TAG Unit A1.2

Scheme Costs

May 2024

Department for Transport

Transport Analysis Guidance (TAG)

https://www.gov.uk/transport-analysis-guidance-tag

This TAG Unit is guidance for the **Appraisal Practitioner**

This TAG Unit is part of the family **A1 - Cost Benefit Analysis**

Technical queries and comments on this TAG Unit should be referred to:

Transport Appraisal and Strategic Modelling (TASM) Division

Department for Transport
Zone 2/25 Great Minster House
33 Horseferry Road
London
SW1P 4DR
tasm@dft.gov.uk

Contents

1. Introduction

1.1.1 This TAG unit builds on the guidance on principles of cost-benefit analysis in transport appraisal in TAG Unit A1.1 - Cost-Benefit Analysis and provides specific guidance on how scheme costs should be estimated and reported. It should be noted that this guidance is intended to be applied to the treatment of costs in the Economic case; the development of cost estimates in the Financial case may and frequently will differ in both presentation and substance.

1.1.2 Estimation of the costs of transport schemes is important for decisions on scheme funding and is a crucial part of the scheme appraisal process. Unrealistic cost estimates that subsequently rise will adversely affect the robustness of the assessment of affordability and value for money of a scheme. There are two main elements of a scheme cost estimate that can be estimated and reported in scheme appraisals: base costs and adjustments for risk or optimism bias (OB). Estimating adjustments for risk – for example through Quantified Risk Assessment (QRA) – and optimism bias are both informative exercises for managing project risk. However, they represent alternative approaches when reporting overall scheme costs in appraisal.

- the base cost[1] (section 2) – the basic costs of a scheme before allowing for risks, though these should incorporate realistic assumptions of changes in real costs over time, e.g. cost increases or reductions relative to the rate of general inflation; **and**
- adjustment for risk (sections 3-3.4) – this should cover all the risks that can be identified, the majority of which then need to be assessed and quantified through QRA. This takes an ‘inside view’ to form a risk-adjusted cost estimate using a ‘bottom-up” approach; **or**
- adjustment for optimism bias (section 3.5-3.6) – to reflect the well-established and continuing systematic bias for estimated scheme costs and delivery times to be too low and too short, respectively, and results in the optimism bias-adjusted cost estimate. This method takes an ‘outside view’ using a “top-down” approach to cost estimation based on Reference Class Forecasting (RCF) techniques.

1.1.3 Theories on cost overruns suggest that there are several means by which optimism bias could be caused, including the psychological tendency for humans and organisations to favour optimism, the economic rationale of advancing projects in which organisations have interests, and the strategic behaviour of stakeholders involved in the planning and decision-making processes. As these causes are likely to affect the objectivity of the risk assessment as well as the base cost estimate, it is likely the scheme costs will

[1] The term base costs may have different meanings elsewhere. In this guidance we refer to these as being the basic costs of a scheme formed in a given price base year, which include realistic assumptions about real cost increases between the price base year and the years in which costs are incurred. The base costs do not include any adjustments for risk and optimism bias.

be systematically underestimated. The size of the optimism bias adjustment, therefore, must take an ‘outside view’ where the uplift amount is based on statistical modelling of similar projects, such as using reference class forecasting (RCF).

1.1.4 RCF is a method of predicting the outcome of a planned action based on actual outcomes in a reference class of similar actions to that being forecast. The development of the theories behind RCF helped Daniel Kahneman win the Nobel Prize in Economics. Kahneman found that, people tend to underestimate the costs, completion times, and risks of planned actions through insufficient consideration of distributional information about outcomes of similar schemes that have already been completed (Kahneman and Tversky, 1977). RCF involves using statistical methods to analyse large samples of projects in order to provide a reliable reference class which is relevant to the project circumstances. Often, different reference classes are required to relate to different parts of project scope.

1.1.5 The Department encourages organisations to systematically collect, forecast and outturn cost data at each project milestone to form reference classes for cost risk forecasting.

1.1.6 The use of QRA does not remove the need to make adjustments for optimism bias and vice versa. Bottom-up QRA refers to project specific cost items and well quantified risks, while top-down optimism bias adjustments seek to capture unforeseen risks which are difficult to quantify ex-ante. The two elements are both informative to managing project risk, with the relative significance of each being determined by how well specific risk and probabilities can be estimated. As projects advance through their stages and scheme promoters improve their cost estimation and risk analysis methodologies, through experience and feedback loops, the ability to assign greater weight to bottom up elements will increase. However even when risks are well identified there will remain a residual requirement for a top-down uplift.

1.1.7 The cost elements outlined above will apply to a given set of objectives, scope, and stage of development of a scheme. A significant change in the objectives/scope of a project will require new base costs, and adjustment for risk or optimism bias. A change of this magnitude would probably trigger a full reappraisal of the project.

1.1.8 Appendix A provides a worked example illustrating the methodology outlined in each part of this section of the guidance.

2. Base costs

2.1.1 Base costs are the first component of a scheme cost estimate. The base cost represents the basic costs of the scheme made up of investment (or capital), maintenance and operating costs, for a given price base. They usually comprise of a point (i.e. most likely) estimate of rates and quantities required for a project.

2.2 Real cost changes over time

2.2.1 Base cost estimates should use realistic assumptions about real cost changes, e.g. cost increases above or below inflation measured by the GDP deflator. Analysts should consider current and forecast inflation from industry sources appropriate for their scheme and clearly present the assumptions and sources of evidence used. A strong justification would be expected for any assumption of zero real cost inflation.

2.2.2 As a baseline assumption, section 3.6 recommends including for real cost inflation over and above the GDP deflator of 2.1%, for appraisal where a bespoke real cost inflation estimate is not available. This is based on a reference class forecast of the difference between GDP deflator and construction sector specific inflation, as set out in OGP (2020). For schemes which have more limited exposure to inflation through appropriate commercial strategies or bespoke real cost inflation forecasts, an alternative approach is recommended based on a reference class forecast for optimism bias in inflation allowances for previous UK projects. This leads to a total uplift on scheme costs of around 4.3%.

2.2.3 When forming base costs in a given price base year, different components of cost should be adjusted by a real cost increase relevant to that particular component. For example, some cost components may be priced in foreign currencies, with a material impact on cost trends. More detail on converting nominal prices to real prices is given in TAG Unit A1.1 and the worked example in Appendix A.

2.2.4 Analysts may feel that it is appropriate to make allowance for the risk of costs increasing above inflation in their Quantified Risk Assessment. More detail is given in section 3.2.

2.3 Investment costs

2.3.1 Investment costs (often referred to as capital costs) should be distinguished from operating costs. Table 1 on the next page, lists the potential main components of investment costs: construction; land and property; preparation and administration; and traffic-related maintenance costs. This is also the component of scheme costs that the OB uplifts detailed in Section 3.5 should be applied to.

2.3.2 Construction costs should include fees for project management, procurement, design, legal and third party costs. Land and property costs should include the implicit costs of any resource that is acquired without financial payment such as 'land gift', including that from a local authority. Transport & Work Act Order (TWAO) application costs and the costs associated with obtaining statutory approvals should also be included in the investment costs. All costs borne by the private sector should include non-recoverable indirect taxation (e.g. landfill costs, fuel duty and so on).

2.3.3 Only the costs which will be incurred subsequent to the economic appraisal and the decision to go ahead should be considered. 'Sunk' costs, which represent expenditure incurred prior to the scheme appraisal and which cannot be retrieved, should not be included. The costs of land or property purchased prior to an appraisal should be treated as sunk costs, unless the purchase costs could be recovered by the re-sale of the land or property if the scheme were not to go ahead. These should be based on current market values and not those incurred at the time of their acquisition.

2.3.4 Investment costs should include estimates of traffic-related maintenance and renewal costs. Investment in new transport infrastructure may provide savings in replacing or maintaining existing infrastructure. These avoided renewals can be treated as a maintenance cost saving in the 'with scheme' case

Table 1 Examples of Investment Costs Components

Base Investment Costs	Roads	Railways	Public Transport
Construction Costs	i) Main works contract (including preliminaries, structures, road works general, earthworks, main carriageway, interchanges, side roads, signs, etc.). ii) Ancillary work contracts (including provision of maintenance compounds, lighting, motorway communications, landscaping, noise insulation, etc) iii) Work by other authorities (including Network Rail, local authorities` works, statutory undertakers` works) iv) On site Supervision and Testing	Stations, Route Infrastructure Enabling and Advance Works, Communications, Rolling Stock, Track, Power and Signalling or Passenger facilities. Possession costs for train operators.	For Buses: Providing or upgrading vehicle fleet, New System of Ticketing and Passenger Information, New Stops and shelters, Bus Priority Measures on the highway and passenger information
Land and Property Costs	Acquisition cost, Legal transaction costs, Property management costs, Compensation etc.		
Preparation and Administration Costs	Project Management, Consulting engineers` fees, agent authorities fees, actual costs of pursuing alternative routes (if any) in the early stages of the scheme, Design costs, Public Consultation, Public Inquiry, gaining statutory powers or other licences and consents, compensation, the cost of any surveys carried out during scheme preparation, the costs associated with obtaining statutory orders, and on site Supervision and Testing	Generally as for roads. e.g. the costs associated with obtaining statutory orders	Generally as for roads. e.g. the costs associated with obtaining statutory orders
Traffic-related maintenance costs	e.g. non-routine reconstruction, resurfacing, surface dressing attributable to the investment (such traffic-related costs may be applicable to rail and public transport schemes, as well as highways investments).		

2.4 Operating costs

2.4.1 The appraisal should include realistic and comprehensive operating cost estimates, identifying the main components. All operating cost estimates should include an assessment of real growth over time.

2.4.2 It is important to note the distinction between operating costs incurred by transport providers, referred to here, and vehicle operating costs incurred by transport users which are discussed in TAG Unit A1.3 – User and Provider Impacts.

2.4.3 Operating costs may be incurred by private or public sector providers and are recorded in different places in the standard Departmental tables, i.e. Transport Economic Efficiency (TEE) and Public Accounts (PA) tables. Further detail as to how information on costs should be recorded in the appraisal documentation can be found in section 4 of this TAG unit. Examples of operating costs are provided in Table 2.

Table 2 Examples of Operating Costs Components

Element of Base Cost	Roads	Railways	Public Transport
Operating Costs	Routine and non-traffic related maintenance costs (e.g. drainage, street lighting, fencing, grass cutting, repainting lines etc)	Train and station operating costs (e.g. payroll, fuel and traction and track access and station lease charges). Train leasing charges- which normally includes light and heavy maintenance of rolling stock.	Buses: Enforcement of bus lane Maintenance of stops; Fuel; Payroll.

2.4.4 Staff costs should include allowances for holidays, sickness, shift working, training and overtime. Note that wage rates may increase faster than general inflation. Additional costs may include management costs for park and ride sites and rates for premises used as depots. Where possible, advice should be sought from relevant operators or operating costs from similar existing systems should be used as a reference before adjustments are made for real cost changes.

2.4.5 For public transport schemes it is expected that a whole life cost appraisal is used to establish the total cost of ownership, i.e. the total cost of delivering, operating and maintaining a project. The total cost of ownership will depend on the quality required over the life of the scheme, constant or increasing patronage, service frequency, and the trade-off between maintenance and renewal. Schemes where the project life can be determined from the limited life of its component assets, i.e. with a finite life, will have a planned or contracted life. TAG Unit A1.1 provides guidance on how the residual values should be included for projects with finite lives.

2.4.6 Bus-based schemes may include operating costs falling to the highway authority owing to use of the road network, (e.g. maintenance of bus lane) although, in general, any effects would be expected to be marginal.

2.4.7 Costs per km per year for non-traffic-related maintenance costs of additional infrastructure are given in Table 9/1 of the COBA User Manual, (DfT, 2006).

2.5 Forecasting operating, maintenance and renewal costs

2.5.1 Operating and maintenance costs must be forecast for the whole of the appraisal period. In forecasting future operating, maintenance and renewal costs, analysts should consider:

- the impact of increasing usage or patronage; and
- the potential for cost increases in excess of general inflation.

2.5.2 To gauge the profile of operating and maintenance costs over time it is recommended that estimates should be prepared for three separate forecast years (although this may vary with project type). Analysts will need to use their judgement to choose the number and timing of years to be considered. TAG data book table A5.3.1 may be helpful in forecasting real increases in average earnings for staff-related costs. Interpolation and extrapolation should then be used to cover the whole appraisal period. TAG Unit A1.1 provides further information on the appraisal period.

2.5.3 Detailed analysis for later periods is unlikely to be feasible or worthwhile. However, analysts should take care to ensure that their work is as robust as possible, and based on available evidence. Analysts would be expected to draw on advice on the likely and most appropriate maintenance and renewal regimes to be adopted from experts in this field (scheme design / asset management), with assumptions of costs then appropriately reflecting their guidance. All assumptions and supporting evidence should be fully documented and submitted to the Department.

2.5.4 Projects with long lives may have additional elements of major structural maintenance and/or renewal within the appraisal period. For example, road pavements and drainage may require renewal, as may rail track and rolling stock. Wherever possible, the timing, cost and duration of these major elements of cost should be estimated explicitly. Where this is not possible, these costs may be included in annual maintenance rates, though care must be taken to avoid underestimation.

2.5.5 The need for periodic major maintenance and renewal means that the maintenance costs profile over time is likely to be 'spiky' whereas the operating costs profile is more likely to be fairly constant over time. The appraisal should also include the impact of delays arising from major maintenance or renewal and more detail is given in TAG Unit A1.3.

3. Treatment of cost risk and uncertainty

3.1.1 Risk in the context of this unit refers to identifiable factors that may impact on scheme costs, leading to over- or under-spends. Such risks should be identified and quantified in a Quantified Risk Assessment (QRA) to produce a risk-adjusted cost estimate. This is required for all transport projects with a base cost greater than £5m in 2010 prices, and is encouraged for smaller schemes.

3.1.2 A bespoke uncertainty adjustment, based on a top-down view of the risk profile as opposed to individual risk elements, may also be included to account for unquantifiable risks in place of standard OB rates. This is only recommended where there is robust evidence on which to base these adjustments, as described in 3.5.12. Risks associated with patronage or benefits should be dealt with by sensitivity or scenario testing around the central case. Guidance on handling uncertainty in forecasting is provided in TAG Unit M4 and the Uncertainty Toolkit.

3.1.3 Risk assessment should be proportionate to the size and the stage of development of the project. The time and resources devoted to quantifying risks should relate to how many risks have to be analysed; how difficult that is to do; and the materiality of these risks. Promoters should draw upon professional advice and reference class forecasting when attempting to identify those risks that have been shown to have the most significant impact on scheme costs in the past. The level of detail required may need to be discussed with the Department. As a minimum the Department expects the impact of delays and above anticipated cost increases to be included in the risk assessment.

3.1.4 The risk assessment provides a snapshot of the risks at a particular stage of development and should be kept under review throughout the scheme's development. It is particularly important that the risk assessment reflects the best available evidence and is included in the appraisal at the time it is submitted to the Department as part of a bid for funding.

3.1.5 The Office for Government Commerce (OGC) expects Gateway Reviews to be carried out on all government projects. These reviews will seek evidence that risks have been properly considered before the project can move on to the next stage.

3.2 Quantified Risk Assessment

3.2.1 A Quantified Risk Assessment (QRA) allows an expected value (defined as the average of all possible outcomes, taking account of the different probabilities of those outcomes occurring) of the cost of the scheme to be calculated. This expected value should form the 'risk-adjusted cost estimate'. The QRA follows a four-step process:

- Risk Identification;
- Assessing the Impacts of Risk;
- Estimating the Likelihood of the Impacts of Risk; and
- Deriving the overall distribution and expected value of Risk for the scheme.

3.2.2 All 4 steps are susceptible to bias, as well as errors, and large schemes should consider having fully independent reviews carried out of their QRAs.

Step 1: Risk Identification

3.2.3 Promoters should construct a comprehensive Risk Register listing any identified risks that are likely to affect the delivery and operation of the scheme and present this in the business case. The risk register should list the results of the analysis and evaluation of the identified risks and should be updated and reviewed continuously throughout the scheme development process. Annex 4 of The Green Book [HM Treasury, 2003] provides further information. Table 3 highlights examples of the main types of risk likely to be encountered in a project. Not all of these will be relevant in the context of estimating scheme costs.

3.2.4 Evidence suggests that risks associated with scheme delays and cost inflation are particularly important. These risks should be included in the Risk Register and appropriate consideration should be given to the combined risk of both delays and cost rises above those assumed in the base costs. The risk of impacts associated with climate change on transport infrastructure being greater or less than has been assumed in the base cost estimate should also be considered. This could have important implications for the maintenance profile of costs for a scheme.

3.2.5 The risks associated with changes in scheme design should be identified and recorded in the risk register. However, the risk of making significant design changes, possibly relating to a significant change in scope - where scope is defined as the specified output/objectives of the scheme - should be mitigated prior to submitting the business case to the Department. If any unforeseen, significant changes in scope then do occur, the project should be subject to a full reappraisal, including reconsideration of rejected alternatives.

3.2.6 The risk register also needs to identify who owns the identified risk. For example some risks may be transferable through insurance or financial instruments. In all cases, the risk register should indicate where risks have been successfully transferred. Where a risk has been transferred, the promoter should ensure that it is fully transferred; provide evidence to the Department; and include any premiums paid as part of the transfer in the base cost.

Table 2 Examples of Project Risk

Policy Risk	Legislative risk	The risk that changes in legislation increase costs. This can be sub-divided into general risks such as changes in corporate tax rates and specific ones which may change the relative costs and benefits of different procurement routes.
	Policy risk	The risk of changes of policy direction not involving legislation.
Risk on delivering the asset	Construction risk	The risk that the construction of the physical assets is not completed on time, to budget and to specification. The risk of inflation differing from assumed inflation rates, particularly for any schemes where construction is not expected to start until some years in advance.
	Planning risk	The risk that the implementation of a project fails to adhere to the terms of planning permission, or that detailed planning cannot be obtained, or, if obtained, can only be implemented at costs greater than in the original budget.
	Residual value risk	The risk relating to the uncertainty of the value of physical assets at the end of the contract.
Risk on operating the asset	Operational risk	The risk that operating costs vary from budget, that performance standards slip or that the service cannot be provided.
	Inflation risk	The risk that actual inflation differs from assumed inflation rates.
	Maintenance risk	The risk that the costs of keeping the assets in good condition vary from budget.
Risks on demand and revenue	Demand risk	The risk that demands for the service do not match the levels planned, projected or assumed. As the demand for a service may be (partially) controllable by the government, the risk to the public sector may be less than that perceived by the private sector.
	Design risk	The risk that the design cannot deliver the services at the required performance or quality standards
	Availability risk	The risk that the quantum of the service provided is less than required under the contract.
	Volume risk	The risk that actual usage of the service varies from the level forecast.
	Technology risk	The risk that changes in technology result in services being provided using non optimal technology.

Source: HM Treasury (2003).

3.2.7 To identify the main areas of risk and who owns them it can be useful to organise workshops or 'brain-storming' sessions. These should involve experienced people like managers of the project, financial and economic advisers, designers, operators and maintainers of the existing infrastructure (where there is some), engineering and insurance professionals, professional negotiators, actuaries, and lawyers.

3.2.8 It may be useful to engage specialist consultants who have relevant expertise in facilitating risk identification exercises. However, the engagement of specialist consultants does not eliminate the need for substantial involvement of the project management team. The value of the input by specialist consultants will depend on the quality of the briefings they receive from client team members who better understand the project specific risks.

3.2.9 One source of risk is from ‘catastrophe risk’, such as major wars or natural disasters. Such events would be so devastating that all returns from policies, programmes or projects could be eliminated or at least radically and unpredictably altered. Catastrophe risk is one of the factors making up the discount rate [HMT Green Book, 2003] so it is not necessary to identify such risks as part of the risk assessment.

Step 2: Assessing the Impacts of Risk to Determine Possible Outcomes

3.2.10 Having identified risks in step 1, the next step is to assess the impact of each risk, or combination of risks, should they be realised, in terms of the cost outcomes of the risk. This should be primarily through evidence from similar schemes and / or modelled sensitivity analysis. The range of outcomes should consider both the upper and lower extremes of the possible range, taking into account any reasonable constraints.

3.2.11 The best methods for quantifying the impact of risk will depend upon the information sources available. The best approach is to use empirical evidence from similar schemes whenever it is available, and empirical evidence should be gathered when possible. When it is not, common-sense approximations should be used. , rather than aiming for unrealistic or spurious levels of accuracy. What this means in practice depends on the nature of the risk. The objective is always to obtain an unbiased estimate of the impacts of the risk on the costs of the scheme.

3.2.12 When assessing the consequences of any risk, analysis should not be restricted to only the direct effects but should be extended to ensure all knock-on effects are included. This requires care, as there could be interaction between different risk events. Some risks will affect the costs of either the construction or operation of the project. For example if a plot of land is not available on time, the possible knock-on effects could include:

- costs associated with looking at alternative sites;
- lost management time as a result of litigation/seeking Compulsory Purchase Orders;
- inability to meet contractual commitments; and
- increased input costs resulting from cost increases during scheme delay.

Step 3: Estimating the Likelihood of the Outcomes Occurring

3.2.13 Having identified a broad range of risks and used a systematic approach to assess the potential range of cost outcomes, it is necessary to assess the likelihood of occurrence for each of the possible outcomes.

3.2.14 As with assessing the impacts of risk, it is important that the predicted likelihood of an outcome occurring should be based on experience of past events, taking account of any foreseeable changes or developments, rather than arbitrary estimates. Organisations are encouraged to compile databases of past schemes' cost data including details of the reasons for any cost changes. When available, these could be useful in reaching conclusions as to the likely occurrence of different risks.

3.2.15 Estimating probabilities is not an exact science and inevitably assumptions have to be made. There is nothing wrong with this, but it is important that the assumptions in the assessment are reasonable and fully documented, as they are open to question when submitted to the Department.

Step 4: Deriving the Probability Distribution for the Costs of the Scheme

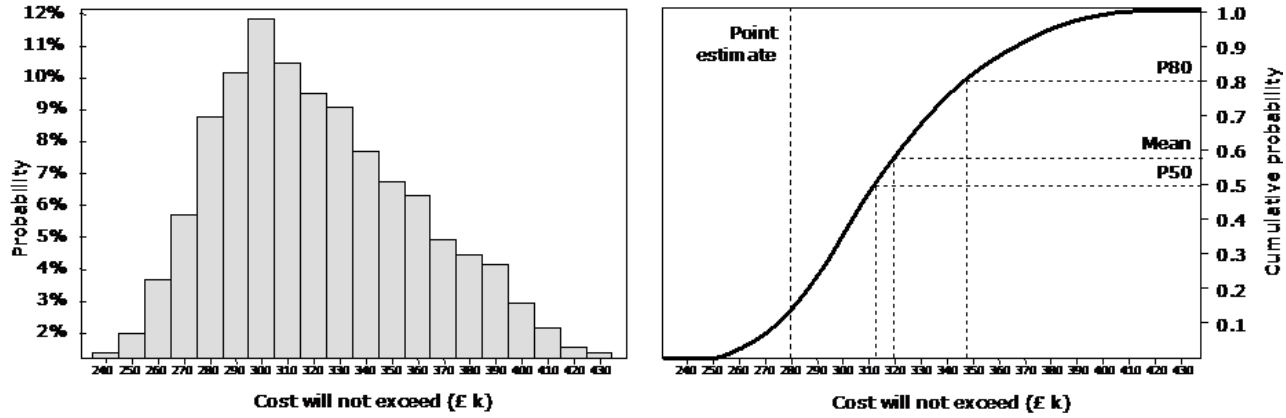
3.2.16 A QRA allows a probability distribution around the costs of the scheme to be derived and enables the expected risk-adjusted cost estimate to be obtained. This expected outcome, also known as the 'mean' or 'unbiased' outcome is the weighted average of all potential outcomes and associated probabilities.

3.2.17 The identified risk assessment and uncertainty analysis (if conducted) will together form the (risk-adjusted) mean estimate of the cost of the scheme. Operating costs and capital costs should all be based on expected values of the cost of the scheme.

3.2.18 Many risks are linked or correlated, i.e. if one risk occurs another risk is likely to occur. Modelling these relationships is easier with appropriate software, e.g. using Monte Carlo simulation to establish the range of costs. Cost risk relating to time delays is often significant and Monte Carlo simulation can also take account of this.

3.2.19 Several methods can be employed to derive the probability that the total project cost (the sum of all the activities considered in the QRA) will not exceed a particular value. The graph on the left in Figure 1 shows the standard probability distribution. This can provide useful information to derive the cumulative probability distribution or S curve (shown to the right). This gives the probability of the scheme cost estimate being less than or equal to any specified value.

Figure 1 Example Probability Distribution for the costs of a Scheme



3.2.20 The cumulative probability distribution shows the probability of cost overrun associated with different risk-adjusted cost estimates. For instance, the P50 value is the budget estimate associated with 50% probability that the project will be delivered within budget and the P80 estimate represents an 80% likelihood that the project will be delivered within a budget. The mean, or expected, value is the weighted average of all outcomes and probabilities.

3.2.21 In the example above, the P50 estimate is £312k, the P80 is £348k and the expected value (the weighted average of all outcomes and probabilities) is £320k, between the P50 and P80 estimate. It is possible to infer the probability that the scheme is delivered to the base cost. In the case represented above, the base cost point estimate £280k. The cumulative probability distribution shows that there is only a 12% probability that the scheme stays within this base case cost estimate.

3.2.22 For smaller schemes, quantifying the impact of scheme risks can be made easier by banding the risks into a smaller number of categories according to their impact. For example, negligible, slight, severe, catastrophic etc. The amount of time and resources that are devoted to quantifying risks should relate to their likely materiality. It may be acceptable to assess the probability of any one outcome occurring using a simple four-point scale, expanded to more levels if appropriate. This scale would use, at a minimum, very unlikely, moderately unlikely, likely or most likely, where the most likely outcome would normally be the central forecast value. This method (along with the assessment of impacts) can be used to inform 'expected' risk allowances to apply on smaller schemes. However, the exact requirements need to be discussed with the Department on a case-by-case basis.

3.2.23 The P(mean), which tends to be higher than the P50 due to the positive (right-tailed) skew of a typical cost distribution, is the level which should be used in economic appraisal.

3.2.24 As outlined by UK and HMT Green Book supplementary guidance on financial cost estimates, the QRA exercise may also be used to inform the setting of realistic budget contingencies. Each level of contingency may be held at different organisational levels with the appropriate governance arrangements to incentivise cost efficiency. For instance, in the example above the P(mean) could be the contingency at the project level while the P80 could be the contingency at the portfolio level. This use of contingency should be restricted to financial or accounting purposes. Optimism bias uplifts are only required for the economic case.

3.3 Responding to risk

3.3.1 In addition to deriving the risk-adjusted cost estimate and in line with the Green Book [HMT, 2003], promoters should prepare risk mitigation plans and provide evidence of a systematic approach to responding to risks. Broadly speaking, responding to risks will involve some combination of tolerating, treating or transferring the risk; or terminating the activity giving rise to the risk.

3.3.2 There are two alternative reasons why risks should be tolerated: either the cost of taking any action exceeds the potential benefit gained; or there are no alternative courses of action available.

3.3.3 The purpose of treating risks is to affect the impact and / or the likelihood of the risk, while continuing with the activity giving rise to the risk. There are a variety of actions that can be taken to treat risks. The Orange Book (HM Treasury, 2013) defines four different types of control:

- Preventive Controls - to limit the likelihood of an adverse risk occurring;
- Corrective Controls - to minimise the impact of adverse outcomes;
- Directive Controls - to ensure that a particular outcome is achieved; and
- Detective Controls - to identify adverse outcomes once realised to minimise their impact.

3.3.4 Any actions taken to treat risks should be proportional to the risks they are designed to control. Every action has an associated cost and it is important that the action offers value for money in relation to the risk that it is controlling.

3.3.5 Transferring risk can be seen as a form of treating risks. For example, insurance, the conventional approach to transferring risk, can be regarded as a form of corrective control as it facilitates financial recovery against the realisation of a risk.

3.3.6 Ultimately some risks will only be treatable or containable to acceptable levels by terminating particular activities. This option is particularly important if it becomes clear that undertaking certain activities jeopardises the value for money of the scheme as a whole.

3.3.7 Table 4 provides a possible set of options to include in a risk mitigation plan.

3.3.8 The key objective of responses to risk is ultimately to reduce the risk-adjusted costs of the scheme. It is important that the implications of decisions taken to respond to risks are factored into both the estimates of base costs and the risk assessment that are submitted to the Department. Therefore, the process of risk assessment and establishing an estimation of costs accounting for risk needs to be undertaken for both pre and post-risk mitigation situations.

Table 3 Options that could be included in a risk mitigation plan

Option	Reason
Active risk mitigation	Identify risks in advance and plan to reduce or eliminate resulting adverse effects; include process to monitor risks; decision making supported by framework of risk analysis
Early consultation	Helps to identify relevant stakeholders and risk mitigation
Avoidance of irreversible decisions	Through understanding causes of delay, through further investigation and improved reliability of project plan
Pilot studies	Acquire more information on risk affecting projects with many unknowns
Design flexibility	Designs adaptable to future changes are less adversely affected by risk than design suited to only one outcome.
Precautionary principle	Precautionary action required to mitigate severe risks
Procurement/ contractual	Risk contractually transferred to other parties
Make less use of leading edge technology	Complex untried technologies tends to have greater levels of uncertainty and risk
Reinstate or develop different options	Alternative options may be considered if current options are found to be more risky than initially thought
Abandon proposals	Proposal may be so risky that it is worth abandoning due to adverse risk

Source: HM Treasury (2011)

3.4 Further information on managing and assessing risk

3.4.1 Further detailed guidance on performing a risk assessment is Annex 4 of The Green Book (HM Treasury, 2020) and Supplementary Green Book guidance on financial cost estimates of infrastructure projects and the treatment of uncertainty and risk (HM Treasury & Infrastructure UK, 2013). The Orange Book (HM Treasury, 2004) provides broader guidance on the principles of risk management that are valid and applicable across all modes. More specific information on risk analysis in railways can be found in TAG Unit A5.3 – Rail Appraisal.

3.4.2 Most risks will be common to a scheme regardless of the procurement route and provisional decisions on the acceptability of major schemes are often taken prior to detailed consideration of the procurement route. The Department expects to see a full assessment of risk for all schemes, irrespective of which procurement route may eventually be chosen. Where there are major risks, promoters will have to demonstrate that such risks are understood and can be actively managed within the public sector or transferred at an appropriate cost to the private sector. The costs should reflect the procurement strategy for the project for example Design and Build (D&B), Design, Build, Finance and Manage (DBFM), Private Finance Initiative (PFI). If a firm strategy does not exist, then the costs should come with a statement on the procurement route assumed for the purposes of the appraisal.

3.4.3 Information on the interaction between QRA and OB cost estimates can be found in section 4, including additional considerations that may need to be given to the QRA.

3.5 Optimism Bias

3.5.1 Optimism bias is the demonstrated systematic tendency for appraisers to be overly optimistic about key parameters. Theories on cost overruns suggest there are several means by which optimism bias could be caused, including the psychological tendency for humans and organisations to favour optimism, the economic rationale of advancing projects in which organisations have interests in, and the strategic behaviour of stakeholders involved in the planning and decision-making processes.

3.5.2 The Green Book [HMT,2003] suggests that appraisers should make explicit, empirically based adjustments to the estimates of a project's costs, benefits, and duration. The guidance in this section focuses upon making adjustments to costs and draws on evidence from the studies summarised in Table 5. Demand and benefit optimism bias should be examined using sensitivity tests (see TAG Unit M4 - Forecasting and Uncertainty and TAG Units for Appraisal Practitioners).

3.5.3 This optimism bias guidance is only applicable to the economic case. The function of optimism bias adjustments is to confirm that the economic case remains robust if historically observed cost overrun were to be repeated and are generally higher where the cost estimate is immature, i.e. when there are significant elements of the project that are not defined or understood, and/or when there is evidence that the QRA is systematically underestimating costs. However, even at FBC there remains significant scope for unforeseen cost overrun. The P values produced by the QRA, such as the Pmean and P80, are more appropriate in establishing ‘contingencies’ at the relevant project and portfolio levels within the financial case. Supplementary Green Book guidance on financial cost estimates of infrastructure projects and the treatment of uncertainty and risk, produced in conjunction with Infrastructure UK, outlines how best to estimate and communicate costs in the financial case.

Table 4 Summary of Recent Studies on Optimism Bias

	Major Determinants of Optimism Bias	Main Features of the study
Mott MacDonald (2002)	Unforeseen cost overrun due to errors or omissions	Sample consists of 50 major public sector projects costing over £40m (not specifically related to transport infrastructure) from 1982 to 2002.

	Major Determinants of Optimism Bias	**Main Features of the study**
Flyvbjerg et al. (2002, 2004)	Intentional underestimation of costs due to different motivational factors.	Sample consists of 258 projects located in 20 countries across 5 continents of which 70% located in Europe and specifically related to transport infrastructure projects. No information on projects from 1998.
Koch (2012)	Not in scope	Koch (2012) finds a p70 cost overrun of 35-40% from a study of 10 UK offshore wind projects and a p60 schedule overrun of 30%.
Infrastructure Risk Group (2013)	Underestimation of costs to secure project approval; difficult fund release processes encouraging excessive contingencies; and requirements to return unused risk monies before completion discouraging mitigation.	Six major cost estimation case studies, including Highways England, Crossrail and Heathrow Airport and views from risk analysts / managers from major infrastructural organisations.
AECOM (2015)	Not in scope.	Sample of 8 Highways England major projects that opened from 2012-14; examination of cost forecasts over time and comparison to outturn cost.
De Reyck et al. (2015)	Cost forecast maturity; project type – enhancement riskier than renewals; and the degree of complexity, i.e. interfaces and parties involved.	Large sample (2050 projects) of Network Rail projects of varying types, sizes and complexity from 2009-2014.
Bayram and Al-Jabouri (2016a) Bayram and Al-Jabouri (2016b)	Not in scope	A study of 420 building projects in Turkey revealed improved cost forecasting accuracy when using RCF. In addition, RCF provided the most accurate forecasts in the early stages of the project.
Awojobi & Jenkins (2016)	Not in scope	Studying hydro-electric dams, Awojobi & Jenkins find project forecasting errors are common, and that RCF can reduce these.
Batselier & Vanhoucke (2016)	Not in scope	Studying a database of 56 projects, Batselier & Vanhoucke (2016) conclude RCF outperforms earned value management (a technique for regular project performance reviews) and Monte Carlo approaches.
Oxford Global Projects (2020)	Not in scope	The report finds that RCF provides more accurate forecasts than conventional cost estimation methods. RCF is also found to increase the probability of delivering a project on time and on budget. Using data from 2,522 rail, road, bridge and tunnel projects, the report also finds that risks are even larger at earlier stages of the project.

	Major Determinants of Optimism Bias	Main Features of the study
		Finally, it demonstrates that OB exists for both cost, schedule, benefit and operational forecasts throughout all project stages.
NIC report (2020)	Not in scope	New research on rail reference class forecasting to support the development of the analysis of the Rail Needs Assessment for the Midlands and the North. The accompanying data set can be used to generate unique reference class forecasts for different types of rail spend and serves as the companion data to the analysis of rail reference classes.

3.5.4 The Department requires a 4 step approach to the adjustment for investment costs optimism bias:

- Step 1: Determine the nature of the project
- Step 2: Identify the stage of scheme development
- Step 3: Apply the recommended uplift factors to the base **capital** cost estimate
- Step 4: Provide sensitivity analysis around the central estimate

Step 1: Determine the Nature of the Project

3.5.5 The first step involves categorising the nature of the project according to the typology given in Table 6. Oxford Global Projects (2020) concluded that within each of the categories identified, the risk of investment cost overruns can be treated as statistically similar.

3.5.6 Should your project type be bespoke or not fit into the categories described above, it may be advisable to develop a bespoke reference class forecast for the project type in question. Please contact tasm@dft.gov.uk in such cases.

Table 5 Project Categories

Category	Example of project subtypes
Rail	Light rail, conventional rail, urban rail, high-speed rail
Roads	Trunk roads, motorways, highways
Fixed links	Bridges and tunnels
Building projects	Stations, depots, concert halls, office buildings, museums

IT projects	IT system development
Land and property	Property purchases
Rolling Stock	Powered and unpowered vehicles

Source: Oxford Global Projects (2020)

Step 2: Identify the Stage of Scheme Development

3.5.7 The Department has identified three main stages in the life of a transport project for which default uplift values have been provided, as illustrated in Table 7 below. The stages should be seen as indicative of the quality of risk assessment and cost estimate typical of schemes at the different stages of scheme development.

Table 6 Stage of scheme development according to scheme category

Category	Stage 1	Stage 2	Stage 3
Local Authority and Public Transport Schemes	Strategic Outline Business Case (SOBC)	Outline Business Case (OBC)	Full Business Case (FBC)
Highways England Schemes	PCF Options Phase	Order Publication/ Works Commitment	Construction Preparation
Railways	PACE Stage 1: Project Definition	PACE Stage 3: Option Selection	PACE Stage 5: Design Development

Step 3: Apply the recommended uplift factors to the base capital cost estimate

3.5.8 Obtain the recommended uplift (appropriate to the category and stage of development) given in Table 8 and apply to the base capital cost estimate.

Table 7 Recommended optimism bias uplifts for different projects at different stages of the life of a transport project

Category	Types of projects	Stage 1	Stage 2	Stage 3
Roads*	Motorway, trunk roads, local roads	46%	23%	20%
Rail	Metro, Light rail, Guided buses on tracks, line upgrades, high-speed rail	56%	33%	30%

Fixed links	Bridges and Tunnels	55%	32%	28%
Building projects	Stations and Terminal buildings	70%	48%	44%
IT projects	IT system development	69%	50%	42%
Land and property	Property purchases	33%	14%	0%
Rolling Stock**	Powered and unpowered vehicles	61%	38%	35%

Sources: Oxford Global Projects (2020)

** Active mode schemes should also apply the roads optimism bias rate.*

*** The Rolling Stock refers to procurement of new rolling stock, rather than existing stock sourced through lease deals.*

3.5.9 As a project develops, the Department expects the scheme cost estimate to be refined based on better quality data and greater definition of project elements. As project-specific risks become better understood, quantified and valued, it should be possible to better capture the factors that contribute to optimism bias within the risk management process, leading to ‘cost maturity’. Therefore, as risk analysis improves as a scheme develops, it is expected that the analysis feeding into the quantified risk assessment will become more certain, reducing the reliance on optimism bias uplifts as reflected in the uplifts above. The allowance for optimism bias should be largest at the initial stage of the life of a transport project (e.g. Strategic Outline Business Case); to decrease in a more detailed business case (e.g. Outline Business Case or Full Business Case). As the figures above show, there remains significant scope for OB at FBC.

3.5.10 The Department expects promoters to apply uplifts at other stages of scheme development as well as those identified. For rail schemes, TAG unit A5.3 gives a more detailed breakdown of uplifts by Network Rail PACE (Project Acceleration in a Controlled Environment) stage, whereas for other categories, evidence is not available to specify uplifts for other stages of scheme development. Therefore, analysts should base the uplift to use on the stage of scheme development relative to those defined in Table 7 and Table 8.

3.5.11 The rail OB rates above are primarily derived from major new build rail projects. For smaller rail enhancement renewals projects with a low cost, the OB rates calculated by UCL (2015) are more appropriate. The OB rates above should be used for any project costing in excess of £7 million (2021 prices), which is approximately the 90th percentile of costs within the UCL (2015) reference class of Network Rail projects. For rail schemes that would benefit from more disaggregated/ bespoke RCFs, research published by NIC (2020) provides up to date OB rates for a range of P-values.

3.5.12 With sufficient evidence, analysts can use uplifts that deviate from those in Table 8 based on the stage of development; quality of risk assessment; and the extent of optimism bias mitigation. In cases where the risk assessment can draw on an extensive reference class database of similar schemes; accounts for unquantifiable risks through a top-down uncertainty adjustment; and is complemented by governance arrangements, such as verification of cost estimates by independent experts, robust and comprehensive cost estimation can potentially reduce the optimism bias adjustment.

3.5.13 The Highways England's Project Control Framework is an example where this has been effectively applied. Equally however, if the scheme or elements of the scheme are particularly novel, it might be appropriate to use uplifts in excess of those presented in Table 8. In general, the Department does not expect to see uplifts used that are below those given for the next stage of scheme development in Table 8 without justifiable evidence (e.g. for a road scheme at Stage 1, the Department would not expect an uplift below 46%).

3.5.14 The business case should contain evidence to support the level of optimism bias, as ultimately the Department will decide upon the uplift to apply for the purposes of making funding decisions, in consultation with the promoter.

3.5.15 In cases where departmental bodies or agencies have released specific guidance on optimism bias for particular types of transport schemes (e.g. local transport, railways and HE schemes), promoters are invited to refer to these more detailed documents.

3.5.16 Where a project includes significant elements of the different project types identified above, it might be considered a combined project, with the differing elements representing sub-projects. The relative size of each sub-project should be determined and the appropriate OB uplifts should be identified and applied to that part of the project. After this has been done, the adjusted costs for each sub-project should be aggregated to establish the total cost for the overall project.

Step 4: Perform Sensitivity Analysis

3.5.17 The fourth step requires sensitivity analysis around the uplift used. It is important to examine the impact of a range of other possible levels of optimism bias on the cost estimates reported in the TEE and PA tables. Sensitivity analysis should be performed at every stage of the life of the project, and further guidance for accounting for uncertainty is provided in section 6.

3.5.18 There is currently insufficient evidence available for the Department to recommend any specific optimism bias uplifts for operating costs. Despite the lack of strong evidence, the Department expects scheme promoters to consider the sensitivity of their scheme's business case to changes in operating costs from those that have been forecast. Scheme promoters will be expected to justify the level of optimism bias applied to operating costs, and similarly justify a decision not to apply any uplift to operating costs.

3.5.19 The Oxford Global Projects report (2020), includes some estimated operating cost OB for rail and road projects, which can be found in the appendices to the report. The Department still believes there is significant uncertainty associated with these results and that they are less robust than the capital cost OB figures presented above. As a result, those OB rates are not included in this TAG unit, but may be a useful starting point for bespoke analysis on operating cost OB where it is material and proportionate to do so.

3.6 Treatment of real cost Inflation

3.6.1 The optimism bias uplifts in this guidance are calculated on the assumption that they will be applied to real-term estimates, and so account for real-term cost overruns. However as discussed in section 2, real cost inflation (defined as inflation over and above the GDP deflator) should also be accounted for. In doing so, additional consideration needs to be given to any optimism bias included in inflation forecasts.

3.6.2 This guidance outlines two different approaches to identify the optimism uplift required for estimates including real cost inflation. The first approach applies the RCF to historical construction inflation in the UK. The second approach uses historic data comparing real-term with nominal cost overruns in past UK projects. Alternative approaches may be used if they can be supported by robust evidence which specifically seeks to account for any optimism bias in forecasting including inflation.

3.6.3 **Method 1: Reference class forecasting based on historical divergence between construction specific and general inflation**

3.6.3.1 This method should be used where there has been no explicit provision for real cost inflation (defined as inflation over and above the GDP deflator recommended in the Green Book) within cost estimates. The risk of unforeseen inflation should be derived from the RCF curve outlined in Figure 2, which compares actual construction inflation against the GDP deflator. The Pmean value from this reference class, a 2.1% uplift on annual GDP deflator inflation, should be used to estimate costs in the core scenario.

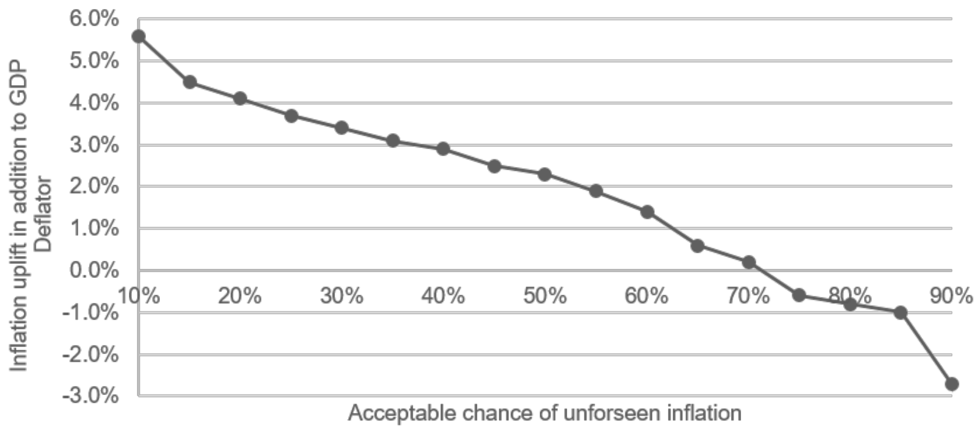
3.6.3.2 An index series using this Pmean RCF value is displayed in TAG Data Book table A1.2.1 – Cost inflation series. If indexing cost prices to a historical year, this series should be used as it chains the RCF values onto outturn infrastructure construction inflation data from the ONS[2].

3.6.3.3 It is recommended that where an alternative approach has been used to incorporate real cost inflation into cost estimates, these bespoke values should be validated against an uncertainty range generated from the distribution implied by the RCF evidence shown in Figure 2. Index series from simulated random draws for P20 and P80[3] are displayed in TAG Data Book table A1.2.1 – Cost inflation series.

3.6.3.4 Where bespoke values fall outside this range on an index basis, this divergence should be justifiable with reference to project-specific inflation risks, and presentation of a sensitivity test using the core, Pmean RCF values should be considered.

[2] Specifically, the ONS Construction Output Prices Index: New work output prices (Infrastructure) series
[3] Draws assumed a normal distribution

Figure 2 Reference class forecast for inflation uplift needed for the GDP deflator for a given acceptable chance of unforeseen inflation.

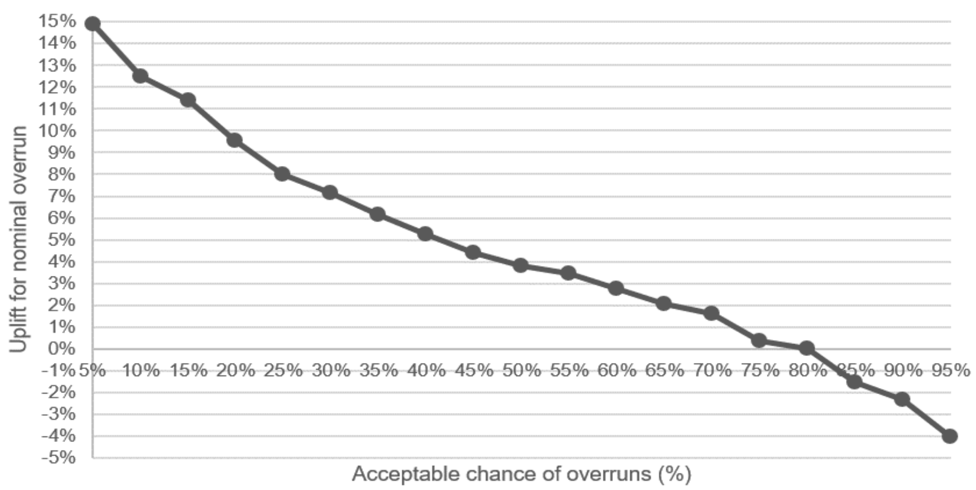


Source: Oxford Global Projects (2020)

3.6.4 Method 2: Reference class forecasting based on past UK projects

3.6.4.1 This method should be used if a project has limited exposure to inflation through specialist technical forecasts or commercial strategies, meaning the RCF curve in Figure 3 should be used, which compares real-terms and nominal cost overruns from UK projects. The Pmean value from this reference class, a total uplift of 4.3% on scheme costs (including the regular OB adjustment), should be used to estimate costs in the core scenario.

Figure 3 Optimism bias of inflation estimates in UK projects



Source: Oxford Global Projects (2020)

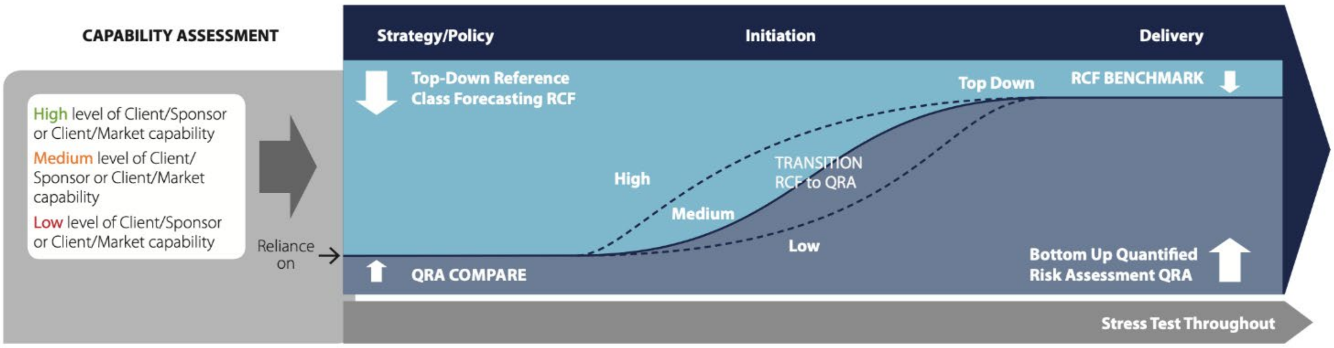
4. Reconciling QRA and OB cost estimates

Guidance on estimation and reporting

4.1.1 While only one cost estimate can be reported in appraisal, it is advisable that both a QRA and OB-adjusted cost are calculated, in order to provide valuable insights and help build an overall picture of scheme costs. This section aims to provide guidance on choosing which cost estimate to use as well as further considerations that might be appropriate, should there be large divergence between the estimates.

4.1.2 As identified in the Oxford Global Projects report (2020), RCF, used to produce the OB estimate, is likely to be more reliable in earlier stages of a project where cost estimates are less mature, while QRA may be more informative in later stages as more detailed information becomes available, as seen in figure 4. Carrying out RCF and QRA analysis in conjunction is advised to inform a project's approach to risk management. At any given business case stage, a significant divergence between cost estimates obtained using QRA and those derived by applying TAG OB rates to the base cost may indicate project risks have been misunderstood.

Figure 4: Transition from RCF based analysis to QRA through the scheme development process



Source: Infrastructure and Projects Authority Risk Management Module (2016), slide 21

4.1.3 Nevertheless there may be legitimate reasons for some difference between the value of the QRA cost estimate and OB-adjusted cost estimate. However effective the QRA exercise, there is always scope for additional uncertainty due to 'unknown unknowns', which cannot be captured using a bottom-up approach such as QRA. The RCF approach attempts to adjust for these 'unknown unknowns' on average, drawing upon a reference class of similar projects. Hence the sum of the base cost and recommended OB uplift may exceed the QRA due to the reflection of these 'unknown unknowns'.

4.1.4 Where the Pmean QRA-adjusted cost estimate exceeds the OB-adjusted cost, this may indicate that the project is drawn from a riskier reference class than the average reference classes underpinning TAG. Where this is the case, and to reflect this uncertainty, scheme promoters may wish to base their OB uplift on a higher p-value, as found in the optimism bias workbook, or indeed it may be advisable to develop a bespoke reference class forecast for the project type in question. Contact tasm@dft.gov.uk if in doubt.

4.1.5 When comparing QRA-adjusted cost estimates and OB-adjusted cost estimates, care should be taken to ensure equivalent costs are compared. Typically, QRAs will encompass the full range of scheme costs, including investment and operating costs. However, at present, TAG only recommends specific OB uplifts for base capital (investment) costs. Hence non-uplifted operating costs may need to be factored in when accounting for the OB-adjusted cost estimate to ensure a true comparison.

4.1.6 Once final estimates for QRA and OB have been arrived at, any remaining divergence between the two cost estimates should be justifiable, either by the risks inherent to the project (in the case of QRA>OB) or the likely presence of ‘unknown unknowns’ (where OB>QRA). Scheme promoters may then choose to present either the QRA cost estimate or the optimism-bias-adjusted cost estimate in their appraisal and Benefit Cost Ratio (BCR). However, given RCF represents a less bespoke but more overarching (top-down) measure of risk, one would typically expect the OB estimate to be a) higher than the QRA estimate, and b) in the majority of cases, the estimate that is chosen to be reported in appraisal in order to fully reflect the potential risks of the project in question.

4.1.7 Where a promoter has chosen to use their own, robustly evidenced top-down uplift (as per 3.5.12), this may be presented in appraisal either on top of base costs, or on top of base and QRA. This reflects the fact that a bespoke top-down uplift may account for project risks in a different manner to the recommended OB uplifts set out in section 3.5.

5. Preparing and reporting scheme costs in the PA and TEE tables

Preparation of scheme costs

5.1.1 All cost estimates should include adjustments for either risk or optimism bias and should be reported in millions of pounds in real prices (in the Department’s base year specified in TAG Data Book table User Parameters); in the market price unit of account (both public and private sector providers perceive costs in the factor cost unit of account so all costs should be converted using the indirect tax adjustment factor in TAG Data Book table A1.3.1 – Values of time per person); and in net present values (discounted to the Department’s base year using the schedule of discount rates in TAG Data Book table A1.1.1).

5.1.2 Analysts should document these key steps using the format in the cost pro-forma. Use of the Department’s TUBA software is recommended and, where

TUBA is used, the risk- or optimism bias-adjusted costs should form the inputs to the software as TUBA will convert the costs to market prices and re-base and discount them to the Department's price base year. Where TUBA is not used, more information on these adjustments is given in TAG Unit A1.1; a worked example is given in Appendix A; and the steps should be documented in the cost pro-forma format.

5.1.3 Section 2 of this TAG Unit provides guidance on the factors that should be included in investment and operating costs. The following paragraphs describe how these costs should be reported, depending on whether they fall on public or private sector providers. All costs should be attributed to the relevant mode.

Public sector provider impacts

5.1.4 Investment and operating costs incurred by a public sector provider should be recorded as positive values in the appropriate rows of the Public Accounts (PA) table, which summarises the financial impact of the scheme on public sector budgets. This is split by the impact on the budget for transport (the 'Broad Transport Budget') and wider public finances, such as indirect tax revenues. The cost of 'land gift' by a Local Authority should be included in the 'Investment Costs' row under 'Local Government Funding'.

5.1.5 Costs to public sector providers might typically include provision and maintenance of roads and car parks; highway maintenance costs arising from bus schemes; the costs of providing, maintaining and enforcing bus priority measures, stops and shelters that fall to the highway authority or PTE; and the costs of investing in rail track and signals.

Private sector provider impacts

5.1.6 Investment and operating costs incurred by a private sector provider should always be recorded as negative values in the appropriate row of the 'Private sector provider impacts' section of the Transport Economic Efficiency (TEE) table.

5.1.7 Private sector provider costs might typically include investment in bus fleets or ticketing and information systems; investment in rail rolling stock or passenger facilities; and the costs of operating bus and rail services.

Transfers between public and private sector bodies

5.1.8 It is important that all costs are correctly allocated and the PA and TEE tables allow for accounting of transfers between public and private sector providers.

5.1.9 The value of 'land gift' by a private sector provider and hypothecated developer contributions should be included in the investment costs recorded under the public sector provider in the PA table. The value of the 'land gift' or contribution should also be recorded as a negative value in both the 'Developer and Other Contributions' row of the PA table (to offset the cost recorded to the public sector provider) and the 'Developer contributions' row of TEE table (to register the cost to the private sector provider/developer).

5.1.10 Similarly, if private sector costs are met, in part or in full, by a grant or subsidy from the public sector, the full cost to the private sector provider should be recorded as a negative value in the TEE table and the value of the grant or subsidy should be included as a positive value in the appropriate rows of both the TEE and PA tables. This includes counting European Restructuring and Development Funds (ERDF) or equivalent grants.

5.1.11 TAG Unit A1.1 - Cost-Benefit Analysis provides guidance on how costs reported alongside other elements covered by the appraisal in the Analysis of Monetised Costs and Benefits (AMCB) table and Appraisal Summary Table (AST).

6. Uncertainty Guidance

6.1.1 This section presents some options to evaluate and present the range of uncertainty around cost estimates.

6.1.2 Alongside this TAG unit, the Department has made available an optimism bias workbook of RCFs by project type, including all P-values at 5 percentile intervals from P5 to P95. Promoters can also refer to the NIC report (2020) for more disaggregated rail scheme RCFs. The P-values for different levels of Optimism Bias from those RCFs found in the workbook can be used to show any desired level of cost uncertainty. The Department expects promoters to consider use of this evidence to illustrate the sensitivity of appraisal results to the level of cost overrun.

6.1.3 The following paragraphs offer some options for presenting uncertainty, but promoters are encouraged to develop their own analysis tailored to fit the needs of their business case.

Analysing the P-value associated with switching the Value for Money (VfM) band

6.1.3.1 We can use the RCF distribution to analyse the sensitivity of a project's VfM rating to cost overrun (please refer to the DfT VfM framework). Given that VfM is an important part of the decision-making process, it is useful to show the likelihood that cost overrun will be sufficiently low or high so as to shift the VfM category. We show this in the following example.

6.1.3.2 After a scheme has analysed its costs and benefits, suppose we have the following summary information. Note that this is a simplified example for explanatory purposes, and therefore omits some elements of scheme costs such as operating or maintenance costs.

Table 9 - Indicative road project cost and benefit summary at OBC stage

Item	Value	Notes
Base cost	£95m	
Base cost with OB uplift (23%)	£117m	£95m x 1.23 = £117m
Scheme Benefits	£200m	200/119 = 1.7
Benefits Cost Ratio (BCR)	1.7	
Cost change needed for BCR of 2	-£17m	200/2 – 117 = -17 (i.e. a decrease in cost)
Cost change needed for BCR of 1.5	£16m	200/1.5 – 117 = 16 (i.e. an increase in cost)
Total cost overrun needed for BCR of 2 (as a % uplift)	5%	= (117-17)/95-1=0.05
Total cost overrun needed for BCR of 1.5 (as a % uplift)	40%	= (117+16)/95-1 = 0.40

6.1.3.3 Once these values are known, the corresponding P-value on the RCF curve (shown below) can be found which will inform the VfM band switching. Linear interpolation should be used between P-values. Note, the required % cost overrun can be negative. The Oxford Global Projects report (2020) contains a range of RCF distribution allowing this analysis to be carried out in a number of scheme types. In the rare circumstance where the P-value required is outside of the range of cost overruns presented in this report, the value can effectively be set at P100 or P0 respectively.

Table 10 - Calculation of switching P-values

Cost overrun level	Expressed as a % of base cost	Associated Pvalue	Notes
P-mean overrun	23%	P60	
Percentage overrun needed for the next highest VfM band	5%	P22.5	Linear interpolation between P20 value (2%) and P25 value (7%)
Percentage change on base cost needed for the next lowest VfM band	40%	P73.6	Linear interpolation between P70 value (30%) and P75 value (44%)

6.1.3.4 Therefore, in this case we can say that there is approximately a 22.5% chance costs will be low enough to shift the scheme up to the next VfM band, while there is a 73.6% chance costs will remain low enough that the VfM does not fall to the next lowest band. Or, equivalently, there is roughly a 26.4% chance that costs will overrun sufficiently to lower the VfM band.

Additional sensitivity testing

6.1.3.5 It may also be useful for scheme promoter to test uncertainty by looking at a standardised BCR range, for example p5 and p95, or an alternative pvalue range that is more appropriate for the scheme as described in section 4.

7. References

Kahneman, D. and Tversky, A., 1977. Intuitive Prediction: Biases And Corrective Procedures. Ft. Belvoir: Defense Technical Information Center.

Department for Transport (2006): QUADRO manual

http://webarchive.nationalarchives.gov.uk/20120925153031/http://www.dft.gov.uk/publications/quadro-4-manual/

Department for Transport (2006): COBA User Manual

https://www.gov.uk/government/publications/coba-11-user-manual

De Reyck, B., Grushka-Cockayne, Y., Fragkos, I., Harrison, J., Read, D. & Bartlett, M. (2015) Optimism Bias Study

EC Harris (2006): Review of Optimism Bias for Highways Agency

HMT (2011) Appraisal and Evaluation in Central Government

H.M Treasury: Treasury Taskforce, (1999) How to Construct a Public Sector Comparator Technical Note 5

H.M. Treasury (2013): The Orange Book, Management of Risk- Principles and Concepts

H.M. Treasury (2004): Quantitative Assessment User Guide

H.M. Treasury & Infrastructure UK (2013): Early Financial Cost Estimates of Infrastructure Programmes and Projects and the Treatment of Uncertainty and Risk

H.M Treasury (2004): The Green Book Supplementary Guidance on Optimism Bias (available at: https://www.gov.uk/government/publications/green-book-supplementary-guidance-optimism-bias)

Flyvbjerg, B. (2004): Procedures for Dealing with Optimism Bias in Transport Planning

Flyvbjerg, B., Holm, M.K., Buhl, S.L. (2005): How (In)accurate Are Demand Forecasts in Public Works Projects? The case of transportation (Journal of American Planning Association, Spring 2005, Vol 71, No.2)

Infrastructure Risk Group (2013): Managing Cost Risk & Uncertainty in Infrastructure Projects

Infrastructure and Projects Authority (2016), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/528952/ipa_routemap_risk_management_module.pdf

Mott MacDonald (July 2002): Review of Large Public Procurement in the UK

Network Rail (June 2005): Project Management Principles of risk management

NIC (2020): Rail Needs' Assessment Reference Class Forecast

https://nic.org.uk/app/uploads/RNA-Reference-Class-Forecast.pdf

OGP (2020), Updating the Evidence Behind the Optimism Bias Uplifts for Transport Appraisals

8. Document Provenance

8.1.1 This TAG Unit forms part of the restructured TAG guidance on the estimation and reporting of scheme costs that was previously in TAG Units:

- 3.5.1 – The Public Accounts sub-objective; and
- 3.5.9 – The Treatment of Costs.

8.1.2 This TAG Unit also covers elements of guidance previously included in TAG Unit 3.9.2 – MSA Cost Benefit Analysis on cost estimation.

8.1.3 In November 2014 this TAG Unit was updated to provide guidance on how Network Rail costs should be treated and reported in appraisal following the decision to reclassify Network Rail as a Central Government body; and to align the GRIP stages equivalent to Stages 1, 2 and 3 in Table 7 with those given in TAG Unit A5.3 – Rail Appraisal.

8.1.4 In December 2016 this TAG Unit was updated to provide clarification on the use of quantified risk assessments and optimism bias uplifts in economic appraisal, and provide revised optimism bias uplifts for rail schemes by GRIP stage.

8.1.5 In July 2021 this TAG Unit was updated to provide updated optimism bias uplift values from the Oxford Global Projects report (2020). These values are now applied solely to the base cost, and the QRA forms a separate cost estimate, either of which can be used in a scheme's appraisal subject to consideration of project risks.

8.1.6 In November 2023 this TAG unit was updated with additional clarification on the application of adjustments for real cost inflation.

8.1.7 In May 2024 this unit was updated with refreshed references to Network Rail's PACE framework (replacing GRIP), and an updated worked example in Annex A.

Appendix A: Scheme cost worked example

A.1.1 This appendix provides a worked example of the steps required to produce costs for inclusion in appraisal for a hypothetical Local Authority road scheme at Outline Business Case stage. The hypothetical appraisal is being undertaken in 2024 and the scheme opening year is 2028.

A.1.2 The example follows the process described in section 2:

- deriving a base cost estimate;
- adjustment for risk and optimism bias;
- re-basing the price base to the Department's base year;
- discounting to the Department's base year; and
- converting to the market prices unit of account.

A.2 Base cost estimate

A.2.1 A1 provides an initial estimate of the investment costs in 2024 prices but taking no account of real increases in construction costs. For simplicity it is assumed there are no maintenance or operating costs post-opening.

Table A1 Components of Investment Costs (£million, 2024 prices)

Calendar Year	Construction Costs	Land Costs	Other Costs	Total
2026	7.9	5	1.5	14.4
2027	6.7	0	2.5	9.2

A.2.2 Base costs should be estimated separately for investment and operating costs in a given price base, taking account of real increases in costs. Therefore the first step is to incorporate real cost increases. A (hypothetical) bespoke inflation model suggests that general inflation (as measured by the GDP deflator) is forecast to be 2.3% per year, while construction costs are forecast to increase by 4% in 2026, by 4.5% in 2027. Therefore the base investment costs, including real cost increases, can be calculated by:

- **In 2026** - £14.4m (initial estimate) x (1.04/1.023)^2 (the real cost adjustment) = £14.88m
- the contribution of real cost increases is £0.48m (£14.88m - £14.4m)
- **In 2027** - £9.2m (initial estimate) x (1.04/1.023)^2 x (1.045/1.023)^1 (the real cost adjustment) = £9.71m
- the contribution of real cost increases is £0.51m (£9.71m - £9.2m)

A.2.3 Table A2 illustrates the estimation of the profile of base costs. Given the use of a bespoke inflation forecast, the real cost adjustment needs to additionally account for any optimism bias in the forecasting of cost inflation (see 'Method 2' in Section 3.6.4). This is applied to the full scheme costs including any adjustments for risk and optimism bias, so is applied later in the cost estimation process.

Table A2 Base Cost Scheme Profile (£million, 2024 prices)

Calendar Year	Cost excluding real cost increases	Contribution due to real cost increases*	Cost inc. real cost increases (Base Cost)
	Investment	Investment	Investment
2026	14.40	0.48	14.88
2027	9.20	0.51	9.71
TOTAL	**23.60**		**24.60**

* Excluding optimism bias in real cost inflation

A.2.4 The base cost estimate for the scheme is £24.60m. This cost estimate should be used for appraisal purposes only and not as the basis for funding bids.

A.3 Adjusting for risk and optimism bias

A.3.1 Table A3 shows the P(mean) risk contribution, which is the weighted average of all outcomes and probabilities, calculated from the QRA of scheme investment costs and how it should be added to the base cost to produce a risk-adjusted cost estimate of £29.10m.

Table A3 Risk-Adjusted Base Cost (£m, 2024 prices)

Calendar Year	Cost inc. real cost increases (Base Cost)	Quantified risk contribution QRA P(mean)	Risk adjusted cost using QRA P(mean)
	Investment	Investment	Investment
2026	14.88	2.50	17.38
2027	9.71	2.00	11.71
TOTAL	**24.60**	**4.50**	**29.10**

A.3.2 The next stage is to calculate the (quantity) optimism bias adjusted cost. From Table 8, the baseline uplift to apply to the base capital cost for a local road scheme at Stage 2 of scheme development is 23%. This should only be applied to investment cost except in cases where the scheme promoter has an estimate for operating cost uplift (see 3.5.18). Table A4 shows that the uplift increases the base cost estimate by £5.66m to £30.25m.

A.3.3 Sensitivity analysis recommends applying a range of uplifts from 0%-30% to investment costs and results in a cost range of £24.60-31.97m.

Table A4 Adjustment for Optimism Bias (£m, 2024 prices)

Calendar Year	Cost inc. real cost increases (Base Cost)	Total contribution of optimism bias to costs for the year	Optimism Bias adjusted cost
	Investment	Investment	Investment
2026	14.88	3.42	18.31
2027	9.71	2.23	11.95
TOTAL	**24.60**	**5.66**	**30.25**

A.4 Reconciling OB and QRA cost estimates

A.4.1 In this case the OB-adjusted cost (£30.25m) is greater than the risk-adjusted cost (£29.10m). We will assume that this is a standard project with no distinctive risks, therefore we can put the cost divergence down to presence of ‘unknown unknowns’ which are picked up in the OB-adjusted cost estimate. As a result it is the quantity OB-adjusted estimate with which we progress, to reflect the potential risks of the project in question.

A.5 Accounting for optimism bias in real cost adjustments

A.5.1 As outlined above, when using a bespoke inflation forecast, the resulting cost estimate (including regular, quantity OB) should be uplifted by the Pmean adjustment of 4.3% to account for historic optimism in the forecasting of real cost increases. Applying this adjustment increases the OB-adjusted cost (£30.25m) to £31.55m. When using the TUBA appraisal software, costs should be inputted at this stage.

A.6 Re-basing to the Department’s base year

A.6.1 The costs so far have been in real prices but in a 2024 price base year. For appraisal purposes the costs should be presented in the Department’s base year. The costs can be deflated to the correct price base by multiplying them by the ratio of the inflation index in the desired base year to the inflation index in the year currently being used. Assuming a Departmental base year of 2010 (and an index value of 100 for that year) and 2.3% general inflation per year, the costs in each year should be multiplied by 100/137.5 = 0.727 to convert from 2024 to 2010 prices.

A.7 Discounting to the Department's base year

A.7.1 As discussed in TAG Unit A1.1, costs should be discounted and presented in present values. TAG Data Book table A1.1.1 provides the schedule of discount rates that should be applied from the year the appraisal is taking place. Our hypothetical appraisal is taking place in 2024. Therefore, in our example a discount rate of 3.5% per year should be applied until 2054, with a rate of 3% per year applied thereafter.

A.7.2 Therefore, to discount back to a 2010 base year, the discount factor that should be applied to the costs in 2026 is 1/(1.035^16) = 0.577; in 2027 is 1/(1.035^17) = 0.557. If operating costs were incurred later in the appraisal period, for example the discount factor for 2047 would be 1/(1.035^37) = 0.290; while the factor for 2087 would be 1/(1.035^44 x 1.03^33) = 0.083.

A.8 Converting to Market prices

A.8.1 The final stage in preparing the costs for appraisal is to convert them from the factor cost to the market price unit of account using the indirect tax correction factor (which can be found in the TAG Data Book).

A.8.2 Table A5 shows the results of applying the price base, discounting and market price adjustments (using an indirect tax correction factor of 1.190) to the OB-adjusted base cost. The choice to present the OB-adjusted base cost was based upon the advice in section 4. The final scheme cost for use in appraisal is £15.54m and are those that should be included in the appraisal tables. In this example all of the costs would fall on public sector providers and should be included in the PA table only.

Table A5 Transport Scheme Cost Estimate to be included in the TEE/PA Table

C. Year	Optimism bias adjusted cost	Optimism bias adjusted cost + 4.3%	Optimism bias adjusted cost in 2010 prices	Discounted optimism bias adjusted cost in 2010 prices	Discounted optimism bias adjusted cost in 2010 market prices
	Investment	Investment	Investment	Investment	Investment
2026	18.31	19.09	13.89	8.01	9.53
2027	11.95	12.46	9.06	5.05	6.01
TOTAL	**30.25**	**31.55**	**22.95**	**13.06**	**15.54**

A.9 Value for Money band-switching calculations

A.9.1 As discussed in section 5 above, using scheme costs and benefits, the percentage overrun needed for the next highest VfM band as well as the percentage change on base cost needed for the next lowest VfM band can be calculated. The formulas used are as follows:

% overrun needed for the next highest VfM band = ((Base cost with OB uplift + cost needed for a BCR at next highest band)/ Base cost) - 1

% change on the base cost needed for the next lowest VfM band = ((Base cost with OB uplift + cost needed for BCR at next lowest band)/ Base cost) – 1