Europe Economics

Analysis to inform ORR's RIS3 Efficiency Review –

Lot 5: Economic Advice

Final report

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Contents

1 Introduction

Europe Economics has been commissioned by the Office of Rail and Road (ORR) to assess National Highways' approach to financial risk assessment and overall approach to risk for RIS3. This includes assessing how risk is considered and modelled in both project-level cost estimates and at a programme- or portfolio-level, as well as assessing National Highways' approach to holding and managing risk budgets, allowances and/or contingencies.

This report presents our review of National Highways' approach as set out in its interim draft Strategic Business Plan (hereinafter the "dSBP").

1.1 Background and objectives of the review

National Highways (formerly known as Highways England) is the body responsible for operating, maintaining and improving the strategic road network (SRN) (motorways and major A roads) in England. It was established in April 2015 and operates as a government-owned, arm's-length company delivering and contributing to the government's long-term plan for the road network.[1] The current road investment strategy (RIS2) covers the second road period (RP2) since the roads reform package of 2015 and runs from April 2020 to March 2025. RIS3 is expected to cover the period from April 2025 to March 2030.

National Highways receives funding from the Department for Transport (DfT) in five-year cycles, called Road Periods. The funding is fixed in nominal terms (i.e. it is not adjusted for inflation). This is in contrast with the funding arrangements in many other regulated sectors in the UK where companies typically receive an allowance in real terms meaning that it is updated to reflect outturn inflation.

As set out in the government's road reform package in 2015, ORR is responsible for monitoring and enforcing the performance and efficiency of National Highways. In addition, ORR also advises the government on the development of the Road Investment Strategies (RIS), including advice on setting challenging and deliverable efficiency targets.[2] Therefore, ORR plays a key role in reviewing and challenging National Highways' strategic business plan to deliver the government's requirements in an effective and efficient manner. As for the current RIS, this includes conducting an Efficiency Review whereby ORR provides advice to the Secretary of State on the level of efficiency proposed by National Highways.

In setting out its approach to the RIS3 Efficiency Review, ORR noted that it considers efficiency, inflation and risk to be closely related concepts and as such seeks to have a good understanding of how National Highways treats inflation and risk in its cost estimates for RIS3. As National Highways is funded in nominal terms, the inflation assumptions it uses in its cost estimates also form part of its wider risk allowance.

ORR also highlighted that it is important that National Highways' risk allowance both at the project and portfolio level (i.e. within Central Risk Reserve, or CRR) are assessed in a robust manner (e.g. supported by robust evidence and avoiding issues such as double counting) and presented in a transparent way. In line with ORR's recommendations from its RIS2 Efficiency Review, it also remains crucial to have clear rules around the risk fund's governance and how it is accessed (including how money is released and utilised if risks do not materialise).[3]

As part its review of the interim draft SBP, ORR has commissioned Europe Economics to assess National Highways' approach to financial risk assessment and overall approach to risk for RIS3 as set out in this interim

[1] National Highways: Corporate Governance [online]
[2] ORR: Holding National Highways to account [online]
[3] ORR (2022): "Road Investment Strategy 3 Our Role and Approach" [online]

dSBP. This includes assessing how risk is considered and modelled in both project-level cost estimates and at a programme- or portfolio-level, as well as assessing National Highways' approach to holding and managing risk budgets, allowances and/ or contingencies.[4] The assessment covers the review of risk funding embedded within 'core' expenditure lines and projects and within centrally-held risk allowances, and considers the types of risks held at each level. The review also looks the appropriateness of National Highways' approach to setting risk allowances for projects at different stages of development. The review also considers any lessons learned from other regulated infrastructure managers and comparators as relevant to National Highways.

1.2 Approach to our review

Our approach to the review comprised three key phases:

- In the first phase we developed a risk assessment framework to underpin the review.
- The second phase involved our initial review of National Highways' approach based on the draft Strategic Business Plan (SBP) it submitted to ORR, followed by a series of workshops to understand in further detail the methodologies proposed for assessing and managing financial risk.
- The third phase involved our in-depth review of National Highways' approach and methodologies against our risk assessment framework, based on the dSBP as well as the additional information provided through the RFIs (request for information) submitted. Our assessment took of any lessons learned from other regulated infrastructure managers as appropriate.

The remainder of this section sets out the different risk concepts relevant for National Highways. Details around the documents and materials considered during the initial and in-depth reviews are provided in the chapters below.

1.2.1 Different risk concepts

The financial risks relevant for National Highways to assess and manage can be considered along a number of dimensions:

- Risks within and outside management control: While in most regulated industries typically only risks outside of management control are eligible for risk adjustment mechanisms, for National Highways financial risks both within and outside management control should be eligible for risk funding. This is because as a publicly funded entity, National Highways needs some way of absorbing risks that arise over the course of investment projects, analogous to an equity buffer available to private companies.
- Project and portfolio level risks: National Highways is exposed to risk both at the project and at the portfolio level, and should assess and manage both types of risk. Project risk funding is typically included as a contingency allowance and thus forms part of the funds available to the project during delivery. Portfolio level risk is typically held in a central risk pot, and drawdowns from this might be expected to be systematically recorded across several projects. For risks that are independent of each other, we would expect that some account is being taken of the potential for risk factors to offset each other across the portfolio as a whole (i.e. some risks may turn out well, others may turn out badly). Similarly, account should be taken of portfolio risks that might be correlated across multiple projects which may exacerbate the overall level of risk.
- Consideration of risk and uncertainty: Risk refers to situations where the probabilities of possible outcomes of decisions or events are known (i.e. the probability distribution is known), while uncertainty reflects situations where the randomness of outcomes cannot be expressed in terms of specific probabilities.[5] There can be confusion between these concepts, including in terms of how they are

[4] We note, however, that assessing the appropriateness of the level of confidence at which National Highways is funded (i.e. as a p-value), either for specific projects or National Highways' plans overall, is a decision for government and therefore outside the scope of the commission.

[5] For example, see: ACCA: "The risks of uncertainty - part 1" [online]

assessed and measured (for example, uncertainty is less suited to quantitative risk assessment, but there are other mechanisms to assess it and it should not be overlooked).[6]

We note that, in line with the scope of the work, the framework focuses on cost risk (e.g. cost overruns, financing costs, risks related to site conditions, planning and other consents, etc.) rather than delivery risk (e.g. on time delivery, risks related to works not fit for purpose, design not meeting requirements, etc.).

1.3 Structure of the report

The rest of this report is structured as follows:

- Chapter 2 presents National Highways' approach to risk for Enhancements.
- Chapter 3 sets out National Highways' approach to risk for Capital Renewals.
- Chapter 4 describes National Highways' approach to risk for the Central Risk Reserve.
- Chapter 5 summarises our conclusions;
- Appendix 1 sets out the lessons learned and examples of risk assessment from comparator organisations; and
- Appendix 2 present our results from sensitivity additional analysis of the CRR allocation model.

[6] Sirius (2023): "Investigation into Network Rail's risk modelling, embedded risk and uncertainty in PR23", p.5

2 Risk for Enhancements

This chapter reviews National Highways' approach to risk for Enhancements for RP3. It begins by setting out the approach National Highways has taken to Enhancements risk in its RIS3 business plan, and then sets out Europe Economics' view on this approach.

2.1 National Highways' approach to financial risk for Enhancements

In this section, we summarise our understanding of the approach National Highways has taken to estimating risk for Enhancements. Our understanding is based on an in-depth review of National Highways' draft Strategic Business Plan (dSBP) and accompanying annexes, the responses provided by National Highways to our Requests for Information (RFI) and information provided by National Highways in a series of online meetings.[7]

Our summary of National Highways' approach is broken down into the following sections:

- Overview of the scope of enhancements for RP3.
- National Highways' overall approach to financial risk for Enhancements.
- Quantifying project risk.
- Portfolio risk allowances.
- Inflation and the link between RET estimates and dSBP funding.

2.1.1 Overview of the scope of enhancements for RP3

Enhancements, in the context of National Highways' dSBP, refer to additions or improvements to the existing strategic road infrastructure. Enhancements vary significantly in size; they can be very large, multi-billion-pound construction schemes (e.g. new sections of motorway), or they can be much smaller projects (e.g. enhancements to a single slip-road). In its dSBP, National Highways defines the following categories of enhancements[8]:

- Committed Enhancements – These are schemes committed during RP1 or RP2 and are either in construction, expected to start by RIS3 or planned to start in RIS3. There are 28 Committed Enhancements schemes.
- Small schemes – These smaller schemes address local performance issues (e.g. congestion, safety) and are generally valued between £2m and £25m.
- Future RIS Development and Enhancement Programme – Development of a pipeline of enhancements that will be delivered in future road periods.

The majority of enhancement expenditure for RIS3 has been allocated to Committed Enhancements, although a range of adjustments to the programme have been made in the context of the affordability constraints associated with the Statement of Funds Available (SOFA) for RIS3. [9] Under the amended plans ("Scenario A"), 10 of the 28 committed schemes are deferred, defunded or cancelled. The only new major enhancement

[7] The RFI responses that informed this chapter were: RFI008, RFI009, RFI013 and RFI071.
[8] dSBP Section A, page 5, paragraph 1.1.1.
[9] dSBP Section A, page 14, paragraph 2.2.7. This is subject to ministerial and change control approvals of National Highways' proposed "Scenario A" programme of Committed Enhancements.

scheme that will be delivered during RIS3 is the A14 Junction 10A.[10] There is an increased focus from National Highways on delivering a higher volume of small schemes, as opposed to large complex schemes.[11]

At this stage in the RIS3 process, the interim dSBP does not include the A303, or schemes announced as part of the government's Network North plans. Nor does it include the costs of the construction phase of the Lower Thames Crossing (LTC) scheme. Costs for the development stage of the Lower Thames Crossing (LTC) scheme are included in the dSBP. Plans for LTC have been developed as a 'self-contained' project and are not covered by National Highways financial risk assessment. As such, they are outside the scope of this review.

2.1.2 National Highways' overall approach to financial risk for Enhancements

The approach taken to estimate the risk funding required for a specific enhancement project is dependent upon that project's maturity (i.e. which stage of the project control framework (PCF) it is in).[12] At the early stages of a project (PCF stage 3 and earlier), the approach is largely "deterministic" because there is not sufficiently detailed information on the scope and costs of the project to enable the development of quantified risk registers and probabilistic risk estimates. Deterministic risk estimates are largely "top-down", based on generic historical benchmark risk percentages and qualitative analysis. National Highways' will often use flat percentages, with the size of the flat percentage reducing as the project matures through the option development stage – for example, 33 per cent, falling to 25 per cent and then 15 per cent. These percentages are informed by external sources, such as the Green Book, with adjustments based on the expert judgement of National Highways. The assumed percentages are periodically reviewed against outturn costs, and were reviewed in conjunction with DfT at RIS2.[13]

As projects progress beyond PCF stage 3, where a contract will have been awarded to a construction delivery partner, more detailed information on the scope and costs of the project becomes available, which allows for a "bottom-up" approach to estimating risk through the development of project risk registers. This enables more quantitative risk analysis tools to be used for generating probabilistic risk estimates. As project delivery progresses, the level of risk and uncertainty diminishes up until project completion.

As discussed in the preceding section, the majority of enhancement expenditure for RIS3 has been allocated to Committed Enhancements. Appendix A of Section A of the dSBP indicates that all but one of the Committed Enhancements projects are at PCF stage 4 or later, and therefore should be beyond the stage where generic benchmark risk percentages are used to estimate risk allowances, instead making use of probabilistic risk estimates.

2.1.3 Quantifying project risk

Risk registers

The first step in the quantification of project risk for sufficiently mature projects is the development of a risk register. The risk registers, generated using "Xactium Risk" software, include cost risks, schedule risks (risks that the project will take longer than expected to complete, which leads to additional costs incurred) and opportunities (positive cost risks).[14] Each risk listed in the register is assigned a PCF stage, a contractual allocation (employer risk or contractor risk), a likelihood percentage (the probability of the risk materialising) and costs for the best, worst and most likely (ML) case.

Schedule Risks

[10] dSBP Section A, page 21, paragraph 2.4.11.
[11] dSBP Section A, page 18, paragraph 2.4.1.
[12] National Highways slidepack: "Enhancement estimating – ORR overview slides" Slide 5.
[13] Information provided in meeting with National Highways
[14] National Highways slidepack: "Enhancement Risk Analysis Slides" Slide 4.

Unplanned delays to projects lead to increased project costs. Big delays can have substantial cost impacts, particularly where these lead to additional inflation costs being incurred due to the prolonged timeline. Delays can also shift costs out of RP3 into future road periods. Project cost estimates and risk allowances should be built on an assumption that significant delays to the project timeline might happen. National Highways model schedule risks to address this possibility. Projects are provided with Risk Breakdown Structures that highlight prolongation risks associated with Development Consent Order and Judicial Reviews during the project lifecycle, which can incur substantial project delays. National Highways builds in a general assumption of a 12-month window between DCO consent and Start of Works for enhancements projects, and does not tailor the allowance for DCO consent to the contentiousness of the project. However, more contentious projects may be more likely to prompt legal challenges and require Judicial Reviews to obtain consent. There are no statutory timescales for Judicial Reviews, which means the assumption of a 12-month window following DCO consent may be inadequate for more contentious projects, and the resulting impacts on schedule risk could be substantial.[15]

The Delivery timescales and risks review carried out by Nichols in February 2022 identified 10 key factors (and 54 sub-factors) from analysis of 125 projects delivered over RIS1 and current RIS2 works. In light of this report, National Highways has developed a Schedule Commitment Risk Matrix.[16] When applied to a project, for each risk factor in the matrix, a proportion of "Risk Float" (additional time for projects to be completed built into the programme schedule) has been calculated, to be incorporated into Enhancement programmes.

The risk factors in the Schedule Commitment Risk Matrix focus on areas within National Highways' control – the matrix does not account for risks outside of National Highways' control, such as delays associated with repeated appeals during the planning process or extended durations related to decisions made by Secretary of State. Delays outside of National Highways' control, such as those mentioned above, are portfolio risks, and are dealt with separately to controllable project risks – we discuss the approach to portfolio risks in Section 2.1.4.

Quantitative risk analysis

The risk registers feeds into National Highways' quantitative risk analysis (QRA). QRA can be sub-divided into quantitative cost risk analysis (QCRA) and quantitative schedule risk analysis (QSRA). National Highways takes the information from a project's risk register and uses it to forecast project costs and/or schedule outcomes. Again, the exact approach to quantification of risk varies depending on project stage and amount of scheme information available, with the approach becoming gradually more probabilistic as more information becomes available. At an early stage of the QRA, some risks will have insufficient information for probabilistic estimation, so the project team takes flat percentages from Infrastructure and Projects Authority (IPA) guidance (e.g. min 20 per cent below ML, max 40 per cent above ML). Once a project is mature enough, the quantification involves Monte Carlo modelling of the risks around the various inputs into a project's costs.

The QRA process includes "correlation modelling"[17], which is intended to account for the potential for two or more risks to be correlated. This includes the potential for delay risks to be correlated - National Highways' QSRA Quality Assurance document notes that "Without a correlated Monte Carlo Simulation there can be little to no credible confidence in completing on or before the planned date".[18] The outputs of the QRA are used to identify the top drivers of cost risk and schedule risk, which can be targeted for mitigation actions by the project team. The mitigating actions will reduce the costs and/or likelihood of a given risk. Therefore, post-mitigation costs and a post-mitigation likelihood percentage are also included in the register for each risk, and typically it is these **post-mitigation** values that form the basis of subsequent risk estimates.[19]

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[15] CEPA's review of Enhancements in it Lot 2 report raises the issue of DCO timeline assumptions.
[16] dSBP Section A, page 43, paragraph 4.4.6.
[17] National Highways slidepack: "Enhancement estimating – ORR overview slides" Slide 18.
[18] National Highways "Quantitative Schedule Risk Analysis (QSRA) Quality Assurance Framework" Section 5.4.
[19] National Highways slidepack: "Enhancement Risk Analysis Slides" Slide 4.

Range Estimate Templates

The second step in quantifying project risk is for the information in the risk register to be transferred to the cost estimating team to be incorporated in overall project cost estimates in Cost Estimates Summary Sheets (CESS) which are a key input for Range Estimate Templates (RETs). The risks and opportunities from the register are allocated to relevant cost headings in the CESS in three-point estimate format, with "Min", "Max" and "Most Likely" values for each cost heading calculated by taking the post-mitigation costs (best, worst and most likely case) from the risk register multiplied by the post-mitigation likelihood percentage. The cost estimating team may propose amendments to the risk register to "ensure comprehensive risk allowance for the specific project based on historic benchmarks based on stage of estimating".[20] Any costs associated with undertaking the mitigating actions are included in a project's base cost estimate in the CESS.

Alongside the project risk/opportunity allowances in the CESS, a separate allowance is included for any remaining project uncertainty. In this context, project uncertainty refers to project-level risks that cannot be easily quantified through the bottom-up approach. The cost estimating team will include project-specific allowances in the project uncertainty section of the CESS, along with explanatory notes of the basis for these allowances. The uncertainty allowances follow the same Min, Most Likely, Max format as the project risk allowances. These uncertainty allowances are based on expert judgement, with explanatory notes in the CESS.

The CESS is a key input into the Range Estimate Template (RET) developed for each project, containing the estimated **base cost, project risk and project uncertainty**, broken down by project stage. The Min and Max costs in the CESS are used as the P2.5 and P97.5 values in the RET, which, along with the Most Likely value, are used to estimate the risk distribution (a PERT distribution curve is assumed) for each project. The output of the RET is risk/opportunity costs for P10, P20 and so on, in 10-point stages. P10 is the cost that the project would expect be at, or below, in 10 per cent of outcomes – in other words, there is a 10 per cent chance of delivering the project for that cost or less. An example of this output from the RET for the A417 Air Balloon project is below. The relevant costs for RIS3 are in the "Excluding Portfolio Risk" column.

Figure 2.1: Example of Range Estimate Template (A417 Air Balloon project)

Range Estimate Distribution

	Incl. Portfolio Risk	Excl. Portfolio Risk
Most Likely	£537,822,232	£528,342,415
Minimum (P2.5)	£453,674,235	£450,850,265
P10	£477,113,218	£472,435,296
P20	£496,305,980	£490,109,970
P30	£511,504,904	£504,106,706
P40	£525,172,567	£516,693,300
P50	£538,172,274	£528,662,615
P60	£551,049,538	£540,442,062
P70	£564,540,979	£552,783,326
P80	£579,671,430	£566,623,870
P90	£599,009,221	£584,313,069
Maximum (P97.5)	£623,492,727	£606,709,298
Mean	£538,290,761	£528,771,001

Source: National Highways "A417 Pre-construction incl structure 9m RET Extract"

2.1.4 Portfolio risk allowances

The next step in the process is to consider portfolio risk allowances for enhancements project. National Highways' approach to portfolio risk for RP3 is different to its approach for RP2. For RP2, the central risk reserve (CRR),[21] from which portfolio risk funding is drawn down when required, was set to reflect a series of "21 Portfolio Risk Factors" for enhancements. This included allowances for delay risks outside of National

[20] National Highways slidepack: "Enhancement Risk Analysis Slides" Slide 4.
[21] The central risk reserve is discussed in further detail in Chapter 4.

Highways' control, such as a delayed decision by the Secretary of State. These 21 portfolio risks continued to be quantified in the RETs for enhancement projects, but they do not feed into the determination of the size of the CRR for RP3. For RP3, the CRR requirement was not calculated statistically during SOFA negotiations, and has been set at a level of £703m. National Highways used Monte Carlo modelling to illustrate how much of the £703m portfolio risk would be required to achieve a P50 level of confidence for the delivery requirements as a whole.

This Monte Carlo model is simple. For each project, the post-inflation base costs from the dSBP financial model (which include project risk, uncertainty and efficiency) are taken as the Most Likely costs for the project. The model then uses the pre-inflation spend, excluding portfolio risk, figures from the RET (for all future spend) to calculate the ratio between min, ML and max costs for the project. These ratios are then applied to the base costs in the CRR model to calculate a min and max for the Monte Carlo, which along with 0, is used for a three-point estimate that proxies for portfolio risk across all enhancements. The @Risk software package calculates a triangular distribution for each project and, assuming no correlation of risks across enhancement projects, and performs 5,000 simulations of the costs across the portfolio of enhancement projects. The resulting shortfalls and overshoots of the funding position (the "base costs" in the model) of each project relative to the simulations' P50 estimate are totalled up and set against the CRR funding position of £703m. The result of this exercise was that National Highways estimated £128m of the CRR was needed to bring the overall funding position for Enhancements to P50.

2.1.5 Inflation and the link between RET estimates and dSBP funding

The RIS3 dSBP funding position for Enhancements is nominal. Inflation for 2025/26 – 2029/30 is included based on National Highways' inflation assumptions for RIS3, which for Enhancements is CPI plus 1.5 per cent. The 1.5 per cent is made up of an RPE adjustment of 0.75 per cent, based on National Highways' input price inflation analysis, and an additional 0.75 per cent risk adjustment.[22]

The RIS3 funding positions, which are annual nominal spending profiles for each project for the years 2025/26 – 2029/30, are broadly aligned with the annual spending profiles in the project RETs, assuming the inflation assumptions used for the dSBP were applied to the RET estimates. The RET estimates have their own inflation assumptions based on 13 different inflation profiles which vary dependent on the nature and timing of the project. Therefore, to reconcile RET estimates and dSBP estimates for enhancement spending in RIS3, RET estimates of spending in 2025/26 – 2029/30 would need to be deflated (by reversing the RET's various inflation assumptions) and then the RIS3 Enhancements inflation assumption would need to be applied consistently. It is important to note that inflation is applied to each projects' costs including risk and uncertainty costs.

However, even if the RIS3 inflation assumptions are applied to the RET estimates, there is not a perfect alignment between dSBP funding positions and RET spending profiles for 2025/26 - 2029/30. The divergence between the two sets of estimates occurs for more than one reason:

- The "Scenario A" positions in the dSBP assume that several projects are deferred or cancelled, so the costs for these projects do not match RET estimates.
- National Highways has noted that in some cases in the dSBP it has made "project specific adjustments for prevailing risks or issues not yet reflected in the estimates". [23]
- The timing of the latest production of a RET estimate (which happen at PCF stages or for specific estimate requests) for a project is often different from the timing of the dSBP funding estimates – the dSBP estimates make use of the Interim Forecast Tool which evolves the forecast costs and profile between formal estimating points and is used to inform monthly updates to outturn forecasts.

[22] This 0.75 risk allowance is the sum of the risk allowances from Steps 5, 6 and 7 of National Highways methodology for deriving its inflation assumptions (see Section B of its dSBP).

[23] National Highways slidepack: "Enhancement Risk Analysis Slides" Slide 14.

2.1.6 Monitoring and reporting risk

Risks and issues should become better defined, managed and mitigated as projects go through their lifecycle (i.e. PCF stages). Given that project risks either materialise or fall away over time, this increases cost certainty and reduces the commercial estimate range.[24]

The risks associated with Enhancements projects are monitored and reported on throughout the lifecycle of the project, with the frequency of estimates increasing as the project matures. In Stages 1 and 2, high-level reports covering the top project risks and the percentage of risk exposure against overall project costs are produced. At Stage 3 (the first stage where QCRA/QSRA is the main analysis underpinning risk assessment), a QCRA is produced and reported to the project team every month, with QSRAs provided on a six-monthly basis.[25] Reports include the top identified risks and the pre- and post-mitigated risk exposure for the project, as well as the cost of mitigations. From Stage 5, where construction preparation occurs, there is further assessment of schedule risks, and the QSRA reports are quarterly, and more detailed.

2.2 Europe Economics' view of National Highways' approach

In this section we set out our view of National Highways' approach to risk for Enhancements.

2.2.1 General approach to financial risk

In our view the following aspects of National Highways' approach to financial risk seem reasonable:

- National Highways uses both quantitative and qualitative approaches to estimating risk and uncertainty.
  - In particular, National Highways uses qualitative tools, such as expert opinion, when projects are at an early stage of maturity such that the scope is not defined in sufficient detail for quantitative analysis, and for project risks that are inherently uncertain. Deterministic risk provisions are also made at the early stages of projects (e.g. 33 per cent of costs) which is in line with practice observed in our case studies.
  - When sufficient details are available, National Highways uses a probabilistic approach to quantify known risks, incorporating Monte Carlo analysis where relevant and taking an approach that considers how two or more risks within a project might be correlated.
- National Highways develops and maintains a risk register for each of its enhancement projects, containing a detailed set of cost and schedule risks specific to each project. Responsibility for maintaining the registers lies with the project team who are well placed to track the risks throughout the project lifecycle. Cost and schedule risks are considered. We note that the length of time allowed for DCO consent is the same across all projects. We consider that the length of time should rather reflect the expected contentiousness of a project, as those potentially involving a judicial review may entail substantial schedule risk beyond that allowed for.
- Quantitative risk analysis, including Monte Carlo analysis, is used to identify key risk drivers within a project so that the project team can implement targeted mitigation actions. This approach should mean that risk mitigation is carried out efficiently by targeting the actions that result in the greatest reduction in cost/schedule risk.
- In terms of monitoring and reporting, National Highways updates the risk estimates for projects at structured intervals as well as produces regular reports. The frequency of updates and reports increases as the project matures and risks become better defined.

In addition, we have identified a number of areas of concern or particular note, set out below.

[24] National Highways: Draft Strategic Business Plan, enhancements (section A), section 6.3.
[25] National Highways "Major Projects Quantitative Risk Analysis Framework" page 6.

2.2.2 Information asymmetry

While, in principle, a number of aspects of National Highways' approach appear reasonable, the highly detailed nature of its assessment across individual projects introduces information asymmetry between it and ORR as to the real probability or size of risks that it faces. This highlights the importance of detailed project-specific reviews of the risk provisions calculated by National Highways, as performed on other Lots within the broader review of National Highways' interim draft SBP.

Such information asymmetry is a general feature of all regulated industries (regulators have various mechanisms to try to ensure that information provided by regulated firms is accurate), and whether regulated firms use this to under- or over-estimate risk will depend on their incentives. For example, if a companies' incentives are to increase the funding allocated to specific projects within its overall funding settlement, it could take advantage of information asymmetry and overstate the risk requirements for enhancements projects. In most regulatory settings, with a privately-owned regulated firm that seeks to maximise profits, there is a clear incentive for the regulated company to take advantage of information asymmetry to overstate its costs so that the regulator sets a higher cap on prices or revenue. For non-profit publicly funded entities there would not be these profit-maximisation incentives, but the incentive to overstate funding requirements may still be at play e.g. to enhance reputation by delivering more projects under budget, deliver on other incentives (e.g. efficiency), or protect itself against high cost/output uncertainty in other cost areas by increasing its overall funding.

Regulated firms may have an incentive to understate the risk and associated costs of enhancements particularly if these are projects which are currently underway or at an advanced stage of planning, to safeguard the continuation of the projects and minimise the risk that they are deemed too expensive and thus cancelled or deferred. Individual project teams may have an incentive to try to protect the continuation of the project they are working on, while senior stakeholders may have an incentive to protect the Value-for-Money cases for projects. Such incentives however are likely to exist at a project- rather than a portfolio-level.

It is beyond the scope of this report to investigate the incentives National Highways faces regarding its funding position. But we note that as in other regulated sectors, the information asymmetry between regulator and regulated firm is difficult for ORR (or other stakeholders such as DfT) to overcome. This highlights the value of project-specific investigations into the risk assumptions and values used across enhancements.

2.2.3 Inflation risk

National Highways' application of inflation risk to risk allowances also raises a concern. As explained earlier, National Highways' inflation assumption for Enhancements for RIS3 (CPI + 1.5 per cent) includes risk allowances of 0.75 per cent. This inflation profile is applied to both base costs and risk allowances to reach the RIS3 funding position for Enhancements.

This approach means that, all else equal, the funding required for National Highways to reach the P50 confidence level for Enhancements should be lower than the figure indicated in the dSBP. Including a substantial risk allowance in the Enhancements inflation profile means that the inflation profile is not representative of "Most Likely" inflation, but instead represents an expectation somewhere above Most Likely.[26] This, in turn, means that the inflation allowance included in the funding estimates for each project are above the Most Likely level. The additional inflation allowance will move the overall project funding for each project above the Most Likely level, which means that the Most Likely funding positions stated in National Highways' dSBP and its CRR Monte Carlo model are mislabelled. The "Most Likely" position stated

[26] The "Most Likely" inflation profile would be the central expectation of Enhancements inflation, which is expected CPI plus the expected wedge between CPI and the input prices relevant to National Highways. In concrete terms, the "Most Likely" inflation profile for Enhancements, based on National Highways' own analysis, is CPI + 0.75 per cent.

in the dSBP actually corresponds to a higher P-value than that indicated by National Highways. This means that the additional funding required to reach the P50 position should be lower than indicated.

A further implication of the incorporation of inflation risk within National Highways' inflation profiles is that inflation risk is being added onto project risk. This reduces the transparency of risk assessment and monitoring, making it difficult to track which risks are being covered by risk funding.

As explained in section 4.2.3 below, and in line with our Inflation Addendum, risk of outturn inflation being different to forecast inflation is a risk which is largely outside National Highways' control and would affect multiple projects within a portfolio, and therefore it is a portfolio risk. As a portfolio risk, it should be included in the Monte Carlo modelling of portfolio risks used to determine the allocation of CRR funding.

2.2.4 Uncertainty allowances

Based on the information provided by National Highways, the uncertainty allowances included in project risk estimates in the RETs are not robustly justified. The RETs include explanatory notes for each uncertainty allowance included, however these are typically brief and lack transparency (based on a selection of explanatory notes). Overall, National Highways should provide more detailed and transparent evidence around how the uncertainty allowances are determined to add robustness to their risk assessment approach.

2.2.5 CRR allocation model

As discussed in further detail in section 4.2.2 below, we identified a number of issues around the CRR allocation model, including:

- The model does not consider real portfolio risks, only proxies based on the ratio between min, ML and max costs for the project which are then applied to the base costs to calculate a min and max variation in the model.
- The model does not consider the possibility of correlated risks. One area in particular that may be subject to underestimation due to this approach is the cost impact of uncontrollable delay risks (such as delays in Secretary of State decisions during the planning process). It is certainly plausible that such delay risks are correlated across projects and National Highways acknowledge that delay risks for a project should be estimated using a correlated Monte Carlo simulation, and we consider a similar logic should be applied to external delay risks for the Enhancements programme. The correlation of risks does not have an impact on the overall P-value of the funding programme at the P50 level, but correlated risks will impact the tails of a distribution, and reduce the funding needed to reach P-values below P50 (e.g. P30), whilst increasing the funding needed to reach P-values above P50 (e.g. P80).
- These issues, along with the mis-labelling of the 'Most Likely' costs (see section 2.2.3), do raise questions about the accuracy of the modelled risk distribution and the P-value calculated for the funding position, and in turn the amount of additional funding required from the CRR.

Additionally, the 0.75 per cent risk allowance included in the Enhancements inflation profile also has an impact on the CRR model results by increasing the absolute level of the base costs (and thus the min and max) in the model, which in turn will increase any demands made on the CRR the model estimates. While this effect is second order to the mis-labelling of the P-value of the "Most likely" position, it is still a shortcoming of National Highways' approach.

3 Risk for Renewals

This chapter reviews National Highways' approach to risk for capital renewals for RP3. It begins by setting out the approach National Highways has taken to capital renewals risk in its RIS3 business plan, and then sets out Europe Economics' view on this approach.

3.1 National Highways' approach to financial risk for Capital Renewals

Capital renewals (or "renewals"), in the context of National Highways' dSBP, help ensure that assets are kept in good condition so that National Highways can deliver the outcomes and services that customers and communities prioritise. Renewals play an especially important role in supporting safety, availability and flow of traffic on the Strategic Road Network.

For RIS3, National Highways' Capital Renewals Programme consists of 11 asset classes including flexible pavements, rigid pavements, structures, tunnels, roadside technology, road restraints, geotechnics, lighting, drainage, soft estate (grassland, woodland, individual trees, ornamental planting, wetland features, wildlife structures, other vegetation and natural features), and ancillaries (e.g. road studs, road markings, cycleways, footways, kerbs, steps, fencing and signs).[27]

In this section, we summarise our understanding of the approach National Highways has taken to estimating risk for capital renewals. Our understanding is based on an in-depth review of National Highways' draft Strategic Business Plan (dSBP) and accompanying annexes, the responses provided by National Highways to our Requests for Information (RFI) and information provided by National Highways in a series of online meetings.[28]

Our summary of National Highways' approach is broken down into several sections[29]:

- Unit rates.
- Risk uplifts to account for project risks.
- Efficiency assumption.
- Post-efficient base estimate.
- Post-efficient most likely (ML) estimate.
- Uncertainty to account for portfolio risk.
- CRR allocation model.

3.1.1 Unit rates

The unit rates for each asset class are provided by the Commercial and Procurement (C&P) team using contractor prices held within the National Highways procurement system.

In particular, National Highways develops a range of scenarios (including the corresponding quantities and units) for various works relating to each asset class. For each scenario, using the bill of quantities, National

[27] National Highways: Draft Strategic Business Plan, risk annex, section 3.12.

[28] The RFI responses that informed this chapter were: RFI 013 Cost estimates and risk model, RFI 017 Renewals detailed data, RFI 037 Renewals unit rates, RFI 211 Renewals unit cost and risk, RFI 230 Renewals base cost year.

[29] We note that different section of the draft Strategic Business Plan cover these aspects in different order. For example, section A of the dSBP includes the step around removing the project risk allowance from unit rates while this is not included in the risk annex in section B.

Highways then determines the cost of construction[30] based on SDF tendered rates. This gives a min, max and most likely (ML) rate for each scenario and region.[31]

The cost of construction, design[32], supervision, other costs (e.g. land, statutory undertakers, local authority, etc.) as well as a risk uplift is added together to give the total scheme costs range estimates for each region and asset class, i.e.:

$$Total\ scheme\ costs = Cost\ of\ construction + design\ and\ supervision + other\ costs + risk$$

In contrast with cost estimates, National Highways does not apply a risk or uncertainty uplift to the volume of work or quantities in the production of the bill of quantities for any specific scenario.

The total scheme range estimates are then divided by the asset quantity to derive a composite unit rate for the asset. National unit rates are determined using the regional total costs range estimates.

For each asset class, the outputs and costs are summarised in a summary sheet which also includes the base year of the costs.[33] Each asset class summarised their outputs and costs for each scenario in a summary spreadsheet, including the base year of the costs used. These sheets are used to benchmark asset class outputs to a 2020 price base.

3.1.2 Risk uplifts to account for project risks

In contrast with enhancements, risk registers are not available for capital renewals. Instead, National Highways determines a risk uplift to account for project-level risks. As noted in the section above, these uplifts are applied to the unit rates as well as included separately in the CRR allocation model (see section 3.1.7 below for further details).

The proposed uplifts for each asset class are determined on the basis of expert judgement on a series of factors including:

- Scope: whether the scope of the activity could be changed to manage risk;
- Experience and confidence in delivery: whether National Highways is experienced in delivering the relevant underlying activity and whether there is little variation in this resulting in higher confidence in scope and costs; and
- Complexity: the scale of complexity of the work to be completed.

In addition, National Highways also carried out a benchmarking exercise for some of the asset classes (e.g. flexible pavements) to support the proposed uplifts.

The size of the uplifts are finalised following expert review by C&P, Safety Engineering and Standards (SES), front line Operations and Finance & Business Services (CPM). The aim of the review is to determine the appropriate level of risk to be considered for the risk analysis, taking account of all commercial and delivery aspects of renewals including how risk could be managed within a wider corporate framework based on the constraints of the SoFA.[34]

National Highways notes that the risk contingency also accounts for unexpected delays to project schedules.[35]

The table below summarises the proposed uplifts, along with National Highways' brief rationale for these.[36]

[30] These includes costs related to: (i) direct works, (ii) indirect works – prelims, and (iii) indirect work – temporary traffic management.
[31] The regions are: East, Northwest, Midlands, North East, South East and South West region.
[32] Design costs are determined as a percentage of total construction costs, based on the design complexity level.
[33] National Highways, RFI 230 renewals base cost year.
[34] National Highways: Risk position by asset class, received on 4 March 2024.
[35] National Highways: Draft Strategic Business Plan, risk annex, section 3.13.
[36] National Highways: Draft Strategic Business Plan, risk annex, section 3.14.

Table 3.1: Summary of risk uplifts for renewals, by asset class

Asset class	Investment case funding level (£m)	Risk uplift suggested by C&P team	Risk uplift following expert review (%)	Rationale for proposed risk allowance
Ancillaries (structures & pavement)	£306m	25%	0%	Ability to flex the output delivered, i.e. manage risk within scope by reducing outputs. Should funding not be sufficient to manage asset, renewals activity will focus on safety critical assets.
Drainage	£401m	30%	30%	Uncertainty in the underlying condition of the drainage asset, risk of unforeseen issues associated with buried assets, and potential supply chain issues due to heavy investment proposed within the water industry. Expert review supported the proposed risk uplifts (30%) due to the risk of hidden defects and wider impacts to safety or other assets.
Geotechnical	£234m	30%	30%	High interdependency with other asset classes including drainage assets and pavement. Expert review supported the proposed risk uplifts (30%) due to the risk of hidden defects and wider impacts to safety or other assets.
Lighting	£275m	25%	0%	Some headroom within asset class as the output comprises a combination of full replacements, variation in renewal (e.g. cabling only) and other solutions (e.g. white lining). Should funding not be sufficient to manage asset, renewals activity will focus on safety critical assets.
Roadside technology	£606m	30%	15%	Supply chain with low resilience and few manufacturers with longer lead times, lack of specialist expertise in the design and installation of the roadside assets. However, with many renewals being undertaken via either direct replacement of asset (i.e. a camera) or component part needing limited physical construction, the risk from direct renewal activity is low.
Road restraints	£303m	30%	30%	85% of renewal activities within the asset class are 'Find & Fix' with an inherent uncertainty as the quality of the asset is unknown until the team is onsite.
Soft estates	£165m	30%	0%	Ability to flex the output delivered, i.e. manage risk within scope by reducing outputs. Should funding not be sufficient to manage asset, renewals activity will focus on safety critical assets.
Structures	£2,474m		Variable (see below)	Highly diverse assets in terms of complexity, size and construction. Most assets are characterised by a range of potential risks and uncertainties. No risk allowance for priority structures due to undefined outputs.
- significant structures	£1,514m	23% and 44%	33%	The significant structures programme has been built based upon individual schemes. As many of these schemes have a cost estimate, the risk contingency from those estimates have been used. For those structures without a detailed estimate a 23% or 44% risk uplift has been applied based upon the complexity of the structure, scale of defect and/ or the stage at which each structure is through the process. Due to the range of risk uplifts across the programme it was agreed a 33% (mid-point) uplift would be applied for the structures programme.
- predictive renewals	£614m	25%	25%	"Other structure" are generally smaller scale projects, with less risk of wider asset damage, suggesting a risk uplift of 25%.

- predictive renewals (other sources)	£104m	25%	25%	As above.
- Avonmouth	£35m	25%	25%	As above.
- priority structures	£207m	0%	0%	Undefined outputs, which inherently represent a risk provision.
Flexible pavements	£1,383m	25%	25%	Benchmarking exercise by C&P found that when the unit rate included project risk at 25%, this was within 2-3% of rate from supply chain (i.e. when the unit rate is uplifted by 25% for project risk, the resulting costs are within 2-3% of what has been observed historically).
Rigid pavements	£823m	25%	20%	Could be impacted by supply chain demand for materials and availability of specialist resources. Risk uplifts of 15% and 30% identified were "life extension" and "reconstruction", respectively which led to a blended rate of 20% based on the project risk.
Tunnels	£111m	25%	23%	Dependence on other assets on the network and the maintenance programme within RIS3 and RIS4. Risks include: the availability of specialised resource to complete works, specialised equipment and machinery, and ability to find suitable closure times to complete the works, which could lead to delays.

Source: National Highways draft Strategic Business Plan, risk annex and Risk position by asset class, received on 4 March 2024.

3.1.3 Efficiency assumption

National Highways applies an efficiency assumption of around eight per cent for renewals. The table below summarises the efficiency assumptions for each asset class.

Table 3.2: Efficiency assumptions for renewals, by asset class

Asset class	Efficiency assumption
Ancillaries (pavement, road restraints and structures)	7.1%
Drainage	7.8%
Geotechnical	6.8%
Lighting	7.8%
Roadside technology	7.8%
Road restraints	8.8%
Soft estates	8.1%
Structures	
- significant structures	9.6%
- predictive renewals	7.2%
- predictive renewals (other sources)	7.2%
- Avonmouth	5.3%
- priority structures	7.2%
Flexible pavements	8.3%
Rigid pavements	8.0%
Tunnels	7.8%

Source: National Highways RIS3 CRR Allocation Model.

3.1.4 Post-efficient base estimate

Using the unit rates developed by the C&P team (see section 3.1.1 above) and the anticipated scope and volumes determined by the assets that need replacing in RP3[37], National Highways estimates the total cost of the programme for each asset class.[38] As noted in section A of the dSBP, this estimate corresponds to the costs under the "maintain performance" scenario for each asset class.[39]

Once a volume challenge reduction is applied (if applicable), National Highways then removes the project risk allowance[40] from the total costs which gives the pre-efficient, post-risk estimates. These estimates do not account for inflation. The magnitude of the project risk allowance that is removed from the total costs (broadly) corresponds to the magnitude of the risk uplifts set out in section 3.1.2 above.

National Highways then takes account of inflation and uses the efficiency assumptions above to determine the post-inflated post-efficient base estimates (excluding both project and portfolio risks). This is the funding level included in National Highways' dSBP.

[37] Further information on the techniques used to determine the volumes for each asset class in provided in Section A of the dSBP. For example, parametric estimate costing is used for flexible pavements. This utilises the Programme Investment Tool (PIT), which provides an assessment of the renewal volume needed for this asset class based on forecast conditions. This volume is then applied to three blended unit rates (50mm, 100mm and 150mm inlay).

[38] We note that within the materials and spreadsheets provided, we have not been able to trace whether the unit rates included in RFI 037 were indeed used to determine the base costs by National Highways.

[39] National Highways: Draft Strategic Business Plan, section A.

[40] We note that National Highways did not remove the project risk allowance for rigid pavements due to an error. National Highways estimated that this equates to approximately £169m of the £1.23bn identified renewals risk gap.

3.1.5 Post-efficient most likely (ML) estimate

Using the risk uplifts set out in section 3.1.2 above, National Highways then determines the post-efficient most likely (ML) cost estimate for each asset class.

3.1.6 Uncertainty to account for portfolio risk

National Highways uses the term 'uncertainty' to reflect portfolio risk across the renewals asset classes. A minimum and maximum unit rate range is determined to form a distribution around the base estimate. These minimum and maximum values have been derived as the simple average across all of the minimum and maximum unit rates provided within the spreadsheets setting out the units rates under different scenarios for each asset class. National Highways uses these unit rate uncertainty ranges as a proxy for portfolio risk.

For all asset classes except significant structures, the unit rate uncertainty ranges are developed by the C&P team based on the above approach. For significant structures, the uncertainty ranges are determined based on the design stage for each project using range from the Association for the Advancement of Cost Engineering (AACE). The ranges represent the expected accuracy range for estimates, which are summarised in the table below.

Table 3.3: AACE range (midpoint between low and high range)

	Design stage*		
	2	**3**	**4**
Uncertainty (low)	-10%	-15%	-22.5%
Uncertainty (high)	12.5%	20%	35%

Note: The class 2 design stage corresponds to a level of project definition between 30 and 70 per cent, while stages 3 and 4 correspond to level between 10 and 40 per cent, and 1 and 15 per cent, respectively.
Source: National Highways draft Strategic Business Plan, risk annex.

The table below summarises the uncertainty ranges for all asset classes.

Table 3.4: Uncertainty ranges for renewals, by asset class

Asset class	Min	Max
Ancillaries (pavement, road restraints and structures)	-24.7%	24.8%
Drainage	-15.7%	15.0%
Geotechnical	-17.0%	22.7%
Lighting	-38.3%	49.9%
Roadside technology	-30.0%	50.0%
Road restraints	-40.3%	45.9%
Soft estates	-51.5%	73.7%
Structures		
- significant structures	-15.0%	25.0%
- predictive renewals	-15.0%	25.0%
- predictive renewals (other sources)	-15.0%	25.0%
- Avonmouth	-15.0%	25.0%
- priority structures	-15.0%	25.0%
Flexible pavements	-23.6%	30.7%
Rigid pavements	-28.8%	39.4%
Tunnels	-15.0%	25.0%

Source: National Highways RIS3 CRR Allocation Model.

3.1.7 CRR allocation model

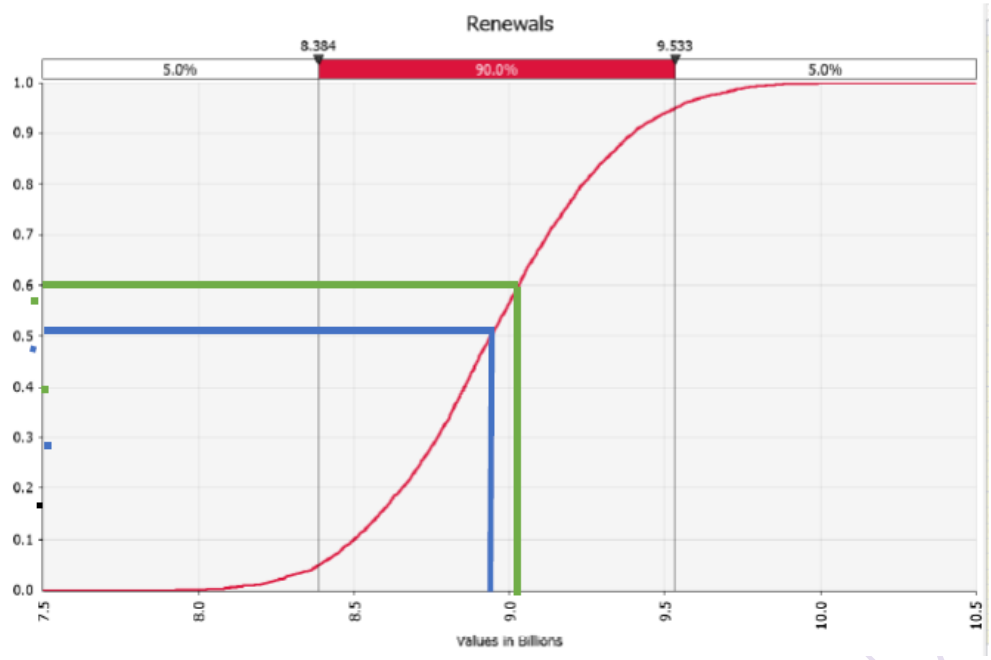
National Highways conducts Monte-Carlo analysis to determine the confidence in delivering the portfolio of asset renewals at the current funding level.[41,42] This is performed within the CRR allocation model.

The Monte-Carlo analysis uses @Risk (in Excel) to run 5,000 simulations across the portfolio of asset renewal projects. Using the unit uncertainty ranges above (or portfolio risk), the model forms a triangular distribution around the post-efficient most likely (ML) position for each asset class to capture uncertainty within the model.[43] Informed by the spread of unit rates, the risk model then estimates the level of confidence in achieving the planned scope of work within the agreed funding position (which is £7.1bn across all asset classes).

National Highways tested the resilience of the funding position using the prioritisation approach set out in section 4.1.3 below. This allocates £128m of the CRR (out of £703m) to enhancements, followed by £553m allocated to significant structures within renewals (to achieve P50). After this, there is only £22m left in the CRR which means that the P-level achieved is low for the remaining asset classes. To reach P50 across the four priority asset classes, National Highways' risk model shows that an additional funding of £273m would be required. This increases to £1.23bn to reach P50 for all renewals.[44]

As shown in Figure 3.1 below, the results suggest that, excluding the use of the CRR, the funding position (£7.1bn) falls short of the P50 confidence level for renewals (£8.94bn) with an additional £1.8bn (£1.23bn + £575m from the CRR) needed to reach the P50 level.

Figure 3.1: National Highways' distribution chart for all renewals



Note: The blue line depicts the P50 position and the green line depicts the P60 position. The current funding level is not plotted on the chart.
Source: Draft Strategic Business Plan, risk annex, section 3.15.17

[41] National Highways: Draft Strategic Business Plan, risk annex, section 3.15.
[42] The funding level in National Highways' dSBP corresponds to the post-efficient base position, i.e. it excludes both the risk uplifts and uncertainty allowances. Nonetheless, this will include inflation risk and contractor price risk.
[43] National Highways: Draft Strategic Business Plan, risk annex, section 3.15.
[44] National Highways: Draft Strategic Business Plan, risk annex, section 3.15.14.

3.1.8 Monitoring and reporting risk

Compared with enhancements, the approach to monitoring and reporting risks appears less formalised for renewals, potentially indicating a more bespoke risk management and monitoring approach for different asset classes. For example, for structures, National Highways noted the role of risk management in selecting its preferred scenario for RIS3, arguing that the total structures asset need identified for RIS3 is both unaffordable and undeliverable. Taking account of the safety needs on the network, National Highways distributed the indicative budget across four structures funding streams based on levels of risk to the road user and current RIS2 commitments. It also summarises its plans to monitor and manage the level of residual risk for the remainder of the schemes.[45]

3.2 Europe Economics' view of National Highways' approach

In this section we set out our view of National Highways' approach to risk for capital renewals.

3.2.1 Unit rates and base estimates

The unit rates and base estimates already capture some elements of price risk.

- The unit rates used to form the base estimates are not based on historical cost outturn and therefore do not implicitly include outturn risk. Any risk associated with project delivery is also removed from unit rates and this risk added later by way of risk uplifts.
- However, as noted in section 3.1.1, the unit rates are based on contractor prices. As such these rates should cover the expected value of unit costs (including a normal level of profit) as that is what suppliers in a competitive market would bid. Therefore, while the unit rates exclude delivery risk (relating to the scope and schedule of works), these would implicitly capture price risk (e.g. risk of the price of materials, labour, etc. going up, and any other price risks beyond complications that would result in a scope change or other material delivery risk), and these costs would already be at the mean level in relation to this area of risk. That this is not identified as a risk provision lacks transparency, and is not clear from National Highways' evidence whether the risk uplifts applied later account for this implicit contactor price risk.
- Base estimates (based on a combination of unit rates, scope and volume) also include inflation as all figures are in delivery year prices. Given the risk uplift of 0.75 per cent[46] that National Highways has included in its inflation profile for renewals[47] this means that a significant risk allowance has already been included in these estimates. This means that "post-efficient most likely (ML) estimates" may in fact be greater than "most likely" – which is how National Highways labels them – if inflation risk is included *on top* of the other risk uplifts. This may be the case as National Highways appears not to have formally recognised the inclusion of a risk allowance in its inflation figures as affecting the risk profile for renewals. This further implies that the gap between the renewals funding level and P50 may be lower than implied by the CRR allocation model. It also means that an inflation risk allowance has been added to the risk uplifts in the CRR model, which lacks transparency. This finding is consistent with Europe Economics' Inflation Addendum report.

3.2.2 Efficiency assumptions

While National Highways applies an efficiency assumption of around eight per cent for each asset class, it does not consider the risk around over- or under-achieving these efficiency assumptions. This could have material implications for the amount of funding required. Given the greater overall uncertainty around

[45] National Highways: Draft Strategic Business Plan, OMR – renewals – structures (section A), sections 8.1 and 8.2.
[46] This is the sum of steps 5, 6 and 7 in National Highways: Draft Strategic Business Plan, inflation annex.
[47] CPI + 1.5 per cent for renewals.

volumes of work required, the implications for renewals may be especially important. Nonetheless, similar considerations also apply to the efficiency assumptions used for the Enhancements portfolio.

We note that in a normal regulatory context it would be appropriate to carry out analysis of funding requirements on the assumption that the regulated company performs efficiently. This is because regulators typically set prices at a competitive level based on the costs of an efficient company, and in principle shareholders rather than customers should bear the consequences of inefficiency. However, regulators in other sectors do consider risks around efficiency assumptions to some extent.[48] Further, due to its funding arrangements National Highways has no equity buffer to absorb overruns caused by cost inefficiency, meaning that these will have to be absorbed within its overall cash budget. Therefore, in the case of National Highways there might be merit in considering the effect of over or under-achieving the stated efficiency assumptions in its risk assessment (e.g. as part of sensitivity analysis carried out). In particular, having the necessary degree of transparency to distinguish between risks of under-achieving efficiency targets and risks of other project overruns (e.g. volume risk) would improve accountability (e.g. to prevent project risk allowances being swallowed up by inefficiency).

3.2.3 Risk uplifts

Our review and analysis indicate that the significant shortfall in funding to reach the P50 level indicated by National Highways is down to the application of substantial risk uplifts for the majority of renewals asset classes. Yet at the same time, the justification provided by National Highways in its dSBP for the risk uplifts lacks transparent and robust evidence.

A key issue is the extent of the evidence provided by National Highways to justify the sizeable risk uplifts, with minimal material included in the dSBP. Further material provided by National Highways as part of this review includes the table of uplifts (see Table 3.1) which is largely qualitative and does not provide detailed or external evidence for justifying the specific uplift percentages chosen.

National Highways also undertook a benchmarking analysis for some of the asset classes. In particular, this analysis compares the estimated unit rates for RIS3 with "historic scheme" or "direct works" unit rates. While all rates are reported in February 2021 prices, the information contained within the spreadsheet[49] does not make it clear whether the RIS3 rates or the historic rates include any delivery risk uplift (although we would expect that outturn costs include any risk that materialised during the delivery of the project). Our review of the benchmarking indicates that the estimated average most likely RIS3 unit rates are higher than the historic weighted mean for a significant number of the assets/ asset classes included in the analysis. Provided that no risk uplift was included in the estimated RIS3 unit rates, any risk uplifts applied would only further increase this rate differential.

Furthermore, the benchmarking exercise only covers a limited range of renewals assets/ asset classes (with 10 of the 39 entries in the spreadsheet market as "not benchmarked" due to a lack of previous examples or bespoke schemes which in National Highways' view are difficult to benchmark), and National Highways acknowledges issues around significant variation in the scope of the estimates and changes within the asset classes.[50] There is also no mapping or read-across provided for how the benchmarking exercise influences the risk uplifts applied across the assets classes, and a significant lack of transparency surrounding the

[48] For example, Ofwat and Ofgem assess the impact of risk on a broad measure of company performance, RoRE (return on regulatory equity). Included in the risk items that can affect RoRE is totex (total expenditure), which represents the risk that company expenditure is below or above regulatory expectations of efficiency. For example see and Ofwat (2022): "Creating tomorrow, together: Our final methodology for PR24 – Appendix 10, Aligning risk and return" [online].

[49] RFI 037, "Asset Renewal rates Benchmark".

[50] For example, in the case of rigid pavements National Highways noted that the historic schemes are Life Extension Works while the RIS3 estimates are for replacing the concrete surface with asphalt.

calculation and use of unit rates across different periods (including the origin of the risk embedded in the units rates and how this has been stripped out) which makes it very challenging to ascertain the underlying evolution of rates over time. The RP2 rates would also not include the full efficiency expected to be realised over the whole of RP2, and therefore they are most likely higher than they ought to be if comparing to RIS3 rates. Overall the benchmarking analysis does not provide convincing evidence to support the proposed risk uplifts.

Other factors also raise some concern as to the robustness and transparency of the evidence for the risk uplifts.

National Highways does not include evidence of sensitivity analysis around the proposed risk uplifts. Sensitivity analysis is considered best practice for modelling exercises where there is uncertainty around certain variable(s) of interest. Reporting the (key) results from any sensitivity analysis conducted alongside the core analysis is also considered best practice in applied economic work, for example using ranges when presenting the funding shortfall In this case, it would be especially important to assess the impact of the uncertainty associated with the uplifts based on a mix of qualitative evidence, (internal) expert judgement and a benchmarking exercise which do not provide very extensive or robust evidence to support the proposed uplifts.

Whilst National Highways does undertake Monte Carlo modelling, which is a way of statistically measuring risk, this only applies to a small portion of the total risk considered (the "portfolio risk" element). The key driver of the funding shortfall stems from the project risk uplifts which are not subject to statistical modelling.[51]

The qualitative evidence provided by National Highways (as summarised in Table 3.1 above) also does not account for the possibility that risks may not materialise. National Highways has stated that it considers all the risks to be one-sided as the base scenario assumes a minimum level of renewals activity, and risk uplifts are only applied where there is no flexibility to descope activities.

In the case of rigid pavements, National Highways did not remove the project risk allowance included in the unit rates[52] before adding the risk uplifts in the CRR allocation model. National Highways' subsequent analysis estimated that the double counting of risk for this asset class due to this error equates to approximately £169m of the £1.23bn identified renewals risk gap.

Overall, while the proposed risk uplifts are the key driver of the indicated shortfall in funding to reach the P50 position, they are not supported by convincing or transparent evidence.

3.2.4 Portfolio risks

As the uncertainty ranges have been determined by using averages across the minimum and maximum of the various unit rates within National Highways' spreadsheets used to generate unit rates for each asset class, they are not modelling portfolio risk in the strictest sense (which ought to be risks affecting the portfolio of projects as a whole). In particular, the risk element stems entirely from the unit rate variation which lacks transparency and clarity around why these are suitable proxies for portfolio risks.

In addition, this approach also means that National Highways only considers 'portfolio risk' at a very aggregated level for each asset class without further information on what elements of portfolio risk are being considered for each asset class separately.

[51] We replicated National Highways' RIS3 CRR allocation model under an illustrative scenario where no project risk uplifts are applied to any of the renewals asset classes, which shows that the additional funding required to reach the P50 position is significantly reduced. For further details, please see Appendix 2.

[52] National Highways: Draft Strategic Business Plan, section A (OMR), renewals - rigid pavement, p.48.

3.2.5 CRR allocation model

As discussed in further detail in section 4.2.2 below, we identified some issues with the CRR allocation model, including:

- The model does not consider real portfolio risks, only proxies derived from unit rates.
- The model does not consider the possibility of correlated risks across the portfolio.
- The 'most likely' values used in the model (before portfolio risk is applied) may in practise be greater than Most Likely as they already include inflation risk. This undermines the validity of the model results as a whole and the estimated P50 funding shortfall.

The Monte Carlo simulation in the CRR model only applies to a very small proportion of risk (the portfolio risk), as the larger project risk uplifts are entered as single-value adjustments to the base costs in the model. This creates an impression that renewals risk has been subjected to statistical simulation and a misleading appearance of robustness to the analysis, which in reality is mainly by top-down, judgement-based risk uplifts.

4 Central Risk Reserve

This chapter sets out National Highways' approach to the Central Risk Reserve (CRR) for RP3 in further detail – some elements of the CRR and its risk model have already been discussed within the enhancements and renewals chapters. It begins by setting out the approach National Highways has taken to the CRR in its RIS3 business plan, and then sets out Europe Economics' view on this approach.

4.1 National Highways' approach to the Central Risk Reserve

The Central Risk Reserve (CRR) was established as part of RIS2 to centrally manage and balance risk across National Highways' programmes. It forms part of National Highways' capital portfolio policies, aiming to provide integrated control of scope, cost, schedule and risk. In particular, the Capital Portfolio Risk Allowance Policy comprises the following two key elements:

- Portfolio Risk Allowance: derived by capital portfolio management, agreed during the RIS negotiations, and controlled through change control at Investment Decision Committee (IDC) level; and
- Project Risk Allowance: derived from a project risk register, managed through change control at Project Committee level.[53]

For RIS3, National Highways' dSBP includes an allocation of £703m to the CRR.

4.1.1 Portfolio risks

The CRR is intended to cover portfolio risks. National Highways' dSBP outlines the portfolio risks the CRR is intended to cover, across the following three risk categories, covering a total of 21 portfolio-level risks.[54]

- Imposed risk/ opportunities include:
  - Health and safety
  - Cultural changes in working hours
  - Changes in standards (imposed)
  - Environmental issues – noise, carbon, ecology
  - Protestors / legal challenge
  - Approach to WebTag, including traffic modelling
  - Sustainability of project management
  - Changing third party requirements e.g. Network Rail
  - Changing third party requirements – statutory undertakers
  - Sustainability/ capacity of supply chain
  - Lack of knowledge/ capability to manage contract/ framework management
  - General capacity of client resource
  - Capacity of design consultant
  - Safety report findings, operation and technological issues affecting design development, construction and commissions of MMS EDS
- Value adding risks/ opportunities include:
  - Improvement in productivity, lean / procurement efficiency savings

[53] National Highways: Draft Strategic Business Plan, risk annex, section 2.5.
[54] National Highways: Draft Strategic Business Plan, risk annex, section 2.5.

- Whole life cost / design for maintenance
- Managing journey time reliability- Network operations
- Impact of technology solutions

- Time related risks/ opportunities include:
  - Delay in decision making process
  - Infrastructure planning commission
  - Government changes in priorities

While each enhancement project's RET includes quantification of the above risks, these risks are not explicitly quantified in National Highways' CRR modelling for RIS3, reflecting a change from RIS2 in the approach taken to defining the CRR requirement. For RP3, the CRR requirement was not calculated statistically during SOFA negotiations, and has been set at a level of £703m, whereas the RETs were constructed based on the RP2 approach, where the aggregated portfolio risks were used to derive the overall portfolio risk value that was funded within the SOFA.

4.1.2 Central Risk Reserve Protocol

The CRR Protocol was established between DfT and National Highways during RIS2 and approved by DfT in March 2023. It sets out the framework, approach and governance arrangements regarding the oversight and management of the CRR.

The Protocol states that the primary purpose of the CRR is to deal with portfolio risks (i.e. risks above the level of individual projects) associated with National Highways' enhancements and capital renewals portfolio from RIS1 and RIS2. Nevertheless, the Protocol also notes that any surplus may be used for project risks and / or to deliver further outputs. In particular, subject to standard approvals, National Highways may seek to transfer surplus reserve funding from one year to the next using the 10 per cent capital flex mechanism.

National Highways notes that the risks that the CRR aims to cover could be seen as wider than the risks that would affect the portfolio. This is because National Highways does not hold 'programme-level'[55] risk funding which means that the CRR is expected to provide some of the reserves typically seen as programme level.[56]

4.1.3 The CRR allocation model

National Highways indicated the following prioritisation approach to access funds from the CRR for RIS3. Once funds have been allocated to enhancements to achieve the target P-level (P50) across the programme, renewals have access to the CRR in the following order of priority:

- Significant renewals.
- Concrete roads (rigid pavements).
- Tunnels.
- Geotech.

National Highways has emphasised that this allocation is merely indicative and that the actual use of the CRR will be aligned to the priorities at the time. [57]

Estimation of the model

[55] Programme risk is defined as "the programme layer contains each of the projects and asset classes which can be categorised under the same type" while portfolio risk refers to the "additional risk which is held at the portfolio layer in the hierarchy, covering risks which occur across the whole portfolio of projects". Source: National Highways Draft Strategic Business Plan, glossary.

[56] National Highways: Draft Strategic Business Plan, risk annex, section 2.5.

[57] National Highways: Draft Strategic Business Plan, risk annex, section 3.7.

National Highways used the CRR allocation model to test the resilience of the funding based on the prioritisation approach set out above (separately for Enhancements and Capital renewals). This involved the following steps:

1. "Base costs" for enhancement projects and renewals asset classes are inputted into the model, taken from the dSBP funding position. The enhancements "base costs" included inflation and project risk allowances. The renewals "base costs" are pre-efficient and post-inflation, with no risk included.
2. "Most Likely" costs are then derived for enhancements and renewals. For enhancements, the Most Likely costs are equal to the base costs (as these already include project risk). For renewals, the efficiency assumptions and risk uplifts are applied to the base costs to derive the Most Likely costs.
3. Uncertainty (portfolio risk): A minimum and maximum unit rate is derived to form a distribution around the Most Likely estimate as a proxy for portfolio risks. For enhancements, the ratio between min, ML and max project costs (including project risk and project uncertainty) from the RET is used to calculate the ratios applied to Most Likely costs in the model. For renewals, the minimum and maximum values have been calculated as a simple average across all of the min/max unit rates provided within the spreadsheets used to generate unit rates for each asset class.
4. Monte-Carlo simulations: The minimum and maximum estimates, along with zero, are used in a triangular distribution for Monte Carlo simulations. The simulations are conducted using @Risk (in Excel) with over 5,000 iterations across the enhancements and renewals portfolios separately. The risk model estimates the level of confidence in achieving the planned scope of work within the agreed funding position, and the shortfall from the amount of funding needed to reach P50.
5. Analysis and results:
    - The P50 value is taken for each of the resulting distributions for each project or asset class.
    - This resulting P50 value is compared with the funding level for each project and asset class to determine whether the resulting P50 value exceeds the funding position. If it does, the CRR (if any funds are remaining) is allocated to the project in order to meet the P50 funding level based on the prioritisation approach set out above.
    - The total funding level is compared with the P50 value to generate the additional funding estimate required to achieve P50 for the current scope of works and risk uplifts.

4.1.4 Management of the CRR

This section sets out National Highways' approach to managing the CRR including the relevant governance and oversight arrangements.

Principles and governance

To ensure control and monitoring, National Highways developed a set of core principles and governance arrangements for the CRR.[58] The core principles are the following:

- risk and contingency budgets will be placed at appropriate levels to incentivise the right behaviours and outcomes;
- portfolio risk fund required to deliver capital 'baseline' programme to P50 (not to fund exogenous risks and additional scope);
- dependant on robust baselines and project change controls to enable effective application, control and reporting;
- there should be central National Highways control through established investment decision committees (IDCs) governance and associated delegations; and

[58] National Highways: Draft Strategic Business Plan, risk annex, section 4.3.

- any surplus built up within the central risk reserve will be monitored and considered for application to deliver additional scope outputs or RIS commitments.

National Highways notes that these are consistent with the principles set out in the IPA Project Assessment Review.

Reporting

National Highways provides regular and targeted project information (including on the level of risk exposure) in line with existing processes (Major Projects and Operations Directorates) to forecast and manage drawdown of CRR. There are specific channels for providing reports on the use of all central risk reserves including quarterly reports to the ORR and bi-annual Investment Portfolio and Decision Committee (IPDC) capital reports for the whole capital portfolio.

In addition, National Highways expects the reporting to include the allocation of the risk reserve to date, (relative to the capital baseline and operational plan), forecasts and predictive analysis of future risk reserve allocation (based on routine forecasts and change control early warnings) and assessment of wider risk across the portfolio to ensure robustness.[59]

External oversight

As part of its bi-annual review, the DfT IPDC will provide external oversight relating to the management of the CRR. The review may request project-by-project and year-by-year evidence to substantiate portfolio analysis. If an agreement regarding the future allocation of the reserve is not reached, DfT may restrict or constrain the annual approval of the reserve within annual funding settlements. Approval to spend part of the reserve outside of the enhancements programme and ring-fenced amount for capital renewals requires the agreement of DfT. The specific process will be agreed on a case-by-case basis.[60]

4.2 Europe Economics' view of National Highways' approach

In this section we set out our view on National Highways' approach to the CRR and its modelling.

4.2.1 Determination of CRR funding

The amount of funding in the CRR has not been determined using a bottom-up assessment of risk. This should entail the consideration and modelling of portfolio risks (e.g. through Monte Carlo analysis) and an assessment of how the cost of the portfolio as a whole is affected by these risks, and thus the suitable size of the risk fund needed to ensure a particular probability of the portfolio being delivered within budget (e.g. P50). The Monte Carlo analysis should model how different risks may offset each other, and also allows for correlated risks to be specified. However, for RP3 the CRR has been set at a level based on an allocation of funding suggested by DfT at £703m, with no apparent consideration of the portfolio risks listed above.

4.2.2 Approach to the CRR allocation model

As noted in the chapters assessing financial risk for Enhancements and Capital Renewals, our review identified some issues around the CRR allocation model.

For both Enhancements and Capital renewals, the CRR allocation model does not consider real portfolio risks, as it only proxies for portfolio risks based on the ratio between min, ML and max costs for the project as a whole (for enhancements) or based on a range for unit rates (for renewals).

[59] National Highways: Draft Strategic Business Plan, risk annex, section 4.4.
[60] National Highways: Draft Strategic Business Plan, risk annex, section 4.5.

In addition, for both Enhancement and Capital renewals, the 'most likely' values used in the model may be greater than Most Likely as they already include inflation risk. This undermines the validity of the model results and of the estimated P50 funding shortfall.

The CRR allocation model contains no (explicit) assumptions regarding how risks might be correlated across the portfolio. Whilst this does not impact the implied funding level at the P50 level, a lack of risk correlation will overstate funding levels below P50 compared to scenarios that include risk correlation.

4.2.3 Inflation risk

As discussed in our Inflation Addendum, the risk of outturn inflation being different to forecast inflation is a risk which is largely outside National Highways' control and affects all projects, and therefore it is a portfolio risk. As a portfolio risk, it should be included in the Monte Carlo modelling of portfolio risks used to determine the allocation of CRR funding. An additional benefit of including inflation risk in the CRR is that the CRR has more stringent governance processes than project risk allowances to ensure that risk funding is used only when necessary and approved.

5 Conclusions

This chapter summarises our key findings and conclusions from the review.

5.1 National Highways' approach to financial risk for enhancements

In our view a number of aspects of National Highways' approach to financial risk appear reasonable. These include:

- National Highways uses both quantitative and qualitative approaches to estimate risk and uncertainty.
- National Highways develops and maintains a risk register for each of its enhancement projects, containing a detailed set of cost and schedule risks specific to each project. However, consider that the length of time for DCO consent should reflect the expected contentiousness of a project, as those potentially involving a judicial review may entail substantial schedule risk beyond that allowed for.
- Quantitative risk analysis, including Monte Carlo analysis, is used to identify key risk drivers within a project so that the project team can implement targeted mitigation actions.
- In terms of monitoring and reporting, National Highways updates the risk estimates for projects at structured intervals as well as produces regular reports. The frequency of updates and reports increases as the project matures and risks become better defined.

However, the highly detailed nature of its assessment across individual projects introduces information asymmetry, which create challenges for ORR (as with all regulators) in assessing the true risk levels. This highlights the value of project-specific investigations into the risk assumptions and values used across enhancements.

National Highways' application of inflation risk to risk allowances also raises a concern. National Highways' inflation assumption for Enhancements for RIS3 (CPI + 1.5 per cent) includes risk allowances of 0.75 per cent. This inflation profile is applied to both base costs and risk allowances to reach the RIS3 funding position for Enhancements. This approach means that, all else equal, the funding required for National Highways to reach the P50 confidence level for Enhancements should be lower than the figure indicated in the dSBP. The additional inflation allowance will move the overall project funding for each project above the Most Likely level, which means that the Most Likely funding positions stated in National Highways' dSBP and its CRR Monte Carlo model are mislabelled.

5.2 National Highways' approach to financial risk for renewals

The unit rates and base estimates for renewals already capture some elements of risk.

- The unit rates are based on contractor prices which means that these rates should cover the expected value of unit costs and would already capture unit (cost) risk.
- Base estimates (based on a combination of unit rates, scope and volume) also include inflation as all figures are in delivery year prices. Given the risk uplift of 0.75 per cent that National Highways has included in its inflation profile for renewals[61] this means that a significant risk allowance has already been included in these estimates. This means that "post-efficient most likely (ML) estimates" may in fact be greater than "most likely" – which is how National Highways labels them – if inflation risk is included *on top* of the risk

[61] CPI + 1.5 per cent for renewals

uplifts. It also means that an inflation risk allowance has been added to the risk uplifts in the CRR model, which lacks transparency.

The significant shortfall in funding to reach the P50 level indicated by National Highways is down to the application of substantial risk uplifts for the majority of renewals asset classes. Yet at the same time, the justification provided by National Highways for the risk uplifts lacks convincing and transparent external evidence supporting the percentages applied.

- The core justification for the risk uplifts provided in National Highways' table is largely qualitative and based on internal judgement.
- The benchmarking analysis conducted does not provide clear or convincing evidence for the magnitude of the risk uplifts to the RIS3 costs. This benchmarking exercise also only covers a subset of assets.
- There is a significant level of complexity in National Highways' use of unit rates across road periods and a lack of transparency in the dSBP and further material about how these rates compare over time and how inherent volume risk has been included and then stripped out.
- Despite the significant uncertainty associated with the risk uplifts, National Highways does not provide sensitivity analysis around the proposed uplift percentages to demonstrate this.

5.3 National Highways' approach to the CRR

Our review identified further issues around the CRR allocation model:

- The model does not consider real portfolio risks, only proxies based on the ratio between min, ML and max costs for the project as a whole for enhancements and unit rates for renewals.
- The model does not consider risk correlation, which while having no impact at the P50 level will overstate funding levels required below P50.
- These issues, along with the mis-labelling of the 'Most Likely' costs, undermines the validity of the model results and the estimated P50 funding shortfall.

For Capital Renewals, the Monte Carlo simulation in the CRR model only applies to a very small proportion of risk (the portfolio risk), as the larger project risk uplifts are entered as single-value adjustments to the base costs in the model. This creates an impression in the dSBP that renewals risk has been subjected to statistical simulation and a misleading appearance of robustness to the analysis, which in reality is mainly by top-down, judgement-based risk uplifts.

The amount of funding in the CRR has not been determined using a bottom-up assessment of risk. This should entail the consideration and modelling of portfolio risks (e.g. through Monte Carlo analysis) and an assessment of how the cost of the portfolio as a whole is affected by these risks, and thus the suitable size of the risk fund needed to ensure a particular probability of the portfolio being delivered within budget (e.g. P50). The Monte Carlo analysis should model how different risks may offset each other, and also allows for correlated risks to be specified. However, for RP3 the CRR is based on an initial allocation proposed by DfT at £703m, with no apparent consideration of the portfolio risks listed above.

Incorporating inflation risk within National Highways' inflation profiles also reduces the transparency of risk assessment and monitoring, making it difficult to track which risks are being covered by risk funding. In line with our Inflation Addendum, the risk of outturn inflation being different to forecast inflation is a risk which is largely outside National Highways' control and would affect multiple projects within a portfolio. As such inflation risk is a portfolio risk and should be included in the Monte Carlo modelling of portfolio risks used to determine the allocation of CRR funding.

5.4 Lessons and examples from comparator organisations

The approaches to financial risk taken by the comparator organisations reviewed (Transport for London, Transport Infrastructure Ireland, Network Rail and Ofwat) suggest a number of similarities with National Highways' approach:

- In general transport infrastructure managers define and manage risk both at the project- and portfolio-level. Project-level risk contingency is often held and managed by project teams, albeit with governance around draw downs, with portfolio risk being held in a central contingency fund (e.g. Transport for London, Transport Infrastructure Ireland), supported by risk registers which are regularly monitored and updated.
- Infrastructure managers also use a range of tools and techniques to assess risk throughout the project lifecycle. These include percentage uplifts (typically applied at early stages of projects) as well as quantitative risk assessment/ Monte Carlo analysis.
- Typically a higher proportion of risk allowance is allocated at earlier stages of a project which is reduced over time as the project matures and risks become better defined.

At the same time we also identified some areas where National Highways' approach could be improved. The majority of the organisations reviewed put a greater emphasis on sensitivity analysis and scenario testing with a view to identify the key factors driving outcomes. For example, sensitivity analysis is a core part of Transport for London's and Transport Infrastructure Ireland's approach and scenario testing lies at the centre of Ofwat's adaptive planning approach. Similarly, monitoring and reporting of risk over project lifecycles are core aspects of risk management undertaken by comparators which received less attention in National Highways' dSBP. Finally, Sirius' recent review of Network Rail's quantitative risk assessment and Monte Carlo modelling also identified a number of considerations that could be relevant to National Highways.

The case studies also shed light on some of the more novel approaches used by other organisations. For example, to increase the robustness of its approach to cost forecasting, Transport Infrastructure Ireland incorporated the use of reference class forecasting into the suite of tools used to determine risk contingencies and target costs. Transport for London introduced the concept of 'retiring risk' requiring project managers to profile the risk funds and return the provision if the project does not use the allocation of funds by the date planned. National Highways may see merit in exploring these (or similar) approaches which may increase the robustness of its analysis and conclusions, for example through combining quantitative analysis with expert judgement to provide robust quantitative evidence for the relevant risk uplifts for renewals asset classes.

The case studies show that project-level risk contingencies are generally managed at the project level, but that there can also be formal governance arrangements for the draw down of this risk so that it is not simply subsumed into project budgets. In the case of National Highways this could add transparency and improved management for both enhancements and renewals project risk, and would encourage risk to be considered formally and separately to the creation of plans. Practically speaking, this would entail the development of formal risk pots per project, with draw-down governance such as application for and justification of draw downs, possibly with different materiality thresholds. The exercise National Highways has conducted for renewals risk in its dSBP is a positive starting point, in that it attempts to consider renewals project risk funds separately from the renewals budgets, although this is driven by uncertainty which prevents detailed project risk analysis. Project risk could also be held within the CRR, however this would depart from general practice whereby central reserves typically only hold portfolio risk contingency.

Appendix 1: Approach to Risk Assessment by Other Organisations

This appendix sets out the key findings from our review of practice in risk assessment and management of risk funding by other regulated infrastructure managers and delivery bodies.

Each case study begins with an overview of the comparator organisation, followed by a description of how they define and manage financial risk, and their approach to assessing and measuring risk, before summarising the key lessons.

Transport for London

This section summarises Transport for London's approach to risk assessment.

Overview

Transport for London (TfL) was created in 2000 as the integrated government body responsible for most of the public transport network in London. TfL has responsibility for several rail networks including the London Underground and Docklands Light Railway, as well as London's road networks, buses, bridges and other surface assets.

TfL's funding comes from a variety of sources, including fare revenue which accounts for 40 per cent of its funding.[62] Other sources include congestion charges, government grants and borrowing. In addition, subject to Government ministerial approval, TfL may also receive more funding if expected inflation is likely to exceed the level assumed in its 2022/23 budget through the inflation review mechanism.[63]

TfL remains on track to deliver the 2023/24 budget, and operating costs were two per cent lower than budget forecast, which was attributed to contingency funds not being used. However, TfL have also seen some cost pressures from reduced operating income (mostly due to a decrease in congestion charge income). These cost pressures have been mitigated through a combination of central contingency and staff cost savings. Despite being on track to be within budget for the year, capital enhancements ended up being lower than budget by £74m – partly due to funding uncertainty and the Government's decision not to provide additional funding to offset higher levels of inflation in 2023/24.[64]

Defining and managing financial risk

Financial risk can broadly be defined as the uncertainties related to TfL's budget, funding sources and unexpected costs which may affect its ability to meet its financial obligations. The main financial risks TfL faces are related to increased costs, such as higher tender prices or unforeseen additional requirements on current projects.

To help maintain a balanced budget, TfL also has a central contingency in place, which is weighted on a probability basis to ensure it has an operational buffer against unforeseeable events and resource constraints.

[62] Transport for London: "How we are funded" link [online]
[63] Transport for London: "Annual Report and Statement of Accounts" [online]
[64] Transport for London (2023): "Quarterly Performance Report" [online]

The central contingency also allows TfL to manage the risk around income from the Ultra Low Emission Zone (ULEZ) and Congestion Charge and that the savings target is not achieved.[65]

TfL's approach to risk for the projects it delivers is summarised in its Business Case Development Manual.[66] In particular, the approach to risk is determined in light of "the level of maturity of the products feeding into the cost estimates, such as the maturity of business case and benefit estimates, requirements and scope".[67]

TfL defines risk allowance as "a provision within the total project budget or forecast that is to be used to deal with anticipated events of uncertain outcome".[68] Examples of risk includes considerations ground conditions, weather, access, productivity etc. and in TfL's view exposure to these risks is best managed by the project delivery team. The risk allowance is controlled via a risk draw down.

Portfolio risk comprises a specific set of risks defined by TfL (e.g. political influences, inflation fluctuation, foreign exchange fluctuation, etc,) which are excluded from project risk exposure calculations. Portfolio risk is analysed and managed centrally rather than at project level.

The estimated final cost (EFC) of a project equals to the sum of the base cost estimate plus the risk provision in outturn (budget) prices. As described in further detail in the section below, risk provision can be calculated either from a QRA or uncertainty depending on the project stage.[69]

In addition, TfL also considered other types of non-controllable risks, summarised in the box below.

Box 1: Other types of non-controllable risks considered by TfL

TfL also accounts for other types of non-controllable risks such as climate, weather, and transition risk. Transition risks are defined as policy and legal, market, reputational and technology related risks, such as adapting to fluctuating consumer demand or maintenance costs from lower emission technologies. TfL gather quantitative data on such risks in order to understand the impact of them within different timeframes and scenarios.[70] While it is not clear as to whether the funding for these risks are held at the project or portfolio level, TfL appears to take a more holistic approach to understanding the impact of climate risks across the organisation, which are reflected at different levels of its 'risk hierarchy'. These risks are reviewed each year, and are also subject to an ongoing review by TfL's sustainability sub-group. For example, TfL monitors weather on online databases and coordinates emergency plans accordingly.

TfL is also exposed to several different financial risks that arise from its borrowing programme, the capital investment programme, and other contractual obligations. TfL defines these risks as follows:

- **Interest rate risk** related to the present or future borrowing requirements of TfL and its subsidiaries.
- **Exchange rate risk** related to specific currency exposures arising from the procurement of goods or services by TfL or its subsidiaries.
- **Commodity price/rate risk** associated with the fluctuations in commodity prices (i.e., fuel, construction materials etc.,) which may affect contractual obligations and procurements.
- **Inflation risk** across all TfL and its subsidiaries.

TfL aims to identify and monitor these risks through several techniques and will pass the risk onto a counterparty if appropriate. If the risks fall into the above categories, TfL may use financial instruments to manage exposure to these risks.[71] If TfL uses derivatives to manage its risk, it will ensure that there are

[65] Transport for London (2023): "Finance Report – Quarter 4, 2022/23" [online]
[66] Transport for London (2017): "Business Case Development Manual" [online]
[67] Transport for London (2017): "Business Case Development Manual" p.32 [online]
[68] Transport for London (2017): "Business Case Development Manual" p.34 [online]
[69] Transport for London (2017): "Business Case Development Manual" [online]
[70] Transport for London (2023): Annual Report and Statement of Accounts [online]
[71] TfL expects to hold all derivative contracts to maturity which means that contingent exposure is a relevant risk factor.

internal agreements or arrangements within TfL to ensure it receives the benefits and protection of using these instruments.

Source: Transport for London (2023): Annual Report and Statement of Accounts [online]

Assessing and measuring risk

As set out in the Business Case Development Manual, TfL uses three risk assessment techniques to determine the estimated final cost (EFC) of a project (i.e. base cost estimate plus risk provision).[72] As summarised in the table below, the approach depends of the maturity and scope of project requirements. TfL considers that only figures calculated using a Quantitative Cost Risk Assessment (QCRA) are categorised as "risk", while other figures are termed as "uncertainty".

Table A1.1: Summary of risk assessment techniques used by TfL

Technique	Exposure category	Suitable for
Range estimate	Uncertainty	Business planning
% uplift		Planning assumption
QRA	Risk	Funded risk

Source: Transport for London (2017): "Business Case Development Manual" [online]

In the early stages of projects uncertainty is used for budgeting and business planning purposes. These stages use the best estimate of risk provision, typically between 20 and 40 per cent of base costs, depending on the individual circumstances of projects. Where applicable, these values should be informed by similar previous projects.

As the project matures, TfL estimates the cost impact of a risk event using a QRA, including Monte Carlo simulations where appropriate. TfL notes that a QRA should always be specified as a range using minimum, most likely and maximum values rather than as a point estimate. For business case appraisal, TfL considers that the risk provision should be set of at the P50 (i.e. P mean) value. The risk provision should also be calculated on the basis of the likely post-mitigation impact, where mitigation is available. TfL's guidance also notes that project risks should be updated throughout the project lifecycle, with the main appraisal based on the most likely level of costs. Worst case costs could then be used as a sensitivity test.[73]

In addition to QRAs, the team of risk specialists at TfL measure risk through a software that allows it to identify, assess and prevent risks that can arise with its diverse project portfolio. Risks are quantified using a project risk assessment quality matrix, and the TfL team has access to the software at any point to ensure that the project- and portfolio-level risks have been considered.[74] The software also enables the risk team to perform Monte Carlo analysis to help predict the possibility and potential financial impact of different risks scenarios, as well as analyse the correlation of risks.

A review of TfL's approach by CEPA in 2022 noted that TfL also has internal assurance processes in place to ensure that projects have been considered and costed appropriately to its degree of risk. As schemes move into construction, a project will mostly hold a P50 level of funding and the difference between that and the P80 is held at the programme level. This provides TfL the flexibility to allocate those funds to whichever project needs it the most.[75] Additionally, to prevent costs going over budget, TfL incorporates a substantial contingency in cost estimates which can be distributed appropriately if left unspent.

CEPA also noted that the QRAs conducted have enabled TfL to provide a specific risk allowance depending on the project using data and modelling, so risks are identified more precisely. However, TfL has also

[72] Transport for London (2017): "Business Case Development Manual" [online]
[73] Transport for London (2017): "Business Case Development Manual" [online]
[74] Riskonnect (2022): "Transport for London keeps the city moving with Riskonnect" [online]
[75] CEPA (2022): "Review and use of Central Risk Reserve and consider implications for monitoring and reporting efficiency" [online]

experienced issues regarding project managers forecasting and reprofiling accurately. As a result, TfL has introduced a concept of 'retiring risk' which means that project managers are required profile the risk funds and return the provision if the project does not use the allocation of funds by the date planned.[76]

CEPA also highlighted practices around rapid regularisation of project overspend. In particular, if the estimate of funds required to complete a project exceeds the budgeted amount, TfL's systems require the overspend to be regularised as soon as possible. Typically this is done by a reallocation across the programme. Alternatively, TfL will seek funds from other programmes or budget transfers from elsewhere within the business. The budget regularisation process is governed through a series of meetings.[77]

Key lessons from Transport for London's approach

Our review of Transport for London's approach to risk assessment suggests the following key lessons for National Highways:

- TfL uses a range of techniques (range estimates, percentage uplifts and QRA) to assess risks throughout the project lifecycle.
  - Allocating a higher proportion of risk allowance (40 per cent) at earlier stages of a project and scaling them down (20 per cent) as the scheme develops appears to be a reasonable way of managing risk as projects develop. This mirrors National Highways' approach to enhancements risk.
  - QRAs (including Monte Carlo analysis) are also an effective tool to allow for a more specific scheme risk allowance, and understanding of how risks may change over the project lifecycle. Again, this mirrors National Highways' approach for enhancements.
  - However, where QRAs are not available, it may be useful to include scenario and sensitivity analysis to provide a more holistic assessment of project risk. In National Highways' case, this would apply to renewals where QRAs are not feasible in the absence of (detailed) risk registers.
- TfL also introduced the concept of 'retiring risk' requiring project managers to profile the risk funds and return the provision if the project does not use the allocation of funds by the date planned. There may be merit in considering a similar approach to managing the CRR in the case of National Highways to promote efficiency.

Transport Infrastructure Ireland

This section summarises Transport Infrastructure Ireland's approach to risk assessment.

Overview

Transport Infrastructure Ireland (TII) was established in 2015 through the merger of the National Roads Authority and the Railway Procurement Agency. It operates as a non-commercial semi-state body, under the aegis of the Department of Transport.[78]

TII provides an integrated approach to the development and operation of the national roads network and light rail infrastructure in Ireland.[79] In addition to its work on road and light rail infrastructure, TII also is

[76] CEPA (2022): "Review and use of Central Risk Reserve and consider implications for monitoring and reporting efficiency" [online]
[77] CEPA (2022): "Review and use of Central Risk Reserve and consider implications for monitoring and reporting efficiency" [online]
[78] Department of Public Expenditure and Reform (2023): "Review of Transport Infrastructure Ireland"
[79] Transport Infrastructure Ireland: "Establishment of TII" [online]

responsible for bridge construction and maintenance, tunnel development, and implementation of road safety initiatives.

TII's two key sources of funds are state grants and toll income. In 2021, state grants accounted for approx. 85 per cent of TII's income, while tolls represented approx. 14 per cent of the funds.[80]

TII and its projects often face issues related to budget overruns, delays and other unforeseen challenges. To help address these issues, TII has developed a variety of tools and techniques for navigating risk and uncertainty. Some of these uncertainty mechanisms include risk assessments, partnerships with the private sector, continuous monitoring and reporting of projects, and contingency planning. TII has integrated the use of expert judgement, Monte Carlo simulation, and reference class forecasting into their risk mitigation efforts.[81]

Defining and managing financial risk

TII's approach to cost forecasting (including risk contingency and management) is set out in TII's Cost Management Manual.[82]

The manual outlines the processes for risk identification, analysis, monitoring and contingency. Once risks are identified, these are recorded in the risk register which is then used as a project risk register. TII distinguishes between 'ordinary' risks and TII programme risk. TII programme risk (or TII risk) is defined as a risk that would affect a portfolio of projects (programme) if it occurs. TII programme risks are generally high value, low probability risks and include strategic risks, reputational risk, 'PESTLE' style risks and exceptional risks. Although identified, TII programme risks are not quantified in the risk registers (i.e. these are excluded from project specific risk contingencies).[83]

TII uses a range of techniques to determine the risk contingency for projects (these are described in the section below). Target cost[84] then incorporates this risk contingency at the 50 per cent confidence level while the total scheme budget[85] includes risk contingency at the 80 per cent confidence level. Depending on the circumstances, contingency of a different confidence level may be used.

Risk registers are live documents subject to ongoing reviews and updates during the lifecycle of the project. This dynamic management of risks and contingency may lead to reviews or revisions of base costs or overall estimates if necessary. As projects advance through different stages, envisaged risks may materialise and get incorporated into base costs. This leads to a progressive decrease in risk contingency over time with a corresponding increase in base costs. Similarly, as estimates are refined and replaced with actual expenditure over time, there is also a decrease in uncertainty and an increase in cost certainty.[86]

[80] Department of Public Expenditure and Reform (2023): "Review of Transport Infrastructure Ireland"
[81] Transport Infrastructure Ireland: "Reference Class Forecasting: Guidelines for use in connection with National Roads Projects" [online]
[82] Transport Infrastructure Ireland (2020): "Cost Management Manual" [online]
[83] Transport Infrastructure Ireland (2020): "Cost Management Manual" [online]
[84] Target cost is defined as "the provision from Phases 3 to 7 of project delivery inclusive of base cost and project specific risk contingency only". Transport Infrastructure Ireland (2020): "Cost Management Manual" p.85 [online]
[85] Total scheme budget is defined as "the total provision from phases 3 to 7 of project delivery inclusive of base cost, project specific risk contingency, TII programme risk contingency and inflation". Transport Infrastructure Ireland (2020): "Cost Management Manual" p.85 [online]
[86] Transport Infrastructure Ireland (2020): "Cost Management Manual" [online]

Assessing and measuring risk

TII uses three main tools to assess and measure financial risk for projects.[87] These are:

- Expert judgement
- Monte Carlo analysis
- Reference class forecasting

When a risk is first added to a risk register, TII carries out a qualitative risk analysis (Q_LRA) to identify the overall risk rating. Quantitative risk analysis (Q_TRA) is then carried out throughout the project delivery to aid the review of project costs estimates as well as the ongoing monitoring and updates to the risk register. TII notes that quantitative risk analysis is not necessarily carried out for all risks included in the project risk register as while some risks (e.g. political, reputational risks) are important, these may not have an impact on the overall project cost. The outcome of the quantitative risk analysis is a range of possible risk cost outcomes at various confidence levels including 50, 80 and 90 per cent. In addition, TII also carries out sensitivity analysis which aids the preparation and revision to risk registers.[88]

Reference class forecasting

More recently TII has incorporated reference class forecasting into its established cost management processes to increase the robustness of its cost forecasting.

In particular, TII noted that the majority of its risks associated with projects are either cost overruns and/ or schedule overruns. Historically, these issues have been explained away as a result of unforeseen external effects, such as poor weather or possession and access delays. However, these are often not the root causes of overruns in most projects. The real root cause is often that project planners systematically underestimate or even ignore risks during project development and decision making, and thus do not adequately prepare for unforeseen conditions and adverse events. Upon analysing its projects and others internationally, TII found that overruns are a result of bad luck or error, optimism bias, or strategic misrepresentation.[89]

[87] Transport Infrastructure Ireland: "Reference Class Forecasting: Guidelines for use in connection with National Roads Projects" [online]
[88] Transport Infrastructure Ireland (2020): "Cost Management Manual" [online]
[89] Transport Infrastructure Ireland: "Reference Class Forecasting: Guidelines for use in connection with National Roads Projects" [online]

Box 2: Summary of reference class forecasting

Reference class forecasting comprises the following three steps:

- First, a sample of similar past projects is identified, including a minimum of 20 to 30 comparable past projects, but even more is ideal.
- Second, the risk of the variable at hand is established based off these past projects through identifying their cost overruns.
- Finally, the risk estimate is adjusted by assessing whether the project at hand is more or less risky than the projects included in the sample.

This process allows for explicit, empirically based adjustments to be made to project cost estimates. These adjustments are based on data from past projects and are also adjusted to reflect the unique characteristics of the project in question. TII also highlights that any adjustment in the final step need to be based on robust evidence to avoid reintroducing optimism bias back into the estimate (identified as one of the root causes of cost overruns).

Therefore, reference class forecasting combines the "outside view" with all distributional information that is available.

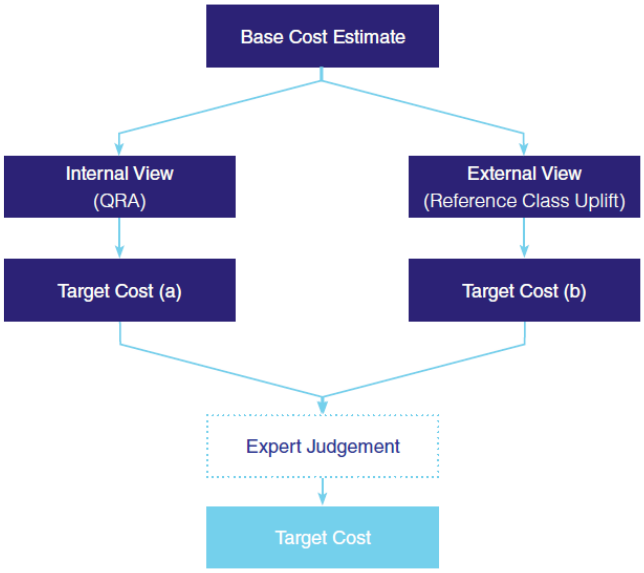
Source: Transport Infrastructure Ireland: "Reference Class Forecasting: Guidelines for use in connection with National Roads Projects" [online]

As shown in the figure below, TII uses reference class forecasting in parallel to Monte Carlo Analysis to determine the target cost for project. In particular:

- TII identifies the appropriate risk allowance for both target cost (usually P50) and total scheme budget (usually P80) using Monte Carlo Analysis (QRA). This constitutes the 'internal view' regarding target cost.
- Separately, TII also prepares a target cost estimate using the relevant reference class uplift. This also considers whether the project is more or less risky than the appropriate reference class and constitutes the 'external view' regarding target cost.

With two different target costs to consider, expert judgement is then used to determine the final target cost of the project.[90]

Figure 01.1: TII's approach to cost forecasting incorporating reference class forecasting



Source: Transport Infrastructure Ireland: "Reference Class Forecasting: Guidelines for use in connection with National Roads Projects" [online]

[90] Transport Infrastructure Ireland (2020): "Cost Management Manual" [online]

Key lessons from Transport Infrastructure Ireland's approach

Our review of Transport Infrastructure Ireland's approach to risk assessment suggests the following key lessons for National Highways:

- Compared with National Highways, Transport Infrastructure Ireland uses a broader range of qualitative and quantitative tools (including Monte Carlo Analysis) to assess and measure risk and also makes more extensive use of sensitivity analysis.
- In addition, to increase the robustness of its approach to cost forecasting, Transport Infrastructure Ireland incorporates the use of 'reference class forecasting' into the suite of tools it uses to determine risk contingencies and target costs. Reference class forecasting provides an 'external view' through combining data related from past projects and adjusting this to reflect the specific characteristics of the relevant project. National Highways may see merit in exploring a similar approach to combine quantitative analysis with expert judgement e.g. to determine the relevant risk uplifts for renewals asset classes.

Network Rail

This section summarises Network Rail's approach to risk assessment, drawing on the recent reviews conducted by Sirius (2023) and CEPA (2022). Although the reviews identified a number of shortcomings in relation to Network Rail's approach, nevertheless we have drawn some lessons for National Highways.

Overview

Network Rail was established by the Department for Transport (DfT) in 2002 and is the owner and infrastructure manager of most of the railway network in the United Kingdom. It is a public sector arm's-length body and reserves the financial and operational freedom to manage the railway network within legislative frameworks by the Office of Rail and Road (ORR).[91] Network Rail's operations, support, costs, maintenance, and renewals expenditure is funded through a combination of grants from the DfT and Transport Scotland, charges levied on train operators and income from other sources (such as its portfolio and real estate).

Most funding (70 per cent) comes from government grants, on a nominal basis i.e., for Control Period 7 (CP7) funding is granted in 2023/24 prices.[92] The remainder comes from fixed track access charges (25 per cent) and property income (five per cent). Network Rail has faced several challenges over the last few years, such as Covid-19 and rising inflation, which have impacted the available funding for rail. To reduce the adverse effects of unforeseen challenges, Network Rail has a variety of mechanisms in place including contingency funds and route-controlled risk funding.

Defining and managing financial risk

Network Rail's financial settlement for CP6 included funds set aside to enable it to manage its financial risks. The funds covered not just portfolio risks (i.e., those affecting the portfolio as a whole), but also cost pressures and limited income which would force Network Rail to reduce its outputs/efficiency.

During CP6, Network rail implemented route-controlled risk funding across three levels:

- P45 to P55 with no risk funding i.e., each region should be financed so that its project is delivered within budget 50 percent of the time.
- P60 with £600m of risk funding which is controlled by the routes.

[91] Network Rail: "Who We Are" [online]
[92] Network Rail: "How We're Funded" [online]

- P80 with the additional allocation of route held 'contingent asset management funding' of £856m and a centrally held portfolio fund of £856m (which provide a headroom against risks at the portfolio level).

Despite ORR's concerns that Network Rail used nearly 70 percent of its risk funding in the first two years of CP6, CEPA noted that Network Rail managed to mitigate the risks that arose with Covid-19, inflationary pressures, and unanticipated costs.[93] A key feature of Network Rails' risk management is its allowance for headroom as it is funded to P80. This reduces the likelihood of having to cancel or delay plans as risks materialise, but also means that a larger proportion of public funds could be tied up if things turn out favourably.

CEPA's review also found that to reduce the probability of reducing/ stopping activities while having access to risk funding, Network Rail has made it mandatory for some routes to improve their forecasting of 'slippage risks' (i.e. project delays). CEPA also stated that Network Rail's baseline plan is intentionally overprogrammed based on anticipating historical delays. This ensures that routes factor in the capacity to undertake additional work which reduces pressure on the overall programme.[94]

Network Rail's overall approach in CP7 includes a dedicated risk funding, including a 'headroom' for each route and a centrally held portfolio fund. The latest analysis of financial risk has meant that Network Rail could face £3bn of additional costs in cash prices.[95] As such, it will hold a contingency fund which can be used for other National programmes if it is not required for risk. In CP6 it set aside £2.7bn risk funds which it used across a variety of unexpected circumstances such as inflation, Covid-19, and industrial actions.

Assessing and measuring risk

CEPA noted that Network Rail regularly updated its risk modelling to oversee the feasibility of delivering a plan within the available funding.[96] Additionally, it appears that Network Rail releases risk funding for 'discretionary' initiatives if it decides that it no longer needs to fund emerging risks.

Sirius[97] investigated Network Rail's risk modelling for PR23 and made some observations regarding its current methodology. While there is an Enterprise Risk Management (ERM) framework in place, formal risk quantification is not currently accounted for in Network Rail's budgeting process to establish the effect of risk on output budget distributions, and how it may help inform decisions about risk contingency funds. This is due to the lack of clarity between the definitions of risk and uncertainty. Therefore, Sirius recommended including quantified risk impacts in modelling and outputs would enable Network Rail's budgeting process to be more informed.

Sirius also noted that uncertainty estimates are made for each year, but tend to have diverging annual profiles in later years due to risk not being explicitly quantified or modelled. While headwinds and efficiencies may contribute to the increasing uncertainty over time, there are additional risks which have not been factored into the model which contribute to these profiles.[98]

In terms of the Monte Carlo simulations conducted by Network Rail, Sirius found that costs are aggregated to higher levels of *before* Monte Carlo modelling which prevents the identification of how specific input costs

[93] CEPA (2022): "Review use of Central Risk Reserve and consider implications for monitoring and reporting of efficiency" [online]
[94] CEPA (2022): "Review and use of Central Risk Reserve and consider implications for monitoring and reporting efficiency" [online]
[95] Network Rail (2023): "England and Wales Strategic Business Plan Control Period 7" [online]
[96] CEPA (2022): "Review use of Central Risk Reserve and consider implications for monitoring and reporting of efficiency" [online]
[97] Sirius (2023): "Investigation into Network Rail's risk modelling, embedded risk and uncertainty in PR23" [online]
[98] Sirius (2023): "Investigation into Network Rail's risk modelling, embedded risk and uncertainty in PR23" [online]

contribute to changes in overall project costs. In addition, this also increases the spread of potential outcomes and increasing the value of confidence intervals such as the P80 figure.[99]

Key lessons from Network Rail's approach

Previous reviews of Network Rail's approach to risk assessment suggests the following key lessons for National Highways:

- Network Rail's allowance for headroom and funding to P80 over CP6 has been helpful in reducing the need to stop or delay projects as risk materialised, such as mitigating the impact of Covid-19. However, it does mean that if things turn out favourably, a potentially significant amount of public funds are tied up and unable to be used elsewhere.
- Network Rail also regularly reruns its risk models to monitor risks and confidence that it can deliver projects within funding levels. This process of quantitative risk monitoring facilitates more informed decision about how to use risk funding most optimally.
- The challenges faced with the budgeting process and identification of risks through Network Rail's modelling approaches provides an opportunity for National Highways to learn from them. This highlights the relevance of measures to address issues with the identification of risk and budgeting issues experienced by Network Rail, such as refining modelling techniques, accounting for optimism bias and avoiding aggregation of cost and uncertainty before Monte Carlo modelling.[100]

Ofwat

This section summarises the adaptive planning approach proposed by Ofwat in the context of a 25-year long-term delivery strategy for the UK water and wastewater sectors at the 2024 price review (PR24).

In general utility companies (including water and wastewater companies) may be considered less relevant as comparators given that utility price controls include uncertainty mechanisms that cannot be applied to National Highways, and most utility companies are privately owned companies which have an equity buffer that can absorb shocks. With this context in mind, instead of covering Ofwat's broader approach to financial risk, this case study focuses on adaptive planning – first introduced by Ofwat at PR24 – to identify lessons from novel approaches to quantitative risk assessment used in other sectors that focus on construction and maintenance cost and risks relating to infrastructure projects.

Overview

Ofwat was established in 1989 and is a non-ministerial government department that is responsible for the economic regulation of the water and sewerage industry in England and Wales. Its main objectives are to protect the interests of consumers, ensure that water companies can finance and carry out their statutory functions and secure the long-term resilience of water supply and wastewater systems.[101]

As water and sewerage services are not provided in competitive markets, Ofwat sets the price, investment and service package that customers receive from their provider. The price limits are reviewed every five years, and Ofwat is currently working on the 2024 price review (PR24) which will set the prices for the period between 2025 and 2030.[102]

[99] Sirius (2023): "Investigation into Network Rail's risk modelling, embedded risk and uncertainty in PR23" [online]
[100] Sirius (2023): "Investigation into Network Rail's risk modelling, embedded risk and uncertainty in PR23" [online]
[101] Ofwat: "Who we are" [online]
[102] Ofwat: "Price reviews" [online]

Defining and managing risk and uncertainty

A key element in Ofwat's long-term delivery strategy for the UK water and wastewater sectors at PR24 is adaptive planning. Adaptive pathways help to set out what activities will be dependent on certain circumstances and also shows what activities are required in most or all plausible futures. Adaptive planning helps companies plan the profile of key interventions across time by showing what activities are needed now and which ones may be decided at a later point when there is more certainty around what is needed, thus minimising the risk of stranded assets. Therefore, adaptive pathways focus on the main areas of risk and uncertainty faced by water companies.[103]

In particular, Ofwat requires companies to set out the areas of greatest uncertainty in their strategy and explain how they have account for uncertainty in each area. The strategy should describe the uncertainties that could have the biggest influence and how changes in underlying factors may affect the strategy in future. Ofwat notes that while companies may account for some of the uncertainties in alternative pathways, wider scenarios or sensitivity testing, some uncertainties may not be meaningfully alleviated through these techniques (e.g. where parameters for scenario testing cannot be determined). In these cases, companies are also required highlight to these uncertainties in their strategy.

Informed by UK Government's Supplementary Green Book Guidance, Ofwat also notes that adaptive planning should be used so that investments can adapt to changing risks. Decisions regarding different adaptation actions should account for both the magnitude and urgency of risks which means that the suitability of different actions will depend on the context of the decision.[104]

Assessing and measuring risk and uncertainty

Ofwat considers that all key enhancement activities should create adaptive pathways in order to plan how strategies will adapt to possible changes. To this end, companies should set out a core adaptive pathway (for enhancement activities) as well as a range of alternative adaptive pathways.

Core adaptive pathway

The core adaptive pathway includes 'no and low' regret investments (e.g. investments required in both benign and adverse scenarios or across a wide range of possible scenarios, etc.) or investments needed to keep future options open. The core pathway is consistent with the best practice adaption techniques and should include all activities that need to be undertaken to be ready for plausible future scenarios. No-regret investments are likely to deliver outcomes efficiently under all plausible scenarios and low-regret investments are likely to deliver outcomes efficiently under a wide range of plausible scenarios.[105]

Alternative pathways and scenario testing

Through monitoring and review of the core pathway, decision and trigger points are considered to decide if an alternative path should be taken. Decision points are times at which a decision on moving to an alternative pathway should be taken and trigger points are the point at which an alternative pathway will be followed.[106] Alternative pathways are packages of investments that should be taken only under certain circumstances (trigger points).

Scenario testing is essential to adaptive planning as it helps provide confidence that investments within pathways are likely to deliver what they set out to do in the range of plausible futures. Ofwat has eight common reference scenarios representing both 'adverse' and 'benign' scenarios (see Box 3 below) reflecting

[103] Stranded assets are defined as "assets that have suffered from unanticipated or premature write-downs, devaluation or conversion to liabilities". Source: Lloyds [online].
[104] Ofwat (2022): "PR24 and beyond - Final guidance on long-term delivery strategies" [online]
[105] Ofwat (2022): "PR24 and beyond - Final guidance on long-term delivery strategies" [online]
[106] Ofwat (2022): "PR24 and beyond - Final guidance on long-term delivery strategies" [online]

four key drivers of uncertainty around future enhancement spending (climate change, technology, demand and abstraction reductions). Companies are required to use these reference scenarios as part of their sensitivity testing of their enhancement investment strategy.

In addition, companies can develop further scenarios to ensure that their strategies are robust to a wide range of plausible futures, accounting for changes in material company-specific or local factors (e.g. socioeconomic factors, capacity of supply chain, etc.). Ofwat emphasises that the scenarios companies use to test their long-term delivery strategy are plausible.[107]

Box 3: Key parameters for benign and adverse scenarios

A benign scenario is a scenario that describes a less demanding change in a material factor than expected. Meeting long-term objective under a benign scenario may involve low enhancement investment. A benign scenario around the key factors would be:

- Climate Change: greenhouse gas emissions are strongly reduced (RCP2.6[108])
- Technology: faster development than expected
- Demand: lower growth forecasts and legislation on building regulations and product standards
- Abstraction Reductions: current legal requirements in (England and Wales)

An adverse scenario describes a more demanding change in a material factor than expected. Meeting long-term objectives under this scenario may involve a high enhancement investment. An adverse scenario around the key factors would be:

- Climate Change: greenhouse gas emissions continue to grow unmitigated (RCP8.5)
- Technology: slower development than expected
- Demand: higher growth forecasts
- Abstraction reductions: enhanced scenario (in England)

Source: Ofwat (2022): "PR24 and beyond - Final guidance on long-term delivery strategies" [online]

Monitoring of adaptive pathways

Ofwat notes that effective monitoring of adaptive pathways is a key principle of an adaptive approach. As part of their long-term delivery strategy companies should set out how they will monitor and review the metrics, trigger points and other key elements of their strategy.

Companies' monitoring plan should identify:

- the metrics that will be monitored, how these will be calculated along with the source of the data;
- the frequency at of monitoring and reviewing the metrics;
- the threshold metrics will be monitored against and the action to be taken when the threshold is reached; and
- reporting (including to Ofwat and other regulators) and publication arrangements regarding the monitoring of the metrics and the progress against the long-term delivery strategy.[109]

Key lessons from Ofwat's approach

Our review of Ofwat's adaptive planning approach suggests the following key lessons for National Highways:

[107] A plausible scenario is a scenario that is possible but not necessarily the most likely.
[108] Ofwat sets the reference scenarios for climate change based on Representative Concentration Pathways (RCPs), as adopted by the Intergovernmental Panel on Climate Change (IPCC) and the latest UK Climate Projections (UKCP18).
[109] Ofwat (2022): "PR24 and beyond - Final guidance on long-term delivery strategies" [online]

- Ofwat proposes to use an adaptive planning approach based on different scenarios to allow companies to account for risks and uncertainties in delivery strategy. However, as the approach is used in the context of a 25-year long-term delivery strategy for the water and wastewater sectors, this may not fit well with the five-year time horizon National Highways considers when it develops its Strategic Business Plan for RIS3.
- At the same time, the approach seeks to identify the key uncertainties that could have the biggest influence on companies' strategy and set out how changes in underlying factors may affect decisions. National Highways may benefit from an approach that allows for the identification of the key drivers of project and/ or portfolio-level risks which could then be used as sensitivity tests to indicate the funding level required, in particular around renewals.
- The development of a range of scenarios and sensitivity testing is an integral part of Ofwat's approach, allowing companies to test and understand how changes in underlying factors may impact their (long-term) strategies.
- Companies are also required to develop dedicated monitoring and reporting arrangements for adaptive pathways.

Appendix 2: Additional Analysis of the CRR Allocation Model

We conducted further analysis of the CRR allocation model to investigate how the results might change under a different set of assumptions around the risk uplifts applied to the renewals asset classes. This was to test what was driving the significant funding shortfall demonstrated in National Highways' CRR model for renewals. We note that this exercise is not intended to imply that a realistic scenario would be one where no project risk uplifts are applied; it is rather to test the impact of the risk uplifts on the CRR model results.

The table below summarises the results from this analysis. In particular, it indicates that the funding gap to the P50 position decreases to approximately £0.15 billion when no risk uplifts are applied to any of the renewals asset classes (equating to an approximate 90 per cent decrease compared to the base case where all relevant risk uplifts are applied). This shows that the majority of the funding shortfall is driven by the risk uplifts, and that the Monte Carlo simulation within the CRR model only applies to a small percentage of renewals risk.

Table A2.1: Summary of simulation results for renewals

Simulation	P50 cost (£ billion)	Total funding level (£ billion)	Gap to P50 position (£ billion)	Remaining CRR (£billion)
Base case (as presented in dSBP)	8.94	7.64	1.30	-
Alternative scenarios				
No risk uplifts	7.30	7.15	0.15	0.49
No risk uplifts, expect for significant structures	7.80	7.64	0.17	-

Note: These calculations are not precise estimates, as Monte Carlo simulations generate a range of possible outcomes, and the specific outcome can vary slightly from one simulation run to another. These estimates are intended for reference only, to gauge the impact of making changes to assumptions in the model.

In the section below we provide further details of the additional analysis.

Overview of additional analysis

We replicated National Highways' analysis using its RIS3 CRR Allocation Model. This model sets out the calculations used to inform the allocation of the CRR (for both Enhancements and Renewals). We ran additional quantitative risk analysis (QRA) for renewals by changing the following assumptions:[110]

1. Applying no project risk uplift to all project costs.
2. Applying no project risk uplift except for significant structures.

The P50 shortfall for renewals as currently estimated in the model is approximately £1.30 billion, as the P50 cost is £8.94 billion and total funding[111] is £7.64 billion. The total funding of £7.6 billion comprises £7.1 billion in allocation funding and £0.558 billion of funding from the CRR (which is what remains of the total £0.703 billion of CRR funding after £0.145 billion has been used for enhancements).[112]

[110] We note that the results from this analysis are indicative.
[111] Total funding in the model refers to funding level + central risk reserve (CRR).
[112] Enhancements have a priority over the renewals for the use of the CRR allowance.

We note that when we run the National Highways' CRR model, we found marginally different P50 values for each asset class compared to the results provided by National Highways (as shown in **Table A2.1**) Thus, we were unable to fully reconcile the resulting P50 gap in the CRR model with the corresponding figure in National Highways' dSBP.

Alternative scenarios

We replicated the renewals QRA analysis without the percentage risk uplifts and investigated the P50 shortfall for the following two scenarios:

- No risk uplift for any asset class.
- No risk uplift for any asset class, except for significant structures. Significant structures had a risk uplift of 33 per cent.

No project risk uplift to all assets

The P50 shortfall reduces to approximately £0.15 billion for renewals after the CRR is allocated, where the P50 cost is £7.30 billion and total funding is £7.15 billion. The total funding comprises of £7.1 billion in allocation funding and £0.07 billion of CRR. There is a remaining CRR allowance of £0.49 billion after it has been used for enhancements (£0.15 billion) and renewals (£0.07 billion).

We note that we have not changed any of the CRR allocation assumptions in the model and are just reporting the summary results generated. The CRR is allocated based on a priority order for renewals assets. The rankings have only been allocated for five assets. We have also investigated the impact of other renewals asset classes having access to CRR funding. Our results indicate that in this scenario all asset classes are able to achieve P50 from available funding and there is still some CRR allowance left.

No project risk uplift to all assets, except significant structures

The P50 shortfall reduces to approximately £0.17 billion for renewals, with a P50 cost of £7.80 billion and a funding level of £7.64 billion. The total funding comprises of £7.1 billion in allocation funding and £0.56 billion of CRR funding. This P50 shortfall assumes the CRR allowance of £0.70 billion is used up, mostly by significant structures (£0.55 billion of the remaining £0.558 billion CRR for renewals).