ICAO

Doc 10170

Manual on Economic and Financial Analyses for Aviation Infrastructure Projects

First Edition, 2022

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

ICAO

Doc 10170

Manual on Economic and Financial Analyses for Aviation Infrastructure Projects

First Edition, 2022

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Published in separate English, Arabic, Chinese, French, Russian
and Spanish editions by the
INTERNATIONAL CIVIL AVIATION ORGANIZATION
999 Robert-Bourassa Boulevard, Montréal, Quebec, Canada H3C 5H7

For ordering information and for a complete listing of sales agents
and booksellers, please go to the ICAO website at www.icao.int

First Edition, 2022

Doc 10170, *Manual on Economic and Financial Analyses for Aviation Infrastructure Projects*
Order Number: 10170
ISBN 978-92-9265-751-2 (print version)

© ICAO 2022

All rights reserved. No part of this publication may be reproduced, stored in a
retrieval system or transmitted in any form or by any means, without prior
permission in writing from the International Civil Aviation Organization.

AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA			
No.	Date	Language	Entered by

FOREWORD

ORIGIN AND OBJECTIVE

At the Fifth Joint Meeting of the Airport Economics Panel (AEP) and the Air Navigation Services Economics Panel (ANSEP) (AEP-ANSEP/5), held in May 2015, a working group was established to develop guidance material incorporating recommendations made by the Multi-disciplinary working group on the economic challenges linked to the implementation of the aviation system block upgrades (MDWG-ASBU) on: a) cost-benefit analysis, business case study and economic impact analysis, and b) financing scheme (recommendation AEP-ANSEP/5-1/1 refers). The Sixth Joint Meeting (AEP-ANSEP/6), held in May 2017, further recommended to develop a standalone guidance document on economic and financial analyses. In December 2021, the guidance document was adopted by the Eighth Joint Meeting (AEP-ANSEP/8).

The objective of this manual is to provide practical guidance to States, airport managing and operating entities, air navigation services providers and designated charging and regulatory authorities in conducting analysis to support investments decisions in aviation infrastructure.

SCOPE

The manual provides an overview on how to conduct economic and financial analyses for aviation infrastructure projects, with a particular focus on cost-benefit analysis. It takes into account the existing guidance on cost-benefit analysis, business case and economic impact analysis in the *Airport Economics Manual* (Doc 9562) and the *Manual on Air Navigation Services Economics* (Doc 9161), and aligns terminologies with a view to achieving a common understanding of these concepts. Supplementary material is provided in the appendix and provides concrete examples and references in conducting such analyses.

The guidance in this manual is presented in three chapters. Chapter 1 provides definitions on cost-benefit analysis, business case, economic impact analysis and cost-effectiveness analysis, and explains the difference between each other. Chapter 2 provides guidance on making decisions on when to conduct a cost-benefit analysis or business case. Chapter 3 describes the scope of a cost-benefit analysis and the process in conducting the analysis by steps. References to existing guidance and its application to specific aviation investment projects are included in the appendices, which will be reviewed and updated periodically.

SOURCES

This manual has been developed with the assistance of a group of experts on airport economics and on air navigation services economics. The principal sources were Docs 9562 and 9161. Additional source documents include reports, studies and other guidance material available from States and other organizations.

Contents

GLOSSARY

LIST OF ACRONYMS AND ABBREVIATIONS

ADS	Automatic dependent surveillance
AEP	Airport Economics Panel
ANSEP	Air Navigation Services Economics Panel
ANSP	Air navigation services provider
ATM	Air traffic management
ATM/CNS	Air traffic management/communication, navigation, surveillance
ATS	Air traffic service
BCR	Benefit/cost ratio
CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis
ECAC	European Civil Aviation Conference
EIA	Economic impact analysis
GDP	Gross domestic product
IRR	Internal rate of return
KPA	Key performance area
NPV	Net present value
R&D	Research and development

Chapter 1

COST-BENEFIT ANALYSIS, BUSINESS CASE, ECONOMIC IMPACT ANALYSIS AND COST-EFFECTIVENESS ANALYSIS

1.1 Organizations are often faced with decisions on how best to pursue their objectives, especially on investment decisions. They use evaluation techniques that focus on the options, and search for the one that maximizes net benefits. Every major investment decision taken by a State, an airport or a provider of air navigation services should be supported by analyses to demonstrate costs and benefits accruing from investment in infrastructure to service providers, users and, as appropriate, the wider community. Consultation with users should assist States and service providers with their major investment decisions. With regard to analyses undertaken, commonality in approach within a State or region would be desirable.

1.2 Economic and financial analyses of major aviation infrastructure projects are becoming an increasingly important component of proposals seeking government funding or private financing. These activities are crucial given that airports or air navigation service providers can make an important contribution to a State's economy by generating employment and other economic activity, not only at the airport and the surrounding community, but also for the country as a whole.

1.3 There are various types of evaluation techniques that organizations and States can use depending on what type of analysis they want to include. This manual highlights four of the more commonly used evaluation techniques: cost-benefit analysis (CBA), business case, economic impact analysis (EIA) and cost-effectiveness analysis (CEA). Given the prominence that CBA plays in the evaluation process of public sector investment projects, the primary focus of this manual will be on providing a comprehensive overview of CBA.

1.4 It is important to note that these evaluation techniques are all tools that support planning and decision-making. In many instances, these tools can be used in concert with each other to form a broader strategic vision of the project, program or policy being evaluated. A negative result from any of these evaluation techniques should not necessarily rule out making the investment.

1.1 WHAT IS A COST-BENEFIT ANALYSIS?

1.1.1 A CBA (also known as benefit-cost analysis (BCA)) aims to identify the investment option that best conforms to the economic goal of maximizing net societal benefits. It examines all costs and benefits related to the production and consumption of an output, whether the costs and benefits are borne by the producer, the consumer or a third party. As the CBA takes into account both public and private benefits and costs of a project, it tends to be more appropriate in cases where projects are publicly funded.

1.1.2 The ultimate objective of a CBA is to determine if a project is cost-beneficial or to assess which option yields the greatest net benefits by comparing the benefits and costs to all parties involved. Therefore, a CBA objectively identifies all costs and benefits, and where possible converts them into the common monetary units of measures. It also takes full account of the times at which the costs are paid and benefits accrue. A CBA obviously goes well beyond a financial analysis that focuses on the project's financial accounts and cash flows.

1.1.3 A CBA involves evaluating a project option(s) against a base case, which should describe the scenario that would be likely to occur in the absence of the project being evaluated. Defining and clearly articulating the base case is a crucial and often challenging aspect of the analysis.

1.1.4 A CBA will help to:

a) identify all costs and benefits from a societal perspective;

b) quantify these costs and benefits to calculate the economic value of the project;

c) make cash flow projections;

d) select the best option;

e) classify costs and benefits by order of importance; and

f) determine the critical factor(s) of success.

1.2 WHAT IS A BUSINESS CASE?

1.2.1 A business case describes the business justification for undertaking a programme or group of projects. An important purpose of it is to facilitate coordination with all parties involved in the investment decision and to support negotiations with financial institutions. The development of a business case is a complex process and includes a number of assumptions and assessments, and the information required goes beyond the scope of the organization's budget and business plan. Typical assessments in a business case include financial analysis (or evaluation), strategic drivers, organizational performance factors, cost-benefit analysis (covered in more detail below), risk assessment and stakeholder impact.

1.2.2 A business case sets out the context, identifies the issue(s) to be addressed and provides a detailed description of the proposal selected, as well as the rationale for its selection from among other options, and a comprehensive assessment of its benefits, costs and risks. The other options should also be described together with their benefits, costs and risks. In addition, a business case may provide analyses of, and information on, products and services, markets, employees, technologies, facilities, equipment, capital, financing, contingency plans, etc.

1.2.3 Financial analysis is critical, and a business case should include information such as overall cost projections, cash flow statement and capital and financing factors. Strategic drivers of the investment decision include relevant information and analysis of the market, other products and services and political and social environment factors that cannot be measured in financial terms.

1.2.4 Organizational performance, productivity and critical success factors should be identified and discussed mainly as non-financial benefits. These elements could be wide ranging depending on the nature of the investment decision, for example, improvements in service, cost efficiency, reductions in delay, human workload and productivity, facilities and equipment use, technological productivity, contingency plans, safety and security improvement and compliance with standards and regulations. Concerning labour intensive areas, human resources issues also need to be assessed with regard to the demands of recruitment, redeployment, training and discharging.

1.2.5 Identification of key risk factors, together with the indicators that would signal changes in the results, is necessary in a business case. For each risk factor, mitigating measures should also be indicated.

1.2.6 Finally, a business case should identify and evaluate the impacts on stakeholder groups and users of airport or air navigations services. For example, in the case of the construction of a new terminal or the expansion of an existing one, a business case would try to identify what the impact would be on airport users, such as aircraft operators, passengers and forwarders, and on providers, such as ground-handling services, catering and other services. This assessment is to indicate the potential divergence of interests between stakeholder groups and propose appropriate advance mitigation measures, if possible.

1.3 WHAT IS AN ECONOMIC IMPACT ANALYSIS?

1.3.1 An EIA of a major investment project identifies the cumulative economic effects of the project. It goes beyond the projected or existing generation of revenues and employment, and assesses the wider contribution made or expected to be made to the national, regional or local economic development. The results of such assessments are often used in the decision-making process of determining the economic viability of an investment in aviation infrastructure. An EIA is commonly conducted for publicly funded projects especially when there is public concern about the potential impacts of a proposed project or policy.

1.3.2 The contribution of an infrastructure project to the economy can be assessed on the basis of the following factors from which direct, indirect and induced economic activities can be derived: sales revenues, labour income, tax revenues, capital investment and employment. Accordingly, economic impact assessment can be designed to collect information on a wide range of economic activities taking place both on-site and off-site the infrastructure, in the surrounding region, or even throughout the State. It is important to recognize that EIAs do not attempt to net out benefit/cost transfers to/from other sectors or regions of the country.

1.3.3 Economic impact assessments include information on the number of jobs directly provided by the parties related to the infrastructure such as the airport operator, air carriers, air navigation provider, and companies dealing with procurement and aircraft servicing, maintenance and repair. Direct and indirect employment could represent a sizeable labour income and constitute a major segment of the region's or the State's economy.

1.3.4 Beyond the direct and indirect economic impact of the infrastructure project concerned, there is the induced impact created by spending labour income from direct and indirect activities. For infrastructure of medium to large scale, input-output models are applied to identify the multiplier effect[1] throughout input-providing and consumer industries. An economic impact assessment can reveal the share generated by the infrastructure investment and multiplier effects in a State's gross domestic product (GDP).

1.4 WHAT IS A COST-EFFECTIVENESS ANALYSIS?

1.4.1 CEA is similar to CBA except that it does not attempt to place a value on the major benefits of a proposal. In cases where it is not possible to assign monetary values to all costs and benefits, alternative assessment techniques such as CEA can be useful.

1.4.2 A CEA compares the costs of alternative ways of producing the same or similar outputs/benefits. It is often used to identify the option that meets a predefined objective at a minimum cost. Therefore, a CEA provides evaluation of the relative effectiveness of alternative interventions in achieving a given objective. Results of a CEA are useful for projects whose benefits are very difficult to evaluate, while costs can be predicted more confidently.

1. Normally expressed as a factor showing how much the direct economic impact of the investment project is increased by the indirect and induced economic effects of project activities. The value of the multiplier will differ between States.

1.5 WHAT IS THE DIFFERENCE BETWEEN COST-BENEFIT ANALYSIS, BUSINESS CASE, ECONOMIC IMPACT ANALYSIS AND COST-EFFECTIVENESS ANALYSIS?

1.5.1 There are similarities between these different techniques: all are formal techniques for generating facts to help decision-makers make more informed decisions, however, their use should be matched to the context in which the decision is being made.

1.5.2 A business case goes beyond financial analysis and includes a much broader range of information. It will often include key components of a CBA as an input alongside a wider set of qualitative and quantitative assessments that are fundamental to determining the value of the project, such as safety, security, environment, economic development, human performance and strategic fit.

1.5.3 A business case is also a collaborative process generally involving a multi-disciplinary team and it is targeted at ensuring ownership and buy-in for the investment decision. The main audiences involved in the business case are:

a) business case practitioners;

b) project or programme team members;

c) validation experts (those in charge of assessing the various performance impacts);

d) impacted stakeholders; and

e) decision makers.

1.5.4 While CBA techniques play an important role in a business case, the primary role of CBA is to systematically measure the costs and benefits of a proposed project, policy or programme from a societal perspective. A CBA is generally used to evaluate projects that are publicly funded as it identifies all costs and benefits associated with a project, policy, or programme proposal whether accrued by the producer, consumer or a third party. As such, CBAs are generally viewed as providing a “neutral” and objective assessment of a project. A CBA attempts to measure all benefits and costs in monetary terms in order to compare the monetized benefits to the monetized costs of various projects, policies and programmes under consideration. The results of a CBA can then be used to determine the most advantageous way forward from a social perspective.

1.5.5 A CBA goes beyond a financial evaluation that focuses on the project’s financial accounts and cash flows. In addition, there are differences between a financial evaluation and a CBA on the treatment of capital costs. While a financial evaluation would normally re-state the capital costs into annual depreciation and interest expenses, a CBA measures capital costs by the cash expenditures required in future years rather than by depreciation and interest. The cash stream of expenditures is compared to the stream of benefits and the annual net amounts are discounted to compute a net present value (NPV) for the investment option.

1.5.6 The purpose of economic impact assessments is to estimate the total economic impact of an infrastructure or project on the level of economic activity, for example, employment, value added, regional output and taxes, in a region. It differs from CBA in that it is not assessing whether society is improved from the project proposal, but rather measures the increase in total economic activity expected from the project, comprising direct, indirect and induced impacts.

1.5.7 While a CBA answers whether the economic benefits outweigh the economic costs of a given policy, a CEA is primarily used when it is difficult to quantify the benefits of a particular project and instead focuses on the most cost effective method to meet the project’s objectives.

1.5.8 To illustrate the difference in scope between a financial evaluation and a CBA, consider:

a) **The extension of a passenger terminal at an airport.** The financial evaluation would look at the financial cash flows and required user charges associated with this investment, while a CBA would consider the benefits and costs to all parties involved. These would include the air carriers' benefits from improved passenger processing and the passengers' benefits from time-savings. Additionally, if considering the wider social effects, they would include positive effects, such as the increased economic activity generated or supported by the infrastructure expansion. Negative effects, such as increased traffic and noise experienced by individuals living or working in the vicinity of the airport, also need to be taken into account.

b) **The installation of radar in a previously non-radar airport location.** The financial evaluation would look at the financial cash flows and required user charges associated with this investment, while a CBA would consider the benefits to and costs for all parties involved. These would include the benefits to aircraft operators from fuel savings and to passengers from time-savings and to the economy at large. Additionally, if considering the wider social effects, the negative effects like increased traffic and noise experienced by individuals living or working in the vicinity of the airport would need to be taken into account.

Chapter 2

WHEN SHOULD A COST-BENEFIT ANALYSIS OR BUSINESS CASE BE CONDUCTED?

2.1 Every major investment decision taken by a State, an airport or a provider of air navigation services should be supported by analyses to demonstrate to providers, users and, as appropriate, the wider community, the costs and benefits accruing from investment in infrastructure. CBAs and business cases should be tailored to be proportionate to the size of planned investment, and an appropriate use of resource should add value to the decision-making process. In general, CBAs and business cases may be developed for the benefit of decision makers during the formulation of national development policies, in particular to support investment decisions in aviation infrastructure.

2.2 Consultation with users should assist States and providers with their major investment decisions. With regard to analyses undertaken, commonality in approach within a State or region is desirable and most States or regions will have agreed guidance or processes for undertaking such analyses.

2.3 The decision of when and to what extent CBAs and businesses cases are to be conducted should take into account the different key decision points in the life cycle of a particular investment programme.

2.1 WHEN SHOULD A COST-BENEFIT ANALYSIS BE CONDUCTED?

2.1.1 A CBA can be used by States and organizations to assess whether investment projects should be undertaken from the perspective of economic and social costs and benefits to all parties concerned. What counts as benefit to one part of the economy does not necessarily count as a benefit to the economy as a whole. A CBA requires establishing a framework analysing and identifying all associated costs and benefits, then assigning a dollar value to each and, finally, tallying the total value for comparison of the costs and benefits.

2.1.2 A CBA can be conducted at different times in the project life cycle. For example, an ex-ante CBA can be conducted prior to making the decision on whether to go forward for a project and whether or not resources should be allocated to the project. A CBA can also be conducted during the development phase of a project to evaluate investment options. An ex-post CBA can be conducted after the project is completed to apply the learnings of this project to future projects.

2.1.3 Different assessments are generally warranted at the different lifecycle stages due to the level of data that is available at that time and the amount of time that is proportionate to spend to prepare such an evaluation. In the case of research and development (R&D), following the identification of needs and concept definition, a State or organization would be looking for a very high-level assessment of whether there are potential benefits to be exploited in a particular area and might consider a high-level strategic CBA using a proportionate and acceptable technique at that point in time. Evaluation at this stage would look to help answer the question: “Is it worth our investment to explore possible benefits in this area?”

2.1.4 As further details emerge and the project decision moves into the R&D validation and feasibility stage, a more detailed CBA assessment would be possible and warranted in order to be able to comprehensively compare the possible options that could be industrialized and deployed. Evaluation at this stage would look to help answer the question: “Should we continue to invest in this area, and if so, which of the possible options should we commit to?”

2.1.5 Finally, the investment programme moves into the most important milestone stage of deciding to invest in actual deployment and operations. At this stage, a full business case would require the inclusion of the assessments of all factors relating to the financing of the investment, the impact on performance and operations, risks, safety and security, as well as economic development and stakeholder impacts. It is useful to refer to relevant planning processes, for example, the Global Air Navigation Plan[1], in particular to assess needs and the different available solutions that can best fulfill them. Evaluation at this stage would look to help answer the question: “What are all the possible implications of proceeding to deployment with this investment, and given these, should we proceed?”

2.2 WHEN SHOULD A BUSINESS CASE BE CONDUCTED?

2.2.1 A business case is specific to a project, a policy or a programme proposal and covers the lifecycle of the proposal. It provides information, which is necessary to make informed decisions on whether to proceed with the investment and in what form. It serves as a business justification in situations when reluctance to a proposal is foreseen, significant impact is expected on either current business or internal infrastructure arrangements, or substantial allocation or reallocation of resources is required.

2.2.2 An important purpose of a business case is to facilitate coordination with all parties involved and to support the negotiations with financial institutions. It can be a presentation or a proposal to an authority by an organization seeking funding, approval or both for an activity or project. Once approved, a business case becomes the basis for the project as it documents the rationale for creating the project, the key benefits to be delivered and their associated risks.

2.2.3 For a business case to be successful, it needs to explain the business problem or opportunity to be addressed by the proposed project, the motivations driving the project and the alternative resolutions available. The potential costs and benefits of each alternative solution should be determined to the degree that they are known and through conducting a set of assessments such as CBA, financial analysis and risk management. Hence, a business case is usually carried out after a CBA. A preferred or optimal solution should be recommended taking into account factors including the strategic objectives of the State or organization concerned, budget, cash flow, required timescale and quality criteria of the project.

2.2.4 With time, as situations change, a business case needs to be updated with new information as necessary and appropriate, and when resources of the project need to be justified. This is important for the decision-making process throughout the entire life cycle of an investment project.

---

1. Available at https://www.icao.int/airnavigation/Pages/GANP-Resources.aspx

Chapter 3

WHAT SHOULD BE INCLUDED IN A COST-BENEFIT ANALYSIS?

3.1 As described in Chapter 1, the development of a business case is a complex process. It includes a number of assumptions and assessments, typically financial analysis, strategic drivers, organizational performance factors, CBA, risk assessment and stakeholder impact. It provides a comprehensive assessment of its benefits, costs and risks. In addition, a business case may provide analyses of, and information on, products and services, markets, employees, technologies, facilities, equipment, capital, financing, contingency plans, etc.

3.2 Given the importance of the role that CBA plays in a business case, or on its own, this chapter highlights the key components that should be included when conducting a CBA. How a CBA is used in a business case will depend on the purpose of the business case. For instance, if the business case is internally focused, a CBA may play a less prominent role, and a traditional financial analysis may be given more weight. For a business case that is externally focused and designed to inform stakeholders and incorporate societal impacts, a CBA may play a more prominent role.

3.3 Assuming that most of the projects, policies and programmes under consideration are either directly or indirectly publically funded with the ultimate aim of maximizing the social welfare associated with public aviation, the focus of this chapter is to identify the steps component of a CBA. A well-designed CBA consist of the following steps:

a) define the objective and scope;

b) specify assumptions;

c) define the base case and identify alternatives;

d) set the evaluation time horizon;

e) identify the costs and benefits;

f) compare the costs and benefits;

g) conduct sensitivity analysis;

h) consider distributional aspects; and

i) make recommendations.

3.4 Approaches to business cases and CBAs may differ by jurisdiction and therefore these guidelines should not serve as a prescriptive list but rather as a reference tool for reviewing or undertaking the assessments. In fact, some organizations may use the terms business case and CBA interchangeably. The following sections highlight the key factors to be considered for each of these stages and underline some of the issues unique to aviation that may arise.

3.1 DEFINE THE OBJECTIVE AND SCOPE

3.1.1 A first step in any evaluation should be to define and describe the problem. The objectives with the desired benefits and outputs for the investment project, regulation, or policy, must be clearly stated.

3.1.2 It is a common failing for evaluations to describe an action only in terms of the inputs required to accomplish it rather than the desired benefits and outputs from the action. For example, the objective of providing airspace surveillance should be stated in terms of the expected improvements in benefits (enhanced safety, increased system capacity, reduced costs, better weather detection, increased traffic, etc.) rather than as a need to procure a new radar system.

3.1.3 The scope of the analysis should be clearly identified by defining the timescale, geographic area, relationship to other projects, developmental stage and possibly indicative cost estimates. The scope should also state whether there are indirect cross border or network impacts that need to be taken into account, or at least identified.

3.1.4 In addition, the scope needs to address which users are affected. In the case of airspace users, for example, they are mobile by nature and can use the given geographic area only from time to time as well as operate in other areas. Identifying the airspace users will help to ensure there is no double counting or forgotten benefits or costs. Synchronization between different geographic areas can also improve respective CBAs or business cases.

3.1.5 Clarifying the objective and scope of the evaluation provides the focus and perspective for conducting the analysis, which is crucial for identifying the costs and benefits to be included in the assessment. This stage may be time consuming, but many projects and evaluations fail because the scope and objectives are not clear from the start.

3.1.6 Changes in the aviation sector may impact many different stakeholders and it is essential to ensure that the objective and the scope of the analysis clearly indicates the potential impacts for different stakeholders. This can be an important consideration when the analysis is intended to support a business case. Non-quantifiable and non-financial factors may differ greatly between different groups of stakeholders and should be noted. Including stakeholders in the development of the objective and the scope will allow for identifying and addressing the potential different factors in advance.

3.2 SPECIFY ASSUMPTIONS

3.2.1 Any evaluation will require assumptions to be made. This may be because of lack of data and information, or because the project will have an impact in future years and therefore involves a substantial amount of uncertainty. In aviation, investment and regulatory evaluations generally include assumptions on aircraft fleet characteristics, levels of aircraft activity, equipment life, number of passengers and/or shipment revenues, the cost of fatalities and injuries or the value of passenger time, personnel and other resources required.

3.2.2 Other assessments may include newer types of aircraft with advancements in technology, unmanned aircraft systems, new types of aviation fuel and environmental goals. Any assumptions made should be explicitly stated in terms of their basis of justification, such as judgment or econometric forecast.

3.2.3 The assumptions should also address the other planned changes to occur in the meantime which may affect the base case. A rigorous approach is needed at this stage to ensure that benefits are not double counted or overestimated at later stages.

3.2.4 It will not always be possible to specify all assumptions at the beginning of a project. The process of updating and identifying new information gaps is interactive and should occur during the entire period of the analysis.

3.3 DEFINE THE BASE CASE AND IDENTIFY ALTERNATIVES

3.3.1 There are different ways to achieve a desired objective. In evaluations, it is important to identify all reasonable ways to achieve the desired objectives and to compare the expected results of these alternatives against a base case scenario.

3.3.2 The base case provides the benchmark against which the proposed project or investment can be measured. It is the “do nothing” or “maintain status quo” option that describes what is likely to occur in the absence of the project being evaluated. It does not imply that the base case is a costless option. The base case should be considered as what needs to be done to maintain the current or prescribed levels of service, rather than simply continuing in the existing state. The question in concern is whether the proposed project can achieve the desired objective in a better way compared to the base case scenario. An analysis cannot begin without a credible base case scenario.

3.3.3 If an option is being considered as providing an improvement to the status quo, it should be included as a project alternative. It is not necessary to include every possible alternative ways of achieving the project objective in the evaluation. Many technically possible alternatives may be ruled out from the beginning as inferior to others that are being evaluated; however, caution should be taken in making decisions to remove alternatives from the evaluation. A decision to remove an alternative from the evaluation should be well founded and supportable, and should not be made based on past practice or external constraints. Successful identification of alternatives is often not confided to a single area of expertise. Therefore, it is advisable to involve one or more technical experts at this stage of the evaluation.

3.3.4 It is also important that the alternatives included in the evaluation are defined in a consistent and fair manner. In particular, comparisons between two alternatives cannot be made if they are at different scales, occur at different times, or involve different ownership.

3.3.5 Involving stakeholders at this stage is vital to ensure that the base case identified is a true representation of current operations and that all possible feasible alternatives are identified.

3.4 SET THE EVALUATION TIME HORIZON

3.4.1 The time horizon for the analysis is a critical decision as future streams of costs and benefits must be adjusted by a discount factor from the year in which they occur to a base year for the evaluation.

3.4.2 The evaluation time horizon should cover the entire time period over which the project’s costs and benefits occur. The determination of an appropriate time horizon will be specific to each evaluation, but factors such as the lifespan of capital investments, the period over which a policy is likely to apply, and other demographic, economic or social factors that may affect the suitability of the project’s objectives should be considered. In general, physical capital investments such as airport runways or terminals will have a longer time horizon for evaluation compared to air navigation technology developments or other government policies or regulations.

3.4.3 The outcome of the analysis can be improved if costs can be spread across time, and therefore longer time periods will generally result in more positive results; however, the time horizon set must be realistic and reflect the lifecycle of the operational improvement and technologies or capabilities employed. The analysis should use generally recognized lifecycle estimates.

3.5 IDENTIFY THE COSTS AND BENEFITS

3.5.1 All costs and benefits must be identified for the base case and for each of the alternatives under consideration in the analysis. The identified costs and benefits should be quantified in monetary value where possible. Intangible costs or benefits, such as those that cannot be evaluated in monetary terms, should be listed and described for the decision maker. If possible, a range in which a monetary value could be reasonably expected to fall should be reported. Intangibles should not be neglected, as they are often extremely important to the overall decision-making process.

3.5.2 There are several factors that need to be considered when identifying costs and benefits. The primary focus is to compare the incremental costs and benefits caused by the project rather than those that are merely associated with the project in some way. The analysis must avoid double counting and must therefore maintain a consistent point of view throughout. In a CBA, resources that are created or used up are counted, and therefore, resources that are simply transferred from one place or entity to another are not counted as costs or benefits. The opportunity cost is the true value of any resource foregone and must be included even if explicit cash transactions are not involved. A sunk cost that is irretrievably made or committed should not to be counted in a prospective CBA because it will not be affected by the decision in question.

3.5.3 Each individual evaluation will identify its own set of relevant costs and benefits and this will vary significantly between different types of project objectives. Typical cost categories could include capital infrastructure, fleet, IT equipment and software, staff costs, maintenance and repairs, aircraft and passenger delay costs and the social cost of externalities such as noise or CO_2. Typical benefits will fall into the ICAO key performance areas (KPAs) of access and equity, capacity, cost effectiveness, efficiency, environment, enhance passenger experience, flexibility, global interoperability, participation by the air traffic management (ATM) community, predictability, safety and security. Ideally, any relevant societal costs and benefits should be included; however, in many cases it will not be possible to quantify all of these costs and benefits. Instead, they would be described in qualitative terms and be included in a separate section of the analysis.

3.5.4 In terms of potential productivity gains, projects of airports and air navigation services providers (ANSPs) may have different considerations that need to be taken into account. At an airport, for example, an investment in an enhanced baggage handling system may reduce the number of agents required in the future thereby reducing future operating costs. Transportation efficiency benefits may also accrue to the air carriers and would include savings arising from the quicker turnaround of aircraft, and possibly greater service reliability and predictability. For an ANSP, for example, an investment in modern air traffic services (ATSs) technology may reduce the number of air traffic controllers required in the future thereby reducing future operating costs. Transportation efficiency benefits may also accrue to the aircraft operators and would include savings arising from the more efficient operation of aircraft and greater service reliability and predictability. Such efficient benefits also occur to the travelling public in terms of travel time-savings. These savings frequently constitute an important efficiency benefit.

3.5.5 The measurement of safety benefits requires an analysis of the safety risks, which are a composite measure of the probability and the severity of an adverse occurrence. A CBA takes the consequences determined by a risk analysis and attributes a specific monetary value to them. Where accident losses involve tangible goods such as property, accident risks can be valued on the basis of replacement or repair costs. Where losses have intangible consequences such as personal injury or loss of life, the proper valuation of accident risk becomes more uncertain and judgmental, and should be approached with care. Given the difficulties involved with measuring safety benefits, they are often not quantified in these analyses unless the safety benefits would differ among the options considered or prove decisive in establishing a positive net benefit for a single infrastructure investment. Where a project cannot be justified by consideration of the non-safety benefits, it may be necessary to consider whether the project will lead to an improvement in the level of safety. In some situations, safety benefits will be the primary purpose of a project and the change should be pursued even if the CBA is not positive.

3.5.6 Projects may have negative or positive effects that are experienced by third parties, such as environmental impacts. The identification and measurement of these effects are less readily identifiable and may have no obvious market value. It is nevertheless useful to list these and quantify them using analytical techniques, if possible. The impact on the environment is an important factor in many large transportation projects. Whether considered as a cost or as a negative benefit (environmental effects are often unintended and typically negative), these effects are difficult to measure precisely. Nevertheless, it is important that they be identified and carefully evaluated. Extensive research has been carried out in the quantification of environmental effects.

3.5.7 For additional information on the more technical aspects of undertaking CBAs or business cases, there are many existing guidance documents on conducting CBAs or business cases. Guidance documents that are more relevant to aviation or transport studies have been listed in Appendix A for reference. This is not an exhaustive list and there may be other reference documents relevant to a particular State or region that could also be used.

3.5.8 The realization of benefits and the incurrence of costs are likely to vary greatly between the different stakeholders affected by the change being proposed. It is important to recognize the distribution of costs and benefits across different stakeholder groups as well as identify the overall values. In some cases, for operational improvements, the party who has made the investment may receive very few or none of the benefits. The extent of this will depend on the nature of the operational improvement and the strength of competition in the area of the specific service value chain where the benefits are created.

3.6 COMPARE COSTS AND BENEFITS

3.6.1 Once all costs and benefits have been identified and forecasted, they then need to be converted into a comparable format in order to determine if a project is cost-beneficial or to assess which option yields the greatest net benefits. In order to convert the net cash stream of costs and benefits into a comparable format, they need to be discounted to “today’s value” or the value in the base year for the project. As mentioned above, the need for discounting stems from the fact that the value placed on costs and benefits depends on when they occur. One unit of currency spent or accrued in the future is worth less than the value of one unit of currency today because of inflation and the time preference for money, because of the opportunities foregone during the year.

3.6.2 In CBA analysis, the generally accepted approach to address inflation and to ensure that all the benefits and costs are measured on an equivalent is to measure them in constant (real) dollars of a given year, usually the year in which the CBA is conducted. If the CBA study takes place in 2022, the value of a unit of output from a project, regardless of the future year in which it is realized, should be presented in terms of its 2022 dollar value. A unit of a given output will generally maintain the same constant dollar value throughout a project’s life. Only in a situation where the relative value of an output is expected to change over time, that is, a unit of this output will become relatively more valuable when valued in terms of other real outputs, would the application of a changing value (in constant dollars) be appropriate. The use of constant dollars greatly reduces the complexity of later discounting of benefits and costs. For the purpose of discounting, the real interest rate would be used in the present value formula.

3.6.3 While it is possible to conduct the analysis in nominal terms, that is, terms that are not adjusted to the inflation rate, this is not a recommended approach when conducting a CBA, since it leads to needless complexity with respect to discounting future benefits and costs. It should be noted, however, that when conducting a financial analysis, such analyses are frequently done in nominal terms. In this case, for the purpose of discounting, a nominal rate of interest would be used in the present value formula.

3.6.4 It is very important to follow only one of the approaches above, and to not mix and match approaches across the different types of costs and benefits. The choice of the right discount rate is also a key decision for the evaluation. When doing an analysis from a private sector entity perspective, a common approach is to use the nominal interest rate on a financial asset with similar risk properties as the project is being considered. This choice must be made carefully to prevent producing misleading results. When doing analysis from a public sector perspective, in the context of

social cost-benefit analysis, all costs and benefits should be converted into their certainty equivalents and then a "real" risk free discount rate should be used. If public financing is used, other adjustments may also need to be made. In summary, in making choices about discount rates, it is critical to make sure that issues such as uncertainty, crowding-out of private investment by debt-financed projects and deadweight loss in tax-financed projects, are accounted for.

3.6.5 Costs and benefits do not necessarily follow the same distribution of cash flows arising from a financial evaluation. In addition, benefits accruing to aviation users may be insufficient to cover the total costs of the project.

3.6.6 Once costs and benefits have been discounted and are in a comparable format, then different criteria are available to establish whether the benefits exceed the costs for any or all of the alternatives. These include net present value (NPV), benefit/cost ratio (BCR), internal rate of return (IRR) and the payback period.

3.6.1 Net present value (NPV)

3.6.1.1 NPV is generally the preferred method for the evaluation of projects. NPV is the sum of the discounted project benefits less discounted project costs. Using NPV as a decision rule, a project is potentially worthwhile (or viable) if the NPV is greater than zero, that is if the total discounted value of benefits is greater than the total discounted costs.

3.6.1.2 The advantage of NPV is that when considering a single project, it is easy to determine whether to go ahead with the project, which is when the NPV is positive. When considering multiple, mutually exclusive projects, choosing the one with the highest NPV is a clear approach to selection. The disadvantage of NPV is that it may be difficult to account for distributive impacts and any impacts that are not monetized.

3.6.2 Benefit/cost ratio (BCR)

3.6.2.1 The BCR is the ratio of the present value of benefits to the present value of costs, and can be expressed as:

$$BCR = \frac{PV_{Benefits}}{PV_{Costs}}$$

3.6.2.2 A project is potentially worthwhile if the BCR is greater than 1. This means that the present value of benefits exceeds the present value of costs. Using this decision rule, the alternative with the highest BCR would be the most favourable.

3.6.2.3 The advantage of BCR is that it can help order projects in situations where one is choosing among projects with scarce resources. The disadvantage of BCR is that projects of different sizes are not comparable. The shifting cost as negative benefits, and vice versa, may lead to distortion in results when comparing across options.

3.6.3 Internal rate of return (IRR)

3.6.3.1 The IRR is the discount rate at which the NPV of a project is equal to zero, that is discounted benefits equal discounted costs. 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 would be the most favourable.

3.6.3.2 The advantage of IRR is similar to that of BCR in that with scarce funds one can choose projects in the order from the highest IRR, and it can be useful for projects for which it is difficult to determine a suitable discount rate. However, IRR does not adjust for projects size and can give the wrong answer if costs come after benefits, and can give multiple answers making it difficult to know which one to use.

3.6.4 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. Many organizations have an agreed "rule" for a cut-off date for payback in order to assess whether or not to undertake the project. The disadvantage of the payback period is that it is a measure of time rather than value. It does not discount cash flows, nor does it take account of cash flows beyond the payback period. The advantage of the payback period is that it is a simple measure, and in some cases, stakeholders are more interested in shorter term returns rather than longer term societal benefits.

3.7 CONDUCT SENSITIVITY ANALYSIS

3.7.1 In a CBA, the outcome is typically influenced by several uncertain factors. A complete picture of the situation is best presented if this uncertainty is explicitly considered and decision makers know how likely, or how 'sensitive', the outcome is to change in uncertain factors. This analysis also helps to communicate the extent of the uncertainty and risk of the project to decision makers. This type of analysis also provides feedback on the economic analysis process used in the evaluation, based on which key assumptions can be updated, additional alternatives can be identified or the methodology can be revised. This can make the economic analysis process iterative and ultimately improve the quality of the analysis.

3.7.2 Techniques for understanding the impact of uncertainty include sensitivity analysis, Monte Carlo simulation and decision analysis. By using these methodologies, it is possible to examine how the outcomes of the different alternatives hold up to changes in assumptions and, with the given uncertainty, if the project is worth undertaking.

3.7.3 Robust research and development (R&D) and validation are also instruments to assess the potential impact and reduce uncertainties.

3.7.1 Sensitivity analysis

Sensitivity analysis examines how the total cost of NPVs or other outcomes vary as individual assumptions or variables are changed. It can be used to test the robustness of the analysis as well. In cases where the impact is insignificant or has no effect on the sign of the NPV, one might conclude that the project is insensitive to a particular value. However, in cases where a small change in an assumption has dramatic effects on the NPV or outcome, then the project would be considered sensitive to this variable and thus, caution should be exercised during the decision-making process.

3.7.2 Monte Carlo simulation

Monte Carlo simulation is a tool for considering many more possible combinations of changes compared to basic sensitivity analysis. It uses simulation techniques to calculate the entire range of all possible outcomes of the project and the likelihood of each actually occurring.

3.8 CONSIDER DISTRIBUTIONAL ASPECTS

3.8.1 For many governmental investments and regulations, the recipients of the benefits are not those who bear the costs. From an overall perspective, society's welfare is improved as long as all accepted projects and regulations have benefits in excess of costs. This is true because those who benefit could fully compensate those who bear the costs and still be better off. However, while the potential for compensation may exist, it may not occur, or it may require further initiatives to implement. If costs are imposed on parties who neither benefit nor are compensated, the impact will be inequitable.

3.8.2 A CBA should identify gainers and losers of governmental investments and regulations, and whether gainers actually compensate losers. When costs and benefits have significant distributional effects, these should be analysed and discussed.

3.9 MAKE RECOMMENDATIONS

The final outcome of the analysis is a recommendation concerning the proposed objective. The presentation of the conclusions and recommendations of the analysis should be clearly articulated so that decision makers and other entities have a clear understanding of the merits of the proposed project, policy or programme. The final recommendation should contain two main parts: a decision as to whether the activity should be undertaken, and if so, the alternative that should be selected to achieve the proposed objective.

Appendix A

GUIDANCE AVAILABLE ON HOW TO CONDUCT A COST-BENEFIT ANALYSIS

Many guidance documents are available on how to conduct a cost-benefit analysis (CBA) for the aviation industry or for investment projects in the general public sector. The examples provided below are a comprehensive, but not exhaustive list of relevant resources, and will be reviewed and updated periodically.

1. AVIATION-SPECIFIC RESOURCES

a) Australian Government, Civil Aviation Safety Authority, *Cost-Benefit Analysis Methodology* (2007)

b) U.S. Department of Transportation, Federal Aviation Administration, *Airport Benefit-Cost Analysis Guidance* (2020)

c) U.S. Department of Transportation, Federal Aviation Administration, *Economic Analysis of Investment and Regulatory Decisions — Revised Guide* (1998)

d) Doramas, Jorge-Calderón, *Aviation Investment: Economic Appraisal for Airports, Air Traffic Management, Airlines and Aeronautics*, Second Edition (2021)

e) Seamless Traveller Journey Cost Benefit Analysis — World Travel and Tourism Council (2020)

f) EUROCONTROL publications:

1) *Air Traffic Management Cost Benefit Analysis Beginners' Guide* (2006)

2) *Air Traffic Management Cost Benefit Analysis Quality Checklist* (2006)

g) EUROCONTROL — European Model for Strategic ATM Investment Analysis (EMOSIA)

Note.— EMOSIA is the common approach for cost-benefit analyses of European ATM projects. The objective of EMOSIA is to facilitate decision-making by understanding the global impact on ATM performance of any proposed change, thus reducing investment risk. It is a platform for making informed decisions on ATM/CNS (air traffic management/communication, navigation, surveillance) investments and ensures that all parties involved speak the same language when deciding. EMOSIA is the first cost-benefit analysis tool developed by the European ATM/CNS community for the European ATM/CNS community. With EMOSIA, informed decisions can be made on ATM/CNS investments that are traceable, consistent and transparent. EMOSIA users are able to compare different projects in ATM, different stakeholder options and the results obtained at different stages of a project.

1) User guide: a step-by-step guide of EMOSIA

2) Overall model: document describing the overall model

3) Military model: document describing the military model

4) Airport model: document describing the airport model

5) General aviation model: document describing the general aviation model

6) Airlines model: document describing the airlines model

7) Brochure: an introduction to EMOSIA

8) Architecture: document describing the architecture of the EMOSIA model

9) Approach to assess the benefits and costs of ATM investments

2. GENERAL GOVERNMENT AND TRANSPORT RESOURCES

a) European Commission, *Guide to Cost-Benefit Analysis of Investment Projects* (2015)

b) New Zealand Treasury, *Cost Benefit Analysis including Public Sector Discount Rates* (2020)

c) New Zealand Treasury, *The Treasury's CBAx Tool* (2021)

d) Government of Canada, *Policy on Cost-Benefit Analysis* (2018)

e) Government of the United Kingdom, *The Green Book: appraisal and evaluation in central government* (2022)

f) Australian Government, *Cost-benefit analysis — Guidance note* (2020)

Appendix B

EXAMPLES OF AVIATION-RELATED COST-BENEFIT ANALYSIS STUDIES

1. GENERAL

1.1 EUROCONTROL

a) Automated Data Measurement System: Set of input and output files for the initial evaluation of the costs and benefits of an application to automate data collection at airports

b) Controller Pilot Data Link supported by ATN in Europe: *Link 2000+ Cost Benefit Analysis Review*: This document contains the latest review of the cost-benefit analysis carried out for the LINK2000+ programme aiming at implementing controller-pilot data link communications (CPDLC) services in the core area of the ECAC (European Civil Aviation Conference) region

c) European Model for Strategic ATM Investment Analysis (EMOSIA): A Practical Example

d) Report of the dry run of EMOSIA in 2003: This study contains an overview of the EMOSIA approach and its application to an example looking at investment in sector productivity tools

1.2 Examples of cost-benefit analysis assessments

a) Value of an average passenger flight in the EU 27

b) Economic benefits of European airspace modernization

c) Inefficiency in European airspace

d) Economic benefits of reducing aviation taxes in Latin America and the Caribbean

e) Foregone economic benefits from airport capacity constraints in the EU 28 in 2035

2. AIR TRAFFIC MANAGEMENT

2.1 EUROCONTROL

a) Scoping Study — European ATC Harmonisation and Integration Programme (EATCHIP) Overall Cost-Benefit Scoping Study: An overview of the economic feasibility of EATCHIP

b) Controlled and Harmonised Aeronautical Information Network (CHAIN) CBA: A study of the CHAIN programme, including a software support tool known as the European Data Integrity Tool (E-DIT)

c) Dynamic Management of the European Airspace Network (DMEAN) Scoping CBA: An initial assessment of the DMEAN programme, prepared in order to seek approval for the programme from EUROCONTROL Member States

d) DMEAN Full CBA: A full cost-benefit analysis undertaken to investigate the economic case for implementing the programme

2.2 United Kingdom

a) United Kingdom Civil Aviation Authority, CBA on Continuous Climb Operations (CCOs): A strategic level CBA for implementing fully systemized CCOs in the United Kingdom

3. AIRSPACE AND NAVIGATION

3.1 EUROCONTROL

a) Reduced Vertical Separation Minima (RVSM) — Re-Validation of Cost-Benefit Assessment of Reduced Vertical Separation Minima: A reassessment of the business case for reduced vertical separation minima, updating a study from 1997

b) European Geostationary Navigation Overlay Service (EGNOS) — Multi-Modal Costs and Benefits — A study of the aviation case in ECAC: This report presents the results of a study to assess the value to the aviation community of the introduction into service of EGNOS in the 38 States of the ECAC region

c) Free route airspace (FRA): Results of a cost-benefit analysis of FRA in Europe

d) Landing Systems Business Case: A business case to define the optimum solution for the transition to the future landing system(s) in the ECAC region. It compares the relative financial merits of ILS, MLS and GLS

4. COMMUNICATION

4.1 EUROCONTROL

a) Controller Pilot Data Link supported by ATN in Europe: *Link 2000+ Cost Benefit Analysis Review*: The latest review of the cost-benefit analysis carried out for the LINK2000+ programme aiming at implementing CPDLC services in the core area of the ECAC region

b) LINK 2000+ CBA Review: A review and update of the previous cost-benefit analyses carried out for the LINK2000+ programme, which aims to implement datalink services in the core area of Europe

5. SURVEILLANCE

5.1 EUROCONTROL

a) Mode S — Phase 1 of a Mode S Cost-Benefit Analysis Project: A preliminary study to collect and collate all Mode S and datalink studies undertaken or foreseen in Europe and other regions

b) Mode S — Phase 2 of a Mode S Enhanced Surveillance Cost-Benefit Analysis: An assessment of the costs and benefits generated by the operational use of Mode S in the High Density Area of Europe from 1998 to 2015

c) ATC Radar Tracker and Server (ARTAS) CBA: A cost-benefit analysis assessing the implementation of ARTAS in the ECAC region, taking into account the potential Mode S and automatic dependent surveillance (ADS) implementation

d) ADS — High Level CBA: An initial analysis of the implementation of ADS in the ECAC region with the objective of making a first estimate of all cost items and identifying the potential benefits provided or enabled

e) The Case for Enhanced Surveillance: A study to assess the value of Enhanced Surveillance in the core area of Europe, based on the use of eight downlinked aircraft parameters

f) The Case for Enhanced Surveillance — Revised CBA: A revision and update of the CBA prepared as part of the earlier study of enhanced surveillance

6. AIRPORTS

6.1 EUROCONTROL

a) Airports Initial Business Case Assessment: A framework for assessing the costs and benefits of implementing one or more elements of the airport operations programme and an initial high-level assessment of potential benefits

b) Study of Airports Collaborative Decision-Making (CDM) Level 1 Applications: An initial cost-benefit analysis for airport CDM derived from EUROCONTROL airport trials at several major European airports, concentrating mainly on Brussels Airport

c) Study of Airports CDM Levels 2 and 3 Applications: Forthcoming

d) Advanced surface movement guidance and control system (A-SMGCS) Generic CBA: An analysis of the anticipated benefits and costs of implementing A-SMGCS Levels 1 and 2, using the results of simulations and operational trials

---

Appendix C

AVIATION INFORMATION AND DATA SOURCES TO SUPPORT COST-BENEFIT ANALYSIS OR BUSINESS CASE

1. DATA INPUTS AND TEMPLATES FOR COST-BENEFIT ANALYSIS

a) EUROCONTROL (2014)

1) Standard Inputs for EUROCONTROL Cost-Benefit Analyses

2) Overall model data input table: excel spreadsheet to gather input data for the overall model

3) Military data input table: excel spreadsheet to gather input data for the military model

4) General aviation data input table: excel spreadsheet to gather input data for the general aviation model

5) Airport data input table: excel spreadsheet to gather input data for the airport model

6) Airline data input table: excel spreadsheet to gather input data for the airline model

7) ANSP data input table: excel spreadsheet to gather input data for the ANSP model

8) Baseline ANSP 2010: excel spreadsheet containing assumptions about the baseline for the ANSP. It includes assumptions about traffic growth and ANSP costs in 2010.

9) Baseline — ATM improvements by 2010: excel spreadsheet containing assumptions about the ATM improvements that will have been implemented by 2010

10) Baseline airlines 2010: excel spreadsheet containing assumptions about the baseline for airlines. It includes assumptions about traffic growth, delay, flight inefficiency, route charges and other airline costs in 2010.

11) Baseline general aviation 2010: excel spreadsheet containing assumptions about the baseline for general aviation. It includes assumptions about traffic growth, delay, flight inefficiency, route charges and other general aviation costs in 2010.

12) Airline spreadsheet generated by EMOSIA: spreadsheet generated in step 2 of EMOSIA containing inputs for the airline model and outputs such as the cash-flows and the net present value. It can be reused for other projects by entering different inputs directly in the spreadsheet.

13) ANSP spreadsheet generated by EMOSIA: spreadsheet generated in step 2 of EMOSIA containing inputs for the ANSP model and outputs such as the cash-flows and the net present value. It can be reused for other projects by entering different inputs directly in the spreadsheet.

14) Air Transport Infrastructure Costs: A briefing on air transport infrastructure costs

15) The potential for cost-effective CO_2 abatement in commercial aviation (presentation)

b) U.S. Department of Transportation, Federal Aviation Administration

1) *Economic Values for FAA Investment and Regulatory Decisions, A Guide: 2021 Update*, see https://www.faa.gov/regulations_policies/policy_guidance/benefit_cost

2. DATA INPUTS ON ECONOMIC BENEFITS IN AIR TRANSPORT FOR COST-BENEFIT ANALYSIS

a) Economic benefits of aviation for the global and regional economy:

Aviation Benefits Report (2019), see https://www.icao.int/sustainability/Documents/AVIATION-BENEFITS-2019-web.pdf

b) Economic benefits of aviation for national economies:

An analysis from the International Air Transport Association (IATA) on the contribution of air transport to the national economies and a detailed country-level assessment for about 60 countries.

3. COST OF DELAY

a) EUROCONTROL

1) Cost of Delay — Evaluating the true cost to airlines of one minute of airborne or ground delay: The results of a study by the University of Westminster to evaluate the cost of delay to airlines

2) Cost of Delay — Model based on the University of Westminster Report: The model enables the tables within the report to be reproduced but also allows users to change the input data to produce their own updated values. It should be noted that the model is not protected to allow the user to change the logic within the model.

3) Cost of Delay — Notes: Notes on estimating the cost of delay based on the University of Westminster Report and the cost of delay model

4) Examples of CBA assessments on the cost of delay:

i) Inefficiency in European airspace

ii) Economic benefits of European airspace modernization

b) U.S. Department of Transportation, Federal Aviation Administration

1) *Calculating Delay Propagation Multipliers for Cost-Benefit Analysis* (MITRE Corporation) (2010)

4. EMISSIONS

a) *ICAO Engine Exhaust Emissions Data Bank* (Doc 9646)

1) Doc 9646 was published in 1995 and contains information available as of October 1993. The Data Bank has since been further developed in electronic form and is available at: ICAO Aircraft Engine Emissions Databank | EASA (europa.eu)

b) *Committee on Aviation Environmental Protection, Eleventh Meeting* (Doc 10126), Montréal, 4–15 February 2019

5. NOISE

a) Noise certification database (NoiseDB)

6. TRAFFIC FORECASTS AND TOOLS TO ASSESS DEMAND

a) ICAO Long-term Traffic Forecasts

b) ICAO Post-COVID-19 Forecasts Scenarios

7. FUEL CONSUMPTION

a) Jet Fuel Price Monitor: The jet fuel price index provides the latest price data from the leading energy information provider Platts. The index and price data show the global average price paid at the refinery for aviation jet fuel at the reported date.

Appendix D

REFERENCES

1. ICAO PUBLICATIONS

Manual on Air Navigation Services Economics (Doc 9161)

Airport Economics Manual (Doc 9562)

2. OTHER PUBLICATIONS

Australian Government, Civil Aviation Safety Authority, *Cost Benefit Analysis Procedures Manual* (Canberra, 2010)

EUROCONTROL, *Business Cases and Cost Benefit Analyses* (Retrieved 29 September 2014 from EUROCONTROL)

EUROCONTROL, *The CBA Methodology — EMOSIA* (Retrieved 29 September 2014 from EUROCONTROL)

European Commission, *Guide to Cost-Benefit Analysis of Investment Projects* (Brussels, 2008)

HM Treasury, *The Green Book: Central Government Guidance on Appraisal and Evaluation* (London, 2022)

New Zealand Treasury, *Cost Benefit Analysis including Public Sector Discount Rates* (Wellington, 2020)

Treasury Board of Canada Secretariat, *Canadian Cost Benefit Analysis Guide — Regulatory Proposals (Interim)* (Ottawa, 2007)

U.S. Department of Transportation, Federal Aviation Administration, *Economic Analysis of Investment and Regulatory Decisions — Revised Guide* (Washington DC, 1998)

— END —

ISBN 978-92-9265-751-2