3.1 Introduction

CBA is a tool used to undertake an economic evaluation of an investment proposal, change in policy or regulatory arrangement. It is specifically concerned with identifying and measuring (where practical), and then discounting future costs and benefits to present values to enable the calculation of the net economic worth of project options.

CBA involves an incremental assessment: that is, evaluating a project option(s) against a base case. Defining and clearly articulating the base case (sometimes referred to as the ‘do nothing’ option) is often one of the more challenging aspects of CBA. In practice, while most costs and benefits can be quantified, the measurement of all the projected costs and benefits can sometimes prove to be elusive.

This Chapter presents a discussion on a number of important elements involved in preparing a CBA. The information provided includes both practical guidelines and a discussion on key underpinning principles of the CBA approach to project appraisal.

3.2 Project Identification

The project identification phase represents the first stage in undertaking a CBA, and comprises:

- Defining the problem
- Clarifying the problem(s), key issues(s), etc
- Identifying specific objectives and / or service needs
- Consulting with stakeholders
- Scoping the project (eg, timing, relationship to other projects, developmental stage, and indicative cost estimates).

These elements are consistent with established CASA practices as well as those of some of its major stakeholders’ and industry partners.

3.3 Specification of Project Options

The range of viable (or technically feasible) options may vary according to the nature of the problem. At the project identification stage, a large range of project options may be generated and assessed at a preliminary level.

Viable project options must then be specified accurately for a detailed CBA.
3.4  Defining the Base Case

Options are evaluated relative to a base case. **CBA cannot be conducted without a base case.** The base case provides the benchmark against which the proposed project, an ACP, can be measured.

The base case is a ‘do nothing’ option. The ‘do nothing’ option requires a clear description of what is likely to occur in the absence of a project/policy change. This should not necessarily imply that the base case is a costless option: ‘doing nothing’ does not necessarily mean ‘spending nothing’. In other words, the base case or ‘do nothing’ option means including only those changes to the existing situation that are for all practical purposes, unavoidable between the present day and the end of the evaluation period. Similarly, maintaining the *status quo* should be considered as what needs to be done without the project to maintain the current or prescribed levels of service or policy, rather than simply continuing in the existing state. It is important that the base case is defined as the option that will maintain the existing level of service/performance. The base case can therefore be expressed as what would happen without the project if the project objectives were to be met. If an option is viewed as providing an improvement to the *status quo*, it should be included as a project option.

One useful way to consider the base case is as the ‘without project’ option, which in turn could be a ‘do nothing’ option (in the strictest sense) or a ‘do minimum’ option.

Quantification of the ‘do nothing’ option necessitates identification of the incremental costs and benefits from the project. The project options are incremental to the base case—ie, Net Project Benefit is Option Benefit minus Base Case Benefit.

Costs and benefits must be carefully considered as to whether they are an outcome of the project. Calculating costs and benefits by reference to the situation pre-project is not correct as it overlooks changes to the existing situation that are unavoidable between the present day and the end of the evaluation period.

3.5  The Role of Value Management

There are a range of techniques that can be used to enhance the rigor and effectiveness of a CBA. One approach, Value Management (VM), has proved to be effective as a complimentary tool to CBA.\(^1\) VM addresses the technical and functional dimension of a project/proposal as opposed to the resource allocation perspective that is dealt with by CBA.

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\(^1\) Whilst the term ‘complimentary’ is used here, in the practical sense, use of the VM (or similar) approach becomes an integral part of the initial steps of the CBA process as it will assist in successfully completing the first 3 steps as shown in Figure 2.1.
VM is an approach that can encompass strategic objectives and structured analyses of an overall project assessment methodology. When used as an input into the preparation of a CBA, VM typically involves a formalised meeting(s) with key stakeholders (usually including technical/specific subject-matter experts) in a facilitated workshop to provide a forum for issues, risks and areas of uncertainty to be raised. VM outputs can include identifying what benefits are the most highly valued and the best way to divert resources to realise these valued benefits – and ensuring that options considered are suitable for the objectives being addressed. The selection of a proposal-specific evaluation period different from the recommended evaluation period, in Section 3.8.4, could be an agenda item for a VM workshop.

VM workshops are particularly useful exercises where it may be problematic defining the base case or where the technically feasible options or likely impacts are complex and may present the non-technical analyst (in an airspace sense) with some conceptual and clarity concerns. A VM workshop with some experienced industry stakeholders may prove extremely useful in gaining an understanding of the likely behavioural changes that may follow from the implementation of a particular ACP, for example. The approach is also useful in quickly moving from a long or ill-defined listing of options to a ‘firm’ short list of well-articulated options (and sub-options) that can be widely understood.

The use of VM should be considered a potentially useful initial element of an ACP cost-benefit analysis as an aid to an effective evaluation.

There are other related techniques, such as the Value Measuring Methodology\(^2\), which in effect combine multi-criteria assessment techniques (discussed later in the Manual) with CBA techniques to arrive at an evaluation approach that attempts to ‘quantify’ both monetary and non-monetary aspects of options under investigation. These techniques are typically adopted where Government policy criteria are major ‘influences’ on investment decision-making.

### 3.6 Role of the Department of Defence

The Statement directed CASA and the Department of Defence to work closely in order to administer a ‘civilian/military airspace management regime’:

“Close coordination of civilian and Defence airspace requirements is to be facilitated under a Memorandum of Understanding (MOU) between CASA and Defence, assisted by:

- Placement of Defence officers within the Office of Airspace Regulation (OAR) to work as OAR officers, but also holding delegated powers under Defence legislation. This will help ensure that decisions on Defence needs for access to airspace are met through the one regulatory body; and

3.7 Valuing Costs and Benefits

3.7.1 Quantitative and Qualitative Costs and Benefits

Costs and benefits that can be directly expressed in economic terms are referred to as ‘quantitative’. Costs or benefits that cannot be quantified in economic terms are referred to as ‘qualitative costs’ and ‘qualitative benefits’. It is important here to understand that ‘quantitative’ in this sense means quantified in monetary terms. Even though something can be expressed numerically, it may not necessarily be able to be quantified in the economic sense by the assignment of a monetary value.

Furthermore, there are many variables that are not sold in any market for which it is still possible to estimate values and thereby represent them in monetary terms. A prime example is the concept of value of travel time, where minutes saved can be converted into dollars of estimated savings (refer to Section 3.7.5). The concept of the Value of a Statistical Life (VSL) (refer to Section 3.7.6) falls within this category in the CBA context.

Only those quantified costs and benefits directly attributable to the project/proposal are subject to the discounted cash flow analysis (discussed in detail in Section 3.8). However, all qualified costs and benefits should be identified and described (including the identification of the affected parties and the nature of the impacts involved) in the CBA report as this could be important information for the decision-maker.

There is another class of benefits that can be considered in CBA though not included in the discounted cash flow analysis of benefit streams referred to as ‘enabled benefits’ (see Section 3.8). As opposed to actual (or delivered) benefits realised from the project/proposal, there may be a number of enabled benefits that only materialise if another project/proposal is carried out; the so-called ‘enabling project’. These enabling projects should be clearly identified and described in the CBA as should projects that are dependent on the enabling project. In the same way, as qualitative benefits should be identified and described in the CBA report, so too should enabled benefits be presented separately to the decision-maker.

3.7.2  Valuation in Resource Cost Terms

CBA is concerned with the flow of real resource costs and benefits, and therefore excludes market distorting instruments of policy such as taxes and subsidies. Taxes and subsidies are market imperfections that can cause social costs and benefits to differ from private costs and benefits as measured in the marketplace. They are regarded as transfer payments from one part of the economy to another. CBA is about endeavouring to measure the value of all costs and benefits that are expected to result from the proposal/project. It therefore includes estimating costs and benefits that are ‘unpriced’ and not the subject of normal market transactions but which nevertheless entail the use of real resources.

In economic evaluation, all inputs to the analysis (such as time, fuel, maintenance, etc) are valued in resource cost terms. Generally, resource costs equal market prices plus subsidies less taxes. In order to maintain consistency, the resource cost approach should be used.

3.7.3  The Concepts of Sunk and Opportunity Costs

Sunk costs are costs that have already been incurred and that cannot be recovered to any significant degree. Sunk costs are sometimes contrasted with variable costs, which are the costs that will change due to the proposed course of action. In evaluating a project, only variable costs are relevant to a decision; sunk costs are excluded from the analysis.

If the project includes an asset that is owned prior to the project, the asset should not be treated as ‘sunk’ and of no value if the asset has an alternative use with a positive realisable value. In this example, the cost attributable to the asset is the opportunity cost of the asset if utilised in the project in question i.e. the cost of the asset minus the ‘value’ of the asset in its alternative use. This is an important aspect as the conceptual basis for valuing costs in CBA is their ‘opportunity cost’.
Implementing a program or policy requires the use of resources (or inputs) that could be utilised elsewhere. The opportunity cost reflects the benefits forgone by society in not using these resources for an alternative purpose. The opportunity cost of a resource is measured by its value in the ‘next best’ or most valuable alternative use.

### 3.7.4 Externalities

Externalities are the costs incurred by the wider community (ie, non-users) that are a direct effect of the project. Examples of external costs and benefits are noise pollution, air pollution, greenhouse emissions and other environmental effects. Externalities are often referred to as ‘spill over’ costs (or benefits) such that other parties receive a benefit for which they do not have to pay or incur a cost for which they are not automatically compensated. An external benefit is often termed a positive externality; an external cost a negative externality.

While there are various approaches to the valuation of externalities, such as contingent valuation and the ‘dose-response’ approach, for the purposes of most CBAs, it will be sufficient to identify the nature and quantum of the effects and then apply ‘default’ values to elements such as air pollution and noise pollution. These would be on the basis of estimated changes in ‘output’ of pollutions multiplied by ‘cost values’ derived from environmental and scientific studies.

In most cases, approximations will be the norm as opposed to precise measurements. For example, a cost of noise and air pollution may be applied in the evaluation on the basis of defined units per take-off and landing by aircraft type.

The difficulty in including externality costs and benefits in evaluations is common across most transport sectors, not so much because of their relevance but because of theoretical and practical constraints on measurement. Externalities should be included in CBA where the method for measurement (and valuation) has broad professional support and the time and resources needed to establish estimates are available. At the least, an attempt should be made to describe the issues in terms of the sources and nature of the externalities involved.

### 3.7.5 Value of Travel Time

It is generally accepted that people place a value on time in a range of work and non-work situations. There has been a substantial volume of international research (mostly in the surface public transport domain) dedicated to estimating values of travel time (VoTT) and related savings and the impact this has on demand, in particular.

Changes in airspace regulations can impact on the travel times of aircraft users and passengers on commercial and charter flights, for example. These changes (measured typically in minutes per passenger), valued on the basis of dollars per hour for non-working time (for commuting, for example), can be a significant source of benefit in transport CBA and need to be captured in the evaluation. Where available, data that enables some disaggregation of travel time savings by trip purpose (eg, leisure or business or commuting, etc) should be adopted.
In most transport applications, it is usual to ‘weight’ time spent waiting (e.g., delay) at a level greater than time spent travelling as this time is typically perceived as less desirable. In public transport evaluations, a ‘weight’ in the range of 1.5 to 2.0 (based on a substantial body of Australian and overseas research) is typically adopted for waiting time relative to time spent actually travelling (i.e., in-vehicle time).

It is reasonable to assume that there is a relationship between VoTT and income, albeit at a high level. It is usual to assume therefore that the VoTT changes over time and this is addressed in CBA by applying the following formula:

Forecast growth in VoTT = Elasticity of the average VoTT with respect to Gross Domestic Product (GDP) \cdot (Real GDP Growth percentage per annum – Population growth percentage per annum), where an elasticity value of 0.8 is recommended for non-working time (e.g., commuting time) and 1.0 for working time.

VoTT are provided in the SEV guidelines and should be used as ‘default values’. Growth rates for VoTT are also provided.

### 3.7.6 Value of a Statistical Life

Transport accidents impose a range of impacts on people and organisations. These include casualty related costs such as human costs, loss of output due to injury and medical and healthcare costs. Human costs include pain, grief and suffering to the casualty, relatives and friends. In the case of fatalities, it represents the intrinsic loss of enjoyment of life ‘over and above’ the consumption of goods and services. Loss of output due to injury is typically based on estimations of the present value of expected loss of earnings plus non-wage payments. Medical and healthcare costs are those associated with hospital emergency services, treatment, rehabilitation, etc.

Accident related costs can include material damage (to aircraft or facilities), police and fire service costs, disruption costs, insurance costs, legal and court-related costs (but not ‘settlements’) and the cost involved in accident investigations.

The Common Risk Management Framework\(^4\) directs the following:

> “8.12 Agencies will use Economic Values published by the Bureau of Transport and Regional Economics (BTRE) in relation to the value of a statistical life.” (p. 8)

The latest BTRE report that provides information that can be utilised in preparing a CBA is:


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The BTRE analysis is based on adoption of the Human Capital approach (as opposed to a *willingness-to-pay* (WTP) approach which can take more time and cost substantially more money due to the elaborate surveys required) that in effect puts the major value of a person’s life as the productive output of that individual over their working life. It therefore assumes that the productive output of the economy will be forgone if a significant input to the production – one person – were removed. The loss is valued at the income forgone during recuperation for injured persons and over the expected remaining life for fatalities. The BTRE also adds the value of household and volunteer work to this value as well as values for lost quality of life and the costs associated with accidents and incidents as cited previously.

The concept of VSL is not without controversy, and alternative approaches to that used by the BTRE in the particular report cited exist and are often championed (including by the BTRE themselves in its Report 113 when discussing the application of its results).\(^5\) Importantly, the BTRE notes:

> “Ideally, willingness to pay studies should be used to assess safety improvements on a project by project basis, incorporating the values and tradeoffs of actual people. This would be a context specific approach, allowing users to reveal how much safety they wish to buy.” (p. vii Report 113)

> “While this analysis based on the human capital approach is transparent, human capital type analyses are often likely to produce lower bound estimates. Preferably, and in principle, willingness to pay studies of Australians should be used to determine the value of specific safety improvements in Australia. Such studies should be context specific, allowing those who will be affected by certain proposals to express their own views on how much safety they wish to buy.” (pp. 27-28 Report 113)

There is a view that the Human Capital approach provides a conservative minimum estimate to valuing a statistical life as it does not, among other things, fully address or ‘capture’ the value of the leisure, health and joy that people experience. Furthermore, the approach, because it is mostly related to forgone earnings, could be argued to value less the lives of children, elder people, volunteers etc. Other concerns relate to the uncertainty about future earnings and life expectancy assumptions as well as discount rates used and the fact that in the Australian context most of the data used relates to General Aviation (GA) activity as opposed to scheduled Regular Public Transport (RPT) services.

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\(^5\) The article cited in the references by Kip Viscusi and Joseph Aldy - *The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World*, provides useful reading for those wishing to explore and understand the concept and techniques for measurement more.
In order to ‘address’ some of the concerns associated with the Human Capital approach and the BTRE data specifically, particular reference to the cost of accidents is contained in the discussion of sensitivity analysis in Section 3.10. In the absence of Australian-specific WTP values, the BTRE data provides a useful (and transparent) starting point for an estimate of VSL until better information is available. Furthermore, in the absence of an Australian-specific VSL based on societal WTP estimates for reductions in small risks of premature death, the BTRE cost of accidents data is a transparent ‘default’. Analysts need to be aware that VSL has no application to an identifiable person or to very large reductions in individual risks. It does not suggest that any person’s life can be expressed in monetary terms. The concept’s sole objective is to assist in valuing the likely benefits of proposals.

As in the case of VoTT, it is reasonable to assume that there is a relationship between the VSL and incomes (again, at a high level). Therefore, it is usual to assume that the VSL changes over time and this is addressed in CBA by applying the following formula:

\[
\text{Forecasts growth in VSL} = \text{Elasticity of the average VSL with respect to GDP} \times (\text{Real GDP Growth percentage per annum} - \text{Population growth percentage per annum}),
\]

where an elasticity value of 1.0 is recommended.

Furthermore, it may be necessary to examine the composition of the VSL to determine whether relative cost adjustments are also merited.\(^6\) This is particularly so because there is typically a gap of several years between studies used to determine the default values.

3.7.7 Residual Values

The residual value is the value of an asset at the end of the evaluation period.

This may be an estimate of its market value (if any) or its remaining value in use. For projects involving the introduction of assets with long lives compared to the evaluation period, a residual value must be included. Another way of considering residual values is that they reflect that the asset will generate future benefits beyond the evaluation period.

It is recommended that residual values be treated as ‘negative costs’ as opposed to benefits in the discounted cash flow analysis, that is, an offset against capital costs incurred in implementing the proposal or project. Readers should note the implications for the calculation of the benefit-cost ratio from this approach. In most cases, it will suffice to estimate the residual value of an asset, in the absence of a market value, by using a straight line depreciation approach based on an agreed economic life of the asset in question. Where asset lives are not readily available, the treatment in the official accounts (eg, Annual Report) should be adopted.

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\(^6\) This should not be confused with a re-valuation associated with a rise in real incomes as measured by GDP.
3.7.8 Decommissioning Costs

It is not uncommon in preparing a CBA to come across situations where existing facilities/assets are made redundant and require dismantling or some other method of disposal. The costs involved in decommissioning facilities resulting from the proposal under review need to be included. This may also include costs of site restoration. If there are salvage values associated with redundant equipment or facilities, these should also be included as appropriate (and not confused with residual values).

3.7.9 Secondary Effects

Secondary effects typically relate to benefits and are effectively benefits that are the consequences of the project or proposal. These can also be referred to as ‘indirect’ or ‘second round’ effects and are a common source of ‘double counting’ in CBA, particularly where distributional/allocative analysis has been undertaken.

Where the project/proposal is a catalyst in stimulating other investments in production, businesses or property, it is legitimate to include the benefits of these new activities only if their own incremental costs are also included.

The analyst needs to be sure if including secondary benefits, they are not including benefits for effects that are the direct result of benefits that have already been counted. For example, if travel time savings to aircraft passengers has already been counted and these savings are the sole cause of some other benefit/positive effect, it would be a case of ‘double counting’ to include this latter effect in the evaluation as the estimate of travel time savings would have already ‘captured’ benefits.

3.7.10 The Rule of Half and the Concept of Consumer Surplus

The ‘rule of half’ is based on the concept of consumer surplus. Consumer surplus is a fundamental aspect of welfare economics of which CBA is an important analytical framework. The use of this concept to value aviation project benefits is illustrated by the following example.

Assume that an ACP will reduce the cost of travel due to reductions in travel time and aircraft operating costs. In Figure 3.1, the demand curve for flights is shown by AB: as the cost per flight decreases, the number of flights taken increases. Suppose the existing costs per flight is C₁. At that cost, the number of flights undertaken is F₁, and the consumer (aircraft passenger) expenditure on the flight is the cost per flight multiplied by the total number of flights (the area C₁F₁O). The consumer valuation of F₁ flights is the area ACF₁O. The consumer surplus is the total valuation of F₁ flights by the consumers less the expenditure on the flights (ACF₁O less C₁F₁O or area ACC₁).

Assume the ACP will reduce the cost per flight from C₁ to C₂. For the existing flights F₁, the change in consumer surplus is the reduction in cost per flight (C₁ – C₂) multiplied by the number of existing flights F₁. It is ACDC₂ less ACC₁ (area C₁CDC₂). The cost reduction will also result in additional or generated flights so that the total number of flights will increase from F₁ to F₂. Valuation of the benefits resulting from the reduction in cost per flight to the consumers is given by the change in the value of consumer surplus.
### 3.7. Valuing Costs and Benefits

#### 3.7.7. Valuing Costs and Benefits

The benefits of the additional flights \( (F_2 - F_1) \) are given by the summation of the total amount that each new trip maker would be willing to pay to make the flight, less the cost of the flight \( C_2 \). It is the area \( CED \) (shaded). If the change in flight cost is small, then it may be assumed that the demand curve section \( CE \) is linear and that \( CED \) is a triangle.

Therefore, generated benefits \( = \frac{1}{2} (F_2 - F_1)(C_1 - C_2) \).

#### 3.7.11 Option Values

The concept that underlies option values can be explained using the following example. Consider a strategy or plan which includes the re-opening of an abandoned air route linking a number of remote communities/towns to a major town or city that has connections nation-wide. Even if a particular individual living in one of the communities served by the new route does not intend to use the air service with any regularity, they may still value having the option to use the service if they choose. For example, a car-owner may value the ability to use the service when for whatever reason they cannot drive or their car is unavailable.

A non-car-owning resident who generally does not travel beyond the community may value the knowledge that, should they need to reach the town or city, the facilities exist for them to do so, at reasonable cost and with a reasonable level of convenience. In addition, those who do intend to use the service on a regular basis may also have an option value, over and above the value of their intended use of the service, since they too may value the options offered for air travel over those already taken account of in their individual plans and expectations.

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**Figure 3-1 Consumer Surplus and Valuation of Consumer Benefits**

<table>
<thead>
<tr>
<th>Number of Flights</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_1 )</td>
<td>( C_1 )</td>
</tr>
<tr>
<td>( F_2 )</td>
<td>( C_2 )</td>
</tr>
</tbody>
</table>

The benefits of the additional flights \( (F_2 - F_1) \) are given by the summation of the total amount that each new trip maker would be willing to pay to make the flight, less the cost of the flight \( C_2 \). It is the area \( CED \) (shaded). If the change in flight cost is small, then it may be assumed that the demand curve section \( CE \) is linear and that \( CED \) is a triangle.
3.8 The Concept of Present Values and Discounting

In most projects, the costs and benefits are going to be spread out over time. Since people are not indifferent with respect to the timing of costs and benefits, it is necessary to calculate the present value of all costs and benefits. It is therefore important that the valuation of costs and benefits takes into account the time at which they occur, since people generally prefer to receive benefits as early as possible and pay for costs as late as possible.7

Discounting is performed for two reasons:

1. Immediate income or benefits are preferable to future income or benefits (social time preference).

2. Capital investment has an opportunity cost: it could earn a rate of return in other sectors of the economy if it were not used for the current project (opportunity cost of capital).

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7 This time preference concept is a fundamental concept of cost-benefit analysis.
The standard approach to valuing costs and benefits that occur at different times is based on the fact that a dollar today is worth more than a dollar tomorrow. The approach reduces a time stream of costs or benefits to an equivalent amount in the price year’s dollars. This amount is known as the present value (PV) of the future costs and benefits.

The PV is calculated using the method of compound interest and the rate that converts future values into PV (ie, the discount rate). The PV of costs and benefits can be expressed as follows:

\[
PV_{\text{Cost}} = \sum_{n=0}^{N} \frac{C_n}{(1 + r)^n}
\]

\[
PV_{\text{Benefit}} = \sum_{n=0}^{N} \frac{B_n}{(1 + r)^n}
\]

Where:
- \(C_n\) = costs in year \(n\) expressed in constant dollars
- \(B_n\) = benefits in year \(n\) expressed in constant dollars
- \(r\) = real discount rate
- \(n\) = evaluation period in years.

In the preparation of a CBA, this process is known as the Discounted Cash Flow (DCF) method and can be readily set up in a standard spreadsheet-modelling environment such as MS Excel.\(^8\)

### 3.8.1 Selection of a Discount Rate

The discount rate is used to convert costs and benefits that occur in different time periods to PV so that they can be compared. It is based on the principle that, generally, society prefers to receive goods and services now, rather than later, and to defer costs to future generations – this is known as 'social time preference'. The selection of the discount rate has an impact on the magnitude of the reported results.

The generally preferred approach is to use a real discount rate, that is, to exclude any inflationary component of market rates. Inflation must be treated consistently across both the applied discount rate and the costs and benefits components of the evaluation. However, it is noted that if costs and benefits are measured in nominal (or current) dollars, then a nominal discount rate should be used.

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\(^8\) Advice and ‘tips’ for analysts on ‘good practice’ for setting up a DCF model within a spreadsheet environment are provided later in the report.
A common practice in estimating the ‘social time preference’ is by using the Australian Government’s borrowing rate. The yield on long-term Australian government bonds is generally in the order of six per cent. However, alternative measures of opportunity cost exist, such as the Social Opportunity Cost (SOC) of Capital, which is determined by the equivalent return that may be able to be received by another project, whether in the public or private sectors. This application is problematic in a practical sense due to the limitations associated with project choice. However, it is important to consider that the SOC is generally higher than the Government borrowing rate.

A related discount rate is the Project-Specific Cost of Capital (PSCC) rate, which is a market-based assessment of the project’s volatility. In the Capital Asset Pricing Model (CAPM), this risk is a measure of the non-systematic (e.g., business cycle) risk relationship between the market as a whole and the individual project. Market risk is a premium on the project expected return to compensate investors for the volatility involved in their investment. Recent estimates of Australia’s market risk premium for equities, which are a typical base for project risk assessment, are around six per cent.

Most State government Treasury Departments publish a prescribed real discount rate to apply to economic evaluations. This framework does not prescribe a benchmark real discount rate, since it varies from one year to the next. However, it is noted that use of the cost of capital rate ensures that the true opportunity cost of capital is reflected in project/proposal evaluation and that resources are used efficiently.

Currently, the New South Wales Treasury directs use of a seven per cent real discount rate in economic appraisal (CBA)\(^9\), the Victorian Government directs use of a six per cent real rate\(^10\) and Queensland Treasury provides the following advice:

> “These guidelines suggest the choice of discount rates for specific projects be made by agencies in consultation with the Queensland Treasury Analyst for your portfolio (who will consult with Strategic Asset Management Branch and QTC). This section provides some guidance on the factors influencing the choice of discount rates.

> As noted in section 2.1.4.1, the choice of discount rate should be consistent with the basis for valuing costs and benefits in the analysis of project options: where the flow of costs and benefits is expressed in real (constant dollar) terms, a real discount rate should be used where the flow of costs and benefits is expressed in nominal (current dollar) terms, a nominal discount rate (including an allowance for inflation) should be used.

---


\(^10\) Department of Infrastructure (2005) Guideline on economic, social and environmental cost-benefit analysis, Melbourne, Victoria.
The following reference points may be used in determining the discount rates for projects:

- the interest rate for Government borrowings for a term relevant to the expected duration of the project (for example, for Queensland, this would be the interest rate for 10-year QTC bonds for a project expected to generate most costs and benefits within 10 years). An allowance for inflation can be deducted from this rate if costs and benefits are expressed in real terms.

- the long-term average real economic growth rate, with an additional allowance for major risks and time preference for current consumption. As this is a real discount rate, an allowance for inflation would need to be added to discount flows of costs and benefits expressed in nominal terms.

- the rate of return on debt and equity for comparable private sector projects (as a public sector project would be competing with other activities for debt and equity capital).

Where any of these methods are used to determine a discount rate, sensitivity testing with higher or lower variations on the chosen rate should be used to allow for a margin for error, and the possibility of the project having unique characteristics which would limit the relevance of rates of return for other projects as a benchmark.” (p. 50)

The Office of Best Practice Regulation (OBPR) in its Best Practice Regulation Handbook suggests use of an annual real discount rate of seven per cent. CASA has adopted this discount rate. It is also noted that the OBPR advises that it will publish updates to the suggested discount rate on its website – http://www.obpr.gov.au/.

3.8.2 Price Year

The price year in an economic evaluation is the year in which the value of all costs and benefits are expressed. That is, the dollar units represent the same purchasing power.

3.8.3 Selection of the Base Year

The base year is the year to which costs and benefits are discounted to arrive at a PV. The base year affects the magnitude of the reported results, with an earlier base year resulting in lower magnitude of results. When undertaking project evaluations, it is preferable to discount to the base year in which the decision to proceed will actually be made so that PV means just that.

The base year is usually the same as the price year. Generally, the base year and the price year should be the year in which the evaluation is conducted. The base year must be common to all alternatives being considered.

12 Australia Government (2007), Best Practice Regulation Handbook, Canberra (pp. 120, 121, 130).
3.8.4 The Evaluation Period and Economic Life

The PV of costs and benefits are measured over a set evaluation period. In comparing projects, it is important to evaluate options over the same time period. For aviation technology projects, typical evaluation periods are likely to range from five to 15 years, depending on the type of project and the economic life of the principle asset. This relatively short evaluation period also reflects the ‘dynamics’ of aviation technology development where changes can be more rapid, for example, than in other transport sectors.

The economic life of a project is the period of time over which the benefits to be gained from the project may reasonably be expected to accrue. Benefits from a project are limited ultimately by its physical life. It is also further limited to its technological life. Future regulatory changes may also affect the economic life of a particular project. Economic life is a key variable and it is important to make the best possible determination. This is clearly an example of an element that could be ‘agreed to’ at a VM workshop and then ‘tabled’ when scoping the elements of the CBA.

Assets with economic lives shorter than the evaluation period should only occur when considering a range of options with different economic lives. One approach is for the short lived assets to be assigned a replacement or renewal cost and this cost should be included in the analysis for the year in which it is expected to be incurred.

The key issue is to ensure that the period chosen is sufficiently long enough to ‘capture’ all potential costs and benefits of the ACP. It is recommended that a 10-year evaluation period be adopted. Where a different period is selected, the choice must be detailed and a rationale provided in the CBA report.

3.8.5 Treatment of Inflation and Interest Rates

It is important that the effects of inflation do not distort the cost and benefit streams. Inflation causes the costs and benefits that occur later in the evaluation period to appear higher than they should. This causes bias towards projects with later benefits.

Inflation does not increase the real value of costs and benefits; it only increases their monetary value. The monetary value of costs and benefits should be expressed in ‘real terms’ at the general price level prevailing in the year the evaluation is conducted, because inflation simply raises all cash values by a given percentage. Real or constant prices – prices net of inflation – are thus used in CBA.

Interest payments should be excluded from the evaluation because they are implicitly reflected in the discounting process.
3.8.6 Relative Prices

It is possible (even likely) that the prices of different inputs used in an ACP may not move at the same rate, resulting in relative price changes. The expected relative price change can be accounted for directly.

If there is good reason to believe that an input is going to increase at a different rate from others, then the correct rate in period $t$ is imputed by multiplying the input using the following expression:

$$P = \frac{(1 + g)^t}{(1 + p)}$$

Where:

- $P =$ relative price
- $g =$ rate of increase in the nominal price of the input
- $p =$ general rate of inflation (eg, CPI)
- $t =$ time interval.

If differential rates of inflation are expected for individual cost or benefit items, the difference between the expected value of the costs and benefits needs to be included. Where cost or benefit items are expected to increase at a rate greater than general price inflation (eg, as typically measured by the Consumer Price Index – CPI), then they should similarly be adjusted upwards. This may occur with wages or civil construction costs, for example. The advice of the Federal Department of Finance and Administration in its *Handbook of Cost-Benefit Analysis* (January 2006) should be taken in this regard:

“If there are good reasons for thinking that particular cost or benefit streams will not follow general price movements, those changes in relative prices should be built into the analysis.” (p. 60)

It does need to be recognised that this can introduce a problematic situation, namely trying to estimate an inflator value for the particular cost or benefit stream over a (potentially) long time period.

If there is a situation where the analyst has strong evidence to believe that a particular category of costs or benefits is highly likely to grow at a rate ‘over and above’ general inflation (eg, CPI), there is a risk of underestimation of effects in the economic evaluation. The use of a VM session could be useful here in soliciting the views and/or experience from relevant experts or gaining ‘direction’ to appropriate statistical or other data.

The approach recommended is to increase the particular cost and/or benefit stream(s) by the difference between CPI and the expected rate of change (which may vary over time also) prior to discounting. Obviously, where adjustments are significant, sensitivity testing will become an important consideration.

Where this approach is taken for any category of cost or benefits, there should be sufficient supporting documented evidence provided in the CBA report to show the rationale underpinning the approach being adopted.
3.9 Decision Criteria

There are a number of alternative criteria for the assessment of the economic value (net economic worth to society) of projects. These criteria are outlined in the following sections. While there are a number of criteria available, it is recommended that Net Present Value (NPV) be viewed as the preferred decision criteria for CBA and any variation from this rule must be well documented in the CBA report and a clearly articulated rationale provided.

3.9.1 Net Present Value

NPV is perhaps the most straight-forward CBA measure. It is the sum of the discounted project benefits less discounted project costs. It can be expressed as the following formula:

\[ NPV = \sum_{n=0}^{N} \frac{B_n - C_n}{(1 + r)^n} \]

Where:
- \( B_n \) = benefits in year \( n \) expressed in constant dollars
- \( C_n \) = costs in year \( n \) expressed in constant dollars
- \( r \) = real discount rate
- \( n \) = evaluation period in years.

Using NPV as a decision rule, a project is potentially worthwhile (or viable) if the NPV is greater than zero; i.e. the total discounted value of benefits is greater than the total discounted costs.

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14 As with the DCF method discussed earlier ‘advice’ on setting up for the calculation of the various decision criteria within an MS Excel spreadsheet environment are provided later in this report.
Table 3-1: Decision Rules with NPV

<table>
<thead>
<tr>
<th>If</th>
<th>Meaning</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV &gt; 0</td>
<td>The project would be worthwhile</td>
<td>The project should be accepted</td>
</tr>
<tr>
<td>NPV &lt; 0</td>
<td>The project would not be worthwhile</td>
<td>The project should be rejected</td>
</tr>
<tr>
<td>NPV = 0</td>
<td>The project neither adds or subtracts value</td>
<td>The project could be accepted since the required rate of return is being obtained</td>
</tr>
</tbody>
</table>

When comparing mutually exclusive alternatives, the alternative that yields the highest NPV would be chosen.

Whilst the NPV rule is generally straight-forward there are a number of issues that can arise with its use. These relate to:

- The impact of budget constraints
- Complementarities among projects
- The interaction of budget constraints and project timing choice
- Comparison of projects with different lengths of life.

3.9.2 Benefit-Cost Ratio

The Benefit-Cost Ratio (BCR) is the ratio of the present value of benefits to the present value of costs. The BCR can be expressed as follows:

\[
BCR = \frac{PV_{\text{Benefits}}}{PV_{\text{Costs}}}
\]

Where:

\[
PV_{\text{Benefits}} = \sum_{n=0}^{N} \frac{B_n}{(1 + r)^n}
\]

\[
PV_{\text{Costs}} = \sum_{n=0}^{N} \frac{C_n}{(1 + r)^n}
\]

A project is potentially worthwhile if the BCR is greater than 1. This means that the PV of benefits exceeds the PV of costs. Under this decision rule, if alternatives are mutually exclusive, the alternative with the highest BCR would be chosen.

It is recommended that the BCR is not adopted as the prime decision rule. BCRs can sometimes confuse the choice process when the policies under consideration are of a different scale, yielding misleading results. For example, if proposal A has a PV of benefits of 200 and PV of costs of 100, it has a NPV of 100 and a BCR of 2. If the alternative proposal, B, has a PV of benefits of 600 and costs of 400, it has a smaller BCR (1.5) but a larger NPV (200). It would be more efficient to choose proposal B.
3.9.3 Internal Rate of Return

The Internal Rate of Return (IRR) is the discount rate at which the NPV of a project is equal to zero, i.e., discounted benefits equal discounted costs. In algebraic terms, the IRR is the value of \( r \), which solves the equation:

\[
0 = \sum_{n=0}^{N} \frac{B_n - C_n}{(1 + r)^n}
\]

A project is potentially worthwhile if the IRR is greater than the discount rate applied in the evaluation. If projects are mutually exclusive, this rule suggests that the project with the highest IRR should be chosen.

There are a number of potential problems with using the IRR for decision-making:\(^{15}\):

- It may not be unique; that is, there may be more than one discount rate at which the NPV is zero. This problem only arises where annual net benefits change more than once from positive to negative (or vice versa) during the discounting period.

- IRRs are percentages (i.e., ratios), not dollar values. Therefore they should not be used to select one project from a group of mutually exclusive projects that differ in size. This scale problem always arises with the use of ratios, including benefit-cost ratios, cost effectiveness ratios, and IRRs.

Nonetheless, as long as it is unique and scale is not an issue, the IRR conveys useful information to decision-makers who want to know how sensitive the results are to the discount rate.

3.9.4 Net Present Value per Dollar of Investment

Net present value per dollar of investment (NPV/i) contains elements of NPV and BCR criteria. It can be expressed as:

\[
NPV/i = \frac{\sum_{n=0}^{N} K_n}{(1 + r)^n}
\]

Where:

- \( K_n \) is the capital cost for year \( n \).

NPV/i can be useful where proportions of the capital costs are funded from other sources. The alternative with the highest NPV/i should be chosen.

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3.9.5 Payback Period

The project’s payback period is determined by counting the number of years it takes before cumulative forecast cash flows equal the initial investment. This criterion requires an agreed ‘rule’ for a cut-off date for payback and any such rule would be arbitrary as the worth of the project has little to do with such a date.

3.9.6 Recommended Decision Criterion

There is often debate about the most appropriate decision rule. The advice from the Department of Finance and Administration is clear:

“Other decision rules such as benefit-cost ratio and internal rate of return may be included with caution in the analysis alongside the net present value criterion. However, these rules can be misleading and should not be used in place of the net present value rule.”¹⁶ (p. 62)

For additional discussion on these issues, The Department of Finance and Administration’s Handbook (pp. 57-59 and 134-140) and the OBPR’s Best Practice Regulation Handbook (pp. 119-128) provide useful advice.¹⁷ Also, Boardman et al (2006) Cost-Benefit Analysis: Concepts and Practice.

3.10 Allowing for Risk and Uncertainty

Until now, it has been assumed that single-value estimates of future costs and benefits will be applied in the CBA. This is consistent with the assumption that future costs and benefits are known with a high degree of certainty. In many cases, some of the costs and benefits involved in a project evaluation will be uncertain. It is important to take into account the potential variation surrounding these estimates. Estimates of possible outcomes that affect the economic viability of the project—whether it be from a financial, safety or environmental perspective - will need to be defined, evaluated and treated.

Risks associated with aviation projects are to be evaluated under the Common Risk Management Framework (the Common Framework).¹⁸ Risks are subjected to the Common Framework and a CBA for their management, which will contribute towards the overall cost of the project. Realised risks—issues—will affect the overall viability of the project and hence coordination of the risk management with the project assessment will optimise the project decision. It will be necessary to conduct the risk management processes to provide the relevant inputs to the project CBA once the scope of the project has been defined.

¹⁶ Handbook of Cost-Benefit Analysis, Department of Finance and Administration, Canberra, January 2006
¹⁷ Refer to Reference list at the end of this report.
¹⁸ Common Risk Management Framework for New and Changed Operational Requirements within Aviation, Department of Transport and Regional Services, Department of Defence, Civil Aviation Safety Authority and Airservices Australia, February 2007 (consultation draft – Draft 1.3).
Risk management and the economic evaluation (the CBA) should use the same set of standard values, SEVs as appropriate.  

The following section discusses internal project risk assessment from an economic perspective and from the perspective of preparation of a CBA.

3.10.1 Sensitivity Analysis

As CBA involves estimating many factors that are subject to uncertainty, it is not appropriate to rely on a single value. Therefore sensitivity analysis should be used to gauge the potential for a decision variable to diverge from its estimated value.

Sensitivity analysis is also used to calculate the effect of variation of inputs on the decision criteria, such as NPV and/or BCR.

Sensitivity analysis involves defining a range of values for an uncertain variable in the appraisal and assessing the effects on the CBA of assumptions or estimates within the defined range. This will highlight those variables for which a change in the input value has a significant effect on the outcome of the CBA.

For the significant factors, the following should be listed:

- Assumptions and estimates on which the appraisal has been based
- An upper and lower bound of the range of critical or particularly uncertain estimates and the assumptions on which this range is based
- The resultant NPV at the upper and lower bound of each estimate.

A useful approach—a so-called partial sensitivity analysis—is to examine how the NPV changes as one variable varies over a plausible range (holding other variables constant). This approach is particularly important to apply for the most important or uncertain variables.

It is important to extend sensitivity analysis to the discount rate that is applied to the project cost and benefit streams. Suppose that a discount rate of six per cent was adopted, sensitivity testing at four per cent and eight per cent can accommodate uncertainty about the level of the opportunity cost of capital during the project period ahead. In this regard, it is noted that the OBPR suggests sensitivity analysis with a real discount rate of seven per cent be at three per cent and 11 per cent. Given that the recommendation to CASA is to adopt a 7 per cent real discount rate, sensitivity testing as per the OBPR (ie, at three per cent real and 11 per cent real) is also recommended.

In addition, use of more than one test discount rate may assist in focusing on key uncertainties in cases where there are significant differences in the time profile of net benefits of project alternatives.

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19 The Standard Economic Values report is a companion document to this report.
20 Australia Government (2007), Best Practice Regulation Handbook, Canberra (p. 130).
As noted earlier, the values included in the CBA are the ‘most likely’ or ‘best’ estimates. Sensitivity analysis provides information about the effect of errors (under or over estimates) on the viability of the project; and provides a test of the robustness of the results to changes in the original assumptions. Considerations of key project risks should also be incorporated into the sensitivity analysis.

The 'tests' to be applied should also include:

- Variations to the capital expenditure quantum and spend profiles (eg, timing of expenditure)
- Variations to the estimates associated with operating costs of alternatives
- Variations in assumptions about ‘take-up’ rates and other key assumptions with respect to technology and systems as is appropriate
- Variations in demand/use profiles and ‘ramp up’ over time.

The development of scenarios with combinations of changes to assumptions can be a useful approach, particularly in terms of deriving reasonable ‘worse case’ and base case scenarios.

Defining and developing a range of possible sensitivity tests could be a task/element of a VM workshop at the beginning of the evaluation.

Given the context of CBA of ACPs, it is recommended that specific sensitivity analysis be incorporated around two important aspects associated with risk. An important input into evaluations is likely to be risk analysis/modelling associated with determining safety aspects such as the probability of (increasing or reducing) accidents and fatalities.

It is recommended that specific sensitivity tests are applied to the values for the costs of accidents, in part to counter the degree of debate about appropriate valuations. It is recommended that specific sensitivity tests be adopted that draw upon some of the literature around the use of WTP based estimates of statistical values of human life. Furthermore, it is recommended that consideration be given to applying a disproportion factor (DF) specifically to an assessment of the risks associated with fatalities and initiatives being proposed to reduce fatalities. In evaluations where the major rationale underpinning expenditure is a reduction of safety risks (particularly where levels are currently deemed adequate) as opposed to the generation of other benefits (eg, travel time reductions, aircraft operating cost savings etc), it is recommended that DF analysis be undertaken to augment and/or further inform the evaluation. This is discussed in more detail in Section 3.14.

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21 As discussed in Economic Benefit-Cost Analysis Comparing Enroute Class E and Class C Airspace, Access Economics Pty Ltd, 30 April 2004, for Airservices Australia or in some of the reports/studies referenced in the BTRE Report 113.
3.10.2 Risk Assessment

Where the project/proposal under investigation does not require a formal risk assessment separate to but related to the CBA, sensitivity analysis within the CBA should suffice.

However, should it be deemed necessary\(^{22}\) to undertake a risk assessment as part of the CBA the following advice is provided.

Risk assessment with the CBA will involve reiterations of the economic evaluation where new or updated data is provided. Furthermore, a specific focus on the various risks associated with options can be undertaken. Risk analysis for each of the options can be undertaken and could involve drawing upon material from other elements of the study, for example: information about the range of potential outcomes and the probability of each occurring (i.e., the probability distribution). The key source of this information will be, ideally, empirical evidence eg:

- Observed outcomes for projects with similar characteristics
- Professional advice from study team engineers
- Statistical analysis, eg, risks of specific events
- Time series data of values of key variables (eg, exchange rates)
- Historical evidence of cost and program delivery overruns.

The compilation of a risk register and risk log which incorporates assigned probabilities and/or an impact exposure matrix will be important in endeavouring to quantify the most significant risks for the risk analysis. The register establishes a list of possible project risks, type of risk descriptions, likelihood (or probability), inter-dependencies with other sources of risk, expected impact counter measures, and risk status etc.

Statistical evidence and/or study teams’ expert judgement about the probability of specified risks occurring will be used to calculate the expected value of costs and benefits. Monte Carlo simulation can be used to provide an indication of the range and distribution of possible outcomes (recognising that the key to this sort of modelling is quantifying data inputs).

A key feature of the analysis is the determination of the appropriate level of risk adjustment—which will be a function of how much risk can be assumed to have been incorporated into costs and benefits (savings).

The probability/impact exposure matrix measures can provide an indication of the extent to which costs or benefits are vulnerable to a given risk and can be used to indicate which risks are most material to the business case.

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\(^{22}\) Advice should be sought from the General Manager OAR about the level and detail of risk assessment that would be appropriate.
Furthermore, it could be decided to undertake a quantitative risk assessment (QRA) in order to adjust the business case which would involve drawing the distinction between ‘planned’ costs (typically point estimates) and benefits (based on an assumption of ‘all going well’) and ‘expected’ costs and benefits (which would incorporate allowances for difficulties such as cost and time overruns). This would result in calculation of the expected (or risk-adjusted) value, which is the weighted-average of all potential outcomes and associated probability.

In developing the QRA, it will be necessary to prepare estimates of realistic ranges within which cost might fall and to attach to this a likelihood of occurrence. This can be done by utilising a 3-point estimate for each risk element (triangular distributions), which would represent 3 possible costs (eg, low, most likely, and high) and expressing these in terms of the relative likelihood (or probability) of alternative outcomes within an overall range as illustrated in Figure 3.2.

Risk analysis software (eg, @Risk and Crystal Ball—which incorporates Monte Carlo simulation) could be used to simulate the entire project option by solving (or iterating) it numerous times. This could, for example, involve preparation of 3-point estimates for all risk activities in order to enable evaluation of overall project risk.

![Figure 3-2: Cost Probability Distribution for a Cost Activity](image)
Such a simulation analysis could be used to derive a standard probability (or bell-shaped distribution) that could provide an indication of the probability that the total project costs will not exceed a particular value. From the probability distribution it could then be possible to derive a cumulative probability curve (typically, S-shaped as per Figure 3.3) of expected project out-turn costs at various levels of probability (this process could also be applied to benefit streams as well as costs).

![Cumulative Probability Curve](image)

**Figure 3.3: Example – Cumulative Probability Curve**

As noted earlier, the level of risk analysis that is directly included within the CBA or undertaken ‘externally’ and then utilised in preparing the CBA should be determined prior to undertaking the CBA.

The BTRE’s report, *Risk in cost-benefit analysis* (Report 110, 2005) provides useful discussion on the treatment in CBA.

**3.10.3 Optimism Bias**

Experience has shown that project and policy planning has long been afflicted by Optimism Bias (OB). Research has shown that there is a demonstrated, systematic, tendency for project appraisers (and/or sponsors) to be overly optimistic. This suggests that the probability of a project or proposal going wrong can exceed that of the outcome proving better than planned, ie, that risks are biased. To redress this tendency, it is recommended that appraisers make explicit, empirically based adjustments to the estimates of a project’s costs, benefits and duration.
3. Principles of Cost Benefit Analysis
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It is suggested that a specific OB analysis\textsuperscript{23} be undertaken to ensure a high level of certainty can be attached to capital costs and other key cost element estimates. This would involve adjustments to cost and benefit estimates to reflect the potential to underestimate costs and overestimate benefits that can be inherent in the early planning stages of projects.

OB is a generic risk, and adjustment for it should be a routine part of project appraisal. The preferred approach to applying OB to risk adjusted estimates is to move away from the generic percentage increases for capital and operating costs and replace these with OB estimates established for separate project components. For example, in deriving capital costs, OB may be established for various operation cost components, such as labour, access charges, etc. Where this is impractical or not warranted in cost grounds, use of percentage increases can suffice.

Determination of the appropriate OB factors could be a task included in a VM workshop. It is noteworthy that the UK Treasury guidelines published a schedule by type of project and ‘technology’ projects (as opposed to for example, civil engineering works) attract a substantially higher ‘penalty’. As with other areas of risk analysis, if there are recent empirical studies or projects to reference, this should be done (with positive as well as less-than flattering examples cited).

3.11 Issues and Limitations of Cost-Benefit Analysis

As with any analytical technique, there can be some inherent areas of possible deficiency. In undertaking CBA, analysts and reviewers need to be aware of some key criticisms that can, and have, been levelled at the method.\textsuperscript{24}

These can be associated with:

- The use of monetary values for costs and benefits including non-monetary items such as values for a statistical life, value of travel time savings and values for other intangibles.

\textsuperscript{23} Defined in “Handbook of Cost-benefit Analysis” (Dept. of Finance and Administration, Canberra, 2006) as when the favourable estimates are presented as the most likely or mean estimates. Suggested remedies are sensitivity analysis, loading of the discount rate and the clear enunciation of assumptions and their supporting rationale. In the UK, a formal approach to Optimism Bias has been introduced to capital works appraisal. In the UK Treasury’s Green Book (Appraisal and Evaluation in Central Government, 2003) and the Dept. for Transport’s Transport Analysis Guidance (2003) specific values for OB are set out be applied to appraisals depending upon the type of capital works involved. For example, on capital expenditure a range of 10% to 200% is recommended for “Equipment and or Development” projects where these are defined as “projects that are concerned with the provision of equipment and/or development of software and systems (ie, manufactured equipment, Information and Communications Technology (ICT) development projects) or leading edge projects”. This formal process was put in place based on the findings, inter alia, of two important reports: “Underestimating Costs in Public Works Projects – Error or Lie?”, Flyvbjerg, APA Journal (2002) and “Review of Large Public Procurement in the UK”, Mott MacDonald (2002). The 3 key areas (accounting for over half the bias estimate from a range of 26 specific items under review) of bias identified by Mott MacDonald were associated with Degree of Innovation involved, Inadequacy of the Business Case and the Technology involved.

\textsuperscript{24} In many cases, criticisms have more to do with the behaviour of analysts undertaking CBAs and not necessarily the method itself.
3. Principles of Cost Benefit Analysis
3.11. Issues and Limitations of Cost-Benefit Analysis

- Bias in assumptions in order to make a proposal ‘look good’.
- Concerns that the process of preparing a CBA can be complex and onerous on analytical resources and information requirements.
- The view that CBA is an inequitable process as all beneficiaries are treated equal irrespective of the identity of the beneficiaries (e.g., no reflection of socio-economic circumstances in ‘weighting’ costs and benefits to members of society affected by proposals).

The following sets out some points useful to consider by way of refuting many of the criticisms levelled at CBA:

- “Bias in assumptions in order to make a proposal look good”— is a criticism of the analyst carrying out the CBA rather than of CBA as a policy/investment evaluation method. As noted below, a clear articulation of assumptions and transparent analysis can address this criticism.

- “Application of monetary values to human life”— this criticism is misdirected. Lives are not being valued; the values are for reductions in the risks of premature death. Hence the use of the term, the value of statistical life (VSL). Proposals are not designed to protect identifiable individuals from certain death but rather to protect large populations from collective mortality risks. VSL is the relevant concept for judging such proposals.

- “Concerns that the process of preparing a CBA can be complex and onerous on analytical resources and information requirements”— it is not uncommon for analysts tasked with preparing a CBA to face time pressure and resource constraints. The decision to quantify, and with what degree of effort, should reflect the value of the increased precision that can be obtained and the costs of obtaining it. Moreover, CBA is not necessarily complex and onerous. The analysis should be commensurate with the magnitude of the problem and the size of the potential impacts. Using a CBA framework can be quite simple for less significant issues and of modest cost.

- “The view that CBA is an inequitable process”— it is often argued that CBA takes the existing distribution of income as given and does not consider the equity implications of the policies that it seeks to evaluate. In other words, unweighted WTP measures virtually assures proposals that are slanted in favour of the preferences of high-income individuals. This criticism is directed at the way net benefits of individuals are aggregated to obtain estimates of the community’s net benefit. This criticism is legitimate as far as it goes. CBA does not take equity into account. However, that need not be the case. Analysts can weight in any number of ways the impacts on low-income and high-income individuals, the problem is that someone must state explicitly what the weights should be and from where ‘correct’ weights should be sourced. No unique set of equity weights have been determined through the political process, and as a consequence ‘no weighting’ has become the default in CBA. In part this is where using an MCA approach as supplementary to the CBA can aid decision-making. As discussed earlier, even with no weighting, more disaggregated CBA can provide important information about the impacts on particular groups of people.
With these potential limitations or ‘concerns’ in mind, the best advice is to clearly articulate all assumptions and ensure that all analyses involved in the evaluation are verbally and numerically explicit about the assumptions on which they are based and the reason for those assumptions. Where possible, effort should be made to describe impacts and effects in qualitative as well as quantitative terms and describe any unique features and/or issues. The aim should be to provide decision-makers with as much supplementary contextual information as is both reasonable and practical.

3.12 Role of Multi-Criteria Analysis

In many policy decision-making settings there is a requirement (and practicality) to prepare supplementary assessments that are either ‘stand-alone’ or used in conjunction with CBA. This is particularly the case where hard-to-quantify factors need to ‘captured’ as part of the advice to policy makers.\(^{25}\)

In order to overcome the view (put forward by some commentators and academics, for example) that CBA relies heavily on monetary valuations\(^{26}\) and the alleged omission of factors for which money valuations are difficult or impossible, the use of multi-criteria analysis (MCA) as supplementary (as opposed to an alternative) is often adopted.\(^{27}\)

The MCA approach is often used as a supplementary measure to CBA to examine qualitative values when assessing significant change proposals or investment decisions. There would not be any real necessity to contemplate using MCA where it is obvious that the vast majority of costs and benefits of a proposal have been satisfactorily identified, quantified and monetised.

As noted previously, the Australian Airspace Policy Statement has specified a number of key general principles for airspace administration that CASA must take into account, namely:

- Safety – ‘the Government expects the safe operation of Passenger Transport operations to be the first priority in airspace administration’
- Efficient use of airspace is a benefit to the aviation sector and the Australian economy
- Protection of the environment from the effects of, and associated with, the operation and use of aircraft
- Access to airspace will be open to all users unless there are justifiable reasons to deny access in terms of safety, efficiency, environmental protection or national security

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\(^{25}\) For example, the Value Measurement Methodology mentioned earlier is one such approach used in the USA for Federal Government-sponsored e-commerce projects of national significance.

\(^{26}\) This should not necessarily viewed as a weakness, but is arguably a critical strength of CBA.

\(^{27}\) It is worth noting that exactly what constitutes multi-criteria analysis is hard to say and variations on the theme are common. There is in practice no established theoretical framework or uniform set of principles (unlike that that exists for CBA). Terminology also varies.
Airspace administration will take account of national security—National security refers to Australia’s defence, security, international relations or law, coupled with the need to protect the Air Traffic Management system.\textsuperscript{28}

Adoption of an MCA technique can provide a means for CASA (and/or third parties preparing proposal submissions) to assess these principles (or criteria) for each major ACP.

The form of MCA discussed in this section is known as the Goals Achievement Matrix (GAM) method. The primary focus of the GAM method is on selected socio-economic or other objectives as opposed to the effects on particular community groups.\textsuperscript{29}

The approach does not seek specifically to focus on sectoral interests, and does not require effects to be expressed in monetary values. Objectives can be weighted to reflect their relative importance to the analyst or decision-maker. Whereas CBA employs a well-established methodology in specifying and estimating various effects or impacts, the choice of impacts in MCA is typically more arbitrary and usually derived via a consultative approach.

Typically, MCA includes the determination of factors/criteria for inclusion and then a scoring system (with or without weighting) to reflect the relative importance of each in the overall assessment. The attainment of a single number score for options under the MCA can be developed. This typically involves adoption of a uniform scale. Scoring is usually undertaken using a scale, such as a scoring scale that runs from 0 to 5, for example: ‘Negative effect/Inconsistent’, ‘Remotely meets/Weakly Consistent’ ‘Partially Meets/Moderately Consistent’, ‘Substantially Meets/Strongly Consistent’ and ‘Best Meets/Fully Consistent’. Symmetrical scales are also widely used.

Whilst the scaling approach (like all scaling approaches) is subject to debate, it does have the benefit in that it converts all impacts to a common range of values and also preserves relativities for each effect under the different options when scores and scales are combined. Figure 3.4 provides an example of a MCA that could be adopted to supplement the CBA approach outlined in this report.

\textsuperscript{28} Minister for Transport and Regional Services, Mark Vaile, \textit{Airspace Act 2007 The Australian Airspace Policy Statement}, 28 June 2007, Canberra.

\textsuperscript{29} These objectives could also be referred to as ‘impacts’, ‘goals’, ‘attributes’, ‘criteria’ or ‘effects’ when discussing multi-criteria analysis.
Furthermore, it may be worth considering widening the scope of the ‘performance’ criteria under which to assess proposals to capture performance parameters for Air Traffic Management as provided by the ICAO. It is noted that use of the ICAO supported criteria would:

- Align with the global industry body’s positioning
- Allow for an even wider range of issues for consideration by decision-makers.

The ICAO parameters are divided into three groups and are presented in the table below.

<table>
<thead>
<tr>
<th>Societal</th>
<th>Operational Performance</th>
<th>Performance Enablers</th>
</tr>
</thead>
<tbody>
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<td>Safety</td>
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<td>Access and Equity</td>
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<td>Predictability</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3-4: Multi-Criteria Analysis Framework**
A similar scoring framework to that presented in Figure 3.4 could be developed for the factors in the table above.

Importantly, when undertaking MCA, it is crucial to recognise that in an ideal situation the first-best approach to assigning values to the effects of proposals/options is to estimate monetary values, as in CBA. For this reason, *inter alia*, MCA should only be viewed as a supplementary tool to CBA. Furthermore, it is recognised that the *Achilles’ heel* of the MCA approach is the weighting/scoring values ascribed to criteria/impacts as well as the potential to ‘double count’ impacts where they are captured directly within the CBA and then also included in a supplementary MCA.

Best practice in MCA usually involves agreeing scoring and weighting frameworks with the decision-making agency and/or key stakeholders (typically ‘experts’ in particular subject matters of relevance to the evaluation at hand) and then providing a rationale as to why each criteria received a particular score/weight relative to other criteria. It is not uncommon to arrive at a near consensus position via the use of VM workshops, where a selection of key ‘players’ agree to the scoring systems/weightings to be adopted. The aim is for this process to be as transparent as possible to avoid subsequent ‘concerns’ about the relative scores and/or weightings applied.

In developing the approach, a comparative summary of the proposal and alternatives is useful where the broad achievement against each criteria (or goal) is set out in one table. The varying proportional shading of the ‘Harvey balls’ (as seen previously in Figure 3.4) will visually indicate the options that perform best overall. As noted earlier, this summary can be taken one step further with scores attached to each level of achievement. Furthermore, scores can be weighted differently for each criteria/goal.

### 3.13 Ex-post Evaluation

Often a major short-coming with public sector project appraisal is the absence of ex-post evaluations. That is, asking the question: “how good was the evaluation undertaken on project X”? This process involves re-visiting the original evaluation one or two years after project implementation and re-running the discounted cash flow analysis with new updated values for key inputs including capital costs and other key inputs.

This process can also aid in building-up a database of ‘lessons learnt’ and other useful aids for future proposal evaluation.

It is recommended that CASA adopt a formal process for ex-post evaluation of ACPs and other project appraisals with a view to initially, reviewing all CBAs and other projects and some time later, reviewing a sample on a regular basis.
3.14 ALARP, Issues of Disproportionality and Cost-Benefit Analysis

The Common Framework is premised, inter alia, on the concept of As Low As Reasonably Practicable (ALARP), which in the risk management context involves weighing a risk against the trouble, time and money needed to control it. The Guidelines to the Australian and New Zealand Standards on Risk Management\(^{30}\) notes that risks in the ALARP region are also in what it refers to as the ‘Tolerable Region’.

In CBA, as far as is possible, costs and risk reductions (benefits) are converted to a common set of units—money—in order to undertake comparisons and discounted cash flow analysis of future streams of benefits and costs.

In CBA, when the NPV is greater than zero\(^ {31}\), a proposal/project is deemed economically justifiable as society is better off in aggregate terms. However, under the ALARP approach, the rule is basically to adopt a proposal unless the costs of doing so are grossly disproportionate to the risk. Importantly, the Australian and New Zealand Standards on Risk Management provides the advice:

“Selecting the most appropriate option involves balancing each option against the benefits derived from it.”\(^ {32}\) (p. 21)

It may be that there are cases where the costs could outweigh the benefits and the initiative could still be reasonably practicable to implement. However, the key qualifier in this regard is the concept of intolerable risks whatever the benefits. The Guidelines to the Australian and New Zealand Standard on Risk Management sets out three levels (bands) of risk: an upper band where adverse risks are intolerable; a middle band (or ‘grey’ area) where there is a need to balance the costs and benefits, and a lower band where positive or negative risks are negligible, or so small that no risk treatment measures are needed. Importantly, the Guidelines include the following statement, which is of relevance in the broader CBA context:

“When risk is close to the intolerable level the expectation is that risk will be reduced unless the cost of reducing the risk is grossly disproportionate to the benefits gained. Where risks are close to the negligible level then action may only be taken to reduce risk where benefits exceed the costs of reduction.”\(^ {33}\) (p. 65)

This should be the key governing principle in this regard.

In terms of considering by how much costs can outweigh benefits before being judged grossly disproportionate, this depends on factors such as how big the risk is to begin with (where, typically, the larger the risk, the greater can be the disproportion between the cost and the risk).

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\(^{31}\) The present value of benefits > present value of costs.


From an ALARP perspective, CBA:

- On its own, does constitute an ALARP case
- Should not be used to argue against the implementation of relevant good practice, unless an alternative measure(s) can be demonstrated unequivocally to be at least as effective
- Enables the use of sensitivity analysis to support conclusions suggesting that costs are disproportionate to the benefits of implementing a proposal
- Should not be used to argue against statutory duties
- Should not be used to justify risks that are intolerable (supported by appropriate analysis) or justify what is evidently poor engineering.

A specific sensitivity analysis to indicate the relative importance of risk mitigation measures (where these are far and away the key rationale underpinning the proposal) should be provided, which illustrates the ratio of costs over benefits relative to 1 x DF where DF is the ‘disproportion factor’. Where costs over benefits is greater than 1 x DF the proposal would be regarded as not justified for the risk reduction achieved.

DFs that may be considered gross vary from upwards of 1 depending on a number of factors including the magnitude of the consequences and the frequency of realising those consequences, i.e. the greater the risk, the greater the DF. Factors of 3 or more (with an extreme value of 10) are deemed appropriate for sensitivity analyses. As with a number of aspects in risk management, the issue of a gross proportionality factors is one of debate and active consideration in the Australian aviation sector and caution must be exercised in any application.

This area of analysis would be supplementary to the main CBA and only appropriate where risk mitigation and reduction are the over-riding objectives of the proposal (i.e. the expected source of the majority of benefits). This analysis should be undertaken by specialist risk modellers in a way consistent with the previously cited Australian / New Zealand Standards, and elements incorporated into the CBA only as appropriate.

### 3.15 Use of Spreadsheets

CBA can necessitate a substantial amount of numerical analysis. This includes estimation of the PVs of future cost and benefit streams as well as calculation of various decision criteria e.g. NPV and BCR. Use of a spreadsheet can also be beneficial for undertaking a range of supporting calculations (e.g. determining user benefits or changes in aircraft operating costs associated with a change proposal) which are used in the DCF analysis (which is central to CBA). It is envisaged that a spreadsheet developed ‘model’ will be required to undertake a CBA.
In developing a ‘model’ for undertaking the various calculations required in undertaking a CBA it is not unreasonable to expect that such as ‘model’ within a spreadsheet environment to contain a range of ‘sheets’ such as some setting out:

- Details of the model structure (i.e., a ‘control’ sheet)\(^{34}\)
- Details of parameter values to be used in the evaluation such as discount rate, the evaluation period (years), value of passenger travel time, average aircraft operating cost per hour by aircraft type, etc
- Details of sensitivity analysis and risk analysis (as appropriate)
- Calculations i.e., one or more sheets where the analyst may undertake a range of supporting calculations associated with determining specific costs and benefits to be included in the DCF analysis (e.g., reductions in average flying times between particular airports, aircraft operating cost savings etc) - including data sources / references etc\(^{35}\)
- The main DCF table where costs and benefits in monetary terms are converted from undiscounted to discounted values and from future values to present values as well as a range of selection criteria are calculated such as NPV, BCR and IRR.

Where possible inputs should be ‘parameterised’, that is, the number of calculations that involve ‘hard-wired’ inputs (numbers) should be minimised and the use of formulas encouraged that ‘pick-up’ data from a parameters and / or calculations sheet(s). This is particularly useful where the values of particular inputs may change after review and additional validation etc.

Good practice typically means that the ‘template’ of the main DCF table would enable someone reviewing the work to readily identify the various cost and benefit streams (by category) ‘captured’ in the evaluation – e.g:

- Capital costs (i.e., major capital items such as equipment, land, construction items, etc)\(^{36}\);
- Maintenance costs (i.e., annual/recurrent costs of asset maintenance)
- Other recurrent costs (e.g., consumables, energy costs, etc)
- Training costs\(^{37}\)
- Decommissioning costs (e.g., redundant equipment)

\(^{34}\) A simple flowchart can be a useful tool in a control sheet where the flowchart illustrates the linkages between the various sheets of the spreadsheet and sets out the function (i.e., what is done there) and inter-relationships etc.

\(^{35}\) Depending on the amount of supporting analysis to be undertaken, it may be prudent to have separate sheets for particular issues, e.g., a sheet for use in estimating passenger travel time savings; a separate sheet for estimating operating cost savings to the various aircraft operators etc.

\(^{36}\) Capital costs should not be confused with financial costs of raising capital for investing in assets (of various classes). Capital costs are the resources (i.e., exclusive of taxes etc) costs of the asset acquired.

\(^{37}\) It can be useful to separately show in the DCF tables ad hoc (or once-off) costs that are specific to implementing a change or investment initiative. This is particularly the case with items such as change proposal-specific training, production of new maps, charts and educational and user information material, for example.
3. Principles of Cost Benefit Analysis

3.15. Use of Spreadsheets

- Residual values
- User benefits (may be presented for various ‘classes’ – eg, aircraft operators (operating cost savings), commercial airline passengers (travel time savings), GA operators, etc;
- Accident cost savings including estimated reductions and increases in fatalities (as determined by supplementary risk/safety modelling).

This listing will vary from case-to-case and in practice it should be determined by discussions between the analyst and more senior management of their agency as to the level of disaggregation to be provided. It is recommended that the aim should be to provide sufficient disaggregation in the discounted cashflow tables to enable ready review and reasonable scrutiny (obviously the key costs and benefits items should be clearly identified as should those where there is particular ‘sensitivity’ and / or uncertainty about them). There is no ‘single one template’ but a number of key elements of ‘good practice’ as noted above.

The Queensland Treasury guidelines\(^{38}\) provide some useful advice on CBA and related analytical techniques vis-à-vis formats, and the reference – \textit{Benefit-Cost Analysis: Financial and Economic Appraisal using Spreadsheets}\(^{39}\) – also provides some good practical advice and examples.

It is recommended that summary information from the CBA calculations is presented in the report, whereever practical, in tabular and graphic formats (albeit with more detailed tables contained in attachments and appendices to the main report).

For example, the groupings of the various benefit streams could be presented in a pie chart or histogram to readily illustrate where the major benefits come from, e.g. travel time savings to RPT passengers and operating cost savings to RPT aircraft operators etc. Sensitivity analysis also lends itself to summary presentations of results in graphic format where the ‘base’ result can be compared with the outcomes (eg, NPVs) under the various sensitivity tests and scenarios. The illustration overleaf provides a possible way to present summary results of a CBA showing the NPV, benefits and costs as well as distribution of benefits and results of sensitivity tests.


The sensitivity tests conducted are: 4% and 8% discount rates; capital costs +/- 20%; benefits streams +/- 20%.

**Figure 3.5: Illustration of a possible way to present CBA results**