



**NEW ZEALAND**  
GOVERNMENT PROCUREMENT

## Planning Construction Procurement

# A guide to risk and value management

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**MINISTRY OF BUSINESS,  
INNOVATION & EMPLOYMENT**  
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## About this guide

### Purpose

This guide provides New Zealand public sector agencies ('agencies') with basic guidelines on both risk and value management activities for construction projects. The guidelines are also designed for the construction industry, so that they understand the expectations of Government in terms of good practice approaches to risk and value management.

This guide aims to provide agencies, even those who are new to delivering construction projects, with basic knowledge of the fundamental principles, processes and terms used in this field.

### Related documentation

This document supplements the MBIE *Guide to Mastering Procurement*, which provides guidance around the eight stage procurement lifecycle.

This guide, *Planning Construction Procurement – A guide to risk and value management*, is part a series being developed by New Zealand Government Procurement (NZGP) to support agencies in using good practice when planning construction procurement.



See the guide *Planning Construction Procurement – An overview to the guides*, for details of the current suite of guides, how they relate to the eight stage procurement lifecycle and links to relevant government policy.

### How this guide was developed

NZGP developed this guide, *Planning Construction Procurement – A guide to risk and value management*, in consultation with agency and industry users. It is published on the website [www.procurement.govt.nz](http://www.procurement.govt.nz)

### How this guide is structured

This guide is structured as follows:

Section	Provides information and guidance on...
1	Getting Started: <ul style="list-style-type: none"> <li>• Overviews and principles of risk and value management</li> <li>• Key messages regarding risk management and value management</li> <li>• Stages of the project lifecycle when risk and value should be managed</li> </ul>
2	The practical tools for applying risk management on projects: <ul style="list-style-type: none"> <li>• Stages of the risk management process</li> <li>• Using risk registers</li> <li>• Feedback on how the project responded to risks</li> <li>• Roles and responsibilities</li> </ul>
3	The practical tools for applying value management on projects: <ul style="list-style-type: none"> <li>• Value management activities</li> <li>• Value management process</li> </ul>

Section	Provides information and guidance on...
4	Appended details of: <ul style="list-style-type: none"> <li>• Contingency using quantitative risk analysis</li> <li>• Risk based cost estimation (simplified and advanced approaches)</li> <li>• Adjusting programmes for risk (simplified and advanced approaches)</li> <li>• Monte Carlo simulations</li> </ul>
5	Appended list of links to external good practice construction procurement references

**Alignment with ISO 31000:2009**

This guide has been designed to align with the principles expressed in ISO 31000:2009. Users of this guide are therefore advised to refer directly to ISO 31000:2009 and any subsequent amendments thereto for full information on the topic.

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# 1. Getting started

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## Overview

This guide explains how risk and value are managed. These processes are fundamental to the successful delivery of projects and should be used throughout the life of the project. Risk and value management processes are also fundamental tools for ensuring that the asset being constructed delivers all of the intended benefits over its entire lifecycle. The guide summarises the key principles of risk and value management in the context of construction projects and describes the practical steps that need to be taken over the project (and asset) lifecycle.

MBIE promotes the use of risk management and value management as essential tools for the successful delivery of construction projects. Value management helps the client to identify the best way of meeting a business need. Risk management is used to manage the risks associated with the solution that offers best whole-of-life value to the client. Risk management should not be seen as a barrier to innovation; the most successful projects have well understood and effectively managed risks. A measured, well-understood and effectively managed risk can also add significant value to the outcomes of a project.

The approach defined in this document, contains a systematic overview, focus, and reference point for risk management. Better decisions, processes, plans, and programmes are the intended results. The goal is to enhance our chances of success and to minimise the potential for failure, through greater risk awareness and proactive management.

## Principles

Risk and value management are interrelated tasks that should be carried out in parallel. For convenience, risk management is described first in this guide, as poor risk management is known to be a major cause of project failure.

In practice, value management exercises are carried out first, to determine exactly what constitutes value to the client from delivery of the project. The preferred option (or options) are identified, together with the risks that are likely to occur if that option was implemented. The project team repeats the parallel exercises of defining value and associated risks until they arrive at the optimum balance of value and risk. These processes are then continued iteratively throughout the life of the project.



## DEFINITIONS

**Client** is a broad term used to describe the public sector agency responsible for procuring and delivering the project.

**Investment Decision Maker** is the organisation that approves funding for a proposed investment.

**Senior Responsible Officer (SRO)** is the person designated within the client as the owner of the investment and overall business change; responsible for securing funding and delivering the desired outcomes.

**Project Board** is the governance group within the client, established to oversee the delivery of projects; responsible for providing the project manager with the necessary decisions required to progress the project and a vehicle for overcoming any obstacles to the project.

**Project Manager** is the person designated within the client with responsibility for translating the requirements of the SRO and delivering the project. The project manager reports to the project board, keeping them regularly informed of progress and highlighting any foreseeable problems.

**Risk** is the consequence of uncertainty on the objectives of the project. A risk can either manifest as a threat (negative consequence) or an opportunity (positive consequence).

An **opportunity** is an event with an identifiable cause and a probability of occurrence that leads to a positive outcome.

A **threat** is an event with an identifiable cause and a probability of occurrence that leads to a negative outcome

**Risk management** is the coordinated activities that are undertaken by the Client to direct and control risks.

**Value** is the benefit to the client, and – for projects delivered by the public sector – to the country, of undertaking the project.

**Value management** is the process of making explicit the functional benefits of a project, and appraising those benefits. Value management is strategically and organisationally focused, and ensures that the project achieves a strategic fit with the core business of the client.

**Value engineering** is the organised approach to providing the necessary functions at the lowest cost and at the specified quality.

## Risk and risk management

Successful risk management requires senior management commitment, ownership and understanding of the process, and an active risk management regime reviewed regularly in a constructive ‘no-blame’ culture.

Attitudes to risk have a significant effect on the success of the project. An objective of ‘not failing’ will have a very low tolerance of risks of any kind. Conversely, an objective of ‘succeeding’ will encourage participants to be more innovative, to take more risk where appropriate and to make more effort to monitor and manage the recognised risks.

The scope and delivery environment can differ from one project to the next, so it is important to tailor the risk management process to suit the objectives and requirements of each project.



### **RISK MANAGEMENT IN CONSTRUCTION PROJECTS**

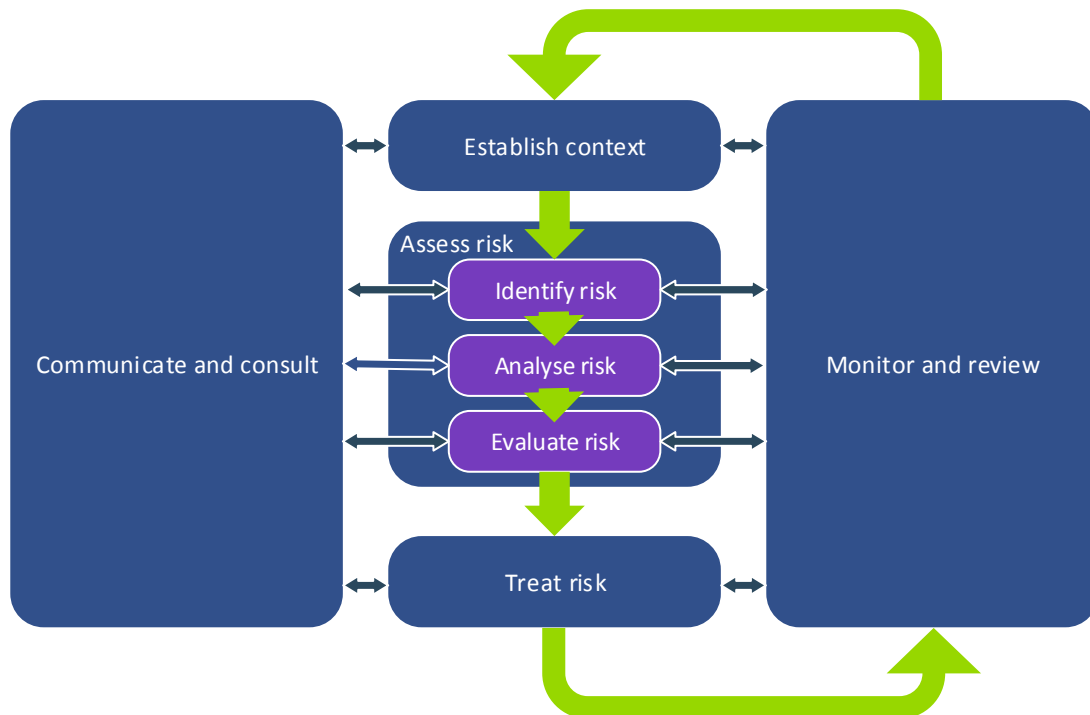
This involves:

- Establishing the context of risk management (establishing the basic parameters and process, including how the risk management process should be tailored for the specific project and how risk management may impact other project decisions, such as the selected delivery model)
- Ensuring that members of the team have the opportunity to engage in a dialogue that will promote agreement of an appropriate allocation of risk between all parties
- Identifying and assessing each risk in terms of consequence and likelihood (this should involve reviewing risks on previous similar projects and common industry risks)
- Allocating responsibility for managing each risk with the party best able to do so
- Establishing and maintaining a combined risk register, agreed by the entire project team (including key supply chain members)
- Establishing procedures for actively managing and monitoring risks throughout the project and during occupation on completion
- Updating risk information throughout the life of the project
- Ensuring control of risks by planning how risks are to be managed through the life of the project to contain them within acceptable limits

This is shown graphically in Figure 1 below.



**Figure 1-** Risk management process -



Management of risk is an ongoing process throughout the life of the project, as risks will be constantly changing. Risk treatment strategies should be in place to deal quickly and effectively with risks if they arise. It is important for the entire project team (including key supply chain members) to work together from the earliest possible stages on an open book basis to identify risks throughout the team's entire supply chain.

### Key messages about managing risk

- A common risk management process should be understood and adopted at all levels within the project team, and the risk register regularly reviewed and updated throughout the project lifecycle.
- Risks inherent in the maintenance and demolition of a facility should be considered during design development and the decisions about risks kept on the register for future reference.
- The buildability and maintainability of the facility are central to its long-term value; there must be ownership and management of these risks.
- If the project team does not include the facilities manager, the facility management (FM) risks should be considered and owned early on – usually by the client.
- The project lifecycle runs from inception until demolition/disposal of the facility. In a disposal, whoever acquires it will need to know the risks upon transfer.
- It is imperative for successful project delivery to use subject matter experts to assess risks.
- There must be adequate time and effort early on to identify and analyse the risks, and to develop risk treatment strategies governing how they are to be managed and funded (the calculation of the project contingency).
- Risks should be allocated to individual risk owners within the project team, who should fully understand the risks for which they are responsible.
- Clients should not make any financial commitment to a project or a major change, unless the project team has conducted a risk review.

- The risks should be managed actively throughout the life of the project in accordance with the risk treatment strategies. These risk treatment strategies should deal with all risks, whether retained by the client or transferred to others in the project team.
- The business case should include a time element and the risks of that changing should be kept constantly under review.



Risk management arrangements within procurement and contract documents should include risk allocation that:

- is clear and unambiguous
- achieves best value for money across the whole life of the asset
- represents a fair balance between risk and control
- creates no conflicts of interest in those required to give independent advice to the client.

Clients need to be aware that uninformed transfer of risk to the supply chain may lead to unnecessary cost escalation on the project. Placing the responsibility for managing risks with those best placed to do so achieves the best value for money across the life of the asset.

Client ownership of risks and responsibility for their management involves:

- the investment decision maker, who should be made aware of the risks to the project
- the project board, who should receive regular reports on the status of significant risks, and make any requested decisions regarding risk treatment
- the senior responsible officer (SRO), who should ensure that the risks are adequately considered in the project preparation and management
- the project manager, who should continuously manage and monitor, and regularly report, on the risks.

Risk management and the selected delivery model are interrelated. Risk allocation should be considered as part of the evaluation of an appropriate delivery model, as different models will entail differing degrees of risk transfer. For advice on delivery models, see *Planning Construction Procurement – A guide to developing your procurement strategy*.

### EXAMPLE

For the planning associated with building a new library, the territorial authority has many aspects to consider; their internal delivery capability, the complexity of the project, their organisational risk tolerance, and the likely risks of undertaking the project. Ultimately the territorial authority shortlists two delivery models for further consideration; client-led design (traditional) and design & build.

These two models differ significantly in terms of risk acceptance by the client and transfer to consultants and contractors. The territorial authority decides that it has the capability (through a mixture of in-house and consultant resource) to manage any design quality and interface risks itself, therefore it chooses to proceed with the client-led design delivery model.

## Value and value management

Value, in its broadest sense, is the benefit to the client – or the wider country, for many projects delivered by the public sector. It confirms the project is worth doing and quantifies the evidence of this in business terms (though not necessarily in financial terms), e.g. creating a better working environment or improving the experience of patients during treatment. In this guide, managing value means making the right choices to obtain the optimum balance of benefit in relation to cost and risk. Value management provides a structured approach to the assessment and development of a project, to increase the likelihood of achieving these requirements with optimum whole-of-life value for money.

Value engineering is a continuous process, in which all the components and processes involved in construction are critically appraised to determine whether better value alternatives or solutions are available. It helps reduce wasteful processes and inefficiency in specific aspects of the design, construction, maintenance and operation.

Value management is also important because it enables stakeholders to define and achieve their needs, through facilitated workshops that encourage participation, team-working and end-user buy-in.



Value management should focus on function and value for money over the whole of the life of the asset, rather than on reducing cost.

The benefits that can be achieved through this approach include:

- a better understanding of the business needs, including the flexibility required to meet future needs
- simple, clear definition of specific stakeholder needs
- consideration of all options, alternatives and innovative ideas
- achievement of optimum value for money while satisfying the range of user requirements
- prevention of unnecessary expenditure through reducing waste and inefficiency
- improved team-working with joint ownership of solutions.

### Key messages about value management

Value management is about enhancing value, rather than cutting cost – although this could potentially be a by-product. The principles and techniques of value management aim to achieve the required quality at optimum whole-of-life cost during the process of developing a project. The principles centre on the identification of the requirements that will add demonstrable value in meeting the business need. Workshops led by value management facilitators are often used to identify value to the business. These workshops should involve stakeholders, members of the project team and key members of the supply chain.

Value management aims to maximise project value within time, cost and quality constraints. However, it should be recognised that improving whole-of-life project value sometimes requires extra initial capital expenditure. The key differences between value management and cost reduction are that the former is:

- positive, focused on value rather than cost, seeking to achieve an optimum balance between quality, whole-of-life cost and time
- structured, auditable and accountable
- multi-disciplinary, seeking to maximise the creative potential of all project participants (including the client), working together as an integrated project team.

Value engineering is a part of value management, and considers specific aspects of the design, construction, operation and management. All projects are likely to include some unnecessary costs. However, cutting cost without proper analysis is likely to lessen value. Unnecessary cost should only be removed where wasteful processes and/or practices contribute to cost. Any loss of functionality or quality diminishes value. Investment in developing the brief and/or design is often cut. However, this is likely to lead to delay and cost overruns further on in the project, due to changes and potential misunderstandings.

Whole-of-life costing is a vital element of value management. It covers all the costs relating to a facility, from project inception through to disposal. (See *Total Cost of Ownership – an introduction to whole-of-life costing and Cost Benefit Analysis including Public Sector Discount Rates*.) It is essential to base the value management approach on the whole-of-life cost of ownership, rather than acquisition alone. This optimisation process is often undertaken in an iterative manner, using a whole-of-life project cost model. The solution ultimately selected should be the one that represents the lowest net present cost while meeting all of the client's key requirements for scope, time, quality, etc.



## Guide to Total Cost of Ownership

### Cost Benefit Analysis including Public Sector Discount Rates

Health and safety, employment standards, sustainability, design quality, buildability, operation and maintenance and disposal, and any other relevant issues, should all be considered during value management reviews and evaluation of options.

The SRO should establish a workable value management framework for continuously reviewing the project development against the client's needs and objectives.

### EXAMPLE

While planning to deliver a comprehensive refurbishment of a health-care facility, the local district health board is presented with a number of options relating to the scope of the project.

- The first option involves essentially keeping the facility at its current size and layout. It mostly involves refresh of furniture, fittings and equipment (FF&E). This option comes at an estimated cost of \$27M, with cash benefits over ten years of \$5M – mostly in terms of reduced maintenance costs.
- Option 2 involves adding a further wing to the facility. This allows increased space for patient beds, as well as replacing the same FF&E in Option 1. This option comes at an estimated cost of \$50M, with cash benefits over ten years of \$25M. The benefits from this option are a combination of reduced maintenance costs, and improved patient health benefits gained by the additional capacity.
- The final option involves building a new facility of a similar size to the existing one, on a different site. This option comes at an estimated cost of \$150M, but has a calculated cash benefit over ten years of \$200M. This benefit is derived from being closer to the patient population, increased operating efficiency (driven by a new layout), reduced operating and maintenance costs.

Many factors affecting the district health board will determine the correct choice, such as patient needs and numbers, available technology, government health priorities, funding etc. However, it can be seen that Option 3 is the only one whose benefits outweigh costs, and therefore (in the absence of further information) is likely to be the best value choice.

## When to manage risk and value

Risk and value management are continuous processes throughout the project lifecycle. These activities inform key decision points as shown below. Figure 2 shows the main points in the procurement process where risk and value management activities take place and summarises these activities. This summary also shows how risk and value management activities align with the Gateway and Better Business Case (BBC) processes run by Treasury. Regardless of whether a particular project uses Gateway and/or BBC, the different stages and types of risk and value management shown below still apply.

**Figure 2 - Risk management and value management – review points**

Stage name	Gateway Stage	BBC Stage	Risk and value management approach
Strategic assessment	Before Gate 0		<b>Value management</b> to identify stakeholder needs, objectives, outcomes and priorities High level <b>risk assessment</b> of potential project options
	Gate 0	Strategic Assessment	
Business justification & options	Before Gate 1		<b>Value management</b> study to evaluate options that could meet user needs High level <b>risk assessment</b> to establish high level project budget including base estimate and contingency
	Gate 1	Indicative Business Case	
Delivery strategy	Before Gate 2		<b>Value management</b> to develop output-based specification, to refine and evaluate options that satisfy project brief, objectives and outcomes. <b>Risk management</b> to identify risks for each procurement option, cost of managing them (through avoidance, design/reduction, acceptance, share or transfer); revise contingency
	Gate 2		
Investment Approach	Before Gate 3		<b>Value management</b> to apply selection and award criteria <b>Risk management</b> – update risk register and revise base estimate and contingency
	Gate 3	Detailed Business Case	
Concept Design	Before Decision Point 1		<b>Value engineering</b> study to optimise whole-life design quality and cost. Project team to assess buildability of options <b>Risk management</b> – identify residual risks and continue to manage risks and contingency; agree and implement collective risk management approach with supply chain
	Decision Point 1		
Detailed Design	Before Decision Point 2		<b>Value engineering</b> study to optimise whole-life design quality and cost. Project team to assess buildability of design <b>Risk management</b> – identify residual risks and continue to manage risks and contingency; continue to implement joint risk management approach with supply chain
	Decision Point 2	Implementation Business Case	
Readiness for service	Before Gate 4		Finalise design and start construction <b>Risk management</b> ongoing during construction (including participation by supply chain) <b>Value engineering</b> for detail of finishes etc.
	Gate 4		
Operational Review & Benefits Realisation	Before Gate 5		<b>Risk management</b> ongoing during operations and maintenance; hand over any outstanding risks to business as usual/operations team <b>Value management</b> review and feedback of lessons learned
	Gate 5		

The SRO should ensure that a risk management plan is prepared that addresses each of the following areas, at the commencement of the project. This risk management plan can form part of the project execution plan.

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## 2. Risk management in practice

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### Risk management activities

Risk Management is the process of identifying, analysing and taking action on risks (either opportunities or threats) throughout the life of a project, to help ensure it achieves its objectives.

Risk management should be proactive, rather than reactive. Risks should be managed at the earliest opportunity within the project lifecycle.

Risk management practice involves several stages:

- communication and consultation
- establishing the context
- risk assessment (comprising risk identification, risk analysis and risk evaluation)
- risk treatment
- risk monitoring and review.



#### DEFINITIONS

Each identified risk is assigned a **risk owner**, who is the person or entity with the accountability and authority to manage a risk.

**Establishing the context** involves defining the parameters both within and outside the project that should be taken into account when managing risk. It also involves setting the scope and criteria for the agency and/or project's risk management policy."

**Risk identification** is the process of discovering, identifying and describing risks.

**Risk analysis** is the process of understanding the nature of a risk and determining the likelihood and consequence of risk.

**Risk evaluation** is the process of comparing the results of risk analysis with the established risk criteria, to determine whether the risk and/or its magnitude are acceptable or tolerable.

**Risk treatment** is the process of modifying risk.

### Communication and consultation

Successful risk management is dependent on effective communication and consultation with stakeholders.

Involving stakeholders in the risk management process will assist in:

- developing a communication plan
- defining and agreeing the risk context
- ensuring that the interests of stakeholders are understood and considered
- bringing together different areas of expertise for identifying and analysing risk
- ensuring that different views are appropriately considered in evaluating risks
- ensuring that risks are adequately identified

- securing endorsement and support for each risk treatment strategy.

Stakeholders should contribute to the interfacing of the risk assessment process with other management disciplines, including change management, project and programme management and also financial management.

### Establishing the context

Context is the key to managing risk effectively. It is first necessary to establish and understand the overall operating environment in which risks have to be managed. This is primarily done by establishing the risk context. When doing this, it is important to consider both the:

- external environment, e.g. factors like political, regulatory, technological, economic, etc., and
- internal environment, e.g. factors like governance/organisational structures, policies, capabilities, culture, etc.

Establishing the context defines the basic parameters for managing risk, and sets the scope and criteria for the rest of the process. Establishing the context includes considering internal and external parameters relevant to the organisation as a whole, as well as the background to the particular risks being assessed.

In establishing the context, the risk assessment objectives, risk criteria, and risk assessment programme are determined and agreed.

By establishing a risk context, the organisation is defining its objectives and the external and internal parameters within which it will manage risk. A well-established risk context allows the organisation undertaking the risk management exercise to:

- meaningfully identify, analyse, and evaluate risk
- encourage associated success through the project the organisation will deliver.

Context includes:

- Establishing the **external context** involves familiarisation with the environment in which the organisation and the system operate including:
  - cultural, political, legal, regulatory, financial, economic and competitive environment factors, whether international, national, regional or local
  - key drivers and trends having an impact on the objectives of the organisation
  - perceptions and values of external stakeholders.
- Establishing the **internal context** involves understanding:
  - capabilities of the organisation in terms of resources and knowledge
  - information flows and decision-making processes
  - internal stakeholders -
  - objectives and the strategies that are in place to achieve them -
  - relationships, perceptions, values and culture
  - policies and processes
  - standards and reference models adopted by the organisation
  - structures (e.g. governance, roles and accountabilities)
  - consideration of capability gaps to be filled by use of contracted specialist resources to assist in risk assessment.



- Establishing the **context of the risk management process** includes:
  - defining accountabilities and responsibilities
  - defining the extent of the risk management activities to be carried out, including specific inclusions and exclusions
  - defining the extent of the project, process, function or activity in terms of time and location
  - defining the relationships between a particular project or activity and other projects or activities of the organisation
  - defining the risk assessment methodologies
  - defining the risk criteria
  - defining how risk management performance is evaluated
  - identifying and specifying the decisions and actions that have to be made
  - identifying scoping or framing studies needed, their extent, objectives and the resources required for such studies.
  
- Defining **risk criteria** involves deciding:
  - the nature and types of consequences to be included and how they will be measured
  - the way in which likelihoods are to be expressed
  - how a level of risk will be determined
  - the criteria by which it will be decided when a risk needs treatment
  - the criteria for deciding when a risk is acceptable and/or tolerable
  - whether and how combinations of risks will be taken into account.

## **Risk assessment**

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation.

Risk assessment provides an understanding of risks, their causes, consequences and their likelihoods. This provides input to decisions about:

- whether an activity should be undertaken
- how to maximize opportunities
- whether risks need to be treated
- choosing between options with different risks
- prioritising risk treatment options
- the most appropriate selection of risk treatment strategies that will bring adverse risks to a tolerable level.

## **Risk identification**

The purpose of risk identification is to identify what might happen or what situations might exist that might influence the achievement of the objectives of the project or organisational outcomes. Once a risk is identified, the organisation should identify any existing controls such as design features, people, processes and systems.

The risk identification process includes identifying the causes and source of the risk events, situations or circumstances which could have a material impact upon objectives and the nature of that impact

Possible approaches for identifying risks include:

- Checklists
- Judgments based on experience and records
- Brainstorming/workshops
- Scenario analysis
- Fault-tree analysis, and
- Decision-tree analysis

The approach used will depend on the nature of the activities under review, types of risks likely and/or the preferred approach of the project manager in consultation with the SRO.

Team-based brainstorming (facilitated workshops) is a common approach used in risk management process. It encourages a commitment of time by people associated and involved in the project, allows different perspectives to be considered and incorporates differing experiences and expertise. For less clearly defined situations, such as the identification of strategic risks, processes with a more general structure, such as 'what-if' and scenario analysis could be used.

Where resources available for risk identification and analysis are constrained, the structure and approach may have to be adapted to achieve efficient outcomes within budget limitations. For example, where less time is available, a smaller number of key elements may be considered at a higher level, or a checklist may be used.

Risks on similar project and similar industries (both domestic and international) should be investigated during the risk identification process, to include the widest range of potential risks in the assessment.

### **Controls**

A control is an existing process, policy, device, practice or other action that acts to minimise a threat or to enhance an opportunity. They are often deemed to be business-as-usual activities that exist independently of specific risk treatment actions, and are usually being actively applied at the time of risk identification.

It is worth noting that a single control may manage more than one identified risk and that controlling actions may be owned or operated by someone (or a group) different to the nominated risk owner.

A risk treatment action, once completed, becomes a control.

### **Risk analysis**

Risk analysis is about developing an understanding of the risk. It provides an input to risk assessment and to decisions about whether risks need to be treated and about the most appropriate treatment strategies and methods.

Risk analysis involves consideration of the causes and sources of risk, their consequences and the probability that those likelihoods can occur. Factors that affect consequences and likelihood should be identified. An event can have multiple consequences and can affect multiple objectives. Existing risk controls and their effectiveness should be taken into account.

- **Current** risk ratings are based on the effectiveness of the control, the likelihood of the risk occurring and its potential consequences. These ratings are then plotted against a matrix (heat-map) to determine the 'current risk profile'.
- **Residual** risk rating is an assessment of the risk after treatment actions have been undertaken and are complete. These assessments, while a prediction of the success of the specific treatment, provide an indication of the potential benefits derived to the organisation and its objectives from the treatment of the risk. It also provides information on the value of the investment of resource, time and costs of the treatment actions in dealing with the risk. Again, these ratings are then plotted against the matrix (heat-map) with the completed matrix being the 'residual risk profile'.

Risk analysis includes estimating the range of potential consequences that might arise from an event, situation or circumstance, and their associated likelihood, in order to measure the level of risk. However, in some instances, such as where the consequences are likely to be insignificant, or the probability is expected to be extremely low, a single parameter estimate may be sufficient for a decision to be made.

**Figure 3 – Example qualitative risk probability descriptors**

Descriptor	Probability rating	Broad definition of occurrence
Almost Certain	Over 75%	Will undoubtedly happen/recur, possibly frequently. History of frequent occurrence. The event is expected to occur in most circumstances.
Likely	50% to 75%	Is likely to happen/recur, can be viewed as a persisting event or circumstance. Likely the event will occur within a one year timeframe.
Possible	25% to 50%	Might happen or recur occasionally. Possible to occur at least within a one to two year period.
Unlikely	5% to 25%	Do not expect it to happen/recur, although it may do so. Unlikely to occur within a one to two year period and, if it was to occur, would so over a five to 10 year period.
Rare	5% or less	This is highly unlikely to happen/recur. Event may happen in exceptional circumstances. No or minimal history of occurrence.

**Figure 4 – Example qualitative risk consequence descriptors**

Descriptor	Broad definition
Substantial	Event(s) make it difficult, if not impossible, for a project to fully deliver on all of its objectives, resulting in permanent delivery loss.
Major	Event(s) require significant SRO involvement and decision-making. Events may also require respective stakeholders to assist in stabilising delivery of the project to deliver on all of its objectives. Events shape delivery of the project.
Medium	Event(s) do not destabilise the core delivery or strategic approach by the project to deliver all of its objectives. Event(s) impact smaller number of work streams and can be managed by the project manager.
Minor	Event(s) can be managed so that the project delivers all of its objectives. The project manager manages within existing budgets, timeframes and design quality/outcomes. Events are isolated to one or a small number of work streams.
Very Low	Event(s) can be managed so that the project delivers all of its objectives. Brought to the project manager for attention only. Managed by the project manager within existing resources and as business as usual.

Methods used in analysing risks can be qualitative, semi-quantitative or quantitative. The degree of detail required will depend upon the particular application, the availability of reliable data and the decision-making needs of the organization. These three methods are described below:

- A **qualitative assessment** defines consequence, likelihood and level of risk by significance levels such as “high”, “medium” and “low”, may combine consequence and likelihood, and evaluates the resultant level of risk against qualitative criteria. A descriptive written statement of relevant information about a risk should consider:
  - the stages of the project when it could occur
  - the elements of the project that could be affected
  - the factors that could cause it to occur
  - any relationship or interdependency on other risks
  - the likelihood of it occurring
  - how it could affect the project.
- **Semi-quantitative assessment** methods use numerical rating scales for consequence and probability and combine them to produce a level of risk using a formula. Scales may be linear or logarithmic, or have some other relationship; formulae used can also vary.
- A **quantitative assessment** estimates practical values for consequences and their likelihoods, and produces values of the level of risk in specific units defined when developing the context. Full quantitative analysis may not always be possible or desirable due to insufficient information about the system or activity being analysed, lack of data, influence of human factors, etc. or because the effort of quantitative analysis is not warranted or required. In such circumstances, a comparative semi-quantitative or qualitative ranking of risks by specialists, knowledgeable in their respective field, may still be effective. In

cases where the analysis is qualitative, there should be a clear explanation of all the terms employed and the basis for all criteria should be recorded. A Monte Carlo simulation (as described in Appendix B) is a common type of qualitative risk assessment.

**Risk evaluation**

The purpose of risk evaluation is to:

- make decisions based on the outcomes of risk analysis about which risks need treatment, and
- to prioritise treatments.

Risk evaluation involves comparing estimated levels of risk with risk criteria defined when the context was established, in order to determine the significance of the level and type of risk.

Risk evaluation uses the understanding of risk obtained during risk analysis to make decisions about future actions. Ethical, legal, financial and other considerations, including perceptions of risk, are also inputs to the decision.

Decisions may include:

- whether a risk needs treatment
- priorities for treatment
- whether an activity should be undertaken
- which of a number of options should be followed

The nature of the decisions that need to be made and the criteria which will be used to make those decisions were decided when establishing the context but they need to be revisited in more detail at this stage now that more is known about the particular risks identified.

The simplest framework for defining risk criteria is a single level which divides risks that need treatment from those which do not. This gives attractively simple results but does not reflect the uncertainties involved both in estimating risks and in defining the boundary between those that need treatment and those that do not.

The decision about whether and how to treat the risk may depend on the costs and benefits of taking the risk and the costs and benefits of implementing improved controls.

**Figure 4 – Example qualitative risk matrix (heat map) of likelihood and consequence (for threats)**

Threat Risk Matrix						
Likelihood	Almost Certain	Moderate threat	High threat	High threat	Extreme threat	Extreme threat
	Likely	Moderate threat	Moderate threat	High threat	Extreme threat	Extreme threat
	Possible	Low threat	Moderate threat	High threat	High threat	Extreme threat
	Unlikely	Low threat	Moderate threat	Moderate threat	High threat	High threat
	Rare	Low threat	Low threat	Low threat	Moderate threat	High threat
		Very Low	Minor	Medium	Major	Substantial
Consequence						

**Figure 5 – Example qualitative risk matrix of likelihood and consequence (for opportunities)**

Opportunity Risk Matrix						
Likelihood	Almost Certain	Substantial opportunity	Substantial opportunity	High opportunity	High opportunity	Moderate opportunity
	Likely	Substantial opportunity	Substantial opportunity	High opportunity	Moderate opportunity	Moderate opportunity
	Possible	Substantial opportunity	High opportunity	High opportunity	Moderate opportunity	Low opportunity
	Unlikely	High opportunity	High opportunity	Moderate opportunity	Moderate opportunity	Low opportunity
	Rare	High opportunity	Moderate opportunity	Low opportunity	Low opportunity	Low opportunity
		Substantial	Major	Medium	Minor	Very Low
						Consequence

### Risk treatment

Having completed a risk assessment, risk treatment involves selecting and agreeing to one or more relevant options for changing the likelihood of occurrence, the effect of risks, or both and implementing these options.

Risk treatment involves identifying the range of options for treating risks, assessing these options and the preparation and implementation of treatment plans. Once implemented, treatments provide or modify existing controls. The decision to progress a risk treatment action lies in the first instance with delegated powers, after which agreement must be obtained from the SRO.

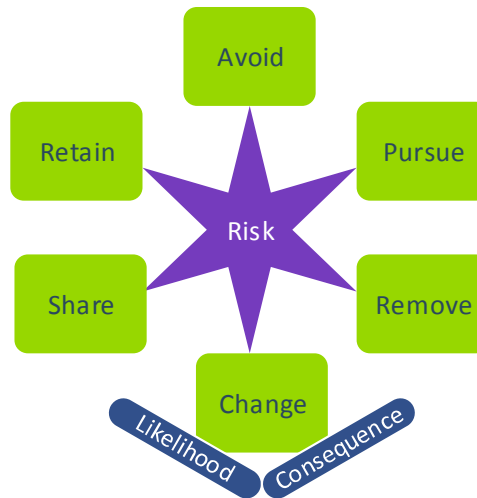
Risk treatment is a cyclical process of deciding that current risk levels are not tolerable, generating new risk treatment(s) and assessing the effect of that treatment, until a level of risk is reached which is one that the organisation can tolerate, based on the agreed risk criteria.

Not all risks require treatment. Some will be acceptable when measured against risk tolerance and/or appetite statements, or when lowering the ratings is deemed insufficient to justify the treatment costs, and only require occasional monitoring throughout the period.

Treating risks involves the following steps:

1. Identify possible risk treatment options.
2. Select the most beneficial treatment option(s).
3. Assign treatment ownership (where not the risk owner).
4. Prepare risk treatment plans.
5. Monitor and review treatment actions on a regular basis.

**Figure 6 – Risk treatment options**



Descriptor	Broad definition
Avoid the risk	Change activity processes or objectives to avoid the risk
Pursue the risk	Pursue the risk or enhance its opportunity of occurrence
Remove the risk	Remove the source of the risk
Change the likelihood	Undertake actions aimed at reducing the probability of occurrence <sup>1</sup>
Change the consequence	Undertake actions aimed at reducing the impact of the threat
Share / transfer the risk	Share ownership and liability to a Third Party (e.g. Insurance)
Retain the risk	Accept the impact of the risk (should it occur) through informed decision

Risk treatment options should be based on an understanding of how the risk(s) would arise. This includes, not only the immediate causes of an event, but also the underlying factors that influence whether the proposed treatment will be effective.

Unless otherwise agreed by the SRO, risk owners are accountable for developing effective treatment plans. Risk owners can delegate responsibility (but not accountability) to their direct reports or service providers, in order to develop and/or implement the treatment plan.

Once treatment option(s) have been selected, they should be consolidated into an action plan. Risk owners can delegate responsibility (but not accountability) to their direct reports or service providers, in order to develop and/or implement the treatment plan.

A plan may impact on multiple risks, so consideration needs to be given to combining and comparing actions. This can resolve potential conflicts and reduce duplication of effort.

Risk treatment action plans should include (and are not limited to):

- Identification of responsibilities
- A timeline and priority order for implementing treatment actions
- The cost(s) and resources required for the treatment activities(s)
- Identification of appropriate monitor and review activities.

Clients are encouraged to consider a portfolio/programme approach to risk management. This is the concept that an individual project may not have the ability or budget to absorb the impact of certain risks, but the client as a whole does. This approach can lead to long term value realisation by the client, as fewer low probability/high consequence risks are transferred to the supply chain, and any associated risk premiums are saved.

<sup>1</sup> Enhancing the probability or impact if an Opportunity

## Monitoring and review

The discipline of risk monitoring and reviewing enables the risk owner or SRO to:

- Track the effectiveness of control or treatment actions
- Continue to obtain and include new information about identified risks, improving the basis on which they are being assessed (if risk information is out of date, the SRO could make poor decisions that could have otherwise been avoided)
- Identify emerging risks
- Consider and evaluate whether the risk context is changing or remaining static, and how or what the impact of this might be
- Determine if the risk profile of a risk, project or programme is changing (positively or negatively), and
- Provide assurance on the quality of the information being presented.

The common output from monitoring and reviewing step of risk management process is a risk report provided for governance, management or operational level activity and review.

## Risk Register

Details of all risks should be captured in the risk register. However, the detailed nature of the risk register means that it can be difficult to capture a meaningful summary of the current exposure to risk. The status of key risks should be reported regularly to the SRO and project board – when a previously identified key risk materialises, the SRO immediately understands the consequence and can make an informed decision on the way forward.



### Risk register template -

Regular recording of the progress of risks is essential, because their status can change rapidly. If an unforeseen risk occurs, it is essential to:

- immediately record it and report it to the SRO and/or project board (as appropriate), and
- recalculate the overall project risks as soon as possible.

The new risk could potentially indicate a common mode of failure relevant to other risks.

Each agency or project team should also decide how risks of a certain ranking are dealt with. For example, a summary of the extreme threats and opportunities could be reported to senior level via project board meetings for example, so as to concentrate on the areas of highest risk. Lower level risks could then be dealt with at project team meetings.



It may be useful for a client to have their risk register peer reviewed by an independent subject matter expert, to gain additional certainty that significant risks have been identified and managed appropriately. -

## Risk response feedback

To complete the cycle, feedback should be encouraged from all those involved in the delivery of the project on how well risks were managed, and how this could be improved. This information can be used to improve risk management performance in future projects. It should normally form part of the post project review.

The project execution plan should contain the risk register and risk management plan. This should:

- define acceptable levels of risk in the areas of quality, cost and time
- detail the risk reduction measures to be taken to contain risks within those levels
- outline cost-effective fall-back plans for implementing if and when specific risks materialise
- identify the resources to be deployed for managing risks
- explain the roles and responsibilities of all parties involved in risk management
- describe how risks are to be monitored

## Roles and responsibilities relating to risk

The SRO should have responsibility for overall risk management on the project. They should produce the risk management plan with the support of the project manager, independent client advisers, subject matter experts and the remainder of the project team, and monitor its implementation. They should review the risk management plan and individual risk treatment strategies throughout the life of the project and in particular at each major decision point in the project; the review should include risks transferred to other parties in the project team. A requirement for risk management should be incorporated in tender documentation arrangements, i.e. participation in risk workshops and ongoing risk identification and review.



### SRO RESPONSIBILITIES

SROs should ensure that risk is being addressed properly. They should:

- approve a project only where risk allocation and management have been clearly dealt with and where the delivery model fits the risk that the client intends to retain
- keep risk monitoring and management on the agenda of progress review meetings during the life of the project
- ensure that the risk analysis is revisited if project objectives or key assumptions change
- inform the investment decision maker if the client's risk exposure changes.

Before any financial commitment is made, the investment decision maker should also understand and accept the degree of risk to which the project exposes the client and be satisfied that appropriate risk management plan, risk treatment strategies and contingency are in place, as set out in the business case. Reporting to the investment decision maker should thereafter be on a highlight basis to show that the level of exposure remains acceptable (using summary reporting on Red, Amber and Green status of risk, for example, as described above). Reporting should also show that, before approval, the budget implications of any proposed major changes to the project have been identified and adequate provision made or sought.



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## 3. Value management in practice

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### Value management activities

Value management and value engineering should be carried out at regular stages in the project (see Figure 2). They can be used for any or all of the following:

- establishing what value means to the client in terms of business benefits and priorities
- identifying and agreeing business needs
- identifying and evaluating options (including delivery model options) for meeting business needs
- selecting and agreeing the best option to meet business needs (that is, confirming whether or not a project is required)
- defining clearly and agreeing the project objectives (through stakeholder buy-in)
- selecting and agreeing the best project option, drawing on the expertise of independent client advisers
- setting and weighting the selection and award criteria for the appointment of the supply team
- evaluating the supply teams' bids against the selection and award evaluation criteria
- refining the design to maximise value and eliminate waste and those aspects not directly related to meeting the project objectives
- identifying and selecting project options to deliver maximum benefit when budget is constrained.



A value management approach helps with decision making at all levels. The concept of value relies on the relationship between satisfying many differing needs and the resources used in doing so. The fewer resources used and the greater the satisfaction of needs, the greater the value. Stakeholders (including internal and external customers) may all hold differing views of what represents value. The aim of value management is to reconcile these differences and enable the client to achieve the greatest progress towards its stated goals with the use of minimum resources.

## The process

The SRO should ensure that a value management plan is drawn up and incorporated in the project execution plan. It should establish reviews at key stages:

- **Project inception** (before Gate 0): this review identifies the needs of the stakeholders and informs the decision on whether or not a project is required. Value management is the tool for strategic options appraisal and making a choice: do something/do nothing/maintain status quo. It should result in:
  - a description of the stakeholder needs and priorities
  - confirmation that a project is needed.
- **Options appraisal** (before Gate 1): this review identifies key priorities and constraints; it also identifies and examines possible solutions. It makes explicit the client's values and priorities, the project needs and objectives, and key project constraints and risks. It aims to eradicate the need for late changes. It should result in:
  - a description of the project – what has to be done to meet the objective and priorities
  - a statement of the primary objective
  - expected lifespan of the facility and projected payback period
  - ranking of project priorities
  - a preferred option for further development
  - a decision to proceed.

This balanced statement of need, objectives and priorities, agreed by all stakeholders, helps the SRO to produce the project brief.

- **Procurement strategy** (before Gate 2): to evaluate the available delivery model options and define the procurement strategy. This review should help ensure that the delivery model selected will meet the objectives set for the project. It should result in:
  - a clear statement of the processes to be provided and/or accommodated
  - a preferred delivery model and contract strategy
  - the basis of a case for the continuation of the project
  - value management in making choices between design options.
- **Output specification** (also before Gate 2): this review considers the output specification against the background of project needs, priorities and the objectives hierarchy developed at earlier reviews. It should result in:
  - a thorough evaluation of the output specification
  - clear recommendations for a response from an existing supply team or new external procurement
  - the basis of a submission for final approval to invite registrations of interest for tenders for the design and construction of the project where a new project is required.
- **Outline design**: to ensure that the required functionality and quality are confirmed before proceeding to detailed design.
- **Detailed design** (before approval for construction to begin): value engineering reviews of the design. These focus on the project team's expertise in improving buildability so that works are implemented faster, more efficiently and safely and at lower whole-life cost construction (after Decision Point 2 and before Gate 4), to resolve any issues on site as required.
- **In-use** (before Gate 5): to inform the ongoing management and operation of the facility.

Each of these reviews provides an additional opportunity to undertake concurrent risk assessments on the options under consideration.

The precise format and timing of reviews will vary according to circumstances. If there are too many, the design and construction process may be disrupted and delayed. If there are too few, the opportunities for improving definition and the effectiveness of design proposals may be lost.

Lessons should be captured and learned about particular approaches that improve speed of construction, reduce whole-life costs and/or improve value, including health and safety. For large or complex projects there may be a number of value engineering reviews, each focused on individual elements of the design. The usual way that value management is implemented is through structured workshops that are led by an independent facilitator.

Value engineering usually follows a job plan, which involves a series of steps that need to be followed in order to determine the most promising options or proposals:

- **Orientation/identification:** this involves the identification of the business problem, the customer needs and priorities.
- **Information:** this step involves the collection of information/data regarding values, costs, risks, programme and other project constraints.
- **Speculation generation:** this involves the generation of ideas to meet the needs and priorities previously identified. This is usually best undertaken via a workshop with all the stakeholders and project team members. The principle is that ideas are generated in a 'criticism-free' atmosphere, which promotes free-thinking and creative ideas.
- **Idea evaluation:** this step identifies the most promising options from the last stage.
- **Idea development:** the most promising options are developed and appraised. This may be undertaken by sub-groups of the workshop.
- **Recommendation/decision/implementation:** the results from the last stage are presented to the workshop group and a decision is made on which proposal to pursue. An action plan is prepared to take the proposal forward.
- **Feedback:** the success of the options implemented is assessed to provide lessons learned and inform future projects.



Contractors, consultants and suppliers can be invaluable sources of ideas during value management and value engineering processes. They are often involved in many projects that have experienced (and solved) similar issues, and may generally be more aware of advances in technology and good practices than the client.

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## 4. Appendix A: Contingency using quantitative risk analysis

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Quantitative risk analysis (QRA) forms part of the New Zealand Treasury Better Business Cases for Capital Proposals Toolkit(s). The Detailed Business Case within this toolkit defines QRA as ‘a modelling technique that makes risks, and the financial or time impact of those risks, more explicit to decision-makers.’ It enables better decision-making, based on information that is considered and representative of potential real-life outcomes.

When using the better business case (BBC) framework, QRA is a mandatory process for detailed business cases. This provides assurance that all key risks have been identified and are being managed accordingly. Even when not using the BBC framework, it is highly recommended that QRA is performed on complicated and/or high value construction projects.

Using QRA, the SRO understands the probabilities of different cost outcomes for the project. This probability information increases the accuracy of the project’s estimated cost, and is used to determine the project’s contingency budget – a figure which will be:

- a high percentage of budgets in the early stages of a project, and
- a lower percentage of budgets as the project progresses and design and market information is collected.

### Monte Carlo risk analysis

Monte Carlo risk analysis is a modelling technique that uses statistical sampling and probability to simulate potential real-life outcomes from the effects of uncertain variables. It can be used with cost or time inputs, to model outcomes. The approach provides an assessment of the likely combined effects of multiple risks on key variables within the estimate or programme. Take care with this type of analysis, to ensure risk relationships and correlations are modelled appropriately, and that the input values used truly reflect the potential values attributable to the risk or uncertainty. A poorly conceived or poorly developed quantitative risk model will provide poor and unreliable results.

### Risk-based cost estimating

A key objective for any programme of works is to complete:

- on time
- to budget, and
- to the necessary specification.

An estimate of costs is developed for each project. This estimate reflects:

- the level of detail available at the time of development – usually single-point values, plus
- a generic contingency – usually a fixed percentage of the total cost.

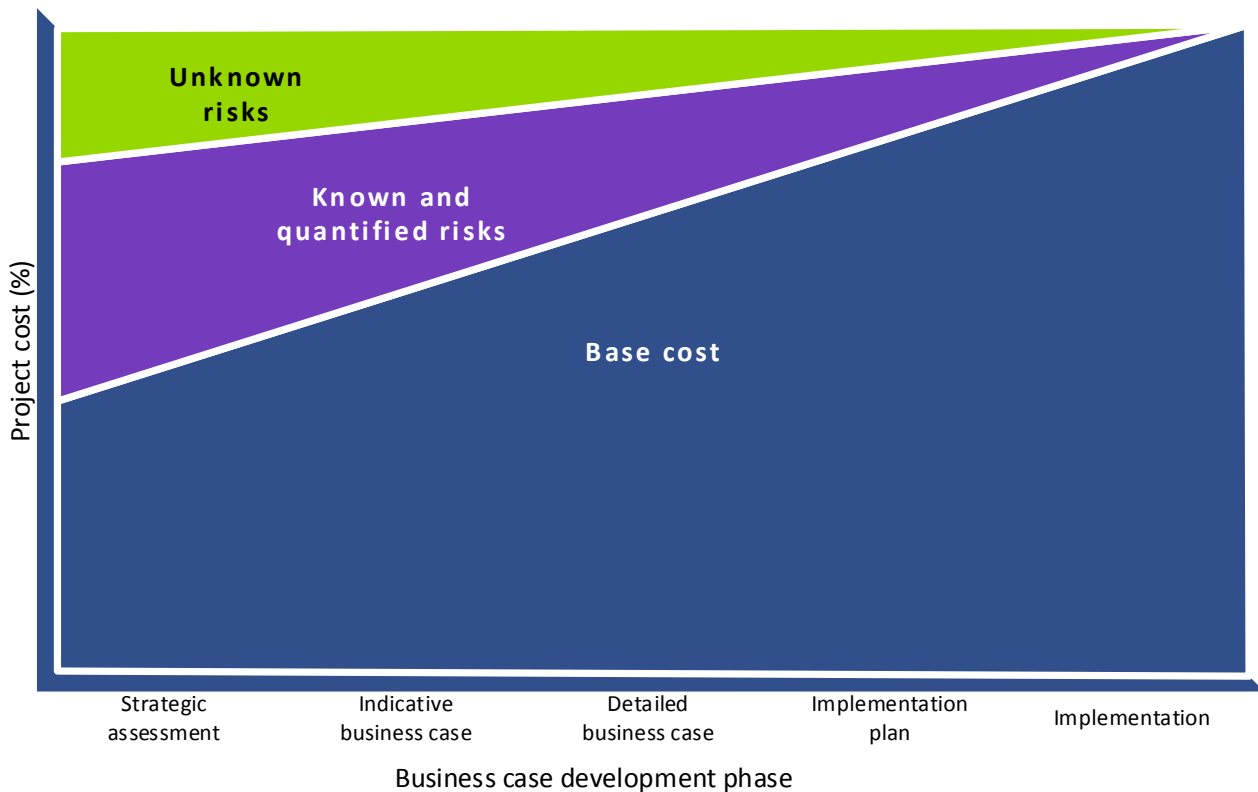
Historical and anecdotal evidence indicates these estimates tend to increase over time, as project scope changes or risks eventuate.

The theory and basis of risk based cost estimating involves assigning a cost value to each identified risk (i.e. those within the risk register), which can be challenged and interrogated through expert opinion or historical/sampled data. It recognises that more information becomes available and known as a project develops, and (conversely) as known information increases, unknown or uncertain items reduce. This more detailed view of potential sources of cost can then be quantitatively modelled to provide an overall level of contingency for the project.

The advanced approach to risk-based cost estimating uses probability values derived from Monte Carlo modelling techniques. For the purposes of a project, the organisation should define which P-values to use, for example: 'P50 = Expected Cost'. P values can only be derived with a Monte Carlo simulation.

The fundamentals to risk-based cost estimating are demonstrated in Figures 7 and 8 below.

**Figure 7 – Components of uncertainty through business case phases**



### Simplified approach to financial risk contingency

Financial risk contingency is characterised by and established through risk analysis of semi-quantitative data using expert interpretation.

The simplified approach uses semi-quantitative risk analysis techniques, which require:

- Identified risks from the risk register – both opportunities and threats
- The target probability of occurrence rating<sup>2</sup> – derived from the risk analysis, and
- The target financial consequence rating<sup>8</sup> – derived from the risk analysis undertaken.

This approach uses expert opinion to establish likely levels of financial contingency appropriate for the project items and identified risks.

<sup>2</sup> This information provides the boundaries of the risk analysis information. Expert interpretation is then used to refine this assessment for modelling purposes.

## Advanced approach to financial risk contingency

Financial risk contingency is characterised by and established through risk analysis of quantitative data using computer based modelling techniques.

The advanced approach uses quantitative risk analysis techniques which require:

- Identified risks from the risk register – both opportunities and threats
- The target probability of occurrence rating<sup>3</sup> – derived from the risk analysis
- The target financial consequence rating – derived from the risk analysis, and
- Variables of quantum and rate associated with measured items within the cost estimate.

It uses computer based modelling of Monte-Carlo simulation techniques. This simulation uses probability of occurrence, financial consequence values and probability distribution functions to statistically analyse potential real-life outcomes of the forecast out-turn cost<sup>4</sup> of the project.

The advanced approach to risk modelling includes:

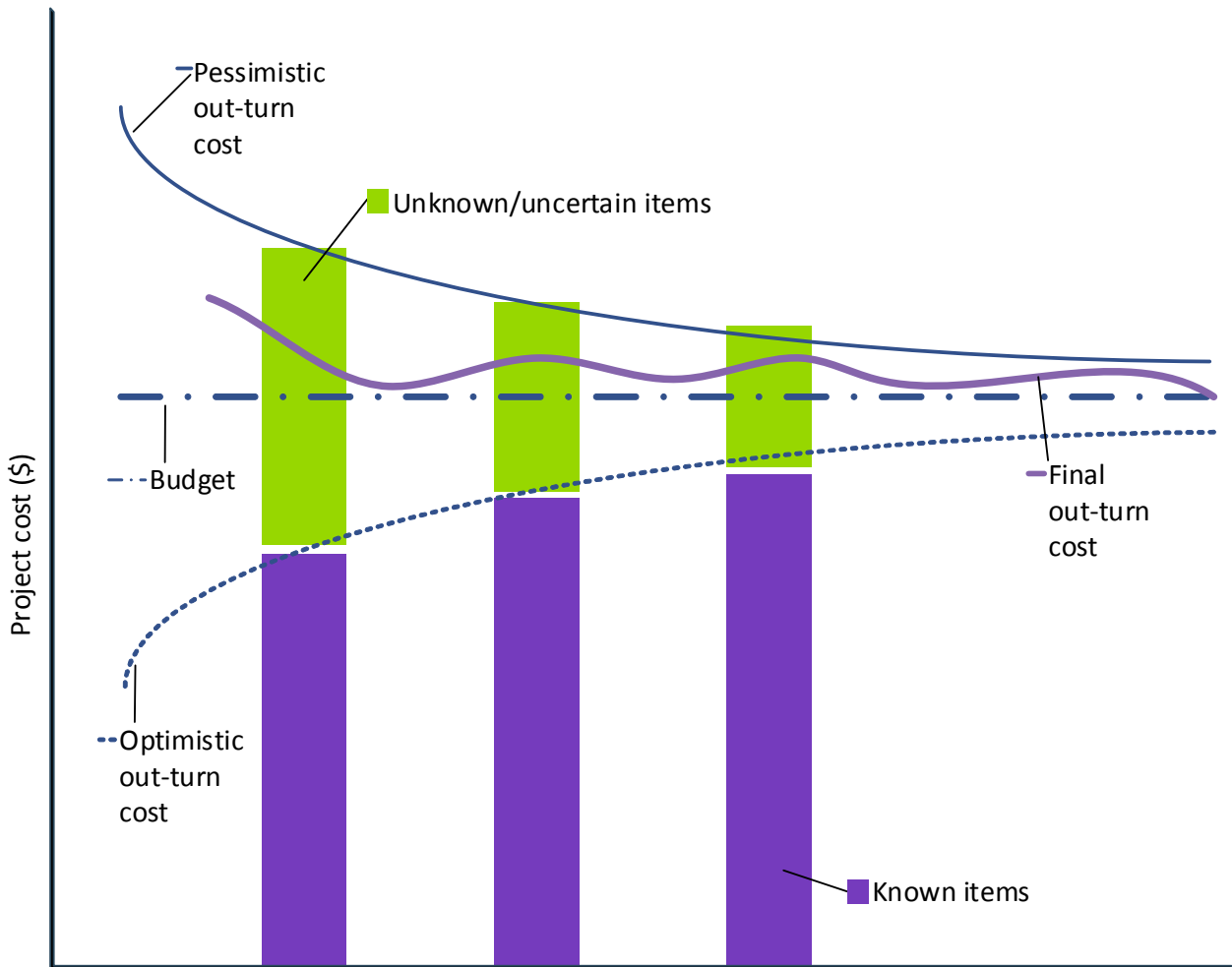
- Building the statistical model
- Defining probability distribution functions that allow potential real-life outcomes to be represented
- Simulating outcome distributions and histograms
- Outcome information such as graphs and tables that can be used and interpreted by decision-makers, and
- Explicit information that can be challenged.

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<sup>3</sup> This information provides the boundaries of the risk analysis information. Expert interpretation is then used to refine - this assessment for modelling purposes. -

<sup>4</sup> The cost of the project paid (by the client) at the completion of the project. -

**Figure 8:** Forecast final out-turn cost through development phases



## Risk Adjusted Programmes

Risk adjusted programmes (RAPs) are an analysis of a project programme that includes the scheduled task, its duration and potential variables to those duration(s) and identified risks (from the risk register) to provide the expected completion date (ECD) for a project or programme of works.

By allowing additional information of uncertainty and risk to be included in the programme tasks, we can produce more accurate and realistic plans. These provide the decision makers more information on duration and timing of project programmes. It helps with managing projects by effectively providing answers to questions such as:

- What is the chance of finishing on time?
- What chance do I have of completing the project by a given date?
- What tasks are most likely to cause project delay, and potentially by how much?

Risk analysis of a project programme requires these steps:

1. Create the project programme/task schedule.
2. Make assessment of tasks duration(s) and variables.
3. Identify discrete risks that potentially influence the programme tasks
4. Gather risk information such as optimistic and pessimistic durations and probability distributions
5. Simulate the programme duration using a Monte-Carlo approach.

### **Simplified approach risk adjusted programmes**

The simplified approach to risk adjusted programmes is characterised by and established through risk analysis of semi-quantitative data, using expert interpretation.

This approach uses semi-quantitative risk analysis techniques, which require:

- Identified risks from the risk register – both opportunities and threats
- The target time consequence rating – derived from the risk analysis
- The target probability of occurrence rating<sup>5</sup> – derived from the risk, and
- Variables of time associated with individual tasks

This approach uses expert opinion to establish the ECD associated to the programme of works.

### **Advanced approach risk adjusted programmes**

The advanced approach to risk adjusted programmes is characterised by and established through risk analysis of quantitative data, using computer based modelling techniques.

The advanced approach uses quantitative risk analysis techniques which require:

- Identified risks from the risk register – both opportunities and threats
- The target time consequence rating – derived from the risk analysis undertaken
- The target probability of occurrence rating<sup>6</sup> – derived from the risk analysis undertaken, and
- Variables of time associated with individual tasks.

It utilises computer based modelling of Monte Carlo simulation techniques. This simulation uses probability of occurrence, time impact values and probability distribution functions to statistically analyse potential real-life outcomes of the ECD associated to the programme of works.

The advanced approach to risk modelling includes:

- Building the statistical model
- Defining probability distribution functions that allow potential real-life outcomes to be represented
- Simulating outcome distributions and histograms
- Outcome information such as graphs and tables that decision-makers can use and interpret, and
- Explicit information that can be challenged.

### **Advantages of quantitative risk analysis**

Using quantitative risk analysis as a basis for cost estimation and programme scheduling can provide a number of advantages over traditional methods, including the following:

- Risk analysis changes the entire paradigm of how the project team thinks about and addresses project delivery. The process of building a risk analysis model encourages an open discussion about risks and uncertainty.
- Cost and time forecasts are not forced into the 'pigeon hole' of single point values. Instead, risk analysis recognizes that cost estimates and programmes are inherently uncertain. Traditional methods ignore or attempt to average out the risk and uncertainty.
- The process helps the project team to identify risk drivers that management should focus on, to reduce costs and time.

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<sup>5</sup> This information provides the boundaries of the risk analysis information, expert interpretation is then used to refine this assessment for modelling purposes

<sup>6</sup> This information provides the boundaries of the risk analysis information, expert interpretation is then used to refine this assessment for modelling purposes

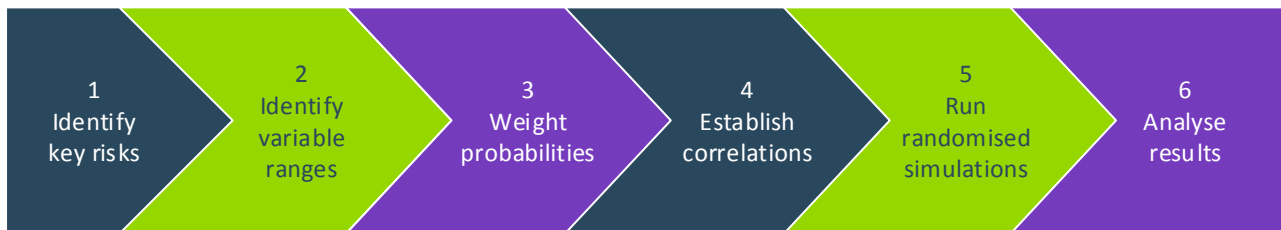


- It allows stakeholders to better understand the project’s risks, the probability of the actual costs being above the base estimate (or budget), and the completion date to move.
- Quantitative risk analysis models should be very transparent and have all assumptions clearly documented, to encourage acceptance by all stakeholders. This transparency also allows managers to identify areas that are the root causes for cost and time overrun (technical, political, optimism bias).
- Sensitivity analysis helps identify areas of the project that have most potential to cause uncertainty. These are therefore the areas of the project most likely to cause cost or time over-run, and are the areas where the project team should concentrate their risk management efforts.

## Monte Carlo Simulation: Steps

Monte Carlo simulations often involve highly complicated mathematical models or specialised computer software; for agencies that do not possess these capabilities/tools in-house, there are a number of consultants available who perform this type of work. MBIE will have a panel of providers (through the All-of-Government Consultancy Contract) available for agencies to use for this type of work.

**Figure 9 –Monte Carlo simulation process**



The series of steps normally followed in the Monte Carlo simulation are listed below:

1. - Identify the key project risks.
2. - Identify the range limits for these project variables (i.e. best and worst case scenarios for each).
3. - Specify probability weights for this range of values: how likely is the risk to occur, and how likely is the best case scenario compared to the worst case? Some commonly used probability distributions for analysing risks are normal, uniform, triangular and step distributions.
4. - Establish the relationships for the correlated variables. (If one risk influences the likelihood of another risk occurring, this needs to be noted.)
5. - Perform simulation runs based on the identified variables and the correlations. In order to generate a sufficiently random distribution, simulation runs may number in the thousands.
6. - Statistically analyse the results of the simulation run. A cumulative probability distribution of all the simulation runs is plotted and it can be used to interpret the probability for the result of the project being above or below a specific value. This cumulative probability distribution can be used to assess the overall project risk, or conversely the funding required in order to have a certain chance of successfully delivering a project – i.e. funding required to have a 95% chance of successfully delivering the project based on the known risks (P95).

## When to use Monte Carlo Simulation

MBIE and Treasury recommend using a quantitative risk assessment – a Monte Carlo simulation or other method, as appropriate – on any construction projects that meet one or more of the following criteria:

- Has many risks
- Has risks that are intrinsically linked (or complicated to understand/evaluate)
- Is technically complicated, innovative or is a type of structure that is built infrequently either by the client or the NZ market in general
- Has a total estimated whole-of-life value over NZ\$25M
- Requires a high degree of project cost and/or schedule certainty.

## 5. Appendix B: Further guidance

Originator	Code	Guidance document	Link
International Organization for Standardization (ISO)	ISO 31000:2009	Risk Management - Principles and Guidelines	<a href="http://www.iso.org/iso/home/standards/iso31000.htm">http://www.iso.org/iso/home/standards/iso31000.htm</a>
	IEC 31010:2009	Risk management — Risk assessment techniques	<a href="http://www.iso.org/iso/catalogue_detail?csnumber=51073">http://www.iso.org/iso/catalogue_detail?csnumber=51073</a>
Standards Australia (ASA)	AS4183:2007	Value Management	<a href="http://infostore.saiglobal.com/store/Details.aspx?ProductID=311952">http://infostore.saiglobal.com/store/Details.aspx?ProductID=311952</a>
Royal Institute of Chartered Surveyors	–	RICS draft guidance note – Value engineering and value management	<a href="https://consultations.rics.org/consult.ti/value_engineering/viewCompoundDoc?docid=863924">https://consultations.rics.org/consult.ti/value_engineering/viewCompoundDoc?docid=863924</a>
New Zealand Transport Authority (NZTA)	Z/44	Minimum Standard – Risk Management	<a href="https://www.nzta.govt.nz/assets/resources/minimum-standard-z-44-risk-management/docs/minimum-standard-z-44-risk-management.pdf">https://www.nzta.govt.nz/assets/resources/minimum-standard-z-44-risk-management/docs/minimum-standard-z-44-risk-management.pdf</a>
	SM014	Cost Estimation Manual	<a href="http://www.nzta.govt.nz/assets/resources/cost-estimation-manual/docs/cost-estimation-manual-sm014.pdf">http://www.nzta.govt.nz/assets/resources/cost-estimation-manual/docs/cost-estimation-manual-sm014.pdf</a>