Infrastructure and Projects Authority

Cost Estimating Guidance

A best practice approach for infrastructure projects and programmes

Reporting to Cabinet Office and HM Treasury

Contents

Cover image courtesy of Kier Group plc

Infrastructure and Projects Authority

Foreword

This government has an ambition to bring about a revolutionary step-change in how it delivers major projects. For this ambition to succeed, we need a sustained focus on the core principles of project delivery.

Delivering major projects is always a challenge and even more so during these unprecedented times. The Infrastructure and Projects Authority (IPA) is determined to ensure projects are set up for success from the very start. These early decisions often determine the success or failure of a project much further down the line and if done correctly will ensure that projects deliver real benefits for people and communities across the UK.

Central to project discipline is the use of expert, evidence-based cost estimates. Establishing an early and accurate cost estimate is a key factor in selecting the right projects and delivering them on time and on budget.

However, a cost estimate is not a single figure that is determined at the start of a project and fixed from therein. The cost estimate evolves over time as the project matures and is inherently linked to the development of the project scope and schedule.

The cost estimate should be presented as a range to account for the level of risk and uncertainty inherent in the project and this range should decrease as the project develops.

At the heart of developing a robust cost estimate of the three 'P's:

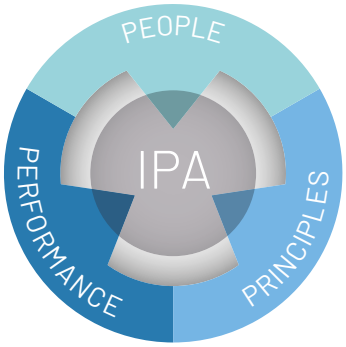
- **Principles** - of cost estimating to get the basics right and address common pitfalls
- **People** - roles, skills and behaviours needed to deliver, assure and own the cost estimate
- **Performance** - steps for improving the quality and consistency of cost estimates and surrounding processes

This document sets out, for the first time, a best practice approach to cost estimating which should be used by all major infrastructure projects and programmes in the UK. This guidance document is for all project delivery team members including Senior Responsible Owners and Project Directors.

Nothing less than world class delivery will do and this document is another step towards that vision, helping those involved in project delivery to thrive and deliver projects and programmes to the benefit of all the citizens in the United Kingdom.

Nick Smallwood
Chief Executive, Infrastructure and Projects Authority

Introduction



The government is committed to transforming the way infrastructure projects are selected, procured and delivered. This guidance document sets out an expert, evidence-based approach to cost estimating which is critical to underpin successful project delivery.

About this document

This document sets out a best practice approach to the development of cost estimates for infrastructure projects and programmes. It is targeted at those involved in the sponsorship, leadership and delivery of projects to support better quality project cost estimates and improved decision making.

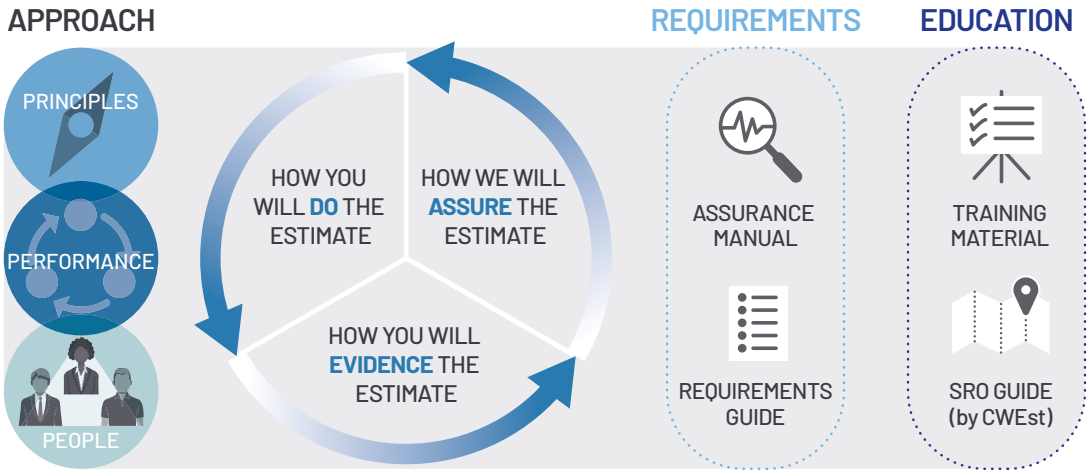
Applying the IPA's priorities of principles, people and performance this document covers:

- **Principles for best practice cost estimating** outlining the fundamentals that underpin a good cost estimate to get the basics right and address common pitfalls
- **Roles and responsibilities** in producing, reviewing and owning the cost estimate to make informed decisions
- **Cost estimating process** that should be followed to produce a robust, assured and transparent cost estimates which can be used with confidence to support successful delivery.

This guidance document is part of a suite of documents, including:

- **Cost estimating guidance** – setting out a best practice approach to cost estimation for all team members
- **Cost estimating requirements** – a technical guide setting out the detailed requirements for cost estimating teams and professionals to produce and assure cost estimates
- **Training** – to support professional development and promote the adoption of consistent methods

Figure 1 – IPA's Approach to improve cost estimating for government



Introduction

> "This guidance sets a precedent for reliable cost estimating and will further increase confidence in decision making, at a time when we are investing billions in the UK's infrastructure."
>
> Catherine Little
> Director General, Public Spending, HM Treasury

What is cost estimating?

Cost estimating is the process of forecasting the financial and other resources needed to complete a project within a defined scope and schedule. A cost estimate is not a single figure that is determined at the start of a project and fixed from therein. The cost estimate evolves over time as the project matures and is inherently linked to the development of the project scope and schedule. The cost estimate should be presented as a range to account for the level of risk and uncertainty inherent in the project. This range should decrease as the project develops.

How are cost estimates used?

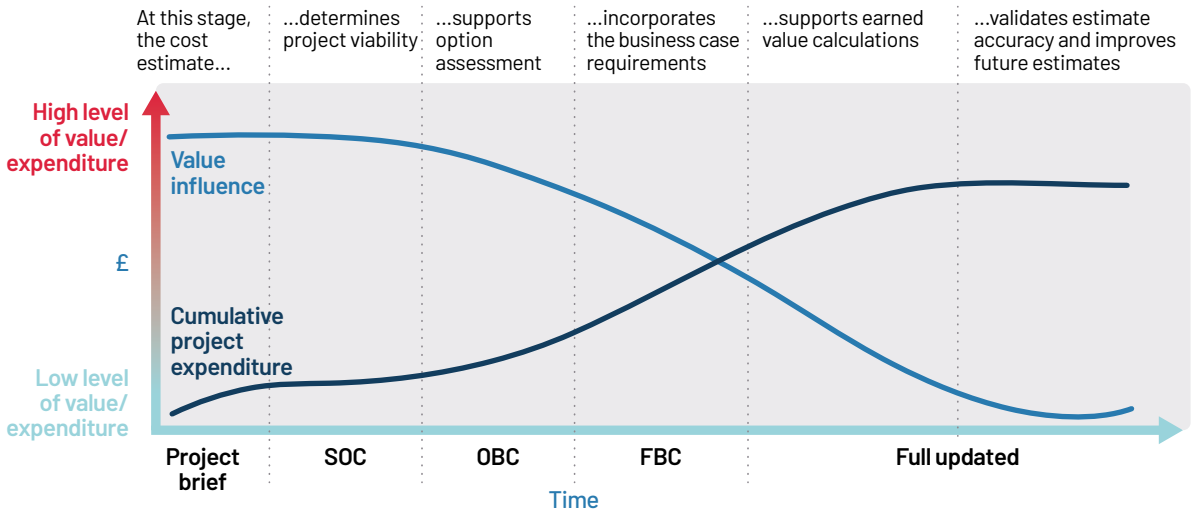
Cost estimates have many different uses, including:

- **Decision making** – underpinning the business case at each stage gate (SG) in line with HM Treasury's Green Book, supporting the calculation of Cost-Benefit Ratios as well as affordability and funding considerations
- **Commercial** – informing commercial strategies and enabling procurement of suppliers
- **Control** – a baselined, realistic cost estimate sets a key element of performance monitoring during execution

Setting up for success

IPA's eight principles[1] for project success illustrates the importance of investing enough time at very early project stages, often referred to as front end loading. This is because the ability to impact the value a project will deliver is greatest in its early stages, as illustrated in the graph below. The creation of a robust cost estimate linked to an agreed scope and schedule is a key factor in choosing the right projects and delivering them to cost and value.

Figure 2 - The importance of setting the project up for success



1 Principles of Project Success www.gov.uk/government/publications/principles-for-project-success

Introduction

Approach to developing guidance

The development of this best practice approach to cost estimating was informed by cost estimating guides, industry reports, public and private sector practice and academic papers. In addition, this guidance has been developed and tested collaboratively with over 50 industry professionals and representatives, including an IPA-chaired panel comprising cost estimating experts, senior industry professionals and academics, and the Cross-Whitehall Cost Estimating Group (CWEst). IPA is grateful to all of these contributors for their support.

Scope

This guidance is focused on developing capital cost estimates for government infrastructure projects and programmes. Whilst some of the concepts may be applicable more broadly, for example to non-infrastructure and non-construction projects, it has not been designed with those in mind. Additionally, it does not focus on whole life cost, wider environmental (carbon, water footprint) or social outcome calculations. Whole life cost and carbon should be considered at each stage of the life cycle along with the cost estimate to inform project decisions.

> **"As one of the critical elements of project delivery, this guidance on the development of cost estimates will help more projects to secure the right outcomes, particularly when used in conjunction with other best practice on setting up projects for successful delivery."**
>
> Rachel Skinner
> President, Institution of Civil Engineers

An overview of the cost estimating process

Cost estimating is the process of forecasting the financial and other resources needed to complete a project within a defined scope and schedule. Accurate and reliable cost estimates are crucial to policy development, decision making and enable effective delivery.

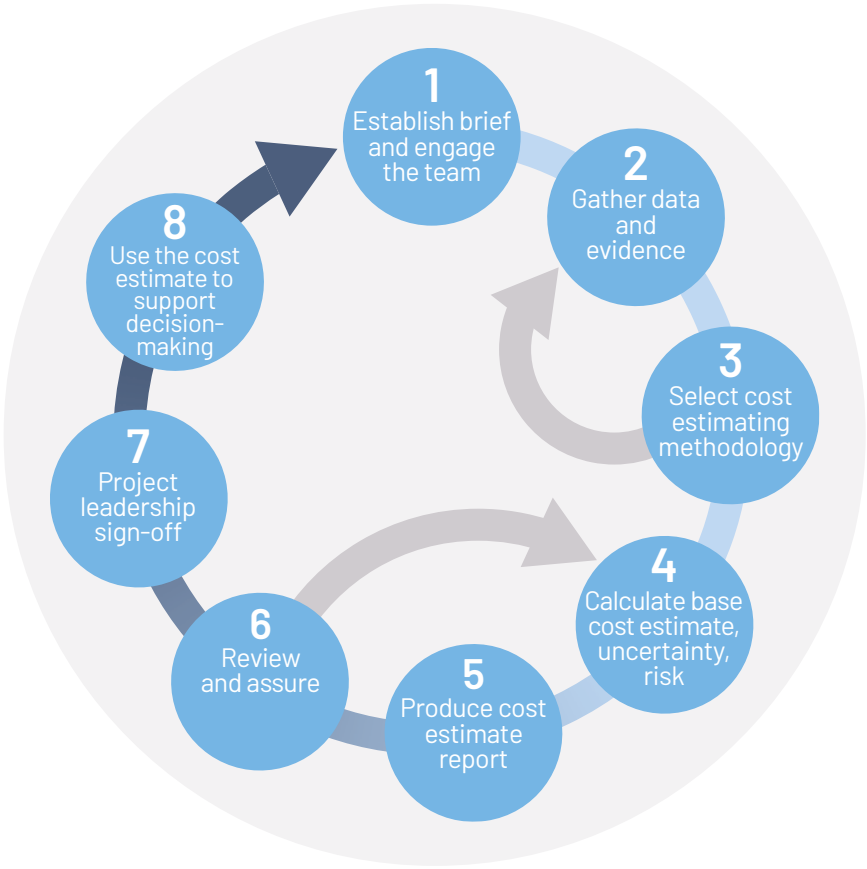


Figure 3 -
The 8 steps of the cost estimating process

The Cost Estimating Process is built as a cycle of eight steps (see Figure 3), summarised below, with more detail set out later on.

Step 1: **Establish brief and engage the team**
Set out clear requirements and identify the right technical team to produce the cost estimate.

Step 2: **Gather data and evidence**
Build an evidence base and document key assumptions.

Step 3: **Select cost estimating methodology**
Give a clear justification for the chosen methodology and revisit Step 2 if additional data is required.

An overview of the cost estimating process

Step 4: **Calculate base estimate, uncertainty and risk**
Prepare the Anticipated Final Cost and a range of possible values reflecting the level of risk and uncertainty inherent in the project.

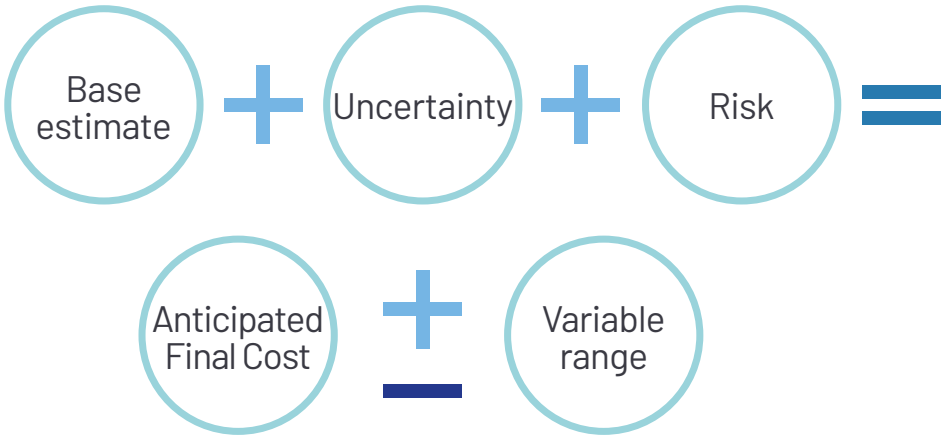
Step 5: **Produce cost estimate report**
Document the methodology, assumptions and evidence-base on which the cost estimate is built and recommend priority areas to reduce uncertainty.

Step 6: **Review and assure**
Consider the appropriate type of review and level of assurance based on the impact the cost estimate will have in decision-making and the risk of error in the calculations. Revisit Step 4 if an error is identified.

Step 7: **Project leadership sign-off**
Ensure the Project Director and Senior Responsible Owner (SRO) understand the maturity of the cost estimate and accept ownership in preparation for stage gate (SG) review and approval.

Step 8: **Use the cost estimate to support decision-making**
Present the cost estimate as a range to account for the level of risk and uncertainty inherent in the project.

At the centre of every cost estimate is the following equation:



Delivering value

When followed consistently and supported by the requirements and assurance, this approach will enable higher quality cost estimates to be produced consistently.

Principles for best practice cost estimating

Get the basics of project cost estimating right

These principles set out the fundamentals that underpin a best practice approach to cost estimating. Ensuring adherence to these principles throughout a project's lifecycle will enable more successful delivery.

Further detail on each principle is set out below. Project leadership should ensure the right people, processes and technology are in place to fulfil these principles.

Clear ownership

There is **clear ownership and accountability** for the estimate

Right skills

The estimate requires **suitably qualified and experienced personnel** and a **collaborative environment**

Front-end loading

Investment to develop the project early on drives better outcomes and **enables more accurate estimates** at every stage

Appropriate method

The **appropriate estimating method evolves across project stages**

Risk-adjusted

The estimates are **risk-adjusted**, presented **clearly** and **consistently**, showing a **range** of possible outcomes

Evidence-based

Estimates are **transparent, robust and data-based evidence**

Reviewed and assured

Project teams use **review and assurance** to improve the quality of their estimate

Continuous improvement

An approach to **continuous improvement** is essential to **increasing the quality** of estimating practices and more generally

> "Accurate cost estimating of rail investment projects is essential in ensuring we develop and deliver good projects that best serve our passengers whilst making good use of investment funds. Setting a best practice standard for cost estimating will support our teams provide guidance and ensure we take a consistent approach on all our investment projects."
>
> Stuart Calvert
> Capital Delivery Director, Network Rail

Principles for best practice cost estimating

Clear ownership

Clear ownership and accountability for the cost estimate is fundamental to its reliability and being trusted as an input to decision-making.

- Project leaders rely on cost estimates to make informed decisions that have significant impact. The SRO must own the cost estimate and be accountable for its use in decision-making.
- The cost estimate is not a supplementary exercise but a fundamental part of the project. It is intrinsically linked to project scope, schedule, commercial arrangements, risks and mitigations and cannot be developed independently from those decisions.
- As project definition builds over time, critical assumptions will evolve. Scope and schedule management discipline underpin the reliability of the cost estimates.
- All individuals involved in the cost estimating process must have clear responsibilities and the accuracy of the cost estimate should be monitored as a key performance metric for the project.

Right skills

Projects must have the right people involved in the cost estimation process at the right time to deliver a robust cost estimate.

- All the team members interacting with the cost estimate from leadership, execution and assurance functions must understand the maturity of the cost estimate and factor this into decision-making.
- The qualification, training and experience required depends on the complexity of the project and the cost estimating methodology.
- The tools and techniques used to produce reliable cost estimates often require specialist input and expertise.
- A culture of challenge, trust and openness unlocks collaboration, which improves decisions. A cost estimate produced in this environment is likely to prove more accurate as its assumptions will be appropriately challenged and validated.

Principles for best practice cost estimating

Front-end loading

Robust planning, design and preparation in the early stages of a project's lifecycle are essential in driving successful delivery.

- The ability to impact the value a project will deliver is greatest in its early stages through setting clear objectives and translating these into option selection and project requirements.
- Whilst successful project initiation can take more time at the beginning, this will be repaid many times over later on in delivery. Investment to develop projects at an early stage has been clearly linked to more accurate cost estimates and improved outcomes.
- An investment of 3% to 5% of the project's total cost is expected prior to construction commencement.
- Early involvement of external stakeholders (e.g. Early Contractor Involvement (ECI) both supports and enables better cost estimates.

Appropriate method

No single cost estimating method is appropriate for the duration of a project's development. The method should reflect the quality of available data and the level of project definition.

- The scale and complexity of the project affects the availability of high quality data. Repeatable assets should have access to mature cost data and benchmarks, whereas novel, one-of-a-kind projects may find a lack of available data.
- The cost estimating method used must reflect the maturity of available data and the level of project definition. The cost estimating team should select the method that is most suitable based on the information available.
- At each stage the cost estimate informs different project decisions, the selected methods must cover the requirements of the project stage.
- Projects in earlier phases may be using a less mature method whilst more advanced phases may have progressed, thus a mixture of methods may be in play at any given point in time.
- Early cost estimates should rely on top-down methods such as analogy or scenario models whilst later stages should build on the detail of the project bottom-up, for example using first principles or statistical modelling.

Principles for best practice cost estimating

Risk-adjusted

The cost estimate should be presented as a range reflecting the level of risk and uncertainty at each stage.

- Decision makers need a clear understanding of the cost estimate, to make informed decisions aligned to the project strategy and risk appetite. The cost estimate must articulate how it links to scope, design, schedule and risk.
- As a realistic view of the Anticipated Final Cost, the cost estimate must include an allocation for risk and uncertainty.
- The cost estimate must always document assumptions and exclusions. This enables the team to understand the cost drivers and test for sensitivity.
- A clear and consistent breakdown of the cost estimate supports comparisons across projects. Projects must use a consistent categorisation of costs to contribute to a shared body of knowledge.
- Cost estimates must present ranges of possible outcomes to articulate the level of confidence in the underlying calculations. The ranges should narrow as the project and data matures.

Evidence-based

Cost estimating teams should report the data sources and processes used to develop the cost estimate and ensure that the cost estimate covers the full scope of the project.

- Cost estimates are subject to scrutiny and demonstrating the source of data improves the trust, reliability and repeatability in the calculations and findings. The quality of the cost estimate is reliant on the maturity of the input data and this must be communicated to decision-makers.
- Critical assumptions and exclusions must be communicated and the working methods must be traceable to enable cost estimate transparency.
- Tools and techniques such as benchmarking and sensitivity analysis improve the robustness of the cost estimate. Cost estimates must apply consistent units, baselines and adjustment for inflation to ensure comparability throughout project stages.
- The level of maturity of the information underpinning a cost estimate must reach adequate maturity for the project stage (SOC, OBC, FBC) and type. A cost estimate reference class and attendant confidence level should be based upon the evidenced level of maturity of scope development achieved, rather than having reached the stage gate approval milestone.

Principles for best practice cost estimating

Reviewed and assured

Cost estimates that are reviewed and assured appropriately will be improved and become more reliable, further driving project discipline.

- Projects should set out their review and assurance regime at the start of the project and validate it between stage gate approvals.
- Effective review and assurance build rigour around the cost estimating process and increase confidence in the cost estimate, enabling project leadership to make decisions.
- Projects should seek validation against standard methodologies and peer review to enhance the cost estimating communities of practice.
- Internal and external/independent assurance progressively builds confidence, supporting a culture where the cost estimate is relied on and trusted.
- The cost estimate should be reviewed and validated in advance of each project stage gate; with changes in the cost estimate between gates explained.

Continuous improvement

Capturing lessons learned and cost data from previous projects will improve future cost estimates.

- Lessons learned from previous projects and retrospective evaluation of cost estimates against actuals should be used to progressively refine methodologies and assumptions.
- Checkpoints should be in place at each project stage to identify differences and articulate them in upcoming stage gate decisions.
- As projects apply a consistent approach and a robust methodology, they generate data that should inform evidence-based validation of assumptions, increasing the maturity of benchmark and input data for delivery bodies and across sectors.
- The cost and performance data used to compile the cost estimate should be compared against actual data during delivery to improve cost intelligence in subsequent phases and projects.

Roles and responsibilities

EQUIP OUR PEOPLE WITH THE RIGHT KNOWLEDGE

People are at the heart of project delivery. Without suitably qualified and experienced personnel at each step of the project, the project is not likely to be successfully delivered. This section outlines the key roles and functions that interface with the cost estimate.

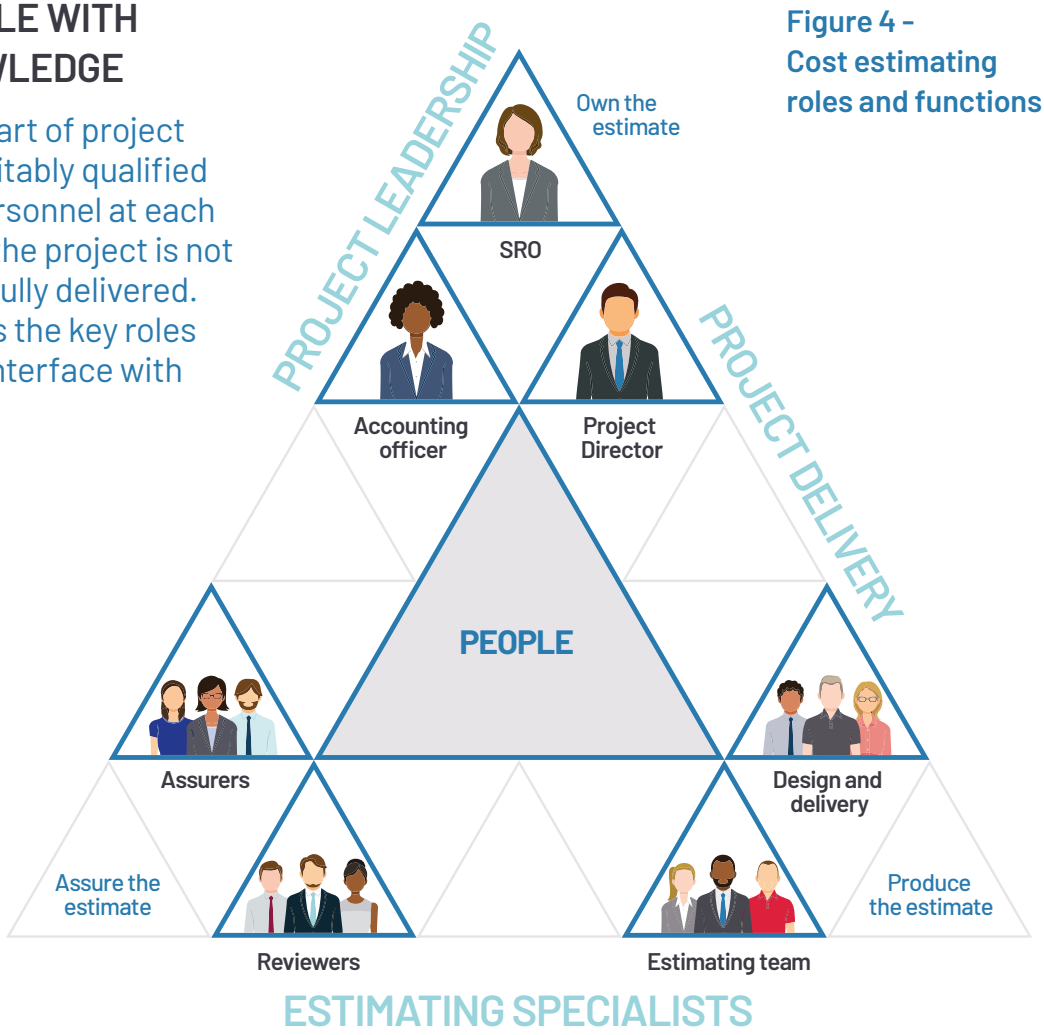


Figure 4 - Cost estimating roles and functions

Roles and functions

Roles and functions can be broadly split into three categories: those who produce the cost estimate, those who assure the cost estimate and those who own the cost estimate:

- **Produce** – Project design, delivery and cost estimating teams produce an effective cost estimate by working in collaboration. Any changes to the project scope or critical assumptions should be effectively communicated and controlled between the functions, and the cost estimating process should inform technical decisions.
- **Assure** – Reviewers and assurers undertake a robust review and independent assurance process.
- **Own** – Once the cost estimate has been produced, reviewed and assured, project leadership consisting of the SRO and the Project Director accept ownership of the cost estimate to make significant decisions on the overall project. **The SRO is ultimately accountable for project performance in line with the cost estimate.**

Roles and responsibilities

Role descriptions

Project leadership

Accounting Officer

Role description	**To assure Parliament and the public of high standards of probity in the management of public funds.**
Responsibilities	■ Safeguarding the public funds for which they are in charge in charge ■ Accounting Officer assessments as and when required (e.g. if the project departs from the agreed plan) ■ Provide evidence to Parliament when called to account
Specific interface with the cost estimate	■ Accountable in front of sponsor and controlling bodies representing HMG for the financial performance of the project ■ Challenge the SRO and Project Director on the project deliverables ■ Mitigate the risk of management biases regarding the cost estimate

Senior Responsible Owner (SRO)

Role description	**To ensure the project delivers the business case benefits and outcomes. The SRO has ultimate accountability for the project.**
Responsibilities	■ Champion the project in the wider stakeholder environment ■ Define outcomes and provide strategic direction ■ Own the business case and track benefits realisation ■ Manage the strategic risks and issues of the project
Specific interface with the cost estimate	■ Confirm Go/No-go project progression considering the cost estimate and any review or assurance recommendations ■ Review, challenge and accept the cost estimate, understanding its components, uncertainty and risk at each stage gate ■ Manage strategic risks to the project cost estimate
Example qualifications and experience	■ SRO Fundamentals ■ Major Projects Leadership Academy ■ Experience delivering major projects

Roles and responsibilities

Project delivery

Project Director

Role description	**To ensure that the project is delivered and objectives are achieved within the agreed time, cost and quality constraints.**
Responsibilities	■ Manage and lead the project on a day-to-day basis ■ Develop the business case ■ Track delivery within budget ■ Work with the SRO to manage senior stakeholders (e.g. Project Executive) ■ Create the project delivery culture and behaviours supporting successful delivery
Specific interface with the cost estimate	■ Challenge the cost estimate for robustness and understand sensitivities ■ Ensure the cost estimate is produced in line with project requirements ■ Review the critical assumptions periodically to ensure they align to the reality of the project ■ Manage risks to the cost estimate and overall project
Example qualifications and experience	■ Chartered Project Professional (ChPP) ■ Major Projects Leadership Academy ■ PRINCE2 Practitioner / Agile Project Management ■ RICS Fellow

Project Design and Delivery Team

Role description	**To ensure that the objectives are clearly defined and achieved within the agreed time, cost and quality constraints.**
Responsibilities	■ Delivery of the day-to-day project activities ■ Raise and manage risks and issues ■ Regular reporting and tracking of progress against plan ■ Support the Project Director in meeting their obligations
Specific interface with the cost estimate	■ Provide a clear view of assumptions to cost estimators ■ Establish a change control process to ensure changes, assumptions and scope additions are considered and reflected in the cost estimate ■ Provide relevant cost-related information to estimators ■ Seek and present appropriate benchmarking information
Example qualifications and experience	■ APM Project Management Qualification/Practitioner Qualification ■ Experience delivering a large project

Roles and responsibilities

Cost estimate specialists

Cost Estimating Team

Role description	**To produce a cost estimate based on the scope, assumptions and exclusions agreed with the project team.**
Responsibilities	■ Report progress against the plan to the Project Director ■ Liaise with project delivery team on an ongoing basis ■ Engage Subject Matter Resources to provide guidance when required
Specific interface with the cost estimate	■ Propose and document the cost estimation methodology ■ Produce the cost estimate as per the methodology ■ Collect evidence clearly and consistently aligned to the cost breakdown structure ■ Prepare evidence material for reviewers and assurers ■ Capture data as input and output
Example qualifications and experience	■ Experience using cost estimating tools ■ Experience producing cost estimates ■ RICS ■ Incorporated Cost Engineer ■ Certified Professional Cost Engineer

Reviewers and Assurers

Role description	**To review the cost estimate and provide assurance that the cost estimate is robust and accurate.**
Responsibilities	■ Liaise with project reviewers and assurers to ensure alignment ■ Report risks and issues identified to the Project Delivery Team/ Project Director
Specific interface with the cost estimate	■ Conduct independent internal reviews of the cost estimate at each stage of the project ■ Conduct independent external reviews of the cost estimate at each stage of the project ■ Produce a summary report of the risks and issues with the cost estimate
Example qualifications and experience	■ Certified Professional Cost Engineer ■ Experience developing cost estimates ■ Experience reviewing cost estimates ■ IPA Accredited Reviewer

Cost estimating process

Producing robust, assured and transparent cost estimates is fundamental to driving world class project delivery. The cost estimating process is embedded in continuous improvement methodology and thus is not necessarily linear.

This section outlines an approach framework to producing cost estimates which have improved accuracy, through clear accountability and consistent data capture across sectors.

The approach performance framework is built as a cycle of eight steps. The requirements guide provides further detail on the expected process and checks that practitioners must perform at each step.

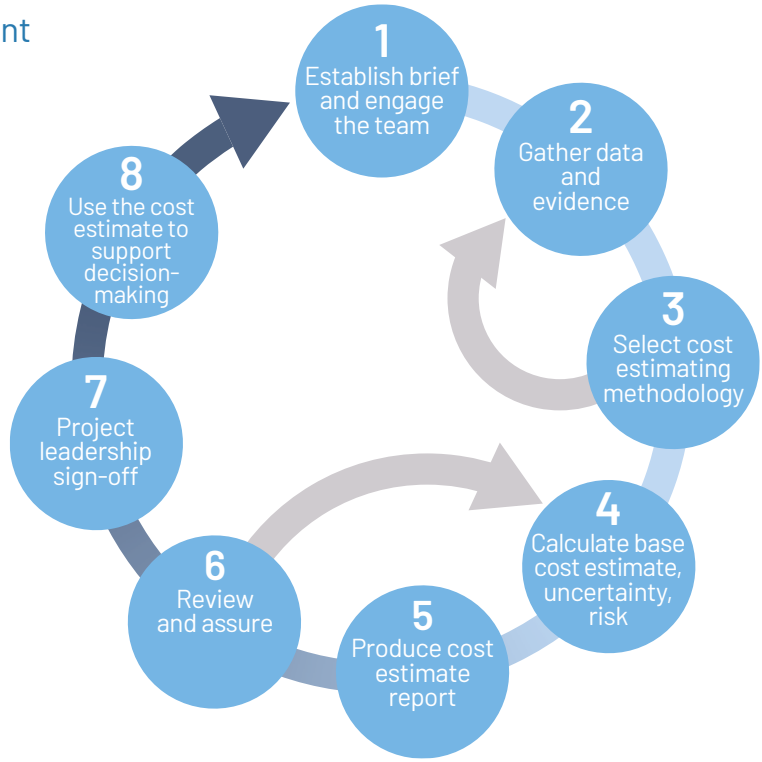
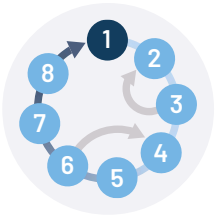


Figure 5 - Cost estimating performance framework

At the centre of the cost estimating process lies a shared conceptual understanding of the cost estimate presented as an anticipated final cost with a variable range to assert the confidence around it, built out of the component parts of every cost estimate:

- **Base cost estimate** – a position of the most likely cost of each component based on available data
- **Uncertainty** – the sensitivity around assumptions, tied to the maturity of the project definition
- **Risk** – acknowledging the impact of probability driven events

Cost estimating process



Step 1: Establish brief and engage the team

Understand project brief outcomes

Establishing a full project brief and setting clear objectives at the outset of the project and at the start of each stage gate cycle is an important step in producing a robust cost estimate. The project brief information should provide a clear understanding of the context and requirements of the cost estimate. This will inform the appropriate resource considerations, support the production of a detailed plan of works and enable clear definition of accountabilities. A clear cost estimate production strategy should be agreed, including the overall cost estimate timeline, sign-off protocols, ways of working, required assurance levels and accountabilities.

Get the right team

Using the information gained from the project brief, the focus should turn to identifying the right technical team to produce the cost estimate. For more complex projects, specific attention and additional investment should be considered to ensure the correct specialisms (e.g. tunnels, bridges, highspeed rail etc) and experience are available at the right time of the project. The team should engage the market to understand the capacity and current market climate.

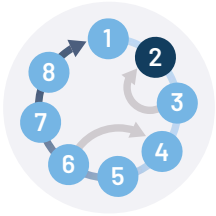
Driving behaviours

The right team environment will promote positive behaviours and clear communication channels that are critical to support open discussion and challenge. The cost estimate should not be developed as an isolated exercise, but a collaborative team effort where design and delivery stakeholders provide timely input.

Set up review points

The project leadership should agree clear cost estimate review and assurance points using a review panel, independent assurance or 'critical friend' approach comprising diverse views with expertise tailored to that required in the project. This should be documented in the project's integrated assurance and approvals plan. The reviewers should have continuity across the life cycle of the project to improve the knowledge base and implement lessons learnt.

Cost estimating process



Step 2: Gather data and evidence

Establish a standard structure

All cost estimates should adopt a consistent "Level 0" cost breakdown structure as shown in the Figure 6. While different sectors and different project types may adopt industry-recognised cost classifications, a common high-level breakdown supports comparisons, benchmarking and consistent language at the lowest common denominator across projects.

The recommended cost breakdown is consistent with the IPA Best Practice Benchmarking[2] guidance document.

Figure 6 - Level 0 Cost breakdown structure

Cost Breakdown		
	Escalation	Costs relating to changes in market prices during a project lifecycle, such as inflation and market factors, interest rates or applicable taxes.
	Land and Property	Costs relating to acquisition of land and allocation of property for the project, including costs of relocation and movement where applicable.
	Admin.	Costs related to general business overheads such as owner's costs or the sunk development costs during early development stages
	Indirect costs	Costs incurred that cannot be attributed to any one section of the works; they may be fixed or time-related. This includes for example design costs.
	Direct costs	Costs incurred on labour, material, plant and equipment, etc., i.e. costs that are directly accountable to the project including overhead & profit, temporary works. The direct costs are likely further broken down in discipline-specific and (preferably) industry-standard and asset specific Cost and Work Breakdown Structures. Direct cost elements should also include embodied carbon costs.

2 IPA Best practice benchmarking (2019) www.gov.uk/government/publications/best-practice-in-benchmarking

Data integrity

Building a credible and robust cost estimate is reliant on a good foundation of evidence supported by high quality data. The less robust the evidence and data available, the more uncertainty a cost estimate will have. Benchmarking should be introduced and used to challenge the integrity of the data, with specific attention to areas of high value within the cost estimate.

The quality and maturity of the data should improve progressively. The cost estimating team must review the underlying data throughout the project lifecycle, incorporating new information and any lessons learned as the project develops.

Document assumptions

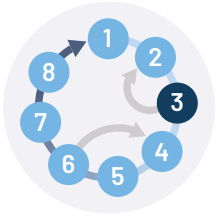
Documenting assumptions is a fundamental activity when building a cost estimate. Assumptions should be communicated clearly across the different project stakeholders (SRO, Project Director and Project team) as the cost estimate is developed. This ensures that the context which underpins the cost estimate is both clear, agreed and correctly interpreted by the cost estimating team in line with the project direction.

Whilst a cost estimate is often based on a design freeze or a snapshot in the project development, the cost estimating team should record different types of assumptions:

- **Engineering assumptions** – The project design will include technical decisions around constructability, scope options and alternative methods of construction, temporary works and specifications. The cost estimating team should work closely with the designers to understand areas that may appear in design documentation but may not be mature.
- **Cost estimating assumptions** – in the development of the cost estimate the team will assume market conditions, prices, efficiencies, production rates. These assumptions should be validated against the basis of cost estimate, benchmarks or expert opinion.
- **Execution and commercial assumptions** – to address variance in procurement and contracting structures, approach to risk and delivery management.
- **Tolerances** – depending on the quantification or measurement techniques, bills of materials, quantity take-offs and drawings will have inherent levels of inaccuracy.

Assumptions around risk should be captured within the risk register as minimum likelihood, impact, mitigation action, dependency, assumptions and justification of cost associated. These should be continuously reviewed throughout the project and estimate cycle.

Cost estimating process



Step 3: Select cost estimating methodology

There are many recognised methods for cost estimation. Identifying the most appropriate one based on the project's maturity and the quality of underpinning data is critical. It is important that the methodology selected is supported by a clear evidence-based justification.

The cost estimate methodology should be reviewed and reflected upon as the cost estimate evolves and as the project progresses through the project stages. It is common to combine and use different methods to produce a cost estimate in situations where a sub-component of the project is mature whilst other areas do not have enough definition or evidence data.

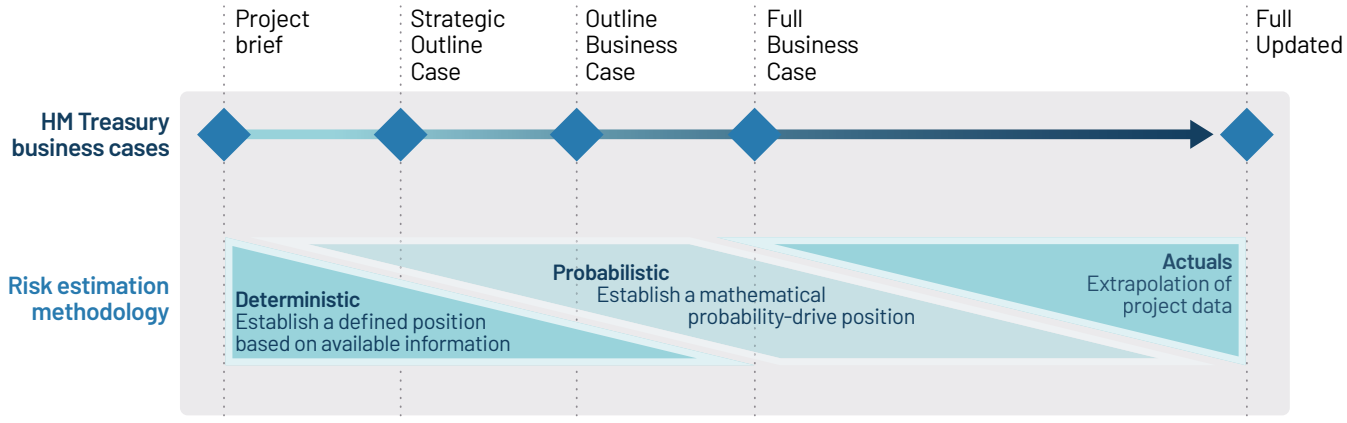
Once the methodology is selected, the project team may return to Step 2: Build/collect evidence to revisit the cost estimate data requirements.

Deterministic vs Probabilistic

There are two common cost estimating approaches (both in cost estimating cost and risk):

- **Deterministic** – this approach is based on methods to establish a position based on known data points. The methods can articulate specific uplift/correction for example assuming material wastage efficiency or interpolating average values, or more complex methods that include subjective input like expert opinion.
- **Probabilistic** - this approach is based on building mathematical models that produce a probable distribution of expected costs. These methods rely heavily on input data and assumptions of probability, distribution and correlation. Whilst they provide very sophisticated outputs, they may provide false levels of confidence if applied on low maturity data such as a low sample size.

Figure 7 – Progression of cost estimating methodologies



Deterministic methods should be favoured during the early life stages of the project, usually providing faster and more reliable answers to handle the volume of options. Whilst deterministic cost estimating methods such as analogy cost estimating or scenario-based modelling are more appropriate at SOC for a high complexity project, they should not be considered for routine projects where available data and maturity support the use of probabilistic methods, such as output based simulation and Monte Carlo.

Top-down vs Bottom-up

Another key differentiation in the cost estimating methodology is between an approach to treat the entire project or the individual items as the starting point:

- **Top-down methods** – Higher-level (such as benchmarking) methods start with a cost estimated complete, or total, figure for a project which is then broken down into smaller pieces. A top-down approach can be used to fill gaps when detail is not available and to validate bottom-up calculations. A top-down approach is better suited to strategic decision making from an encompassing view of the project. These methods include, for example, analogy (comparison with similar projects).
- **Bottom-up methods** – Articulating "first principles" that underpin each cost estimate decision to address an accurate view of the individual cost item which is then aggregated and grouped. This approach is heavily reliant on a complete understanding of the project as missing portions would not be accounted for, therefore best for mature datasets.

Both these approaches contribute to the cost estimate accuracy, so the cost estimating team should choose between them or complement them to improve the cost estimate quality.

Suggested methods

Project size, complexity, project stage and the objectives of the cost estimate should influence the method for cost and risk estimation.

Cost estimating methods

- **Parametric cost estimating** – Flexible to the level of available information, this method serves early calculations for repeatable projects and enables comparisons of complex/novel projects or sub-components using benchmark data.
- **First principles (bottom-up) cost estimating** – Is the preferred method for FBC stage gate. As it relies on complete data, this method is best suited to phases where design maturity is medium/high. The clarity in the link of the variables makes it suitable for sensitivity analysis and identification of cost drivers. It is laborious, so may not be ideal for projects with several options. Repeatable projects may benefit from reusable templates from more developed precedents.
- **Analogy cost estimating** – It is very useful in repeatable projects and in calibration or validation exercises for novel projects. As the method is based on assumptions of comparability, it should only give wide ranges so suitable at early stages.
- **Expert opinion**– It is very adequate for novel or complex projects, at early stages and in option comparison. Its subjective nature may be questioned at later stage decisions.

Cost estimating process

Risk cost estimating methods

- **Scenario Based Modelling** – It provides rigorous and reliable cost estimates even under limited data contexts. It makes it particularly appropriate for complex/novel projects at early stages. As it builds on explicit assumptions it also serves option comparison analysis.
- **Method of moments** – The calculation of the combined probability of risks based on their statistical properties is useful when the data is mature. This method is useful to provide quick responses for repetitive projects or to articulate the combined probability of scenarios.
- **Quantitative Risk Analysis/Input Based Simulation/Monte Carlo** – It is the most common method for late stages of a project. It relies on complete data sets and assumptions; is very sensitive to input data quality. Novel/complex projects may lack the required data maturity at the very early stages, so this method may provide false certainty and it is not recommended.

Nuclear Decommissioning

Use of Scenario Based Modelling (SBM)

An organisation was in the process of planning the decommissioning of existing nuclear power reactors across the UK.

Initial risk analysis had been completed using the Monte Carlo methodology with a range of individual risks. Due to the limited data available on the correlation between these risks, it resulted in a much lower value than was expected.

Given this, the complexity of the project and lack of benchmarking information, the organisation decided to use SBM instead underpinned by a number of realistic downside and upside scenarios.

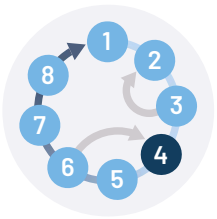
The SBM consisted of three core steps:

1. Identifying risks and assigning a high, mid and low impact based on expert judgement. From this a set of 10/15 anchor risks were established.
2. Through workshops scenarios were created each based around an anchor risk, each describing a mild, moderate or severe downside, or in some cases an upside.
3. For each scenario, the cost models were updated to estimate the cost impact of the scenario taking into account dependencies in schedule risks.

The SBM approach had a number of benefits:

- Achieved alignment of client executives on key risks and drivers of uncertainties which could then feed into wider decision making.
- Resulted in more credible range of scenarios given the first-of-kind nature of project and timelines (30 year+).
- Strategic risk log established which was used to manage and mitigate risks through both the programme and operational phase of decommissioning.

Cost estimating process



Step 4: Calculate base estimate, uncertainty, risk & opportunity

This step is the core of the cost estimating practice, where the key components of the cost are quantified.

Base cost estimate

The base cost estimate is the calculation of the expected cost, based on the available information, the assumptions and the method selected.

It is critical to review and understand the implications of information maturity. This will condition the selection of appropriate methodologies and establish the cost estimate dependencies.

The base cost estimates of the overall project and sub-components should be consistent with the Level 0 breakdown (refer to Step 2), and aligned to a subsequent cost breakdown structure. The granularity of the cost estimate depends on the design maturity available.

Escalation (Inflation)

The base cost estimate must be base dated to a given point in time, which can either be past, current or future date. Common practice is to base date the cost estimate to the current date. If the base is historical or future dated, then the cost estimate report must contain clear evidence on the mechanism (i.e. index name) and calculation that has been used to account for inflation between the current and historical/future date. If a project is base dated at the current date, inflation risk can be calculated and treated as a separate element as detailed within Level 0 of the breakdown.

Cost estimating uncertainty

Uncertainty is driven by three factors:

- **Decisions** – variability due to lack of design maturity; for example, the length of railings in a highway project. Design divergence is encouraged at early stages and is healthy for project performance, as narrowing options too early may result in poor choices that condition the project outcomes. The cost estimate should acknowledge and reflect such variability. If the variance across these alternatives triggers material differences, the design options should be handled as separate cost estimate exercises. The uncertainty is resolved by a complex and progressive decision process, either narrowing the variance towards the preferred option or ruling out entire segments deemed unviable.
- **Lack of data maturity** – based on information that is generic or extrapolated from experience or assumptions. For example, geotechnical data for ground works. As they are known unknowns they can be corrected through research or investigation (following the same example, performing geotechnical analysis). This investigation requires investment, so should be reserved for areas where the sensitivity of the uncertainty is material to the project (in this example, if the rock composition would affect the performance of boring materially affecting the assumed length of the project).

- **Bias or error** – conscious or unconscious assumptions that lean towards values that are not accurate. Choosing references may ignore specific conditions for the project under evaluation (sampling bias), available information may reflect only projects that were successfully completed (survival bias), or assumptions may reflect a good-willed intent towards success (optimism bias). As unknown uncertainties, bias and error should be corrected through systematic review (comparing against benchmarks), thorough documentation of assumptions (to elicit discrepancies), expert opinion and cross-reference of calculations.

As the project matures, the uncertainty decreases and the resulting ranges shrink (see step 5). The underpinning information must be continuously reviewed to reduce the range of uncertainty as the project progresses through stage gate approvals.

Upon completion of the base cost estimate, a sensitivity analysis should be performed to establish boundary conditions around each value as:

- **Reasonably pessimistic** – a position that takes into consideration pessimistic assumptions on rates, efficiency or quantities, and is therefore higher than expected.
- **Most likely** – a position based on the best-known data and judgement of the design, delivery and cost estimating team (usually the base cost estimate).
- **Reasonably optimistic** – a position based on assumptions of higher efficiency and therefore lower than the most likely cost.

These individual outputs will be dependent on the availability, variability and maturity of the input data. As they are aggregated from sub-components to form an overall position for the project (in bottom-up calculations), the reasonable low, medium and high points are adjusted.

Evidence shows that projects are more likely to go above than below the most likely value. The three points are usually skewed towards the high end. The cost estimating team should adjust the expected cost for each item to reflect the probability distribution. After such adjustment to account for probability distribution, the Anticipated Final Cost for each item is different (usually higher) from the most likely value.

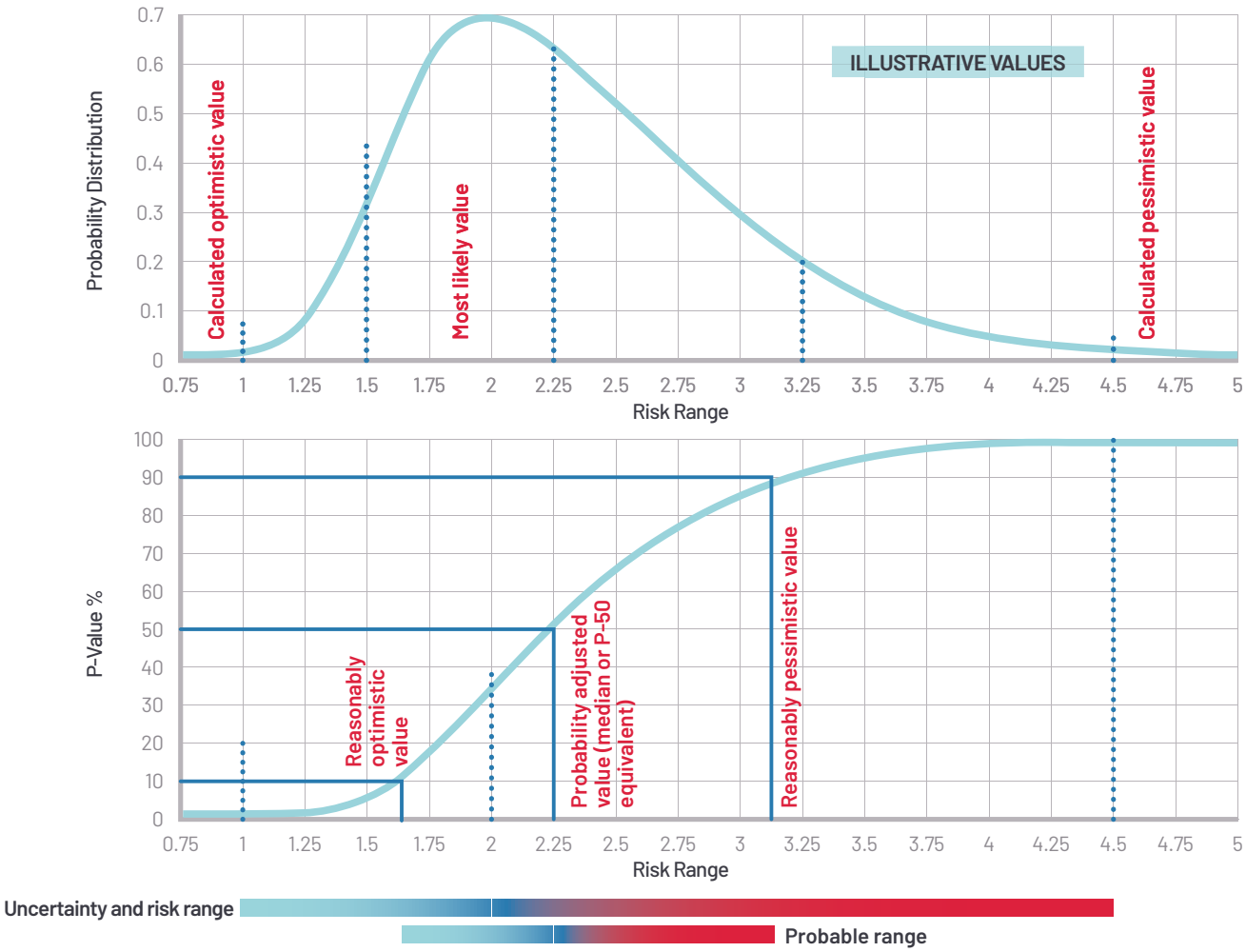
Accounting for risk

Risks are integral components that should be modelled to reflect external threats and prospects to project performance based on their probability.

Projects must consider measures to manage the risk to avoid or reduce the impact and/or probability of disruption should the event materialise. This mitigated position should be quantified, considering the post-mitigation probability, residual impact and inclusion of the cost of mitigation activities. High probability risks should be factored in as if they had materialised (accounting for the full residual impact), and the opposite probability calculated as an upside opportunity.

Cost estimating process

Figure 8 - Interpreting P-Values: Understanding P-Values



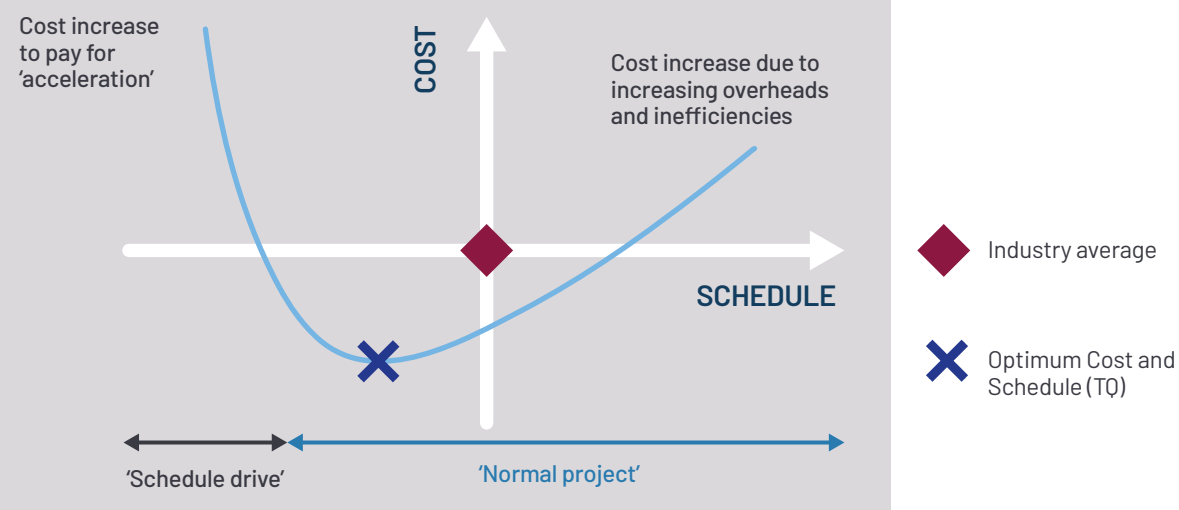
The types of risk that must be considered building the cost estimate are:

- **Known risks** – risks are known and captured in the project risk register; the effects are largely known and can be quantified. These risks are developed and detailed as the project maturity increases. Assumptions around impact and probability should be documented and tested for sensitivity. Correlation between risks (the linked probability of one risk occurring subject to a different one materialising) is difficult to analyse and has an impact on probabilistic methods.
- **Strategic risks** - risks that have been influenced by business decisions which impact a project (such as a change in policy affecting the project development).
- **Scope risks** – risks that reflect uncertain events or conditions related to the project scope.
- **Schedule risks** – risks that are a result of significant changes to the project programme/ schedule. A poorly defined schedule must be considered as a cost driver with significant impact on the cost estimate (see Fig. 9). Project delays have disproportionate effects on cost, so optimistic schedule assumptions should be flagged in cost reviews.
- **Behavioural risks** – risks that arise as a result of the human psychology in a work context and the culture that drives these behaviours.

The risk management approach must be coordinated with the cost estimate, so that the quantification of risks is consistent with the project execution.

Cost estimating process

Figure 9 - Schedule development



Other aspects of risk to consider

While they could be analysed with similar methods and tools, two types of probability-driven factors should be handled separately:

- **Opportunities** – the upside probability that some expected costs may not be incurred or that some high-probability risks that were factored as part of the expected project cost.
- **Material/critical risks** – risks that, should they realise, would impact the project in such a way that would compromise its continuity. These risks should be documented and handled separately, regularly reported to the project leadership and accounted for separately (as allocating a contingency fund would not prevent the need for reassessing the project). Other terminology to address these risks are "blowout risks", "show-stopper risks", "tombstone risks" or "black swan events".

These two categories may distort the cost estimate and should be accounted for and reported separately to the overall cost estimate.

Project contingency

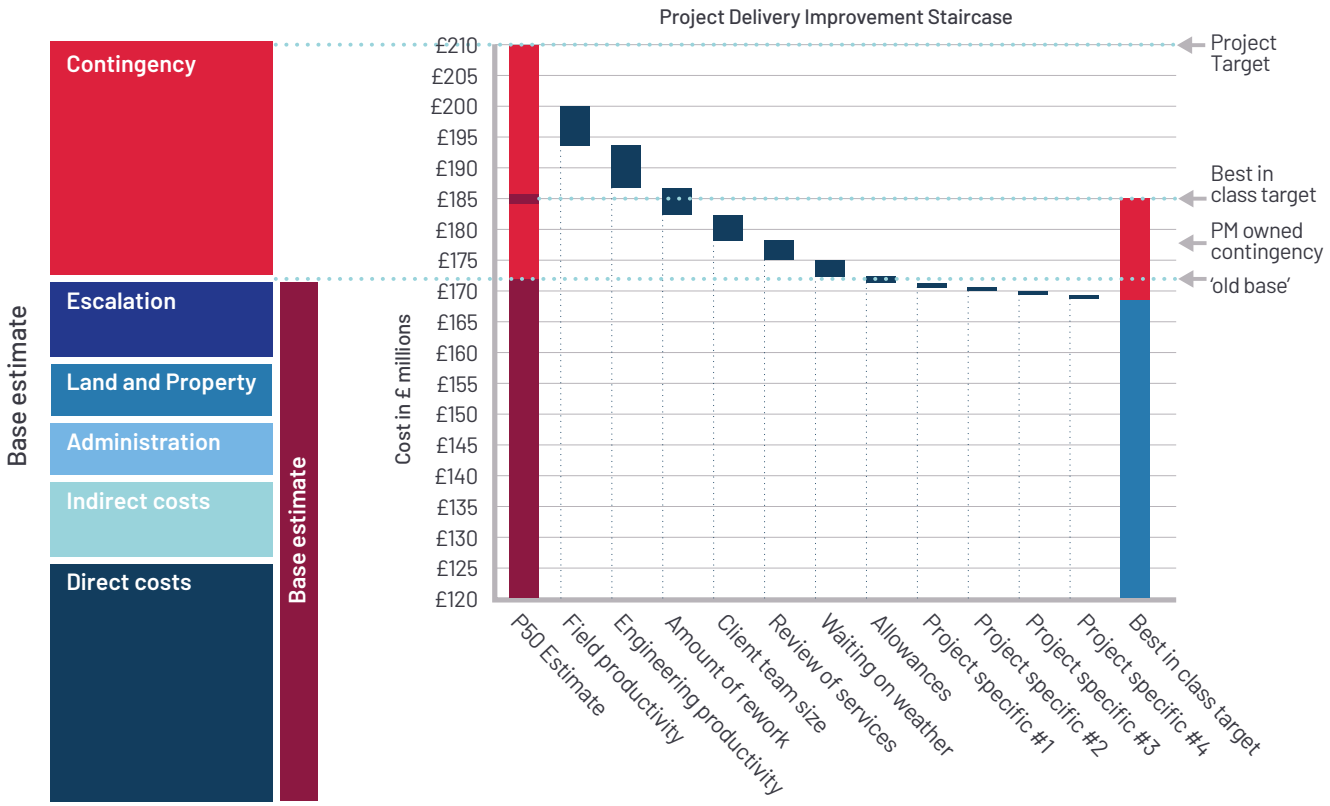
The assessment of the different risk types and associated mitigation should inform an overall project contingency which will be included to form the Anticipated Final Cost (See Figure 10).

The assessment of the different risk types and associated mitigation and post mitigated cost should inform an accurate representation of the overall risk management costs. Projects should reserve funding to address the impact of risks materialising. This funding should be proportional to the impact of the risk and adjusted to the probability of the risk materialising. The project contingency is therefore cost estimated at a probability value. The project team must evaluate an optimistic, median and pessimistic spend to face risks. The median (or P-50 equivalent) value of risk should be allocated to the Anticipated Final Cost of the project.

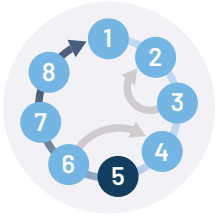
Contingency should be used to address risks that materialise in the project. As a project becomes more defined and scope and risks are further identified, the size and allocation of contingency must be revised. Projects should not reallocate or repurpose contingency even if it stays within the same project cost envelope.

The allocation of contingency could be driven by the risk ownership of the project management while sponsors, and ultimately HM Treasury may hold "unallocated contingency" across projects and portfolios. Project teams, delivery bodies, departments and ultimately HM Treasury should retain portions of the contingency proportional to their ability to address the risks.

Figure 10 – The components of a cost estimate



Cost estimating process



Step 5: Produce cost estimate report

After completing the calculations of the cost components, the cost estimating team must consolidate them into a clear and consistent report that will support project decisions.

The cost estimate is not a single number but an approximate value which must be understood in context of:

- The rationale and methodology used in producing the cost estimate which should include reference to the Work breakdown structure
- Evidence the information upon which it is based, including sources and maturity
- Assumptions upon which the cost estimate is based, and exclusions from the cost estimate total
- The costs in aggregate (starting from a common "Level 0") and more granular breakdown depending on the design maturity
- Threats and opportunities for consideration by the Project Director/SRO. Key risk information should be summarised within a single page
- Prioritised recommendations of next steps, including priority areas to further narrow the uncertainty
- Evidence of review undertaken on the cost estimate

The cost estimate must clearly articulate the anticipated final cost and a range of possible values reflecting the confidence of the cost estimate.

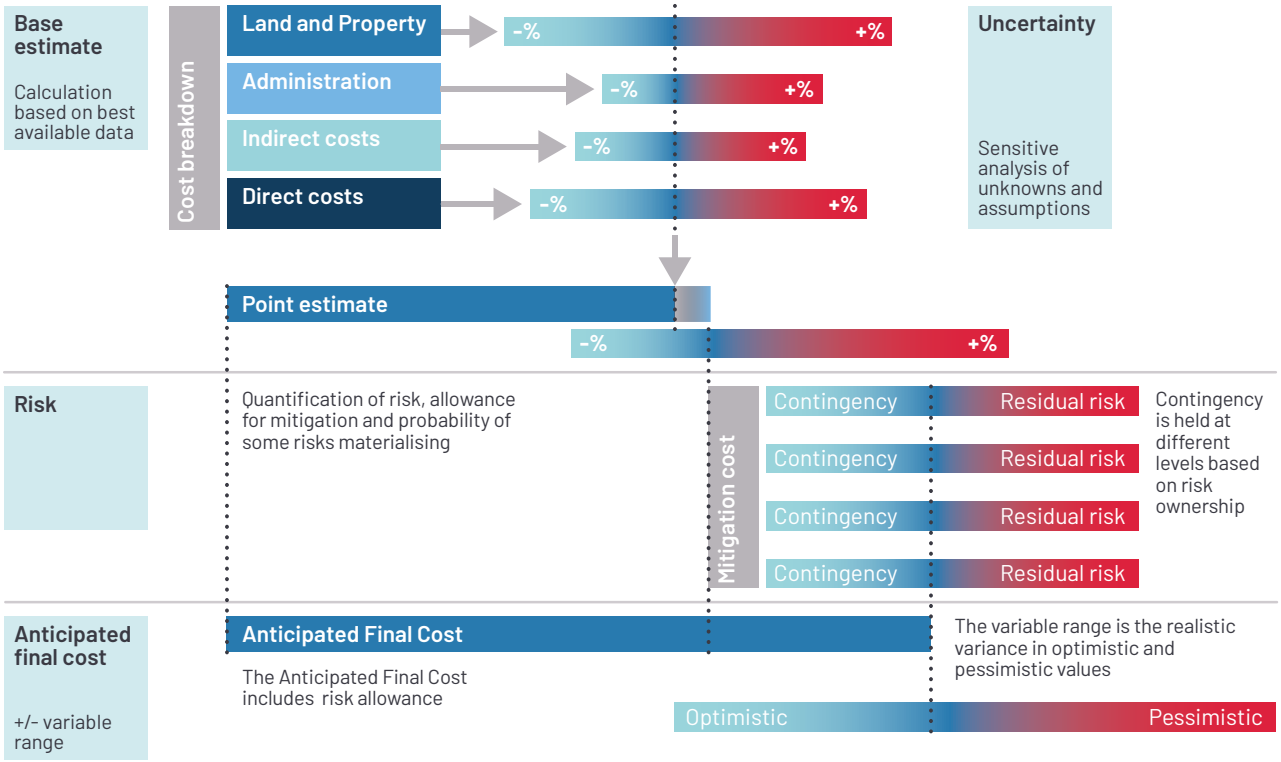
Anticipated Final Cost (AFC)

The AFC is the value that the project should expect as the target out-turn, addressing the various cost components. It is the aggregate of the value of the base cost estimate, adjusted to address cost estimating uncertainty, plus an allowance for project contingency to address expected risks. The cost estimate must present the "Median Scenario/P-50 equivalent" cost, meaning that the estimator believes that there are comparable probabilities of the actual outcome to be higher or lower than this threshold.

Material changes to the AFC should be flagged and investigated, to understand the cause of the variance. Common causes are changes in scope or identification of risks that were not accounted for. SROs should pay attention to value engineering, changes in contingency allocation or optimistic "recovery strategies" to keep the project within previous figures, as they often indicate wider challenges.

Cost estimating process

Figure 11 – Build-up of Anticipated Final Cost and confidence range



Range of possible values

As the AFC is based on probability, the cost estimate is calculated with an expected range defining the reasonable envelope for the project out turn.

The confidence in the cost estimate, and therefore the range associated to it, depends on the maturity of the input data, including the definition of the project scope, schedule and risk.

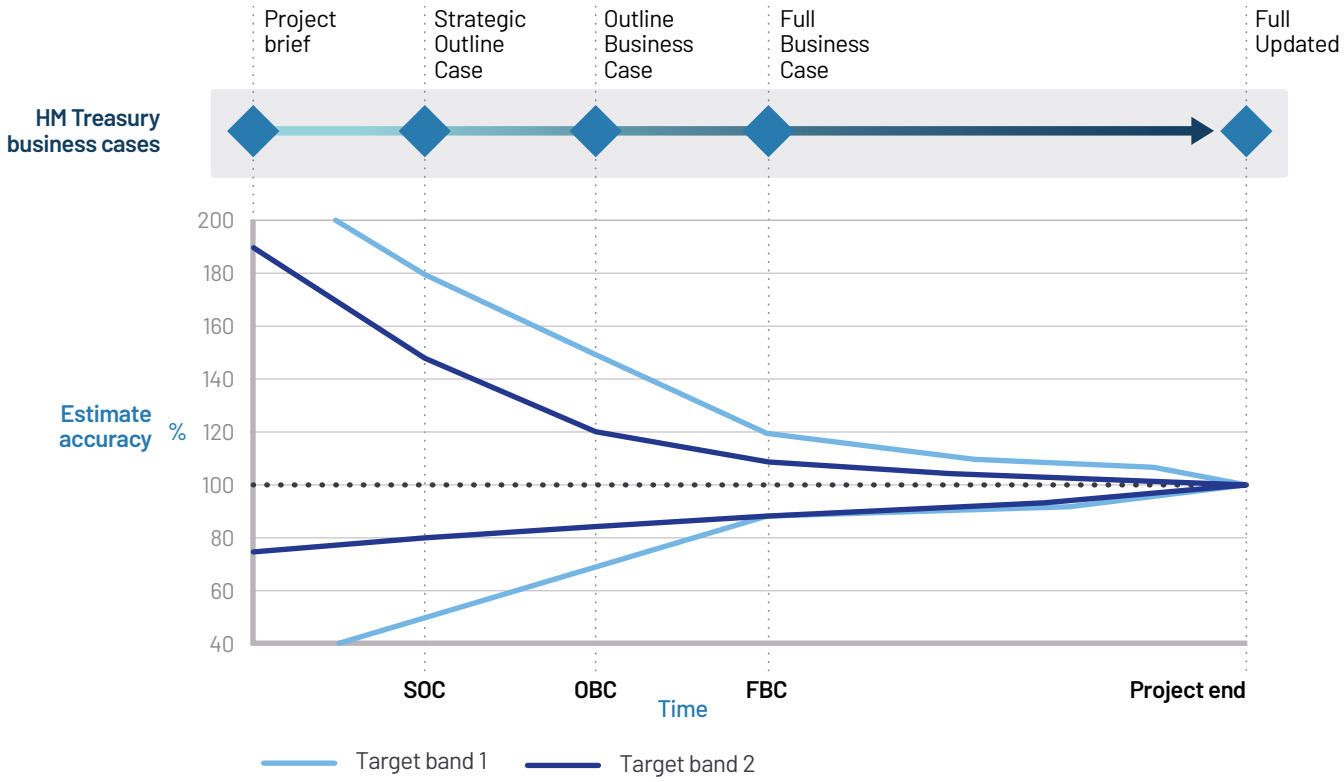
The cost estimate confidence range is determined by the evaluation of the cost drivers and their definition and the cost estimate class. The range is expressed as a percentage of the AFC rather than as a probability range. It should be noted that should scope significantly change post the application of the confidence range on the AFC, then the cost estimate should be re-baselined rather than rely on the range envelope to capture every eventuality.

At each project stage the cost estimate range must be evaluated against target thresholds. If the cost estimate falls outside of the expected range, the project leadership should question if the project has achieved enough maturity to pass the gate or if further development and definition would provide the necessary confidence to progress to the subsequent stage.

Most projects will be required to fall within the acceptable ranges; however by exception projects may be able demonstrate that whilst at the expected maturity and complied with all requirements, the cost estimate retains a higher degree of uncertainty. IPA will evaluate these projects on an individual, exceptions-only basis.

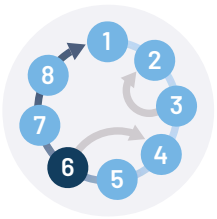
Cost estimating process

Figure 12 - Cost estimate range through the project stages



Stage Gates	SOC		OBC		FBC	
Ref. Classification	5		4-3		3-2	
Typical project maturity	<5%		30%		>60%	
Target range	-20%	+50%	-15%	+30%	-10%	+10%
By exception	-50%	+100%	-30%	+50%	-10%	+20%

Cost estimating process



Step 6: Review and assure

Reviewing and assuring cost estimates is a leading practice to improve the accuracy of and confidence in the cost estimate.

It is important to establish the aims, objectives and expectations for reviews up front (see Step 1) to prevent any confusion or ambiguity once the project is underway.

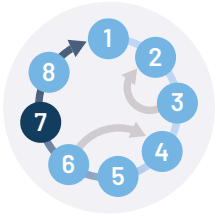
The review and assurance plan should articulate the inputs, outputs and required project interactions to ensure clarity in communication and accountability.

It should also identify the different types of reviews which will be sought on the cost estimate at various points. Continuity of the review team is preferred to build trust and foster better interaction with the project team.

When the project complexity and size justify it, assurance should be undertaken by a completely independent team from that of the project's estimators, designers, managers, executives, sponsors and stakeholders.

Assurance is particularly important leading up to leadership sign off and decision making on the cost estimate at key stage gates.

Cost estimating process



Step 7: Project leadership sign-off

The purpose of the sign-off process is to give project leadership an opportunity to clarify and challenge the cost estimate data, understand it and formally acknowledge their ownership to rely on its insights when governing the project.

The documents covered in the sign off process are:

- Project cost estimate (range around an Anticipated Final Cost, broken down to sufficient level of granularity)
- Cost estimate report
- Risk register
- Assumptions register
- Any observations and recommendations captured in the review and assurance

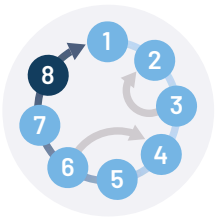
When accepting the cost estimate, the project leadership must understand and validate the relationship of the cost estimate alongside the scope, schedule, options and commercial strategy of the project.

It is the role of the Project Director to ensure that formal acceptance and completeness of the cost estimate has been met and to communicate that they are satisfied with the cost estimate deliverable to the SRO.

As the SRO has ultimate accountability for the project it is their responsibility to understand and accept ownership of the cost estimate and to prepare for project decisions. This will include providing assurance to the Accounting Officer that the cost estimate has been prepared in accordance with this guidance and the HM Treasury Green Book, as part of seeking Accounting Officer approval for the Outline Business case.

The formal sign off and satisfaction on the core requirements of the cost estimate must be captured in a written statement that IPA will request from the SRO as part of formal stage gate approval review.

Cost estimating process



Step 8: Use the cost estimate to support decision-making

The steps in this framework provide a consistent approach to cost estimates which are robust and therefore inform and support sound decisions regarding setting project direction.

Cost estimates are key inputs to the project stage gate milestones as defined by the Green Book and stage gate requirements:

SOC	OBC	FBC
A broad cost estimate range should be provided to support strategic decisions and unlock initial investment to develop the project.	A cost estimate is provided with slightly smaller ranges for each option to support the assessment and selection, ruling out options based on cost-benefit analysis.	The cost estimate should have a narrow range and is a key input to FBC, enabling a final go/no-go decision.

At early stages of the project, the cost estimate is subject to changes driven by the project's design, scope and requirements. Project leadership needs to participate in budget and stage gate approval decisions independently from, but with consideration to the cost estimate.

At the later stages of the projects the cost estimating process set out here, that delivers an AFC with a variable range, which should be used by decision makers to help set realistic budgets, considering affordability, value for money and wider considerations on the outcomes required from the project.

The expected accuracy range as highlighted in step 5, presents the cost estimate as three values which establish a probable cost envelope. They present the most-likely out-turn cost, reasonably optimistic and pessimistic out-turn costs based on the level of scope definition and taking into consideration some contingency for unknown risks threats.

Depending on the organisational risk profile and strategic importance of the project the "reasonably optimistic/pessimistic" envelope of costs should be considered at each stage gate and measured against the affordability threshold, when setting the budget for the project.

- If the reasonably pessimistic cost estimate falls above the affordability threshold, it is reasonably unrealistic that the solution will be affordable.
- If the reasonable best case falls below the affordability threshold, it is reasonably realistic that the solution will be affordable.
- Where the affordability threshold falls between the upper and lower ranges of the envelope, the project team will need to consider what actions are appropriate.

Therefore the process should be used to lend weight to discussions held with decision makers, regarding the positioning of the project within a realistic cost range to ensure that successful delivery is challenging but achievable. It is recommended that as the project progresses the methodology set out here is actively used and revisited to help set and challenge the appropriate budget and support key decisions to keep successful delivery on track.

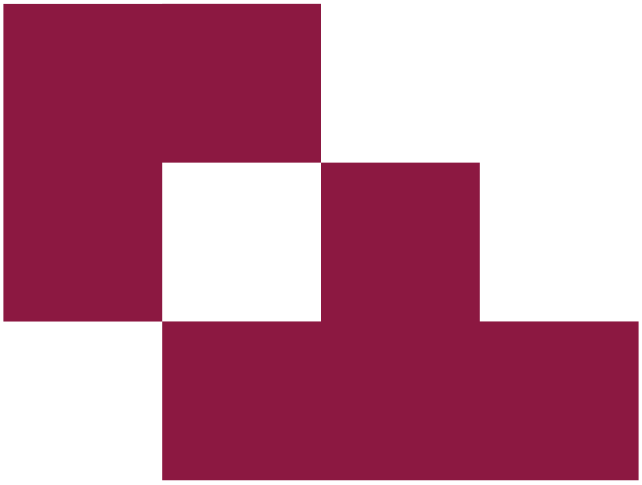
Summary

By setting out a standardised approach to cost estimating in this document, the government hopes to establish a foundation which will enable infrastructure projects and programmes to create more consistent, robust and ultimately more accurate cost estimates in the future.

Cost estimating is only one of a number of tools needed to ensure a project is delivered successfully. Establishing an accurate cost estimate early on in the project's life cycle however, will go a long way in helping to inform important policy, procurement and investment decisions later on. While this document sets out a guide to cost estimating for experts in the field, **it should also emphasise to all project delivery professionals that cost estimating has a profound impact at every stage of a project's development and delivery**.

It is important to remember that a baselined, realistic cost estimate is a key element of performance monitoring during a project's execution. It is not a fixed single figure that is determined at the start of a project, but is a range that evolves over time as the project matures and which should narrow in scope as the level of risk and uncertainty inherent in the project decreases.

There is clear demand from government and beyond for more expert, evidence-based cost estimates to ensure projects are set up for success at the very start of their inception. **The IPA looks forward to supporting cost estimators, project delivery professionals and organisations outside of government in implementing these cost estimating methods going forward, so as to drive more effective project delivery outcomes in the future.**



Appendix

Appendix A - Glossary

Term	Definition
3- Point cost estimate	A cost estimate which gives three estimation figures: the reasonably optimistic case, the most likely and the reasonably pessimistic case.
Analogy cost estimating	Assumes that similar projects have similar costs and uses past projects to build the cost estimate. Useful for mature and repeatable projects.
Anticipated Final Cost	A cost estimate or forecast of the final cost which is compiled prior to the completion of the project which considers the risk exposure at the time the cost estimate is made using risk analysis.
Base cost estimate	The building blocks of an estimate (see IPA Level 0). Does not include risk or contingency.
Base date	The date at which costs contained in the cost estimate are deemed current such as Q1 2021.
Basis of Cost Estimate	A collective term for the information upon which the cost estimate has been produced.
Benchmarking	Market testing of outputs and costs to ensure parity and value.
Bottom-up Cost Estimating	Otherwise known as first principles cost estimating, a detailed analytic cost estimate produced by analysing the resources (e.g. labour, materials, equipment etc.) required in significant detail.
Contingency	The part of a budget to deal with uncertainties and risks. It may be allocated at project or programme level, but this does not necessarily imply that expenditure of contingency is delegated to the relevant project or programme manager.
Correlation	A measure of how two or more variables are related to one another (e.g. there may be a positive correlation between two risks; if one occurs the likelihood of the other occurring increases.).
Cost Breakdown Structure	CBS created and developed based on the WBS and can be used to create and allocate costs to each part of the building project.
Cost Performance Index	A measure of the cost efficiency of budgeted revenues, expressed as a ratio where CPI = Earned Value/Actual cost. If CPI is less than one, the project is over budget.
Escalation	An increase in costs from a baseline position.
Expert Opinion	Quantification of risk models using the experience and knowledge of suitable people. Useful when addressing complex projects that require judgement for validation. Main criticism is the subjective nature (judgement of judgement) so cross-referencing independent appraisals is recommended.
FBC	Full Business Case.

Appendix

Term	Definition
First Principles	An cost estimating technique based on making cost estimates of every work package (or activity) in the work breakdown structure and summarising them to provide a total cost estimate of cost or effort required.
Material/Critical Risk	Risks that should they realise would impact the project in such a way that would compromise its continuity. These risks should be documented and handled separately, regularly reported to the project leadership and accounted for separately. Other terminology to address these risks are "blowout risks", "show-stopper risks", "tombstone risks" or "black swan events".
Method of Moments	The method of moments is a mathematical construct to derive the probability of two or more risks based on their separate distribution and correlation. Useful in simple models or to test boundary conditions in probabilistic scenario-based models; it is not sample-based but sensitive to distribution and correlation assumptions.
MPRG	The Major Projects Review Group (MPRG) Panels challenge projects on deliverability, affordability and value for money at key points in the HMT approvals process (SOC, OBC, FBC) and as required at other points during their lifecycle.
OBC	Outline Business Case.
Opportunity	A risk event that could have a positive effect on objectives.
Optimism Bias	Adjustment of Point cost estimate cost to address an uncertainty and risk allocation. Calculated by multiplying the cost by a tabulated factor derived from historical data of actual project out-turn.
Output Based Simulation	Relies on historical data to cost estimate the overall uncertainty and risk allowance at output levels of high-level break-down of the project. Is less sensitive to correlation mistakes.
Out-turn	Cost Estimate of likely "should cost" at time of construction.
P-Number	A measure of confidence constructed using probability. For example, the 80th percentile cost (also known as the P80) is such that the probability of the final cost being less than P80 is 80%. (P50 is also known as the median).
Parametric Cost Estimating	A cost estimating technique that uses a statistical relationship between historic data and other variables (for example square meterage in construction, lines of code in software development) to calculate a cost estimate.

Appendix

Term	Definition
Quantitative Risk Analysis / Input Based Simulation / Monte Carlo Method	Models the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It gives a probability distribution, where a P-number indicates the percentile of the cost estimates which fall below that given value.
Risk	An event that may affect the schedule or delivery of the project, which may or may not occur.
Risk Management	A systematic application of principles, approach and process to identifying, assessing and controlling risks to provide a disciplined environment for proactive decision-making.
Risk Register	A comprehensive, up to date, structured database of identified risks including detail such as the impact, likelihood, mitigation.
SOC	Strategic Outline Case.
Scenario Based Modelling	An assessment of the amount of cost reserve needed to protect a program from cost overruns associated with cost estimating the impact of various scenarios, in which adverse events occur, against the program baseline. Generates scenarios which are realistic and reflect plausible events.
Schedule	Normally referring to a Gantt style project or programme.
Schedule of Works	List of items to be costed with quantity, description and unit of measurement. Defined against an agreed methodology and work breakdown structure with granularity dependent on maturity of data.
Uncertainty	The variability in the cost based on the variance in assumptions, or the lack of confidence in the data that informs the Point cost estimate calculation.
Variable Range / Range cost estimate	Probability distribution assigned to elements of base cost estimate and risk analysis performed for each project. Monte Carlo based analysis to determine 'most likely' outcome.
Work Breakdown Structure	A WBS deconstructs an end-product into successive levels with smaller specific elements until the work is subdivided to the lowest level WBS components, or work packages, for which the cost can then be cost estimated.

Appendix

Appendix B – Acknowledgements

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Appendix

Appendix C – Useful documents

Infrastructure and Projects Authority, Requirements Guide (2021):
www.gov.uk/government/publications/cost-estimating-guidance

Infrastructure Projects Authority, IPA Mandate (2021):
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/949868/IPA_Mandate_2021.pdf

Infrastructure and Projects Authority: Setting up for success: The Importance of Front-End Loading (2020):
https://ipa.blog.gov.uk/2020/09/09/setting-up-for-success-the-importance-of-front-end-loading/

Infrastructure and Projects Authority: Principles of Project Success (2020):
www.gov.uk/government/publications/principles-for-project-success

HM Treasury: The Green Book: Appraisal and evaluation in central government (2020):
www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

HM Treasury: The Magenta Book: Central government guidance on evaluation (2020):
www.gov.uk/government/publications/the-magenta-book

National Audit Office, Lessons learned from major programmes (2020):
www.nao.org.uk/wp-content/uploads/2020/09/Lessons-learned-from-Major-Programmes.pdf

Infrastructure and Projects Authority: Best practice in benchmarking (2019):
www.gov.uk/government/publications/best-practice-in-benchmarking

Infrastructure and Projects Authority: People, Performance and Principles: The IPA's priorities for 2020 (2019):
https://ipa.blog.gov.uk/2019/09/24/people-performance-and-principles-the-ipas-priorities-for-2020/

Infrastructure and Projects Authority: The role of the Senior Responsible Officer (2019):
www.gov.uk/government/publications/the-role-of-the-senior-responsible-owner

Infrastructure and Projects Authority: The art of brilliance (2019):
www.gov.uk/government/publications/the-art-of-brilliance-a-handbook-for-leaders-of-transformation-programmes

HM Treasury: Accounting officer assessments guidance (2017):
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/645068/Accounting_officer_assessments_guidance.pdf

Ministry of Defence: Defined pricing structure guidance (2017):
www.gov.uk/government/publications/defined-pricing-structure-guidance

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Infrastructure and Projects Authority and HMT: Project Initiation Routemap (2016):
www.gov.uk/government/publications/improving-infrastructure-delivery-project-initiation-routemap

HM Treasury, Treasury Approvals Process for Programmes and Projects (2016):
www.gov.uk/government/publications/treasury-approvals-process-for-programmes-and-projects

Infrastructure and Projects Authority: Assurance review toolkit (2011):
www.gov.uk/government/collections/infrastructure-and-projects-authority-assurance-review-toolkit

Infrastructure and Projects Authority: Delivery Confidence Assessment (2011):
www.gov.uk/government/publications/guide-on-delivery-confidence-assessment

Office of Government Commerce: OGC Gateway process (2007):

Review 1: Business justification:
www.gov.uk/government/publications/ogc-gateway-review-1-business-justification-guidance-and-templates

Review 2: Delivery strategy:
www.gov.uk/government/publications/ogc-gateway-review-2-delivery-strategy-guidance-and-templates

Review 3: Investment decision:
www.gov.uk/government/publications/ogc-gateway-review-3-investment-decision-guidance-and-templates

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