OFFICE OF RAIL AND ROAD

PR19 supplementary document: asset management findings

ORR Periodic Review of HS1 Ltd 2019 (PR19) draft determination

30 September 2019

Contents

Introduction

This document outlines our review of High Speed 1 Limited (HS1 Ltd)'s approach to asset management, as set out in its 5 Year Asset Management Strategy (5YAMS) and considers whether it is consistent with its General Duty, as set out in the Concession Agreement between the Secretary of State and HS1 Ltd.

The report is broken down into 23 technical areas. For each technical area we have outlined how we undertook our review, summarised the relevant technical information and stated which areas we deem are or are not in line with best practice.

In those areas which are not in line with best practice, we have identified specific improvements that need to be made in order to ensure the final 5YAMS is consistent with HS1 Ltd's General Duty. We have attempted to quantify what impact these improvements might have on the total costs presented by HS1 Ltd.

In total, we identified deficiencies in 7 areas that need to be remedied by HS1 Ltd ahead of our Final Determination.

There were also some areas where we felt the 5YAMS was likely to be in line with best practice but either the evidence was not conclusive, or we felt that alternative solutions might provide some additional benefit. In these areas we have provided specific recommendations for HS1 Ltd to consider when responding to our draft determination.

In total, we provided 28 recommendations.

Scope of this review

The review described in this technical report addresses the asset management elements of the 5YAMS.

Specifically, this review aims to determine whether the plans set out HS1 Ltd's 5YAMS are consistent with the General Duty[1].

The concession is for a 30 year period to 31 December 2040, however HS1 Ltd is required to consider whole life decisions based on a 40 year horizon.

[1] As set out in the HS1 Concession Agreement.

General methodology

We undertook a desk-based review of HS1 Ltd's 5YAMS document.

In addition to HS1 Ltd's 5YAMS, we reviewed the following supporting documents:

- HS1 Ltd Asset Management Policy
- HS1 Ltd CP3 list of proposed renewals submission
- Network Rail (High Speed) (NR(HS)) Ltd Five Year Asset Management Statement for Control Period 3, including:

– Specific Asset Strategies:

(1) Mechanical & Electrical

(2) Traction Power Supply

(3) Track

(4) Overhead contract Systems

(5) Signalling & Communication Systems

(6) Civils

– Strategic Asset Management Plan

– Operations Strategy

– Safety Strategy

– Rail Plant Strategy

– Possessions Strategy

– CP3 Project Delivery Strategy

- CP3 Plan initial report on CP3 Review – undertaken by Vertex systems engineering
- HS1 Ltd's Asset Decision Support Tool (ADST) Sensitivity Analysis Report – undertaken by AMCL
- HS1 Ltd's AMEM Route Assessment Report undertaken by Asset Management Consulting Limited (AMCL).
- HS1 Ltd Phase 1 Delivery Strategy - undertaken by Bechtel
- HS1 Ltd Phase 2 Master Plan - undertaken by Bechtel
- HS1 Ltd Phase 2 Masterplan Cost Estimate Summary – produced by Bechtel
- HS1 Ltd Whole Life Cost Document – February 2019
- HS1 Ltd Whole Life Cost Decision Support Tool and CP3 pricing methodology

- HS1 Ltd Future Train Control System – report produced by SNC-Lavalin
- HSR OMR Effectiveness Study Final Report – produced by Rebel
- Associated data books provided by HS1 Ltd

This review was carried out by our Engineering and Asset Management team of specialist engineers supported by Railway Safety Directorate colleagues, drawing on their experiences and parallels from the recent periodic review (PR18) of Network Rail Infrastructure Limited, our ongoing monitoring of HS1 Ltd and our previous periodic review of HS1 Ltd (PR14). In addition we drew upon specialist external consultant support. This exercise built on the reviews commissioned by HS1 Ltd. Our CP3 review took place against some slippage of renewal projects in CP2 into CP3 along with a slightly increased rate of asset failures.

While HS1 Ltd's 5YAMS submission was being finalised, we had worked to gain progressive assurance of its plans over a period of seven months between July 2018 and January 2019, focused around a number of key themes (see Table A).

Table A Progressive assurance timeline

Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19
Engineering Assurance Meetings with NR(HS)	**Asset Management Strategic Context**	**Engineering & Strategic Decision Making**	**Intervention Volumes**	**Control Period 3 Costing**	**Long Term Cost and Deliverability**	**How HS1 Ltd made changes to meet customer expectations**
Vertex Engineering Assurance Meetings with NR(HS) Professional Heads	Specific Asset Strategies (SAS)'s	Whole Life Cost models	Vertext Engineering Assurance Findings	Asset Decision Support Tool	Deliverability strategy volumes and long term costs	HS1 Ltd satisfaction of General Duty as per Concession Agreement
	Asset Management System	Vertext Engineering Assurance Report.	Review SASs & Single View Of Plan	NR(HS) CP3 Renewals Costs	Annuity costs	Asset Management Excellence Model and improvement roadmap
	Asset Management Documentation (Policy, AMOs, SAMP, Roadmap	CP3 Project Charters / Single View of the Plan Excel Sheet	Long term volumes	NR(HS) Fixed Price to deliver Operator Agreement in CP3	Final Asset Management Excellence Model Report	Key changes or areas for development agreed
	Deliverability Strategy	40 Year Renewals Volumes	CP3 Project Charters (SVOP Excel Sheet)	OMR Effectiveness Study (Rebel Benchmarking		

Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19
	Bechtel Deliverability strategy Phase 1 and Phase 2 reports	NR(HS) CP3 Renewals Costs	40 Year Renewals Volumes	Draft annuities costs		
	Asset Management Excellence Model	NR(HS) Fixed Price to deliver Operator Agreement in CP3	HS1 Ltd Accounting treatments process			
		OMR Effectiveness Study (Rebel Benchmarking)				

In addition to holding the above meetings, we undertook five site visits in conjunction with HS1 Ltd and NR(HS), the latter having an Operator Agreement with HS1 Ltd to discharge a number of their key concession obligations in regards to operation, maintenance and renewal activities:

- August 2018 visit to Singlewell Infrastructure Maintenance Depot (SIMD) to evaluate Vertex Systems Engineering[2] review of Strategic Asset Strategies on behalf of HS1 Ltd
- January 2019 site visit to north portal area of North Down tunnel to inspect the condition of assets proposed for renewal in CP3.
- January 2019 night site visit to Thames Tunnel to inspect the condition of assets proposed for renewal in CP3.
- June 2019 - CP3 Renewals work bank meeting – SIMD– To review the proposed CP3 renewal portfolio - involving interviews with each professional head.
- June 2019 – CP3 operations, maintenance review – SIMD - To review NR(HS) maintenance, operations, delivery, project management office and efficiency review.

As our review progressed, we commissioned additional detailed studies and developed in-house tools to examine specific technical areas in more detail. These detailed methodologies are described within the relevant sub-sections of this report.

[2] Vertex having been commissioned by HS1 Ltd to undertake an independent engineering review of the Strategic Asset Strategy (SAS) documents produced by NR(HS).

Structure of this report

The findings of this review are divided into four sections:

- HS1 Ltd approach to asset management (including HS1 Ltd's capability, processes, strategies)
- Operations and maintenance
- Renewals in CP3
- Renewals in CP4-CP10

These sections are divided into a total of 23 sub-sections, covering specific items such as pricing, risk or deliverability.

Each sub-section is presented in the same format, comprising:

i. **Specific questions:** Any technical questions which we needed to answer, over and above the assessment of whether the 5YAMS is consistent with HS1 Ltd's General Duty.

ii. **Detailed methodology:** Any additional techniques or resources we used, over and above general methodology described above.

iii. **Summary of key information:** We have repeated or summarised some key information from the 5YAMS (or other sources), so that readers can understand our findings without detailed prior knowledge of the source documents.

iv. **Findings:** All our findings are classified as follows:

[green] = We consider these areas of the 5YAMS to be in line with best practice and efficient.

[amber #] = We considered that these areas are likely to be in line with best practice but either we did not see clear evidence, or we identified opportunities for improvement. We have provided recommendations which we expect HS1 Ltd to consider in its response to our draft determination.

[red #] = In these areas, we considered that there were specific elements which were not in line with best practice, or were inefficient. For any red items, there are two additional headings:

v. **Improvements required (red only):** We have identified specific deficiencies in HS1 Ltd's 5YAMS, which we require HS1 Ltd to remedy in its response to our

draft determination, in order for us to be able to determine that the final 5YAMS is consistent with HS1 Ltd's General Duty.

vi. **Quantitative targets (red only):** For any improvements, we have attempted to quantify the impact this might have on cost plans. For example if we felt that an assumption was too conservative then we have indicated what a more reasonable assumption might look like, and undertaken some additional analysis to estimate the difference in total cost. These estimates are approximate and are intended to show the scale of improvement which HS1 Ltd should be targeting. These are not bottom up cost estimates – HS1 Ltd will need to develop new cost estimates in light of our proposed actions.

All recommendations and improvements are summarised in Chapter 5, along with our draft conclusions.

1. Asset management

Asset Management Capability

Specific questions

1.1. Is HS1 Ltd's asset management capability consistent (or not) with HS1 Ltd's General Duty?

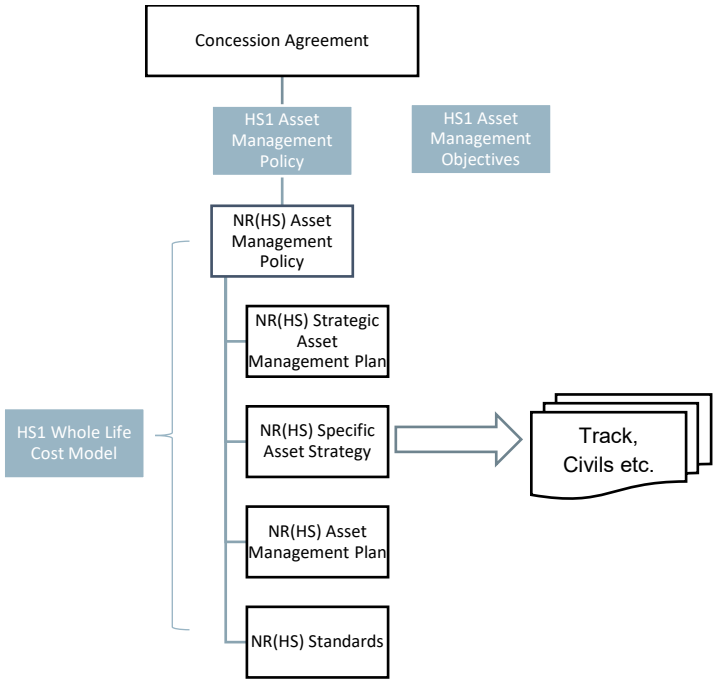
Detailed methodology

1.2. See general methodology.

Summary of key information

1.3. For CP3 HS1 Ltd has refreshed its Asset Management Policy (AMP) and created a new set of HS1 Ltd Asset Management Objectives (AMOs). Through the Operator Agreement, Network Rail (High Speed) Ltd (NR(HS)) is accountable for the development of a suite of documents (see Figure 1.1) that set out how HS1 Ltd's policy and AMO's will be met.

Figure 1.1 HS1 Ltd Route Asset Management System (source 5YAMS)



1.4. In 2018 HS1 Ltd commissioned Asset Management Consulting Limited (AMCL) to undertake an independent asset management maturity review. AMCL previously assessed HS1 Ltd and NR(HS) in 2012, when NR(HS) was known as NR(CTRL). This was a PAS 55 gap analysis assessment which also produced a 'roadmap' of minimum actions for HS1 Ltd to consider if it wished to gain PAS 55 certification.

PAS 55 was the pre-cursor to the 'Publicly Available Specification' on Asset Management, published by the British Standards Institute, and pre-dated ISO 55001 which is the current international standard on Asset Management.

1.5. AMCL found that HS1 Ltd and NR(HS) had both made steady progress in their levels of asset management maturity, although both HS1 Ltd and NR(HS) continue to face a number of systemic challenges. These challenges predominately spanned the plan-do-check-act of asset management and many of those were in the stages of being addressed by a range of existing or developing initiatives.

AMCL makes use of a scoring range of 0-100 over 39 subjects utilising the Global Forum on Maintenance and Asset Management (GFMAM) framework grouped in to six subject groups. The respective scores for 2012 and 2019 are shown in Table 1.1, along with the % change.

Table 1.1 Asset Management Scores CP2 vs CP3

Group	2012 Assessment	2019 Assessment	change (percentage points)
Strategy and Planning	40%	48%	+8
Decision Making	42%	47%	+5.
Lifecycle Delivery	44%	50%	+6.
Asset Information	29%	39%	+10
Organisation & People	42%	48%	+6
Risk & Review	39%	43%	+4

Source: AMCL review

1.6. A score between 30% and 40% would indicate that an organisation's asset management activities are developed, embedded and have become effective. A score of 45% would indicate broad compliance with ISO 55001 requirements. Over

the six areas HS1 Ltd achieved an average score of 46%, asset information being the most significant weakness at 39%.

1.7. Asset information (that is, having accurate information to support the maintenance requirements and renewal analysis process) is a focus for optimum planning of renewals. This raised concerns that renewals might not be being scheduled based on sufficiently accurate and robust data, but instead indicates that HS1 Ltd is over reliant on engineering judgement, leading to non-optimisation of asset renewal frequencies.

Findings

1.8. HS1 Ltd working in accordance with ISO 55001 is in our view a demonstration that it is operating in accordance with accepted best practice. We recognise that demonstrating that an organisation is working consistently in accordance with best practice is challenging, especially for what is still a relatively new entity, and that HS1 Ltd has made progress since 2012. This is reflected in its overall score across the six areas of 46%. [green]

1.9. HS1 Ltd particularly fell short in two areas: asset information, and risk and review. This is possibly explained by HS1 being a relatively new asset with only a limited time period of data upon which to make decisions. We **recommend** that HS1 Ltd develops an action plan with set milestones for implementation in CP3 of the recommendations contained within the wider AMCL report. [amber 1]

1.10. We **recommend** that HS1 Ltd undertakes a follow up review during CP3 to establish progress and set themselves a goal of obtaining accreditation to ISO55001. [amber 2]

1.11. While we understand that the contractual arrangements contained within the Operator Agreement place ‘back to back’ responsibility on NR(HS) to develop responses and then be responsible for delivering a number of HS1 Ltd’s concession obligations, our review often indicated that HS1 Ltd had limited ownership and understanding of what NR(HS) had produced. This resulted in a significant portion of our challenge having to be directed towards NR(HS). This situation was worsened by a number of key individuals leaving HS1 Ltd during the review process and their replacements only being in post for a short time. We **recommend** that, in future 5YAMS submissions, HS1 Ltd fully documents and then demonstrates the assurance activities it has undertaken on NR(HS)’s contribution. This will become more critical as the HS1 asset ages and the infrastructure manager moves into a mature operating mode, or if there is a change in delivery agent(s). [amber 3]

Asset Stewardship

Specific questions

1.12. Under the Concession Agreement (Schedule 10, Section 1 – Asset Stewardship), HS1 Ltd is required to produce:

- an asset management policy which describes HS1 Ltd's general operation, maintenance and renewals principles and procedures;
- an asset management plan which sets out how such general operation, maintenance and renewals principles will be achieved;
- an indicative Renewal and Replacement timetable;
- an asset maintenance plan detailing asset-specific procedures and standards for asset types in respect of operations, maintenance and renewals; and
- a description of how the condition, capability and capacity of the assets comprising the HS1 Railway Infrastructure will be maintained.

Detailed methodology

1.13. See general methodology.

Summary of key information

1.14. In September 2018 HS1 Ltd published an updated Asset Management Policy (AMP) which stated that:

HS1 will continually improve Asset Management Capability in line with other leading industry practitioners. This will follow the principles of ISO 55000 asset management best practice…..

1.15. Strategic documentation such as the Strategic Asset Management Plan (SAMP) and Specific Asset Strategies (SASs) documents that form part of the AMS are stated as being periodically reviewed based on any new information and will be subject to formal review processes to ensure that asset management plans are in line with the most up-to-date understanding of HS1 infrastructure.

1.16. The CP3 AMP stated aim is to achieve the following key objectives:

- sustainable delivery of AMO;
- minimised disruption by maintaining current performance levels whilst increasing HS1 Ltd's delivery and maintenance effectiveness;
- delivery of necessary heavy maintenance, refurbishment and renewals activities in line with the agreed renewal and refurbishment plans; and

- minimised impact of renewals delivery on Train/Freight Operating Companies and passengers.

1.17. NR(HS) is using the AMO to plan the intervention strategies to align with customer expectations. The weightings used to determine the relative importance of each objective are shown in Table 1.2.

Table 1.2 HS1 Ltd Asset Management Objectives

Weighting	AMO	Weighting	AMO
25%	Safety	15%	Cost
20%	Punctuality	15%	Passenger satisfaction scores
20%	Availability	5%	Passenger comfort

Source: 5YAMS

Findings

1.18. A key element of demonstrating good practice asset management is underpinned by the existence of a published asset management policy. [green]

1.19. However we **recommend** that the policy would benefit from: presenting a view on the current asset management status; what will be improved during CP3; and setting clear measurable targets and associated milestones. [amber 4]

1.20. We found that HS1 Ltd developed an Asset Management System (AMS) framework, which provides a line of sight between HS1 Ltd AMOs and their AMP, and then cascaded these down to NR(HS)'s asset management approach for maintenance and renewals. [green]

1.21. AMOs are clearly defined and agreed with key stakeholders. [green]

1.22. However, we note that the agreed AMOs will tend to drive behaviours which are not usually best practice:

- a strategy of having a significant reactive resource on standby to deal with any potential disruption to service; and
- a strategy of replacing assets before they would normally demonstrate a decrease in reliability.

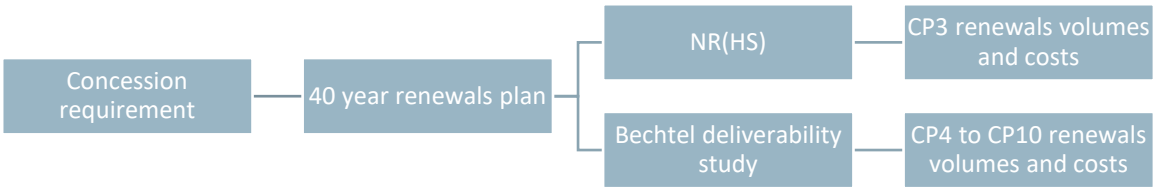
Hence we **recommend** that these weightings should be subject to review at a suitable frequency, to ensure they are still representative of current and future stakeholder needs. This aligns with improving the plan-do-review process in response to AMCL's 2019 findings. [amber 5]

Asset life planning

Specific questions

1.23. HS1 Ltd constructed its 40-year plan in two parts (see Figure 1.2). For CP3 NR(HS) had responsibility for developing the renewals plan, whilst for CP4 to CP10 HS1 Ltd commissioned and instructed Bechtel to develop a longer term plan based of NR(HS)'s recommended renewal frequency, but then applying the consultant's expertise on delivery opportunities and unit rates.

Figure 1.2 Process for renewals volumes and costs



1.24. Because HS1 Ltd's 40 year plan is split between NR(HS) and Bechtel, we assessed the following questions:

- are the total costs in the 5YAMS based on a coherent 40 year plan? That is, do NR(HS) and Bechtel's plans fit together?;
- are NR(HS)'s delivery plans reasonable for CP3?;
- are Bechtel's delivery plans reasonable for CP4-10?;
- what level of asset condition is NR(HS) looking to sustain over the 40 years – and is this appropriate?; and
- what are the key cost drivers and what is HS1 Ltd doing to manage these in the long term?

Detailed methodology

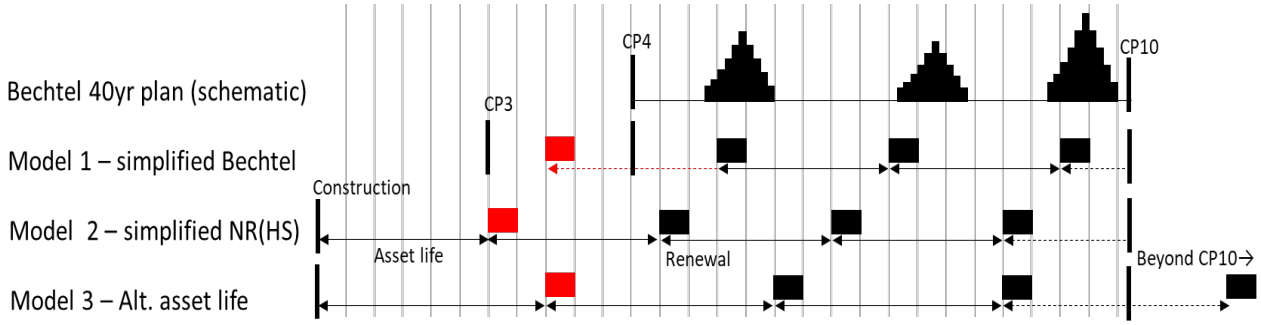
1.25. To address these questions, we have reviewed in detail NR(HS)'s 5YAMS as well as Bechtel's reports.

1.26. Furthermore, we developed a simple model to compare directly the NR(HS) and Bechtel models and to allow basic sensitivity analyses. The model is shown schematically in Figure 1.3 and outlined as follows:

- Bechtel's detailed plan showed volumes in each quarter of each year, so one cycle of renewal might be spread over several years and the gap between two cycles is somewhat ambiguous;
- Our model approximates each renewal cycle as a discrete point, with a constant (average) gap between cycles, representing the asset life (Model 1 in Figure 1.3);
- While Bechtel did not include volumes in CP3, the model can be extrapolated back to show implied renewal cycles in CP3 (red points in Figure 1.3);
- The design lives and volume plans in NR(HS)'s SASs were used to produce an equivalent model, for direct comparison against Bechtel's model (Model 2 in Figure 1.3);
- The model also allowed us to carry out a sensitivity analysis, adjusting the design lives from those indicated by NR(HS) and to measure the impact on total volume (hence total direct cost) within the 40-year period (Model 3 in Figure 1.3);

  Finally, the model allowed us to extrapolate forwards, beyond CP10, to estimate volumes (and hence costs) in future control periods and future 40 year plans.

Figure 1.3 Overlay of NR(HS) renewals mode



1.27. Pricing and deliverability of Bechtel's CP4-CP10 plans were reviewed as part of a detailed cost review which we commissioned (see Chapter 5 for further details).

Summary of key information

1.28. NR(HS)'s SASs identified several assets where NR(HS) are assuming shorter design lives than the original manufacturers' specifications. Our sensitivity analysis (using our simple model) indicated that the majority of these changes had minimal impact on the total 40-year cost. For example, air conditioning, drainage and expansion joints accounted for a 1-2% difference in direct cost within 40 years.

1.29. In planning over such a long horizon it could be feasible to expect that big ticket items repeating at year 40 could be delivered in later years and hence significantly

reduce average costs during the 40 year horizon, however our approach was to consider attainment of steady state and not to leave a large uncovered cost beyond it.

1.30. Our model highlighted a large number of expensive renewals towards the end of the 40-year period, specifically relating to track (ballast, re-railing and sleeper renewals). Together, these renewals at the end of the 40 year period make up more than 40% of the total 40-year direct renewal costs.

1.31. The large costs associated with these track renewals mean that if asset lives were much shorter than NR(HS)'s estimates (i.e. if additional renewal cycles were needed within 40 years) this would put significant pressure on the available funding. We note that in CP2 there have been instances of sleeper damage following maintenance tamping, so NR(HS)'s maintenance plans need to be cognisant of the impact that damage to assets could have on the long-term costs.

1.32. NR(HS) noted that it did not currently (as at June 2019) have the capabilities to deliver the CP3 works as planned, but it is implementing an improvement plan with quantitative measures and scheduled targets, to ensure that it will be ready to deliver all the CP3 works.

1.33. NR(HS) confirmed that it had plans for continuous improvement across CP3, but that these are not linked to Bechtel's proposed delivery methods for CP4-10. As a result, NR(HS) is not committed to the direct costs or level of risk assumed in HS1 Ltd's plans for CP4-10, as these were based on Bechtel's delivery assumptions.

1.34. We challenged NR(HS) on what efficiencies and capability improvements it could make in the longer term, to reduce the cost of these renewals at the end of the 40-year period. NR(HS) clarified that it was not in a position to invest in improvements beyond the end of CP3, because there is no certainty that its contract will be extended beyond CP3. In addition, as the bulk of CP3 renewals were of a type that have not been previously undertaken, NR(HS) did not have a benchmark against which to forecast any efficiencies in delivery.

1.35. The uncertainty and potential impacts around market testing for a delivery partner for further control periods is discussed elsewhere in this report.

Findings

1.36. We found that Bechtel's and NR(HS)'s plans were consistent in terms of volumes and asset lives. This was because Bechtel had been instructed by HS1 Ltd to plan using NR(HS)'s projected asset life without further validation (see section on Specific Asset Strategies (SAS)). Equally NR(HS) did not verify/validate Bechtel's delivery

approach (see Chapter 5). There were some minor discrepancies in the number of renewals cycles in CP3 or in CP4-10. These are listed below for information, but do not jeopardise the CP3 plans [green]:

- points heaters – Bechtel's plan implies a cycle in CP3 which is not in NR(HS)'s plan;
- Area 4 ballast and re-railing – Bechtel's plan indicates only one cycle in 40 years, NR(HS)'s indicates two; and
- fire suppression systems – Bechtel's plan indicates 10-year life and implies a cycle in CP3 while NR(HS)'s plan indicates 20-year cycles with none in CP3.

1.37. Our review of the 5YAMS (including NR(HS)'s SASs) indicated that assumptions around asset life were based more on engineering judgement rather than quantified evidence and appear to be overly conservative. This results in an increased number of renewals over a 40-year cycle. Given the sensitivity of the total long-term costs to track renewals, HS1 Ltd should be focussing on condition-based renewals supported by robust asset deterioration modelling, rather than just renewing after a certain period of time or an individual asset failure, to maximise asset life. [red 1]

Improvements required

1.38. HS1 Ltd (and its delivery agents) should perform its own sensitivity analysis around critical design lives which are based on engineering judgement. This should focus on track assets (rail, ballast and sleepers) as these make up a significant portion of the total renewals cost. [red 1]

1.39. HS1 Ltd (and its delivery agents) needs to demonstrate how it will ensure evidenced-backed condition-based renewals and include this in its long term planning. Again, this should focus on track assets which dominate the total renewal cost. [red 1]

Quantitative targets

1.40. We used our simple model to quantify the potential impact of condition based renewals and less conservative design lives.

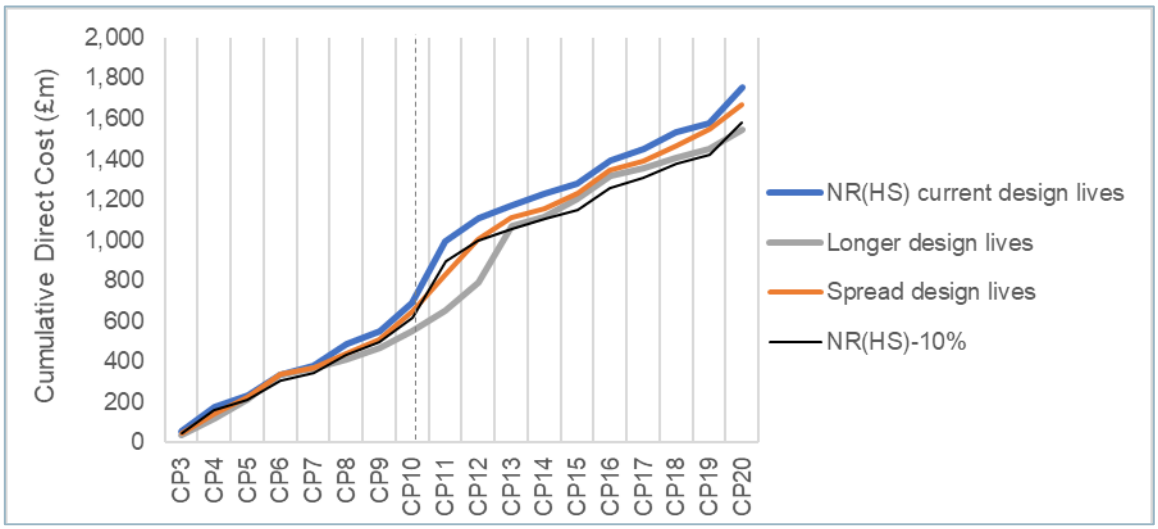
1.41. We considered a range of design lives for track assets and extrapolated our model up to 100 years beyond CP10. Cumulative costs for different scenarios are presented in Figure 1.4. For example the lower (grey) line represents design lives equal to or slightly longer than the 'original design lives' from NR(HS)'s SASs;

1.42. Using condition based renewals, some sections of the assets might need to be renewed earlier than the assumed design life, while some might be serviceable for much longer. We have represented such a scenario by the orange ('spread') line in

Figure 1.4. For example NR(HS) assumed a sleeper design life of 50 years, but the 'spread' line assumes a range from 45 to 60 years;

1.43. Up to CP10 (i.e. the current 40 year plan), the 'spread' model is roughly equivalent to **a 10% reduction in total volume** (and hence direct cost) compared to the 5YAMS.

Figure 1.4 Estimated renewals costs for future control periods, for different design life scenarios[3]



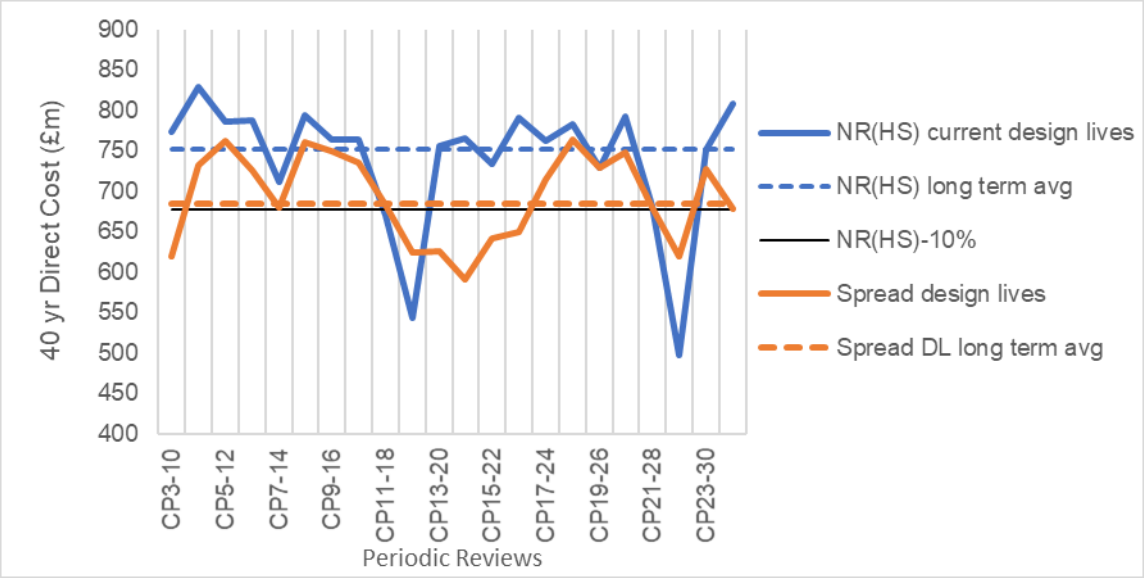
1.44. The 10% reduction noted above relates to condition based renewals to achieve longer asset lives. This does not account for technological advancements (i.e. more durable assets) or efficiencies to reduce delivery costs, which are discussed in the accompanying supplementary document setting out the financial framework for funding. Also, none of the models account for slippage (delays) in the actual delivery of the renewals plans.

1.45. Based on Figure 1.4, more asset condition data need to be collected and reviewed over the next three control periods, to provide certainty of the long-term plans.

1.46. Because the total direct cost is so dependent on sleeper renewals, and these are on a roughly 50-year frequency, there can be major fluctuations in 40-year annuity calculations. This is shown in Figure 1.5, where the large troughs occur when sleeper renewals fall just outside a 40-year assessment.

[3] Excludes signalling replacements.

Figure 1.5 Estimates of future 40-year cost assessments[4]



1.47. Figure 1.5 demonstrates the challenges of basing the annuity calculation on a 40-year period. Making a different prediction about design lives (which is based largely on engineering judgement) can have a major impact on the 40-year renewal cost (blue vs orange lines). But for each scenario, the 40-year costs also fluctuate significantly from one periodic review to the next, potentially impacting decisions around annuity payments.

1.48. The steady state lines in Figure 1.5 are based on an average over 100 years and support our proposed 10% saving through condition based renewals for longer asset lives (the 'spread' model).

Asset-specific procedures and standards

Specific questions

1.49. Under the Operator Agreement there is a requirement for NR(HS) to produce and submit an Operator Agreement Asset Management Strategy which is consistent with and satisfies HS1 Ltd concession obligations.

[4] Excludes signalling replacements.

Detailed methodology

1.50. See general methodology.

Summary of key information

1.51. A key document in NR(HS) meeting this requirement is NR(HS) SAMP.

1.52. The SAMP sets out that each discipline as part of NR(HS) is required to demonstrate its compliance with statutory and rail standards through a Safety Management System. Compliance with NR(HS) Technical and Regulatory Standards is a key aspect of network operations. Compliance is mandatory with a view to the license to operate, relevant stakeholders, interactions and compliance requirements.

1.53. Level 1 standards are supported by the Level 2 procedures that in turn are underpinned by method statements (Level 3) documents which outline work instructions including processes for operations.

1.54. The SAMP and associated appendices have then been used to directly inform HS1 Ltd's 5YAMS submission.

Findings

1.55. While we consider that the strategic plan states the objectives, the methodology is not clear. We **recommend** that the SAMP should include commitments to how the stated aims will be achieved along with key milestones. Whilst achieving ISO55001 accreditation is to be applauded, HS1 Ltd and NR(HS) should be looking at how they move forward to achieve the same level of asset management maturity as being demonstrated by others. The SAMP would also benefit from showing the current scope/capacity of the AMS system and the plan for future status/scope/capability improvement. [amber 6]

Condition, capability and capacity of the assets to be maintained

Specific questions

1.56. We sought to identify any cases of optimism bias and to ensure that the concession handback condition has a high likelihood of being met. We have taken this to mean being in a "steady state" cycle of operations, maintenance and renewals, and able to meet the performance requirements. It does not mean that the infrastructure should be maintained in an "as new" condition.

Detailed methodology

1.57. See general methodology.

Summary of key information

1.58. NR(HS) has produced, on behalf of HS1 Ltd, a suite of SASs aimed at optimising asset performance of key assets through their lifecycle by adopting a structured whole-life cost approach to operations, maintenance, and renewals including asset disposal. These have then been used to inform HS1 Ltd's 5YAMS submission.

Findings

1.59. We consider that the SASs contain sufficient information on condition and capability of the assets to be maintained. [green]

1.60. While the SASs present the current condition of the assets, we **recommend** that the SASs should also present the expected condition of the assets at the end of the control period; concession period; and at the end of the 40-year renewal plan period. This would help to clarify the condition of the asset at handback and whether this represents a 'steady state' condition. Our more detailed review of these renewal plans is set out in Chapters 5 & 6. [amber 7]

Whole Life Costing

Specific questions

1.61. We sought to confirm whether the 5YAMS can meet performance requirements while minimising the Whole Life Cost (WLC), which is a fundamental objective of asset management.

Detailed methodology

1.62. Prior to HS1 Ltd submitting its 5YAMS, we met with HS1 Ltd, NR(HS) and their specialist consultants, to gain assurance that consideration of WLC had been taken into account in the development of operations, maintenance and renewals plans.

Summary of key information

1.63. HS1 Ltd commissioned Pell Frischmann to develop an Asset Decision Support Tool (ADST). The ADST supports decisions on how HS1 Ltd operate, maintain, renew and enhance the route infrastructure assets.

1.64. In undertaking WLC into consideration, HS1 Ltd advised that a two stage approach had been adopted:

- In stage one, all asset groups were subject to a preliminary WLC analysis as part of a wide range of scenarios (do nothing, as norm, sweat, enhanced) etc. by NR(HS).
- In stage two, over 100 preliminary ideas were then taken forward for further refinement in the ADST using up to 25 scenarios, by HS1 Ltd.

1.65. HS1 Ltd commissioned AMCL in 2018 to conduct a sensitivity analysis on the ADST to understand the impact of input uncertainties on the model output. AMCL identified that as a complex model, the ADST includes a significant number of parameters.

1.66. AMCL concluded (in line with our expectations) that service life / condition trigger intervention points and service life inputs have the highest overall impact on the decisions made against options/scenarios created. Next on the list are task (no. of shifts) and fault rate with medium overall impact. The impact for the other parameters were relatively low.

1.67. AMCL recommended that users of the ADST should pay extra attention to the high and medium impact parameters when creating options to change the inputs. Effort should be taken to minimise the level of uncertainties on these inputs in order to minimise the risk of making sub-optimal decisions.

1.68. AMCL in their AMEM report recommended that HS1 Ltd and NR(HS) should establish and agree a unit cost framework for both renewal and maintenance decision-making, ensuring that these frameworks are effectively and independently reviewed by each organisation as required within their formal management review processes.

Findings

1.69. We found that the ADST is a reasonable computer simulation which helps to compare the relative WLCs of different operations, maintenance and renewal input scenarios. Inputs were largely based on the judgement of NR(HS) professional heads rather than real-time renewal and maintenance cost data, but this seemed reasonable given the relatively new condition of the assets and lack of historical data on asset degradation. [green]

1.70. Whilst any model outputs are only as good as the information put in, the ADST approach represents a significant advance over the approach undertaken in developing the 5YAMS for CP2. Previously whole life costs were estimated and captured in asset specific policies written by external consultants. For CP3 estimated whole life costing have been calculated with HS1 Ltd and NR(HS) tools and captured in the SAS's owned by NR(HS) professional heads. [green]

1.71. The above would be further enhanced by HS1 Ltd and NR(HS) reaching agreement on a unit cost framework for both renewal and maintenance decision-making, ensuring that these frameworks are effectively and independently reviewed by each organisation as required within their formal management review processes as recommended by AMCL.

1.72. As the ADST is key in supporting decision-making by comparing its WLC outputs among alternative options, it is important for HS1 Ltd to understand how robust the comparison is and that ensure it is in a position to challenge and then discuss with stakeholders and funders any outputs before settling on the final strategy. We **recommend** that HS1 Ltd should conduct (and document) regular feedback sessions with stakeholders as more data become available and the plans develop. This may help to explain to stakeholders how the agreed AMOs are driving the selection of high-cost, low-risk options, in line with AMCLs identification of a lack of plan-do-review being embedded in HS1 Ltd's asset management processes. [amber 8]

Specific Asset Strategies (SAS)

Specific questions

1.73. None (assessment undertaken for consistency with best practice; timely, efficient and economical manner).

Detailed methodology

1.74. We observed the independent review of the SASs by Vertex Ltd in 2018, commissioned by HS1 Ltd.

1.75. We undertook our own review of each SAS and the rail plant strategy as this also fed into the CP3 renewal plan.

1.76. This review was supported by us undertaking both day and night site visits with NR(HS) professional heads to gain a fuller understanding of the SAS drivers and recommended outputs.

Summary of key information

1.77. The SAS documents set out the strategy for the management of asset disciplines on HS1 Infrastructure, for CP3 and beyond. The documents are based on NR(HS)'s understanding of the asset portfolio and its condition, performance, risks and associated costs. In general terms, the specific asset policies contain details of:

- HS1 asset management objectives & levels of service;

- asset composition and current condition;
- asset criticality, risks and costs;
- asset lifecycle management strategy;
- CP3 renewal plans and 40-year renewal plan; and
- capability improvements and enhancements.

1.78. Six SASs have been developed for the higher risk assets together with an overarching asset management plan that sets out the key objectives for the SASs and the approach adopted by HS1 Ltd.

1.79. Vertex notes some specific areas for improvement whilst their overall conclusion was that:

the SASs that they had seen and the discussions with the Professional Head's plus further documentary and site evidence gives them confidence that NR(HS) understand the condition and the degradation profiles of their assets and have made realistic plans for the next Control Period. Some flexibility in the timing of remedial action and the ability to adjust the programme to deal with changes to the reliability of certain assets types is still required.

1.80. A key driver of the development of the SAS's has been a desire to move away from intervention frequencies being driven by manufactures recommendations to one based on intervention strategies informed by real experience, in line with current best practice. This is however still work in progress, due to the limited asset condition degradation data available for this relatively new system. As the system ages, more data should become available which will in turn allow greater accuracy of future asset condition projections and renewal requirements. Overall we would expect this to reduce the long-term renewal requirements as long as appropriate asset interventions are implemented.

1.81. The SASs reference the importance of good quality asset data without setting out what the minimum asset data requirements are to be, how the data is to be recorded and at what frequency.

1.82. HS1 Ltd advised that NR(HS) has an Asset Knowledge Standard which covers topics such as data quality, data coverage and data capture. Data/measures for asset condition requirements have also been documented in more detail within a Joint Asset Condition Measures Report.

Findings

1.83. In line with Vertex's findings we concluded that the SASs represent a significant step forward in the development of asset management practice on the HS1 network. Broadly we found them to be good high-level documents, which build on existing practices using age as a proxy for replacement frequency. In general they follow best practice, having to make a number of assumptions for asset degradation based on limited real time data. [green]

1.84. However we did not observe much evidence of SASs exploring the potential benefits of greater remote or automated monitoring. We **recommend** that HS1 Ltd give this additional consideration. [amber 9]

1.85. Also, we did not observe much evidence of any challenges to established practice that might introduce efficiency benefits. We **recommend** that HS1 Ltd give this additional consideration. [amber 10]

1.86. The SASs all showed clear alignment to the AMOs. (It is however noted elsewhere in this report that the current choice of AMOs appears to drive a zero-failure tolerance and early replacement strategy that comes at a financial cost, through more intensive maintenance activities and renewal frequency). We would wish to see HS1 Ltd implement an effective plan-do-review-action cycle in order to attain optimal outcomes. [green]

1.87. The quality of asset management planning is entirely dependent on the quality of information held about the assets, and the asset system more widely. We remain of the view that good asset data is fundamental to asset management, and we **recommend** that HS1 Ltd, should, rather than NR(HS), sets out its minimum asset data requirements and establishes a methodology to measure and report against its asset data quality in its annual statement of asset management. [amber 11]

1.88. We challenged NR(HS) on what level of traffic growth that had allowed for within their CP3 plans. NR(HS) advised that it had assumed that the current levels of usage would continue in CP3 (within a nominal 1% change) and it would continue to plan on this basis until they were formally advised otherwise by HS1 Ltd. This was validated by Vertex in its review of the SAS's undertaken on behalf of HS1 Ltd:

The use of today's service levels when developing the proposals does not take into consideration HS1's aspirations to increase traffic in the future….[green]

1.89. We are satisfied that no over ambitious growth has been factored in to the renewal and maintenance requirements at this review. Should traffic usage change in the

future then this will have to be factored into the maintenance and renewals plans. [green]

2. Operations and maintenance

Operations and maintenance capability

Specific questions

2.1. Is HS1 Ltd's operations and maintenance capability consistent (or not) with HS1 Ltd's General Duty?

Detailed methodology

2.2. See general methodology.

Summary of key information

2.3. Operating and maintenance costs for HS1 Ltd comprise a number of elements as shown below in Table 2.1 along with the % difference between CP3 exit vs CP2 exit.

Table 2.1 CP3 operation and maintenance cost summary vs CP2 exit (£m, February 2018 prices)

	CP2 exit £m	20/21 £m	21/22 £M	22/23 £m	23/24 £m	24/25 £m	Total £m	% difference CP3 exit vs CP2
NR(HS) operations and maintenance costs[1]	41.1	41.9	41.8	41.0	40.8	40.0	205.5	-3%
HS1 Ltd Costs								
Subcontracted	3.9	3.7	3.7	3.8	3.8	3.8	18.7	-5%
Internal	9.6	7.9	8.2	8.6	8.5	8.0	41.2	-17%
Pass through	18.5	19.1	19.1	19.1	19.1	19.1	95.4	+3%
Freight costs	0.6	0.4	0.3	0.4	0.4	0.4	1.8	-37%
Total operating and maintenance costs	73.7	73.0	73.1	72.8	72.5	71.2	362.6	-3%

[1]See Table 2.2
Traction electricity is not included in this table as it is charged separately to operators as incurred.
The NR(HS) cost shown in this table is the Annual Fixed Price in the NR(HS) 5YAMS with adjustments for the Operator Agreement 1.1% increase and the freight-specific element of the NR(HS) costs.
Numbers may not add up due to rounding

Source: HS1 Ltd

2.4. Overall HS1 Ltd has forecasted a reduction of 3% in total operating and maintenance costs between CP2 exit and CP3 exit as shown. HS1 Ltd direct staff costs are broadly held flat from CP2 outturn (£4.5m at CP2 end vs £4.6m p.a. CP3). The most significant decrease financially is HS1 Ltd's reduction in their internal costs of £1.6m. This element of the costs covers staff headcount, reflecting the tasks needed to comply with the long term obligations under the Concession Agreement with a

reduced use of consultants (-£1.4m) and more work being delivered in-house. Our assessment of the spending plan can be found in the supplementary document setting out the CP3 financial framework.

2.5. HS1 Ltd has also proposed that £6m should be spent in CP3 on the planning of renewals before CP4, elements of which may build on the work previously undertaken in CP2 in this area, such as the Bechtel study.

2.6. HS1 Ltd's subcontracted costs are primarily single-choice supplier long-term arrangements which HS1 Ltd has identified as having limited potential for further savings. These include for example:

- the Operations and Maintenance Agreement (OMA) relating to costs incurred in relation to the interface assets between Network Rail Infrastructure Limited and HS1 Ltd;
- maintenance of HS1-owned GSM-R equipment. In CP2 this was provided by NR(HS) as an additional service. For CP3, NR(HS) has included this cost in its annual fixed price thus removing it from HS1 Ltd costs;
- connection charges for HS1/UK Power Networks power assets into the national grid. Standard charges are based on UK-wide regulated tariffs;
- costs arising from a revised energy performance regime as part of the contract with UKPNS which for CP3 have been added to pass-through costs (a total of £0.5m per annum).
- "other" railway costs, primarily £0.9m for the rescue locomotive; £0.6m for Ashford IECC; and £0.9m for route-specific PR and marketing; and
- police service agreements with the British Transport Police, regulatory fees based on ORR costs incurred and other small regulatory and safety fees.

2.7. HS1 Ltd for CP3 advised that the only other costs it anticipates may relate to Brexit and a potential market test. These are not quantified by the 5YAMS.

2.8. As previously explained HS1 Ltd delegates the provision of operations, maintenance and renewals under the terms of an Operator Agreement to NR(HS).

2.9. The Operator Agreement with NR(HS) runs until the end of 2047, beyond the end of the HS1 Ltd concession (2040). However HS1 Ltd does have an option to undertake a market test during CP3. HS1 Ltd has indicated that it is taking the following factors into consideration before making this decision, required by 1 April 2020:

- confidence that better value for money would be realised;
- strength of a potential bidder market to ensure a competitive process;

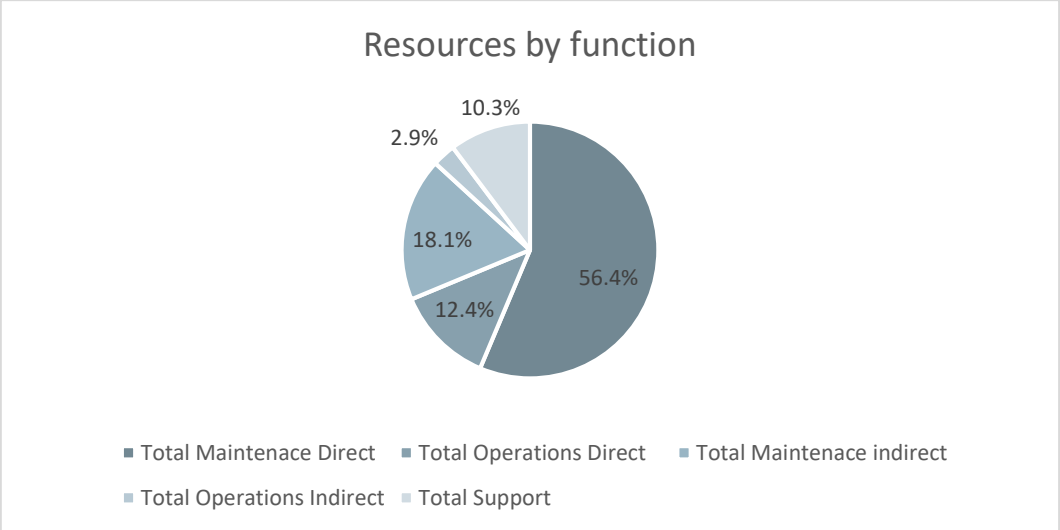
- certainty of no negative impacts on safety;
- the need for a manageable transition process to avoid any disruption to services; and
- wider stakeholder agreement.

2.10. In total NR(HS) costs make up around 56% of the total operating and maintenance costs. NR(HS) receives payment of an annual fixed price to cover the operations and maintenance elements, which is developed and agreed at the start of each control period. Funding for specific activities such as asset renewals and additional services are managed through separate arrangements.

2.11. NR(HS) is expected to be at 318 FTE[5] headcount to undertake route operation and maintenance activities at the start of CP3, an increase in 8 over the CP2 exit. HS1 Ltd advised us that it had challenged the increase within NR(HS) and that it was satisfied that this is required to increase technical leadership within NR(HS) to address recent performance issues and to increase resilience.

2.12. Figure 2.1 indicates the relative percentage of staff by function, the majority being focused on direct maintenance activities and operations. By the end of CP3 NR(HS) plans to have reduced this back down to 307 by upskilling non-frontline staff i.e. indirect and support staff, and continuing to appropriately resource the organisation.

Figure 2.1 NR(HS) resources by function



Source: NR(HS)

[5] Support services provided by Network Rail Infrastructure Limited national function and South East Route are not included in headcount, rather they are shown in the support cost line of Table 4.2 Annual Fixed Price for CP3 (£m, Feb 2018 prices)

2.13. Of the total operation and maintenance headcount, 10 staff per year will be fully recovered from working on either station or route projects. In addition through additional effectiveness NR(HS) hopes to release additional operation and maintenance capacity over the course of CP3 that can be utilised on renewals and their costs recovered. NR(HS) would hope to achieve a operation and maintenance FTE reduction of 9 in year 1 of CP3, rising to 17 in year 5.

2.14. Maintenance-related costs associated with the above headcount are summarised in Table 2.2.

Table 2.2 Annual Fixed Price for CP3 (£m, Feb 2018 prices)

	CP2 exit [1] £m	20/21 £m	21/22 £m	22/23 £m	23/24 £m	24/25 £m	Total CP3 £m	% difference CP3 exit vs CP2
Infrastructure		23.8	23.8	23.6	23.6	23.6	118.4	
Operations		5.6	5.6	5.6	5.6	5.6	28	
Support		3.5	3.5	3.6	3.6	3.5	17.7	
Other		5.1	5.1	5.1	5.1	5.1	25.5	
Operations and maintenance costs[2]		38.0	38.1	38.0	37.9	37.9	189.9	
Net efficiency[3]		(1.0)	(1.2)	(1.8)	(1.9)	(2.5)	(8.4)	
Operations and maintenance costs (post-efficient)	36.6	37.0	36.9	36.2	36.0	35.4	181.5	
Management Fee @ 8%	2.9	3.0	3.0	3.0	2.9	2.8	14.5	
Contract risk @ 4.33%	1.8	1.6	1.6	1.6	1.6	1.5	7.9	
Annual fixed price	41.4	41.6	41.5	40.7	40.4	39.7	203.9	
+1.1% escalator[4]		0.5	0.5	0.4	0.4	0.4	2.2	
-freight specific costs		-0.1	-0.1	-0.1	-0.1	-0.1	-0.7	
Operations and maintenance costs	41.1	41.9	41.8	41.0	40.8	40.0	205.5	-3.0%

[1]CP2 exit restated reflects the NR(HS) pre-efficient costs. [2] See section 2.15 for details of changes from CP2. [3] See section on Operations and maintenance efficiencies for details. [4] This relates to the contractual arrangements set up by DfT at the time of sale. Our understanding is that; this is based on the expectation that rail costs inflate more quickly than RPI. Numbers may not add up due to rounding

Source: HS1 Ltd

2.15. The increase between the end of CP2 and the start of CP3 is driven by the principle of baseline change (that is, change of scope) between control periods. The £1.4m increase is comprised of:

- £0.27m constituting a change as a result of employment law, for example calculation of annual leave payments based on employees normal pay. HS1 Ltd has accepted this change from NR(HS) following a employment tribunal.
- £0.20m – investment in asset management capabilities which were not originally factored into CP2, including attainment of ISO55001. HS1 Ltd requested this as referenced in their 5YAMS.
- £0.24m – increase in resilience of the EMMIS[6] desk by increasing heads, HS1 Ltd approved this, with a linked decrease in HS1 Ltd operations and maintenance subcontractor costs.
- £0.34m – RIN-F[7] maintenance (£2k pa), IT Computer maintenance (£72k pa), GSM-R[8] maintenance (£241k pa), Fire Suppression (£20k pa) – within HS1 Ltd costs in CP2.
- £0.35m – works originally submitted as renewals, but reclassified as operations and maintenance for CP3 by HS1 Ltd:

– bearing refurbishment (38.8k);

– Camley Street heritage structures in Yatch Basin (191k);

– viaduct expansion joints (64.5k);

– bridge paintwork protection systems (20.9k);

– relay tester (33.1k).

Although now maintenance items, these were not previously within the fixed cost scope of the Operator Agreement and have now had to be included as additional scope for CP3. HS1 Ltd has stated that this was challenged robustly and that it will continue to challenge the cost and how the work is going to be delivered.

Findings

2.16. We are satisfied with the background and reasoning for the increase in operating and maintenance costs from CP2 exit to CP3 start costs. [green]

2.17. We agree that HS1 Ltd is right to undertake appropriate preparation before market testing the Operator Agreement. However next steps, including stakeholder

[6] Electrical, Mechanical Management and Information System

[7] Register of Infrastructure

[8] Global System for Mobile Communications part of the European Rail Traffic Management System (ERTMS)

engagement, should be taken now in order to provide clarity to both existing and future suppliers, and to allow for effective and efficient planning of operations, maintenance and renewal activities in what will be a critical phase for HS1 Ltd. [green]

Operations and maintenance risk

Specific questions

2.18. None (consistency with best practice; timely, efficient and economical manner).

Detailed methodology

2.19. See general methodology.

Summary of key information

2.20. As part of the Operator Agreement NR(HS) holds operation and maintenance risks in the following areas:

- asset risk: damage not caused by NR(HS) to the infrastructure leading to increased maintenance, train delays or other unforeseen costs;
- third-party/external risk: costs incurred as a result of third-party events (eg. vandalism) or external events (eg. adverse weather);
- supplier risk: uncontrollable delays or financial costs related to legacy suppliers of original project systems (eg. HS1 Ltd signalling system);
- HS1 Ltd/customer-driven risk: events related to assets and operations, such as a change in operating environment or maintenance disruption caused by events outside the control of NR(HS) (eg. late running services from the continent); and
- other risks: including insurance claims (below excess) and events which cannot be allocated to items above, and which are not recoverable via insurances or considered re-opener event.

2.21. The contract risk (previously known as risk premium) provides for downside risks from externally-caused events that are entirely outside of NR(HS)'s control. The contract risk is calculated as a percentage of the post-efficient operation and maintenance annual cost.

2.22. Ahead of CP3, NR(HS) stated that it had utilised a Quantitative Cost Risk Assessment methodology to review which risks it holds and which of those are out of its control. NR(HS) has also reviewed the likelihood of these risks occurring and their impact should they materialise. This identified a risk value of 4.33% of the operation

and maintenance cost and reflects risk exposure at P80[9] - this compares to 5% in CP2.

2.23. Under the Operator Agreement, the outperformance sharing mechanism for operations and maintenance costs allows NR(HS) to retain 50% of outperformance in years 3, 4 and 5 of CP3, returning 20% to HS1 Ltd, and 30% to train operators. Due to the definition of the outperformance share, even though NR(HS) spent £0.5m under the PR14 forecast for Year 3 of CP2 (that is, 2017-18), no money was returned to HS1 Ltd or operators.

2.24. NR(HS) makes the point that the Operator Agreement requires them to hold the risk, for items that are outside their total control, such as trespass. While the company can seek to minimise the opportunities for a trespass incident, it cannot stop it altogether and to a certain extent relies on the authorities to deal with an incident. NR(HS) believes that it has therefore taken a view on the potential risk and priced accordingly.

2.25. Over CP2 it has reimbursed service operators the following amounts due to operational disruption for events that were at its risk - see Table 2.3.

Table 2.3 NR(HS) customer-driven risk payments

	15/16 £m	16/17 £m	17/18 £m	18/19 £m
Amount	2.1	0	0	1.7

2.26. In its benchmarking report Rebel identified that:

Best practice in contracts is that risks are allocated to the party that can best control the risk. A review of the risk allocation indicates that NR (HS) in part takes a lot of risks that they cannot control.

Findings

2.27. CP3 will pose a greater challenge with an ageing asset base and an increasing volume of renewals. Based on NR(HS) commercial risk exposure we consider that a risk allowance of 4.33% is reasonable and represents a 13% reduction on the percentage used in CP2. [green]

[9] Value at which there is a 80% chance of the project coming in at a lower cost (known as the P80 estimate)

2.28. We agree with Rebel's assessment that risk is best placed with those who can control the risk. We **recommend** that HS1 Ltd should evaluate the allocation of operation and maintenance risk with funders to determine if risk allocation could be better apportioned. This may then lead to a reduction in the overall cost. [amber 12]

Operations and support costs

Specific questions

2.29. The following question framed the assessment for this area:

- is the pre-efficient cost of operations based on good estimating practice which reflects the conditions under which the work will be delivered?

Detailed methodology

2.30. See general methodology.

Summary of key information

2.31. HS1 Ltd's operations strategy is owned by NR(HS) which is then aligned to HS1 Ltd's AMOs. It aims to:

- deliver minimum operating standards and train performance of less than 10 seconds delay per train;
- consider changes to operational context and planning in CP3 and beyond (routes and stations);
- be linked to asset management strategies, resilience and renewals plans for CP3 and beyond;
- have a strong focus on how the passenger experiences its overall journey on the HS1 network, especially at the interface between route and stations; and
- consider mitigation measures for key strategic risks (to HS1 Ltd operations) through the delivery of five key objectives.

2.32. Support costs are related to contract management staff, safety and assurance functions and business case development.

2.33. NR(HS)'s operations strategy sets out its operational approach for CP3. NR(HS)'s CP3 strategy is to build upon an approach adopted in CP2 to continue to increase operational resilience through greater alignment between operations and asset management and improved integration with the wider industry.

2.34. NR(HS)'s operations strategy identifies a number of key strategic risks to the HS1 operation along with a suite of work streams to mitigate these risks, that is, reducing their impact or likelihood of impacting performance and safety. The key strategic risks identified included, but were not limited to:

- route / station security events such as theft, trespass and terrorism;
- failure to respond to operational incidents effectively;
- large service-affecting asset failures;
- large operational incidents such as derailment. de-wirement or run-through; and
- lack of workforce provision, for example, skill drain or need for bespoke roles.

2.35. NR(HS) has stated that these work streams will be strengthened and developed throughout CP3, although no timescales or output metrics have been provided.

Findings

2.36. Given that no significant new performance risks or changes to path volumes is anticipated, we are content with NR(HS) proposing to maintain existing operational arrangements and resources and to drive continuous improvement to processes already established in CP2. [green]

2.37. Where NR(HS) has stated that workstreams will be implemented and developed throughout CP3 to strengthen resilience to key risks, we **recommend** that a resource programme should be provided with key milestones along with expected output metrics that can be reviewed as part of the monitoring process. [amber 13]

Maintenance costs

Specific questions

2.38. The following question framed the assessment for this area:

- is the pre-efficient cost of maintenance based on good estimating practice which reflects the conditions under which the work will be delivered?

Detailed methodology

2.39. Our desk-based review of the 5YAMS was supplemented by meetings with both HS1 Ltd and NR(HS).

2.40. We have also taken into account the benchmarking report undertaken by Rebel, commissioned by HS1 Ltd.

Summary of key information

2.41. Broadly, NR(HS) delivers maintenance of track, signalling, electrical and plant, and off-track asset categories using in-house resources supplemented by external contractors for specialised activities or where this is appropriate to manage fluctuations in workload such as seasonal tasks.

2.42. We challenged NR(HS) with regard to the work mix between internal and external resources. It stated that it elects not to subcontract unless expertise or capacity is not available within NR(HS) to prevent layers of fee.

2.43. We previously highlighted the need for HS1 Ltd to have robust processes in place to monitor compliance with the Operator Agreement. In their asset management maturity report AMCL identified that:

[Operation and maintenance] expenditure is an agreed flat fee paid by HS1 to NR(HS) for the base level of service required under the OA. Although the work volumes that underpin this expenditure are understood, the trade-off between these and renewals, and the opportunity to optimise [operation and maintenance] activities to pro-actively manage cost, performance and risk is not effectively incentivised. Monthly invoices are not contingent on delivery of the underlying work plan, and assurance of this by HS1 has not been strong during CP2.

2.44. In response to this a Quarterly Assurance Board, a joint forum for assurance between HS1 Ltd and NR(HS), was established. It is independently chaired, has a terms of reference with the main objective of providing the right level of assurance aligned with all relevant agreements and responsibilities.

2.45. The asset management approach to CP3 seeks to fundamentally shift maintenance and inspections from largely time-based to risk-informed inspections and renewals, which in theory would result in some staffing efficiency.

2.46. For example, we were informed that proposed switches and crossings (S&C) replacements are based on risk to performance given the condition of the asset as outlined in the track SAS. As a result, inspections of the S&C have been re-prioritised pre- and post-renewal based on the risk to the asset management objectives as found in the Level 2 standards. These Level 2 standards include the failure modes and response levels based on the last inspection/maintenance and identify the next required intervention. Under this example the renewal will remedy the poor condition and therefore likely remove the higher frequency inspections towards the end of life. However there may be a requirement for additional and heightened inspections directly post-commissioning to ensure potentially early-life failures are managed.

Findings

2.47. We found that as part of NR(HS)'s objective of maturing its asset management capability in CP2, NR(HS) has improved its cost-capture approach. NR(HS) has identified all the activities that take place on the railway and developed a bottom-up approach to capturing the time it takes to perform them using a Cost Time Resource (CTRs) resource. This has enabled it for the first time to perform activity-based estimates, combining activity-based plans (ABPs) and maintenance unit costs. [green]

2.48. We reviewed the use of ABPs in our PR18 determination of Network Rail Infrastructure Limited's maintenance planning. We found that while it is a recent innovation, it is a positive step towards better transparency and understanding of maintenance costs by providing an enhanced ability to improve efficiency in the planning and delivery of maintenance. [green]

2.49. In the final year of CP2 there has been a small but noticeable increase in faults. This is not totally unexpected as the asset ages, but we **recommend** that maintenance interventions and inspection frequencies be revisited as more HS1-specific failure data becomes available. [amber 14]

2.50. Maintenance not undertaken correctly can in some instances have a worse impact than not being undertaken at all. During our site inspections we highlighted to HS1 Ltd areas where we felt maintenance was not as effective as it should be and that this may be a contributing factor to the need for early renewals of some assets. As an example, a set of cross passage doors had been badly damaged by the ingress of water, which appeared to have been occurring over some considerable time. We did not see any indication that proactive steps have been taken to stop the ingress or manage the water flow away from the doors. We **recommend** that water ingress issues identified on site visits are followed up. [amber 15]

2.51. In CP2 there were a number of research and development (R&D) projects that were targeted at improving maintenance effectiveness. We have seen little evidence that these were being taken forward in CP3. There are a number of techniques which we feel should be considered such as the use of in service trains to monitor overhead line equipment and track condition; rail milling to maximise asset life; and remote monitoring of points, that are already in use elsewhere in the UK or close to being adopted. We accept that the unique nature of HS1 would require further tailoring before implementation and would require co-operation from fleet operators. We **recommend** that HS1 Ltd reviews how it incentivises and monitors such efficiencies in maintenance. R&D is explored further in Chapter 4. [amber 16]

2.52. NR(HS) has identified that the introduction of greater asset management effectiveness in CP3 will free up the equivalent of ten maintenance resources. We agree that these resources could be utilised to support the delivery of renewals projects in order to not just deliver cost efficiency, but also retain competence, resilience and corporate knowledge. [green]

2.53. In general we deemed it is a reasonable strategy to retain maintenance resources at the suggested level to meet the stated AMO. However should the AMO's be changed or new technology or maintenance techniques introduced that necessitate different skill sets or resource requirements, then this may need to be revisited. Any changes In NR(HS) workforce would be subject to existing consultation procedures. [green]

2.54. NR(HS) pays for maintenance out of the annual fixed charge while renewals are paid for separately with an added project management payment and management fee. Under this arrangement there is a potential disincentive for NR(HS) to undertake increased maintenance activities to optimise asset life and push for early renewals instead. We **recommend** that HS1 Ltd reviews how it incentivises its delivery agent(s) to maximise asset life through effective and efficient maintenance activities. [amber 17]

2.55. We assume HS1 Ltd will act upon AMCL's conclusion that it should take a more proactive stance on gaining assurance that planned maintenance activities are undertaken; that they are effective; and that maintenance is effectively balanced against renewals. This will become more critical as NR(HS) moves from a time-based to a condition-based maintenance regime. [green]

2.56. The implementation of the Quarterly Assurance Board is a key step in clarifying roles and responsibilities between HS1 Ltd and NR(HS). However it is still at an early stage and we **recommend** an independent review of the effectiveness of this newly established board be undertaken in CP3. [amber 18]

Operations and maintenance efficiencies

Specific questions

2.57. The following question framed the assessment for this area:

- are the post-efficient costs of operations and maintenance costs reflective of realistic efficiency target-setting?

Detailed methodology

2.58. We have compared NR(HS)'s planned efficiencies against the benchmarking report undertaken by Rebel, commissioned by HS1 Ltd.

2.59. Our desk-based review was supplemented by meetings with both HS1 Ltd and NR(HS).

Summary of key information

2.60. HS1 Ltd commissioned Rebel to undertake an operating and maintenance cost benchmark. The objectives of this assignment were to assess HS1 Ltd and NR(HS) Ltd operations, maintenance and renewals strategies and processes against similar European high speed organisations.

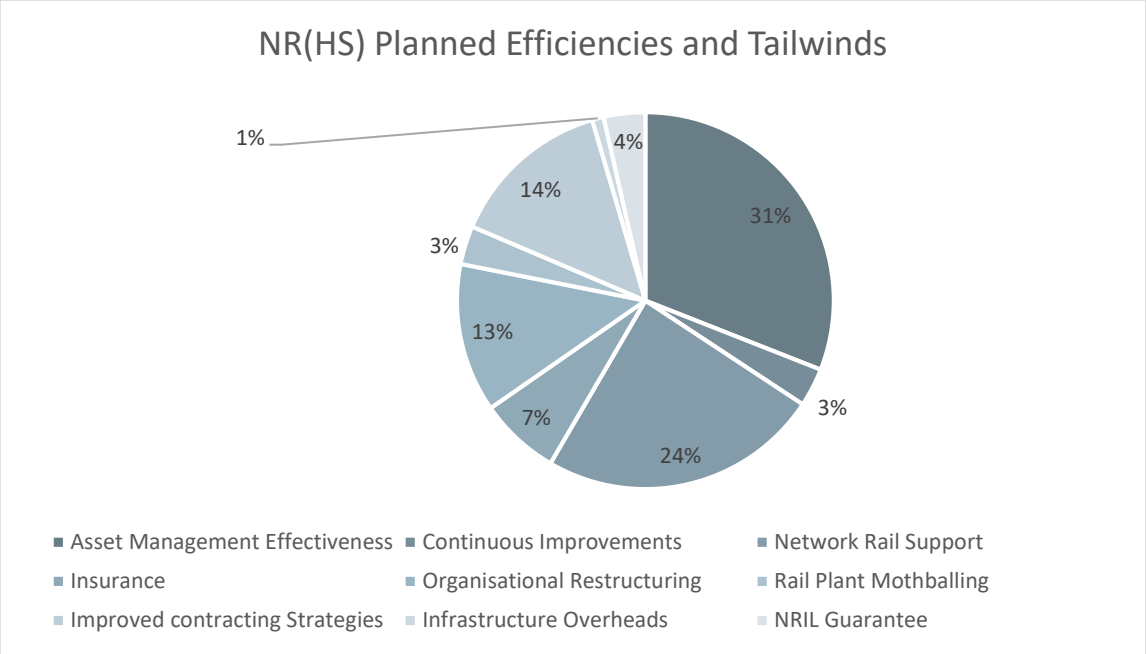
2.61. This cost benchmark combines traditional top-down cost benchmarking with bottom-up best practice and lessons learned. The findings and recommendations were issued in September 2018. The benchmarking findings identified that a potential 18% cost reduction could be achieved across both HS1 Ltd and NR (HS) Ltd organisations. This was categorised in three main areas as summarised in Table 2.4, along with the NR(HS) response.

Table 2.4 Summary of Benchmarking outputs and response

Benchmarking		NR(HS) CP3
Area	Potential %	Saving % (vs CP2 Exit)
Reduction in operation and maintenance organisational costs	6.6%	Around 11.2%[2]
Reduction in support costs	9.8%	12.7%[2]
Network optimisation[1]	1.9%	N/A
[1]HS1 Ltd would need to remove these assets from the Operator Agreement. [2] Inclusive of net efficiencies, recoveries and a collaborative efficiency target		

2.62. The Operator Agreement requires NR(HS) to be economic and efficient, as it operates as part of a regulated utility, there is an expectation of year-on-year efficiency. NR(HS) has set out a number of efficiencies and tailwinds for CP3 to deliver the projected savings in operation and maintenance organisational costs (see Table 2.4). The percentage breakdown for these are set out in Figure 2.2.

Figure 2.2 NR(HS) Planned Efficiencies by category



Source: NR(HS)

2.63. The elements in Figure 2.2 being achieved by:

- improving possession utilisation by deploying multi-disciplined teams into single work sites;
- integrating maintenance and renewals planning under a single view of the plan. In addition, moving to a risk-based maintenance regime;
- NR(HS) rapid response teams undertaking both reactive and routine maintenance activities. The impact on train performance needs to be assessed given variable time to site: NR(HS) will undertake an impact analysis and engage with stakeholders to determine if this model is appropriate for the HS1 network; and
- working closely with HS1 Ltd on collaborative efficiency targets and exploring improved ways of working together.

2.64. Under the fixed price arrangement the financial risk in not achieving this target rests with NR(HS). However should it not be achieved then there may be a risk that delivery of the Operator Agreement would be affected and HS1 Ltd must put in place a robust mechanism to ensure that this is not the case.

2.65. Overall, the NR(HS) support function costs will be reduced by around 12.7% (see Table 2.4). These being achieved by:

- reallocation or removed the non-specified costs; and
- Network Rail Infrastructure Limited corporate charges reduced by 10% net. This includes reductions in excess of 20% for contributions to Network Rail Infrastructure Limited's national functions, guarantee & South East Route staff.

For further details see our supplementary document on financial framework findings.

2.66. Network optimisation opportunities were not fully explored within HS1 Ltd's 5YAMS.

Findings

2.67. NR(HS) has undertaken its own benchmarking which it shared with us, to understand how the pricing of NR(HS) activities captured in the CTRs compares with the costs of similar activities by Network Rail Infrastructure Limited's South East route using the ABP tool. NR(HS) activities were found to either be similar or more effective than on the traditional network. The only case where this was not true was tamping, where NR(HS) costs were significantly higher. It is important to note that standards for ballast compaction/quality on high-speed assets are significantly higher than the traditional network, so a difference is to be expected. [green]

2.68. We consider that realistic efficiency targets have been set for operations and maintenance by NR(HS), with the support cost efficiency savings being broadly in line with our expectation, based on our PR18 determination of Network Rail Infrastructure Limited. [green]

2.69. While we have not fully reviewed all of NR(HS) proposed initiatives in terms of realism and deliverability, we did challenge NR(HS) on its confidence that they were achievable. It confirmed that they were. [green]

2.70. Rebel in its report identified that network optimisations could yield lower overall maintenance cost and lower performance penalties by:

- eliminating Southfleet Junction;
- considering changes to the St Pancras track layout;
- evaluating the utilisation of certain loops on the network; and
- simplifying bi-directional functionality.

We **recommend** HS1 Ltd further explores the above items to determine if there is a business case for their adoption, and that this would benefit from being undertaken as a matter of priority, so that any network optimisation can be aligned with the renewals planning process. [amber 19]

2.71. HS1 Ltd has not set themselves an efficiency target (see section on Renewals risk for CP3). On balance we are satisfied that this is reasonable, subject to HS1 Ltd financially containing our wider challenges set out in this report, including being more proactive in assuring operations, maintenance and renewal activities. [green]

3. Renewals in CP3

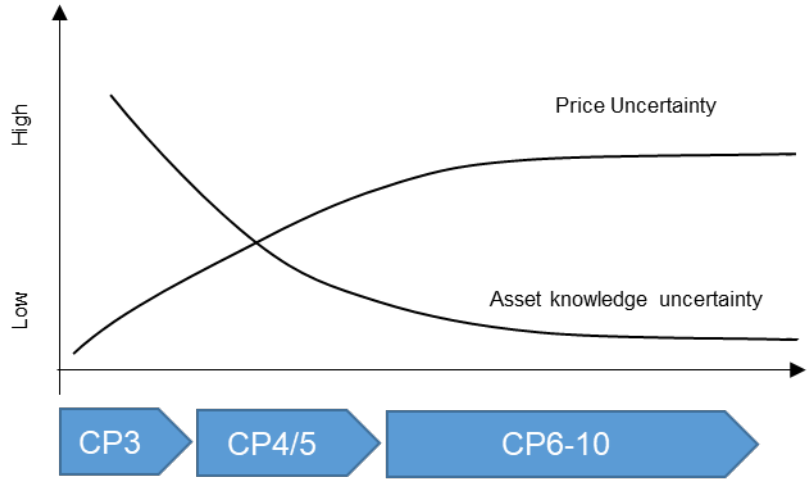
Renewals pricing for CP3

Specific questions

3.1. Our focus was establishing if the processes followed by HS1 Ltd (and its delivery agents) to develop costs were reflective of best practice. This covered both the maturity of the process, but also looking at a sample of specific examples to determine whether costs seemed appropriate.

3.2. As well as determining if costs were reasonable, we sought to understand cost uncertainty. There is a degree of uncertainty at this stage of the concession around the accuracy of the cost estimate for the 40-year horizon, due to the difference between theoretical design life and actual experience, along with the anticipated benefits of technology. We expect that this uncertainty will continue to be refined over time as more in-service data become available. The effect of uncertainty on cost estimates is illustrated in Figure 3.1.

Figure 3.1 Schematic of relationship between time, asset knowledge & price uncertainty



Detailed methodology

3.3. We commissioned Frazer-Nash to undertake a review of how renewal cost estimates had been derived. NR(HS) and Mott MacDonald (their cost consultants, see section on Delivery agents, project management and Tier 2 fees for CP4-CP10) explained that the costs had been developed bottom-up. Having established the line of sight, Frazer-Nash selected a sample of projects to test the estimating process. Frazer-Nash then requested additional information in order to understand how the base

costs were derived for a sample of 15 renewal projects that accounted for 80% of the overall cost of the CP3 programme.

Summary of key information

3.4. NR(HS) has adopted Network Rail Infrastructure Limited's approach to cost planning, using its Rail Method of Measurement (RMM) to develop the CP3 project delivery cost plan. NR(HS) cost plans are aligned to the Governance for Railways Investment Projects (GRIP) system used by Network Rail Infrastructure Limited, and the Gate process used by HS1 Ltd as outlined below.

Figure 3.2 GRIP and Gate Alignment

Source: HS1 Ltd

3.5. NR(HS) engaged an external estimating body (Mott MacDonald) to complete its Gate 1 pricing. The Gate 1 price was an assessment of the most likely cost of a project, based on the scope of work identified using historical cost data.

3.6. The CP3 renewal cost plans were prepared to represent the total Anticipated Final Cost (AFC) which is made up of two key components: Base Cost Estimate and Risk Allowance

$$Base\ Cost\ Estimate + Risk\ Allowance = AFC$$

3.7. The Base Cost Estimate provides an estimate of the most likely cost of the project and includes:

- base construction works cost
- NR (HS) labour
- NR (HS) overhead & profit
- contractor install & commissioning
- design
- project management and other project costs

Subsequently NR(HS) removed the project management costs and presented these separately at a portfolio level.

3.8. Any cost plan must always be regarded as an approximate figure and will be subject to uncertainty both above and below the most likely cost.

3.9. Frazer-Nash found that where data were available, the estimates were created to reflect historical information (through direct experience on the HS1 network in CP2, or from Network Rail Infrastructure Limited) and in discussion it was clear that reasonable assumptions had been made. In some cases, quotes had been used and for a small number of projects Rough Order of Magnitude (ROM) costs have been adopted. The provenance of ROM costs was not always clear in the pricing charter constructed using Network Rail Infrastructure Limited's RMM workbooks.

3.10. NR(HS)'s contract with HS1 Ltd allows for a price for renewals to be submitted as either a lump sum, target price or an estimate. Renewals are currently priced as estimates until they are fully developed ready for implementation at Gate 4 at which point they are procured by HS1 Ltd as a lump sum. The use of target cost had not been tested to date.

Target price - partial or full price risk transfer

3.11. While contracts may vary slightly on how a target price strategy is implemented, the fundamentals are the same. HS1 Ltd have indicated that it would like to use target costs for CP3 renewals by implementing a simple target cost arrangement that would allow it to scope up correctly after Gate 3 and enhance the competitive tender process by having a clear statement of works and efficiencies on estimating resource.

3.12. The setting of the target price can be achieved in a number of ways but in the context of the Concession Agreement this could be achieved through a form of Early Contractor Involvement. The objective would be to represent a reasonable estimate of a realistic price for delivering the renewal. The target price would be adjustable during the contract term, most commonly for variations to requirements. Where the actual costs plus the agreed overhead and profit margin vary from the target price, a pain/gain sharing mechanism would be applied. In this way parties are incentivised to seek cost effective solutions.

3.13. The use of target costs involves significant expertise and is unlikely to be cost effective in small value renewals, being better suited to larger projects or programmes of similar projects.

Findings

3.14. As a result of its review Frazer-Nash concluded that:

- a line of sight exists between the key documents that substantiate the proposed financial provisions for CP3 with respect to infrastructure and plant renewal projects; and
- direct project costs have generally been prepared in a logical manner and appear appropriate given the limited availability of historical data specific to HS1. These have been reviewed, and in some cases inputted to, by the relevant Professional Heads. [green]

3.15. By adopting an estimate strategy, followed by lump sum payment, neither HS1 Ltd or NR(HS) are exposed to any significant cost risks. Yet, even when a cost has become firmly fixed, there are numerous factors that can lead to the cost increasing. Whatever the reason, delays almost invariably increase costs. In our view this approach does not financially incentivise either HS1 Ltd or NR(HS) to seek to challenge and mitigate risks occurring that are not held by themselves, beyond their general contractual obligation and reputational considerations. [red 2]

3.16. Our review identified the following specific error:

- one Mechanical and Electrical project (renewals of fan controls) had been incorrectly priced at £410k when it was reported that it should have been £250k. [red 3]

Improvements required

3.17. HS1 Ltd should review how it incentivises cost reductions for renewals projects, for example, by considering the use of target costs for large projects or programmes of similar projects. [red 2]

3.18. Mechanical and Electrical renewals cost should be corrected, if incorrect. [red 3]

Quantitative targets

3.19. During PR18, we reviewed Network Rail Infrastructure Limited's business plans for the Great Britain rail network (not including HS1). Even though Network Rail Infrastructure Limited is more mature at cost estimation than HS1 Ltd or NR(HS), due to longer experience of its assets (and therefore it is more difficult for Network Rail Infrastructure Limited to find further efficiencies), it has targeted a 1.8% efficiency (as a percentage of total operating, maintenance and renewal spend) over the next 5 years, through improved contracting strategies. [red 2]

3.20. Given the fact that NR(HS) is less mature than Network Rail Infrastructure Limited (and therefore it may be easier to find efficiencies) and also that NR(HS) will gain some benefit from efficiencies in central Network Rail Infrastructure Limited functions, we consider that HS1 Ltd should be seeking to achieve savings on the CP3 renewals costs, through improved cost strategies. We have quantified this at approximately 1.8% of the total CP3 renewals costs, based on the level of efficiency Network Rail Infrastructure Limited is proposing over the next 5 years. [red 2]

3.21. Mechanical and Electrical renewals cost should be corrected, if incorrect, from £410k to £250k (difference of £160k). [red 3]

Renewals programme and delivery for CP3

Specific questions

3.22. None (consistency with best practice; timely, efficient and economical manner).

Detailed methodology

3.23. As well as our desk-based review of the 5YAMS, we undertook our own review of the renewals programme, along with the timescale of these renewals.

Summary of key information

3.24. NR(HS) reported in its 5YAMS that it had undertaken a risk based assessment of HS1 assets and then used this as a basis for prioritising its renewal plans. Key risks anticipated in CP3 were stated as including but not limited to:

- ageing of assets, as a large proportion of assets approach mid-life;
- greater likelihood of faults and failures already observed in CP2 that are likely to get worse in CP3;
- obsolescence of assets particularly signalling & communication systems, and electrification & plant assets; and
- increased renewal volumes in CP3 that will require a new assessment of maintenance requirements for relevant assets (including any early life failures)

3.25. For CP3 HS1 Ltd has put forward a portfolio of 54 projects, consisting of 51 firm and 3 provisional projects. The breakdown of projects by asset type is set out in Table 3.1.

Table 3.1 Proposed CP3 renewals by asset type (HS1 Ltd Appendix 4 5 YAMS)

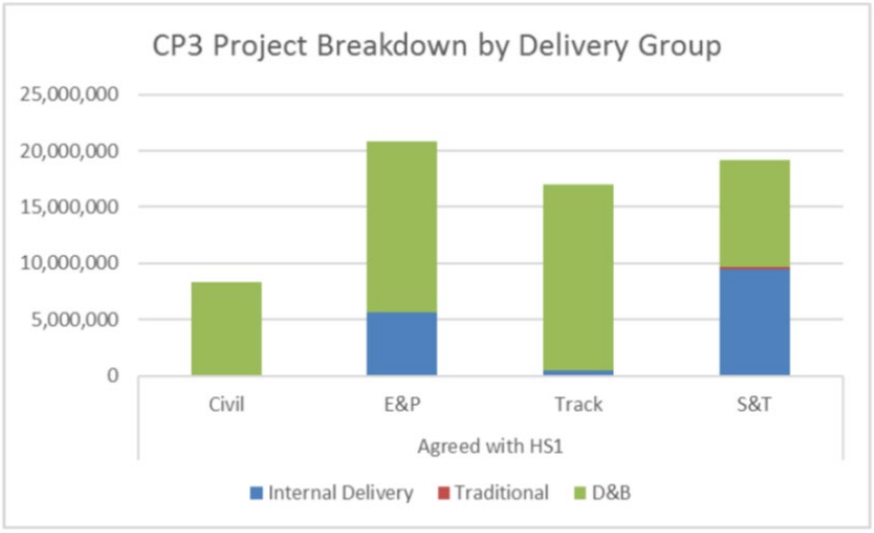
Asset type	Number of projects	Estimate £m
Track	4	17.6
Civils and Lineside	13	8.7
Signalling and Communication	12	16.8
Electrical & Power	20 (3 provisional)	11.9 (excluding provisional items)
Rail Plant	5	6.7
Total	54	61.8
Above exclude NR (HS) mark-up, risk and PMO costs. Estimates may not add up due to rounding		

Renewals delivery strategy for CP3

3.26. HS1 Ltd has indicated that it will be making greater use of design & build in CP3 (see Figure 3.3). In this approach, a single supplier is responsible for performing both design and construction and providing expertise in a specific area. The use of this approach is therefore considered especially suitable by HS1 Ltd for track renewals as a supplier will offer specialised design, construction and expertise on how to undertake ballast cleaning and track re-railing on a high-speed railway which requires hand back at full line speed.

3.27. The remainder of renewals are proposed to be delivered by use of NR(HS)'s direct labour organisation (DLO). In this approach, NR(HS) would perform design, if required, and construction activities using its in-house maintenance team. It is ideally suited for simple and low risk activities. This is the approach taken in CP2 and proposed for some of the workbank for CP3. The key consideration is that the in-house resources will require sufficient capacity to deliver these work banks.

Figure 3.3 Proposed Renewal Strategies by Asset (source HS1 Ltd)



3.28. We sought assurances that NR(HS) could secure resources when it does not yet have a signed-off plan. We were assured that NR(HS) has secured use of Network Rail Infrastructure Limited's frameworks and is in discussions, pending agreement on the CP3 plan, to buy in support from Network Rail Infrastructure Limited's new regional structure. However the priority for Network Rail Infrastructure Limited is to deliver the renewals of the traditional railway, rather than allocate key resources to the HS1 network. While NR(HS) accepted that it cannot secure resources until it has funding certainty, it could also consider European contracts where appropriate, although we are unsure if this would have a cost or time impact and if so at whose risk. As an example we understand that currency exchange fluctuation is not a priced risk.

Findings

3.29. While we found the lists of Signals and Telecommunications renewals were generally well supported, this was less true for the other asset areas. For plant and E&P there was still considerable uncertainty around the scope and timing of the proposed renewals. For example:

- NR(HS) were unable to demonstrate any supportive reliability engineering data[10] for a number of the E&P proposed renewals which requires further supporting quantitative evidence to be produced, and
- for rail plant there was some uncertainty around the supply market's appetite to undertake the proposed renewal of the control system at a value of £4.6m.

Whilst for track there was uncertainty around the deliverability of proposed ballast renewals planned towards the end of CP3. For civils we felt there was a need for further justification for undertaking all the open route drainage renewals proposed in CP3. We **recommend** HS1 Ltd provides further substantiation for these items. [amber 20]

3.30. The relatively immature development of both scope and programme for renewals in CP3 has led us to conclude that some element of the CP3 renewals will be better phased into CP4 to give greater certainty of delivery and to free up capacity to deal with CP2 renewals that will now be delivered in CP3, due to slippage. [red 4]

3.31. There is a probability that some of the renewals scheduled for CP4, may need to be brought forward into CP3, or priorities may need to change within CP3. Therefore we

[10] Depending upon the mechanical/electrical design, operating context, environment and/or maintenance effectiveness, a machine's failure rate as a function of time may decline, remain constant, increase linearly or increase geometrically

recommend that HS1 Ltd reviews its strategy to ensure sufficient flexibility and resilience around the CP3 and CP4 renewals programmes. [amber 21]

Improvements required

3.32. In order to ensure the 5YAMS is consistent with its General Duty, it is necessary for HS1 Ltd to make adjustments to CP3 renewals. Our review suggests the following adjustments are appropriate, subject to consultee views [red 4]:

- 50% reduction of local release control, moving £225k of work into CP4;
- 50% reduction in Building Management Systems, moving £115k of work into CP4;
- reduction in UPS, integral rectifiers and batteries renewals by 50% by moving £3.85m of work into CP4;
- re-phasing of the supply contract overhaul for the MPV control system into CP4 to reflect the uncertainty around supply chain availability;
- 20% of £16.58m total ballast refurbishment moved into CP4; and
- open route drainage rephased over two control periods (£990k in CP3 and £990k in CP4).

Quantitative targets

3.33. The potential impact of the above changes are shown in Table 3.2.

Table 3.2 Potential adjustments to CP3 Renewals expenditure

Asset type	Number of projects in CP3	CP3 Estimate £m	Proposed move into CP4 £m
Track	4	14.3	3.3
Civils and Lineside	13	7.7	0.9
Signalling and Communication	12	16.8	
Electrical & Power	20 (3 provisional)	7.9 (excluding provisional items)	4.0
Rail Plant	5	2.1	4.7
Total	54	48.8	12.
Removed (under sleeper pads)[11]	1	-0.03	
Correction for incorrect pricing of inverter fans		-0.16	
Total		48.6	12.9

[11] One of the proposed track renewal projects (sleeper pads at £30k) was not in our view a renewal, rather it is a R&D activity and should be funded as such. We do however think that greater use of sleeper pads could bring greater resilience and life extension and should be a prime candidate for R&D funding.

Asset type	Number of projects in CP3	CP3 Estimate £m	Proposed move into CP4 £m
Numbers may not add up due to rounding			

Project management costs for CP3

Specific questions

3.34. Are project management cost estimates in line with best practice?

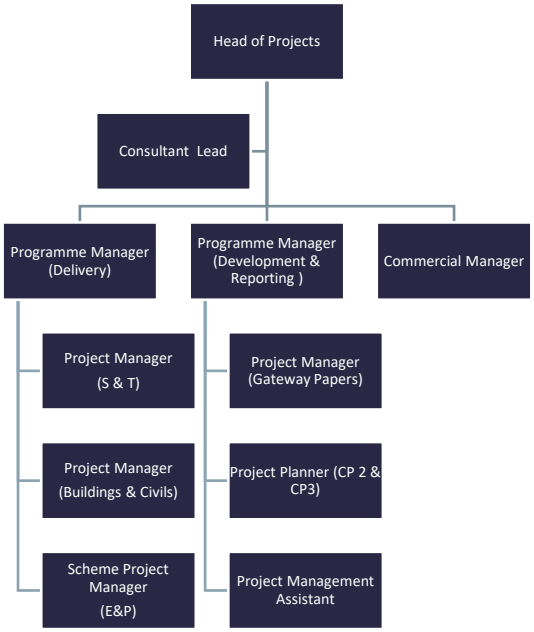
Detailed methodology

3.35. As well as our desktop review of the 5YAMS, we benchmarked the breakdown of project costs against recent renewals and enhancements projects by Network Rail Infrastructure Limited.

Summary of key information

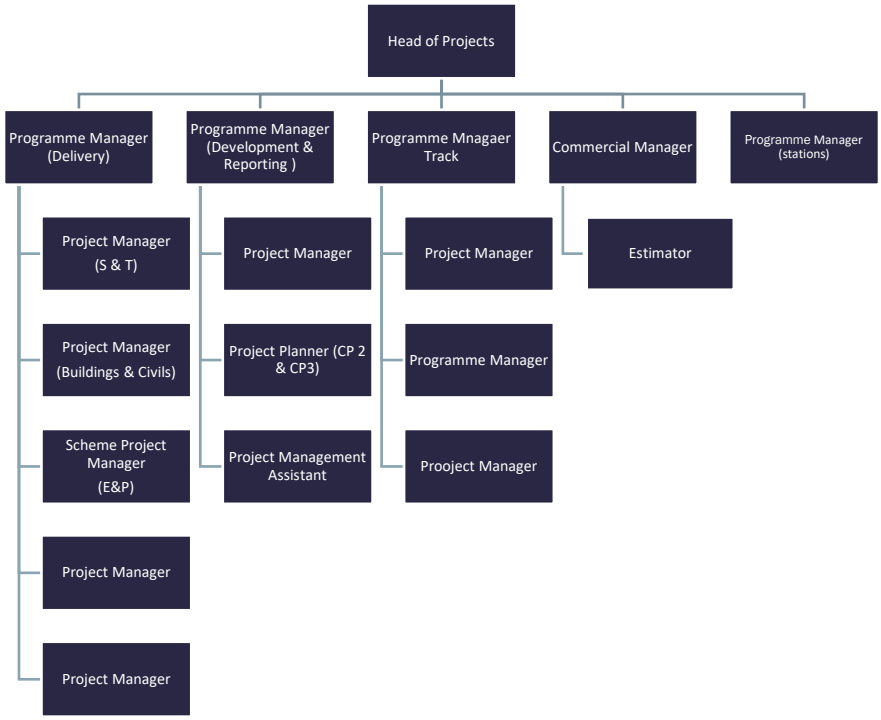
3.36. HS1 Ltd in its 5YAMS suggested that project management costs for CP3 would be around £9.4m (15%) of the renewal costs of £61.8m. This would increase the headcount of the project management office of NR(HS) from 11 to 17 route related roles (see Figures 3.4 & 3.5).

Figure 3.4 CP2 Dedicated renewals PMO organisational structure



Source: HS1 Ltd

Figure 3.5 CP3 Proposed PMO organisational structure



Source: HS1 Ltd

3.37. We benchmarked NR(HS)'s CP3 projects by activity, against the expected ranges for other similar rail projects. See Table 3.3.

Table 3.3 Comparison of percentage breakdown of project cost elements

	Works delivery cost elements					Additional costs elements		
	Average works costs	Average prelims	Average contractors margin	Average design fees	NR(HS) PMO costs	NR(HS) Margin	Other project costs	Risk %
CP3 Track	64%	6%	7%	8%	c. 15%	10%	8%	26%
CP3 Civils	65%	8%	7%	7%			1%	26%
CP3 S&C	58%	11%	8%	10%			-	26%
CP3 E&P	67%	4%	7%	5%			-	26%
CP3 Rail Plant*	75%	1%	8%	1%			-	26%
Network Rail Infrastructure Limited comparison **	50-65%	11-20%	5-7%	6-10%	8-12%	N/A	N/A	c. 13%

	Works delivery cost elements					Additional costs elements		
Repeatable Network Rail Infrastructure Limited building project.	c. 50%	c. 20%	c. 10%	c. 10%	c.10 %	N/A	N/A	10-15%
Numbers may not add up to 100% due to rounding. - Works costs and prelims could be considered as a total. *Rail plant is procurement activity - no significant design or project management fees. ** Figures for enhancements - may vary slightly against renewals (We would assume lower prelims, design and OHPs for renewals) and vary between programmes.								

3.38. Our benchmarking also compared the PMO headcount to the value of projects being delivered. Infrastructure Projects (Network Rail Infrastructure Limited's project delivery arm resource) plans work on a value of one person for every £1.5m of spend[12]. This would equate to:

Table 3.4 Calculation of PMO headcount using Network Rail Infrastructure Limited ratio

	Value of renewals over five years £m	Calculated Head count
5 YAMS Renewals spend proposed for CP3	61.8 (excluding risk)	9
Potential adjustments to CP3 renewals expenditure - Table 3.2	48.6 (excluding risk)	5

Findings

3.39. Increasing the headcount of NR(HS)'s project management office to 17 appears to be excessive for a portfolio of 54 projects (3 of which are provisional) over five years. We recommend that HS1 Ltd reviews this proposal. [amber 22]

3.40. We found that NR(HS)'s total project management costs are greater than would normally be expected, being in the region of 15%[13], as opposed to 8-12% for other UK rail projects. We therefore consider that the 5YAMS is inefficient in relation to these costs. [red 5]

[12] ORR Periodic Review of Network Rail Infrastructure Limited 2018 Supplementary document - Review of Proposed Costs, page 31

[13] Based on PMO costs of £9.4m and renewals of £61.8m as per Appendix 4 HS1 Ltd 5YAMS

Improvements required

3.41. As set out above, we would expect efficient costs to be in the region of 8-12% in order to be consistent with HS1 Ltd's General Duty. HS1 Ltd should review NR(HS)'s proposed project management costs in light of the lower values achieved by Network Rail Infrastructure Limited on UK rail projects. [red 5]

Quantitative targets

3.42. Our benchmarking against other UK rail projects indicated that project management costs should be reduced to circa 10% of the agreed renewals value in CP3. [red 5]

Renewals risk for CP3

Specific questions

3.43. A key focus of our review was to ensure that there had been no excessive compounding of risk by multiple adjustments being applied for:

- quantity of renewals to be undertaken;
- timing of the renewals being undertaken, that is, more often than required;
- underestimating or ignoring future technical gains in asset life;
- underestimating or ignoring future efficiencies from the use of robotics and artificial intelligence in asset maintenance activities;
- inflated base rates for renewals; and
- general risk percentages then applied on top

Detailed methodology

3.44. Following our desktop review of the 5YAMS, we benchmarked key risk values against other UK rail projects.

3.45. We commissioned Frazer-Nash to undertake a review of the portfolio Quantified Risk Assessment (QRA) of risks and opportunities performed by NR(HS).

Summary of key information

3.46. NR (HS) used the same approach as Network Rail Infrastructure Limited for calculating risk, using an industry standard QRA methodology. This method uses a measure of uncertainty based on the number of events that could be experienced during the control period, and their impacts. The key risks identified against each proposed CP3 renewal are as follows:

- availability of access due to late-running train services;
- non-UK transport and storage of materials;
- supplier & contractor costs: experienced supplier not in UK market, use of existing suppliers and economies of scale;
- change in policy & practices;
- other – delay payments to operators: unplanned disruption payments (under Schedule 8 of the track access contract) due to plant failure or planned disruption payments (under Schedule 4 of the track access contract) due to track re-ballasting;
- risks arising from HS1 portfolio management / tripartite decision making at each gate and project; and
- Network Rail Infrastructure Limited national contracts excluding the HS1 network.

3.47. Under the risk assessment methodology, each asset type has been assessed against these drivers to identify a low, spot and high estimate to calculate the potential cost range.

3.48. These estimates are used to construct triangular probability distributions for each of the main areas. These probability distributions are used in a Monte Carlo model to estimate the likelihood of delivering the renewals portfolio at the projected spend.

3.49. As a result of this analysis NR(HS) has proposed that an additional £17.7m (26%) allowance should be applied to the renewals portfolio to reflect risk and uncertainty. We have compared this figure against the risk allowances for other similar projects. These comparisons are presented in Table 3.5.

Table 3.5 Comparison of risk and uncertainty percentages

Item	Risk and Uncertainty
NR(HS) operations and maintenance	4.3%
NR(HS) renewals	26%
Total operations, maintenance and renewal	10.7%
Network Rail Infrastructure Limited South East Route – operations, maintenance and renewal	6.5%
Network Rail Infrastructure Limited England and Wales – operations, maintenance and renewal	6.4%
Private sector rail industry comparator for operations, maintenance and renewal	7%

3.50. Being a relatively small business with a limited number of renewals, we note that there are fewer opportunities to spread risk than there would be with a larger portfolio of projects.

3.51. Based on the above benchmark comparisons we asked Frazer-Nash to take a view of what a suitable risk allowance for CP3 would be. It considered that cost uncertainty can be considered at three levels:

- base cost estimating (initial labour, plant and materials estimates, working assumptions etc.);
- efficiency risks (asset specific risks that materialise once the site and scope of work are defined and contracts are let, causing variance to the base estimate); and
- delivery risks (higher-level cross-asset risks; changes to legislation; change in exchange rates etc.).

3.52. Fraser-Nash developed a high level review of the key risks of a representative sample of renewals planned for CP3. There findings are shown in Table 3.6.

Table 3.6 Base cost uncertainty for sample projects

Asset Type	Value £m	Uncertainty	Comments
Civils	5.95	L-M	The work types are straightforward. Some cost uncertainty around access road length is covered by assumption.
E&P	12.78	M-H	£5.34m linked to ROM costs for plant/machinery works (agreed with Head of Profession) and represent high uncertainty. Balance is UPS replacement works and an assumed split of different sized installations (medium uncertainty).
S&T	16.06	M-H	£3.4m costed by HS1 Ltd based on CP2 experience (low uncertainty). £8.1m with no breakdown or provenance provided (including £1.47m ROM estimate as quote not provided by equipment supplier) represents high uncertainty. The balance (£4.55m) has some supporting material, in part based on CP2 materials supply, but estimate refers to clamplock rather than HPSS points operating equipment.
Track	16.00	L	Reasonable volume of work, based on Network Rail Infrastructure Limited norms. Includes provision for additional effort to meet tighter tolerances for high speed. Limited access required to Network Rail Infrastructure Limited high output equipment and Eurotunnel locomotives (compatible signalling) considered nominal risk

Source: Frazer-Nash

3.53. Frazer-Nash's analysis found that the upside opportunities are relatively small with larger downside risks.

3.54. Within the cost uncertainty, Frazer-Nash concluded that it was probable that there was double counting in a number of areas including:

- changes in policy and practices e.g. asset policies, fatigue management or new standards, where an uplift could be applied twice to track;
- where the uplift for track and structures costs may already be included in the catch-all "HS1 portfolio management / prolonged decision making, multiple stakeholders, lack of settlement as per Network Rail Infrastructure Limited impacts ability to deliver the programme" applied to all assets; and
- identification of two references in track covering work site locations contained within "availability of access" and "understanding of maintenance and/or renewals workbanks".

3.55. The financial impacts of the above items are obscured by NR(HS) Monte Carlo analysis which makes them difficult to fully quantify.

Findings

3.56. While we found that that a robust risk assessment methodology had been followed, we feel that NR(HS) had been unduly pessimistic in assessing the probability of a risk occurrence and/or its impacts for risk that are in part within its control or ability to influence. [red 6]

Improvements required

3.57. HS1 Ltd should further reduce the proposed risk allocation for CP3. [red 6]

Quantitative targets

3.58. Ultimately calculation of risk is a matter of judgement and whilst we are in agreement that the HS1 network is unique in the UK, we are also of the view that the renewals being put forward for CP3 are in the main of a similar nature to that previously carried out in the UK.

3.59. From an assurance perspective, it is not possible to calculate a definitive risk number without undertaking a detailed risk assessment, and development of mitigations and costings - in effect a fully detailed QRA. We have however concluded, based on our benchmarking comparators and Frazer-Nash's finding, that the proposed risk allowance is inefficient and should be revised.

3.60. Applying a total risk percentage in line with comparators would suggest reducing the CP3 renewals risk allowance to the region of 13% to give an overall average of around 7% across operating, maintenance and renewals. In doing so it is important to acknowledge that within the CP3 renewal portfolio there is not an even distribution

of renewal projects costs. Five of the proposed 51 projects make up over 50% of the total renewals costs. Therefore should one of these projects experience a significant risk event then this could have a detrimental impact on the funding of the remainder. This is balanced in our view by none of the CP3 renewals being of a complex nature; the proposed renewals being generally of a repetitive nature; and NR(HS) being an experienced supplier in the rail industry. NR(HS) is also backed by Network Rail Infrastructure Limited, whose own benchmarking[14] comparisons show that it has consolidated its position as an example of best practice in strategic planning among European railways and UK utilities.

Research and development

Specific questions

3.61. None (consistency with best practice; timely, efficient and economical manner).

Detailed methodology

3.62. See general methodology.

Summary of key information

3.63. HS1 Ltd's stated asset policy is to strive to provide best-in-class asset stewardship and adopt a pioneering approach to problem solving and development.

3.64. HS1 Ltd's 5YAMS does not include specific funding for R&D for CP3, unlike in CP2. NR(HS) highlighted that to realise further savings, structured long-term investment in people and technology is required. We challenged HS1 Ltd on this statement, given that Network Rail Infrastructure Limited has considerable R&D programmes. We were advised that NR(HS) had engaged with Network Rail Infrastructure Limited regarding R&D programmes. While a full review of schemes had not been conducted, the differences between standards and systems between Network Rail Infrastructure Limited and NR(HS) had in the past challenged the adoption of some of these technologies, although NR(HS) reports that it is in discussion with other high speed networks to identify areas of best practice that could be easily adopted.

3.65. While we found that R&D undertaken in CP2 had so far only demonstrated limited benefits, we considered that there would be a longer-term incentive for R&D funding in CP3 to develop methodologies such as those that would extend track life and avoid mass sleeper replacement. The potential financial benefit of such methodologies could be significant. AMCL in its assessment of asset management

[14] Network Rail Infrastructure Limited Asset Management Policy, January 2018

excellence highlighted the need for HS1 Ltd to encourage NR(HS) to innovate over the longer-term by enabling NR(HS) to share in any realised future benefits that result from their innovations.

3.66. We were also informed that the current uncertainty around possible market testing for operations, maintenance and renewal activity was restricting NR(HS)'s ability to build an internal business case for HS1-specific R&D activities that might require a pay back over several control periods. It is important that there are no cross-subsidies between public and private sector to prevent state aid leakage. If HS1 Ltd is to benefit from Network Rail Infrastructure Limited's wider investment in R&D then there is a need to ensure that it is a contributor.

3.67. Good asset management demands innovation. By its very nature, the discipline should always be looking to the future. This is true for exploring the potential application of the latest technologies or planning repetitive asset interventions for the next 40 years. The nature of R&D activity means that returns are not certain and that many are likely to accrue in future control periods. There must be a clear line of sight between proposals for R&D and outcomes, including steps to define and track potential benefits.

3.68. HS1 Ltd has stated that, unlike its CP2 submission, any R&D projects in CP3 must be self-funding.

Findings

3.69. It is important that a firm commitment to maintaining adequate levels of R&D investment in CP3 and beyond is made by HS1 Ltd. Without investing in adequate levels of R&D it is unclear how HS1 Ltd's asset policy can be achieved. [red 7]

3.70. We recommend that any R&D governance process should regularly review benefit realisation and challenge investments. This could be achieved by the establishment of an R&D review panel made up of HS1 Ltd along with funders and stakeholders. In addition we believe that there are opportunities for third party funding of R&D that could be explored by HS1 Ltd. [amber 23]

Improvements required

3.71. HS1 Ltd should commit to investment in R&D, through a reliable funding mechanism. [red 7]

Quantitative targets

3.72. Our concern is around the lack of a funding mechanism for R&D, rather than the magnitude of R&D funding. Hence we have not attempted to quantify a change to the total cost.

4. Renewals in CP4-CP10

Renewals planning for CP4-CP10

Specific questions

4.1. None (consistency with best practice; timely, efficient and economical manner).

Detailed methodology

4.2. See general methodology.

Summary of key information

4.3. HS1 Ltd commissioned Bechtel to develop a 35-year plan (CP4-CP10) covering the anticipated renewal interventions required on the HS1 network over this period. This renewals deliverability study comprised two phases. The first phase set an outline strategy for renewals delivery, and established frameworks for the team to build upon in the second phase looking at pricing and deliverability.

4.4. The Bechtel study in particular sought to:

- confirm that the renewals are deliverable with limited disruptive access;
- develop the HS1 Plan – a high-level master plan for the renewals workbank with an estimated cost; and
- make recommendations for further development.

4.5. The renewal methodology aims to implement renewals in the current available engineering access periods within the timetable, including and accounting for potential impacts of single-line working. Access constraints defined the volume, plant and labour requirements. The methodology focussed on using high-output plant on a seasonal basis with proposed options for potential locations for conducting the logistics of the renewal operations.

4.6. The Bechtel study, as part of the deliverability study assumed that HS1 Ltd would adhere to asset stewardship best practice and plan for 40 years as required by the Concession Agreement. The total costs for CP4 to CP10 renewals submitted by HS1 Ltd were built up as follows:

- Direct costs: plant, labour and materials to deliver the renewal volumes (the Rate Book in the deliverability study).

- Tier 2 management fee of 10% of direct costs. The Tier 2 contractor is responsible for the delivery of the works. Includes management, engineering, accommodation etc.

- Client contingency at 30% of total contracted costs (direct costs + Tier 2 management and fee) covering regulatory/political changes, missing scope, escalation, currency depreciation etc.: 30% is the figure recommended by Bechtel on the basis of its global cost database and infrastructure project experience.

- Delivery integrator cost based on estimated headcount to deliver the Integrator role.

4.7. The proposed volumes and productivity rates were stated as being in line with international industry practice, which approximately triples the volumes traditionally achieved in the UK, and is estimated to be 33% more efficient than the existing UK rail sector. The deliverability study did not consider the proposed upgrade of the signalling system.

4.8. The study's aim was stated as providing innovative, but achievable, solutions that would allow HS1 Ltd to implement the renewal programme with minimal disruption to operational service. It verified that performing the works without disrupting the service is largely achievable and defined the challenge to the supply chain for the elements of work for which this is not currently achievable.

4.9. At this very early planning stage the preliminary cost were indicative / conceptual estimates with a -50%/+100% level of accuracy. The CP4 to CP10 calculation is based on the best estimate of £1,442 million as set out in Table 4.1, including replacement of the signalling system. Each of the cost elements had an associated level of uncertainty used by HS1 to estimate the range for each element.

Table 4.1 CP4 to CP10 renewal costs

Costs £m 2018 prices	Low	Best Estimate	High
Direct costs -30% to +50%[1]	586	837	1,256
Tier 2 management and fee -50% to +100%	42	84	167
Total contracted costs	628	921	1,423
Client contingency / risk -30% to +50%	193	276	415
Total managed costs	821	1,197	1,838
Delivery integrator / Project Management costs -30% to +50%	167	239	358
Totals	989	1,436	2,196
Preparation and planning in CP3 – 30% to +50%	4	6	8
Total	992	1,442	2,204
[1]Includes £90m for replacement of signalling system. Numbers may not add up due to rounding			

Source: HS1 Ltd 5YAMS

Findings

4.10. We found the planning methodology for renewals in CP4-CP10 to be in line with best practice (noting the issues around the input design lives, discussed in the section on Asset life planning). [green]

Renewals pricing for CP4-CP10

Specific questions

4.11. None (consistency with best practice; timely, efficient and economical manner).

Detailed methodology

4.12. Following our desktop review of the 5YAMS, we commissioned Frazer-Nash to review Bechtel's direct costs methodology.

Summary of key information

4.13. Frazer-Nash found that CP4-10 direct costs had been generated by reference to Bechtel's own rate book for the deliverability study using building blocks such as access requirements; volumes of work; construction sequencing; and plant and labour requirements to develop bottom-up cost estimates for each renewal activity.

4.14. The use of cost overlays for CP4-10 broadly followed the same principles as those applied by NR(HS) for CP3. Frazer-Nash identified that there were, however, some additional layers, and that there was therefore the potential for double counting. For example, the Delivery Integrator overlay was taken to be equivalent to the role currently performed by NR(HS) and its management fee. HS1 Ltd's renewal project management costs are a function of the Delivery Integrator. There was potentially a further overlay line item that covered planning and mobilisation that would, at least in part, be expended in CP3. These two items represent costs of up to £107.9m.

4.15. Bechtel made a number of productivity assumptions to generate the base cost estimate. This was achieved by using lower rates than those used by NR(HS). For example, the basic track labour rate was lower than that used for NR(HS)'s CP3 5YAMS, and train driver rates were significantly less with minimum shifts likely to be 8 hours midweek and 12 hours at weekends. If a continental contractor were to be engaged to undertake the track renewal programme, shift rates are likely to be lower than their UK equivalent, however, provision for subsistence and home leave travel would need to be incorporated.

4.16. Material rates generally looked reasonable but there were some inconsistencies in key areas that will need further review by HS1 Ltd.

4.17. Frazer-Nash concluded that:

> *For CP4+, the methodologies for delivery on site have been well thought through and clearly presented. The proposed base estimate costing is optimistic with a generous uncertainty factor applied. The underlying labour rates are generally lower in comparison with CP3 estimates and there are some significant, clearly stated, cost omissions e.g. provision for a materials handling depot to support the increasing workload. Proposals for transportation of materials from source to worksite (and associated costing) are not shown. These omissions should be covered by the uncertainty factor but it is important that stakeholders understand that the actual base costs will be higher than predicted but are unlikely to be as high as the base estimate plus uncertainty*

Findings

4.18. The Bechtel documents provided a logical, comprehensive and detailed build up to the costs with a clear understanding of how the works could be delivered. The labour rates used were variable and looked to be low or very low in many areas compared to that currently being achieved in the UK against European comparators (although this needs to be seen in the wider context of different countries' legislation). [green]

4.19. There were some specific omissions in Bechtel's assumptions. In particular no provision had been made for a materials handling depot to support what will be a significant ramp up in work compared with earlier control periods. We **recommend** that HS1 Ltd should be aware of this and should ensure that stakeholders do not become solely focussed on the low base cost numbers by explaining clearly that the CP4-10 direct costs contain a number of omissions and is based on certain assumptions that will need to be quantified during CP3 and that these may either a positive or negative cost impact. See section on CP3 preparations for CP4-10 for further details. [amber 24]

4.20. This document does not consider the overall efficiency challenge for HS1 Ltd in CP4-10, including any productivity and technological change considerations. This is considered in the financial framework supplementary document.

Treatment of implementation of new signalling system

Specific questions

4.21. Should the proposed implementation of the ETCS Level 3 system be treated as a Renewal or a Specified Upgrade under the Concession Agreement?

Detailed methodology

4.22. See general methodology.

Summary of key information

4.23. The signalling control system used on the HS1 network uses an in-cab signalling system as used on the French high speed network, and coloured light signals used at London St Pancras International. While HS1 Ltd, Getlink (the owner of the Channel Tunnel), Société Nationale des Chemins de Fer français (SNCF) and Infrabel have the same basic system, there are currently five different signalling variants. This means a train operator must carry out safety validations of its systems on each of the five before it is allowed to run on the London-Brussels route. The time and cost of carrying out these checks is seen as a barrier to encouraging more international traffic on to the railway.

4.24. Each infrastructure manager's signalling system expires at a different time. SNCF and Infrabel must replace their systems by 2028 to 2030, while the existing signalling and train control system on HS1 is anticipated to reach its end of life in CP6 (2035 to 2040) as stated in the NR(HS) Specific Asset Strategy – Signalling & Communication System.

4.25. The types of systems currently used by HS1 Ltd, Getlink, SNCF and Infrabel are the target of gradual replacement with the European Train Control System (ETCS), a European standard signalling system intended to replace all 'legacy' European signalling systems over the coming decades.

4.26. HS1 Ltd is proposing to install, test and commission ETCS in 2032, when the existing system reaches its 25-year design life.

4.27. The project to upgrade to the ETCS signalling system has been estimated at around £500m across the four operators with HS1 Ltd pricing the UK section at around £90m

4.28. The expected change to ETCS Level 3 was included in HS1 Ltd's PR14 5YAMS as a Specified Upgrade under the Concession Agreement. However, for PR19, HS1 Ltd proposes that the installation of ETCS is driven by obsolescence and not by a need to upgrade the current system and so should now be classified as a renewal.

4.29. Below are set out the relevant definitions in the Concession Agreement[15] :

"Renewal and Replacement": means the substitution or replacement of an asset comprised in the HS1 Railway Infrastructure with an asset or part of an asset of the

[15] Concession Agreement, Schedule 10 1.0 Definitions

same type or equivalent to the asset comprised in the HS1 Railway Infrastructure from time to time consistent with HS1 Co's General Duty, and excludes Specified Upgrades and any other upgrades;

"Specified Upgrades": means major upgrades of the signalling system, control systems or trackform for:

(a) HS1 comprised in the HS1 railway infrastructure, including any such upgrades required in connection with the implementation of a TSI requirement; and/or

(b) the Network Rail Infrastructure Limited network, where such upgrades are a consequence of the implementation of a TSI requirement and are required to be undertaken pursuant to a maintenance contract with Network Rail;

4.30. In its 5YAMS, HS1 Ltd gave the following reasons for proposing that ETCS should be treated as a renewal:

" - We do not propose to undertake a major upgrade of the existing signalling system. Rather, we intend to replace the existing signalling system with equivalent technology in advance of the date of the existing system's obsolescence, which is currently forecast to be around 2035;

- We do not expect that ERTMS [European Railway Train Management System, comprising ETCS and in-cab technology] will provide significant additional capacity or substantial operational benefits other than those that are inherent in a modern signalling system; and

- The installation of ERTMS is not driven by the need to implement a TSI requirement. HS1's current signalling system is not TSI-compliant. Having reviewed the market and the research conducted by SNCL, we have formed the view that we could implement either a TSI-compliant or non-TSI-compliant system when we replace the current signalling system, subject to relevant approvals. It is unlikely that a non-TSI-compliant system would be commercially available and viable at the date of the replacement of HS1's existing system."

4.31. HS1 Ltd explained that it took a different approach in PR14, because *"ERTMS was believed to offer significant operational advantages over the current system that would require us to bring forward an enhancement to the network".*

4.32. HS1 Ltd's proposal to reclassify from a Specified Upgrade to a renewal is broadly supported by a report that it commissioned from SNC Lavalin. That report concluded that:

"…. The purpose of this study was to create an 'order of magnitude' business case for the change of the HS1 train control system. The analysis shows that, based on the currently available information, there is no requirement to replace the existing TVM / KVB based system before 2035. In 2035 an ERTMS Level 3 solution would be the most beneficial option, however the decision to change at that point would still be due to obsolescence of the existing system rather than financial benefits of doing so.

…. It is unlikely that changing the train control system alone will allow HS1 to reliably provide additional capacity on the route. Assessment of other infrastructure restrictions such as power, station capacity and the physical track layout will be required. If the driver for changing the train control system is capacity then the business case should be structured around the costs and benefits of all the changes required to release the additional capacity, of which modifying the train control system is one element."

4.33. We have considered HS1 Ltd's proposal against our understanding of ETCS. We consider ETCS to be a major upgrade of the signalling system as it provides an increase in functionality. The current TVM / KVB system is broadly equivalent to ETCS Level 2, using a track-based train detection system to define block sections. ETCS Level 3 will be the safest and most efficient system available at the time of the change, requiring no trackside equipment and allowing for improved ability to adjust speeds to either enhance or recover performance more quickly.

Improvements required

4.34. HS1 Ltd should begin planning for ETCS signalling replacement as a Specified Upgrade. [amber 25]

Renewals risk for CP4-CP10

Specific questions

4.35. A constant risk allowance has been set for CP4-CP10. We sought to determine if this value was reasonable.

Detailed methodology

4.36. Following our desktop review of the 5YAMS, we commissioned Frazer-Nash to review the application of risk to cost estimates.

Summary of key information

4.37. Risk / contingency has been set at a blanket 30% for CP4-10.

4.38. Frazer-Nash highlighted that the Bechtel costing had a number of significant exclusions that would have to be funded. These included:

- some significant gaps in methodology as no provision had been made for a materials handling depot to support what will be a significant ramp up in work compared with earlier control periods;
- how materials will be delivered to site or trans-shipped from Network Rail Infrastructure Limited-gauge vehicles to European gauge plant was not clear;
- the labour rates used were variable and look to be low or very low in many areas; and

4.39. While there were some specific omissions in Bechtel's assumptions, it is likely that a contingency allowance would cover these. How this should to be treated within the annuity calculation is addressed in our separate supplementary report on the financial framework for CP3.

Findings

4.40. Frazer-Nash concluded that the 30% blanket risk allocation appeared to be high, though offset to some extent by Bechtel's use of very low base costs. We recommend that HS1 Ltd revisits the allocation of risk for CP4-CP10. See our supplementary document setting out our financial framework findings, for our proposed treatment of this item. [amber 26]

Delivery agents, project management and Tier 2 fees for CP4-CP10

Specific questions

4.41. None (consistency with best practice; timely, efficient and economical manner).

Detailed methodology

4.42. See general methodology.

Summary of key information

4.43. HS1 Ltd has proposed adopting a delivery integrator model to facilitate it delivering longer term renewals. Under this model HS1 Ltd would appoint a partner organisation that would then undertake renewals project management using Tier 2 supply contracts let by HS1 Ltd. How delivery risk is to be allocated is still to be determined by HS1 Ltd.

4.44. Our review of CP3 renewal costs concluded that project management costs should be in the region of 8-12% depending on the complexity of the projects being delivered. A fee for the PMO function would then be charged. Under the Operator Agreement, a 10% margin on all renewals costs is added to the project management fee. On this basis we consider that a total of 20% of the renewal cost for project management is a reasonable allowance at this early stage, although under a competitive market test it is not unreasonable to expect that this could be reduced.

4.45. Other options for project management were also set out in the Bechtel study:

- HS1 Ltd to directly manage Tier 2 contractors – this involves a higher level of risk as HS1 Ltd could be more liable for any issues happening in the field.
- HS1 Ltd to contract to a Tier 1 general contractor – this structure could pass more risk to the Tier 1 contractor to manage and pass on to Tier 2 suppliers.
- delivery partnership led by HS1 Ltd – a structure with a delivery partner who would supply HS1 Ltd's gaps in its organisation. The renewal would still be led by HS1 Ltd so the company may take on more risk than the delivery partner.
- delivery partnership led by the delivery partner – this method would be like the above structure but have more delivery partners within the project organisation and be led by the delivery partner. In this case, the delivery partner could take more risk than HS1 Ltd.

4.46. This report seeks to establish whether the planning allowance put forward is justifiable. How this is to be treated within the annuity calculation is addressed in our separate supplementary report on the financial framework for CP3.

4.47. Simple benchmarking of Bechtel's estimate against typical railway renewal costs indicated that suppliers and Tier 2 contractors would be seeking a fee of around 10%.

Findings

4.48. At this stage we are unable to offer a definitive view on whether the delivery integrator approach would deliver the best outcome, only that it is one of a number of options that HS1 Ltd could adopt. Regardless of the strategy adopted there will be a cost attached to it. Other options as set out in the Bechtel study might offer better allocation of risk and value for money. [green]

4.49. We **recommend** that the final agreed approach needs to be subjected to a compelling business case strategy supported by a competitive tender process to ensure funders are not being asked to pay an inappropriate premium for any risk

transfer. It would be a concern if the final model selected led to a significant dilution of HS1 Ltd's accountability under the Concession Agreement. [amber 27]

4.50. We agreed that the estimated Tier 2 costs are reasonable, although they would be driven by the supply and demand factors prevalent at the time of tender. [green]

CP3 preparations for CP4-CP10

Specific questions

4.51. None (consistency with best practice; timely, efficient and economical manner).

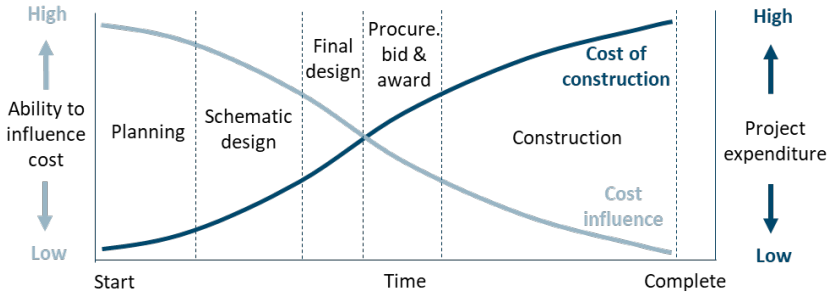
Detailed methodology

4.52. See general methodology.

Summary of key information

4.53. The Bechtel deliverability review identified the requirement to undertake preparation and planning in CP3 in order to deliver CP4-10. Bechtel suggested that this would be in the order of £6m. How this figure was derived was not clear, but it would equate to around 0.7% of the total estimated contracted renewal costs (5% of planned CP4 renewals). Accepted project management theory is that money spent in the early stage of project planning has the maximum influence on the total project cost, as shown in Figure 4.1.

Figure 4.1 Cost Influence Curve



4.54. HS1 Ltd has included £5.6m in CP3 to develop sufficient capability to deliver works in CP4 based on the Bechtel methodologies.

Findings

4.55. The cost review (discussed in the section on Renewals planning for CP4-CP10 and the section on Renewals pricing for CP4-CP10) concluded that Bechtel's methodologies were plausible but aggressive, in terms of the productivity they expect to achieve and the low base unit rates. More importantly, Bechtel's delivery plans rely on plant or technology which are not currently available to NR(HS) and NR(HS) is not

able to commit to meeting the productivity levels set out in the Bechtel plan. [amber 28]

We **recommend** that any market study are concluded as soon as possible, to provide certainty around the deliverer for CP4 (at least). HS1 Ltd then needs to agree its delivery strategy with funders early in CP3, to ensure readiness for CP4 and beyond.

5. Our draft conclusions

Is the 5YAMS in line with HS1 Ltd's General Duty?

5.1. While the majority of content in the 5YAMS was considered in line with best practice, we noted seven specific items which require improvements (with potential cost implications).

5.2. We have also provided 28 recommendations requiring follow-up activities or additional evidence to support decisions in the 5YAMS.

5.3. Table 5.1 sets out the areas with proposed improvements or recommendations:

Table 5.1 List of recommendations and proposed areas for improvement

Chapter	Subject	Recommendations (amber)	Improvements (red)
1	**Asset Management**		
	Asset Management Capability	3	0
	Asset Stewardship	2	0
	Asset life planning	0	1
	Asset-specific procedures and standards	1	0
	Condition, capability and capacity of assets to be maintained	1	0
	Whole Life Costing	1	0
	Specific asset strategies	3	0
2	**Operations & Maintenance**		
	Operations and maintenance capability	0	0
	Operations and maintenance risk	1	0
	Operations and support costs	1	0
	Maintenance costs	5	0
	Operations and Maintenance Efficiencies	1	0
3	**Renewals in CP3**		
	Renewals pricing for CP3	0	2
	Renewals programme and delivery for CP3	2	1
	Project management costs for CP3	1	1
	Renewals risk in CP3	0	1
	Research and development	1	1
	Renewals in CP4-CP10		

Chapter	Subject	Recommendations (amber)	Improvements (red)
4	Renewals planning for CP4-CP10	0	0
	Renewals pricing for CP4-CP10	1	0
	Treatment of implementation of new signalling system	1	0
	Renewals risk for CP4-CP10	1	0
	Delivery agents and project management for CP4-CP10	1	0
	CP3 preparations for CP4-CP10	1	0

What are our proposed improvements and recommendations?

5.4. Our proposed improvements and recommendations, for consideration by HS1 Ltd in its response to this draft determination, are listed in Table 5.2 and Table 5.3 below.

Table 5.2 List of proposed improvements

Item	Chapter	Brief description of improvements for HS1.
1.	1	Sensitivity analysis of assumed design lives for track assets and consider condition based renewals to be undertaken by HS1 Ltd.
2.	3	HS1 Ltd to consider alternative estimating strategies, to incentivise cost reductions for renewals.
3.	3	HS1 Ltd to address specific corrections to Mechanical and Electrical renewals costs.
4.	3	HS1 Ltd to consider specific items to move from CP3 to CP4, or remove.
5.	3	HS1 Ltd to review project management costs, in light of benchmarking
6.	3	HS1 Ltd to reduce risk allowance on CP3 renewals, in light of benchmarking
7.	3	HS1 Ltd to commit to investment in R&D

Table 5.3 List of Recommendations

Item	Chapter	Brief description of recommendation for HS1 Ltd	Action by date
1.	1	HS1 Ltd to develop an action plan with set milestones for implementation in CP3 of the recommendations contained within the wider AMCL's report.	Plan to be developed by end March 2020.

Item	Chapter	Brief description of recommendation for HS1 Ltd	Action by date
2.	1	Undertake a follow up review of progress towards ISO55001	By end of Year 3 in CP3.
3.	1	Future 5YAMS to document and demonstrate the assurance activities HS1 Ltd has undertaken on suppliers' contributions.	In advance of CP4 5YAMS submission.
4.	1	HS1 Ltd to update their Asset Management Policy with current status and CP3 targets/milestones	By end Jan 2020.
5.	1	AMOs should be subject to review at a suitable frequency	Plan & programme to be developed and agreed by end March 2020.
6.	1	SAMP should outline how the stated aims will be achieved and by when.	At next revision or no later than end of December 2020.
7.	1	SASs should present the expected asset condition at end of control period, handback and end of the 40 year plan.	At next revision or no later than end of December 2020.
8.	1	Regular feedback of ADST outcomes should be shared with stakeholders by HS1 Ltd.	Plan & programme to be developed and agreed by end March 2020.
9.	1	Additional consideration of remote or automated monitoring should be given by HS1 Ltd.	At next revision or no later than end of December 2020.
10.	1	Additional consideration of efficiencies, outside normal railway practice should be undertaken by HS1 Ltd.	By end Sep 2020.
11.	1	HS1 Ltd to set out the minimum asset data requirements and then report on data quality annually	At next revision or no later than end of December 2020.
12.	2	HS1 Ltd to review operations and maintenance risks ownership with funders.	Plan & programme to be developed and agreed by end March 2020.

Item	Chapter	Brief description of recommendation for HS1 Ltd	Action by date
13.	2	Provide a resource programme with milestones for NR(HS) resilience of key risks workstream.	At next revision or no later than end of December 2020.
14.	2	Maintenance frequencies to be revisited as more HS1-specific failure data becomes available.	During CP3.
15.	2	HS1 Ltd to follow up on water ingress issues identified on site visits.	By end Dec 2019.
16.	2	HS1 Ltd to review incentives and monitors of efficiency in maintenance.	Plan & programme to be developed and agreed by end March 2020.
17.	2	HS1 Ltd to review incentives used to maximize asset life before required renewal.	Plan & programme to be developed and agreed by end March 2020.
18.	2	HS1 Ltd to commission an independent review into the effectiveness of their Quality Assurance Board.	By end of year 1 of CP3.
19.	2	HS1 Ltd to explore with stakeholders if network optimisations could yield lower overall maintenance cost and lower performance penalties.	Plan & programme to be developed and agreed by end March 2020.
20.	3	HS1 Ltd to provide further evidence to substantiate a number of highlighted renewals in CP3, should they still believe that they are critical.	In response to Daft Determination.
21.	3	HS1 Ltd to ensure flexibility and resilience to changes to renewals programme (within CP3 and to/from CP4).	Plan & programme to be developed and agreed by end March 2020.
22.	3	HS1 Ltd to review NR(HS) PMO headcount, in light of Network Rail Infrastructure Limited benchmarking.	In response to Daft Determination.
23.	3	HS1 Ltd to establish R&D panel to review benefits and investments.	Plan & programme to be developed and

Item	Chapter	Brief description of recommendation for HS1 Ltd	Action by date
			agreed by end March 2020.
24.	4	HS1 Ltd to ensure awareness that Bechtel's CP4-10 direct costs contain a number of omissions and assumptions that will need to be quantified during CP3.	In response to Daft Determination.
25.	4	HS1 Ltd should begin planning for ETCS signalling replacement as a Specified Upgrade.	Plan & programme to be developed and agreed by end March 2020.
26.	4	HS1 Ltd to review blanket 30% risk, See ORR Periodic Review of HS1 Ltd 2019 (PR19) supplementary document setting out our financial framework findings.	In response to Daft Determination.
27.	4	HS1 Ltd to agree business case with stakeholders for CP4-10 PMO model.	Plan & programme to be developed and agreed by end March 2020.
28.	4	HS1 Ltd to aim to conclude market study as soon as possible, to allow time for investment in CP3 to be ready for start of CP4	Plan & programme to be developed and agreed by end March 2020.

What impact could these actions have on costs?

5.5. For each proposed improvement we have provided a quantified estimate of the possible impact on the total operating, maintenance and renewal costs. These are intended to provide an approximate target for HS1 Ltd when assessing our proposed improvements (see Tables 5.4 & 5.5) – these are not detailed bottom-up estimates.

Table 5.4 Estimated impact of proposed changes to CP3 renewals

Item	£m
CP3 Proposed renewals (see Table 3.2)	48.6
NR (HS) Margin of 10%	4.9
Risk of 13%	6.3

Item	£m
PMO of 10%	4.9
Sub total	64.7
Efficiency challenge of 1.8%	-1.2
Target Total	63.5
Work carried forward / deferred adjustments (Table 56 of 5YAMS)	-0.9
Application of risk, PMO and efficiency adjustments on work carried forward / deferred of 20%.	-0.2
Preparation and planning for CP4-10 (section 4.6 of 5YAMS) to be expended in CP3	5.6
Total	68
Numbers may not add up due to rounding	

5.6. Our quantified cost impacts for CP3 & CP4-10 are summarised in Table 5.5.

Table 5.5 Quantified cost impacts

Chapter	Subject	Change
1	Asset life planning CP4-10	10% reduction in total renewals direct cost
3	CP3 renewals efficiency	1.8% efficiency on total CP3 renewals cost
3	Renewals programme and delivery for CP3	Adjustment of around £12.9m of renewals from CP3 to CP4
3	Project management costs for CP3	5 percentage points reduction in PMO costs
3	Renewals risk in CP3	13 percentage points reduction in risk on CP3 renewals
3	Research and development	Not quantified
4	Risk / contingency / efficiencies CP4-10	See ORR Periodic Review of HS1 Ltd 2019 (PR19) supplementary document setting out our financial framework findings.

This publication is available at orr.gov.uk

Any enquiries regarding this publication should be sent to us at orr.gov.uk