Guidelines for the economic appraisal of EATMP projects
-
the effective use of cost-benefit studies

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ABBREVIATIONS

ADF	Automatic Direction Finder
AEV	Annual Equivalent Value
ASM	AirSpace Management
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Service(s)
B/C	Benefit/Cost
CASA	Computer Assisted Slot Allocation
CBA	Cost-Benefit Analysis
CIP	Convergence and Implementation Programme
CNS	Communications, Navigation and Surveillance
DCF	Discounted Cash Flow
DOC	Direct Operating Cost
EATMP	European Air Traffic Management Programme
EATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
ECBAG	EATMP Cost-Benefit Advisory Group
(M)ECU	(Millions) European Currency Unit
EEC	EUROCONTROL Experimental Centre
EPAC	EATMP Policy and Allocation Committee
EUROCONTROL	European Organisation for the Safety of Air Navigation
EWP	EATMP Work Programme
FDPS	Flight Data Processing System
IATA	International Air Transport Association
IRR	Internal Rate of Return
MAC	Mid-Air Collision
NASPAC	National AirSpace Performance Analysis Capability
NEI	Noise Exposure Index
NPV	Net Present Value
PV	Present Value
R&D	Research and Development
UVA	Utility Value Analysis
VoL	Value of Life
VOR	VHF Omnidirectional Radio Range

FOREWORD

Cost-Benefit Analysis (CBA) is an increasingly important tool in the assessment of investment decisions in the aviation industry. CBA is particularly important to the EATMP programme which involves large expenditure by many states to realise new operational concepts and provide new infrastructure. The value of these concepts and infrastructure can be difficult to calculate because of the complex operational environment and relationships between international stakeholders.

Within the ECAC states, the EATMP Cost Benefit Advisory Group (ECBAG) provides a focus for air traffic service providers and airspace users to discuss CBA. The ECBAG has produced guidelines for the conduct of CBA which are intended to promote the consistent application of CBA in all ECAC states and in EATMP projects and will assist those states that have not conducted CBA to undertake them if they wish. The guidelines aim to:

- explain the role of CBA in the context of the EATMP programme;
- provide guidance on the conduct of CBA.

The guidelines seek to address the types of problems associated with the analysis of EATMP projects, for example:

- the wide geographic impact of many projects, resulting in costs and benefits in many ECAC states;
- the many different stakeholders affected by changes;
- the lack of consensus in the way in which to approach qualitative benefits;
- the considerable effort and cost associated with full, detailed analysis of major changes to the aviation system.

While the guidelines describe the approach that should be taken to CBA, they do not constitute a “recipe book” and do not prescribe a definitive methodology. The guidelines give a framework generally applicable for conducting CBAs, but do not describe in detail how to assess any particular projects.

The guidelines emphasise the importance of the following aspects of CBA:

- CBA provides a support tool to assist decision-makers, recognising that there are always benefits which cannot be economically valued;
- CBA can be applied at all stages of the project life cycle and has value in planning the timing and direction of a project, rather than simply deciding whether or not to implement a project;
- different types of CBA can be applied at different stages of a project, ranging from scoping studies to highly detailed analyses. The stages are sequential and the results of each stage can be reviewed before deciding if further work is required.

The guidelines are aimed at three user groups. Firstly, this summary provides an overview of CBA in EATMP for senior managers and policy makers. Secondly, the main text of the guidelines provides project managers with a fuller description of the role and application of CBA to EATMP. Thirdly, the annexes to the guidelines provide more detailed information and guidance for those actually conducting analyses.

During the compilation of the EATMP guidelines it became clear that, to aid consistency, there was a need for a common database of “standard values” to be used in EATMP CBA. The setting up of such a database has been recommended by the ECBAG with the intention that it be managed by EUROCONTROL’s CBA Cell, which is currently being established. The Cell will provide an international focal point for CBA. The issuing of future versions of these guidelines, updated to reflect the availability of new information, would also be the responsibility of the Cell.

1. INTRODUCTION

1.1 AIM

This document has been produced by the European Air Traffic Control Harmonisation and Integration Programme (EATMP) Cost-Benefit Advisory Group (ECBAG) to aid consistent economic appraisal of projects falling under the EATMP umbrella. The aim is:

- to describe how Cost-Benefit Analysis (CBA) can be used to assist in decision making at all stages in the life cycle of a project;
- to provide guidelines for deciding whether an EATMP project should be subject to an economic appraisal using the cost-benefit approach;
- to provide guidelines for conducting cost-benefit studies;
- to describe the other requirements, e.g. supporting data, that will be necessary to allow cost-benefit studies to be carried out effectively and consistently.

EATMP is a strategy aimed at integrating the Air Traffic Services (ATS) of the European Civil Aviation Conference (ECAC) states in order to meet the expected increase in air traffic demand into the 21st century. Annex A provides background information about EATMP (and where economic appraisal fits into the programme).

These guidelines are aimed at three user groups. Firstly, the summary provides an overview of CBA in EATMP for senior managers and policy makers. Secondly, the main text of the guidelines provides project managers with a fuller description of the role and application of CBA to EATMP. Thirdly, the annexes to the guidelines provide more detailed information and guidance for those actually conducting analyses.

1.2 PURPOSE OF ECONOMIC APPRAISAL

Investments in the aviation infrastructure are required continuously in order to maintain safety and reliability, improve the quality of service and match system capacity with the expected traffic growth. The amounts involved are significant - for example in 1994, the total estimated investment expenditure in the entire ECAC region, in respect of which comparable data were available, amounted to ECU 1.315 billion.

The providers of ATS, the users of these services (primarily airlines) and the financing organisations all need to be convinced of the economic viability of proposed new projects. The decision-maker, who is responsible for sanctioning future projects, will require a clear understanding of the advantages and disadvantages of the proposals. While choices between different proposals must draw on experience and judgement, they normally also benefit from systematic economic appraisal. In the face of a variety of diverse projects it is important to ask, formally, which represent the most effective use of resources.

Typically, methods of economic appraisal are used to help determine :

- whether to pursue a certain course of action or investment;
- which course of action or investment from a set of alternatives, maybe with different objectives and purposes, to choose; or
- how best to achieve a given prescribed objective from a set of options or approaches.

1.3 COST-BENEFIT ANALYSIS

CBA is widely accepted as a vital support tool for economic analysis in Air Traffic Management (ATM) and is used:

- to assist decision makers;
- to provide transparency of issues;
- to quantify the effect of changes to the ATM system;
- to help in achieving user and European consensus for EATMP;
- to help prioritise and compare projects.

A formal definition of an “ideal” CBA might be:

> *"An objective study in which the costs and the benefits of a particular project’s options are fully quantified in economic terms, taking full account of the times at which costs are paid and at which benefits accrue".*

Usually a CBA is conducted as a net present value analysis by cumulating and discounting annual cash flows associated with the proposed project. On the basis of such an approach, summary statistics such as net present value, benefit/cost ratio, pay-off periods and internal rates of return can be determined.

In practice things are not usually quite so straightforward. While costs and most types of benefits can generally be quantified after a little research, an economic breakdown of all the projected benefits can sometimes be more elusive. If, for example, four main benefits are identified for a project but only two or three of these can be quantified, CBA can still provide useful input to the decision-maker. However in extreme cases where none of the claimed benefits can reliably be quantified, CBA can add less value to the decision-making process. In such cases, alternative methods of economic appraisal should be considered (see Annex B).

For CBA to be effective in comparing projects, it must be applied in a consistent manner. The purpose of this document is to explain CBA techniques and to establish a framework for the consistent application of CBA.

1.4 CONTENTS

The information in this document is presented as follows:

- **Role of CBA in project development and decision making** (Section 0). This section describes how CBA can be used at all stages in the project life cycle acting as an aid to decision makers in deciding the scope of the project and in securing project funding;

- **Principles of cost-benefit analysis** (Section 3). This section outlines the key stages in conducting a CBA. The section also contains guidance on setting an appropriate level of detail for a CBA taking account of the project size and scope;
- **The Role of CBA in EATMP** (Annex A). This section provides background information about EATMP and where economic appraisal fits into the programme;
- **Other approaches to economic appraisal** (Annex B). This section provides a summary of other approaches to economic appraisal.
- **Suggested approaches for aspects of CBA** (Annexes C to K). A number of self-contained technical annexes are included which provide further information on key aspects of CBA. The annexes contain:
  - ATM service provider cost savings (Annex C);
  - aircraft operator cost savings (Annex D);
  - capacity and reduced delay benefits (Annex E);
  - reliability benefits (Annex F);
  - safety benefits (Annex G);
  - environmental benefits (Annex H);
  - simulation tools (Annex I);
  - net present value (NPV) method (Annex J);
  - sensitivity analysis (Annex K);

2. ROLE OF CBA IN PROJECT DEVELOPMENT AND DECISION MAKING

2.1 INTRODUCTION

CBA can be used at all stages of a project. A generic project life cycle is illustrated in Figure 2-1.

The life cycle illustrated in Figure 2-1 could apply to a range of project types including:

- Research and Development (R&D);
- implementation;
- operational.

CBA can assist decision taking for all of these project stages. The remainder of this section discusses how CBA can be applied at each project stage.

2.2 IDENTIFICATION OF PROJECT NEED OR OPPORTUNITY

To be most effective CBA should be invoked as early as possible in the project life cycle. Project sponsors will need to know at an early stage (before detailed requirements are drawn up):

- what type of benefits their project is likely to bring;
- how much (approximately) these benefits will be worth in economic terms;
- who will receive the benefits (the beneficiaries);
- what the associated costs are likely to be.

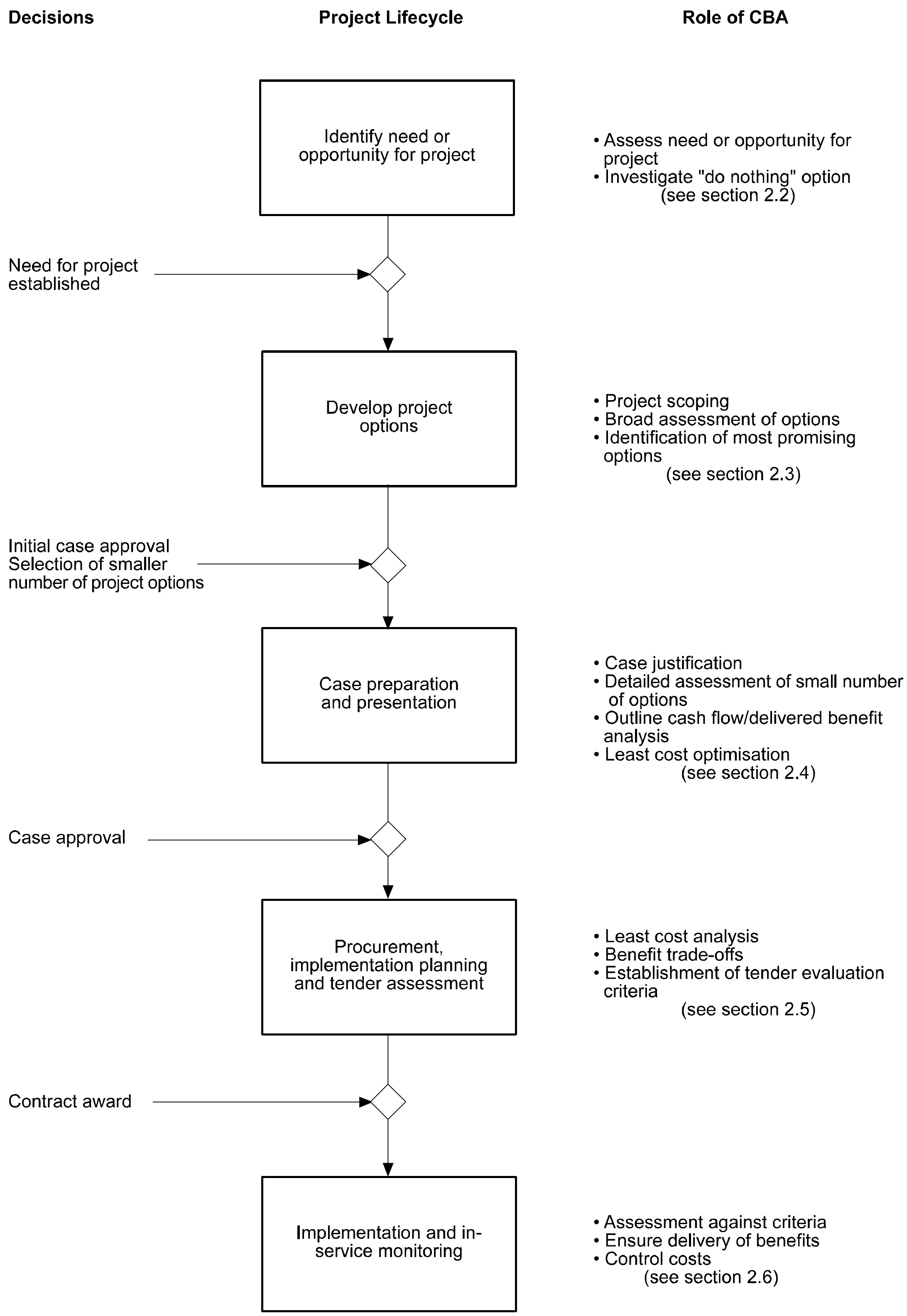
All projects start with the identification of a requirement for the project in terms of need or opportunity. A **need** exists if objectives are not currently being met. An **opportunity** exists if the objectives are being met, but the way that they are being met can be improved.

One of the most useful ways in which CBA can be used to assess the requirement for a project is to ask:

"What will be the dis-benefits if the project does not go ahead?"

This is known as the “do-nothing” option. In some cases there may be no serious dis-benefits associated with the do-nothing option, in which case the “need or opportunity” being addressed by the project may be discredited, and so the project as presented may have to be abandoned altogether. In other cases a clear need or opportunity may be identified. For example, if airspace capacity was outstripped by demand, aircraft operators might lose revenue if the do-nothing option was taken.

Figure 2-1 ***Project life cycle***



Addressing the do-nothing option is the first step in all CBAs. It is very important that it is addressed and evaluated explicitly. As an example, assume that there is concern that there are insufficient air-ground communication channels over Europe, and that this may limit capacity in the near future. A statement such as

> *"If no action is taken, soon there may not be enough air-ground communication channels and this might lead to a lack of capacity"*

does not properly address the do-nothing option. On the other hand, the following would be sufficient to enable a cost-benefit analyst to calculate the economic consequences of do-nothing:

> *"If no action is taken, Europe will be short of between 2 and 5 air-ground communication channels in 1999, rising to a shortfall of between 3 and 10 channels before about 2005. This will force the closure of Sector X sometime between 2001 and 2004, Sector Y sometime between 2003 and 2010 and possibly Sector Z in 2011."*

The more precision in dates and numbers the better, but at this stage only justifiable broad estimates are required.

It is also important to provide broad estimates of the likely project cost to give an indication of the scale of investment necessary to address the problems identified by the analysis of the do-nothing case.

2.3 DEVELOPMENT OF PROJECT OPTIONS

Assuming that a decision to proceed with project development is made as a result of evaluation of the do-nothing option, the project sponsor must develop options which represent different courses of action to meet the project requirements, i.e. “do-something” options. The exception, by definition, is the do-nothing option which does not meet requirements but provides the reference case against which the other options can be appraised. This reference case is also known as the **base case** or base option.

Of the do-something options, one should be a “minimum investment option” designed specifically to meet the requirements at minimum cost. This is often termed the “do-minimum” - as opposed to the do-nothing - option. For example, the partial upgrade of a current system may provide a minimum investment option. Other do-something options may be developed that provide a better quality solution, but these should not exceed the requirements.

CBA is an important tool in the assessment of project options. A “**scoping**” CBA should be carried out for all the project options, in order to assist the decision-maker in deciding on a course of action. It is important that the do-nothing option is re-examined as one of the project options - it may yet prove to be the best course of action.

There is no set formula for what should be included in a scoping CBA. As a rough guideline it should identify and provide a broad assessment of the costs and benefits of all options making it possible to identify the most promising project options.

At the end of this stage of the project development life cycle illustrated in Figure 2-1 it should be possible to present an initial or outline case for initial approval to proceed. Subsequent project development would then consist of a more detailed analysis of a smaller number of project options (see Section 2.4) leading to presentation of a full project case.

2.4 CASE PREPARATION AND PRESENTATION

In order to secure funding for a project a project case will be prepared and presented. The development of a project case may typically involve:

- analysing requirements and defining concepts;
- considering options and conducting initial feasibility analysis and basic CBA;
- bringing together a detailed case for the project, including:
  - implementation and transition planning;
  - detailed analysis of specific system investments and more detailed CBA.

A project case, with a supporting CBA, should be produced before submitting the project for approval and sanction. The CBA will involve:

- a detailed investigation of the costs and benefits of a small number of project options;
- investigation of least cost approaches to each option;
- preparation of cash flows for each option setting out a timescale for investment and delivered benefits;
- use of discounted cash flow analysis to compare options.

Note that the main difference between the detailed CBA for case justification and the scoping CBA used for initial assessment of options is in the level of detail and effort devoted to the analysis. In some cases the two could be combined. Setting an appropriate level of detail for CBAs is discussed in Section 3.2.6.

2.5 PROCUREMENT, IMPLEMENTATION PLANNING AND TENDER ASSESSMENT

Having received approval for a project to proceed, CBA can be used to support procurement, implementation, planning and tender assessment. Possible uses of CBA include:

- **Least cost analysis.** This would be used to derive the minimum investment required to achieve the project benefits. This can be used to set detailed budgets for the project;
- **Benefit trade-offs.** In the procurement process there may be advantages in terms of reduced investment costs if the supplier is allowed as much freedom as possible in achieving delivered benefits. CBA can be used to investigate the impact of system performance on the delivered benefit. For example, if a system is being procured to

replace an existing system that, through poor reliability, was causing delays, reduced delays could be achieved by:

- increased system availability;
- reducing the time taken to recover from failure;

CBA could be used to investigate the dependence of the delivered benefit on these two system performance parameters allowing the supplier some freedom in system design;

- **Tender evaluation criteria.** CBA could be used to establish economic assessment criteria against which tenders could be assessed.

2.6 IMPLEMENTATION AND IN-SERVICE MONITORING

Part of the CBA process is to monitor implementation and in-service performance to check that the planned investment costs are not exceeded and that planned benefits are delivered on time and at a level corresponding to that assumed in the project development process.

Note that an important part of this use of CBA is to provide an audit of the success of CBA in the project development process. It makes possible:

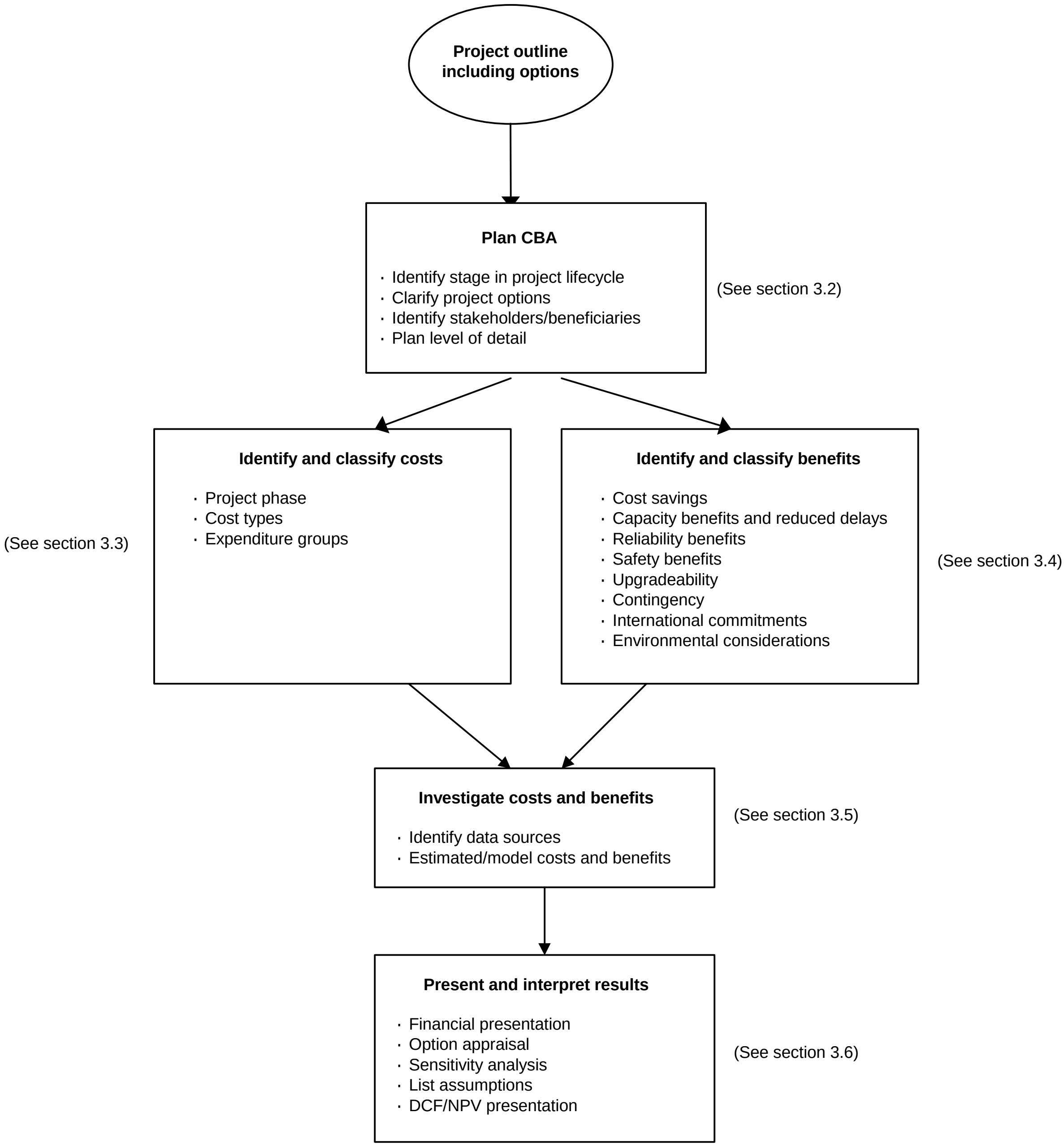
- validation of the cost and benefit models;
- transfer of “lessons learnt” to subsequent CBAs for other projects by providing a validation of assumptions used in the original CBA;
- monitoring of delivered benefits to ensure that subsequent project cases do not double count benefits.

3. PRINCIPLES OF COST-BENEFIT ANALYSIS

3.1 INTRODUCTION

An outline of a typical CBA is shown in *Figure 3-1*.

Figure 3-1 ***Outline of a typical CBA***



The remainder of this section describes each stage of the CBA.

3.2 CBA PLANNING

3.2.1 Introduction

The planning of the CBA should address:

- identification of the stage in the project life cycle to which the CBA will apply;
- clarification of the project options;
- identification of who will be investing in the project (i.e. to whom should the case be justified);
- identification of the beneficiaries of the project and their relationship to the stakeholders;
- the level of detail required for the CBA.

Section 3.2.7 lists some of the main pitfalls in CBA.

3.2.2 Identify relevant stage in project life cycle

The application of CBA to stages of the project life cycle was discussed in Section 2. The following stages were identified:

- identification of need or requirement for the project;
- development of project options;
- case preparation and presentation;
- procurement, implementation planning and tender assessment;
- implementation and in-service monitoring.

The CBA planning process should record which project stage the CBA is to be applied.

3.2.3 Clarify project options

There is a range of information which needs to be provided when developing project options and which needs to be clearly defined. A description of each option must include, inter alia:

- a schedule for the project phase comprising a planning and development schedule and a certification schedule for the option;
- the expected operational date of the option plus an operational schedule (e.g. airspace organisation and structure, route structure etc.) and a replacement schedule (for individual system components);
- type of equipment required if there are different levels of service to be considered, e.g. triple, double or single fit avionics.
- economic life of the option;
- transition schedule: operational requirements on existing system components during the transition period between the current and proposed systems, including a de-establishment schedule;
- the operational capability of the option (important for assessing benefits of the option).

3.2.4 Identify project stakeholders

Most projects promoted in the context of EATMP - aimed at en-route services - will require expenditure by at least one of two main players:

- service providers, including ATS providers and airport service providers;
- users, i.e. aircraft operators.

The ATS providers are generally the National ATC Administrations of the ECAC member states. At present they operate different levels of service, depending on requirements, at different levels of cost to themselves, and ultimately the users. Aircraft operators include commercial airlines, general aviation, military, etc. They have different motives for demanding the service (e.g. commercial, private, defence) and, hence have different "tolerances" to the cost of the service.

The service providers, through the ECAC strategy, are committed to harmonising and integrating the air traffic system in Europe. Through EATMP and national efforts a series of R&D programmes, to be followed by implementation programmes, is to be undertaken. Much expenditure by national administrations (and EUROCONTROL at a regional level) will be required. In many cases implementation programmes could require direct expenditure by the users. The expenditure of national administrations (and EUROCONTROL) on these programmes, once approved, will be reflected in the national costbases and recovered subsequently from the users through route charges.

Note that there are also other potential investors:

- trans-national bodies, particularly the European Commission, through investment programmes such as the Fourth Framework programme;
- private investors, through shareholding in service provider organisations. Private investors are increasingly important in providing funding for most ATM developments.

3.2.5 Identify project beneficiaries

A primary set of beneficiaries from the project is defined as:

- service providers;
- aircraft operators.

In addition a set of secondary beneficiaries which might be considered in CBA where relevant is defined as:

- passengers;
- general community.

It should be noted that there may be conflicts of interest between some of the above parties - a benefit to one may be a dis-benefit to another.

EATMP projects, which are primarily expected to be aimed at improving en-route services, are likely to provide benefits direct to aircraft operators and to en-route service providers. In the majority of projects, therefore, only these two would be considered as beneficiaries.

The geographical scope of the CBA needs to be decided so that the service providers and users to be included in the analysis can be established. For example, if a project is Pan-European then all service providers in the

European area, and all users operating in the European airspace affected by the project should be considered.

3.2.6 Plan level of detail for CBA

It is important to set an appropriate level of effort for conducting a CBA. This will depend on the project phase and the size of project. However, a number of other factors must be taken into account:

- **Has a decision already been made?** Ideally a CBA should be involved from the start of a project. However there may be some situations where irreversible decisions to pursue certain projects or project options have already been taken. In these cases a "post-decision" CBA can add little value and should not generally be undertaken. However, it may be advisable in other cases - where decisions are not irreversible - to conduct a CBA even though money has been committed and work begun:
    - if the project is found to be viable as a result of the "better late than never" CBA then it can proceed as planned, but with an added degree of confidence;
    - if the project is not found to be viable then it can be re-structured.
- **Will a decision be made purely on external factors?** External factors include, for example, political, statutory, or safety grounds or previous commitments that have been made. In this case a CBA will probably add little value to the decision process and so should not be undertaken. CBA techniques may, however, be used to distinguish between the project options for achieving the project's objective.
- **When will a decision be made?** If a meaningful analysis cannot be undertaken in the time available, then either no analysis should be undertaken or - preferably - the time-scales for making the decision should be changed to allow supporting data to be provided.

Assuming that a CBA is required the level of detail needed must be adjusted to the cost of the project and to the sensitivity required for the results. To avoid wasted resources it is preferable to proceed in an iterative manner with, if necessary, several consecutive loops, each new loop presenting an increased level of detail.

The following paragraphs highlight three different levels of detail, corresponding to the first three stages in the project life cycle, illustrated in Figure 2-1:

- **Assessment of need or opportunity.** This corresponds to the first stage in the project life cycle (identification of requirement for the project) and consists of a broad based analysis of the do-nothing option (see Section 2.2).
- **Scoping CBA.** This corresponds to the second stage in the project life cycle (development of project options) and consists of an investigation of project options (see Section 2.3).

- **Full CBA.** This corresponds to the third stage in the project life cycle (case preparation and presentation) and consists of a detailed investigation of a small number of project options (see Section 2.4).

Note that following the assessment of need or opportunity, the decision-maker may decide that further analysis is not required for projects which cost less than a specified lower limit. This may be because the cost of any additional study would not be justified in relation to the relatively low cost of the project. Note also that, based on experience, it is recommended that, in general, full CBAs should not be undertaken for projects costing less than of the order ECU 1,000,000.

In reality, the required complexity of a CBA is a continuum not a set of discrete levels. A CBA should contain the minimum analysis necessary to provide a fair and honest case to the decision-maker.

3.2.7 Pitfalls of CBA

Double counting

Probably the most common problems with large projects in the aviation field arise because of inter-dependencies between different projects. The difference between delivered and enabled benefits is discussed later in Section 3.3. Double counting of benefits can also be a problem. For example, imagine two competing projects, Project A and Project B. Project A is intended to deliver a required 5% increase in airspace capacity from 2005 onwards. Project B is intended to deliver the same capacity increase but by a different method. If Project A is sanctioned, then Project B can no longer lay claim to capacity benefits because Project A will already address the need. Double counting is a simple concept. The difficulty comes in making sure that people are aware of all projects that are being proposed so that efforts are not wasted.

Technology led

Projects may be “technology-led”. This means a new technology offers an opportunity but it may not fully address (or may exceed) the requirement. The principle of “minimum sensible investment” is a good one and should be adhered to. The cost-benefit analyst will need to be aware of what the real requirements of a project are.

Consistency

Consistency across projects is very important in CBA. The same CBA guidelines should be applied to all competing projects. This includes using the same cost and benefit data where applicable. For example, all projects that consider the delays to a particular type of aircraft need to use the same figure for the cost of an hour’s delay for that aircraft.

3.3 IDENTIFYING AND CLASSIFYING COSTS

3.3.1 Introduction

In general the life cycle costs of a project should include all anticipated expenditure directly or indirectly associated with the project. Costs should be categorised according to:

- project phase;
- cost type;
- expenditure group.

3.3.2 Project phase in which cost is incurred

It may be important to distinguish between project phases when establishing the costs of a project. For CBA purposes there are three phases to a project which could be considered:

- costs incurred during R&D;
- costs incurred during implementation;
- costs incurred during operation.

It is likely that the R&D phase will require both investment and increased operating expenditure as proposed systems are tested. The implementation phase will require much one-off investment over a short period as the elements of the new system are installed and certificated. Following implementation there is the operational phase as the new system comes “on-line” - this would normally be identified with an increase (or decrease) in operating costs on an on-going basis.

3.3.3 Cost types

In general project costs should be categorised under three headings:

- **investment costs**, associated with the acquisition of equipment, property, one-off services, one-off operating start-up costs, and other one-off expenditure for the project;
- **operating costs**, comprising:
  - staff - internal/external, civil/military;
  - operations - maintenance & repair, materials, supplies, utilities and other services;
  - overhead - administration, personnel, training;
- **transition costs** occur where it is necessary to maintain parts of the current system during the transition period to a new system. Although such costs would not appear in the base case, they should be identified during option definition and presented as part of the project option cost. These costs are frequently overlooked in CBA.

Note that only investment costs are considered further in this section. Operating costs are generally presented in CBA as incremental benefits relative to the base case. Hence, savings in operating costs are counted as benefits and are described in Section 3.4.

3.3.4 Expenditure groups

EATMP projects will require expenditure from at least one of two main players. In order to achieve ECAC objectives service providers are expected to invest in new ground equipment and users to invest in new airborne equipment. Also, for some projects, service providers may have to invest in a "space" infrastructure, e.g. satellites. Where possible expenditure may be classified into groups. The following groups are suggested:

- ground;
- airborne;
- space.

Where appropriate it may be important to define the provider and user groups for which differing levels of expenditure is expected, and which therefore may have differing views as to the value of the project (see Section 3.2.4).

3.3.5 Examples of expenditure groups

It is recommended that project costs should be established, at least, at the level of both expenditure group (ground/airborne/space) and cost type (investment/operating). Potential investment costs in the three expenditure groups are detailed in Table 3-1 below:

Table 3-1 ***Potential investment costs in the three expenditure groups***

Expenditure group	**Ground**	**Airborne**	**Space**
Expenditure type	type of equipment, land etc (eg for radar need: sensor, antenna, land for site, comms line)	type of equipment	type of equipment (eg new satellite, cost of payload share, etc)
Installation schedule	number of units and dates required	as for ground	as for ground
Equipment cost	unit cost (hardware, software and certification) at constant prices	unit cost as for ground installation costs (Note: need to split retrofit from fit to new aircraft, explicitly stating date after which equipment is assumed standard)	unit cost as for ground

3.4 IDENTIFYING AND CLASSIFYING BENEFITS

3.4.1 Introduction

The potential benefits of a project should be identified and listed. The possible types of benefit are listed below and considered in the remainder of this section:

- cost savings;
- capacity benefits;
- reduction in delays;
- reliability benefits;
- safety benefits;
- upgradeability;
- contingency;
- international commitments;
- environmental benefits.

Each benefit should be classified according to:

- whether it is described in quantitative or qualitative terms;
- whether the claimed benefit is delivered in full or enabled by the project.

Quantitative/qualitative benefits: Benefits that can be directly expressed in economic terms are referred to as “quantitative benefits”. Benefits that cannot be quantified in economic terms are referred to as “qualitative benefits”. It should be re-emphasised that quantitative in this sense means “financially quantified”. A benefit such as "a reduction in aircraft collision risk of $3x10^{-7}$ per year" would be a qualitative benefit, even though it is expressed numerically.

Typically, although not exclusively, the benefit types identified above can be classified as follows:

Quantitative benefits	Qualitative benefits
Cost savings	Safety
Capacity	Environmental
Reliability	International commitments
Delays	Contingency
	Upgradeability

Enabled/delivered benefits: A technical distinction must be drawn between projects that deliver benefits and projects that enable them. A delivered benefit is the actual benefit to be realised from a project. For example, if new en-route radar equipment leads directly to more aircraft flying per hour, then an increased capacity benefit will have been delivered - i.e. nothing else is needed.

When a project can only provide benefits if another project (or some form of further expenditure) is carried out, that project is called an enabling project - the associated benefits are termed enabled benefits. Datalink is a good example of an enabling project. Datalink could be used for a number of applications, e.g. for controller - pilot dialogue, but it has no benefit without further projects to deliver these applications.

Enabling benefits should be clearly identified in the presentation of a CBA and not simply added to the delivered benefits. Projects that subsequently deliver benefits and which are dependent on the enabling project should be identified. If possible for each project that delivers benefits estimates should be made of:

- the level of delivered benefits that are made possible by the enabling project;
- the additional costs associated with finally realising the enabled benefits;
- timescales for when the benefits will be delivered and the additional costs incurred;
- the likelihood of the project being implemented (perhaps by reference to an overall strategy for ATM development).

The estimates can be used to provide a total net value of delivered projects that are enabled by the project under consideration. This information should be presented to the decision maker to give an indication of the extent to which the costs of an enabling project may later be offset by subsequent projects. Note that no direct formula for offsetting the costs of enabling projects is proposed. Rather it is recommended that, in the same way as for qualitative benefits, enabling benefits are presented separately to the decision maker.

3.4.2 Cost savings

Generally, cost savings resulting from the implementation of a project would be attributable to the two main primary beneficiaries:

- service providers;

- aircraft operators.

Reducing the operating costs of the service provider can lead to reduced charges for aircraft operators. The latter are then also beneficiaries for cost savings attributed primarily to the service provider.

Apart from the secondary effect of reduced charges, the aircraft operators' cost may also be reduced by accommodating the optimum flight profile as desired by the operator, i.e. optimum routeing, altitude and speed result in reductions of fuel and oil cost and flight time related operating cost (primarily crew and parts of maintenance costs). Other cost savings for the aircraft operators may result from reduced delays and reduced investment, operating and maintenance costs of new technologies. Further detail on cost savings are presented in Annexes C and D.

3.4.3 Capacity benefits

Increasing the capacity of en-route airspace in order to accommodate forecast growth in air traffic is one of the principal drivers for EATMP projects. It is important, therefore, to make an accurate assessment of the increases in airspace capacity that might be brought about by investments, and of the probable economic benefits associated with such increases.

Assessment of capacity related projects must consider the following factors:

- the capacity of en-route airspace (and also airports), i.e. the limits on the amount of air traffic that can be handled;
- the demand for air travel, which determines the level of traffic on different routes at different times of the day, and the growth of those traffic levels in the future;
- the relationship between capacity and demand, which may lead to a situation of constrained demand on certain routes at particular times of the day, when demand is close to or exceeding capacity;
- the economic costs of constrained demand.

Further detail on capacity benefits, including techniques for modelling capacity benefits, is presented in Annex E.

3.4.4 Reduction in delays

There is a close relationship between delay and capacity benefits since delays are symptomatic of a system operating near to capacity. Figure 3-2 illustrates the relationship between delay and capacity.

There is also a close interaction with reliability benefits (discussed below) since, in a system operating near to capacity, minor disruption (e.g. equipment failure) can "topple" the system, resulting in the forming of a queue which is never dissipated during the remainder of the day.

Reducing delays result in the following benefits:

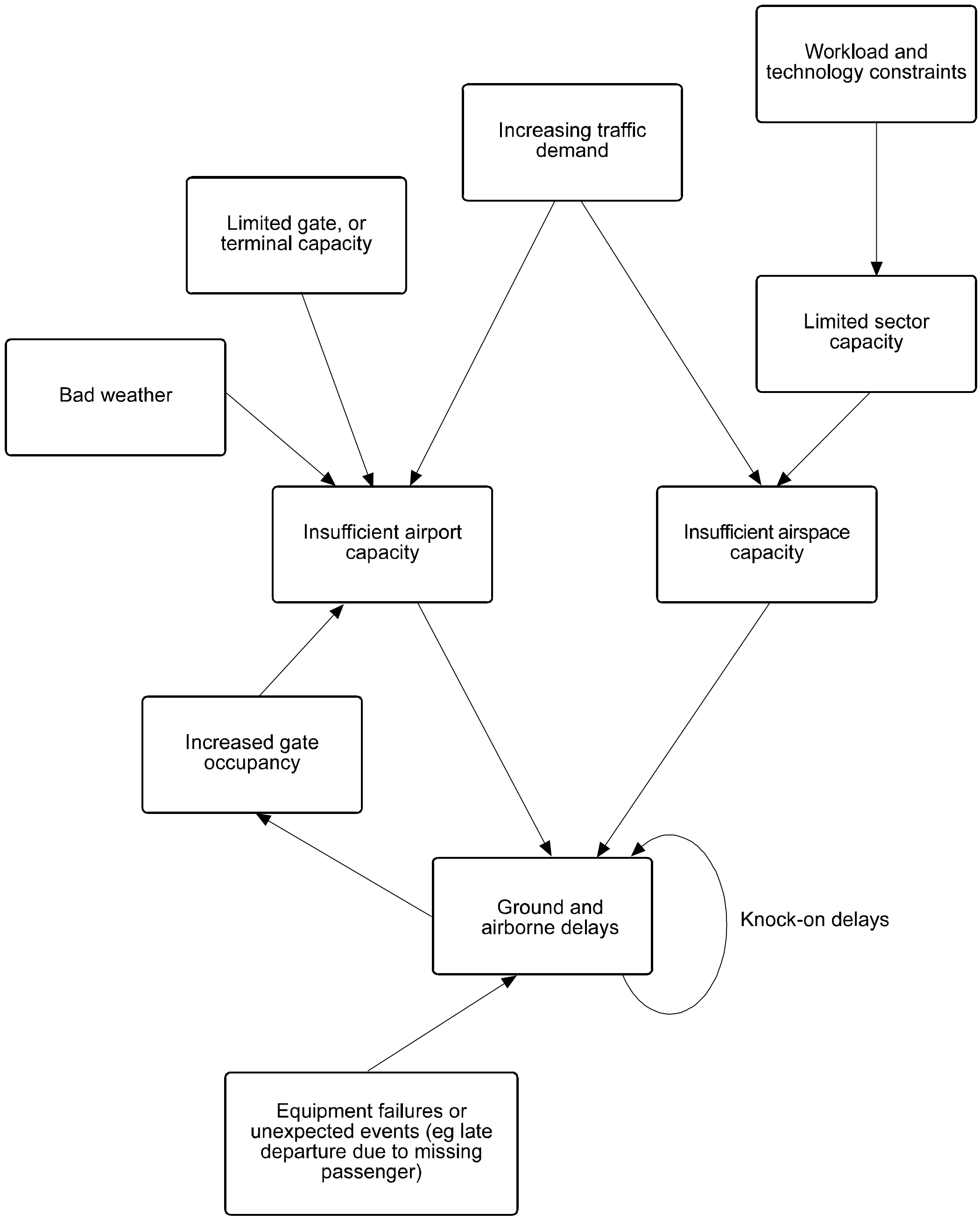
- reduced operating costs to airlines, through reduced fuel burn, simpler (more predictable) crew scheduling etc;
- reduced costs to passengers in terms of time.

"Second order" benefits may also be derived from the fact that delays can result in further knock-on effects where aircraft and crew are out of position for subsequent flights leading to further delays.

Fuel savings resulting from reduced delays could also be cited as a benefit in the "cost savings" section above; this illustrates the potential for overlap between different types of benefit. Unambiguous classification should be carried out at the planning stage to avoid double counting of benefits. Delay cost information can be obtained from aircraft operators and from other sources.

Further detail on delay benefits is presented in Annex E.

Figure 3-2 ***Relationship between delay and capacity***



3.4.5 Reliability benefits

Reliability is usually a consideration in replacement projects, e.g. the replacement of a computer system. Firstly, the operational consequences of a system failure need to be established - if there are any. Advice can be sought from operational units. For example, in the case of a system that prints flight strips automatically, a system breakdown would lead to a temporary reduction in airspace capacity that could be quantified in terms of increased delays - or perhaps flight cancellations. If the reliability could be increased threefold by a new system the benefits could be quantified. Further detail on reliability benefits is presented in Annex F.

3.4.6 Safety benefits

It is vital that the current level of safety is maintained or improved upon when implementing new technology, operating procedures and airspace design. Accidents are very rare. This does mean, however, a lack of data which makes improvements in safety difficult to measure. There are a number of possible approaches that can be used to appraise projects that claim safety benefits - these are discussed in Annex G.

The economic benefits and qualitative approaches are recommended for use in most project appraisals; explicit and implicit approaches would only be considered in cases where safety is the main, or only, benefit that could be quantified.

3.4.7 Upgradeability

New systems could be implemented as a means of facilitating future upgrades to incorporate new functionality. Since a project designed exclusively for such a purpose would be a pure enabler with no delivered benefits of its own, upgradeability must be seen as part of a larger programme and benefits assessed in terms of the goals and objectives of meeting that programme.

3.4.8 Contingency

Some projects might be implemented to provide contingency for other systems. Such benefits could be counted as a safety benefit if, for example, a contingent sub-system is introduced as a method of increasing the overall availability of a safety critical system. However contingent systems could also be introduced as a back up to prevent loss of revenue should a service become unavailable. For example, the UK New Scottish Centre will provide a contingent centre for the UK New En-Route Centre should the service provided by the latter be reduced by, for example, a fire. Assessment of the value of such benefits is difficult and needs to take account of the very small likelihood of events such as fires and also the financial impact of a reduction in service level. It is possible that the need for contingency is a matter of strategy and the role of CBA is to provide a means of assessing how to meet that strategy in the most cost effective way rather than provide a justification for the strategy.

3.4.9 International commitments

Some projects may be necessary to fulfil international commitments. However it should be stressed that, wherever possible, international commitment should be tested by CBA before investment is approved.

3.4.10 Environmental benefits

Environmental issues, which in the aviation industry are primarily to do with noise reduction, can also be difficult to quantify. There are at least three approaches to appraising projects that involve noise: the constraint, qualitative and quantitative approaches described in Annex H.

3.5 INVESTIGATING COSTS AND BENEFITS

3.5.1 Introduction

Costs and benefits must be investigated by:

- identifying relevant data sources;
- estimating/modelling costs and benefits;

3.5.2 Identification of data sources

Possible sources of data for CBA are:

- **Expert opinion.** This is probably the quickest and least expensive. It is most valid if accompanied by the basis upon which the opinion was made and the likely accuracy.
- **Raw data.** These will vary in the level of detail they can offer depending on how directly related they are to the information sought.
- **Models.** These can be expensive and take time, although any assumptions that are made can be tailored to the assessment required.
- **Research.** At times this is widely available and already complete. However, the assumptions made for the research may be incompatible or the results require further processing.
- **Prototyping.** The results of trials of proposed systems may offer valuable data.
- **Databases.** These will vary in usefulness depending on how amenable the framework is to interpretation. Since they are already established they should be inexpensive and quick to use.

In order to apply an homogeneous and consistent CBA methodology throughout the entire ECAC region, it is essential to establish and maintain a common EATMP CBA data base, which contains data that facilitate the conduct of any future economic appraisal while guaranteeing the application of uniform measures to the quantification of costs and benefits. Such a data base will contain common data applicable to the whole ECAC region as well as regional data only relevant for projects of specific regional scope. In addition, extrapolation algorithms and functions need to be recorded that are to assist the translation of certain sets of data available for individual regions and nations to ECAC regions where those are not existent. The database could consist of several parts:

- a cost database, containing:
  - CNS/ATM system technology costs;
  - direct operating costs for users;
  - “follow-up” costs for users;
  - costs of unaccommodated demand;
  - interest and discount rates;
- a traffic forecast database;

- system performance constraints and requirements, including:
  - data on project/programme plans;
  - replacement schedules;
  - operational performance data of aircraft;
  - projections for airport capacity expansion plans;
- performance data of CNS/ATM prototype systems.

The setting up of such a database has been recommended by the ECBAG with the intention that it be managed by EUROCONTROL's CBA Cell.

3.5.3 Estimating/modelling costs and benefits

The process and effort for estimating and modelling costs and benefits depend closely on the type of parameter being investigated and the level of detail required. In some cases spreadsheets may be sufficient, whilst in others large-scale simulations may be required. The range of tools available for modelling costs and benefits is described in Annex I. Considerations for modelling each of the cost and benefit types in this report are given under the discussion of each type of benefit.

3.6 PRESENTING AND INTERPRETING THE RESULTS

3.6.1 Introduction

It is important that the overall results of a CBA are presented clearly to the decision maker. Although reporting procedures may vary in the National ATC Administrations, the same basic information must be reported for all CBAs.

Issues to be considered are the presentation of financial results, the use of results for option appraisal and the performance of sensitivity analysis. This section also gives a summary of the contents list for a CBA.

3.6.2 Financial presentation

The strategy for the financial presentation of the results of a CBA should be decided before the analysis starts because it can affect the way in which benefits and costs are calculated. There are two choices for presenting the benefits and costs:

- **Total benefits and cost:** the total benefits or costs of each project option, independent of the other options, are presented.
- **Incremental costs and benefits:** the benefits and costs of the base case option are presented in full. Then the incremental benefits and costs of each of the other options, relative to the base case, are presented.

Although the two approaches provide the same information, the approach used needs to be made explicit when presenting the benefits and costs.

Note that the presentation of CBA in this section assumes incremental costs and benefits. Hence saved operating costs are presented as benefits in Section 3.4.2.

3.6.3 Using results for option appraisal

Assuming the costs of the project options are known, together with the years in which they will be payable and that (most of) the benefits of the project options are quantified in financial terms, together with the years in which they will accrue, the next step in the CBA process is to appraise the options.

The most popular, and generally the most appropriate, approach to option appraisal is the **Net Present Value** (NPV) method. Through the NPV method, a series of costs and benefits over time are reduced to a single "summary statistic" - the NPV. (Details of this method are included in Annex J.)

The NPV criteria works well if all the projects or project options have the same analysis period. If this is not the case, projects' net cash flows can be expressed as **Annual Equivalent Values** (AEVs). A cash flow item can be translated into a constant annual value for comparative purposes. This method is essentially a simple modification of the NPV approach.

There are other summary statistics that can be derived from the discounting process for use in option appraisal. These include the **Benefit-Cost (B/C) Ratio**, **Internal Rate of Return (IRR)** and the **Payback** point (break-even point). The provision of other summary statistics may at times produce an alternative conclusion to an appraisal. Figure 3-3 illustrates alternative ways of presenting the results of a CBA for three options.

The first graph illustrates the CBA in terms of NPV. Option 2 offers the greatest net value. The second graph illustrates the results in terms of benefit/cost ratio. In this presentation option 1 is best. It is clear that the reason for the different results lies in the absolute size of the costs and benefits associated with each option. The third graph presents an alternative presentation in which both benefit/cost ratio and absolute costs and benefits are illustrated.

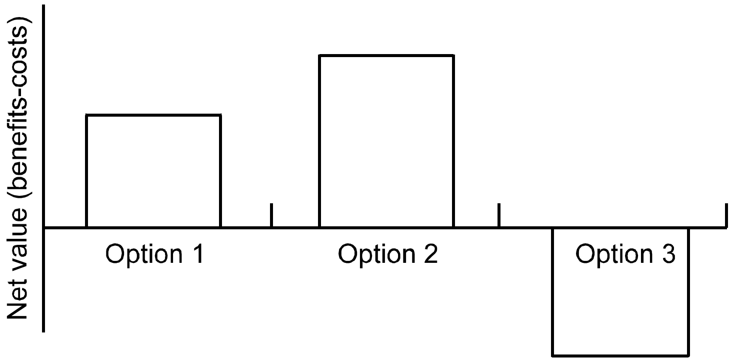
3.6.4 Sensitivity analysis

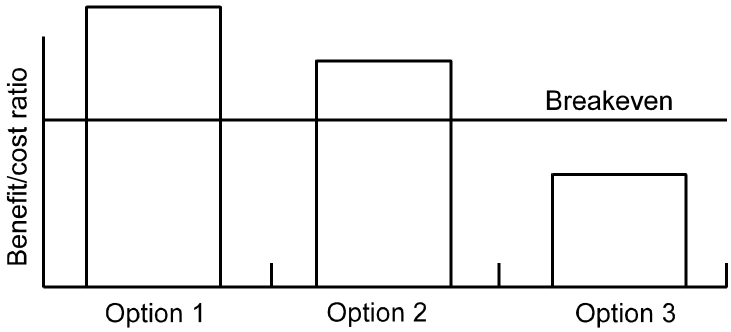
Sensitivity analysis examines the sensitivity of the project's economic performance - its costs and benefits - to the variation of individual parameters in order to identify the most critical issues and the degree of their impact.

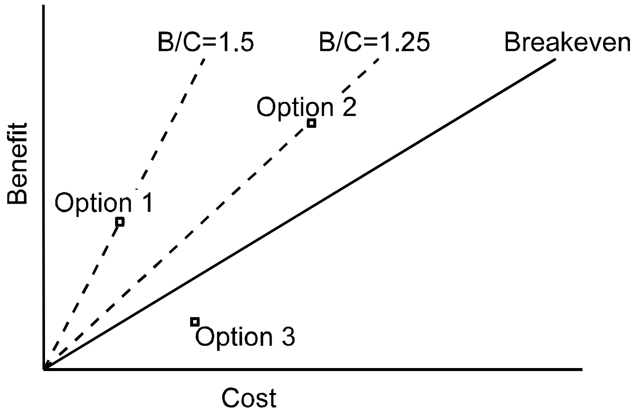
The most significant parameters to be considered in the conduct of a sensitivity analysis will vary from project case to project case. However, the following list contains factors generally important for such an impact analysis:

- projected traffic growth in absolute terms and with respect to the traffic mix;
- capacity increase achieved by the project;

Figure 3-3 ***Alternative presentations of a CBA***







- efficiency improvement in terms of average delay, lateral and vertical flight profiles;
- ATM system costs (ground and space), particularly investment costs (purchase prices installation/introduction) and staff costs;
- unit costs of avionics;
- user direct operating costs;
- financial parameters, such as discount or interest rates;
- project time scales (transition time, implementation/introduction and decommissioning schedule, project life).

More detail on approaches to sensitivity analysis is given in Annex K.

3.6.5 Summary

A summary of a suggested contents list is provided in Table 3-2. The summary can be used in two ways:

- as the basis for a common CBA planning procedure;
- as the basis for a presentation template of the results of a CBA.

In general in presenting the results of a CBA, together with a description of the project objective and project options, a DCF analysis for each project option should be shown. All parameters, including discount rate, project lifetime, etc., must be given. All assumptions must be listed and the results of sensitivity analysis on the assumptions must be reported. Any qualitative benefits or costs that could not be put in economic terms should also be reported where these could affect the decision. The general conclusion of the CBA in terms of the ranking of options should be made explicit.

Table 3-2 ***Recommended contents of a cost benefit analysis***

CBA category	Options	see Section
Plan CBA		
Clarify project options	(to include) project phasing expected operational date type of equipment economic life transition schedule operational capability	3.2.3
Identify project stakeholders	Service providers Aircraft operators Trans-national bodies Private investors	3.2.4
Identify project beneficiaries	Service providers Aircraft operators Passengers Trans-national bodies Private investors	3.2.5
Determine level of detail	Assessment of need or opportunity Scoping (initial assessment of options) Full CBA	3.2.6
Identify and classify costs		
Project phase in which incurred	R&D Implementation Operation	3.3.2
Cost type	Investment Operating Transition	3.3.3
Expenditure group	Service providers Users	3.3.4
Identify and classify benefits		
Type	Cost savings Capacity benefits Reduced delay benefits Reliability benefits Safety benefits Upgradeability Contingency International commitments Environmental benefits	3.4.2 3.4.3 3.4.4 3.4.5 3.4.6 3.4.7 3.4.8 3.4.9 3.4.10
Investigate costs and benefits		
Identify data sources	Expert sources Raw data Models Research Prototyping Databases	3.5.2
Estimate/model costs and benefits	Spreadsheet models Large scale simulations	3.5.3
Present and interpret results		
Financial presentation	Total costs and benefits Incremental costs and benefits	3.6.2
Option appraisal	NPV, AEV, B/C ratio IRR, Payback point	3.6.3
Sensitivity analysis	Select parameters Specify required variation Select high/low scenarios	3.6.4