the same proportion as the renewal cost itself (eg civils bridgeworks 50% avoidable and 50% common). Now all the financing element must be moved to fixed cost category

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3.4.3   Calculation of direct unit costs.

Article 5 of the CIR states that average direct unit costs should be assessed by vehicle or train kilometres, or by gross tonne kilometres. HS1 uses this basis to set freight variable charges (per train km), however for passenger train services variable usage charges are set on a £ per minute basis. We have reviewed the regulations and discussed this with HS1. Our conclusion is that the current method of charging passenger services on a £ per train minute basis remains valid and we therefore support the HS1 proposal to continue to charge on this basis. We base this view on a number of factors described below.

Article 6 of the CIR is a derogation that allows HS1 to assess average unit costs on a different basis to train or vehicle kms. It states that: *"the infrastructure manager may calculate direct unit costs by means of robustly evidenced econometric or engineering cost modelling, provided it can demonstrate to the regulatory body that the direct unit costs include only direct costs incurred by the operation of the train service and, in particular, do not include any of the costs referred to in Article 4."*

HS1 believes it meets the requirements of this derogation and in our audit findings we concur with this view. The CP3 charging model that we audited splits costs into appropriate categories for traffic dependent costs, infrastructure dependent costs and fixed common costs. It also identifies track km and average speed, and journey times or train minutes for different types of train service. This represents a robust modelling approach. In terms of the categorisation of direct costs, including those non-eligible, our audit described above concludes that the latest HS1 model does meet the requirements of the new regulations and does appropriately allocate direct costs. Finally, we observe that journey time is an important factor on a high speed network and useful in helping to optimise capacity and that charging by minute is compatible with this.

3.4.4   Common or Fixed Costs

As noted above HS1 is allowed to recover its full costs; i.e. those other than directly incurred. This is done in accordance with the 2016 Railway Regulations that allows for exceptions to the charging principles set out for directly incurred costs in the CIR. This means that HS1 can recover its fixed or common OMR costs. There are two charging exceptions set out in Schedule 3 of the Railway Regulations. The first exception is in Clause 2 and the second in Clause 3. These state the following:

C2 (1) In order to obtain full recovery of the costs incurred, the infrastructure manager, with the approval of the Office of Rail Regulation under the access charges review or, in the case of a rail link facility, the Secretary of State through the development agreement, may levy mark-ups on the basis of efficient, transparent and non-discriminatory principles, whilst guaranteeing optimum competitiveness, in particular in respect of rail market segments.

(2) The effect of sub-paragraph (1) must not be to exclude the use of the infrastructure by market segments which can pay at least the cost that is directly incurred as a result of operating the railway service, plus a rate of return which the market can bear.

(3) The charging system shall respect the productivity increases achieved by applicants.

C3 (1) Subject to sub paragraph (2), for specific investment projects completed –

(a) since 1988; or

(b) following the coming into force of the Regulations,

the infrastructure manager may set or continue to set higher charges on the basis of the long-term costs of the project.

(2) For sub-paragraph (1) to apply –

(a) the project must increase the efficiency or cost effectiveness; and

(b) the project could not otherwise have been undertaken without the prospect of such higher charges.

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(3) A charging arrangement to which sub-paragraph (1) applies may incorporate agreements on the sharing of the risk associated with new investments.

HS1 applied the second exception in CP2 and believes that still applies for CP3. We support this view.

The HS1 reasoning for the second exception is because Clause 3 requires that to justify higher charges based on the long-term costs of the project, the project (a) must increase efficiency or cost-effectiveness; and (b) could not otherwise have been undertaken without the prospect of such higher charges.

- The first condition is satisfied because the building and operation of HS1 has achieved substantial efficiencies in terms of journey time on inter-capital routes. It also delivers very substantial improvements on journey time for Kent commuters. The project creates enhanced transport hubs at King's Cross / St Pancras and Stratford and a new hub at Ebbsfleet. It contributes to wider economic efficiency by enabling the regeneration of land at those locations. Cost-effectiveness of the project is demonstrated by its delivery in accordance with the planned timetable and budget. Furthermore, HS1 Ltd is subject to five-yearly periodic reviews under the Concession Agreement.

- The second condition is satisfied because the nature of the construction of HS1 and the private risk that was taken was possible only with the prospect that the full costs of running the railway would be recovered. This applies to both the construction phase and the current phase with HS1 Ltd as the concession-granted operator.

We therefore support the HS1 view that there is no basis to depart from use of the second exception (long-term costs of a specific investment project) to recover the total costs of HS1 less the cost directly incurred under the CIR charging principle.

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4   Model Audit Work

4.1   Structure of Model Audit Work

4.1.1   General Description of Model

The HS1 Model is an Excel Spreadsheet which was originally created by PWC for CP1 in 2009. A detailed structure of the model is set out in Appendix B1. The original model has gone through a number of versions from CP1 through CP2 to arrive at this CP3 exercise. The version control tab in the model takes the User through only the variations from the initial establishment of this model as a CP3 Model. The initial version of this CP3 model was created at 30.04.2018. The version of the CP3 Model supplied to FCP was v19b, and in response to audit questions raised by FCP, these points were incorporated into the latest version v21a.

The essence of the current CP3 Pricing model is to calculate a pricing matrix for different operators (expressed in terms of price/minute & price/service). The charges are categorised into four areas:

- OMRCA1 – the 'variable' costs reflecting wear and tear of additional trains on the common track - mainly track costs.
- OMRCA2 – the 'avoidable' long-run incremental cost - costs that would be 'avoided' if an operator ceased operating
- OMRCB – the 'common' costs (long-term costs of the operating phase of the project) - e.g. head-office costs, and costs that vary with track but not traffic.
- OMRCC – 'pass-through' costs - common costs largely beyond the control of HS1 (e.g. insurance, business rates) subject to annual wash-up

These prices are computed by taking the input data and allocating the costs into the categories set out above, and then using train/network data to provide the appropriate denominator for each of these costs.

An important and growing element for CP3 (as compared to CP1 & 2) is the need to price a regular contribution to current and long-term renewal costs. The scale of potential increased costs from CP2 to CP3 has led to HS1 looking in Model v21a at seven (7) different calculation methodologies. We have included a specific reference to the whole-life costing models for renewal assumptions in section 5 of this report.

The model input data in the model is a set of hard-coded sheets of information. We have made enquiry of HS1 and received high-level responses as to the provenance of this data. HS1 have indicated that a review & validation of input data is not required as part of this audit.

4.1.2   HS1 Model Audit Activities

Given that validation of the input data was not included in the audit scope, the Model Audit has been conducted on the following basis:

- Review of each of model tabs for internal logic and layout of data
- Confirmation & tracking of data across spreadsheets
- Identification of methodology (including excel formulae) used within and across worksheets
- Review of the logic of model methodology & assumptions
- Creation of Comment Log (shared with HS1) to identify issues and queries on a regular basis
- Review internal checking & testing functionality used in the model
- Creation of parallel testing spreadsheet –to verify calculation of prices shown in Pricing Summary using alternative and simpler formulae
- Creation of alternative modelling tools as comparison e.g. annuities calculated with Excel financial modelling formulae

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4.2   HS1 Model - Audit Findings

We have found that the CP3 HS1 Pricing Models (version 21a) works in a way consistent with the rules and assumptions that have been explained to us by management and our regulatory review. The model allocates costs to operators and services in consistent way for each charging category.

We have checked that of the issues raised in connection with versions 19b & 21a of the model have been dealt with properly. Both the issues and management's responses are noted in the Comment Log (see appendix B 1.2)

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5   Other Audit Commentary

5.1   Commentary on wider audit considerations for HS1

5.1.1   Model Audit Limitations

The HS1 CP3 model relies upon a lot of hard-coded financial & route data as inputs into spreadsheet. We were asked not to review or audit the sources of this data, and we assume that other audit processes have been put in place to provide assurance to HS1 their use in the model.
In our discussions with HS1 we noted that some input data has been used for historical reasons – in some cases going back many years.

We suggest that a new element to model is created that provides an inventory of source material, where it came from, last time reviewed, and any other audit reviews conducted prior to the model audit. If nothing else, this would enable future users or modelers for future Control Periods to have a clear picture of provenance.

5.1.2   Model Complexity & Version Control

The model is complex in the way it takes the input data and allocates to the charges. The audit approach we applied initially was to check through workings and references in spreadsheets, and to bring issues to the attention of the team. But is was difficult to get an overall assurance for the model, so as an additional tool – we built a simpler parallel model – which gave assurances over the final results.

When checking through the implementation of changes to the model (19b to 21a) it was useful to have the version control log as a summary control, but it was invaluable to have the parallel model to check the calculations and to verify that changes flowed through the calculations correctly.

The model is now many years old and has been amended over a number of years by building changes on changes. As charges and future costs grow, then there be more scrutiny on the model workings and assumptions. We would recommend that HS1 consider redesigning and building a new pricing model that can pick up on a number of issues (including parallel tracking) for the next Control Period.
If HS1 wish to defer the decision to develop the model, we would recommend the use of parallel tracking of model assumptions be incorporated to provide HS1 with on-going model assurance.

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Appendix A – Evidence and Information Provided

A1 - Initial Information provided to FCP on insert date

Title	Author	Published
HS1 CP3 Pricing Model v.19b	Tom Hill	5 April 2019
Comments from opening meeting	HS1	9 April 2019

A2 - Further Information provided to FCP on insert date

Title of Document	Author	Published
Draft Charges paper April 19	James MacKay	16 April 2019
HS1 CP3 Pricing Model v21a	Tom Hill	26 April 2019
Responses on FCP HS1 Comment Log	Various	18 April – 8 May 2019

A3 - Information researched by FCP

Title of Document	Author	Published
HS1 Concession Agreement	DfT	18 December 2017
2013 HS1 5YAMS Consultation	HS1	18 October 2013
2014 ORR CP2 Approval Document	ORR	2014
2019 ORR Approach to CP3	ORR	January 2018
Railways Regulations 2016	DfT	29 July 2016
Commission Implementing Regulation 2015/909 (CIR)	EU	12 June 2015
2015 HS1 Bond Prospectus	HS1	8 April 2015

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Appendix B

B1– Audit Ancillary Material
B1.1 Audit Notes on HS1 CP3 Pricing Model ("HS1 Model")

The HS1 Model is a Microsoft Excel File comprised several worksheet tabs, the key workings as out in the table below. We understand that the original model was created by PriceWaterhouseCoopers ("PWC") to support the Control Period Pricing calculations.

The Properties of the Model that HS1 have supplied to FCP for audit purposes are:

- Originally Created: 13.02.2009
- Size 1.23MB
- Title: CP2 Pricing Model v26
- Renamed: HS1 CP3 Pricing Model v21a

The initial HS1 Model supplied to FCP was v19b. In response to interim audit comments supplied to HS1 various corrections and additions were made and the current version of the HS1 Model subject to Audit is v21a.

HS1 Model Layout – Core Headings
- Opening Description & version controls
- Preliminary inputs
- Inputs
- Supporting Analysis
- Cost processing
- Price presentation

Table of Contents of Each Tab in the HS1 Model

Model Tab	Comments on sheet
Preliminary Inputs	
Opening Balance	Analysis of Renewal Escrow accounts (actual & forecast) for CP2, results in a Forecast Balance of £77.816m by April 2020
Inputs	
Parameters	The tab sets out the core assumptions within the model – and where there is optionality which version is used.
Interest	- Discount rate for cost recovery (2.29%) - WACC (5.1%) - Positive Balances (80% @ 1.22% & 20% @0.70%) - Inflation (2.75%)
Renewals	Seven different methods to calculate renewal costs 1. Annuity of Present Value ("PV") of costs 2. Solve annuity to ensure Escrow Balance = 0 @ year 40 3. Stepped base (midway b/w CP2 & CP3(op2) _ because the potential step-up from CP2 is large – set CP3 to be a midpoint – so Annuity in method 2 becomes the new annuity in CP4 4. As 3 - but if costs in CP3 are underestimated and CP4 needs to be higher. 5. Rolling Annuity based on next 10 years of renewal costs only – recalculated at start of each CP 6. Same as 2 but solving for Escrow = 0 @ year 20

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	7. Force a specific annuity to be used
Freight	£20 per train Km *[Audit Point – what is the provenance of this figure – when was it based]*
Cost to mothball track	Based on the PWC estimate in 2009 of £2,000 per mile. This has been updated only by (i) computing £/km, and (ii) re-based on CPI since 2009 - *[Audit Point – what is the provenance of this figure – when was it based]*
Train Operations	Three types – International, Domestic & Freight. Model allows for more operators to use HS1 in each core sector – but actually International = Eurostar & Domestic = LSER. The model then identifies service patterns for each operation: • Track Type identified for use as international, domestic, freight & common • International – 2 types of train formation – minutes used on track & route Km Train numbers are forced to equal actual annual known numbers of International (17,700) & Domestic (55,400)
NRHS Costs	These are the costs charged to HS1 by Network Rail. They are broken down into cost categories. 1. The first set of columns are for CP3 (2020-2025) [1]– the commentary states that they are expressed in 2018/19 prices – updated by RPI Feb 18. Data is hard-coded and comes from other sheets not seen. 2. The next columns express (as %) the allocation of each cost-category across the four main charges: • % Track & Traffic dependent • % Track dependent, traffic independent • % Operator dependent (*never used*) • % Common Costs 3. There is then a copy of management information pack – showing the same data, and finally 4. There are a set of columns for CP3 showing the same figures as CP2 – 2015-2020 at Feb 2018 prices 5. The tables of data for each year add up to Total Operating Costs to which two overlays are added: • Management Costs – expressed at 8%, and • Risk Costs – expressed at 5% *[In the audit we sample checked on arithmetic and agreed with the 8%, but risk costs have been charges at 4.33% - we were told that for CP2 these were 5% but have been reduced for CP3 to 4.33% - references amended in v21a.* 6. The final columns are the same data for 2020-2025 as above – but without column titles

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[1] In version 19b these were expressed as CP2 data 2015/16 – 2019/20 – but when queried these should have been 2020/21-2024/5 & have been updated in version 21a. As noted above we have not seen evidence of the extraction of data – but the copied MI sheet shows the same data (in millions as opposed to thousands).

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HS1 Own Costs	1. This table takes as its base the output from NRHS Costs on the previous tab but applies a constant uplift to the 2020/21 Costs of 1.1%. *In response to an audit question we were informed that under the Infrastructure Contract that NR has with HS1 then they are able to increase costs in CP3 by 1.1% - we have not validated that assertion*
	2. To NRHS costs are added HS1 Own costs (subcontractor & internal), pass through & freight costs for each year of CP3. Each cell in these columns reference the equivalent costs in the last columns.
	3. These are the same charge % allocations allotted to each cost category as in NRHS costs
	4. The final four columns are hard-coded costs even the NRHS which are the costs on the previous tab increased by 1.1%, brought forward) and therefore have not been validated.
	5. The first and last set of costs are identical with the exception in the first set of the treatment of Ripple Lane Freight Costs – these have been extracted from OMRC Costs and have been used in calculating Freight costs *(verified in audit testing)*
	6. The output is an OMRC cost for each year of CP3
Network	This sheet analyses the whole track covered by HS1 – it identifies specific elements of Track between designated "significant points" – which in turn are referenced by their distance (in Km) from London St Pancras. Each section is identified as either 1 or 2 track, and also by importance & use by which type of operator (international, domestic, both & freight) - *the audit has not sought to validate these core data*
Train Types	For each operator the fleet characteristics are set out in terms of type, formation, speed, weight & specific charging factors. All of the input and reference data for the tables were hard-coded – *the audit has not sought to validate these core data*
Renewals Programme input	The renewals programme sets out for each year from CP3 to CP10 (i.e. 2020/21 – 2059/60) – the expected renewal costs for each type of renewal cost category. There are eight in total, namely for CP3 are: • Track - £22.122m • Civils – track related - £0.713m • Civils – bridgework - £2.878m • Civils – other - £5.827m • E&P – OLE - £0.348m • E&P – Other M&E assets - £17.109m • E&P – Rail Plant - £8.918m • S C & C - £30.164m • CP3 TOTAL - £88.078m The sheet then allows for an alternative stewardship programme to show different figures – but the notes in the model refer to a Bechtel programme that is assumed to already include Stretch & Efficiency Gains. The final table identifies the % allocation for renewals costs across the four charging categories used to calculate charges, namely:

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	• % Track & Traffic dependent
	• % Track dependent, traffic independent
	• % Operator dependent (never used)
	• % Common Costs
	{In our audit questions we raised the seemingly large disparity between CP3 renewal costs and CP4+. We were informed that CP3 data was produced by internal HS1 staff, whereas CP4-CP10 was from the Bechtel study for NRHS – which is why there is an assumption that future efficiencies have been factored in]
Supporting Analysis	
Mothballing	Performs the calculations on mothballing costs in parameters (£2,000/mile) to 2018/19 prices and expressed in Km – so now £2,284/km.
Network Analysis	From base data set out in Network Tab – allocates track used by each operator type, namely: • International only (7%) • Domestic only (10%) • Freight only (2%) • International & freight (13%) • International & domestic (69%)
Train Services	For each operator type (from Train Types tab) relevant characteristics for each train service, namely • Formation • Train Weight • Loading Factor (EMGTKPA) • Minutes on track type • Route Km
Operations	Aspects of train operations for each service type (from input sheets): • Number of Operators • Number of timetabled trains per annum • Weight loading (EMGTKPA) • Total train minutes across each respective track type (intl, domestic, freight) • Total train minutes by operator across common tracks • Freight Train Km
Renewals Programme	This takes the renewals data for periods CP3-CP10 from tab Renewals Programme input, and factors in allowance for uncertainty re future renewal costs in certain areas. • Base costs – although show in the model uncertainty levels of low end (-30%) and high end (+50%) – only the best estimate of 100% of Renewal Programme Inputs is used • However, cost increase assumptions are factored in for CP4 onwards • Management fee mark-up – assumed to be 10% Direct costs • Non-direct costs – (+ 30% on direct costs + management fee), • Project Partner costs – flat cost of £6.820mn Resulting costs are then used to calculate Renewals Annuity costs (see Renewals)

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Renewals	This is the core calculation sheet to derive annuity costs of the renewals programme. As noted above there are 7 different possible methods used in the model. For the purposes of both model versions 19b & 21a – method 2 is the chosen methodology. 1. Annuity of Present Value ("PV") of costs 2. Solve annuity to ensure Escrow Balance = 0 @ year 40 3. Stepped base (midway b/w CP2 & CP3(op2) _ because the potential step-up from CP2 is large – set CP3 to be a midpoint – so Annuity in method 2 becomes the new annuity in CP4 4. As 3 - but if costs in CP3 are underestimated and CP4 needs to be higher. 5. Rolling Annuity based on next 10 years of renewal costs only – recalculated at start of each CP 6. Same as 2 but solving for Escrow = 0 @ year 20 7. Force a specific annuity to be used
Working Calculations	This sets out the resulting annuities for the each of the 7 different methods above and identifies from either the workings for each model (or another assumption) the financing costs included, and by deduction the engineering element of the annuity is calculated. For the chosen methodology, the engineering annuity is spread over the four cost charging allocation categories, and the financing annuity allocated in full to common costs. The annuity is grossed up for the whole period of CP3 (i.e. effectively multiplied by 5 – but the model allows for part years to occur if possible) The sheet then goes on to calculate the relative proportions of track used between: • International only (incl freight on intl tracks), Domestic only, Freight only & • Common Track (equivalent & actual)
Cost Processing Section	
Target OM Costs	This schedule takes the NRHS Costs uplifted by 1.1% for each year (per the opening lines in HS1 Own Costs) and then allocates the uplift for each cost category. The allocation is on a line-by-line pro-rata basis rather than simply using the factor of 1.1%. *Audit Note: the resulting costs are the same – but the process could be made more transparent by showing these allocations (@1.1%) on the previous input schedules.* Interestingly, although the charging % allocations are shown on this sheet the actual allocation calculations don't take place until the next worksheet [Cost Allocations} – again an unnecessary complexity
Cost Allocations	This takes each of the OMRC Costs calculated for each year of CP3, namely: • NRHS Costs • HS1 Direct Costs and allocates across the four charging elements [Economic Cost Category]: • % Track & Traffic dependent

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	• % Track dependent, traffic independent • % Operator dependent (never used) • % Common Costs Pass through Costs & Freight Costs are shown but not used here
C_OMC Target	This sheet works out the annuity costs to be used to calculate OMRC Costs for HS1 Charging [Data Source – Cost Allocations]. It is set out in 3 steps: 1. Calculate total costs for each Economic Category (annuities grossed up for total CP3) 2. Apportion Costs between Train Operators – track & traffic dependent 3. Setting a price – total costs/operator, price/minute per operator, price per service
C_Renewals	Calculates allocated cost of renewals [Data Source – Working Calcs]. It is set out in 3 steps: 1. Calculate total costs for each Economic Category (annuities grossed up for total CP3) 2. Apportion Costs between Train Operators – track & traffic dependent 3. Setting a price – total costs/operator, price/minute per operator, price per service
C_atCost	This sheet allocates each of the annual Pass Through costs between operators on the basis of Total Minutes on HS1 [Source Data – Operations Sheet]. Shown as a cost/operator and price/minute/operator
C-Freight Costs	Freight Costs have been excluded from calculations on several prior sheets used to calculate core costs between international & domestic operators. On this sheet all these disparate costs are brought together and allocated across a number of different categories: • Freight Variable OM Costs • Freight Variable Renewal Costs • Freight Avoidable Costs • Track dependent OM • Track dependent renewals • Other Freight Costs Freight Prices are then summarised in terms of price per Km
Price Presentations	
Pricing Summary	This is the Final Results schedule with OM, Renewals, Pass Through & Total costs shown across services for each operator (in 2018/19 prices) on a price per minute, price per service & proportionate recovery basis. Data Source various calculation sheets e.g. C_OMCTarget
TAA Outputs	This is a summary of the key outputs from the pricing summary table
Check Cost Recovery	Calculation Check sheet – to ensure that overall costs calculated are fully recognised in pricing summary (subject to the assumptions around train usage). In 19b there are errors resulting from the Freight

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	Allocation workings. These were noted in Audit Questions & in 21a some errors have moved to other categories. These are noted as having no impact on final results. [*Note: Audit Tests use a parallel model to validate results so error in this sheet do not reflect model calculation errors but more likely errors in the checking schedule formulae*]
O_PriceFix	Price Output for OMC at Target Cost assuming a Fixed, Indexed price for 5 years – Data Source C_OMCTarget – same data as in pricing summary
O_PriceRenewals	Price Output for Renewals – Data Source C_Renewals – same data as in pricing summary
O_PriceatCost	Price Output for Rates, Insurance & non-Traction Electricity – Data Source C_atCost – same data as in pricing summary

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B1.2 Comment Log Details

HS1 Model Commentary Log
Date: 09/05/2019 George Lynn

No	Tab	Date of Comment	cells_range	Comments	Error	Query	Other	HS1 Comments	Date	Issue Resolved?
								Tom Hill 10/4/19		
1	NHRS Costs	10/04/2019	K59.Q59 - Risk Premium	Column C - referring to 2015/16 - 2019/20 has risk premium described as 5%, but the range has been calculated at 4.33% of OPCost - is that correct?		X		1. The 2015/16 - 2019/20 headings were left over from the CP2 model and have been corrected in a subsequent version 2. The costs provided by NHRS are and have always been for 2020/21 - 2024/5 in 2018/19 prices 3. The change from 5% to 4.33% was made by NRHS in their Jan 2019 update of their 5YAMS but not noticed here - the label has since been updated	18/4/19	Yes
2	HS1 own Costs	10/04/2019	Y8.AC8 - this is is used to populate K8.O8	Both ranges are described as NRHS Costs, but are different to the relevant total rows in NHRS Costs. The range Y8.AC8 is hardcoded values, but each year is equal to respective NHRS Costs column multiplied by a factor of 1.1 (not sure what this represents or is trying to achieve?). Commentary at the top of the table implies that these new costs are now 2018/19 costs. But why multiply 2015/16 - 2019/20 each by 1.1 to get to 2018/19 costs?		X		TH: 1. The 2015/16 - 2019/20 headings were left over from the CP2 model and have been corrected in a subsequent version 2. The costs provided by HS1 are and have always been for 2020/21 - 2024/5 in 2018/19 prices 3. The factor of 1.1 is applied by HS1 to add their Management Fee to NRHS's costs before feeding the HS1 costs across to the Pricing model. This has been made more explicit in a subsequent version JD: a. Your second query (and the subsequent HS1 response) on worksheet HS1_ModelCommentlog related to the multiplier used on NRHS costs. The multiplier is not 1.1 but is an additional 1.1%, i.e. the multiplication factor is 1.011. This is added because this percentage is built into the contractual uplift HS1 has to pay NRHS.	18/4/19	Yes
3	HS1 own Costs	10/04/2019	Y12.AC34	These represent HS1 own costs - are shown in these columns to be equal to 2015/16-2019/20 range of costs. Has any adjustment to 2018/19 costs taken place?		X		1. The 2015/16 - 2019/20 headings were left over from the CP2 model and have been corrected in a subsequent version 2. The costs provided by HS1 are and have always been for 2020/21 - 2024/5 in 2018/19 prices	18/4/19	Yes
4	HS1 own Costs	10/04/2019	K49.O49	Ripple lane costs are treated differently to other freight costs - check follow through & is this correct?			X	TH: Yes. Special functionality is required because most of the Ripple Lane costs are recovered from NRIL not via this Pricing model JD: a. Your fourth query related to Ripple Lane. The response was that most of the Ripple Lane costs are recovered from NRIL. In actual fact they are recovered from three freight companies (DB, GBRF and Colas) but the overarching point is valid: a. these are operators who use only Ripple Lane (and no other part of HS1) and they are by far the biggest users of Ripple Lane, b. consequently the cost of Ripple Lane (after excluding mothballing costs that stay in route and are hence not considered freight) is split with the majority of costs being allocated to these three operators and the (relatively small) balance of Ripple Lane cost allocated to freight users of the HS1 route.	18/4/19	Yes
5	Renewals Programme	10/04/2019	P49.Ax59	Markup for management & uncertainty - this has three adjustments for control periods CP4-CP10 - to allow for uncertainty in renewal costs, management fees & non-direct costs. For CP3 there are no uncertainty adjustments. But for CP4-10 - two of the factors (management fees & non-direct costs) are used. This means that with respect to the annuity methods (described below) that some of these additional factors are included & some not - see comment below.				That is correct - function of the peculiar fashion in which the NRHS workbank was produced separately for CP3 and for CP4-10, with the latter going to Bechtel for costing and the former being costed by NRHS (and its consultant)	18/4/19	Yes

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HS1 Model Commentary Log

Date: 09/05/2019 George Lynn

No	Tab	Date of Comment	cells_range	Comments	Error	Query	Other	HS1 Comments	Date	Issue Resolved?
								Tom Hill 10/4/19		
6	Renewals	10/04/2019	C7:AX17	Picking up the totals from renewals programme tab, risk-adjusted renewal costs are then projected forward from CP3 to CP10 on an annual basis. The annuity values computed in range H8:H15 are calculated with reference to the discount table in row 38 (based off 2.29%) - calculation uses sumproduct(xx) formulae rather than Excel financial formulae (namely NPV & PMT functions). If we compare the two methods, the method actually used produces the same result as a NPV calculation at valuedate April 2020. This will be correct because although prices are brought back to 2018/19 - there will be two years without the relevant annuity - so PV will just rise by (1+2.29%)/2. So although in the spreadsheet discount rates are worked out to 2018/19 - actually they are working to 2020/21 for the purposes of annuity calculations. Is this what HS1 intends? What is the correct Regulatory interpretation?		X	This is the method developed by PwC for the original CP1 model and remains correct. As it happens, although this PV method has been retained in the CP2 and CP3 models, the alternative method used in CP2 was the 'closing balance of zero' and in CP3 we are leaning towards the 'closing balance of zero' method but testing other alternatives	18/4/19	Yes
7	Renewals	10/04/2019	c21:AX35	This section appears not be used - but computes annuities fixed for each Control Period based upon computing annuities for 10-year future renewals. What is the purpose of this application?		X	These are used in Method 5	18/4/19	Yes
8	Renewals	10/04/2019	C53:AX156	In this section we have 6 variations with which to compute the renewals annuity costs - from Parameters tab the methodology is chosen - although for most further GoalSeek analysis must be performed to calculate the annuities. Method 2 is chosen as being the annuity which will leave the Escrow account at zero after 40 years (end of CP10). Both annuity & expenditure rise by inflation (constant at 2.75%). This works because the rates used to compute the annuity are a combination of funding costs & investment income rather than the 2.29% used in other calculations. Escrow account only turning negative in CP9 (2050 in the model). With actual funding assumptions for income (0.7%-1.22%) and costs (5.10%) - query the value of the annuity computations used elsewhere.		X	Yes we have 6 (now 7) alternative methods to choose from. The model is generally set to method 2 but the final decision has yet to be made. The 2.29% is the Real WACC derived from the Nominal WACC of 5.1% but is largely irrelevant because it is only used in the 'out of favour' Method 1 The various annuity calculations are required for comparative purposes	18/4/19	Yes
9	C_Renewals	10/04/2019	H37 & H104	H104 reflects an error in allocating variable costs - and this seems to arise in H37. In that cell the denominator has been altered to reflect the removal of freight costs to allocate variable costs, but this is incorrect as the non-freight costs still have to be allocated by the original totals. The effect of the error is small = £54k	X		Cell H37 Fixed in v21a - hangover from trial of removing Freight from Renewals - reversal of this not fully implemented	18/4/19	Yes
10	Pricing Summary	10/04/2019	I50:I52	Percentages should add up to 100% but only 86.4% - linked to freight adjustment in C_Renewals	X		OK once C_Renewals H37 fixed	18/4/19	Yes
11	Check Cost recovery	10/04/2019	H61 & H70	Check Totals Error for renewals - references by Tom Hill to adjusting for freight costs in version 10	X		Cells K55:o55, K63:O63, K72:O72 Fixed in v21a - hangover from trial of removing Freight from Renewals - reversal of this not fully implemented TH 7/5/19: Check cost recovery is not important - has no impact on the results. These were areas in which Check cost recovery was not updated for the addition of the second freight train or the exclusion of financing from the annuity (but had no impact on the model's results). They have already been fixed in v21b.	08/05/2019	Noted

HS1 Model Commentary Log

Date: 09/05/2019 George Lynn

No	Tab	Date of Comment	cells_range	Comments	Error	Query	Other	HS1 Comments	Date	Issue Resolved?
								Tom Hill 10/4/19		
12	Renewal Programme & Renewals	10/04/2019	General comment	As noted above the renewals programme worksheet has three variation factors - risk of scale of work, management fee costs & non-direct costs which for this model version apply costs from CP4-CP10. Then on the renewals sheet there are 6 variations of computing the renewals annuity values - most of which are dependent upon the initial variation assumptions. There is no evidence that the outputs of using these various factors have been reviewed, or why these assumptions have been used in preference to others. Evaluation & managing the cost of renewing the infrastructure is such a key medium/long term element for HS1 - why are these elements not considered & evaluated further to assess the most effective outcome. With this scale of uncertainty it would be usual to develop some form of stochastic modelling to evaluate these assumptions more effectively. Given HS1 has c £850m bonds to 2038 - is this form of analysis not required by analysts?		X		Seems to be an echo in here! I have spent the last 11 months trying to explain to HS1 that they need to get a proper Risk expert in and analyse their Renewals costs properly. The whole treatment of Risk, uncertainty and Contingency is inadequate but HS1 has been insisting that it must be ok because it was done by Bechtel!	29/04/2019	Noted
13	Regulatory Matters	17/04/2019	Assumptions in compliance with Regulatory Agreements	We have a copy of the December 2017 agreement between HS1 & ORR which amends and restates the Concession Agreements made 2009, 2014 & 2015. Are the assumptions used to construct the spreadsheet set out in this document?			X	ORR isn't party to the conpression agreement? Assume mean Dft? Schedule 10 sets out periodic review requirements. Schedule 10 has not been amended (other than dates). The CA does not provide spficity in terms of model assumptions other than basic issues like recovering our costs, 5 yearly process and the process for long term renewals	29/04/2019	Noted
14	Regulatory Matters	17/04/2019	Assumptions in compliance with Regulatory Agreements	Have the assumptions in the model been validated with the wording of this amended & restated agreement? If not, when was the last time the assumptions were validated with a Concession Agreement			X	The model was validated in CP1 at the time of the original concession agreement. We do not believe subsequent amendments to the CA have altered	29/04/2019	Noted
15	Model Audits	17/04/2019	Model Audit Process	Has HS1 engaged an audit of previous versions of the Pricing Model at any stage, in part or in whole, since its production by PWC? If so, do you have copies of any previous audit reports?			X	We are not aware of previous audits - In meeting of 30/4/19 HS1 explained the roles of Aecom & LeighFisher - but were not aware of specific audit responses	30/04/2019	Noted
16	Updates to the Model	17/04/2019	Updating for Modalities Regs	We have a copy of the draft working paper on how the model should be amended (or not) based upon HS1 draft interpretations of the Reg Models. For the purpose of the audit - what protocol would HS1 like the FCP team to adopt? Options(1) review the draft & compare to Regs, FCP to comment & Final Paper agreed, or (2) HS1 to finalise draft commentary independently and seek FCP assurance on interpretations?			X	Option 1	30/04/2019	Noted
17	Updates to the Model	17/04/2019	Updating for Modalities Regs	We assume that whatever option is agreed HS1 will undertake amendemnets to the Pricing Model to reflect the chosen interpretations - can HS1 Confirm?			X	Yes	30/04/2019	Noted
18	Parameters	18/4/19	H68 -Freight Rate	Model uses a base of £20.00/km - what is the provenance of this hard-coded figure		X		TH - In meeting of 30/4/19 HS1 reported on discussions with TH	30/04/2019	Noted
		18/4/19		Costs are based upon earlier PWC analysis at £2,000 per KM. How is this calculated and what are the assumptions? Is it sufficient to merely to rebase on the use of CPI?		X		We do not have access to the orginal assumptions behind the PWC figure. In CP2 the uplifting approach was approved by ORR. We wouldn't propose changing approach but we recognise it is an area more work may need to be done if requested by the regulator.	30/04/2019	Noted
19	Parameters	18/4/19	H75 - Mothballing							
20	NHRS Costs	18/4/19	O14-Directors costs	The hard-coded number is £0.071 - is this correct? Should it not be £0.571m?	X			We have challenged NRHS - awaiting their response.	08/05/2019	Noted

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HS1 Model Commentary Log

Date: 09/05/2019 George Lynn

Tom Hill 10/4/19

No	Tab	Date of Comment	cells_range	Comments	Error	Query	Other	HS1 Comments	Date	Issue Resolved?
21	NHRS Costs	18/4/19	Q22:T30 - Allocation of costs	Should not more of the plant related costs, e.g. freight have an impact on traffice related costs?		X		No - in our view costs are generanly avoidable than variable. Where we can clearly identify a variable element we have done so	30/04/2019	Noted
22	NHRS Costs	18/4/19	K18:O18 - Recoveries	What is the basis of this recharge - does it properly reflect the Regulations?		X		They are costs that have been incurred. HS1 can recover its full costs under the terms of the CA	30/04/2019	Noted
23	Renewals Programme	18/4/19	P49:Ax59	Comments from TH above suggest that the source of renewals data for CP3 & CP4-10 are different. How do you know that the assumptions used by both parties are consistent and fairly applied?		X		They are different things. CP3 renewals are a plan - fully costed and scheduled by NRHS. CP4 onwards is an indicative 40 year plan to meet the requirements of the concession and to calculate an annuity. We therefore do not believe they need to have the same assumptions. Both the CP3 plan and CP4 - CP10 indicative plan are based on the SAS, asset management objectives and workbank identified by NRHS	30/04/2019	Noted
24	CP3 Pricing	18/4/19	Pricing principles	We note that in addition to OMRC Costs, CP3 charges will include both IRC & AIRC Charges - is this subject to a sparate modelling arrangement & audit process? Are the costs used in this model completely independent of these infrastructure recovery principles?		X		Completely unrelated. The focus is only on the OMRC elements.	30/04/2019	Noted
25	Check Cost recovery	02/05/2019	H16, H33, H72 & H77	In reworking the freight allocations above then the allocation of variable, avoidable & common costs is now causing an error. I have checked the model workings in parallel & think that the checks are not identifying freight in the workings?	X			TH 7/5/19: Check cost recovery is not important - has no impact on the results. These were areas in which Check cost recovery was not updated for the addition of the second freight train or the exclusion of financing from the annuity (but had no impact on the model's results). They have already been fixed in v21b.	08/05/2019	Noted
26	Pricing Summary	02/05/2019	rows 43-48	Freight costs per journey don't seem to work as expected - only pence out - but suspect the levels of rounding of these small proportional costs are having a more significant impact when compared with the larger service levels of passenger fleets		X		TH 7/5/19: there is no issue here - the costs per train are a simple multiplication of the cost per train km by the km per train. There is no rounding involved and all answers are correct to the nth decimal point.	08/05/2019	Noted