Investing under uncertainty

Real options analysis technical supplement – Investment Lifecycle and High Value High Risk Guidelines

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**Contents**

[Background 1](#_Toc515617461)

[Context 1](#_Toc515617462)

[Purpose of this guideline 1](#_Toc515617463)

[Using the guideline 2](#_Toc515617464)

[1. Introduction 4](#_Toc515617467)

[For the majority of investments 5](#_Toc515617468)

[For those investments impacted by significant uncertainty 5](#_Toc515617469)

[2. Uncertainty in public sector infrastructure investment 5](#_Toc515617470)

[2.1 How does uncertainty impact public sector investment management? 5](#_Toc515617471)

[2.2 Difference between risk and uncertainty 7](#_Toc515617472)

[3. Dealing with uncertainty through flexibility in decision making – applying real options theory 9](#_Toc515617474)

[3.1 Limitations of traditional investment decision‑making approaches 9](#_Toc515617475)

[3.2 What are real options? 12](#_Toc515617476)

[3.3 Key elements of real options 15](#_Toc515617477)

[3.4 Types of real options 16](#_Toc515617478)

[3.5 How can real options add value to an investment? 20](#_Toc515617479)

[3.5.1 Identifying the problem to be addressed 20](#_Toc515617480)

[3.5.2 Delaying decision‑making until more detailed information is available 21](#_Toc515617481)

[3.5.3 Providing flexibility in investment strategies to allow Government to respond to prevailing conditions during project delivery 23](#_Toc515617482)

[3.5.4 Options that provide flexibility during the operational phase of an asset: Investing in infrastructure that is more resilient to change 25](#_Toc515617483)

[3.6 Linkages between real options, scenario analysis and adaptive management approaches 27](#_Toc515617484)

[3.7 Real options analysis tools 28](#_Toc515617485)

[3.7.1 Managerial real option tools are strategic, or qualitative, planning techniques that consider the outcomes of changing conditions on a project trajectory, and use this to inform decision‑making. 29](#_Toc515617486)

[3.7.2 Options valuation approaches are mathematical models that empirically estimate the monetary value of real options to an investment. 30](#_Toc515617487)

[3.8 When will real options analysis provide the greatest value? 31](#_Toc515617488)

[3.8.1 Potential additional benefits 33](#_Toc515617489)

[3.8.2 Potential disadvantages 36](#_Toc515617490)

[4. Applying real options analysis throughout the investment lifecycle 37](#_Toc515617491)

[4.1 Managing uncertainty across the investment lifecycle 37](#_Toc515617492)

[4.2 Stage 1: Conceptualise – Assessing when real options analysis may add value to a project 38](#_Toc515617493)

[4.2.1 Real options and the Investment Management Standard 39](#_Toc515617494)

[4.2.2 The real options triage 41](#_Toc515617495)

[4.2.3 Conceptualise summary 46](#_Toc515617496)

[4.3 Stage Two: Prove – Undertaking real options analysis and valuations 47](#_Toc515617497)

[4.3.1 Review and reconfirm the problem definition, benefits and strategic interventions 48](#_Toc515617498)

[4.3.2 Strategic real options in practice 49](#_Toc515617499)

[4.3.3 Cost benefits analysis and real options valuations 52](#_Toc515617500)

[4.3.4 Describing the recommended solution/preferred option 55](#_Toc515617501)

[4.3.5 Real options in the procurement analysis and strategy 56](#_Toc515617502)

[4.3.6 Governance and approvals 56](#_Toc515617503)

[4.3.7 Project management 57](#_Toc515617504)

[4.3.8 Prove summary 58](#_Toc515617505)

[4.4 Stage 3: Procure – Planning for implementing real options 59](#_Toc515617506)

[4.4.1 Cost considerations 61](#_Toc515617507)

[4.4.2 Probity and approvals 61](#_Toc515617508)

[4.4.3 Tendering documentation 62](#_Toc515617509)

[4.4.4 Contracting for the delivery of ‘real options’ 64](#_Toc515617510)

[4.4.5 Stage 3 Procure summary 64](#_Toc515617511)

[4.5 Stage 4: Implement – Implementing real options and dynamically responding to changing circumstances 64](#_Toc515617512)

[4.5.1 Some tips for implementing investments under uncertainty 65](#_Toc515617513)

[4.6 Stage 5: Realise – Measuring success and implementing real options 67](#_Toc515617514)

[4.6.1 In‑project real options 67](#_Toc515617515)

[4.6.2 Measuring benefits realised 68](#_Toc515617516)

[4.6.3 Measuring project delivery (on time and on budget) 69](#_Toc515617517)

[4.6.4 Capturing lessons learnt 69](#_Toc515617518)

[Glossary 71](#_Toc515617519)

[Appendix 1: Types of uncertainty 73](#_Toc515617520)

[Appendix 2: Case studies 75](#_Toc515617521)

[The Channel Tunnel 75](#_Toc515617522)

[Turning investment regret into success with timing options – technology projects 79](#_Toc515617529)

[Building in flexibility for re‑adaptive use – Olympic Games facilities 82](#_Toc515617534)

[Appendix 3: An overview of some real options tools and methodologies and their applications 88](#_Toc515617535)

[Financial options theory 88](#_Toc515617536)

[Decision analysis 89](#_Toc515617537)

[Numerical techniques 93](#_Toc515617538)

[Hybrid or integrated approach 95](#_Toc515617542)

[Tailored analysis 96](#_Toc515617543)

[Appendix 4: Further resources 97](#_Toc515617544)

[Appendix 5: Relationship between the Investment Management Standard and real options analysis 100](#_Toc515617553)

[Appendix 6: The decision‑maker’s checklist 102](#_Toc515617554)

[Appendix 7: Real options and procurement approaches 103](#_Toc515617555)

# Background

## Context

This guide is a technical supplement to the Investment Lifecycle and HVHR Guideline series (the lifecycle guidelines).

Each year, the Victorian Government is responsible for delivering a significant program of asset, infrastructure and information, communication and technology (ICT) investments to support ongoing service delivery. **Government is accountable to the public to ensure investments are successful: *that they achieve value for money, are delivered on time and to budget; and deliver the desired benefits to Victorian communities.***

The lifecycle guidelines support Victorian Government agencies to develop and deliver investments. They provide good practice guidance and tools to help shape proposals and business cases, inform investment decisions and support projects through procurement and delivery. They aim to improve the likelihood of achieving investment success and realising the desired benefits.

The lifecycle guidelines address five key stages of the investment lifecycle, as outlined in Figure 1:

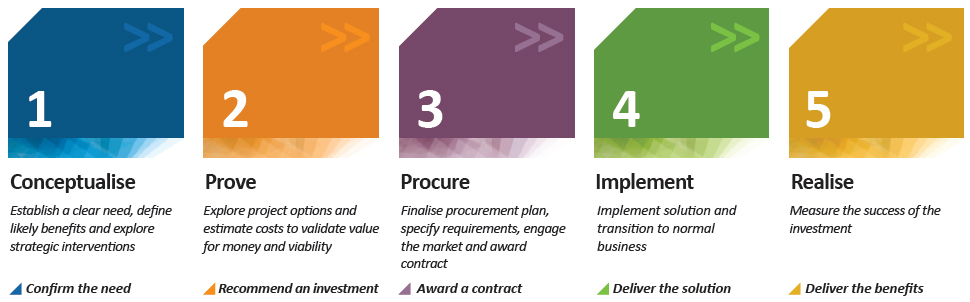


Figure : The investment lifecycle

## Purpose of this guideline

This technical supplement to the lifecycle guidelines provides useful methods and processes to assist agencies successfully manage asset investments impacted by uncertainty.

This guide has a dual purpose, addressed in two distinct parts:

* The first part (Chapters 1–3) presents a theoretical overview of what uncertainty is and how it can impact Government infrastructure investments. It considers how to deal effectively with uncertainty in infrastructure investments, presenting some limitations of traditional decision‑making tools. In particular, it explains real options theory and its application to infrastructure delivery as both a strategic planning tool and an economic evaluation technique.

Real options analysis is an investment evaluation and decision‑making framework. It enables investors to recognise the value of flexibility in project design and to incorporate flexible approaches to better manage projects that are significantly impacted by uncertainty.

This first section largely focuses on proposal evaluation and decision‑making processes. This early planning stage of an investment offers the greatest opportunity to consider uncertainty, shape the investment strategy and influence outcomes.

* The second part (*Chapter 4*) presents a practical guide for considering uncertainty, and applying real options theory and methodologies to infrastructure projects at each stage of the investment lifecycle. This part can be read as a stand‑alone document.

## Using the guideline

### When should I use this guideline?

This guideline may support activities undertaken at **all stages of the investment lifecycle** as uncertainty can impact all aspects of infrastructure development and delivery through to asset operation.

### Who should use this guideline?

|  |  |  |
| --- | --- | --- |
| Your function | Your responsibility | The guideline can help you: |
| **Investor/Senior Responsible Owner (SRO)** | Directing an investment through its development and delivery, approving/recommending changes to budget, time and scope where necessary.  Leading project governance activities.  Delivering the project benefits, managing an asset through its operational life and achieving ongoing service delivery requirements. | * Identify potential uncertainty impacting your project, including the trigger points that indicate when a different action may be required. * Identify strategies to allow you to respond flexibly to uncertainty realised during project delivery and/or the asset’s operational life. * Exercise actions to allow you to respond advantageously to any changing conditions. * Manage stakeholder expectations regarding project delivery and exercising options. |
| **Business case writer** | Planning and developing a full business case for investments of all sizes and types. | * Understand real options analysis and associated real options valuation techniques, and manage consultancies to develop real options analysis. * Cost and analyse options incorporating real options analysis where required. * Build real options trigger points and strategic planning requirements into project plan and procurement strategy. |
| **Project/Program Delivery Team** | Manage an investment through delivery within approved budget, time and scope parameters. | * Reflect real options requirements in project planning, procurement and contract documentation. * Consider real options requirements in tender assessment, decision‑making processes and contract negotiations. * Manage investment delivery through uncertainty, monitoring conditions and triggers, and using approved options to respond advantageously to changing circumstances. * Ensure the value of real options identified in the business case is realised, as appropriate. |
| **Central agency analysts** | Support agencies develop robust investment proposals, and advise Government on their policy merit and deliverability.  Support agencies procure and deliver investments. | * Ensure business cases consider uncertainty and incorporate opportunities to respond flexibly to changing investment circumstances. * Ensure any comparisons of competing investment/project designs deal with the differences in flexibility offered to respond to changing investment circumstances. * Assess any real options valuations incorporated into project cost‑benefit analysis. * Support the SRO and project governance board to consider and exercise any strategic actions or real options, as necessary and to manage stakeholder expectations. |

Table : Who should use the real options guideline?

The tools and techniques presented here are not compliance requirements, and should be scaled to the needs and complexity of the investment.

* + 1. Introduction

When Government decides to undertake an investment, it typically commits to achieving a set of desired benefits by delivering a defined project scope within a pre‑determined budget and timeframe. However, investments are vulnerable to a spectrum of factors that are beyond an investor’s control and can impact the decision to commit to, and deliver, intended investment outcomes and the value delivered by those outcomes.

These uncertainties can have a profound impact on an investment strategy: an investment approach that is considered appropriate under one set of market conditions may become infeasible or undeliverable if circumstances change. An investment strategy may prevent Government from taking up opportunities that arise from changing market conditions, or result in regret if hindsight shows a different course of action would have been preferable. As some infrastructure investments are irreversible (e.g. cancelling or abandoning an investment mid‑course may be almost as costly as finishing a project), effectively dealing with uncertainty may be an important determinant of investment success.

As these uncertainties are generally outside the investor’s control, they may not be able to be managed or ameliorated by the project team.[[1]](#footnote-1) Instead, Government may need to develop flexible investment strategies that anticipate, and can proactively respond to, credible future circumstances and/or our knowledge of those circumstances.

Traditional investment decision‑making approaches commonly limit the consideration of deviations from the original project plan. If an investment is subject to uncertainties, pursuing a flexible investment strategy will almost always be better value for money than pursuing a plan based on assumed future conditions.

This guide considers ways in which agencies can better incorporate flexibility and resilience into their decision‑making processes and investment strategies to enable Government to better respond to uncertainty and change – during the procurement and delivery of infrastructure as well as throughout the asset’s operational life. In particular, it examines how real options analysis can be used to augment traditional investment planning and evaluation approaches.

Real options analysis is an investment evaluation and decision‑making framework that builds on the traditional cost‑benefit framework. It encourages and guides practitioners to embed flexibility into an investment strategy to better structure and manage projects impacted by uncertainty. It incorporates a broad range of methodologies and tools that vary in purpose and complexity, and can be deployed to best suit the requirements of a particular investment.

This guide outlines ways in which real options thinking can be applied to any asset investment, regardless of size or complexity, to better future proof Government’s investments.

## For the majority of investments

It provides practical tools to help agencies apply qualitative or strategic *real options thinking* to a broad range of investments, and to more consistently consider and address uncertainty through all stages of an investment’s lifecycle.

## For those investments impacted by significant uncertainty

It provides a range of resources to help agencies undertake quantitative real options analyses and valuations where warranted. There are a number of mathematical approaches that can be used to undertake real options valuations. Some of these are relatively simple to apply and some are at the more technical end of the spectrum. Staff or consultants with specific technical capabilities may be best suited to undertake these analyses. This guide presents some examples to show how these techniques can be applied. However, the key focus of this guide is on identifying those projects that may benefit from real options valuations to augment business cases, and providing case studies to show how real options thinking and analyses can be applied.

* + 1. Uncertainty in public sector infrastructure investment
       1. How does uncertainty impact public sector investment management?

Government investments are vulnerable to a spectrum of factors that we cannot control and that can impact our preferred investment strategy.

Factors that can impact our decision to commit to, and deliver, a preferred investment strategy are called uncertainties.

Uncertainties differ from risks in that, if they have not been considered in framing a proposal, they cannot be effectively mitigated or ameliorated after committing to the project. They can impact our ability to achieve the intended investment benefits, and therefore influence the preferred investment strategy. See Chapter 2.2 for further information on risk versus uncertainty.

Uncertainties can arise from changes to a range of factors. *Appendix 1* *– Types of Uncertainty* considers some common causes of uncertainty.

If uncertainties arise after Government has committed to a particular investment, they can change the market conditions and investment environment. They can impact the:

* + - **demand** for a service, altering the community need and therefore the nature and extent of the problem; and/or
    - **supply** of a solution, impacting the market’s capability and capacity to deliver the required project scope, achieve time, budget and value‑for‑money constraints, and realise the desired benefits and outcomes.

Uncertainties relate to a range of factors, including:

* demographics
* socio‑economic conditions
* environmental factors, particularly climate change
* policy, legislative and legal controls
* technology changes

Uncertainties can lead to unfavourable conditions that present threats to delivering an investment strategy or to the value gained by delivering the strategy. They can also create favourable conditions that present opportunities for achieving cost/time savings, greater value for money outcomes or enhanced benefits realisation that could not have been reasonably assumed at the business case stage.

These changes to demand and supply forces can profoundly impact an investment strategy’s feasibility. Investment options that are preferred and would be successful under one set of conditions can become unviable (inappropriate, undeliverable or unaffordable) if circumstances change.

For example:

* + - Increases in service need, well above those assumed in the planning phase, can result in the delivery of an asset that does not meet capacity, and/or possibly does not have the flexibility for cost‑effective retrofitting to provide the additional capacity.
    - Decreases in service need, well below those assumed in the planning phase, can lead to asset obsolescence and/or higher than necessary operating costs, accompanied by perceptions of over‑investment or inappropriate investment. A lack of flexibility may not allow the asset to be cost‑effectively redirected to other uses.
    - Changes to preferred service delivery models and methods can result in unsuitable assets that do not meet user needs and expectations, and may delay introduction of the preferred service delivery models and methods for many years.
    - Changes in market capacity and capability can impact Government’s ability to deliver its investment program effectively and meet its service delivery requirements.

In hindsight a different strategy (even a ‘do nothing’ option) may have resulted in a better outcome, leading to ‘regret’ that we didn’t ‘wait and see’ or that things were not done differently. In some instances, Government may take corrective action to complete the investment at significant cost, time delay and/or political risk. In other instances, Government may fail entirely to deliver the intended benefits. Uncertainty is therefore one of the most influential determinants of investment success or failure.

As they are outside the investor’s control, the project team cannot directly manage or ameliorate uncertainties. Therefore, Government must be prepared to *adapt its investment strategy* to effectively deal with uncertainty and change.

To successfully deliver investments within highly uncertain conditions, Government typically needs flexible and resilient investment strategies that anticipate or identify when change may impact an initiative and allow them to respond advantageously to prevailing conditions.

This may be as simple as avoiding some uncertainty by waiting to take action when there is greater certainty on future market conditions or technology, or staging decision‑making rather than locking in all the decisions at the start. It could also include techniques to respond to change during project delivery, such as: creating financial buffers to absorb impacts; shifting impacts to other project partners; minimising Government’s obligations under unfavourable conditions; providing the ability to exit from unproductive pathways cost‑effectively; or leveraging opportunities that may arise. It could further involve future proofing assets to be more resilient to change during their operational life. This may lead to higher costs under expected market conditions and technology, but greater value for money if market conditions and technology are not as expected.

Dealing with uncertainty is particularly challenging for Government agencies involved in delivering major asset investments. These investments are commonly delivered within an uncertain operational and political environment where the users’ needs are constantly evolving. The costs involved are typically high, and aborting a project may be nearly as costly as finishing its implementation.

One of the greatest challenges governments face is to balance the impetus to act immediately in response to media and stakeholder concerns, with the need to act with certainty. Governments are often compelled to invest in a problem without complete certainty or knowledge as they may be criticised for inaction. They may also need to invest in service delivery where there is no current, or even reliably foreseeable, demand, but where the investment will provide insurance against a potential catastrophic event.

‘In our experience, truly agile organizations, paradoxically, learn to be both stable (resilient, reliable, and efficient) and dynamic (fast, nimble, and adaptive). To master this paradox, companies must design structures, governance arrangements, and processes with a relatively unchanging set of core elements – a fixed backbone. At the same time, they must also create looser, more dynamic elements that can be adapted quickly to new challenges and opportunities.’

*‘McKinsey on Organisation: Agility and Organisation Design’, May 2016*

* + - 1. Difference between risk and uncertainty

**Risk** and **uncertainty** are both present in investment delivery. They can both impact project parameters and influence project success. However, while the terms are sometimes used interchangeably, they are different concepts and impact investments in different ways. In this framework, risks and uncertainties require fundamentally different treatments, and therefore we cannot consider and plan for uncertainties using the same tools as risks.

**Risk*[[2]](#footnote-2)*** is a (usually known) event that presents a variance (either positive or negative) from an expected outcome but would not change the desired investment strategy. Risks usually apply to the delivery of a project. If realised, they can impact our ability to complete a project within assumed or approved investment parameters (cost, time, scope). Practitioners can usually estimate the probability of a risk occurring, and their resulting impact(s), with some degree of confidence. Importantly, they are inside the project team’s control to manage and mitigate; practitioners will employ treatments to minimise their impacts on the investment parameters, while still seeking to achieve the defined or approved scope and expected benefits.

In comparison, **uncertainty** is a plausible event or change in conditions that can influence market characteristics (demand and supply). It can invalidate investment assumptions and lead to a ‘future state’ that is different to that assumed during proposal development. Uncertainties are usually associated with the outcomes of a project, including the value of those outcomes when achieved. They can influence the continued need for an investment (or problem), impacting our ability to realise the intended benefits. They are usually factors outside the project team’s control. To deal with uncertainty effectively, the project team may need to adapt its response strategy. Table 2 outlines common examples of risks and uncertainties.

|  |  |
| --- | --- |
| Risks | Uncertainties |
| Forecasts (e.g. of population, economic growth, climate change, transport demand, commodity prices) within expected range | Forecasts (e.g. of population, economic growth, climate change and transport demand) outside expected range |
| Design risks relating to project scope | Future economic conditions such as the comparative strength of the Australian dollar outside expected range |
| Due diligence risks, such as the discovery of environmental hazards, such as soil contamination, asbestos, etc., within expectations | Technological advancements or market disruptions |
| Stakeholder management issues | Future legislative, legal or policy changes at a State or Commonwealth level |
| Loss of key project staff | Conditional outcomes in interdependent investment projects |

Table : Common examples of risks versus uncertainties.

Previously, investment management guidance often considered uncertainty as a subset of risk. Practitioners were encouraged to use risk management treatments to manage the impacts of uncertainty on an investment.

* + - * 1. Why can’t we incorporate uncertainties into our risk matrix?

This is a good question, and is fundamental to changing how we think about – and respond to – any uncertainty impacting on our investments.

Risks and uncertainties require fundamentally different treatments, and therefore we cannot consider and plan for uncertainties using the same tools as risks.

A typical risk matrix will identify project risks, assess their likelihood of occurring and likely impact, and suggest a course of action to address the risks if they eventuate. A successful risk mitigation strategy will result in the risk being managed so its impacts on the project are reduced or ameliorated. The risk may have some impact on time, cost and scope parameters, but essentially the project will proceed unchanged, seeking to deliver the intended benefits from an unchanged service offering.

However, uncertainties are events or conditions, primarily driven by factors outside our control to manage. If an uncertainty resolves in an alternative future state that has a material unexpected impact (i.e. if an uncertainty is realised on a project), we will not seek to manage or mitigate its impact on the base case project, but rather adapt our investment strategy to respond favourably to the new conditions in the alternative future state. A successful strategy to deal with uncertainty will be flexible so a decision can be made to cost effectively change the investment strategy’s course, putting it on a pathway to achieve a potentially different outcome or scope altogether.

Text Box 1: Risk mitigation strategies versus tools for considering uncertainty

* + 1. Dealing with uncertainty through flexibility in decision making – applying real options theory
       1. Limitations of traditional investment decision‑making approaches

Investment decision‑making in the Victorian Government is normally supported by developing an *economic assessment* for a given investment proposal. A proposal appraisal involves identifying, calculating, and comparing the costs and benefits of a proposal to evaluate its merit, either absolutely or in comparison with other options (including ‘business as usual’). It starts by clearly articulating the role of the project in addressing key service delivery challenges. It also requires the full exploration of reform and investment options to address these problems to ensure that the preferred project solution provides the best return for scarce resources.

**Cost‑benefit analysis (CBA[[3]](#footnote-3)) is the primary and preferred economic assessment tool used in the Victorian Government** to inform major public expenditure and regulatory decisions. It is a rigorous, transparent, quantitative method that measures the degree to which individual projects generate net benefits, and allows comparison and ranking of options and projects. It is used to determine whether a proposal offers net benefit to society or if an alternate proposal provides greater net benefit. The expected benefits and costs are then used to calculate the net present value (NPV), the benefit‑cost ratio (BCR) and internal rate of return (IRR) of proposals.

When developing a CBA for an investment proposal, practitioners are often required to value costs and benefits that are not known with certainty, known as ‘expected’ impacts. CBAtechniques effectively consider risk by calculating the expected benefits and expected costs of a proposal, using probability weighted estimates. Risk consideration can be extended through sensitivity analysis, which considers how different assumptions or values for key variables, such as discount rates, affect the value of a proposal. This allows investors to make informed decisions about whether the preferred option would still be worthwhile pursuing if an outcome subject to risk were to eventuate.

However, this traditional CBA approach does not account for the potential impacts of uncertainty on a proposal or the value inherent in being able to respond flexibly to changing conditions.[[4]](#footnote-4)

Traditional CBA and NPV analysis typically makes some fundamental assumptions, including that:

* + - the investment is now or never;
    - the objective is to deliver the approved scope (even as the ‘world’ changes around it); and
    - we account for project risks upfront.

This commonly results in Government committing to an ‘all or nothing’ decision to achieve a set of desired benefits by delivering a defined project scope within a pre‑determined budget and timeframe. There is generally limited opportunity to modify the investment parameters once a project has commenced. If uncertainty eventuates, Government may not have sufficient flexibility to adapt its investment strategy to effectively deal with prevailing conditions, without significantly impacting on project parameters.

By ignoring the value of uncertainty and flexibility in decision making, conventional CBA can introduce bias towards projects that will offer decreased value for money over the long term. For example, traditional CBA and discounted cash flow (DCF) analysis rely on the principle that an investment should generally be funded if the NPV of its future net benefits, under the central assumptions made, is positive. In other words, if it will create more value than it will cost, and offer the highest net benefits of the scenarios considered. The choice of scenarios considered is key in this assessment.

This principle may be relaxed if sensitivity analysis indicates an unacceptable ‘worst case scenario’. However, the choice of scenarios is rarely expanded to include scenarios that provide flexibility to accommodate change, but with lower net benefits under central assumptions.

Traditional CBA can work well if we are projecting future costs and benefits from some historical context, and we are fairly certain of future trends, or the net benefit is similar across the range of uncertainty attached to those future trends. It is not as useful when our estimates of future costs and benefits are based on multiple assumptions about what the future state is likely to look like, and they are difficult to accurately forecast, or where the net benefits change across the range of uncertainty attached to those multiple assumptions. CBA analysis can also lead to an unconscious bias away from non‑deterministic solutions toward familiar and previously successful approaches to solving a problem. In these circumstances, this can prove to be misleading, and prompt investors to reject highly promising, if uncertain, projects.

The traditional CBA approach is an appropriate and effective tool in many instances. However to support Government develop and deliver investment strategies appropriate for the prevailing uncertainties, practitioners need a set of additional appraisal tools and techniques that allow them to develop and build the case for investment strategies that are more flexible and resilient to changing conditions.

Real options analysis is an investment evaluation and decision‑making framework that specifically recognises uncertainty, and the value of managerial flexibility to enable investors to respond to it favourably. It can support Government develop infrastructure investment strategies that are adaptable and better meet evolving community needs.

It can enable Government to limit its obligations under unfavourable circumstances and to acquire greater, more cost‑effective, access to opportunities, essentially ‘insuring’ investments against unforeseen change. It will generally deliver a different outcome from that anticipated in the business case under its central assumptions[[5]](#footnote-5), but can provide an improved value‑for‑money outcome given prevailing circumstances.

When undertaking traditional NPV analysis, we set a range of assumptions that together define a future state we think is the most likely scenario (central assumptions). We then commit to delivering a project solution that anticipates this particular set of conditions.

But what if those central assumptions do not hold?

There are any number of factors that can alter the future state, and this can lead to our proposed solution becoming suboptimal or even entirely regretted.

Real options analysis allows practitioners to consider multiple alternative future states when developing a business case. In doing so, it allows practitioners to consider a number of alternative project trajectories or investment strategies that would suit different conditions, and can help us visualise the most appropriate courses of action to take in each scenario.

Text Box 2: Using real options analysis to improve traditional CBA

A real options approach is consistent with a cost‑benefit framework. It is an approach for identifying and comparing alternative responses to a problem in a way that will deliver the best value for money. It embeds the usual principle of seeking to ensure benefits exceed costs, and ideally by more than is offered by any alternative.

Real options analysis can augment and extend traditional NPV and CBA analysis by providing a set of analytical tools that enable decision makers to consider the value of having managerial flexibility: that is, the value added to projects by allowing practitioners to respond to changing circumstances, optimise the opportunities of an investment over its lifecycle and mitigate any downside risks. In this way, a project’s total value can be considered as the sum of the NPV and real options value (ROV):

|  |  |
| --- | --- |
| **Total project value (TPV)** | **= NPV + ROV** |
|  | **= Net value given central assumptions** |
|  | **+ Net value of flexibility to adjust to changes in central assumptions[[6]](#footnote-6)** |

The NPV captures a base estimate of value under quite specific and often questionable central assumptions; the option valuation adds in the value of having the flexibility to deal with departures from those central assumptions. The proportion of a project’s total value contributed by each component will vary according to the degree of uncertainty associated with the project.

In the early stages of an innovative project, the value of the CBA component will sometimes be low because of the need to use a high discount rate to adjust for the uncertain nature of future cash flows. At the same time, the ROV will most likely be high due to that same uncertainty. As project certainty increases over time, the value of the real option(s) will decrease.

This approach enables investors to consider the potential value of proposals impacted by a high degree of uncertainty, which is lost through the typically biased CBA valuation, while still protecting against the considerable risks of pursuing highly uncertain projects. It can be used to address some of the recognised limitations in the conventional use of CBA.

* + - 1. What are real options?

A real option is the right, but not the obligation, for an investor to undertake certain actions in the future to alter a project pathway (scope) when uncertainty impacts current project scope.

Real options:

* + - **relate to tangible assets:** They are called ‘real’ options because they generally relate to physical assets (differentiating them from traditional financial options that relate to the treatment of financial investments such as stocks);
    - **provide an ability to undertake an action, but no obligation to do so:** A real option provides the investor with the capability to take a specific action in the future. However, there is no obligation to take the action if it would be unsuitable to do so given the prevailing conditions at the time; and
    - **are defined in advance, which gives them value:** real options are distinguished from ‘choices’ or ‘alternatives’ by being defined in advance (often via a contract). It is the flexibility that is derived from investing to enable action to be taken cost effectively, and pre‑defining the action, that gives the option value.

Real options analysis arose as a formal economic valuation technique in the 1970s from the application of *option pricing theory[[7]](#footnote-7)* to the valuation of non‑financial assets. Prior to formalising the discipline as a valuation technique, the principles of real options were often intuitively and strategically applied to a range of investments. Early examples of using real options analysis included incorporating flexibility into an asset investment intuitively through feasibility studies, strategic planning and design engineering.

|  |  |
| --- | --- |
| An example of the intuitive application of real options thinking prior to it being identified as a formal investment planning discipline is the Tagus River bridge in Portugal. The bridge’s design, constructed in 1966, constituted a single‑deck four‑lane road. The design and construction incorporated a stronger structure that would support future expansion. | [Targus River bridge, Portugal](http://www.google.com.au/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwixif3dg8DQAhWHTbwKHc-PA2cQjRwIBw&url=http://boasnoticias.pt/mobile/noticias.php?id%3D24802&psig=AFQjCNFw96TzamtiT4r4gX40RhbhYGVIjw&ust=1480030042443251) |
| By 1993, traffic rates had increased to the point that it was attractive to exercise the option to expand to add two road lanes and a railroad deck. The incorporation of a ‘real option’ into the initial design allowed the business case to consider expansion without more costly structural changes.  Lesson: business cases could cost options that would allow for future incremental expansion at cheaper rates when demand is likely to present a future issue. | |

Text Box 3: Example of the intuitive application of real options analysis – Tagus River Bridge

Real options analysis has been widely and effectively used in mining, energy, natural resources, land development, manufacturing, defence, and research and development sectors. For example, there is substantial evidence of both companies and developers using real options to inform them of the optimal time(s) to buy and hold resource rights or land, and to either take the option (mine or develop the land) or sell the asset. There are also examples of manufacturers using real options analysis to consider the optimal time to increase or scale down operations, and even switch to different types of outputs to meet changing demands.

Although there is significant opportunity to apply real options analysis to infrastructure investment, its application to this field has been gradual. The construction industry has traditionally been loss‑averse, motivating investors and contractors to agree and lock in project targets such as cost, time and quality upfront, and discouraging a decision‑making environment that would promote real options thinking. This has not eliminated risk but rather shifted its incidence to after the delivery phase. The project may well be delivered but unable to justify its costs through the operational phase.

Real options methods have been used in Australia, including for major infrastructure projects: in response to the millennial drought; across major research and development (R&D) portfolio investments, including those of CSIRO, various R&D Corporations and Cooperative Research Centres (CRCs); in the planning of major collaborations in research infrastructure (such as the Square Kilometre Array radio telescope project[[8]](#footnote-8)); in the planning of major educational infrastructure; and in relation to a range of transport planning processes.

Text Box 4 presents some examples where real options analysis has informed Victorian Government investments.

Real options already feature in several completed and ongoing investments.

* In 2014, the former government considered investing in the construction of a heavy rail link from the Avalon airport to the existing track between Melbourne and Geelong. The investment decision was deferred on the basis that the number of flights was too low to justify building the link at that time. However, a preferred rail route was identified and protected, meaning the option to invest is available to government if demand increases sufficiently to warrant this action.
* The Department of Justice and Regulation has recently delivered a new medium‑security prison facility, known as the Ravenhall Corrections Centre. The facility accommodates 1,000 prisoners, however its design has incorporated the built capacity for 1,300 beds to meet future demand.
* The Victorian Government awarded a contract to the Village Park Consortium (VPC), a joint venture between Citta Property Group and Australand Holdings Ltd, to build the 2006 Commonwealth Games Athletes Village. The successful solution required VPC to provide athletes’ accommodation and ‘back of house’ needs for 6,000 athletes and officials. The facility required a flexible design so it could provide the required services for the duration of the Commonwealth Games, but could also be cost‑effectively adapted post‑Games to meet future service needs

Text Box 4: Victorian Government examples of Real Options*[[9]](#footnote-9)* *[[10]](#footnote-10)* *[[11]](#footnote-11)*

* + - 1. Key elements of real options

The design of an option compares one or more alternative strategies that may be used in the future to a reference strategy that is committed to in the present.

It allows an investor to undertake a *pre‑defined action* (‘exercising an option’) often at a *pre‑determined cost* (‘exercise price’), over a *period of time* (the life of an option).

To exercise an option, conditions are monitored. When conditions that signify the trigger are observed, the investor can decide whether to abandon the reference strategy and adopt the alternative strategy (to ‘exercise’ the option) or to keep using the reference strategy.

**Key elements of a real option include**:

* **Option costs**: costs associated with creating the flexibility to change the investment strategy and then maintaining effective access to the option;
* **Exercise cost**: the cost to exercise the option;
* **Life of an option**: the time until the option is no longer valid or available; and
* **Exercise trigger (or exercise signal)**: the conditions that define or signal when a real option should be exercised.

**Example: New technology**

Consider a project that develops two technologies to fulfil a need: a reference technology and an alternative. If at any time during project delivery the alternative solution becomes more attractive, the project may, but does not have to, switch from the default or reference technology to the alternative:

* The cost of retaining the flexibility to switch to the alternative technology is the option cost.
* The ability to switch to an alternative strategy is the type of action allowed.
* Switching to the alternative technology is exercising an option and incurs an ‘exercise price’ to implement.
* The circumstances leading to the alternative becoming more favourable than the reference strategy is the exercise trigger.

The outcome has an improved real‑life total net benefit as opposed to developing the reference technology only. The optimal switch point could not have been determined at project initiation.

Text Box 5: Elements of a real option

In the face of uncertainty, each solution option may be implemented in different ways to respond to the uncertainty. Therefore, each solution option might have a number of investment trajectories (a single sequence of specific decisions and chance events). Each end point investment trajectory is a real option. For each solution option, therefore, there will be a family of real options attached. The way the uncertainty resolves itself at each decision point (called a trigger point) will determine which pathway is taken. Each investment trajectory might have a number of trigger points. The pathway taken at each trigger point is the one most appropriate to the changed circumstances, and retains the flexibility that may be required in choosing subsequent pathways.

Ideally, the use of real options, with well‑defined trigger points, is planned at the business case stage and, if approved, is documented as the investor’s options and/or ‘break points’ in the project contract. Real options are exercised in real time, before or during project delivery or during the operational phase, as events unfold and further information becomes available. The application of real options becomes increasingly problematic if trigger points are open‑ended or are not agreed by all stakeholders and suppliers.

* + - 1. Types of real options

We can describe real options along several dimensions. They are most commonly categorised according to type of managerial action they enable.

There are five primary types of real option actions: timing, scale change, switching, abandon and design options. These are described in the following table, and will ordinarily be exercised following Government consideration and approval.

|  |  |  |
| --- | --- | --- |
| Real option category | Description of real option | Example of real option |
| **Timing options** | Delaying or staging investment until there is greater certainty |  |
| **Option to defer or delay before commencing or committing to the investment** | An investment may be deferred for a period of time without relinquishing the right to invest in the project. The investor is free to choose the optimal time to start the project given the information known about the uncertainties, and their likely impact on the project’s net benefits. This option is often used to wait and see if input/output prices justify developing and/or operating a capital project. Deferral is not always costless – the investor may need to make a smaller investment to maintain this flexibility. However, the value of greater flexibility may outweigh this cost. | Government procures land within a growth‑area subdivision to cater for future service demand. Government buys the land prior to property value increases driven by development. It therefore procures the right to construct a facility at some time in the future when there is a service demand. Common uses of this type of real option include schools, police stations, health services, road and rail corridors, and train stations. |
| **Option to invest in information before committing to the investment** | An investment may be made to obtain better information earlier, prior to making a decision to proceed with an investment. This may reduce the costs associated with delay referred to above. Information options include R&D, resource exploration, education and training. | The Government has decided to reduce the rabbit population but is relying on a solution that is likely to take at least another 10 years to develop without additional investment. In the meantime, rabbits are destroying large swathes of land in Victorian parks. The Government could invest in R&D so it has the option to reduce the rabbit population earlier than it would otherwise. |
| **Option to stage the implementation of the investment (time to build option)** | Project implementation can be staged to introduce a series of decision points into the process. At each decision point (i.e. at the end of one phase and beginning of another), government has the option and flexibility to continue, wait or even abandon the project depending on new information. | This is the most often used option for Government as it allows further work to be undertaken to reduce uncertainties. Funding a project in stages or as a pilot may reduce uncertainty and cost through project evaluation prior to delivering future stages.  Government requires a new ICT system. It appoints a contractor to deliver the system, with the project comprising three stages: i) develop a system specification; ii) develop a prototype; and iii) deliver the end product.  Government can exercise the option to continue or abandon the project at either the end of stage one or two based on an assessment of whether the specification and/or prototype is capable of satisfying the service requirements, or if a more suitable alternative becomes available. |
| **Scale change options** | Expanding or reducing capacity to suit changes in demand |  |
| **Option to alter the scale of the investment (e.g. to expand, to reduce, to shut down and to restart)** | A capital project can be expanded or reduced in scale depending on whether market conditions are more or less favourable than expected.  A reduction option provides the flexibility to reduce service delivery or production output if conditions become unfavourable.  An expansion option provides the flexibility to expand the current state to increase service delivery or production output if demand increases more than expected.  The flexibility to shut down means that once an investment is in operation, the Government has the option to shut down the facility. The shutdown may be temporary, such as during periods when it cannot recover enough revenue to meet its operating costs, or permanent. | A port operator invests in a new port facility as existing infrastructure is operating close to capacity as a result of a recent, rapid increase in trade. A real option may be incorporated as international trade can be dependent on a range of uncertainties. For example, demand can fluctuate depending on changes to global or domestic economic conditions and increasing/decreasing barriers to trade. Changes to ship sizes can also influence port capacity requirements.  **Expansion option:**  When purchasing land for the new port facility, additional land is bought and set aside. This land banking provides the port operator with the option to expand operations if trade demand continues to increase more than expected. |
|  |  | **Reduction option:**  The port operator builds adequate infrastructure to meet current demand trends. However, the facility is designed with flexibility to allow operations to be scaled down efficiently if demand decreases. For example, a facility could be designed to allow partial closure of some sections of the site during times of reduced activity. Capacity might be purchased in modules where some modules could later be redeployed if no longer needed, or if a higher value use emerges elsewhere.  **Shut down and restart option:**  Where there is a medium to long‑term decline in trade demand, the port operator has the flexibility to restructure its operations, concentrating activities in one primary port rather than spreading operations over multiple facilities. Having the ability to exercise an option to temporarily or permanently shut down operations at the new port at a pre‑determined cost gives the port operator the flexibility to undertake this sort of efficiency measure cost‑effectively. |
| **Switching options** | Switching inputs/outputs to suit changes in demand or supply |  |
| **Option to switch outputs or inputs during delivery** | If prices or demand change, agencies can change the output mix of the facility (output/product flexibility). Alternatively, the same outputs can be produced using different types of inputs (input/process flexibility). | **Output shifts:**  When building a new rail line, Government may include the functionality to allow for future changes to rolling stock. This would enable different types of trains to be run on the line, allowing for different suppliers, and changes to characteristics (such as double‑deck carriages or longer train station platforms).  **Input shifts:**  A coal‑fired power station may plan for increased financial penalties for sulphur emissions by using an option to switch from high to low sulphur coal sources in the event such penalties impact on revenue. Similarly, they could switch to a mixture of coal and biomass in the event a carbon tax impacts on electricity generation costs. |
| **Abandon options** | Abandoning the investment |  |
| **Option to abandon the investment proposal or exit the project during delivery** | Some projects have a high degree of uncertainty regarding their potential success or failure. In these instances, an option to abandon can enable government to permanently dispose of an investment if market conditions decline severely, impacting on the strategic need for an investment or the ability to deliver it cost‑effectively. Agencies can realise the resale value of capital equipment, land and other assets in a declining market.  Alternatively, government could undertake a feasibility study and then not proceed further. | After fully considering other technology options and determining no suitable off‑the shelf solutions are available, as a last resort, the Government commits to develop a bespoke technology portal to allow schools and kindergartens to share stories, pictures and other information about a child’s education experience with their families. The initial prototype does not meet requirements effectively. At this time, a new and more effective product becomes readily available.  An option to abandon allows Government to exit the project during delivery for a pre‑determined price on the basis the poor results of the prototype indicate likely project failure. This leaves Government free to consider other emerging solutions. |
| **Design options** | Increasing design flexibility to add greater resilience |  |
| **Growth options** | Options that invest early in the flexibility to upgrade in the future at a much lower cost. An early investment is a pre‑requisite for follow‑on investments opening up future growth opportunities (early investment, e.g. procuring land for future development). | Government constructs a new bridge to a growing suburb, and provides the capacity to add extra lanes. There is no current demand for a wider crossing, however government is planning for increased service demand in the future. |
| **Multiple interacting option** | Opportunities to add value and flexibility to a project through multiple real options, usually of different types, but often interacting in complementary or mutually beneficial ways to add value. | The Victorian Government is delivering a new hospital in a regional city to meet growing demand. There is a possibility the Commonwealth Government will contribute to partially funding the project. The Victorian Government stages project delivery. It commences Stage 1 immediately, funded internally. Stage 1 of the facility is designed so it can operate regardless of whether Stage 2 is funded, but incorporates flexibility to enable additional floors to be added at a later date if additional funding becomes available. (Timing Option)  Australian Bureau of Statistics long‑term population forecasts suggest there is likely to be significant growth in the number of older residents in the proposed hospital’s catchment area in the medium to long term. This section of the community is likely to require specialised geriatric services. The hospital’s design incorporates flexible features to enable part of the facility to be easily reconfigured at a later date, should its service delivery requirements or preferred modes change. |

Table : Types of real options by managerial action

* + - 1. How can real options add value to an investment?

Real options analysis aims to add flexibility to an investment, thereby increasing the practitioner’s ability and opportunities to influence positive investment outcomes. Figure 2below shows the inverse relationship between an investment’s lifecycle (shown as the six Gateway review points) and Government’s ability to continue to influence positive investment outcomes. Government has the greatest ability to influence an investment’s outcome at the concept and feasibility stage and throughout the business case. The ability to influence outcomes decreases throughout procurement and after contract award. Real options analysis aims to increase Government’s ability to influence investment outcomes by increasing opportunities for flexibility throughout procurement, implementation and operation.

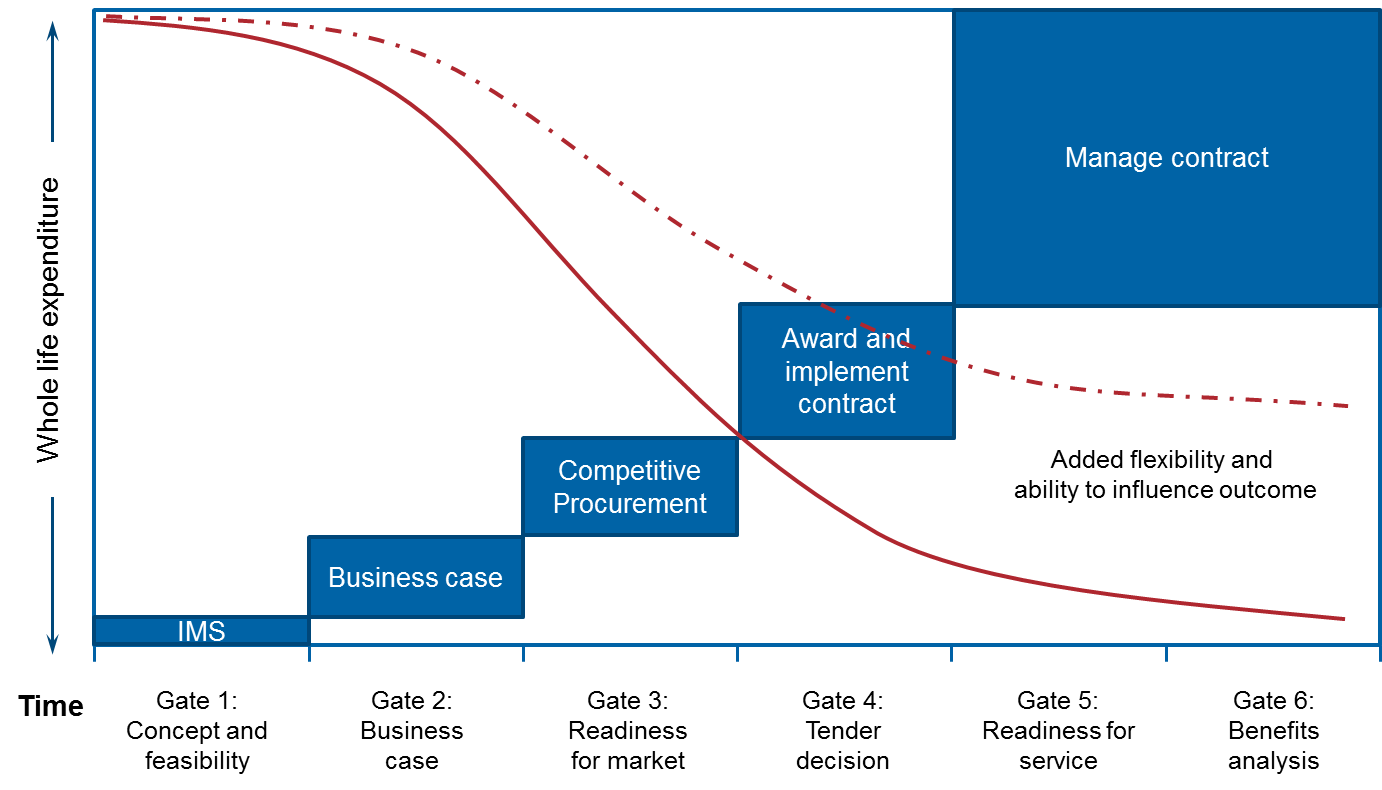


Figure : Real options adding value to an investment through increased ability to influence outcomes across the investment lifecycle

Real options analysis can add value to an investment at four opportunities: identifying the problem to be addressed; prior to committing to an investment; during project delivery; and during the asset’s operational life:

* + - * 1. Identifying the problem to be addressed

Under a traditional project decision‑making approach, the problem to be addressed is identified by considering its cause and effect within a framework of current conditions, and extrapolating based on assumed future conditions.

Under a real options approach, the problem to be addressed is identified by exploring its cause and effect over the whole of the investment’s life, including considering the types of uncertainties that could plausibly occur over this timeframe (and impact the assumed conditions). This approach encourages practitioners to consider more flexible investment strategies that are resilient to changing conditions.

#### Example of using real options analysis to identify the problem

Consider the scenario in which the Government identifies a current shortage of employees appropriately trained in the building trades that support the Victorian construction sector, combined with a decline in enrolments in associated tertiary education programs. The Government provides incentives in the short term to boost related TAFE enrolments, which prove successful: within two years, enrolments in related TAFE courses exceed capacity. The Government decides to provide additional TAFE programs to service this demand. However Government only intends to incentivise enrolments for a five‑year period. There is uncertainty whether demand will stabilise, continue to increase or decline after the incentives are removed.

Under a traditional lens, the problem would be considered as providing sustained additional capacity to meet increased demand. However, under a real options lens that recognises the inherent uncertainty in medium to long‑term demand for the TAFE services, the problem is viewed as needing the ability to respond quickly to address short term increased demand for TAFE services.

While these differences may seem subtle, they can have major implications for the choice of response and the associated investment costs and risks.

The real options approach places key uncertainties into the question, rather than treating them as a complication in answering the question. It encourages practitioners to consider: if the uncertainty cannot be removed, then what is the best way forward given that uncertainty and any consequential risks? As uncertainty can significantly influence the preferred investment strategy, DTF considers problem identification should be considered through a real options lens for **all** projects (see *Chapter 4.2*).

* + - * 1. Delaying decision‑making until more detailed information is available

For many infrastructure investment decisions, particularly those that are irreversible and have uncertain consequences, it may be valuable to have the option to ‘wait and see’ before committing to an investment.

The traditional CBA approach focuses on the net value of delivering an investment now based on the information currently known. Real options analysis recognises there may be increased value in delaying an investment decision to a future date when further information is known and project determinants are more certain or when conditions are more favourable. There may also be increased value in investing in obtaining better information earlier to reduce that delay. Options for obtaining better information earlier include monitoring, R&D, and resource exploration.



Figure a: The potential value of deferring an investment until uncertainty is resolved – Traditional CBA thinking



Figure 3b: The potential value of deferring an investment until uncertainty is resolved – real options thinking (Robinson and Kyng, 2003).

The Hohe See Wind Farm example in Text Box 6 illustrates how a utility company deferred an investment until there was greater certainty in investment conditions (in this instance, greater legislative clarity). In doing so, it ensured a greater likelihood of successfully achieving its intended outcomes.

**Example: Hohe See Wind Farm**

In 2012, the German utility company, Energie Baden‑Wurttemberg (EnBW), delayed its planned €1.5 billion investment to construct a new commercial offshore wind farm in the North Sea from 2012 until 2016.

EnBW initially proposed to begin procuring the facility in late 2012. However at this time, the German Government commenced a review of its Renewable Energy Act, creating a level of legislative and regulatory uncertainty for market participants. Operators were unable to set binding dates for when the proposed wind farm could be connected to the electricity grid and commence operations. EnBW decided to postpone the investment until the legal framework became more certain, stating that the company needed ‘legal clarity and reliable framework conditions to make an investment decision for well over EUR 1.5 billion’. However, it retained the right to undertake the investment at a future date when legislative conditions were more certain.

The German Government approved amendments to its Renewable Energy Act in 2014, and EnBW subsequently reconsidered the Hohe See wind farm. In 2016, EnBW committed EUR $1.8 billion, and expects to complete the project by 2019.

**Outcome:** EnBW deferred a significant investment decision until it had greater clarity regarding regulations and legal requirements, and a better understanding of when it could commence operations. If the company had continued with its planned 2012 investment, the facility may have been completed well in advance of any agreed binding dates allowing it to be connected to the grid. It could also have required retro‑fitting to comply with any new legal requirements, etc. By delaying the investment, EnBW reduced its risk of an irreversible and regretted investment decision.

Text Box 6: Example of delaying an investment until greater information is available*[[12]](#footnote-12)*

Consideration of the optimal time to invest can be supported by qualitative or quantitative real options analysis (see Chapter 3.8).

* + - * 1. Providing flexibility in investment strategies to allow Government to respond to prevailing conditions during project delivery

Government may be required to respond to changing circumstances during project delivery by taking various actions, such as to stage, expand, contract, switch inputs or even abandon the investment project. The traditional CBA/NPV approach assumes a set investment strategy. This can lead to a bias towards projects that do not provide flexibility (e.g. large scale capital investments) relative to more flexible options (e.g. demand‑side options, interruptible contracts or sunset clauses). If uncertainty is realised on a project, Government may face additional costs or other penalties in order to deal with those events if not built into the original contract.

Real options analysis provides an approach to deal with the complexity that further information and future decisions can introduce. It recognises the decision‑making process for large projects must enable the objectives and progress of projects to be regularly recalibrated to account for changing conditions – thus creating space for adaptation before there are irreversible physical and political consequences. Rather than making a one‑time go/no‑go decision, real options analysis enables the investor to stage decision‑making, or to make decisions at certain times to adjust for emerging developments. By providing the flexibility to take action to respond to change, real options analysis may contribute to the investment outcome.

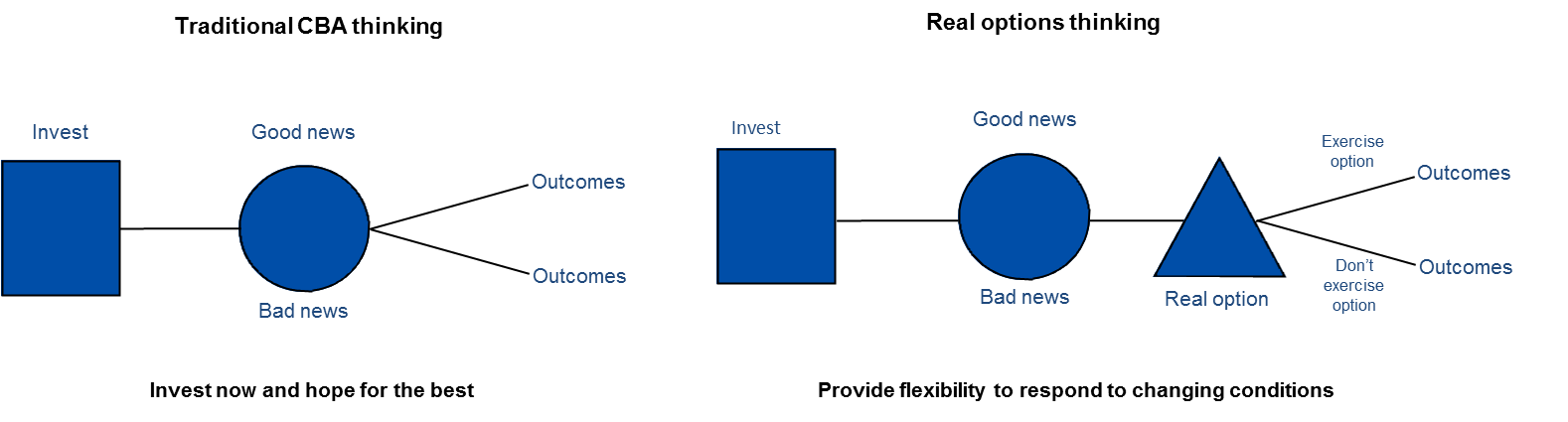


Figure : Option to alter investment strategy during project delivery

In a political context, where a change of investment strategy may be interpreted as failure, real options can temper expectations and provide additional rationale to any potential changes in investment strategy.

In the face of uncertainty, being too decisive too early can be very costly. A formal structure that anticipates and justifies the possibility of later change can provide a powerful means of responding to a negative interpretation of change. They can also benefit situations when governments have changed over the course of project implementation and the investment does not align with a new Government’s priorities and policies.

**Example: National Ignition Facility – Switch option**

The US Department of Energy’s $2.4 billion National Ignition Facility (NIF) needed to develop slabs of laser glass to be used in the testing of nuclear weapons and research.

Laser glass procurement required the production of high‑quality glass slabs called ‘blanks’. No existing glass production technologies could produce the volume of glass blanks needed.

The ability of glass firms to develop new technologies to produce the blanks, and the quality of the glass produced if the production technologies were feasible, were very uncertain. Costs and development schedules were also uncertain.

Although the NIF had relationships with experienced laser glass vendors, none could guarantee successful development within the required time. Therefore, the NIF program managers funded the development of new laser glass production technology.

The NIF needed a higher likelihood of success than any one vendor could provide, so it chose to hire two firms to simultaneously begin initial development of a technology to produce the blanks and to fund these development efforts in phases.

Program managers explicitly incorporated the flexibility to choose at several stages to:

(a) continue funding both companies and their technology development;

(b) fund only one company going forward; or

(c) discontinue funding both companies and explore alternative sources for the blank.

The choice at each stage was based on what the managers had learned about the likelihood of success of the developing firms in meeting expectations (benefits) and the cost of continuing to fund the research and development. Through consideration of real options, NIF managers were able to assess the cost effectiveness of their options at each stage.

Text Box 7: Example of providing flexibility to allow an investment strategy to respond to prevailing conditions during project delivery (See previous page)

Options that provide the flexibility to adapt to and manage changing conditions during the delivery of a project are called ‘Options on Project’.

* + - * 1. Options that provide flexibility during the operational phase of an asset: Investing in infrastructure that is more resilient to change

Infrastructure tends to have a long, useful life. However, it is often designed and constructed to meet only current uses and conditions, but with a long‑planned economic life. Changing service demand, and fluctuations in how services are delivered, can cause functional obsolescence.

Real options analysis encourages Government to think about the long‑term sustainability of its investments. It recognises value can be added to an investment by ensuring the resulting asset is resilient to changing service needs and can stand the test of time. It enables Government to consider and value the cost, not only to deliver an asset, but to manage it over its operational lifecycle. Value can be added to an investment through building in future decision opportunities that can extend an asset’s service capability.

**Fictional example: Responding to uncertain enrolment levels for primary schools**

A number of primary schools in inner‑city or middle‑ring suburbs are experiencing uncertain enrolment levels, driven by the significant demographic change that has occurred in these areas over the past decade. For example, some local government areas that have previously had a high proportion of older constituents (e.g. empty nesters, older workers and retirees), have seen marked growth in the number and proportion of young families. This is increasing the demand for educational services in these areas, in excess of that anticipated due to population growth alone, and related infrastructure is, in some instances, insufficient to meet this demand.

A school in an area experiencing this type of demographic change is considering options to best cater for the increasing demand given the uncertainty regarding long‑term peak enrolments.

The school can currently cater for 350 students. Demographic projections indicate enrolments in most years will increase to between 450 to 475 students by 2025. However, some years may experience higher enrolment levels of up to 550 students. How could the Department of Education manage this enrolment uncertainty through appropriate asset investment?

**Option 1**

The school builds fixed infrastructure with sufficient additional capacity to meet the peak demands of 550 students (seven classrooms). This option enables the school to fully meet the long‑term expected enrolments, however will result in an asset that operates at less than 80 per cent of capacity in most years, based on the expected future state. This represents (possible) over‑investment that could be regretted, especially if demand does not increase as expected.

**Option 2**

The school builds four extra classrooms (fixed infrastructure) to meet the average expected increase in demand (475 students). This option has the benefit of requiring a smaller build footprint, allowing the school to retain space for other uses (such as recreation). It also costs considerably less than Option 1. If enrolments increase as expected, this investment will provide the capacity to meet demand 80 per cent of the time over the period considered.

The school would need to consider strategies to help it cater for the additional demand expected during periods of peak enrolments. Deploying modular, relocatable classrooms could provide the school with the flexibility to cater for peak enrolments only if and when needed, freeing up the space for alternative uses at other times and providing flexibility for surplus capacity to be later redeployed to a higher value use. The school could also employ demand management techniques, such as implementing incentives for families to attend other schools close by.

Option 2 provides the school with greater flexibility to adapt as enrolment conditions change over time. It also decreases the level of over‑investment and the risk of regretting the investment should demand levels not reach the anticipated peaks. Of course, potential differences in classroom quality would need to be assessed – alongside the value of access to greater outdoor space, etc.

Text Box 8: Example of providing flexibility to allow an investment strategy to respond to prevailing conditions during the operational life of an asset: increasing infrastructure resilience

Options that provide flexibility to adapt to and manage changing conditions during the asset’s operational lifetime, after project closure are called ‘*Options in Project*’.

*Appendix 2* contains further real options case studies.

* + - 1. Linkages between real options, scenario analysis and adaptive management approaches

Scenario analysis and adaptive management are other methodologies that can be useful in dealing with uncertainty in infrastructure investment decision‑making. Both have similarities with real options theory, and can be applied either on their own, or as a pre‑cursor to, or in conjunction with, real options analysis.

Scenario analysis is a process of analysing the possible outcomes of a strategy or an investment by considering a range of alternative possible future states, or scenarios, of the world. It is based on the premise that ‘the investment environment is a complex system, characterised by uncertainty that is best understood from the perspective of multiple and plausible futures’[[13]](#footnote-13). It presents several alternative future states for an investment, rather than developing one assumed future, as is often the case in traditional investment decision‑making practices. The scenarios combine to provide a set of distinctive, internally consistent views of future world that can be constructed in the way that probable range of results will be covered. Normally scenario analysis would include optimistic, pessimistic, and more and less probable developments, however all aspects of scenarios should be probable. Consequently scenario analysis illuminates a scope of possible future outcomes, and the investment trajectories leading to these futures. It can be used to test the impact of simultaneous changes of assumptions on investment appraisal or valuation, as well as in planning for ‘external shocks’.

Scenario analysis is a qualitative approach, and can be a useful pre‑cursor to real options analysis in that it provides a good practice methodology for thinking about ‘future states’.

Adaptive management is a methodology for implementing management decisions while learning about which management actions or decisions are most effective at achieving the intended objectives. Often referred to as structured ‘learning by doing’, it incorporates management actions into experiments to compare the effectiveness of different strategies. It allows decision makers to accrue information needed to improve future management, and supports decision making by reducing uncertainty over time.

Scenario analysis, adaptive management and real options analysis all recognise that multiple scenarios and pathways to the future are a better way to manage uncertainty, risks and opportunities than a single view of the future, and all enable the value of future managerial actions to be factored into an economic appraisal of a proposal. In this way, these techniques can help practitioners analyse the value of actions that yield information or add flexibility, allowing them to think about a problem from a different perspective[[14]](#footnote-14). *Figure 5* shows the evolution of valuation techniques, from deterministic methods that do not consider uncertainty, to methods that consider multiple futures, through to approaches that value flexibility.



Figure *: Evolution of valuation techniques* (Strategis Partners, 2014 pg. 6)

* + - 1. Real options analysis tools

**Some facts and fallacies about real options**:

* **It is seen as a valuation and evaluation tool**: It is actually more a strategy planning tool.
* **It is seen as high cost**: But it can offer dramatic cost savings, and places strong emphasis on making sure high costs are incurred only where these are cost effective.
* **It is seen as complex**: But it can result in dramatic simplification, with a clearer understanding of the true problem and with far less daunting information requirements before a robust strategy can be commenced.
* **It is seen as involving complex mathematics such as Black‑Scholes equations**: But it may be applied strategically, or simplified by using decision trees and/or binomial methods.

Practitioners often view real options analysis as a technical and complex economic evaluation process that is too difficult for the average practitioner to use efficiently. It is often thought of as a single mathematical formula, and considered only relevant to a small number of projects. Real options analysis incorporates a broad range of strategic approaches, economic concepts, statistical models and other tools that vary in purpose and complexity, and that can benefit most asset investment proposals. Practitioners can apply the range of real options tools differentially to best suit a particular investment’s requirements.

The real options tools and techniques can be largely categorised as:

* + - managerial/strategic real options tools; and/or
    - options valuation tools.
      * 1. Managerial real option tools are strategic, or qualitative, planning techniques that consider the outcomes of changing conditions on a project trajectory, and use this to inform decision‑making.

**Managerial real options are:**

* strategic approaches that support investment decision‑making by providing a clear picture of the potential impacts of uncertainty, related decision points, and likely consequences of decisions on the project trajectory;
* not costly or time intensive to apply;
* simple to undertake in‑house; and
* likely to benefit most asset investments.

When considering an investment decision, Government has to decide whether to invest now, to take preliminary steps reserving the right to invest in the future, or do nothing. Selecting any one of these choices will create a different investment environment and trajectory, and a set of further decision points into the future. Changing conditions can alter the ‘future state’ during project delivery or throughout an asset’s operational life, creating further potential investment pathways.

Managerial real options thinking and approaches can be used to map, and subsequently navigate, this investment trajectory. They can be used to identify future strategic decision points or triggers, which could alter an investment strategy, and the outcomes of the potential choices. They can then graphically represent the potential alternative trajectories or pathways the investment will take. These pathways may lead to secondary trigger points, and a series of further management decisions and potential investment trajectories. This provides Government with a more comprehensive and intuitive view of the likely future outcomes resulting from decisions taken now.

This process can allow Government to better anticipate future change, and plan how they will respond if certain events or trigger conditions occur. It may identify some managerial actions that can be taken to improve the likely success of a project and reduce the likelihood of needing to make unplanned decisions in reaction to an unforeseen event. Managerial real options approaches are useful for highlighting and communicating to Government any possible disruptions to investment delivery or opportunities that could be leveraged.

This managerial application of real options thinking can be of high value. It may result in a restructured version of the key problem to be addressed, typically in a form that builds uncertainty into the question, and may allow for early prioritisation of strategy decisions that allows quite robust conclusions to be drawn.

* + - * 1. Options valuation approaches are mathematical models that empirically estimate the monetary value of real options to an investment.

**Real options valuations are:**

* statistical approaches that empirically analyse the value of a real option to an investment;
* more costly and/or time intensive to apply;
* more complex – DTF encourages agencies to employ staff or consultants with specific technical expertise to undertake options valuations; and
* likely to benefit only those proposals significantly impacted by uncertainty.

Options valuation techniques provide numerical support to strategic options analysis. They can be used to augment a proposal’s cost‑benefit analysis to quantify:

* + - the impacts of uncertainty on a comparison of potential solution options; and
    - the value that a real option could add to an investment.

There are a wide variety of statistical models that support real options analysis.

Decision analysis, supported by decision trees (outlined in *Sections 4.3.2–4.3.3*), is a real options analysis tool that can be used to explore and graphically represent the uncertain conditions or events (or triggers) that could cause a need to make a decision to alter the investment strategy, and the different investment trajectories that could result from taking these decisions. It can support either qualitative or quantitative analyses. Decision analysis has been proven to be effective when applied to infrastructure development and delivery, and therefore DTF recommends this as the preferred real options valuation tool. There are a number of other tools which may also be effective, and these are outlined in *Appendix 3*. Further resources for applying real options theory to infrastructure investment development and delivery are contained in *Appendix 4*.

The Department of Treasury and Finance (DTF) recommends that **for all projects,** practitioners use qualitative analysis techniques to consider the potential impacts of uncertainty on the problem definition, and on the investment trajectory. This process should be thought of as akin to developing a risk matrix and management strategy to help consider and manage project risk.

**For projects significantly impacted by uncertainty,** more detailed real options analysis, including an empirical valuation of the impacts of uncertainty on one or more solution options, may be warranted.

DTF recommends staff or consultants with specific technical capabilities undertake quantitative analyses. These analyses can be complex, costly and time‑intensive to undertake, and for most investments these costs will outweigh any potential benefits. DTF recommends these real options approaches are only applied where they are likely to add significant value to a project and provide a substantially different strategy to an NPV analysis. The next chapter explores when quantitative real options can be used most effectively.

* + - 1. When will real options analysis provide the greatest value?

Real options can have significant management value when investments involve significant irreversible costs, are vulnerable to changes in the environment and there is scope for flexibility to adapt to uncertainty over time. Real options analysis is less relevant when the investment decision needs to be made up front as an all or nothing commitment or where the investment is unlikely to be significantly impacted by uncertainty.

When will a real options approach add the greatest value to a project? When is it most likely to provide a materially different answer to a conventional approach?

Real options analysis is most useful when the proposal involves:

* + - A significant element of uncertainty, relating to the volatility of the underlying asset and/or the time before we have to make a decision (i.e. exercise the option): the greater the uncertainty in an investment proposal and its ability to deliver the desired benefits, the greater the value of having managerial flexibility to respond to new information.
    - Significant sunk costs that cannot be reversed: if the cost of an investment is fully recoverable, then there is no value in waiting to obtain new information, and hence no option value. However, this is rarely the case once a commitment has been made to a major capital build.
    - Opportunities that provide management with flexibility to respond to the new information: where an operating environment is constantly changing, management may need additional flexibility to adapt. This is particularly important the longer the life of an asset, as the options provide the ability for the decision‑maker to react to new information over a longer period of time.

Table 4 presents some questions to help assess whether real options will be valuable or a traditional CBA method will suffice. It is prudent to consider whether uncertainty needs to be addressed using real options principles in proposals where:

|  |  |  |
| --- | --- | --- |
| Question to answer | Real options are likely valuable if… | Conventional CBA could suffice if: |
| What are the project timeframes? | * decisions affect long timeframes | * the project has a short timeframe |
| What is the expected asset lifecycle? | * assets have long lifecycles and are costly to adapt once delivered | * the asset has a short lifecycle or a high degree of obsolescence |
| Does the project team have enough information about project outcomes that it can proceed with full information? | * uncertainty is large enough that it may be sensible to wait for more information, or to invest in better information earlier, prior to proceeding | * project information is largely complete |
| Are there any **critical dependencies** or **contingent investment decisions**? | * there are critical dependencies or contingent investment decisions | * the investment is stand‑alone |
| Could uncertainty in demand‑side market conditions lead to circumstances in which the investment proposal is no longer feasible or offers a value for money solution, either during project delivery or during the asset’s operational life? | * project benefits/costs are susceptible to unexpected trends in demand for services * changing conditions could lead to circumstances in which irreversible investment decisions are regretted * significant technological change is anticipated * success is vulnerable to long‑term economic conditions * there may be considerable change in demographic or social conditions * the project is vulnerable to political, policy, legislative, regulatory or legal change | * the project is not likely to be significantly impacted by long term economic conditions * the project is unlikely to be impacted by uncertainty in demand‑side market conditions * in each condition the same decision will be made * the project does not have a technological component or technology is proven and stable * the project is not likely to be significantly impacted by demographic, social, political, legal, legislative or regulatory change, or does not have the flexibility to manage such changes |
| Could uncertainty in supply‑side market conditions (such as market disruptions) lead to circumstances in which the investment proposal is no longer feasible or offers a value for money solution, either during project delivery, or during the asset’s operational life? | * project benefits/costs are susceptible to limitations in market supply (e.g. proven solutions, proprietary solutions, evolving technology, market capacity, capability and competition) * changing conditions could lead to circumstances in which irreversible investment decisions are regretted | * the project is unlikely to be impacted by uncertainty in supply‑side market conditions * in each condition the same decision will be made |
| What is the degree of certainty relating to investment costs/ revenues? | * volatility of the costs/revenues is large | * possible outcomes are relatively well known and understood |
| Are there any likely favourable changes to market conditions or opportunities that could be exploited? | * there are likely to be opportunities for enhanced benefits realisation or cost reductions that could be exploited | * there are no foreseeable opportunities to enhance project benefits, reduce costs or improve value for money |
| Is there scope to incorporate flexibility into the investment to deal with uncertainty? | * there is scope to add flexibility into the investment * the benefits of introducing flexibility outweigh the costs * decisions can be phased or undertaken in stages to respond to new information | * there is little or no scope to introduce flexibility into the investment * flexibility will have no value |
| Are there alternative approaches to addressing need where there are significant differences in the level of flexibility built into the approaches? | * some approaches would naturally embed significant flexibility that might have option value | * there is little difference across feasible approaches in the level or type of flexibility offered |
| Will new, **additional information** be available during the project life? | * significantly better information that affects the project’s benefits or costs will become available during the project lifetime * project updates and mid‑course strategy corrections are anticipated | * current information is robust and not impacted by any factors |

Table : At a glance: Questions to assess whether real options will be valuable[[15]](#footnote-15)

If an investment proposal contains a number of the above characteristics, or one characteristic that emerges strongly, this suggests that real options could add value. DTF recommends practitioners consider using quantitative real options analysis during business case development for these proposals. As a minimum, there should be an initial application of the broad real options analysis using the managerial tools, before any decision is taken to not make fuller use of the real options valuation techniques.

* + - * 1. Potential additional benefits

**Proposal development and evaluation**: real options can augment traditional cost‑benefit analysis to build a more robust case for investment. *Table 5* outlines some benefits of using real options analysis to inform the economic evaluation of proposal options and business case development:

|  |  |  |
| --- | --- | --- |
| Stage | Key issues | Benefits of using real options |
| **Identifying the problem to be addressed** | | |
| Identify the problem to be addressed | There is a need to ensure that the right questions are being addressed and the right objectives are set for the project. | The application of real options thinking can clarify the extent to which uncertainties, and management of their consequences, need to be built into the objectives, rather than being treated as constraints on how well the objectives can be achieved. |
| **Project selection and definition of options** | | |
| Decide on the central assumptions for each project to be assessed | Some projects are highly sensitive to the ‘state of the world’, including factors such as demographic change, land use changes, climate and other environmental change, government, legislative and legal changes, price levels in markets, and technological advancement. | Real options can be used to analyse the potential impacts of changing demand and supply forces on investment delivery, informing the problem definition.  Real options analysis encourages project teams to think about how business case assumptions may change over time, and be more sensitive to multiple possible futures.  Project teams are more likely to consider initiatives in the context of other policies, programs and influencing factors. |
| Identify and probe any flexibility inherent in the options already identified | Most approaches embed natural flexibility that could offer high option value if identified and stewarded. This option value is commonly overlooked in traditional CBA assessments. | Real options analysis recognises the value of flexibility options, which may be almost costless.  This process may help to shortlist already identified options, identify additional flexibility that can be recognised in already identified options, and identify additional options (as discussed below). |
| Develop additional flexible options | Project options reflect the current state of play and fixed solution. | Real options thinking can be used to map out the investment trajectory of each project option, setting out future decision points, and likely consequences of decisions. It can be used to explore ways to embed flexibility into an investment strategy to yield the best response given the likely prevailing conditions.  It encourages a broader range of interventions and strategies to be considered. |
| Determine appropriate project staging requirements | Committing to a project in its entirety upfront can risk unnecessarily committing to an unproven, uncertain or potentially excessively costly solution. It provides little scope to respond to changing conditions or taking advantage of opportunities when they arise.  Different components of a project can be subject to different uncertainties. | Project staging can increase certainty and confidence in some aspects of the project, can provide greater flexibility in periods of uncertain demand and supply, and can greatly reduce project risk.  Project staging can allow investors to take advantage of technological and other supply innovations or respond to market disruptions.  Allows for different parts of a project, subject to elements of uncertainty, to be treated differently. |
| **Valuation of costs and benefits** | | |
| Costs | Cost distribution is a key element of uncertainty. | Real options valuations can be used to cost the impact of uncertainty or the value of embedding flexibility into a solution. For example, costs to obtain better information earlier before committing to a project; costs to implement an exit strategy if conditions become unfavourable and a decision is made to abandon a project; or costs to switch inputs/outputs in unfavourable conditions.  Provides a more realistic assessment of costs and benefits over the whole of the asset’s lifecycle, not just implementation.  May counter the optimism bias in proposal costings (when the benefits of a proposal are overestimated and when the costs are underestimated) that are common in NPV analyses. |
| Benefits – impacts and valuation | There is a need to recognise the interaction between quantity demand (including induced demand), and value of unit benefits or costs. | Real options can assist in identifying opportunities for benefit enhancement that could also be captured and costed. |
| Aggregation (Compilation of results) | Bottom line results do not account for the benefits of flexibility | The costs and benefits in a CBA should take account of the likelihood that different options will have different benefits over time. This is critical when it comes to evaluating the value of benefits from the investment |

Table : Benefits of using real options analysis to inform business cases

**Communications**: a real options approach can also help Government communicate *up front* any potential project uncertainty, and their strategies for dealing with the resulting impacts. By articulating these options at project initiation, Government can send a clear message that there is more than one potential investment outcome, and this can help manage perceptions that changing course represents ‘project failure’.

* + - * 1. Potential disadvantages

Some consequences or disadvantages of using real options analysis that investors should be aware of include:

* + - **Greater flexibility can come at additional financial cost:** keeping the flexibility to invest or change the strategy later can involve additional short term costs to obtain and maintain the flexibility – e.g. the purchase or reservation of land and likely restrictions on higher value uses. Real options can increase project delivery costs. For example, staging a project’s delivery can result in increased consultancy, procurement and construction or implementation costs, assuming the project is successful. There may also be a cost associated with executing an option. For example, a contractor may require a payout or form of compensation if a project is delayed, cancelled or significantly modified. This is analogous to the choice between insurance policies – a low premium and high excess (traditional approach), or a high premium and low excess (real options approach). Any higher costs need to be justified through either or both of lower costs in dealing with plausible future environments or higher benefits being attainable under some of those plausible futures.
    - **Real options can impact benefit delivery:** immediate benefits may be lost by delaying a decision, for example delaying the construction of a road may sustain traffic congestion in an area for a period, meaning the Government cannot realise service delivery and economic benefits. Simply reserving the road corridor, without taking further action, may mean that the land is no longer available for its highest and best use.
    - **Greater flexibility can require additional time and effort for decision‑making:** using flexible strategies to manage uncertainty requires constant monitoring and review of the options and regular investment strategy recalibration. This can increase the time and effort executives need to devote to considering and making decisions and to ensure options are exercised appropriately and their value optimised. There can be a real trade‑off. ‘Quick and dirty’ approaches that do not deal fully with the value of flexibility might be reasonable if the potential value of that flexibility is low.
    - **Flexible approaches to infrastructure provision might not align with prescriptive government budgetary and assessment processes designed to deliver fully ‘defined’ projects.** A decision to delay full implementation of a project might be seen as government avoidance or even failure. Government might be avoiding a commitment that would later be deeply regretted, and flexible strategy might offer much better value for money to taxpayers, but these perceptions can still work against the efficient use of real options.
    1. Applying real options analysis throughout the investment lifecycle

The purpose of this section is to provide a practical approach and set of tools to support the use of real options analysis for infrastructure and ICT investments. It outlines the set of actions that may be undertaken at each stage of the investment lifecycle to address uncertainty and real options.

* + - 1. Managing uncertainty across the investment lifecycle

Real options analysis should be considered throughout a project’s lifecycle:

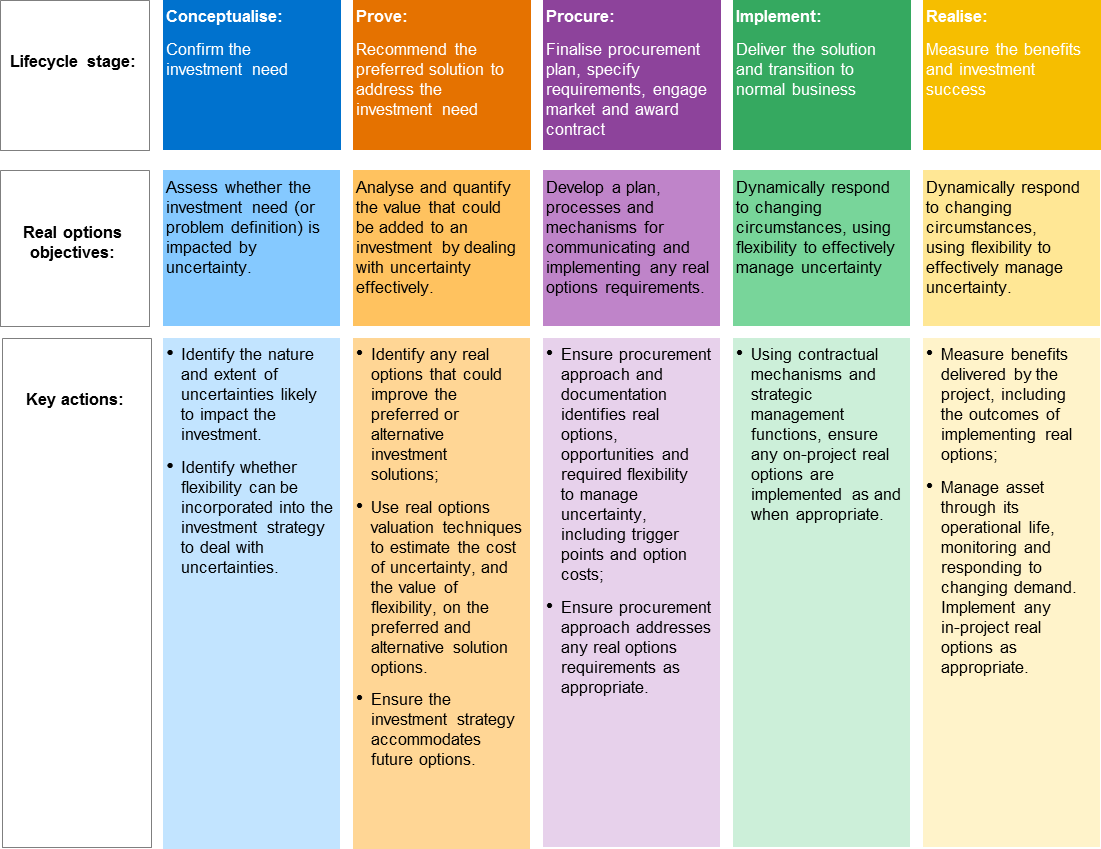


Figure : Impacts of uncertainty across the investment lifecycle [[16]](#footnote-16)

For the sake of simplicity, this section portrays the investment lifecycle as a linear process, with each stage occurring sequentially after the previous stage has been completed. This will not necessarily be the case in practice, especially when a project involves real options. In some instances an investment may undertake some procurement or implementation activities, then require business case recalibration, reconsideration and approval before being successfully delivered. Some investments will be staged, with some components completed, some in procurement or implementation, and others still in the prove stage. In other instances, an investment may be stopped during planning, procurement or implementation, and will not proceed into the implementation or realise stages at all.

* + - 1. Stage 1: Conceptualise – Assessing when real options analysis may add value to a project

|  |  |  |
| --- | --- | --- |
| Lifecycle stage | Real options objectives | Key actions |
| Stage 1: Conceptualise  Confirm the investment need, define likely benefits and explore strategic interventions.  (As required, develop a Preliminary Business Case or Strategic Assessment) | Assess the extent to which uncertainty could impact the investment need, or ‘problem definition’, including both the problem cause and effect and likely derived benefits.  Assess the capability of the proposal to address that uncertainty.  At the end of this stage agencies should understand how uncertainty may impact their proposal, and have identified any high level actions or strategies required to deal with it effectively.  This includes identifying when detailed real options analysis and valuations are warranted. | * Identify key uncertainties impacting on an investment, including:   + changing demand‑side trends;   + changing supply‑side factors;   + interdependencies; and   + dependencies impacting on project or benefit delivery. * Assess the potential impacts of these uncertainties on investment delivery and benefits realisation. * Assess potential strategies to reduce uncertainty. * Assess the extent to which an investment proposal can be flexibly adapted to manage or respond to uncertainty. Consider:   + optimal timing to invest in a proposal;   + circumstances which may cause investment regret;   + opportunities for increasing the value of an investment; and   + interdependencies that may impact on the proposal. * Determine whether there are any uncertainties that need to be considered further in the business case and investment strategy.   **Note:** Undertaking **Investment Management workshops** can assist identify where real options analysis could add value to a project. |

Table : Real options in Stage 1: Conceptualise

Stage 1 of the investment lifecycle, Conceptualise, relates to the initial examination of problems or opportunities that agencies believe warrant government consideration. It requires decision‑makers to consider the merits of a proposal early in its development, and determine whether there is a service delivery need that justifies further investigation, now and by this Government.

Real options analysis should commence in the Conceptualise stage. Generally flexibility is greatest at the earliest point in the project planning and development process, well before demand meets a technical constraint that may force a particular response, and ideally before there is a public commitment to a particular type of solution.

In the Conceptualise stage, agencies should identify any uncertainties that could be realised on their proposal, as well as potential ways to deal with their impacts, that can be further explored in the business case. As outlined in Section 3, DTF encourages agencies to apply real options thinking in a strategic way to any asset investment. This can help identify any managerial actions that can be taken during project delivery or throughout the asset’s operational life to improve benefits realisation. It can also help identify those proposals more significantly impacted by uncertainty that would warrant more detailed real options analysis and valuation in the final business case.

Real options analysis in the Conceptualise stage can be supported by:

* + - Investment Management Standard workshops; and
    - a real options analysis triage process.

4.2.1 Real options and the Investment Management Standard

DTF encourages agencies to apply the Investment Management Standard (IMS) when developing their investment proposals. The IMS is a series of four workshops that bring together the most informed people from government seeking to deliver the project to help shape an investment proposal early in its development. The IMS workshops involve:

Confirming the investment need (Problem Definition workshop)

Identifying the likely benefits (Benefits workshop)

Identifying the preferred response (Response workshop)

Identifying the preferred solution (Solution workshop)



Figure : Investment Management Standard line of enquiry

Appendix 5 provides an overview of the IMS elements and their purpose.

The IMS workshops often identify sources of uncertainty impacting on the problem and benefits definition, as well as on potential interventions and solutions. They are well‑placed to assist agencies identify how real options thinking can be most appropriately applied to an investment.

Uncertainty is considered at each stage of the IMS process as shown in Table 7.

|  |
| --- |
| Problem |
| Consider the organisation’s operating environment:   * Is it characterised by pronounced uncertainty? * Are there any factors outside the control of the organisation that could significantly impact the problem (cause and effect) or the need or demand for an investment, and therefore the preferred investment strategy? This includes considering whether any factors, such as changes in demographics, economic conditions, technological advancements or organisational behaviour that could lead to a change in demand for action outside the expected range, or an external disruption that could present a change in market supply factors that is currently unknown.   + If there is any likelihood that the extent of the problem, or the nature of the demand for an investment, could change over time, this should be captured in the cause and effect diagrams and raised at subsequent workshops for further consideration. |
| **Benefit** |
| Consider whether uncertainty could materially affect the proposed benefits.   * Are there any other potential shifts in the organisation’s current or future operating environment, such as those arising from demographic, economic, environmental, social, political, industry or technological factors, which could fundamentally change the investment’s benefit delivery? * Is achievement of any of the benefits, KPIs or measures, contingent on significant interdependencies or co‑investment in other projects?   + The IMS facilitator should capture any material uncertainty within the Investment Logic Map (ILM) for further consideration in subsequent workshops. Highlight the potential need for a real options workshop in the Benefit Profile. |
| **Response** |
| Consider the operating environment and supply markets.   * Are any of the interventions contingent on material interdependencies? * Would any of the response options become unfeasible if circumstances changed? Could this lead to investment regret? * Will this affect the need for, or approach to, the investment? * Will any of the proposed responses enable Government to respond flexibly to changing circumstances, minimising Government’s obligations under unfavourable conditions or enabling opportunities for benefit enhancement to be leveraged?   + At this stage, the level of uncertainty impacting a project, and extent to which response strategies need to contemplate it, needs to be formally assessed and noted within the real options analysis. |
| **Solution** |
| Consider the solution as a whole, and the operating environment and supply markets.   * Are there any circumstances or scenarios in which the preferred solution would be less successful in delivering the planned benefits or would lead to investment regret? * Are there any conditions or uncertainties whose impacts on the deliverability of the recommended solution are not possible to estimate? * Does the preferred solution provide the flexibility required to respond to uncertainty, minimising Government’s obligations under unfavourable conditions or enabling opportunities for benefit enhancement to be leveraged?   The level of uncertainty impacting a project, and extent to which response strategies need to contemplate it, needs to be formally assessed and noted within the Investment Concept Brief. |

Table : Uncertainty in the investment management process

The IMS can help identify uncertainty and its impacts on an investment and, where those impacts are potentially significant, recommend further investigation. Conducting any further detailed real options analysis will then need to be built into business case development.

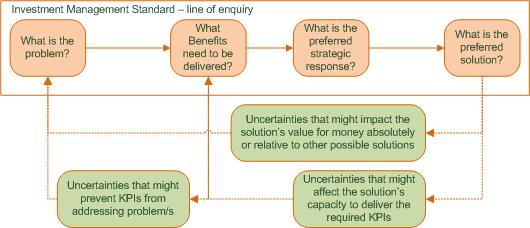


Figure : Real Options approach at Conceptualise stage

The IMS also encourages practitioners to consider the Decision Maker’s Checklist – the 16 Questions tool (see *Appendix 6*), with uncertainty considered in questions 4, 8, 12 and 16.

* + - * 1. The real options triage

DTF recommends undertaking a triage approach at investment initiation stage to determine how real options tools can be differentially and appropriately applied to a particular investment.

The ‘real options triage’ is a strategic exercise that requires agencies to think about the uncertainties that could impact their investment, the vulnerability of the investment to those uncertainties, and the level of flexibility within the investment to adapt its strategy to mitigate those impacts. It draws this information together to identify the most appropriate ways to apply real options thinking to an investment.

The ‘triage’ process should be applied as early as possible in the development of an investment concept. Preferably this should occur during the development of strategic plans, policy statements and election commitments, ideally before the development of feasible options, and at latest, early into the development of the preliminary business case.

The triage guides practitioners through three key stages of thinking:

**Identify and assess the nature and extent of any uncertainties** that may impact on the need for, or the ability to implement, an investment and support a case for investing in some types of flexibility. Consider how uncertainty could impact the causes and effects of a problem, and on benefits realisation.

**Assess the scope for flexibility** within the investment to enable government to anticipate and respond favourably to changing circumstances in a timely manner.

**Draw the information together** and determine any actions that can be incorporated into an investment strategy to better manage uncertainty. This includes identifying where more detailed real options analysis and valuations are warranted. The investor should make a clear decision at the end of the triage regarding whether, and/or the extent to which, a real options approach should be applied to the investment proposal.

Diagram detailing the steps to identify where more detailed real options analysis and valuations are warranted


Figure : Overview of the real options triage process

#### Step 1: Assessing the nature and potential impacts of key uncertainties

The first step is to consider the nature and extent of the key uncertainties that may impact the need or demand for an investment and the desired benefits. Agencies should think broadly about uncertainty, including political, environmental, economic, demographic, social, commercial, legal, regulatory and technological factors impacting on both demand and supply.

Agencies should understand the circumstances where a government action has net benefits and where it does not, and develop triggers for taking alternative approaches. Preliminary probability analysis of uncertainty also needs to be conducted: if the likelihood of uncertainty is deemed to be low, then application of real options analysis is unlikely to yield additional value.

Appendix 1 provides greater detail on the types of uncertainties that may influence a project. The following tool can help consideration of demand and supply‑side uncertainties.

**Issues to consider in characterising the nature and potential impact of the uncertainties**

1. Thinking broadly about the way political, environmental, economic, demographic, social, commercial, legal and technological factors impact on your proposal, list the major identifiable uncertainties that could impact on your project. You should consider:

• Is the investment need (i.e. problem or service demand) likely to change over time (including during project delivery and throughout the operational life of the asset). If so, how?

– Will this change required service levels, or when, where and how a service is delivered?

– Will this impact benefit delivery, resulting in increased or decreased benefits?

– If conditions change, could we be investing in an inadequate, obsolete, stranded or inappropriate asset?

• Are there any uncertainties in market supply forces that can impact investment delivery?

– Could these impact our ability to deliver the necessary project scope on time, on budget and in a way that offers value for money?

• Are there are any dependencies or contingencies that are outside of your control?

– Could these impact project delivery or benefits realisation?

2. What can be said about these uncertainties – in terms of:

• The most likely way that they might play out and the possible extremes?

• Whether probabilities could be credibly attached to representative outcomes?

• Whether lower and/or upper bounds (‘caps and collars’) could be attached to the extreme outcomes?

• Whether there are significant correlations across key uncertainties? For example, would the extreme demand possibilities in relation to a new road proposal be positively or negatively correlated with demands on other roads or rail? Would a blow‑out in construction costs be likely to result in higher or lower future operating costs?

3. Are there any circumstances arising from these uncertainties occurring that might lead you to regret that an investment proceeded in a particular way?

• Are there circumstances in which you would change the investment strategy and take a different approach, or wish you had not proceeded at all?

• Are there circumstances in which a proposed solution would no longer offer the best outcomes over the desired investment period?

• Would an investment strategy be different if you considered the wider network or system perspective instead focusing narrowly on addressing a specific need?

• Would service need aggregation require a solution change?

• Are there any events on the horizon that you would like to be able to anticipate or respond to?

• Are there any opportunities you would like to exploit?

– What are the likely trigger points for these?

– If they occur, what will you need to do to achieve investment success and deliver the required benefits?

4. To what extent does the project itself involve essentially an R&D or Research, Development and Demonstration (R,D & D) process where the investment will be substantially shaped as the project evolves?

• To what extent is there scope to redesign an investment strategy to have more of an R,D&D character by ‘front end loading’ the uncertainties that have the greatest impact on strategy, and by shifting the irreversible commitments to some major costs to later?

• If the strategy requires research and testing as a component to converge on a design, then the likelihood that options methods can help address serious bias in the project evaluation is very high. This can be a feature of major, tailored‑to‑purpose ICT projects, and other projects impacted by high uncertainty.

Text Box 9: Issues to consider when undertaking Stage 1 of the Real Options Triage – Characterising the nature of the uncertainties

#### Step 2: Assessing scope for adding value by building in and/or exploiting flexibility

The second stage in the triage process is to examine the scope for adding value to an investment by incorporating strategies to respond to uncertainties. This includes:

* + - building in flexibility;
    - preserving flexibility that might otherwise be at risk; or
    - planning to exploit, where appropriate, existing flexibility.

Table 8outlines a further set of questions that can help to explore different types of flexibility or options that could be included in an investment strategy. Note that at the Conceptualise stage, a high level analysis of these issues is expected, to be further explored in the business case.

|  |  |  |
| --- | --- | --- |
| Type of option or opportunity | Questions to ask | Examples |
| Influence or shape uncertainty | Have you evaluated the opportunities to limit uncertainty through other regulatory/pricing approaches? | Limit truck weights to reduce uncertainty in road deterioration. |
| Spread or distribute risks | Did you consider all possibilities to divide the risks across the parties involved and assign tasks to those most capable of managing each risk? | Negotiate fixed price contract with road construction company. |
| Investigate/learn | Did you evaluate opportunities to develop knowledge or get more information on the uncertainties?  Are alternative development options for a site known? | Try test sections or similar infrastructure for their maintenance characteristics. |
| Diversify | Did you consider combining projects with a different risk profile to limit the overall risk? | Combine different approaches to reduce traffic jams, such as road information, better public transport, more capacity roads. |
| Exit or abandon | Have you accounted for the fact that the project can be abandoned after the start and a salvage value can be collected? | Stop maintaining infrastructure if more cost efficient alternatives are available. |
| Switch technology, markets, products | Have you considered the opportunity to change inputs (use of materials), outputs (products and markets) and use technology during operation to improve the business case? | Switch between conventional and new technologies or methods of delivery. |
| Grow (project or corporate growth) | Have you considered benefits from new technology, market access, knowledge and experience gained during this investment project?  Have you accounted for the fact that exercising one option can open up further options? | Reserve space for additional lanes.  Use technology developed in other projects/markets. |
| Time | Have you considered the optimal timing for making an investment decision based on information becoming available or investment conditions improving?  Does the value of deferring exceed that of investing now? | Delay project until information on costs and/or benefits are more certain.  Invest in better information earlier.  Delay procurement until completion date is more certain. |
| Phase | Have you considered the opportunity to divide a project or investment into separate investments that can be phased over time?  Did you consider adjusting the definition of a consecutive phase based on the results of the previous one? | Staged development based on priority needs.  Invest early in elements of a project with long delivery times, with flexibility to invest in high cost elements of a project when required. |
| Scale | Have you considered the opportunity to adjust the capacity both up and down? | Allow temporary peak hour car pool or bus lanes. |

Table : Identifying scope for flexibility within your investment strategy*[[17]](#footnote-17)*

Also consider if flexible decision‑making is required to ensure:

* + - benefits can be achieved under uncertain circumstances (uncertainty in demand);
    - value for money can be achieved under uncertain circumstances (uncertainty in market supply); and
    - there is scope to minimise Government’s obligations in situations characterised by uncertainty and irreversibility.

#### Step 3: Draw the triage together – determine the most appropriate approach for dealing with uncertainty for your investment proposal

At this point, agencies should have a good understanding of the uncertainty that impacts the investment, its vulnerability to the uncertainty and the capacity of the investment to respond to the uncertainty. You need to draw all this information together to determine any managerial actions that could be taken to address uncertainty during the investment’s life, and whether detailed real options analysis and valuation is warranted in the business case.

Agencies should liaise with their DTF representative to confirm the appropriate application of real options for each investment.

4.2.3 Conceptualise summary

**Key decision point – End of Stage 1: Conceptualise**

Agencies should decide at the end of Stage 1 Conceptualise whether the investment would be suited to a real options approach and/or further real options probing at full business case stage (Stage 2 Prove). If agencies (and/or DTF) decide further real options work is required in relation to the investment, this should be specified in the preliminary business case or strategic assessment, where relevant. If agencies decide that further real options work is not required in relation to the investment, then the reasoning behind this conclusion should be included in the preliminary business case or strategic assessment, where relevant.

Text Box 10: Key decision point – End of Stage 1: Conceptualise

* + - 1. Stage Two: Prove – Undertaking real options analysis and valuations

|  |  |  |
| --- | --- | --- |
| Lifecycle stage | Real options objectives | Key actions |
| **Stage 2: Prove**  Explore project options and estimate costs to validate value for money and viability.  Confirm the preferred solution to address the investment need.  Develop a business case. | **Ensure any uncertainties identified in the Conceptualise stage, as well as actions to address their impacts, are appropriately considered and incorporated in business case development.**  **Where Stage 1 has identified detailed real options analysis is warranted – undertake a detailed real options assessment and valuation.**  At the end of this stage agencies confirm any real options to be included in the preferred investment solution and alternatives for delivering the investment need. This forms the basis of Government’s funding approval. | * Consider the impact of uncertainty on the preferred and alternative options. * Consider opportunities for increasing the flexibility of an investment to respond to uncertainty, including multiple/alternative inputs or outputs, future‑proofing etc. * Identify any strategic real options to be incorporated into the preferred investment solution. * Where relevant, use real options valuation techniques and other costings methodologies (e.g. decision trees, influence diagrams or binomial models) to estimate the cost of uncertainty, and the value of flexibility, on each solution option. * Value, analyse and assess the value‑for‑money of investment options incorporating flexible approaches to managing uncertainty. * Identify how real options will be incorporated into the procurement strategy and project implementation plan. |

Table : Real options in Stage 2: Prove

The purpose of Stage 2: Prove is to build a rigorous case for investing in a proposal, including proving the proposal has policy merit and is deliverable. Agencies should revisit and revalidate the problem definition, benefits and strategic response developed in the *Conceptualise* stage. In addition, they are required to assess:

* + - the value for money presented by a range of project options; and
    - solution deliverability, including governance, procurement strategy, stakeholder management and risk management.

The key output of this stage is the final business case, including a comprehensive cost benefit analysis of project options, as well as procurement analysis and consideration of project governance, project management, risk management and stakeholder engagement for the preferred solution.

The key real options requirements and objectives of this stage are to:

* + - revisit and reconfirm the problem definition, benefits and strategic interventions, including considering how these are impacted by uncertainty;
    - consider, value and analyse the impact of uncertainty and flexibility with regard to potential investment solutions and managerial actions to be incorporated; and
    - plan how the investor will respond to circumstances as they change and ensure procurement analysis and the resulting procurement strategy, governance and approval arrangements, project management plans and stakeholder management plans all effectively address any real options requirements.

Figures 10 and 11 depict how to apply real options in the development of a Victorian Government full business case.

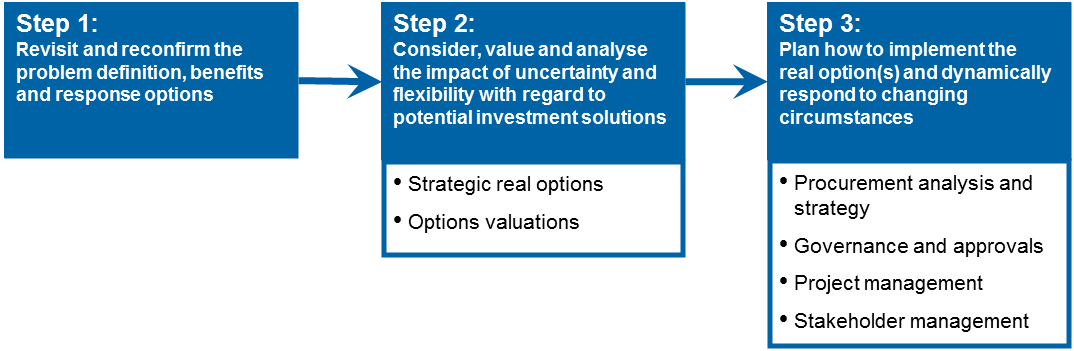


Figure : Real options requirements in Stage 2: Prove

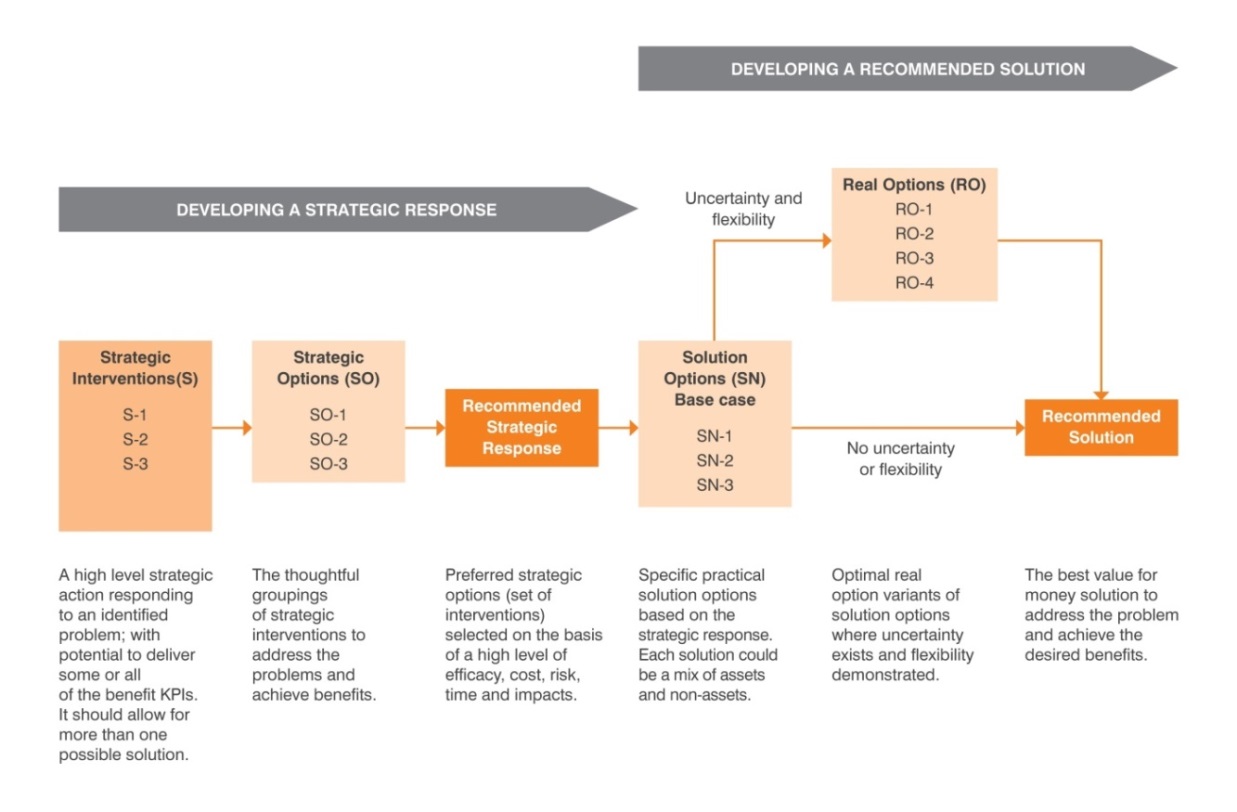


Figure : How to apply real options to Stage 1: Conceptualise and Stage 2: Prove

* + - * 1. Review and reconfirm the problem definition, benefits and strategic interventions

The first stage of developing any business case involves departments reviewing and reconfirming:

* + - that there is a defined problem that requires investment now;
    - that government investment will result in delivering the desired benefits; and
    - any previously identified strategic approaches to address the problem remain appropriate and feasible.

Some uncertainties that existed at the time the strategic assessment or preliminary business case was prepared may be resolved through this process. This may be because greater due diligence and other evidence has become available. The business case should address any remaining uncertainty through real options analysis, either as strategic management practices or valuation exercises.

When defining investment benefits, you need to be aware that using real options can significantly alter a project pathway. This can impact government’s ability to realise a benefit – and can even reduce or remove the need for a benefit to be realised. It may be necessary to outline the investment’s ‘strategic intent’ (i.e. general objectives and outcomes), to be achieved regardless of the trajectory an investment ultimately takes.

For example, an investment’s strategic intent may be to ‘provide long term water security’. The mechanisms, timing and scope of how this is achieved may change over time, but the general intent should not.

* + - * 1. Strategic real options in practice

A degree of uncertainty will exist in most significant asset investments. While in the majority of cases it may not be significant enough to warrant quantitative options valuation and analysis, there may be strategic or managerial actions that could improve investment delivery. The Investor can strengthen their investment strategy by having a clear picture of the key sources of uncertainty that could potentially impact the project, and how and when these are likely to present themselves – and more importantly, plan how they will respond should that eventuality arise. Consider the following approach:

**Review the real options triage undertaken in Stage 1: Conceptualise:**

* What are the primary sources of uncertainty impacting investment?
* When are they likely to occur? What are the likely triggers or lead indicators of changing conditions?
* What impacts could they have?

Develop a set of decision points and managerial actions that can be incorporated into the business case and investment strategy that clearly identify:

* likely events or changing circumstances that could impact the investment delivery (including both those with negative impacts and opportunities that could be capitalised);
* triggers for when to exercise a real option;
* decisions to be made, including accountability for taking the decision; and
* likely outcomes of any decisions, including how it will impact on the remainder of investment trajectory.

Text Box 11: Process for identifying uncertainty and developing appropriate strategies to respond effectively.

**You should consider this activity as being akin to developing a risk management strategy to help you consider and plan for potential project risks.**

As flexibility is the essential element for dealing with uncertainty, it is very important that we consider uncertainty during the options analysis process, when potential to incorporate flexibility into the investment is high. If we leave this process until after a preferred solution is locked in, we may limit flexibility in project.

**Decision trees** can be used as a tool to structure thinking about uncertainty and support the identification and benefit of a real option. They are effective at graphically presenting any optionality within a project by identifying:

* + - trigger points: a change in conditions or an event that represents the uncertainty impacting on the project, triggering the need to respond and deal with the change;
    - decision options: choices of alternative courses of action that can be taken if trigger points are reached; and
    - project trajectories: investment pathways and outcomes that can result at each decision point.

They can capture the logical structure of a problem with one or more alternative end points, and can help a project team crystallise how they think about project implementation. They also provide an easy way of communicating this information to others. This makes them a logical and common starting point for those investments warranting real options valuations.

A decision tree comprises a number of nodes representing an uncertainty or a decision point, which is the point where a source (or sources) of uncertainty impacts the investment. Each branch of the tree represents the path, or trajectory, the investment will take based on the decision made. The end of each branch of the tree represents the investment outcome that will occur given the decisions made and actions taken. Each outcome represents a different future state. The following fictional example depicts this relationship.

#### Case study: Decision tree – qualitative options analysis of a hospital upgrade

‘Roptionville’ is a new outer‑suburb and growth area, with average annual population growth of 15 per cent over the past five years. The closest hospital is a 45 minute drive away, and Government has approved a new hospital to service the area.

There is uncertainty about whether growth will continue at current levels, slow, or stagnate and Government is unclear about the size of the hospital to build, and is considering the following options[[18]](#footnote-18):

* + - **Option 1** involves building a base, non‑upgradable, hospital. This hospital will take five years to complete, and has capacity to service the existing population plus an additional 10 per cent population growth which is in line with medium term growth expectations for the state.
    - **Option 2** involves building a hospital that meets the same capacity requirements as Option 1, but invests in a stronger foundation and structure. This will facilitate future upwards expansion of the hospital if population growth exceeds forecasts.

This information can be set out in a decision tree to help Government visualise the impacts of its decisions:

Hospital demand pressure

Base hospital to meet stable demand growth

Upgradable hospital

Demand increases above expectations

Demand growth stable (no additional cost)

Demand increases above expectations

Demand growth stable (no additional benefit, opportunity cost)

Build a new hospital (high cost and time intensive)

Manage services (potential delays)

Add additional floors to meet increased demand growth

Do not upgrade

Figure : Using a decision tree for qualitative analysis

**Lesson:** This simple decision tree is used to map the uncertainties (uncertainty nodes (circles)), the series of decision points where uncertainty may impact a project and a decision is required (decision nodes (squares)), the course of action possible at each decision point (branches), and the investment outcome (termination point).

The above simple diagram shows how decision trees can be used without numerical analysis to clearly visualise the key decision points within an investment strategy, the conditions or triggers that have the potential to change the investment trajectory, and the likely investment outcomes if uncertainties are realised.

The decision tree can be as simple or as complex as the situation requires. While the above example identifies the decision points to consider the availability of a real option, there are likely to be multiple decision points and triggers for exercising a real option, each with their own probabilities and cost estimates. Building on the above example, this could include the level, or types of demand required before the real option is exercised, and the impact on different decision points including whether to invest in a single, or multiple floors to meet additional demand.

* + - * 1. Cost benefits analysis and real options valuations

Where agencies have decided that detailed real options analysis is required at Stage 2: Prove, practitioners can apply real options valuation techniques to augment their cost‑benefit analyses.

To re‑cap from earlier, a quantitative real options appraisal follows the same principles as a cost‑benefit analysis. Streams of costs and benefits should be compared over time and discounted to generate a NPV. However, the real options approach also considers the value that can be attributed to having increased flexibility to respond to prevailing conditions.

While there are a number of approaches and analytical tools you can use to value alternative real options pathways, the most commonly used tool for major capital infrastructure programs is a decision tree. They are particularly useful when dealing with distinct choices between quite different approaches to achieving the objectives, and where there are a small number of clearly identified uncertainties.

#### Decision trees

In the previous section, we saw that decision trees offer an effective way of mapping out how uncertainties might shape strategies. They are also effective quantitative analytical tools.

If we consider our example again:

* + - **Option 1** (building a base, non‑upgradable, hospital) will cost $75 million. If demand is stable, Option 1 will deliver benefits of $100 million due to improved health outcomes and timely provision of health services. However, if the population increases above expectations, Option 1 will only deliver benefits of $50 million as timely provision of care will diminish and full benefits will not be realised.
    - **Option 2** (building an upgradable hospital) will cost $95 million, with an additional $5 million required if a decision is made to undertake the upgrade. If demand is stable, Option 2 will deliver benefits of $100 million as per Option 1. However, if demand exceeds expectations and further hospital expansion is required, the expected benefits increase to $150 million as a result of enabling a quicker and more cost effective upgrade (as opposed to a new build) that will provide more timely health benefits to the community.
    - Evidence suggests there is a 50 per cent probability of population growing above expectations in the medium‑long term.

Using the above parameters, we can construct a decision tree which maps out the level of total investment we will need under different future states:

50%

50%

50%

50%

Hospital demand pressure

Base hospital to meet stable demand growth

C: $75

Upgradable hospital

C: $95

Demand increases above expectations

Demand growth stable (no additional cost)

Demand increases above expectations

Demand growth stable (no additional benefit, opportunity cost)

Build a new hospital (high cost and time intensive)

Manage services (potential delays)

Add additional floors to meet increased demand growth

Do not upgrade

B: $50

B: $100

C: $5

B:$150

B: $100

Option 1 Net Present Value: (0.5\*‑25) + (0.5\*25) = 0

**Payoff:** 50‑75 = ‑25

**Payoff:** 100‑75 = 25

**Payoff:** 150‑(95+5) = 50

**Payoff:** 100‑95 = 5

Option 2 Net Present Value: (0.5\*50) + (0.5\*5) = 27.5

Figure : Using a decision tree to undertake quantitative analysis (See previous page)

**If we proceed with Option 1**, we will pay a lower cost of $75 million. If demand is in line with expectations, this will represent the cheapest and best value for money solution.

However, there is a 50 per cent chance that population growth will exceed expectations, and that this investment will not adequately meet medium‑long term demand for health services. In this event, the Government would have underinvested in the problem and may need to consider taking further action.

**If we proceed with Option 2**, we will pay a higher upfront cost of $95 million. If demand is in line with expectations, we will have over‑invested in a hospital that exceeds requirements. In this instance, the solution accrues the same benefits as Option 1; but these are more than offset by additional construction costs.

However if demand exceeds expectations, we pay an additional investment of $5 million to upgrade the hospital. The total investment ($95 million initially then $5 million) offers the greatest benefits and value for money. The solution will meet long term requirements, and upgrades will offer a more cost‑effective and timely solution than building another hospital at a different site, or purchasing adjoining land to expand the current hospital.

In this way, we have used a simple decision tree to augment options analysis by factoring in the value of flexibility.

Decision trees have some limitations and disadvantages.

* + - Decision trees represent decisions and uncertainties as discrete ‘branches’. They assume a finite number of defined possibilities. You cannot define demand uncertainty as being a continuous variable or specify a decision that allows any scale of investment between levels A and B. For example, a key uncertainty might be the daily average or peak demand by cars to use a specific route in 2030 – a continuous (effectively) variable. If a decision tree is to be used, the continuous range of possible outcomes will need to be approximated by discrete levels of demand – and ideally not too many or the tree will become very big.
    - Decision trees are most effective for those investments where there are limited sources of uncertainty that could impact on the investment strategy, or where the sources of uncertainty can be aggregated in a limited way. When there are a large number of decision points, decision trees can grow exponentially and become much less user‑friendly, although many of the branches can simply be replicated. A number of decision tree software packages are available which can help practitioners consider investments with a larger number of real options and decision points.

Decision trees and decision analysis are DTF’s preferred real options valuation tools as they have proven most effective in their application to infrastructure investment development and delivery. *Appendix 3* outlines a number of other valuation techniques that agencies could also consider. DTF expects departments to engage appropriately skilled staff and consultants to advise when and how to use these other methodologies, and provides some tips and traps to help practitioners best manage those consultancies and interpret and analyse outputs. *Appendix 4* outlines some additional references that may be useful to practitioners.

#### Assessing consultancies

Agencies will need to remain closely engaged with any consultancies to ensure real options analysis effectively supports their investment development. Some tips to think about:

* + - **Sector knowledge:** Real options analysis requires an in‑depth understanding of the service sector, including the service delivery and operational environment and the types of uncertainty that are likely to impact it, but it is not necessary for the consultant to have this knowledge. It is more important to engage consultants that have a deep understanding of real options analysis, have experience contributing to real options planning and evaluation across many sectors or types of problems, the ability to think strategically (outside the square) and to challenge conventional decision‑making. The consultant can then draw on in depth sectoral knowledge from within the agency or elsewhere.
    - **Garbage in equals garbage out:** Real options analysis can be extremely data‑intensive. Where poor quality or inappropriate data is used to inform analysis, the outputs are also likely to be poor quality and possibly misleading. Practitioners are encouraged to review the quality, accuracy, completeness and currency of all data inputs to models and robustly test their appropriateness for use in the analysis, while noting that real options is a method for working with uncertainty and so some data may not be precise. In contrast to traditional CBA, real options can add value by mapping what is known, and what is not known, about the key uncertainties. Specification of what is not known can be a key input to real options planning.
    - **Time:** Real options analysis can be time‑intensive. Practitioners should ensure sufficient time is provided for options analysis and development to ensure robust outputs. Equally, care is needed to not over‑engineer the analysis which delays decision‑making with little gain. Real options reasoning commonly identifies quickly the benefits of investing in information early, delaying options or staging options without detailed analysis of the later branches in the decision process.
    - **Peer reviews:** Consider using peer reviews to confirm the appropriateness of outputs. Gateway reviews provide important mechanisms to test the robustness of options analysis. Obtaining an independent assessment of the analysis from external consultants will also provide Government with greater assurance regarding the proposed solutions.
      * 1. Describing the recommended solution/preferred option

Analysis of the project options will identify a preferred solution that may be an adaptive process incorporating an upfront investment to secure greater flexibility, and a longer term strategy, subject to how key uncertainties play out.

Government’s approval to proceed with an investment strategy will be on the basis of this preferred solution, and therefore agencies will need to prove that the proposal is deliverable. If the recommended solution comprises a real option(s), the second key task at Stage 2: Prove is to planwithin the business case for how management will respond to circumstances as they change.

In describing the detail of the recommended solution in the full business case template, agencies should clearly outline the real options strategy, including trigger points, indicators of those trigger points, processes for reviewing the trigger points as new information emerges, and alternative trajectories if those trigger points are met. Agencies should specify whether the options are able to be exercised by:

* + - Government;
    - central agency;
    - delivery agency; or
    - the contractor (but options should generally be at the agency’s discretion to exercise).

**It is important to note that exercising some options will require consideration and approval by Cabinet or Cabinet Committee, not just the portfolio Minister and/or the Treasurer.**

During investment delivery, project teams may need to take action quickly in response to changing conditions. Time delays resulting from needing to seek Government approvals can be costly. Consider whether it is possible to seek upfront Government approval (i.e. in the business case stage) for the investor to take decisions to exercise specific actions at appropriate times to avoid these time delays.

This section should outline metrics enabling effective decisions to be taken ‘mid‑stream’ to adapt to changing circumstances as an indicator of a strong, responsible and informed resource manager (rather than attract the stigma of management failure).

* + - * 1. Real options in the procurement analysis and strategy

The procurement strategy section of the full business case should demonstrate that the procurement approach can appropriately accommodate the real options approach. It should include:

* + - **Data gathering** – identify sources of project uncertainty. Consider circumstances or trigger points impacting on each of the alternatives and influencing decision making. Determine the capacity of internal and market resources to manage uncertainties and real options.
    - **Evaluation of procurement approaches** – the short‑listing process should consider the extent to which each of the procurement methodologies will support flexible project delivery, where required, and will therefore accommodate a real options approach to managing uncertainty. If a procurement methodology is a constraint to flexible project delivery, this should be considered as part of the identification and assessment of options. Some value for money analysis is required to assess the cost of insuring against uncertainties versus the cost of those uncertainties being realised.
    - **Preferred delivery model** – document how the Expression of Interest, tender and contract documentation will need to be tailored to manage potential implementation of any real options alternatives.

Will the real option be attractive to the market? Specifying flexibility may create risks that the market is unwilling to take on, even at a price. The structure and maturity of the supplier market will need to be carefully considered to ensure that potential suppliers are capable of responding to changes in the project resulting from the application of real options.

Real options can be used in parallel with any procurement model, however some models will be better suited to certain options than others. *Appendix 7* outlines common procurement methodologies and how they treat real options.

If deemed suitable, the procurement strategy selected must be consistent with the real options thinking, and not lock out the ability for the investment to change course at defined trigger points. This may mean that the procurement approach adopted for each stage of the investment can change.

* + - * 1. Governance and approvals

Governance for investing under uncertainty follows the same general principles as for a traditional government investment. Exercising a real option can significantly alter an investment strategy, so it is important that the governance arrangements clearly indicate:

* + - conditions or triggers for exercising an option;
    - who is responsible for monitoring these conditions;
    - who has the authority to exercise an option; and
    - any requirements that should attach to the exercising of an option.

This may include Ministerial or Cabinet approvals.

The business case should outline how real options metrics and trigger points will be adhered to and ensure that, having designed real options, decisions are taken before any option expires.

It is also essential to communicate clearly with Government itself. In the approval process it should be clearly identified that the project will be subject to real options, seeking approval for both the identification of those events that would trigger a change in the project, the specific change(s) that would follow and the potential funding implications.

It is important to note that potential conflicts that could arise between the investors and the project delivery team perspectives as to when an option ceases to be attractive. Clarity around the roles and responsibilities is critical, and these should be addressed in tender and contract documents.

* + - * 1. Project management

#### Detailed costing and economic evaluation

It is important to consider how any real options or strategies for dealing with uncertainty are considered in the project budget. While project teams are encouraged to refer to DTF’s Investment Lifecycle Guidelines technical supplement, *‘Preparing Project Budgets for Business Cases’*, to inform project costings development, investment optionality may introduce additional complexity.

Firstly, you should consider whether any funding is required up front to establish an option or create flexibility. For example, you may need a small budget allocation for project development works, such as undertaking feasibility studies, site investigations, or to acquire land. Projects that incorporate some aspect of design flexibility during construction to allow for future proofing are also likely to require additional budget in the initial funding commitment. In these instances, the business case should clearly identify any necessary costs required to establish the right to take future action. For example, if you build an asset incorporating the design flexibility to increase capacity at a later date, there may be an initial cost for the benefit of being able to adapt the asset more easily and cheaply at a later date.

Other types of options do not require any up front funding. Noting that an option is simply the right, and not the obligation, to take a specific action, an option is not compulsory. It may only be exercised under certain pre‑defined conditions. If these conditions do not eventuate, there will be no opportunity or need to take the course of action. In these instances, any costs associated with the option are unlikely to be included in the initial funding commitment. For example, where project delivery is staged, funding approval is also likely to be staged, and allocated only upon the successful completion of the previous stage.

The business case should clearly define any optionality and associated costs, as well as the triggers that would indicate an option could be exercised. The department would need to seek funding approval to exercise the option once a trigger point is met or approaching.

**This interface should be clearly outlined in the business case with clear recommendations on holding funding in contingency (either centrally with DTF or with the department) subject to certain triggers occurring**. It is important this is addressed in the minutes of any funding decision where a real option may be exercised, and confirmed with DTF following approval.

#### Timelines and milestones

The project team will need to outline the milestones and timelines for the preferred project option within the business case. Where a project incorporates one or more real options, there are multiple possible project trajectories or future states. In these instances, timelines and milestones should be developed (where possible) for all possible trajectories. This will help inform stakeholders and suppliers of the impacts that executing an option could have on the project schedule.

#### Performance measures and benefits realisation

The Benefit Management Plan should indicate how any optionality may impact the expected benefits (either positively or negatively), as well as the corresponding benefits measurement and monitoring strategies for all possible trajectories.

#### Stakeholder management and communications

Adopting a real options approach implies that there could be significant changes in an investment in response to uncertainties that might affect the investment. Such changes are likely to concern many stakeholders. It is essential to obtain stakeholder responses to those uncertainties and the proposed response.

Communications will be essential in the actual event of a shift in the investment. Determining how such information is managed will be essential in maintaining effective stakeholder relations, and ensuring public sentiment doesn’t effectively extinguish some options. This should be done in consultation with the Government.

* + - * 1. Prove summary

Revisit and reconfirm the problem definition, benefits and strategic interventions:

* + - Some uncertainty may have been resolved as a result of greater information.
    - Where uncertainty still exists, agencies should consider strategies for delivering the investment incorporating flexibility to dynamically manage the uncertainty if circumstances change.

Consider, value and analyse the impact of uncertainty and flexibility with regard to potential investment solutions:

* + - Consider how any strategic real options actions should be incorporated into the business case and any governance structure or approval mechanism required to action any trigger points.
    - For each option that enables uncertainty to be managed through flexibility, undertake real options valuations (using the real options tool kit).

If the preferred solution comprises a real option(s), plan how the investor will dynamically respond to circumstances as they change: ensure procurement analysis and the resulting procurement strategy effectively plans for the implementation of any real options.

**Key decision point – End of Stage 2: Prove**

At the end of Stage 2 Prove, agencies should confirm whether the preferred solution includes one or more real options. If Government approves funding of the investment, this approval should be on the basis of any real options included in the preferred solution.

Agencies should discuss the appropriate application of real options for each investment with their DTF representative.

Text Box 12: Key decision point – End of Stage 2: Prove

* + - 1. Stage 3: Procure – Planning for implementing real options

|  |  |  |
| --- | --- | --- |
| Lifecycle stage | Real options objectives | Key actions |
| **Stage 3: Procure**  Finalise the planned procurement approach, specify requirements, engage the market and award the contract. | **Develop a plan, processes and mechanisms for implementing any ‘on project’ real options requirements**  **Communicate any relevant real options requirements to the market**  At the end of this stage agencies should have engaged a supplier to deliver an investment solution incorporating the real options requirements and awarded a contract incorporating mechanisms to support real options implementation. | * Ensure the procurement approach and plan identifies any relevant real options, opportunities and required flexibility to manage uncertainty, including options, trigger points and option costs. * Ensure due diligence and technical specifications reflect required flexibility (such as multiple inputs/outputs or future proofing) if relevant. * Ensure real options requirements are outlined clearly in any market engagement documentation. * Ensure contract documentation clearly addresses any real options or flexibility requirements, including when and how any real options can be exercised, actions to be taken and the resulting impacts. |

Table : Real options in Stage 3: Procure

In Stage 3 Procure, the Government seeks to purchase the solution that best enables agencies to realise the investment objectives and benefits approved in the Prove stage of the investment lifecycle. It involves seeking market offers to undertake a scope of works, including market testing, tender preparation and documentation, project tendering and contract negotiation. It results in appointing a supplier(s) to deliver the investment outcomes under a contract.

The scope to preserve and extinguish options extends into the procurement and implementation phases through the negotiation of commercial models and terms for investment, and the ongoing governance of the investment.

In the Procure phase, the primary real options objective is to ensure that any relevant ‘on‑project’ real options or flexibility requirements are built into the procurement and contract documentation so that they form part of the deliverable solution.

Procurement and contractual flexibility help Government manage and adapt to uncertainties in a cost‑effective and timely manner. The project tendering or procure phase has the potential to either:

* + - create the flexibility for a proposal to adapt to any uncertainties, as identified under a real options approach; or
    - prevent flexibility by locking in inflexible scope, budgets or timeframes.

The potential to lock in or lock out flexibility can occur through the tender or contract documentation.

To reflect any required solution flexibility throughout the procurement stage, you should ensure:

* + - The procurement plan identifies all known real options and opportunities, and clearly outlines:
      * what the option is, and the decision making required to exercise it;
      * when trigger points will occur, and timing for when these options are likely to come into play (including adverse situations and opportunities);
      * who key stakeholders are (departmental, Governmental and potentially supplier), and their roles and accountabilities to approve and exercise each option;
      * what the likely outcomes are, including success criteria and the impact that exercising the option will have on the investment trajectory;
      * the monitoring and evaluation framework in place to review conditions and ensure options are exercised appropriately and in a timely manner;
      * impacts (including cost and timeliness) of exercising the option on the procurement model and strategy and potentially on (re)negotiations and contract; and
      * any appropriate rights, liabilities and obligations the agency and/or contractor will need to enable the real options strategy to be put into effect.
    - The investment strategy is updated throughout procurement to reflect any certainty gained through new information. For example, any due diligence or information (especially relating to market supply factors and proven solutions) gained through the tender process and may lead to real options being exercised or removed from consideration.
    - All Expression of interest, tender or other market documentation clearly outline any real options and flexibility requirements relevant to the procurement stage to inform suppliers of all potential procurement outcomes, and to allow them to structure their tender accordingly.
    - Contract documentation clearly outlines any real options or required flexibility, when and how any real options can be exercised, and the resulting impacts.

**Note:** The above considerations should be scaled depending on the nature of your investment and any real options.

* + - * 1. Cost considerations

There is likely to be a cost to invest in flexibility to enable an investment to succeed under uncertainty. There may or may not be a higher up‑front cost. Often there is a lower up‑front cost with further costs later when it is clearer how the key uncertainties are playing out.

If an investment strategy ignores uncertainty that is then realised during project delivery, Government may have to agree to costly contract variations to manage the changing conditions. By outlining the required flexibility in the procurement documents, Government benefits from pricing this requirement in a competitive environment when they lodge their tenders for the project.

Investments incorporating real options are likely to have a different risk profile, with some risks retained by government and others transferred to other parties. This is likely to result in a change in price profile – if uncertainty may lead to a change in a project during implementation, the contractor is likely to front‑load its pricing profile to potentially avoid future revenue losses (in the event of termination). You may need to investigate incentives to avoid this, and outline where it may be more cost effective to hold risks centrally (depending on the level of control and likelihood of occurring).

The conduct of a tender requires fairness and clarity. Procurement requires departments, suppliers and stakeholders to all clearly understand the business requirements and any business changes required. If real options are an element of the investment strategy, there is a possibility that changes may occur in the course of an investment in response to the outcomes of defined uncertainties. It is essential that, **where relevant**, all stakeholders have a clear understanding of:

* + - why real options are being applied to the specific project;
    - the circumstances that may stimulate a change in the project, and how these will be measured and monitored;
    - when possible changes might occur or be executed;
    - the nature of the government’s response to those circumstances;
    - the process for executing the change in the project;
    - what would change in the investment strategy in response to specified events; and
    - what the rights and responsibilities of government, stakeholders and suppliers would be in the event of a change in investment strategy.
      * 1. Probity and approvals

Practitioners need to consider whether including any real options in the procurement strategy could impact probity. As with any government project, it is important that all tenderers receive the same tender information, including any amendments that occur during the tender period. It is also important that all tenders are assessed against the same tender evaluation criteria, and that the criteria reflect any material real options relevant to the procurement phase. Practitioners also need to consider how including real options within a procurement process may impact on the government approvals process. The person approving a procurement, whether it be the Treasurer (i.e. for High Value High Risk projects) or a Minister or other officer, should be clearly informed of all potential procurement outcomes and eventualities prior to executing a contract.

**Tips for applying real options at Stage 3: Procure**

* All parties to the procurement should be aware of any uncertainties impacting the investment, and the need for the procurement approach to be adaptable, where relevant.
* Trigger points and governance frameworks for decision making should be clearly set out in the documentation and agreed by all parties.
* Contract documentation should reflect flexibility where relevant.
* It may be appropriate for the procurement model to change at various stages or trigger points if circumstances chance.

Text Box 13: Tips for applying real options throughout procurement

* + - * 1. Tendering documentation

An Expression of Interest phase should be considered for projects involving real options. It is an important opportunity to introduce the fact that real options are being used in a project, to gauge the market’s reaction and to prequalify respondents to ensure mature responses to the real options approach

If the real options approach indicates that the project may be adapted over time in response to uncertainties, then this should be flagged in the tender documentation. The quality of the tender outcomes is linked to the clarity included in the tender. As a result, it is important that tenderers outline the uncertainty impacting an investment, the type(s) of flexibility sought, and the conditions under which each real option will be exercised. The tender documentation should include information on:

* + - the uncertainty to be addressed;
    - how it will be monitored and reported;
    - the trigger points and/or likely timing for a change in the project;
    - how the project will be changed (altered, delayed or even abandoned);
    - approval processes; and
    - the process for notifying the contractor of a change in the project.

#### Incorporating real options into solution design

Where relevant, the tendering documentation should address how real options will be incorporated into the solution design. For example, will the tender seek innovative approaches or will it be prescriptive in how the real options could be delivered? Some options and considerations for incorporating the solution design for key parties are outlined below.

Options for the client agency:

* + - Include options to structure the contract with defined staging, breaks and/or extensions or having sequential contracts.
    - Include credible and deliverable contingency plans, such as defined early termination mechanisms, to allow an exit or abandonment option to be efficiently exercised.
    - Ensure a full description is made in the tender documentation of the client’s options.

Options for the contractor:

* + - Identify and describe how the client agency will use real options in tender documentation.
    - Ensure the mechanisms for exercising or not exercising the options and potential consequences are fully described in the project contract.
    - Explain how the agency will conduct a tender that establishes the baseline project cost, and then invite tenderers to propose and price the value of real options that they can exercise as well as opportunities for savings if they arise during the construction program.

Depending on what is being sought, tendering processes are not just about finding the lowest cost, reliable provider of scripted services. Smart ideas that offer potentially valuable options may emerge during the tendering process. Some tenderers would love to compete in terms of these clever ideas, rather than just on the price of a scripted product. Overly constraining tender responses can eliminate or discourage such ‘competition in ideas’.

There may be scope for documenting one possible specification and allowing non‑conforming offers. However, the incentives remain stacked against a tenderer who has a smart proposal for doing it differently and better, but is not well placed to submit a complying offer. Agencies should carefully consider how they will assess conforming and non‑conforming bids.

#### Real options implications during the preparation of tender documentation:

Consider the wider network

Consider wider network character implications of the commercial model, and of the contracts involved, for risks to the overall network strategy. Ensure that risks are properly allocated inside and outside the portfolio. Decisions in the procurement of one investment may have portfolio impacts outside that investment. Therefore it is important not to lock out flexibility to the wider portfolio when preparing tender documentation.

Revenue guarantees can extinguish options

In relation to Public Private Partnerships, negotiation of this procurement model involves shifting risks around. For example, government might underwrite throughput demand on a toll road. It may well be appropriate that some throughput risk fall more to government, because the toll road managers may lack access to the instruments to manage throughput. By the same token, as soon as such underwriting guarantees are given by government, they can have the effect of altering the attraction of a range of policies and investments outside the project.

* + - * 1. Contracting for the delivery of ‘real options’

It is essential that any real options or required flexibility, including when, how and by whom they can be exercised, is clearly outlined in the contract documentation where relevant. Care needs to be taken to limit any constraints on flexibility that arise because of the commercial model chosen and/or the contract structure and terms. The contract needs to provide for any flexibility that is inherent in the investment strategy, including during the operational phase, where relevant. For example, if the strategy includes options to abandon, scale the project up, or down, then the contract needs to allow the government to exercise these options. A contract may need to incorporate specific clauses to ensure flexibility requirements or opportunities are not locked out.

The contract should also reflect a pricing schedule that contemplates real options being exercised.

* + - * 1. Stage 3 Procure summary

**Key decision point – End of Stage 3: Procure**

At the end of Stage 3 Procure, agencies should have engaged a supplier to deliver an investment solution incorporating the real options requirements and awarded a contract incorporating mechanisms to support real options implementation.

Text Box 14: Key decision point – End of Stage 3: Procure

* + - 1. Stage 4: Implement – Implementing real options and dynamically responding to changing circumstances

|  |  |  |
| --- | --- | --- |
| Lifecycle stage | Real options objectives | Key actions |
| **Stage 4: Implement**  Implement the investment solution and transition to normal business | **The identified real options dynamically respond to changing circumstances and use flexibility to effectively manage uncertainty**  At the end of this stage agencies‑should have implemented any on‑project real options as appropriate during the delivery of the investment solution. | * Using contractual and governance mechanisms and strategic management functions ensure any on‑project real options are implemented as and when appropriate. |

Table : Real options in Stage 4: Implement

Stage 4: Implement relates to delivering an investment solution and transitioning to normal service delivery. It includes project managing the works under contract through to completion and handover to the ongoing business owner. It results in an operational asset that contributes to the department’s service delivery requirements and achieves the desired investment benefits.

If an investment is impacted by uncertainty during the implementation phase, there may be significant changes to:

* + - the scope of works being delivered, and contractual requirements;
    - the benefits being delivered;
    - the procurement methodology;
    - budget; and
    - schedule.

While the overwhelming majority of real options analysis literature focuses on using options valuations to develop a business case for a project, the value of options is realised in the implementation stage. Incorporating an option into a project to help manage uncertainty can add value to that project. Practitioners need to actively monitor the project to ensure it extracts this value. If an option holder fails to make exercise decisions optimally, the options become far less valuable. For example, if you buy car insurance, but do not file a claim when you have an accident, you will have overpaid for the insurance.

Where a project incorporates real options, the objective is to deliver the investment that responds favourably to changing circumstances and delivers the most appropriate infrastructure to support on‑going service needs. This approach requires a different type of contract management. Contract managers not only need to be competent contract administrators, they also need to be service specialists with a practical knowledge of the changing service delivery environment.

Agencies need to actively monitor market supply and demand factors and identify conditions and events that impact on the investment strategy. Practitioners need to dynamically respond to these changing conditions, and adapt the investment as greater information and certainty becomes available. This may include exercising real options at the optimal or appropriate time.

* + - * 1. Some tips for implementing investments under uncertainty

#### Governance requirements and approvals

At the Stage 2: Prove stage, government considers the case for an investment. If it approves the investment, that approval is based on a range of defined parameters, including scope, benefits, procurement strategy, estimated cost and schedule. During implementation, a project director is appointed to deliver the investment within these defined parameters. Where risks or uncertainty impact any of these parameters, the project director will need to seek approval to adapt the investment strategy. You will need to have clearly defined IN the business case (or as early as possible) who has the authority to approve any required changes:

* + - In some circumstances, the project governance board, the Investor or a portfolio Minister may have the authority to approve a change.
    - In some circumstances, the Treasurer’s approval may also be required – for example, the High Value High Risk framework requires the Treasurer to approve any significant contract variations.
    - Government (i.e. Cabinet or a Cabinet sub‑committee) approves most significant asset investments. If the basis of government’s investment decision is fundamentally changed, then government may need to approve changes to the investment strategy.

Agencies should confirm who can make a decision to exercise an option. You should have a clear understanding of the process to approve a decision, and approximately how long it would take. This practice extends to obtaining funding approval. It is likely that the original funding commitment excluded some or all of the costs associated with implementing an option. In these instances, the business case should clearly identify the triggers that indicate an option can be exercised, and the associated costs. The project team will need to seek funding approval if the relevant trigger is met or approaching, and it wants to exercise the option.

#### Monitoring implementation conditions

* + - What events or conditions may lead to a change in investment pathways?
    - How will these events or conditions by monitored, and by whom?
    - How will you confirm and agree the trigger point or optimal/appropriate timing to exercise an option with all stakeholders, including suppliers?

#### Tracking changes

* + - How will information and certainty be fed back into the investment strategy and decision making framework to ensure the project plan reflects the updated investment parameters?
    - How will benefits be recalibrated?

**Key decision point – End of Stage 4: Implement**

At the end of Stage 4 Implement agencies should have implemented any on‑project real options as appropriate during the delivery of the investment solution.

Text Box 15: Key decision point – End of Stage 4: Implement

* + - 1. Stage 5: Realise – Measuring success and implementing real options

|  |  |  |
| --- | --- | --- |
| Lifecycle stage | Real options objectives | Key actions |
| **Stage 5: Realise**  Measure the success of the investment | **Assess the effectiveness of any optionality in enabling the project to respond to uncertainty and changing circumstances while delivering Government’s intended outcomes.**  At the end of this stage, agencies should have assessed the benefits delivered by the project.  Agencies should continue to monitor demand and supply conditions impacting on the investment and implement any in‑project real options as appropriate. | * Assess the effectiveness of the investment strategy, including analysing whether opportunities to manage uncertainty have been optimised to enhance benefits and to minimise downside risks. * Measure benefits delivered by the project, including assessing the outcomes of implementing any real options. * Ensure stakeholders are aware of the impact exercising the real option has had on delivering the intended outcome. It may be necessary to include a communication plan for government to outline the rationale and benefits of the exercised option and variation from the original project. * Manage asset through its operational life, responding to changing demand (alternative outputs) or increased demand (future‑proofing). * Identify whether new options have emerged that should now be considered. |

Table : Real options in Stage 5: Realise

Stage 5: Realise relates to managing an asset throughout its operational life to meet evolving service delivery requirements. A large focus of this stage is measuring the success of the investment: reviewing the extent to which the investment was successfully delivered on time and on budget, and achieved the desired benefits. The review should identify lessons learnt that could inform and improve future investment management.

This stage can also be used to identify whether new options have emerged that should now be considered, and a checkpoint within a multi‑stage project to decide whether and how to proceed further.

* + - * 1. In‑project real options

Throughout its operational life, an asset may need to be adapted to continue to meet evolving demand and service delivery requirements. Departments may need to exercise in‑project real options to support ongoing service delivery. For example:

* + - scaling up or scaling down service delivery;
    - changing inputs or outputs; or
    - temporarily or permanently ceasing service delivery.

Exercising in‑project real options needs to be supported by:

#### Contract mechanisms

Service contracts should clearly indicate the conditions and trigger points which might lead to Government exercising an option, who can exercise the option, and the resulting outcomes and impacts on all parties.

#### Monitoring and reporting

Agencies will need to identify if and when it is appropriate to exercise an option. This decision point should be informed by regular monitoring of demand and supply conditions, asset performance indicators and benefits evaluation.

* + - * 1. Measuring benefits realised

Traditionally, an investment evaluation is a review of objectives, outcomes and benefits against the investment strategy and parameters outlined in the original business case. As we have seen, uncertainty can significantly alter an investment’s parameters and pathway. Where an investment includes one or more real options, the resulting asset – and related service output – may be quite different to that initially envisaged. This could make it difficult to assess against your original objectives.

Firstly you need to clearly understand what benefits you are measuring. Consider:

* + - Whether the original business case assumptions remain realistic and valid?

OR

* + - Has an event occurred or circumstances arisen that have fundamentally altered the investment strategy and parameters, and has this change fundamentally altered the services and benefits you are trying to deliver?

If the parameters have significantly changed, you will need to define an updated set of desired benefits

* + - Has the project team updated the Investment Logic Map and business case during implementation to reflect the altered objectives and any changes to the desired benefits?
    - If not, is there any other documentation that addresses your updated requirements, such as the procurement and contract documentation or project plan?
    - If not, you will need to define your updated requirements. You will need to outline why the benefits have changed from the original business case, supported by evidence addressing how an event or changed demand and supply conditions has impacted the investment parameters.

You may need to develop measures and KPIs that respond to the strategic intent (i.e. general objectives) of the investment.

Be careful to differentiate between direct and indirect investment outcomes. For example, are the benefits that have accrued directly linked to the investment delivery, or can they be attributed to other factors, such as population growth, change in service delivery models, etc.

If your project was temporarily or permanently abandoned, consider how this impacted on benefits delivery.

* + - Has this resulted in cost savings or any unrealised costs beyond the direct project budget?
    - Are the benefits no longer required or are they being met in another way (i.e. by a different investment or service delivery approach, or by a different supply mechanism)?

OR

* + - Do the desired benefits still require government investment or intervention to address them?
      * 1. Measuring project delivery (on time and on budget)

When evaluating how well your project tracked against schedule and budget you may need to consider:

* + - Was the project schedule impacted by an event or changed conditions?
      * Did you have to deliver additional/altered scope?
      * Did you have to time a project to align with interdependencies or factor in market conditions? Did this cause delays or project acceleration?
    - If a real option(s) was included in the procurement documentation, how did suppliers respond?
      * Did they alter their pricing schedule and ‘front‑end’ bids to ensure they received maximum profit? Was this effective?
    - Was the project budget impacted by an event or changed conditions (either anticipated or not)?
      * If the project was stopped, were additional (beyond the project budget) costs avoided?
      * If the project was amended or expanded, what was the relative benefit? (see section 4. 3. 3 on options for valuing this impact)

Note: It is important to remember that successful project delivery does not necessarily translate to a successful investment. When considering the project in total, did the investment result in a value for money outcome? If used, to what extent did using a real options approach contribute?

* + - * 1. Capturing lessons learnt

When thinking about lessons learnt, you should consider all stages of investment development and implementation. You should also think about both the things you did well and opportunities for improvement.

#### Project initiation and business case development

* + - How well was the service need appropriately defined?
    - Did you identify any uncertainty that arose during investment delivery?
    - How well did your investment strategy plan for this uncertainty? Did you have adequate flexibility to respond favourably to changed conditions?
    - Did you effectively identify the most appropriate options to deliver the investment need?
    - How effective was any real options analysis and valuation exercises?
    - Did you identify the most appropriate conditions and trigger points for exercising the options?
    - Did you select the procurement model that best supported your investment strategy, allowing you to effectively exercise real options as necessary?

#### Procurement

* + - Did the procurement documentation adequately communicate any real options?
    - Did all stakeholders, especially potential suppliers but also other government bodies, community sectors etc., clearly understand the real option objectives?
    - How did suppliers respond to the tender – in hindsight, would you have done anything differently?
    - Was uncertainty considered during contract negotiations? How?
    - Did the real option(s) impact the pricing schedule? If suppliers front‑ended their bids, could you have offered any incentives that achieved a better outcome?
    - Did the procurement process present additional innovative solutions?

#### Implementation

* + - How well did you monitor market demand and supply conditions?
    - Were trigger points enacted in a timely manner?
    - Did you anticipate events or changes in conditions that lead to trigger points?
    - How effective were the contract arrangements in managing the investment under uncertainty?
    - How effective was the contractor in delivering the investment under uncertainty?
    - If any real options were exercised, how were these portrayed in the media? Was Government’s messaging effective?

It is important to note that project teams may expend great effort at the start of the project to increase the value of a project by improving investment flexibility and optionality. This value diminishes, and can even be lost completely, if the project team does not monitor conditions and exercise options at the appropriate or optimal time. A post‑project review should consider how effective the project team was at managing and optimising any optionality.

**Key decision point – End of Stage 5: Realise**

At the end of this stage, agencies should have evaluated the success of the projects, including the extent to which real options supported the delivery of the project on time and on budget, realised appropriate benefits delivered, and achieved a value for money outcome.

Agencies should continue to monitor demand and supply conditions impacting on the investment and implement any in project real options as appropriate.

Text Box 16: Key decision point – End of Stage 5: Realise

Glossary

* **Economic assessment:** the process of identifying, calculating and comparing the costs and benefits of a proposal in order to evaluate its merit, either absolutely or in comparison with other options.
* **Exercise cost:** the cost to exercise an option.
* **Exercise date:** the date when an option expires.
* **Exercise trigger:** the conditions or event that define or signal when a real option should be exercised.
* **Investment:** the commitment of an organisation’s resources with the expectation of receiving a benefit.
* Investment types:

|  |  |
| --- | --- |
| Investment type | Description |
| Irreversible investments | Once these investments are in place, they cannot be reversed without losing much of their value |
| Flexibility Investments | Investments that incorporate flexibility in the form of options into the initial stage |
| Insurance investments | Investments that reduce the exposure to uncertainty |
| Modular investments | Investments that create options through product design |
| Platform investments | Investments that create valuable follow‑on contingent investment opportunities |
| Learning investments | Investments that are made to obtain information that is otherwise unavailable |

* **Investment lifecycle:** process of developing and delivering an investment, from project inception and business case development, through procurement and implementation to realising the intended investment benefits.
* **Investor (senior responsible owner):** the senior accountable officer responsible for delivering the investment benefits, usually the officer responsible for the delivery of services relating to the investment.
* **Option costs:** costs associated with creating the flexibility to change the investment’s strategy.
* **Option life:** the time to expiration of an option, or until the option is no longer available.
* **Options in‑project:** a real option that provides flexibility to adapt to and manage changing conditions during the asset’s operational lifetime after project closure. Common in‑project options include providing the ability to defer, phase, abandon, scale up, change the output mix of, or accelerate projects.
* **Options on‑project:** a real option that provides flexibility to adapt to and manage changing conditions during project delivery. Common on‑project options include providing the ability to defer, phase, abandon or accelerate projects.
* **Real option:** the right, but not the obligation, for an investor to undertake certain specified actions in the future to alter a project pathway when uncertainty impacts current project scope.
* **Real options analysis:** an investment planning, evaluation and decision‑making framework that incorporates flexible, qualitative and quantitative approaches to better plan and manage projects that are significantly impacted by uncertainty.
* **Real options triage:** recommended process to consider the extent to which real options analysis should be applied to an investment.
* **Risk:** the positive or negative variance from an expected outcome that would not change the desired investment strategy. Usually apply to the delivery of a project and are inside the project team’s control to mitigate and minimise.
* **Uncertainty:** a plausible event or change in conditions that may impact on the decision to commit to, and deliver, a preferred investment strategy. Are generally outside the project team’s control.[[19]](#footnote-19)

# Appendix 1: Types of uncertainty

The following table provides examples of some factors of uncertainty that may impact on your investment. The uncertainty may impact on the investment when the change in the factor is beyond expectations, rather than a change per se. This list is not exhaustive:

|  |  |
| --- | --- |
| Drivers of uncertainty | |
| **Demographic** | Record population growth |
| Rapid population expansion in growth areas |
| Changing land use patterns (including growth in regional centres and decline of rural towns) |
| Population change e.g:   * Change in birth rates * Ageing population * Changes in sectors of society, for example   + elderly;   + ill health, including mental health;   + Koorie;   + migrant;   + single parent family households;   + single person households; and   + socio‑economically disadvantaged. |
| Increasing inequality and decreasing social cohesion |
| Increase in chronic (preventable) disease |
| Changing workforce and human resource issues |
| Increase in use of services (beyond that attributed to population growth and ageing) |
| Changing community expectations. For example the need for an extension of traditional hours of service delivery |
| **Economic** | Globalisation/populism leading to isolation |
| Changes in global economic conditions and financial markets (e.g. booms, downturns and busts in stock, property and other markets) |
| Fluctuations in Australian dollar worth and impact on competitiveness of Australian exports |
| Structural changes to domestic economic activity |
| Industry sector trends, such as continued rapid decline in manufacturing and heavy industry and increases in service sector industries |
| Declining housing affordability |
| Interstate and international competition for services sector |
| Labour movement of specialist skills |
| **Environmental** | Climate change and increased frequency of extreme weather events |
| Increased prevalence and severity of bush fires |
| Changes to water availability and/or quality |
| Need and community drive for sustainability and ecological health |
| **Governmental, policy, legislative and legal** | Changes to national and State policy agenda and priorities |
| Changes to free trade agreements etc. |
| Asset failure risk |
| **Technological** | Rapid technological change, e.g.   * changing telecommunications; * semi‑autonomous and autonomous vehicles (e.g. driver‑less cars and driverless trains); and * 3D printing. |
| Innovation, technological disruption |
| Increased demand for online delivery of services (and faster delivery of services) |

Table *:* Types of uncertainty

# Appendix 2: Case studies

## The Channel Tunnel

The Channel Tunnel is a rail tunnel running underneath the British Channel linking England and France. After a long decision making process that included two previous failed attempts, the two Governments agreed to construct a fixed link between the countries in 1985. The project was to be delivered by the private sector with no government funding.

In 1994 the proponents delivered what is widely regarded as a major engineering accomplishment. However, it was delivered a year late and cost almost twice the estimated budget. It left the company with a major debt burden that would cripple its operations for the next 13 years.

This case study looks at how both supply and demand side uncertainty impacted the project’s success.

### Project summary

* The British and French Governments have considered the idea of having a channel tunnel linking the two countries for more than 200 years. A first attempt at tunnelling began in 1882, but was soon abandoned due to border security fears. In 1974, a mile of tunnel was completed before the governments cancelled the project because of increasing cost estimates.
* In 1985, the French and British governments invited proposals for a fixed link – not necessarily a tunnel – between the two countries. There were four serious contenders. The Eurotunnel proposal was selected on the basis that it was technologically the simplest and the most financially robust.
* In 1986, the governments entered into an agreement with a consortium to construct the tunnel on the basis of a Build‑Own‑Operate‑Transfer contract. The project was privately financed, with no recourse to government funds or guarantees. It is one of the largest privately‑financed infrastructure projects ever undertaken. The concession was originally awarded for a 55 year period, but was extended to 65 years. It expires in 2052, when Eurotunnel is required to hand it back to the governments.
* The resulting infrastructure is widely regarded as an engineering success. The American Society of Civil Engineers considers it ‘the largest engineering project in the history of humanity’, and one of the seven modern world wonders[[20]](#footnote-20). It comprises three tunnels, two single line rail tunnels and one service tunnel, each 50km long. The tunnel has the longest undersea portion (38km) of any tunnel in the world. It was officially opened in May 1994, with freight and passenger services commencing in June and November of that year respectively.



Figure : Channel Tunnel construction[[21]](#footnote-21)

* **Although it was an engineering success, for many years the project was seen as an investment failure.** The project was impacted by significant time and cost‑overruns. It took almost seven years to build, one year longer than scheduled. The proposal was estimated to cost £4.74 billion (1985 prices), at the time the most expensive construction project ever proposed. The cost finally came in at £9.5 billion ($US21 billion), almost twice the original budget.

### Supply‑side uncertainty

* There were two main factors contributing to the schedule delays and cost increases. Firstly, tunnel construction was disrupted by significant financial difficulties that nearly led to the collapse of the project well before it started operations. This was largely because the complex project financing structure made it difficult to negotiate contract terms, and led to the proponent having unreliable access to equity. Secondly, there was significant uncertainty relating to geological conditions and design requirements. As a result, tunnelling progress was initially poorer than expected, the logistical support requirements for machinery were underestimated and rolling stock requirements were more complex than anticipated. These supply‑side risks and uncertainties meant that when the project was finally delivered, Eurotunnel was left with a massive debt that crippled its operations.

### Demand‑side uncertainty

* Demand‑side uncertainties had an even greater impact on the project’s success. Patronage was significantly less than anticipated. The project’s business case anticipated 17 million users would cross the tunnel in its first year of operation: in reality it saw just over 7 million users. It would take almost 20 years of service before patronage levels would reach those anticipated in the business case: in 2013, 20.4 million people used the tunnel. Even today, patronage continues to be significantly less than projected.
* A 2005 Ex‑Post Economic Evaluation of the tunnel found that the demand forecasts underpinning the business case had ‘largely and systematically overestimated the total size and growth of the cross‑channel passenger and freight markets’[[22]](#footnote-22). This is attributed to two main factors. Firstly, the business case estimated that the overall cross‑channel market would grow much faster than it actually did. Secondly, it assumed that other market competitors, such as ferry services, would concede market share to Eurotunnel. In doing so, it grossly underestimated the capacity and capability of its competitors and their potential to significantly cut their prices and still remain profitable.
* During the Tunnel construction, ferry operators invested heavily in new, larger, more efficient vessels and introduced efficiency measures. As up to 50 per cent of their profits were made on duty free sales (up until it was abolished in 1998), ferries were able to compete aggressively on ticket price. A new market entrant further impacted demand. The popularity of budget airlines, which could compete on both price and time, skyrocketed at this time. On the other hand, Eurotunnel’s original operating concept did not allow any price discrimination, meaning that they could not be price competitive or adjust prices to its customers’ willingness to pay. These demand‑side uncertainties had grave implications for Eurotunnel’s revenue streams and financial stability.

### Investment outcomes

* The combination of crippling debt, resulting from escalating construction costs, and revenue shortfalls, due to inadequate demand, severely impacted the investment success. A cost‑benefit appraisal of the project undertaken in 2005 found that ‘overall the British economy would have been better off had the Tunnel never been constructed, as the total resource cost outweighs the benefits generated’[[23]](#footnote-23).
* The report found that in order to obtain a positive net present value, passenger and freight volumes would need to grow at an annual rate of 10 per cent – unachievable given the limited capacity of the Tunnel and the size of the market. It suggested that a positive NPV for long‑term operation could only be achieved by writing off the unpayable debt. In 2007 this was achieved. Eurotunnel sought bankruptcy protection from the French courts, and was able to undertake a financial restructure leaving it with much less debt. A first dividend to shareholders, promised in 1995, was paid in 2009.
* Since 2007, the company has operated productively in the market and has managed to increase its market share, although patronage remains about half that anticipated. It has also explored other options to increase its investment return.:
  + In 2014 it sought to extend its market further by allowing rail service competition and expansion to other destinations. This has been partly successful, with services now operating to southern France, Rotterdam and Amsterdam.
  + In 2017, construction began on ElecLink, a 1000 MW high voltage direct current connecting the electrical grids of the two countries. The project cost is estimated at €580m, and is scheduled for completion in 2019.

### Real options

This case study intentionally focuses on the demand and supply‑side uncertainties that were realised during this investment’s implementation, and demonstrates the extent to which uncertainties can fundamentally impact investment success. It is also worth discussing whether there are any real options that could have been exercised during project construction that would have improved the investment outcome:

* there is evidence to suggest that the project would have benefited from deferral until greater information on demand trends was available. This includes obtaining greater certainty of passenger travel drivers and trends, as well as better information on competing market participants; and
* there is evidence to suggest an option to abandon the project in the event of unforeseen construction issues or changing market conditions would have allowed the contractor and French and British Governments the flexibility to cancel the project if costs began to outweigh potential benefits.

### Can you think of any other real options that could have been applied to the delivery of this project to improve the investment outcome?

* The project did contain an ‘in‑project’ real option, to be exercised in its operation stage, being the option to open a second tunnel, not before 2020.
* In January 2000, to fulfil the terms of the project concession, Eurotunnel submitted a feasibility study to the government, outlining two potential options for the second tunnel. The first option was to construct a tunnel containing two 46km‑long road carriageways, one on top of the other. This would allow motorists to drive between the two countries in about 30 minutes. The second option was for an additional rail link, allowing freight and passenger services to be separated.
* At this time Eurotunnel noted that it would consider the impacts of the proposal with respect to the company’s financial interests, and ‘neither project would become a reality until demand for the existing tunnel reached full capacity’[[24]](#footnote-24), anticipated in 2025.
* The British and French Governments were required to decide whether to proceed with one of the options by 2010. At that time, the existing tunnel was operating at about 50 per cent of its full capacity[[25]](#footnote-25). The Governments made the decision to **not exercise** the option to construct a second tunnel. This was no doubt the right decision to make at the time: the real option to increase the capacity of the asset did not offer sufficient value to outweigh the costs and delivery risks, given the low level of demand. However, in rejecting this option, the Governments will likely be required to pay the cost of losing this option, through higher procurement and construction costs, if they do decide to build a second tunnel in the future.

## Turning investment regret into success with timing options – technology projects

In 2012, the U.S. Air Force cancelled an ICT project after investing $US1.03 billion, and more than seven years of development, to deliver a system that did not demonstrate any significant military capability. The Air Force took the decision after an internal project review identified that it would require another five years and $US1.1 billion to deliver one quarter of the original project scope, with implementation delayed until 2020.

**Cancelling the project under these circumstances was no doubt the right action. The project had received a lot of criticism for the level of time and money invested to date, and little internal, political or public support for the project remained[[26]](#footnote-26). However, should the project have been cancelled earlier? If real options principles had been considered, could it have helped reduce the level of investment regret associated with this project? Let’s consider…**

### Project summary and timeline[[27]](#footnote-27):

* The Air Force initiated the Expeditionary Combat Support System (ECSS) project in 2004 in an ambitious attempt to replace more than 240 outdated Air Force computer systems with a single system. It aimed to support Air Force logistics and global supply chains, as well as to help provide the core financial information required for auditing purposes.
* The Air Force proposed to purchase commercial‑off‑the‑shelf software and to adjust the current Air Force business processes to accommodate the software capabilities, rather than develop a bespoke system. Market research indicated no single commercial‑off‑the‑shelf application could perform all of the functions necessary to accomplish the program, so the procurement strategy allowed for ‘bolt‑on’ applications.
* The procurement approach included two sequenced acquisitions: firstly the commercial‑off‑the‑shelf product solution; followed by a systems integrator. The Air Force awarded the off‑the shelf software contract to Oracle in October 2005, and the systems integrator contract to Computer Sciences Corporation in September 2006. Both contracts were awarded on the basis of a firm fixed price.
* The Air Force planned to deliver the project in three stages, or ‘releases’, with no pilots. This meant that each stage would be deployed to all Air Force facilities or bases at the same time.
* Work began on specifying all of the eventual systems processes, as well as concurrently reviewing the legacy environment. This work was significantly more complex and onerous than estimated. New requirements were added to the scope of works during project implementation. The Air Force also requested bespoke system modifications to help it integrate with business operations, rather than change business processes to accommodate the commercial‑off‑the‑shelf software as originally intended. This caused significant schedule delays.
* From 2009‑2011, the Air Force conducted three major reviews and restructures of the program and contract. Each review found that there were significant shortcomings in program progress, and that the project was failing to meet its objectives. After the third review in 2012, the Air Force cancelled the project.

### What went wrong?

In 2013, the Air Force’s Acquisition Incident Review (AIR) team investigated the project, and publically released an executive summary[[28]](#footnote-28) of its report. The review found a number of root and contributing causes of the project failure, including:

* ineffectual project governance, leading to decision uncertainty;
* poor understanding of existing data, processes and systems, and poor definition of future requirements;
* lack of tactical transition and execution plans;
* difficulties in implementing organisational change, including organisational cultural barriers;
* high staff churn; and
* unrealistic development environment that didn’t mirror the operational environment.

These are all common causes of project failure, and certainly not unique to this project.

The AIR team suggests that the project began to derail during the implementation phase, and their findings firmly point to project management practices as the biggest contributors to project failure. However, were there any earlier warning signs that could have been heeded? Let’s consider if there were any demand or supply‑side uncertainties that may have contributed to the project’s problems:

### Was there any uncertainty in the project?

Initially, demand for the project seemed fairly certain. The Air Force planned to deploy the system globally across all its operations and facilities and to remove all existing applications from use. Whilst the AIR team found that the end‑user community generally lacked confidence and trust in the project, the organisation would most likely have had sufficient policy levers to ensure its widespread adoption had it been implemented successfully.

However the project did contain a high degree of technical and functional uncertainty. The AIR team found the project ‘lacked defined requirements’ and that ‘the Air Force didn’t understand the ‘As‑Is’ or the ‘To‑Be’ architectures’. In fact it found that ‘no one in the organisation understood the data and business processes across all 240 systems that were to be replaced prior to appointing the contractors’. Many of these systems were developed by individual business units for a specific purpose, in isolation of broader Air Force processes. Even after the AIR team had completed their investigation, ‘the number of systems [the] ECSS was to replace is unknown’. This suggests that while the Air Force assumed the end product would be adopted across all relevant business units, there was a high level of uncertainty around how, why, by whom and how often it would be used.

There was also a high degree of market supply uncertainty. This was first identified in the procurement process: the Air Force could not identify a single supplier to provide the required scope of works; and they needed additional ‘bolt‑on’ applications to augment the software solution. It was reinforced when the three major project reviews found the program was not delivering the expected functionality and benefits.

The Air Force’s internal capability to deliver the project was also uncertain. According to the AIR team the ECSS acquisition was at least 28 times larger than any similar system development ever attempted by the Defence Department, and probably around 100 times larger than any project the Air Force had ever successfully delivered. The AIR team found the project team underestimated ‘the sophistication needed in tackling the enormous and complex effort’.

Despite this uncertainty, the Air Force proceeded with the procurement with limited project staging, without conducting any pilots and with a firm fixed price contract leaving little scope for change if adverse circumstances arose.

### Adopting real options principles could have helped this project in a number of ways:

As the Air Force improved the technical and functional definition of both the ‘As Is’ and ‘To Be’ architectures, it gained a clearer picture of the purpose and usage of the incumbent legacy systems. As the contract was awarded on the basis of firm fixed price, there was no flexibility to respond advantageously as this new information became available. However, this new information could have been used to re‑assess the demand projections and validate the expected benefits. Trigger points could have been set to prompt a re‑evaluation of the benefit‑cost ratio if demand or usage projections decreased significantly as the project went on. Exit clauses could have been built into the contracts that would have allowed the Air Force to cancel the project at certain milestones if prevailing conditions did not reflect project assumptions.

Given the high degree of uncertainty regarding the market’s ability to deliver the required scope, the project could also have benefited from a greater degree of project staging. The Air Force could have included a number of pilots in the implementation phase, and these could have been used as check points to evaluate whether the system was delivering the required functionality. Again, contract exit clauses could have been used to allow the team to cancel the project if system functionality requirements and other project success criteria were not being sufficiently met or the expected benefits were not being realised.

Using abandonment options could have supported the Air Force embark on such a high‑risk project. It could have provided the governance board with a clear decision‑making framework for taking appropriate action under a range of circumstances, It could have provided a legitimate exit strategy in the event of adverse conditions, and could have reduced political fallout by making it clear from the beginning that stopping the project was a potential result and not indicative of project failure.

## Building in flexibility for re‑adaptive use – Olympic Games facilities

Olympic (and Commonwealth) Games facilities are noteworthy examples of potentially long lived assets with short service lifespans.

Each Games, a host city is required to provide a facility, or ‘village’ where athletes will reside for the duration of the Games. This facility is typically a significant development, and may be either partially or wholly funded by the public sector (although can also be delivered by the private sector). It can take several years to plan, design and construct, and yet is only needed for its primary intended use for a period of approximately one month. A host city will need to provide a range of other event venues, many of which may also have no on going function.

The International Olympic Committee (IOC) has very specific design requirements for Olympic facilities, and these often do not align with the needs of other prospective users of the sites. This creates significant challenges for adapting the facilities for future uses. As a result, many past Olympic host cities have built great venues for the Games, but years later some of these venues sit underutilised or abandoned because there was little use for them following the events.

Planning for the subsequent use of these facilities is therefore critical to ensure the investment can provide long lasting functions and benefits. Options for embedding flexibility into the building design can help to future proof these assets against functional obsolescence.

With Olympic related real estate development, a Government or developer’s typical opportunity, or option, to slow, delay or abandon a project due to market conditions or other variables is removed. ‘The Games must go on’ – and that means that the Olympic Village development, or any other Olympic venue, still needs to be delivered despite prevailing conditions outside Government’s control. However by applying design flexibility in the early planning of these venues, Government can create a real option which enables it to take advantage of market conditions or opportunities at a future time. These types of real options provide the investor with greater service potential or other value over time, and provide a level of future proofing. The following discussion considers how flexibility and resilience can be used to enhance the long‑term benefits derived from investments that are primarily short‑term focused.

The first modern Olympic Village was constructed for the 1932 Los Angeles Games. The Village consisted of several hundred buildings, including 550 portable houses for athletes, as well as other amenities such as five dining halls, amphitheatres, a bank, hospital, dental laboratory, fire station and post office. The LA Olympic Games Committee planned to dismantle the site after the Games concluded and sell the portable houses. Considering these games were held in the middle of the Great Depression, this provided an affordable solution to meet the immediate service requirement that also provided ongoing function and benefits. The strategy was successful with every house being sold – many being shipped across America and even overseas.

Since then, Olympic Games have left host cities with a legacy of venues – some providing long‑term service value, while others have become white elephants and been abandoned. What seems to be the determining factor in ensuring the longevity of these facilities is the level of future proofing undertaken during the early planning phase to ensure building design is flexible to accommodate future uses.

For example, many critics suggest that the 1976 Montreal Games organisers were focused on creating architecturally iconic venues, and did not adequately consider their long‑term use. As a result it was widely reported that the city was left with a collection of remarkable facilities that have struggled to find continued, appropriate use – and a public debt of more than $1 billion that was not paid off until 2006. One venue, the Velodrome, remained open as a sporting facility until 1989. It was then successfully repurposed as a Biodome, a centre dedicated to ecology and environment[[29]](#footnote-29). However, as this was not a pre‑conceived use for the facility, it required three years of extensive renovation to enable this adaptation.

Similarly, for the 2008 Beijing Games, the organising committee wanted to create an iconic stadium to showcase the opening and closing ceremonies. The resulting National Stadium, known as the ‘Bird’s Nest’, cost $US428 million to construct. It will be used again for the opening and closing ceremonies of the 2022 Winter Olympic Games, otherwise it is heavily underutilised – since 2008 it has held only a handful of events a year. Costing $9 million a year to maintain, the venue was unsuccessfully suggested as the permanent headquarters of the Beijing football team, and there are now plans to use part of the stadium to anchor a shopping mall.

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| --- | --- |
| Beijing Olympic Stadium (Before)  Before: The stadium during the Games  Figure : Beijing Stadium: before and after | Beijing Olympic Stadium (After)  After: Disused and falling into disrepair*[[30]](#footnote-30)* |

However, other host cities have considered future use opportunities during the early planning of Olympic venues, and have incorporated flexibility into building designs to ensure their re‑adaptability. In this way, they have created sustainable assets that provide ongoing service function and value.

There are numerous examples of Olympic villages that have been successfully converted to a new use after the Games’ completion. These have been delivered in many different ways, from utilising all existing facilities (Los Angeles, 1984) to creating alliances with established institutions in Atlanta and Salt Lake City, and building entirely new neighbourhoods in a ‘new urbanisation’ effort to revitalise an area of the host city (Barcelona, 1992 and Sydney, 2000). Lake Placid, 1980, even went to the extreme of using a newly‑built medium security prison as part of its Olympic Village in an effort to provide a safe and secure facility for athletes.

Salt Lake City established its 26 hectare Olympic Village within the University of Utah campus. It utilised existing dormitory and institutional buildings, and constructed new buildings that would be converted to student housing facilities following the Olympics. This Village was a success, mostly due to the fact that the legacy uses of the Olympic facilities were well known during the design and planning stages. Although the Olympic Games were the initial driver for the new buildings, the site redevelopment was specifically designed for the University of Utah’s future use. The project team then considered how they could use design flexibility to incorporate Olympic requirements. This approach ensured the university was left with fit‑for‑purpose buildings.

Barcelona, home of the 1992 Olympic Games, has been heralded as a city that used the Games to its advantage. It had wanted to revitalise its run‑down industrial waterfront for decades before it won an Olympic bid. It used the Games as a catalyst to effect plans that had long been in the pipeline and would have been carried out anyway. Again, they planned for how the site would be used in the long‑term, and adapted it for its interim use during the Games. The result was a redeveloped beach‑front site, reconnecting the waterfront and the city, and creating a huge tourism drawcard.

For the 2000 Sydney Games, a 90 hectare site known as Newington Estate was selected for the location of the Athlete’s Village. The government‑owned site was situated 16km from the Sydney central business district. In 1997, the Sydney Olympic Park Authority signed a $590 million contract with a property development consortium to plan, design, finance and construct the village. It needed to provide housing for the 15 300 competitors and officials of the Games and subsequently for 7 500 competitors and officials for the Paralympic Games. The consortium would also carry out the reinstatement work on the Olympic Village after the Paralympics, and sell the reconfigured properties.

The consortium built nearly 900 townhouses, 700 apartments and nearly 300 modular homes. It has since been transformed into a successful residential suburb dominated by two and three‑bedroom houses. Forward planning to create a long‑term mixed use neighbourhood was the key to this successful transformation – the modular design of the facilities made conversion easier and more economical.



Figure : The Sydney 2000 Olympic Athlete’s Village[[31]](#footnote-31)

The 2008 and 2012 Beijing and London Olympic Villages claim similar success stories. In both cases, large sites were redeveloped to include quality accommodation and mixed use public open space. Both villages have since been transformed into vibrant neighbourhoods.



Figure : Beijing Village today – a successful integration into the surrounding neighbourhood fabric[[32]](#footnote-32)

Perhaps one of the starkest examples highlighting the benefits of future planning in Olympic infrastructure delivery is the investment undertaken for the 2004 Athens Games. The Greek Government invested heavily in preparation for the Games, upgrading a number of existing facilities and constructing new, purpose‑built facilities. A number of these sites are an investment success, while others have been abandoned and the investment has been left to decay. The most significant factor influencing this dichotomy is the extent to which the asset’s planning and design considered future uses.

The existing Olympic Stadium was upgraded in preparation for hosting a number of Games events, including the opening and closing ceremonies. The upgrade readied the venue for Olympic events, but also considered the stadium’s ongoing use. This proved to be a highly successful investment, as the stadium continues to be heavily used for football, sports competitions and music performances.

Similarly, when planning and designing the Olympic Village, the Government considered how the housing stock could be best designed to meet the Olympic Committee’s requirements while ensuring it could be readily adapted to suit residential needs. After the Games concluded, the Government sold the properties via ballot. There was a high demand for affordable housing, and 100 per cent of the properties sold. Today, the village maintains a high occupancy rate.

In contrast, the Government also redeveloped the former international airport site into a major sports complex, incorporating an indoor arena as well as outdoor baseball, softball, hockey and kayaking facilities. The facilities within the site were purpose‑built for the Games events with little or no design flexibility to enable re‑adaptive use. The facility, situated prominently on the waterfront just seven kilometres south of central Athens, was abandoned shortly after the Games. It fell into disrepair and has since been used as a temporary refugee encampment. Critics suggest this was primarily due to a lack of foresight and future planning. One industry expert suggests the Athens organising committee started to consider the future use of this Olympic venue less than two months before the start of the Games, when planning for re‑use needs to occur as early as during the bid process. [[33]](#footnote-33)

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| --- | --- |
| Image result for athens olympic baseball stadium  In its glory before the Games[[34]](#footnote-34) | Image result for athens olympic baseball stadium  After the Games – Refugee encampment[[35]](#footnote-35) |
| Figure : Athens baseball venue before and after the 2004 Games | |

A decade later, the Government is now planning to redevelop the site into the Hellinikon Metropolitan Park, a major seaside centre of hotels, residences, shops and public facilities and open space. *Figure 19* shows the extent of the vacant site in its prominent waterfront location within the densely populated suburbs of Athens.



Figure : The former airport site[[36]](#footnote-36)

When completed, the park will be one of the largest in Europe, and is expected to play a large part in the socio‑economic revitalisation of the city. Had a level of future planning been imposed, the Government could have harnessed the considerable money it invested to develop a world class Olympic venue to deliver these benefits 10 years earlier at potentially a much lower cost.

# Appendix 3: An overview of some real options tools and methodologies and their applications

This appendix outlines the basic application of the following real options valuation tools and methodologies:

* Black‑Scholes financial options model
* Decision analysis, supported by decision
* Numerical techniques
* Hybrid or integrated approach
* Tailored analysis.

Decision analysis is DTF’s preferred approach, and it has proven to be a more effective approach for infrastructure investment applications. However practitioners should be aware that no single approach is capable of dealing with all types of investments or all types of uncertainties. Many of the valuation models outlined here incorporate assumptions which can limit their application to infrastructure investment development and delivery. Selecting a particular approach to decision‑making implies a trade‑off in dealing better with some types of uncertainty over others. DTF encourages practitioners to discuss which valuation techniques support their investment’s unique characteristics with DTF and appropriate consultants.

## Financial options theory

Real options valuation theory has its roots in financial option theory, and many of the real options valuation methodologies are derived from financial options models, such as the Black‑Scholes and Bermudan models: DTF’s preferred options valuation methodology is Decision Analysis, supported by Decision Trees. As discussed in detail below, it has proven to be a more effective approach for infrastructure investment applications.

**Traditional options valuation techniques: Black Scholes (European) and Bermudan valuation techniques**

The first real option valuation approaches developed were the Black Scholes (or European) and Bermudan models. These were based on models developed in the financial sector to price financial assets such as shares of stocks and bonds.

The development of these models was pivotal in raising awareness of the limitations of traditional cost benefit analysis in appraising alternative investments in the presence of uncertainty. They played a crucial historical role in raising interest in the wider use of options methods to better manage risk and uncertainty.

These real options approaches are the focus of much of the real options theory and literature. They have been applied extensively to some sectors, such as mining, where investment decisions are relatively simple and certain.

However, there is little likelihood that the Black Scholes approach to option valuation will have much to offer in planning and managing big ‘lumpy’ capital investments of the type envisaged for these guidelines. Both these approaches assume that:

future asset behaviour and value conform to well defined processes and are reasonably predictable;

markets are complete and arbitrage opportunities are available;

sources of uncertainty are few and independent;

payouts or other costs of delaying decisions are small; and

planners have one or few options.

None of these assumptions hold well for major infrastructure projects or technology product development, where asset value behaviours are not well defined or market based, many sources of uncertainty exist and interact, and delaying decisions can be very costly.

**These traditional valuation techniques do not sufficiently address the complexities of infrastructure and ICT investment decisions, and DTF does not recommend their use for asset investment**

## Decision analysis

Decision analysis (including decision tree analysis) has long been used by engineers in systems design to examine contingent decisions and the implications of uncertainty for the design and valuation of project options.

A decision tree maps the sequence of decision and uncertainty ‘nodes’. Each branch of the tree represents a way that the project might reasonably evolve given what is known about the key uncertainties and the flexibility or optionality available to respond to the changed future state. Types of flexibility include to change, increase or decrease scope or delay or abandon.

There are decisions at each decision node, being the options available to the decision maker once the path has reached that node. This can be as simple as a decision to either commit now to build, or defer the commitment. This decision defines two distinct, and usually mutually exclusive, paths. In other cases, the number of available decisions may be much greater, but the principle is the same. **At each decision node, what is sought is the decision that offers the greatest forward net value (avoiding the sunk cost fallacy), and factoring in the effects of uncertainty.**

The uncertainty nodes identify where a factor or uncertainty may manifest and potentially influence the project (also referred to as trigger points). The decision maker will assign probabilities to each outcome. Unlike some other real options tools, these outcomes need to be specified as discrete possibilities in decision analysis, even if this means approximating a continuous outcome or uncertainty. For example, a price outcome might be approximated by two or more ‘representative’ prices, each with a specified probability. Average daily transport demand in a given period may be approximated by several outcomes within the plausible range (for example, low, medium and high). Wider forms of decision analysis can either avoid or reduce the impact of this requirement. Decision tree analysis is a special case of dynamic programming, and the more general version does not face this restriction. The objective is for the discrete probabilities, where appropriate, to approximate a continuous distribution giving a richer more robust analysis than a single point most likely estimate.

Decision analysis recognises that the ideal value maximising decision (or decision path) will be revealed only as uncertainty resolves through time.

However, in almost all practical cases, the uncertainty cannot be fully resolved before a commitment is needed. In those cases, the most appropriate decision is the decision which leaves the most valuable set of forward options on the table, given the remaining uncertainty. In addition to recognising that decisions which leave future flexibility can create value decision analysis also recognises that decisions which block off future options (even out of the money ones) can destroy value.

Decision analysis will not commonly lead to a major, irreversible pre‑commitment in the first period, if delay and strategic investment in better information could offer greater value, or if the commitment can be ‘staged’ at modest additional cost while reserving options. But, as with other real options methods, the value of this flexibility to needs to be weighed against the costs associated with delay.

Decision analysis:

* structures the problem in a way that is intuitively understandable;
* is able to deal with multiple sources of uncertainty;
* defines optimal choices based on the consideration of the probabilities and outcomes of each choice; and
* identifies an ‘optimal’ strategy over many periods of time.

The discipline of identifying the different states of the world or scenarios and the decision points is valuable in developing an understanding of the project. Indeed, the very process of mapping out a decision, even a highly skeletal tree, provides a structured way of setting down the essence of the problem and the range of possible ways forward. It can be viewed as inviting input to the scenario modelling in the form of statements about what is not yet known (the key uncertainties, but with scope for structuring them, for identifying their key drivers and for attaching values, or even just upper or lower bounds on the values, and any associated probabilities). The resultant tree then affords a *language* and a defined scenario of the future state that can be used by the parties to the decisions that need to be taken, to compare views on structure and assumptions in evolving the specification.

New options and strategies can be identified as the flexibilities and constraints are identified. Identifying tender or operational strategies and contractual implications is a particular advantage of decision tree analysis. It is common for the very structure of the tree to point to areas of potentially high value – for example, ‘if commitment A could be made conditional on outcome B, then risks would be greatly reduced and value may be added’. It can thereby become a valuable tool to design better strategies, which can be added into the decision tree as new decisions emanating from key decision points. Tenders and contracts can be written in a way which pre‑emptively hardwires the decision points in a cost effective manner.

Figure 20 shows the structure of a decision tree for a simple project. In the diagram, squares denote decision points, and the circle denotes a chance node.

The project involves an initial decision about whether to start the project, which Stage 1 costs $10 million, and a later decision whether to complete Stage 2 of the project or abandon it. Completing Stage 2 the project costs a further $30 million. Before making the second decision, managers are able to observe the initial outcomes, and determine whether these are favourable.

Promising stage 1 initial outcome

Un‑promising initial outcome

Invest in Stage 1 of the project ($10m)

Do not invest

Complete project ($30m)  
Project worth $60m

Stop project  
Project worth $0

Complete project ($30m)  
Project worth $20m

Stop project  
Project worth $0

No cost or payoff

Period 0 1 2 3

Figure *:* Decision tree structure

Once the tree has been laid out, decision analysis solves the tree from left to right, in principle working down each branch, to find the best possible decision at each point. One decision rule commonly used is to select the decision which offers the best average value, where average is a weighted average of the present values by their probabilities[[37]](#footnote-37).

At the decision point in period 2, the value of completing the project is the discounted worth of the project less the cost of completing the project i.e. 60/1.1 less 30 = $24.54 million. If the project is stopped at this point, its value is 0. Weighting each of these outcomes by their respective probabilities and discounting by one period gives the expected value in period 1 of investing in the initial project [0.5 \* (24.54) +0. 5 \* (0)]/1.1 = $11.16 million].

Discounting this value back a further period and comparing with the initial cost of the project suggests that it would be worthwhile undertaking, but only just. Figure 21 shows this process of rolling back the decision tree to determine the optimal initial decision.

EV = 11.16/1.1 – 10  
 = 0.14

Do not invest

EV = 11.16

Period 0 1 2

Value = 60/1.1 – 30  
 = 24.54

Value = 0

Prob = 0.5

Prob = 0.5

Figure : Rolled back decision tree

One of the disadvantages of the decision tree approach is that it can become cumbersome, with ‘bushy trees’ because it is necessary to set out all (or at least a sufficient number) of the possible scenarios. However, modern software packages facilitate the construction of decision trees through their replication facility (called ‘cloning’).

Furthermore, any decision tree that starts with a decision node, implying one of several up‑front decisions, is amenable to being broken down into separate trees, each of which can be solved and then compared to the others. This can aid in making the process more tractable, but the overarching structure of the full decision tree, with all the up‑front decision options identified, is still powerful in conceiving the problem and progressively improving the design of possible solutions.

Commercial software packages also commonly allow the incorporation of Monte Carlo simulation to calculate expected payoffs and the sensitivity of optimal decisions under plausible variations in key parameters. These Monte Carlo simulations are not restricted to the use of discrete representations of key uncertainties.

Simulation addresses the problem of the ‘flaw‑of‑averages’. [[38]](#footnote-38) It also enables the likely bounds of outcomes to be tested – for example to test the sensitivity of the conclusions to changes in the discount rate or changes in the probability of factors beyond the control of the firm.

While decision‑tree analysis is a useful first step in managing strategic investments, it does not provide valuations which are consistent with valuations in financial markets. In particular, standard decision analysis does not recognise that risk, and hence the appropriate private sector discount rate, will vary throughout the life of the project.

One possible approach is to incorporate a changing discount rate into the decision tree. For the private sector, this is likely to be most appropriate where there are distinct phases in the project, with very different risk profiles. One such example is a project involving exploration for oil, followed by production if the field is successfully developed. The exploration task is subject to very high specific risks, suggesting that a high discount rate is appropriate for the initial stages of the decision tree. However, once exploration has been undertaken and development of the field begun, the risks become much lower. Accordingly, the private sector discount rate used within the decision tree should be lower for this stage in the project. The Victorian Government discount rate policy for economic analysis of costs and benefits derives from an ‘opportunity cost of capital’ framework.

Varying risks can be dealt with using numerical techniques.

In many cases the construction of a standard decision tree, combined with appropriate sensitivity testing, will yield the key insights required for informed decision‑making. In many cases, the slight inaccuracies in option valuation that follow from the lack of adjustment for market risk will be immaterial.

Decision tree analysis can become quite complex and require a lot of data. However, it does not typically start out like this.

Decision analysis initially focuses on characterising the key uncertainties and the strategy elements that might prove useful. These are assembled into decision tree that is usually quite skeletal. The decision tree can be the focus for collaborative agreement on the nature of the problem and the strategy features likely to prove valuable and robust given the nature of the uncertainties.

In many practical cases, there may be little value in pushing the decision analysis further. The initial decision analysis may have enabled robust conclusions to be drawn about the next steps. Additionally, the key trade‑offs that will drive the choice of next steps may have been identified with further research as part of the development of the strategy and its business case.

Pushing the development of the tree further makes greatest sense when the early analysis indicates the best strategy is highly sensitive to key information gaps. The decision tree’s structure allows the cost of key uncertainties to be inferred, and to probe the cost‑benefit of investing further in reducing the high cost uncertainties.

Starting with a decision tree does not involve commitment to a complex process. But there is a possibility to progress to a complex assessment if (and only if) the early indications are that a sound strategy decision requires that extra complexity.

In some cases, early development of a skeletal decision tree may logically progress to a next stage in which one of the other tools discussed below plays a more prominent role.

## Numerical techniques

Numerical techniques are another form of computational analysis which can be used in addition to continuous time or discrete decision tree approaches. Effectively, numerical methods assume regular, discrete movements in important variables.

They tend to retain the non‑causal modelling assumption of the Black‑Scholes formula, but make it easier to relax some of the assumptions of the Black‑Scholes formula to deliver a practical solution to more complex problems.

However, as with the Black‑Scholes model, numerical techniques are less likely than decision analysis to fit well with the structure of major capital investments.

### Binomial method

The most commonly used numerical procedure is the binomial method, which uses an iterative process to trace the evolution of an option’s key underlying variables in discrete time. In using the model, the practitioner will develop a binomial ‘lattice’ or tree. The lattice will comprise a series of nodes, or points in time, between the valuation date and the option’s expiration date. Each node in the lattice represents a possible price of the underlying asset at a given point in time. In this way, the lattice approximates the behaviour of the underlying asset.

The binomial option pricing model assumes a perfectly [efficient market](https://www.investopedia.com/articles/02/101502.asp). Under this assumption, it is able to provide a mathematical valuation of an option at each point in the timeframe specified. The binomial trees assume that in each time period the value of the asset moves up or down by a given percentage movement. These up and down movements and their corresponding probabilities are determined on a risk‑neutral basis – i.e. the expected return on holding the asset is equal to the risk free rate. Valuation is performed iteratively, starting at each of the final nodes (those that may be reached at the time of expiration), and then [working backwards](https://en.wikipedia.org/wiki/Backward_induction) through the tree towards the first node (valuation date). The value computed at each stage is the value of the option at that point in time.

This approach is sometimes referred to as the Marketed Asset Disclaimer (MAD) approach. It assumes the present value of cash flows is the best unbiased estimate of the market value of the project if it were a traded asset. The volatility of the cash flows are determined subjectively (i.e. without reference to market traded data) often using a Monte‑Carlo simulation of the inputs to estimate the volatility. This volatility is then used to model a binomial process over time.

The basic concept underpinning the binomial approach could be applied to those major Government investments where, although there is uncertainty about future levels of demand, historical demand patterns have been modelled and the statistical pattern is well understood.

### Multinomial method

The binomial approach may be extended by considering three or more discrete possible changes that might occur at the end of each short time period, implying a trinomial or multinomial distribution of outcomes at each point in time (rather than two changes in a binomial method). These can then be tracked through multiple time periods to deliver an inferred statistical distribution of possible outcomes, and to infer values for different options strategies.

For example, a multinomial approach may allow for a price to rise 1 per cent, to fall 1  per cent, or to remain stable, with probabilities attached to each. More complex forms of evolution are also possible.

The multinomial approach can be viewed as a form of decision tree, involving far more uncertainties, but of a form that may keep them tractable.

The constraints discussed for binomial models are equally applicable to multinomial models. They may have a role to play in special circumstances, but do not seem a natural fit for major capital investment programs.

### Simulation

Binomial and multinomial methods are special cases of Monte Carlo simulation of how a key uncertainty will play out. Further extension into more sophisticated ways of statistically modelling these uncertainties is possible and may have value in special cases. Any of these methods may have value in informing the development of scenarios for a decision tree. But again, they do not seem to offer a great fit for major capital investments.

## Hybrid or integrated approach

The hybrid or integrated approach allows for both market‑based or public risks and project specific or private risks.

Private risks do not require any risk adjustment because they are unique to the project. Managers and investors can diversify this form of risk away. Consequently, project risks can be analysed within decision analysis using a constant risk‑free discount rate.

On the other hand, markets risks must be taken into account as they cannot be diversified away. For market risks, option pricing is applied using market data to adjust the project outcomes to obtain a risk‑neutral valuation. Thus the probabilities used in the decision tree are adjusted to ensure overall expected return from the project equals the risk‑free rate. As with the Black‑Scholes approach, the process requires detailed statistical information on the price and volatility of the project outcomes for which a replicating portfolio is identified.

Once the risk‑neutral adjustment has been made, the market risks can be combined with the project risks and analysed through standard decision analysis using a constant risk‑free discount rate. Option values are obtained by rolling back the tree using risk adjusted probabilities (for market risks) and ordinary probabilities (for project risks).

Thus, the integrated approach involves the following steps:

* Building a decision tree representing the investment alternatives. This needs to identify all of the managerial decision points, as well as any influences/chance points.
* Identifying each risk as either public or private.
* For public risks, identifying the replicating portfolio and assigning risk‑neutral probabilities. This involves assembling data on comparable traded assets and calculating their volatility.
* For private risks assigning subjective probabilities, for example, based on experience from comparable projects.
* Applying a spreadsheet cash‑flow model at each tree end‑point, and calculating the NPV using the risk‑free rate.
* Rolling back the tree to determine the optimal strategy and its associated value.
* Sensitivity analysis can then be conducted to test the robustness of the conclusions.

The advantages of the hybrid method are that:

* it combines the best of the decision analysis and options analysis into a practical means of valuing projects;
* it permits the consistent choice of discount rate for valuation, namely the risk‑free rate; and
* it can be implemented, as appropriate, as an extension to the initial decision tree analysis to guide decisions as to whether it is worth pushing the analysis deeper.

Under the hybrid approach of adjusting for market risk, decision trees can yield the same values as option pricing models.

The hybrid or integrated approach is based on the most accurate and consistent theoretical and empirical foundation. However it requires more effort as a result.

## Tailored analysis

In some cases a tailored or bespoke approach can be undertaken building on pre‑existing simulation tools that are already in use for the application under consideration. The tailored or bespoke analytical tool would need to incorporate the same framework and principles as other real options tools.

Appendix 4: Further resources

## Victorian Government investment management guidance

Other relevant documents and information sources you should consider when developing investment proposals for the Victorian Government include:

* Investment Lifecycle and High Value/High Risk Guidelines – Victoria (2012 and updates):
  + http://www. dtf.vic.Gov. au/Investment-Planning-and-Evaluation/Investment-professionals-toolkit/Investment-lifecycle-and-High-Value-High-Risk-products
* The Asset Management and Accountability Framework, and the associated AMAF Guidance Material:
  + [http://www. dtf. vic. gov. au/Investment-Planning-and-Evaluation/Understanding-investment-planning-and-review/What-is-asset-management](http://www.dtf.vic.gov.au/Investment-Planning-and-Evaluation/Understanding-investment-planning-and-review/What-is-asset-management)

### Real options guidance – other jurisdictions

A number of jurisdictions have developed guidance for dealing with uncertainty and using real options analysis to inform their investment management practices. These include:

* ‘Adaptive Investment Management – Using a real options approach in transport planning’, ACIL Allen Consulting – report to the New Zealand Government Ministry of Transport, June 2014.
  + [http://www. transport. govt. nz/assets/Uploads/Our-Work/Documents/Adaptive-investment-management-real-options-approach-summary-report. pdf](http://www.transport.govt.nz/assets/Uploads/Our-Work/Documents/Adaptive-investment-management-real-options-approach-summary-report.pdf)
  + provides background on using real options in investment planning, outlines real options analysis methodologies and provides some illustrative case studies.
* ‘Adaptive Investment Management – Using a real options approach in transport planning’, Ministry of Transport, New Zealand Government, May 2016.
  + http://www.transport.govt.nz/assets/Uploads/Our-Work/Documents/MOT-Real-Options. pdf
  + considers types of uncertainty impacting on transport projects, and using real options analysis to inform their development.
* ‘Accounting for the Effects of Climate Change – Supplementary Green Book Guidance’, Department of Environment, Food and Rural Affairs, June 2009.
  + https://www.gov.uk/government/publications/green-book-supplementary-guidance-environment
  + provides guidance on managing infrastructure investments impacted by climate change‑related uncertainty.
* ‘Real options and investment decision making’, Ofgem, UK Government, March 2012.
  + [https://www. ofgem. gov. uk/publications‑and‑updates/real‑options‑and‑investment‑decision‑making](https://www.ofgem.gov.uk/publications-and-updates/real-options-and-investment-decision-making)
  + provides guidance on using real options analysis in investment appraisals, focusing on the gas and electricity sector.

### Real options applications – academic papers

**Climate change**

* Buurman, J., & Babovic, V., ‘Adaptation pathways and real options analysis: an approach to deep uncertainty in climate change adaptation policies’, Journal of Policy and Society, Vol. 35, Issue 2, pp. 115‑192, June 2016.
* Dobes, L., ‘*Getting real about adapting to climate change: Using ‘real options’* *to address the uncertainties*’, Agenda: A Journal of Policy Analysis and Reform, Volume 15, No. 3, pp. 55‑69, 2008.
* Lazarow, N., ‘*Real options for coastal adaptation*’, Department of Environment and Energy, <https://coastadapt.com.au/sites/default/files/factsheets/T4W5_Real_options.pdf>, 2016.
* Linquiti, P., & Vonortas, N., ‘*Real option analysis as a tool for valuing investments in adaptation to climate change*’, Center for International Science and Technology Policy, George Washington University, <https://www.researchgate.net/publication/267263579_Real_Option_Analysis_as_a_Tool_for_Valuing_Investments_in_Adaptation_to_Climate_Change>, 2011.

### Health

* Favato, G., Baio, G., Capone, A., & Mennine, F. ‘*A novel method to value real options in health care: the case of a multicohort human papillomavirus vaccination strategy*’, US National Library of Medicine, <https://www.ncbi.nlm.nih.gov/pubmed/23806328>, 2013.
* Ozogul, O., Karsak, E., & Tolga, E., ‘*A real options approach for evaluation and justification of a hospital information system*’, Journal of Systems and Software, Volume 82, Issue 12, pp 2091‑2102, <https://www.sciencedirect.com/science/article/pii/S016412120900168X>, December 2009.
* Sewalk, S., Roebuck, T., Chinowsky, P., & Elzarka, H., ‘*Building an expansion (real) option for a hospital under construction*’, 52nd Associated Schools of Construction Annual International Conference Proceedings, <https://www.researchgate.net/publication/321679062_Building_an_Expansion_Real_Option_for_a_Hospital_Under_Construction>, 2016.
* Van Reedt Dortland, M., Voordijk, H., & Dewulf, G., ‘*Real options in project coalitions in Dutch health care: two case studies of construction projects*’, Journal of Construction Management and Economics, Vol. 31 – Issue 3, 2013.
* Wernz, C., Gehrke, I., & Ball, D., ‘*Managerial decision‑making in hospitals with real options analysis’,* Information Systems and e‑Business Management, <https://doi.org/10.1007/s10257-013-0230-3>, 2015.
* Williams, D., & Hammes, P., ‘*Real options reasoning in healthcare: an integrative approach and synopsis*’, Journal of Healthcare Management, Vol. 52, Issue 3, pp. 170‑186, May‑June 2007.

### Housing and real estate

* Kraatz, J., Matan, A., Mitchell, J., & Newman, P., ‘*Rethinking social housing: effective, efficient, equitable*’, Sustainable Built Environment National Research Centre, [http://sbenrc.com.au/app/uploads/2014/09/1.31\_Final‑Report\_9.11.15.pdf](http://sbenrc.com.au/app/uploads/2014/09/1.31_Final-Report_9.11.15.pdf), 2015.
* Mintah, K., ‘*Real options application to Australian property development*’, School of Property, Construction & Project Management RMIT University, Melbourne, Australia, <http://www.prres.net/papers/Mintah_Real_options.pdf>, 2016.
* Mintah, K., Higgins, D., Callanan, J. & Wakefield, R., ‘*Staging option application to residential development: real options approach*’, International Journal of Housing Markets and Analysis, Vol. 11, Issue 1., pp. 101‑116, 2018.

### Public Transport

* Easson, M., ‘*The Application of a Theory of Real Options (TRO) to the Decision‑making of Mega Urban Transport Projects*’, Transport Planning, School of Architecture, Building and Planning, University of Melbourne, [**https://minerva-access.unimelb.edu.au/bitstream/handle/11343/90837/Michael%20Easson%20PhD%20final%202016.pdf?sequence=1**](https://minerva-access.unimelb.edu.au/bitstream/handle/11343/90837/Michael%20Easson%20PhD%20final%202016.pdf?sequence=1), 2016. **High‑speed rail transport valuation**
* Pimentel, P., Azevado‑Pereira, J., & Couto, G., ‘*High speed rail transportation value*’, The European Journal of Finance, Vol. 18, Issue 2, pp167‑183, 2012.

### Roads

* Penninga, J., ‘*A real option tool for decision‑making in road widening projects*’, Faculty of Technology, Policy & Management. Delft University of Technology, https://repository.tudelft.nl/islandora/object/uuid:d5a3fe31-c42d-449d-b9bd-89e10319e4b1/datastream/OBJ1/download
* Blanka, F., Samaneza, C, Keshar, T., Baidyab, N., & Guimaraes, M., ‘*Economic valuation of a toll road concession with traffic guarantees and the abandonment option*’, University of Rio de Janeiro, <http://www.scielo.br/pdf/prod/2015nahead/0103-6513-prod-0103-6513168713.pdf>, 2016.

### Sport and recreation

* Cabral, S., & Francisco Silva Jr., A., ‘An approach for evaluating the risk management role of governments in public‑private partnerships for mega‑event stadiums’, European Sport Management Quarterly, Vol. 13, Issue 4, pp 472‑490, 2013.

**Note:** If you find a useful article please email it to [investmentmanagment@dtf.vic.gov.au](mailto:investmentmanagment@dtf.vic.gov.au) and DTF will add it to this list of useful references.

Appendix 5: Relationship between the Investment Management Standard and real options analysis

The Victorian Government’s Investment Management Standard (IMS) establishes a set of simple practices that enable organisations to select the investments that matter most and shape and implement them so they deliver the maximum benefit and best value for money. The practices can also be used to help prioritise investments, develop policy, evaluate programs and improve the organisation’s effectiveness.

The IMS supports a way of thinking characterised by evidence‑based discussion, robust logic and simple storytelling. It brings together the best thinkers on a subject to discuss and shape new investments in two‑hour facilitated discussions (workshops) to address the four questions that are fundamental to investment decision making:



Figure : The IMS line of enquiry

The number of workshops required is determined by the nature of an investment. Large and complex investments might require four separate workshops, which would produce four documents critical to establishing a sound business case. Small and simple investments might require just one or two workshops and would produce an Investment Logic Map (ILM) and a Benefit Management Plan. The four workshops are described below.

| PROBLEM |
| --- |
| Successful investments are made as a considered reaction to an identified or emerging problem. This workshop focuses on:   * defining the problem that needs to be addressed; * validating that the problem is real; and * specifying the benefits that will result from addressing the problem.   The output of this workshop is the first version of an ILM with the problems and benefits defined. |
| **BENEFIT** |
| Investments are often shaped with little understanding of the benefits expected to be produced. This workshop will:   * identify the KPIs, measures, targets and timelines the investment will need to deliver; and * specify how the delivery of the benefits will be measured and reported.   The output of this workshop is a Benefit Management Plan (BMP) including a Benefit Map and Benefit Profile. |
| **RESPONSE** |
| Business cases for new investments often fail to consider the full range of things that could be done to address the identified problem. This workshop will:   * explore the interventions that could deliver the expected benefits; * formulate and evaluate a mix of response options; and * assess response options and potentially select the preferred response.   The output of this workshop is a Response Options Analysis Report. |
| **SOLUTION** |
| This workshop ensures a solution is developed, which is consistent with the foundations established in previous workshops. This workshop will:   * confirm the preferred response and the interventions it contains; * identify and evaluate the changes and assets that are required to implement the preferred response and deliver the benefits; * define a recommended solution; and * identify cost range, timeframe for project and benefit delivery, key risks, uncertainties, dis‑benefits and critical assumptions associated with the recommended solution.   The output of this workshop is an Investment Concept Brief (ICB). |

Table : The IMS workshops

Investors are encouraged to consider the potential impacts of suchuncertainty within the suite of IMS workshops.

The IMS process distils an investment proposal into a simple, clear narrative. By necessity and design it can ignore some of the proposal’s complexities. It is however important the IMS process is used to identify, explore and capture any uncertainty related to the investment.

A suitable approach for considering uncertainty during each of the IMS workshops is described below:

* **Problem Definition workshop** – consider the organisation’s operating environment. Is it characterised by pronounced uncertainty? Are there any factors outside the organisation’s control that could significantly impact the cause and effect of the problem or the need or demand for change?
* **Benefits Definition workshop** – consider whether the realisation of any of the proposed benefits may be materially affected by uncertainty. Is achievement of any of the benefits, KPIs or measures, contingent on significant interdependencies?
* **Response Definition workshop** – consider the operating environment and supply markets. Are any of the interventions contingent on material interdependencies? Will this affect the need for, or approach to, the investment? Would any of the response options become unfeasible if circumstances changed?
* **Solution Definition workshop** – consider the operating environment and supply markets. Are there any conditions or uncertainties where it is not possible to estimate the impact on the deliverability of the recommended solution? Does the recommended solution need the flexibility to respond to uncertainty?

Appendix 6: The decision‑maker’s checklist

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1. Is it clear what the problem is that needs to be addressed – both the cause and effect? | | | 5. Have the benefits that will result from fixing the problem been adequately defined? | | | 9. Has a reasonable spread of interventions been identified and packaged into sensible response options? | | | 13. Consistent with the preferred response option, has a reasonable spread of project options been analysed? | | |
| Yes | Partial | No | Yes | Partial | No | Yes | Partial | No | Yes | Partial | No |
| 2. Is there sufficient evidence to confirm both the cause and effect of the problem? | | | 6. Are the benefits of high value to the government? | | | 10. Is there evidence to demonstrate the response options are feasible and can respond to future uncertainty? | | | 14. Is the recommended solution the best value for money and have opportunities for building flexibility been identified and analysed? | | |
| Yes | Partial | No | Yes | Partial | No | Yes | Partial | No | Yes | Partial | No |
| 3. Does the problem need to be addressed now and by this government? | | | 7. Are the KPIs SMART and will they provide strong evidence that the benefits have been delivered? | | | 11. Were the options evaluated fairly to reflect their ability to respond to the problem, deliver the benefits? | | | 15. Is the solution specified clearly and fully and have opportunities for adding value been identified and costed? (all business changes and assets) | | |
| Yes | Partial | No | Yes | Partial | No | Yes | Partial | No | Yes | Partial | No |
| 4. Does the defined problem capture its full extent/scope including sources of future uncertainty? | | | 8. Have the sources of uncertainty and key dependencies critical to benefit delivery been considered? | | | 12. Is the preferred response option the most effective way to address the problem and deliver the benefits? | | | 16. Can the solution really be delivered (cost, risk, uncertainties, timeframes etc.)? | | |
| Yes | Partial | No | Yes | Partial | No | Yes | Partial | No | Yes | Partial | No |

Appendix 7: Real options and procurement approaches

|  |  |  |
| --- | --- | --- |
| Procurement model | Ability of method to manage a real options approach | |
| **Pros** | **Cons** |
| **Construct only** | Flexibility can be fully considered during the planning and design phase.  Flexibility can be retained by entering into a construct only contract for specific project elements as decisions are made to proceed with that project element | May pay a higher cost to contract progressively for project elements  If contract entered into upfront for multiple project elements, may not facilitate a real options approach  Does not allow for innovative solutions to emerge until late in the process  No incentive to facilitate a real options approach during operations phase |
| **Design and construct and variants** | Flexibility can be fully considered during the planning phase  May allow for innovative solutions to emerge at the design stage | Poor contractual flexibility does not facilitate a real options approach  No incentive to facilitate a real options approach during operations phase |
| **Managing contractor** | Flexibility can be fully considered during the planning phase  Allows for innovative solutions to emerge at the design stage  Provides greater flexibility for a real options approach than the traditional design and construct | The trigger points, and how they will be exercised, need to be clearly set out in the contract  No incentive to facilitate a real options approach during operations phase |
| **Early contractor involvement** | Allows for innovative solutions to be identified early in the process  Could improve the ability of the contractor to implement a real options approach |  |
| **Alliance** | Flexibility can be fully considered during the planning phase  Use of functional requirements specification rather than design specification could increase design flexibility opportunities | The trigger points, and how they will be exercised, need to be clearly set out in the agreement  No incentive to facilitate a real options approach during operations phase |
| **Public Private Partnership** | Use of functional requirements specification rather than design specification could increase design flexibility opportunities  Contractor involvement in service delivery could provide an incentive to consider in‑project options | Depending on contract, contractor may not have appropriate incentives to adopt a real options approach |
| **Build Own Operate (BOO)** | Flexibility can be fully considered during the planning and design phase  Provides an incentive to facilitate a real options approach during the operations phase | Constrains real options approach – does not allow innovative solutions to emerge until after design phase |

Table : Using real options with different procurement methodologies

1. The investor may choose to invest in new information earlier to reduce the uncertainties, before committing to a more significant investment. [↑](#footnote-ref-1)
2. See DTF’s *Risk Management Guideline* (2013) for further information on addressing risk in investment management. [↑](#footnote-ref-2)
3. Source: The Department of Economic Development, Jobs, Transport and Resources *Guidance on addressing risk and uncertainty in economic assessments* (2016) [↑](#footnote-ref-3)
4. These features are not inherent in the CBA approach. Flexible adaptive strategies may be identified and included as part of these assessments. However, if there are added costs to build in flexibility, where that flexibility would not be needed under the central assumptions used in the assessment, these alternatives may be rejected on the grounds of offering lower net value under the central assumptions. Similarly, in comparing two approaches, one of which inherently offers greater flexibility but where that flexibility would not be used under central assumptions, the more flexible approach may be undervalued by CBA as it is commonly implemented. [↑](#footnote-ref-4)
5. Traditional CBA does not usually rank alternatives based on their ‘expected’ net benefits as the term is usually defined; it ranks them based on net benefits under central, or base case, assumptions. These two approaches to ranking can, and commonly do, differ dramatically. [↑](#footnote-ref-5)
6. Van Putten, A., & MacMillan, I., ‘Making real options really work’, Harvard Business Review, December 2004 Issue https://hbr.org/2004/12/making-real-options-really-work [↑](#footnote-ref-6)
7. *Option pricing theory* is a tool conventionally used in the finance sector to value the future price of exchange traded assets or instruments such as equities, bonds, currencies and derivatives. [↑](#footnote-ref-7)
8. The Square Kilometre Array is a next‑generation radio telescope that, when complete, will far exceed the capabilities of any existing radio telescope. The SKA telescope will be used by scientists to make ground‑breaking discoveries about the universe. [↑](#footnote-ref-8)
9. Willingham, R. ‘Preferred route revealed for Avalon Airport rail link, but no start date in sight’, The Age, 19 September 2014, <http://www.theage.com.au/victoria/preferred-route-revealed-for-avalon-airport-rail-link-but-no-start-date-in-sight-20140919-10j748.html>. Accessed on 14 September 2017. [↑](#footnote-ref-9)
10. Ravenhall Prison Project Summary, February 2016, Department of Treasury and Finance, http://www.dtf.vic.gov.au/Infrastructure-Delivery/Public-private-partnerships/Projects/Ravenhall-Prison-Project [↑](#footnote-ref-10)
11. Citta Property Group. ‘Commonwealth Games Village’, https://citta.com.au/portfolio/commonwealth\_games\_village/ , last updated 2013. [↑](#footnote-ref-11)
12. Energie Baden-Wurttemberg, November 2012, https://www.enbw.com/company/press/press-releases/press-release-details\_10734.html [↑](#footnote-ref-12)
13. Daszynska‑Zygadlo, K., ‘Scenario planning and real options analysis in integrated risk management process’, 6th International Scientific Conference – Managing and Modelling of Financial Risks, Wroclaw University of Economics, Institute of Financial Management, 2012. [↑](#footnote-ref-13)
14. Strategis Partners, ‘Real options: A state of the art’, [http://www.strategispartners.com.au/wp‑content/uploads/2014/03/Strategis‑Partners‑Real‑Options‑The‑State‑of‑the‑Art‑2014.pdf](http://www.strategispartners.com.au/wp-content/uploads/2014/03/Strategis-Partners-Real-Options-The-State-of-the-Art-2014.pdf), 2014 [↑](#footnote-ref-14)
15. Adapted from van Rhee et al (2008) in the *CIE (2016) Addressing risk and uncertainty in economic assessments* report prepared for the Department of Economic Development, Jobs, Transport and Resources. [↑](#footnote-ref-15)
16. See the Investment Lifecycle Guidelines – Overview document for further information on the Investment Lifecycle: http://www.dtf.vic.gov.au/Publications/Investment‑planning‑and‑evaluation‑publications/Lifecycle‑guidance/Investment‑lifecycle‑and‑High‑Value‑High‑Risk‑guidelines‑Overview [↑](#footnote-ref-16)
17. Adapted from van Rhee et al (2008) in the *CIE (2016) Addressing risk and uncertainty in economic assessments*, report prepared for the Department of Economic Development, Jobs, Transport and Resources. [↑](#footnote-ref-17)
18. An additional option that could be considered is to build a larger hospital upfront with more limited scope for upgrading. This may be the preferred strategy if there is a high likelihood that demand growth will be strong early and there is a low likelihood of technological development. However, it is not considered in this example so as not to over‑complicate the example. [↑](#footnote-ref-18)
19. The investor may choose to invest in new information earlier to reduce the uncertainties, before committing to a more significant investment. [↑](#footnote-ref-19)
20. http://www.7wonders.org/civil‑engineering‑wonders/ [↑](#footnote-ref-20)
21. <http://www.telegraph.co.uk/travel/destinations/europe/france/articles/The-Channel-Tunnel->20-fascinating-facts/ [↑](#footnote-ref-21)
22. Anguera, R. ‘The Channel Tunnel – An Ex‑Poste Economic Evaluation [↑](#footnote-ref-22)
23. Anguera, R. ‘The Channel Tunnel – An Ex‑Poste Economic Evaluation [↑](#footnote-ref-23)
24. [http://www.telegraph.co.uk/travel/destinations/europe/france/articles/The‑Channel‑Tunnel‑20‑fascinating‑facts/](http://www.telegraph.co.uk/travel/destinations/europe/france/articles/The-Channel-Tunnel-20-fascinating-facts/) [↑](#footnote-ref-24)
25. Wallis, S. ‘UK Rail from the Channel Tunnel and beyond’, December 2006, https://www.tunneltalk.com/UK-rail-links-Dec10-Plans-for-the-future.php [↑](#footnote-ref-25)
26. Kanaracus, C. ‘Air Force scraps massive ERP project after racking up $1B in costs’, PC World, 14 November 2012, [https://www.pcworld.idg.com.au/article/442099/air\_force\_scraps\_massive\_erp\_project\_after\_ racking\_up\_1\_billion\_costs/](https://www.pcworld.idg.com.au/article/442099/air_force_scraps_massive_erp_project_after_racking_up_1_billion_costs/) [↑](#footnote-ref-26)
27. Expeditionary Combat Support System Acquisition Incident Review Team Final Report – Executive Summary. <http://www.thepercellgroup.com/home/wp-content/uploads/2013/12/ecss_publicly_releasable.pdf> [↑](#footnote-ref-27)
28. Expeditionary Combat Support System Acquisition Incident Review Team Final Report – Executive Summary. [http://www.thepercellgroup.com/home/wp‑content/uploads/2013/12/ecss\_publicly\_releasable.pdf](http://www.thepercellgroup.com/home/wp-content/uploads/2013/12/ecss_publicly_releasable.pdf) [↑](#footnote-ref-28)
29. http://www.cbc.ca/news/canada/montreal/montreal‑olympics‑venues‑stadium‑cost‑1.3679041 [↑](#footnote-ref-29)
30. Images: [https://www.dotproperty.com.ph/blog/olympic‑villages‑before‑and‑after](https://www.dotproperty.com.ph/blog/olympic-villages-before-and-after) [↑](#footnote-ref-30)
31. Image: http://www.realestate.com.au/news/olympic‑villages‑past‑and‑present/ [↑](#footnote-ref-31)
32. Image: http://www.realestate.com.au/news/olympic‑villages‑past‑and‑present/ [↑](#footnote-ref-32)
33. http://www.today.com/news/what-happens-olympic-venues-after-torch-goes-out-2D12152101 [↑](#footnote-ref-33)
34. https://www.baseball-fever.com/forum/general-baseball/ballparks-stadiums-green-diamonds/42862-international-ballparks/page11 [↑](#footnote-ref-34)
35. http://edition.cnn.com/2016/03/09/europe/greece-refugees-olympic-park-airport/index.html [↑](#footnote-ref-35)
36. https://theculturetrip.com/europe/greece/articles/what‑will‑become‑of‑athens‑old‑international‑airport/ [↑](#footnote-ref-36)
37. Another rule used is to take account of the risk attitudes of the user/firm, and build a risk‑adjusted objective function. [↑](#footnote-ref-37)
38. The so‑called ‘flaw of averages’ dictates that a function of expected inputs will only equal expected output if there is a linear relationship between all variable inputs and output. Thus in general ε[f(x)] ≠ f(ε[x]). Where key uncertainties include the possibility of major structural shifts in the nature of demand and usage, such as might flow from networked driverless vehicle technologies, and/or where strategy adaptation to such changes is permitted, the impacts will almost never be linear. This is a problem for the use of cost‑benefit methods applied to a base case. Where there are variable inputs, a proper assessment of a project’s NPV will often require a Monte‑Carlo or similar simulation to derive the expected NPV (instead of using the expected values of each input). This expected NPV can then be compared with the value of the project after allowing for flexibility, to derive the value of the option. [↑](#footnote-ref-38)