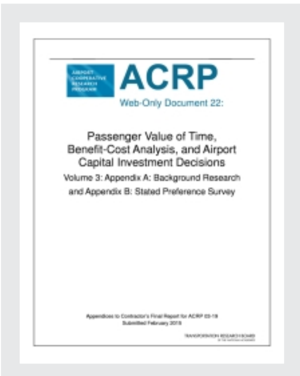

ACRP

Web-Only Document 22:

Passenger Value of Time, Benefit-Cost Analysis, and Airport Capital Investment Decisions

Volume 3: Appendix A: Background Research and Appendix B: Stated Preference Survey

Passenger Value of Time, Benefit-Cost Analysis and Airport Capital Investment Decisions, Volume 3: Appendix A Background Research and Appendix B Stated Preference Survey

DETAILS

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Appendix A: Background Research

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TABLE OF CONTENTS

1 Annotated Bibliography and Literature Review

This appendix identifies published guidance concerning passenger value of time, benefit-cost analysis and airport capital investment decisions. Literature is reviewed on the following topics:

- U.S. airport capital investments – The references are helpful in identifying the different types of airport capital investment projects and the types of analysis that may be required for different types of projects, depending upon funding sources.
- Benefit-cost analysis (BCA) and other methods for evaluating capital investment decisions –The references methodology are grouped according to the following sub-topics: (1) BCA and (2) other methods of evaluating capital investment decisions. Federal regulations and guidance identify BCA as the primary tool for evaluating significant capital investment decisions. However, other methods can also be used depending upon the purpose, user and audience of the analysis, for example: financial feasibility analysis and economic impact analysis.
- BCA transportation applications – References on actual BCA applications to airports and other transportation modes provide illustrations of BCA and approaches to economic valuation of different types of benefits and costs associated with airport capital investments.
- Economic valuation – The references cover both theory and empirical estimation of the following economic values relevant to the evaluation of airport capital investments:
    - travel time
    - statistical life
    - noise effects
    - climate and air quality effects

Although this research project involves multiple factors that drive capital investment decision making, the scope of the research effort emphasizes analysis of passenger value of time. In reviewing literature on the value of time, it is important to recognize that values can differ significantly depending on context. The reasoning is that different types of studies focus on the perspectives of: (1) passengers; (2) airlines and GA aircraft owners, (3) transportation users and (4) the ultimate beneficiary (in terms of cargo).

These different perspectives can be important because short-term choices of travelers tend to focus mainly on the trade-off between marginal out-of-pocket cost and marginal difference in travel time. On the other hand, choices of vehicle type are made by the owner (an airline or general aircraft owner), and tend to focus on average operating costs with a broader definition that also includes fuel and maintenance costs, as well as full wage and overhead costs for pilots and crew. The longer-term choices of transportation service provider include further considerations of reliability and market pricing of the delivery services provided, and that pricing may be determined more by market supply and demand conditions than by operating costs. Finally, the productivity benefit of an on-time arrival for a traveler (or freight delivery) can be quite different from the market price that is charged for the transportation service.

General References: On Airport Capital Investment Planning and Finance

Airports Council International-North America, Airport Capital Development Costs 2009-2013, Washington, D.C., Feb. 2009.

The Airports Council International-North America periodically updates its estimate of capital development costs for the airports that comprise the national airport system of the United States, as defined by the Federal Aviation Administration. This document reports on the latest update. It provides an inventory of airport capital development costs by location (i.e. airside, terminal and landside) and project type (i.e. terminal, capacity, access, reconstruction, standards, security, environment, safety, and others). The total capital development cost estimates for large, medium, and small hub airports are based on survey responses from 26 large hub, 26 medium hub, and 21 small hub airports. The estimates for non-hub, commercial service, reliever, and general aviation airports were obtained from the Federal Aviation Administration (FAA) National Plan of Integrated Airport Systems (NPIAS).

De Neufville, R. and A. Odoni, *Airport Systems Planning, Design, and Management*, McGraw-Hill, New York, N.Y., 2003.

This book addresses professionals who need to deal with current issues in airport planning, management, and design. It covers both the development and management aspects of airports, which include topics such as the following:

- airport site characteristics
- layout of runways, taxiways, and aircraft apron
- design of passenger buildings and their internal systems, including security
- analysis of environmental impacts
- planning for ground access to the airport
- air traffic control
- management of congestion and queues

- determination of peak-hour traffic
- financing, pricing, and demand management

Horonjeff, R., F. McKelvey, W. Sproule, and S. Young, *Planning and Design of Airports*, Fifth Edition, McGraw-Hill, New York, N.Y., 2010.

The authors provide guidance on every aspect of planning, design, engineering, and renovation of airports and terminals. In airport capital investment decision making, this reference is useful in providing a description of the various facilities and infrastructure at airports, a guide to planning their development and renovation, and an overview of finance strategies for airport capital improvements. In particular, Chapter 13 discusses fundamental strategies for funding large capital programs, including the following: federal funding under the Airport Improvement Program (AIP) and the Passenger Facility Charge (PFC) programs; state funding and local funding; bond financing; and private investment. Chapter 13 also describes the basic process for formulating a financial plan for airport capital improvements and determining the financial feasibility of the capital program.

Nichol, C., *ACRP Synthesis 1: Innovative Finance and Alternative Sources of Revenue for Airports*, Transportation Research Board of the National Academies, Washington, D.C., 2007.

ACRP Synthesis 1 provides an overview of alternative financing options and revenue sources available to airports. It discusses common capital funding sources and capital financing mechanisms used for airport capital investment and is, therefore, useful in identifying the type of decision analysis required depending upon the source of capital funding. The report identifies the following principal sources of funds for airport capital projects:

- proceeds of bonds and other forms of debt
- PFC revenues
- AIP grants from the Airport and Airways Trust Fund administered by the FAA
- internally generated capital resulting from retained airport revenues
- security grants from the general fund and administered by the Transportation Security Administration (TSA)
- state grants and local financial support

U.S. Department of Transportation, Federal Aviation Administration, *Airport Improvement Program (AIP) Handbook*, updated Jun. 19, 2009. [Online]. Available: http://www.faa.gov/airports/aip/aip_handbook/.

The AIP Handbook provides guidance and sets forth policy and procedures to be used in the administration of the AIP. It identifies the types of airport capital investment that are eligible for different types of AIP grant funding. It also identifies

the types of information and analysis that the FAA requires airport sponsors to submit along with their applications for funding.

U. S. Department of Transportation, Federal Aviation Administration, "Airport Master Plans," *Advisory Circular No. 150/5070-6B*, Jul. 29, 2005. [Online]. Available: http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.information/documentNumber/150_5070-6B.

This Advisory Circular (AC) provides guidance for the preparation of master plans for airports that range in size and function from small general aviation to large commercial service facilities. The AC covers the following topics: (1) process of preparing master plan studies, and (2) elements of master plan studies. Chapter 12 of the AC provides guidance in conducting financial feasibility analysis to demonstrate an airport sponsor's ability to fund projects recommended in the master plan. The financial feasibility analysis must include the following:

- identification of funding sources for the Capital Improvement Program (CIP)
- projection of revenues and expenses (pro forma cash flow analysis) for each year of the CIP
- methods to enhance airport revenues

U.S. Department of Transportation, Federal Aviation Administration, *National Plan of Integrated Airport Systems (NPIAS)*, updated Aug. 21, 2009. [Online]. Available: http://www.faa.gov/airports/planning_capacity/npias/.

The National Plan of Integrated Airport Systems (NPIAS) identifies more than 3,400 existing and proposed airports that are significant to national air transportation and thus eligible to receive federal grants under the Airport Improvement Program (AIP). It also includes estimates of the AIP-eligible needs of these airports that are not otherwise funded (e.g., the amount of AIP money needed to fund infrastructure development projects to comply with airport safety requirements, meet current design standards, and add capacity to congested airports). The FAA is required to provide Congress with a five-year estimate of AIP-eligible development every two years. The NPIAS comprises all commercial service airports, all reliever airports, and selected general aviation airports.

Wells, A. and S. Young, *Airport Planning and Management*, Fifth Edition, McGraw-Hill, New York, N.Y., 2004.

Wells and Young discuss the fundamentals of, and current developments, in airport management. The book provides guidance on airport site selection, design, access, financing, law and regulation, capacity, technological advances, and other issues essential to the development and management of airports. Chapter 7 on financial planning provides a guide to the development of a financial plan, which consists of an evaluation of the financial feasibility of the implementation of proposed capital improvement projects in an airport master plan.

TransSolutions, Strategic Insight Group, Aviation Resource Partners and Kimley-Horn Associates, *ACRP Report 55: Passenger Level of Service and Spatial Planning for Airport Terminals*, Transportation Research Board, Washington, D.C. 2011.

The objective of ACRP Report 55 was to examine passenger perceptions of service related to space allocation in specific areas within airport terminals. The research of passengers levels of service address passenger perception of disutility. A key finding of the research is that in order to reduce rising stress, travelers must perceive that they are in control of their journeys. Waiting in a security line and time in an aircraft (although not part of the research conducted on terminal service) are examples of trip components when passengers are not in control and have limited choices of how they can spend their time. On the other hand, when at the gate, passengers can shop, eat, read, work, or simply try to relax. The ACRP 55 Research Team found that it is important for passengers to feel that they are in control of the success of their journey. For example, the finding that passengers' perceptions of wait time is an expression of the success of their journey.

Methods for Evaluating Airport Capital Investment Decisions

Benefit-Cost Analysis Methods for Evaluating Airport Capital Investment Decisions

American Association of State Highway and Transportation Officials, *a Manual on User Benefit Analysis of Highway and Bus-Transit Improvements*, Washington, D.C., 1997.

This manual provides guidance on user benefit analysis for highway and bus-transit improvements. It does *not* directly address cross-modal efficiency impacts, wider economic benefits associated with business productivity, or localized benefits for communities.

Cambridge Systematics, Inc., Economic Development Research Group, Inc., and Boston Logistics Group, Inc., *Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects,* U.S. Department of Transportation, Washington, D.C., Aug. 2006. [Online]. Available: http://www.dot.gov/freight/guide061018/guide.pdf.

The purpose of this guide is to provide a thorough economic analysis framework to assess the benefits and costs of potential freight investments. The guide covers topics such as the national scale of benefits, the public and private benefits, and logistics and supply chain effects. It recommends a Five-Step Analysis Process:

- Identify the nature and transportation purpose of the project.
- Identify the expected direct economic impacts.

- Apply transportation impact evaluation tools to assess the incidence of effects on shippers, carriers and other parties.
- Apply economic impact evaluation tools to assess wider effects on the economy.
- Apply decision support methods to identify the substantial positive and negative impacts of the project for the economy (at the local, state or national level).

While the focus is on multi-modal freight investments (affecting air, sea, rail and truck modes), the procedures described for measuring benefits include factors of direct relevance for airport capital investments. That includes benefits from reduced congestion (operating cost and travel time savings), increased reliability (saving business logistics costs) and enhanced safety (accident reduction cost savings), which are expressed in terms of how they affect overall shippers, carriers and facility operator costs, and broader impacts on economic competitiveness.

ECONorthwest and Parsons Brinckerhoff Quade & Douglas, Inc., *TCRP Report 78: Estimating the Benefits and Costs of Public Transit Projects, A Guidebook for Practitioners*, TRB, National Research Council, Washington, D.C., 2002. [Online]. Available: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp78/guidebook/tcrp78.pdf.

This guidebook was developed largely to support transit planners in state, regional, and local government who evaluate transit investments. It is divided into five sections:

- Section I explains how to use the guidebook and provides an overview of benefit-cost evaluation concepts and their application to transit projects.
- Section II addresses the basic benefits and costs of transit projects.
- Section III discusses other benefits and costs of transit projects, including impacts on land use and land development, economic impacts, and the distribution of impacts.
- Section IV provides an example with sample analyses.
- Section V consists of appendices that provide a bibliography, integrated models for conducting comprehensive benefit-cost analysis, sample calculations, and conversion factors for calculating constant dollar value over time.

While the guidebook focuses on transit application, the BCA concepts and measurement approaches discussed in the guidebook can provide general directions for measuring the costs associated with aviation. For example, Section II of the guidebook addresses impacts such as reduced air, water, and noise pollution, and provides guidance for estimating the cost of accidents.

Executive Office of the President, *Regulatory Planning and Review*, Executive Order (EO) 12866, Sept. 30, 1993, as amended by EO 13258 of Feb. 26, 2002 and EO 13422 of Jan. 18, 2007. [Online] Available: http://www.whitehouse.gov/sites/default/files/omb/assets/omb/inforeg/eo12866/eo12866_amended_01-2007.pdf

With this EO, the federal government began a program to reform the regulatory process and make it more efficient. While the EO does not provide guidelines on methodology, it establishes the principles and the requirement for the documentation and analysis of the costs and benefits of proposed regulatory action. Specifically, Section 6(a) (3) (C) requires that, for significant regulatory actions within the scope of Section 3(f) (1), the following information is provided:

- An assessment, including the underlying analysis, of benefits anticipated from the regulatory action, together with, to the extent feasible, a quantification of those benefits
- An assessment, including the underlying analysis, of costs anticipated from the regulatory action, together with, to the extent feasible, a quantification of those costs
- An assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, identified by the agencies or the public, and an explanation why the planned regulatory action is preferable to the identified potential alternatives.

Section 3(f) (1) defines "significant regulatory action" as any regulatory action that is likely to result in a rule that may:

- Have an annual effect on the economy of $100 million or more, or
- Adversely affect in a material way the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities.

Executive Office of the President, *Principles of Federal Infrastructure Investment*, Executive Order 12893, Jan. 26, 1994.

This EO requires federal agencies to develop and implement plans for infrastructure investment and management consistent with the following principles:

- Systematic analysis of transportation infrastructure project benefits and costs
- Efficient management of infrastructure
- Greater private sector participation in infrastructure investment and management
- Project decision making at the appropriate level of government.

The Executive Order requires agencies to evaluate infrastructure investment at both the program level (e.g., Airport Improvement Program level) and individual project level.

Executive Office of the President, Office of Management and Budget, *Regulatory Analysis*, Circular No. A-4, Sept. 17, 2003. [Online]. Available: http://www.whitehouse.gov/omb/circulars_default.

This Circular provides the OMB's guidance to federal agencies on the development of regulatory analysis as required under Section 6(a) (3) c) of Executive Order 12866, "Regulatory Planning and Review," the Regulatory Right-to-Know Act, and a variety of related authorities. It is designed to assist analysts in the regulatory agencies by defining good regulatory analysis and standardizing the way benefits and costs of federal regulatory actions are measured and reported. It identifies and provides guidelines for the following three basic elements of a good regulatory analysis:

- A statement of the need for the proposed action
- An examination of alternative approaches
- An evaluation of the benefits and costs – quantitative and qualitative – of the proposed action and the main alternatives identified by the analysis

The Circular identifies and describes BCA and cost-effectiveness analysis (CEA) as the two analytical approaches to be used in regulatory analysis.

Executive Office of the President, Office of Management and Budget, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Circular No. A-94, Oct. 29, 1992. [Online] Available: http://www.whitehouse.gov/omb/circulars_default.

To promote efficient resource allocation through well-informed decision making by the federal government, this Circular provides general guidance for conducting benefit-cost and cost-effectiveness analyses. The circular applies specifically to:

- Benefit-cost or cost-effectiveness analysis of federal programs or policies
- Regulatory impact analysis
- Analysis of decisions whether to lease or purchase
- Asset valuation and sale analysis

The Circular recommends the use of BCA in formal economic analyses of government programs or projects, and the use of cost-effectiveness analysis, a less comprehensive technique, when the benefits from competing alternatives are the same or when a policy decision has already been made to provide a particular benefit. In identifying and measuring benefits and costs, analyses should include comprehensive estimates of the expected benefits and costs to society based on established definitions and practices for program and policy evaluation. Social net benefits, not benefits and costs to the federal government, should be the basis for evaluating government programs and policies that have effects on private citizens or other levels of government.

The Circular provides specific guidance on the discount rates to be used in evaluating federal programs whose benefits and costs are distributed over time. In particular, the Circular specifies the use of a real discount rate of 7 percent in constant-dollar benefit-cost analyses of proposed investments and regulatory policies.

FHWA (Federal Highway Administration), *Economic Analysis Primer*, Report by the Office of Asset Management, Washington, D.C., 2003 [Online]. Available: http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer.cfm.

This primer is intended to guide the application of economic analysis to highway projects. The concepts and methodologies described are also applicable to airport capital investment projects. The primer covers the following topics:

- What economic analysis is and why it is important to transportation decision making
- Inflation and discounting
- Actual applications of economic analysis methodology, especially life-cycle cost analysis and benefit-cost analysis
- Forecasting traffic growth – an important input to BCA
- Risk analysis
- Economic impact analysis – presented as a complement to economic analysis

Federal Railroad Administration, *Benefit-Cost Methodology for the Local Rail Freight Assistance Program*, U.S. Department of Transportation, Washington, D.C., 1990. [Online]. Available: http://www.maine.gov/mdot/freight/pdf/benefit.pdf.

This manual provides guidance for the application of BCA to projects proposed for funding under the Local Rail Freight Assistance Program.

Forkenbrock, D. and G. Weisbrod, *NCHRP Report 456: Guidebook for Assessing the Social and Economic Effects of Transportation Projects*, TRB, National Research Council, Washington, D.C., 2001. [Online]. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_456-a.pdf and http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_456-b.pdf.

This guidebook is intended to improve the capacity of transportation professionals to take into account a wide array of social and economic effects when evaluating transportation projects affecting any mode of travel. Emphasis is placed on methods, tools and techniques most likely to produce analyses that can be understood by community residents and decision-makers. The guidebook defines 11 general types of social and economic effects and provides insights into, and

evaluations of, the methods, tools, and techniques available to assess them. These are: changes in travel time, safety, changes in vehicle operating costs, transportation choice, accessibility, community cohesion, economic development, traffic noise, visual quality, property values, and distributive effects.

GRA, Incorporated, *Economic Values for FAA Investment and Regulatory Decisions, A Guide*, Final Report, U.S. Federal Aviation Administration Office of Aviation Policy and Plans, Oct. 3, 2007.

This report provides an update of economic values, often called “critical values,” used by the FAA to make investment and regulatory decisions. These economic values are used to evaluate the benefit-cost of investments, including certain AIP grants and regulations subject to FAA decision making. The application of these economic values to corresponding physical quantities permits the valuation of physical quantities in dollars.

The report presents economic values that fall into four categories:

- Passenger-related values: the value of passenger time, the value of an avoided fatality, and the value of avoided injury.
- Aircraft-related values: aircraft capacity and utilization factors; aircraft operating and ownership costs; aircraft replacement and restoration costs; and aircraft performance factors.
- Labor-related values: labor costs in aircraft manufacturing industries; salaries, benefits, and training costs for GA pilots; air carrier flight crew training costs; and other aviation-related labor costs.
- Aviation accident investigation costs: federal government accident investigation costs and private sector accident investigation costs.

Landau, S., G. Weisbrod, and B. Alstadt, “Applying Benefit-Cost Analysis for Airport Improvements: Challenges in a Multi-Modal World, Economic Development Research Group Working Paper,” Boston, Massachusetts, Mar. 2010.

Based on work done for ACRP Synthesis 13 (Landau and Weisbrod, 2009), the authors examine the issues that may arise when evaluating airport projects that have multi-modal impacts. Issues arise because of the BCA guidance for airports and for other modes differ in their treatment and valuation of certain benefits. The authors compare the BCA guidance for airports and for other modes, and discuss similarities and differences.

Landau, S. and G. Weisbrod, *ACRP Synthesis 13: Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis*, Transportation Research Board of the National Academies, Washington, D.C., 2009.

This synthesis defines and describes benefit assessment techniques used by airports, as well as other transportation modes. It highlights best practices and identifies

inconsistencies in how benefits are calculated. It also identifies aspects of the FAA BCA guidance that appear to have caused confusion among BCA practitioners. The synthesis is based on a review of literature, covering existing guidance publications and completed BCA reports submitted to the FAA to support federal grant requests under the Airport Improvement Program. The synthesis provides a summary of the 24 BCA reports reviewed.

Litman, T., *Transportation Cost Analysis: Techniques, Estimates and Implications*, Victoria Transport Policy Institute, Victoria, B.C., Canada, Jun. 2002.

This report develops a framework for estimating and comparing the total costs of various forms of transportation. It includes an extensive review of previous cost studies. Twenty cost elements are defined and discussed, and existing estimates are summarized. Cost estimates are provided for eleven travel modes under urban peak, urban off-peak, and rural travel conditions.

Mishan, E. and E. Quah, *Cost Benefit Analysis*, Fifth Edition, Routledge, New York, N.Y., 2007.

This textbook provides a detailed guidance on cost-benefit analysis (CBA), also known BCA. CBA is the systematic and analytical process of comparing benefits and costs in evaluating the desirability of a project or program. The textbook discusses the basic concepts of benefits and costs in terms of changes in consumer surplus and producer surplus, shadow prices and transfer payments, external effects, investment criteria, value of time savings, and uncertainty.

Minnesota Department of Transportation, Office of Investment Management, *Benefit Cost Analysis Guidance*, 2005. [Online]. Available: http://www.dot.state.mn.us/planning/program/benefitcost.html.

The Minnesota DOT provides an extremely basic overview of the BCA procedure. With a focus on highway studies, the paper provides a description of the key components of BCA, the types of costs and benefits that might be evaluated, and discounting. Important considerations include a thorough assessment of the geographic and temporal scale and scope of the project and accurate estimations of the benefits and costs.

Portney, P., “Benefit-Cost Analysis,” *The Concise Encyclopedia of Economics: Library of Economics and Liberty*, 2007. [Online]. Available: http://www.econlib.org/LIBRARY/Enc/Beneftit-Cost Analysis.html.

Portney presents a critical discussion of BCA, which initially gained widespread use in the evaluation of water projects in the United States in the late 1930s. Since then, it has also been used to analyze policies affecting transportation, public health, criminal justice, defense, education, and the environment. Portney raises the following key issues in BCA:

- To ascertain the net effect of a proposed policy change on social well-being, we must first have a way of measuring the gains to the gainers and the losses to the losers. Implicit in this statement is the central tenet of BCA: the effects of a policy change on society are no more or no less than the aggregate of the effects on the individuals who comprise society.
- Benefits and costs, even though typically expressed in dollar terms in BCA, go well beyond changes in individuals' incomes. Examples include improved well-being from cleaner air through improved visibility and reduced risk of disease.
- Benefits and costs are flip sides of the same coin. Benefits are measured by the willingness of individuals to pay for the outputs of the policy or project in question. Costs are measured by the amount of compensation required to exactly offset negative consequences. Willingness to pay or compensation required should each be the dollar amount that would leave every individual just as well off following the implementation of the policy as before policy implementation.
- Certain benefits, such as reduced health risks or improved visibility, do not lend themselves to market pricing. Two approaches are available to attribute a dollar value to these benefits: the contingent valuation method, which asks people how much they are willing to pay for such benefits; and using values revealed in actual market transactions.
- Sometimes costs have ripple effects on parties not directly involved in the project or policy. Techniques for making more sophisticated cost estimates that cover ripple effects are still in infancy and so virtually all BCAs still use direct expenditures as rough measures of true social costs.
- Government policies or projects typically produce streams of benefits and costs over time rather than in one-shot increments. Because people prefer a dollar today to one ten years from now, BCA typically discounts future benefits and costs back to present values. Not only are there disagreements about discount rates, discounting it raises ethical problems especially when projects or policies have significant intergenerational effects.
- The willingness to pay for the favorable effects of a project or policy depends on the distribution of income.
- In theory, gainers must compensate losers, but in practice, compensation is seldom paid. Even the most efficient projects create some losers, which can undermine support for BCA in general.

Standard Inputs for EUROCONTROL Cost Benefit Analysis, Edition Number 4.0, EUROCONTROL, Brussels, Belgium, Oct. 2009.

This document provides a set of standard values for commonly used data items in EUROCONTROL (European Organisation for the Safety of Air Navigation) cost-benefit analyses. The values have been assembled from a variety of sources and are expressed in euro at 2009 price levels. The values include passenger value of time derived from three different sources, including the 1998 edition of the Federal Aviation Administration Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs. However, the recommended values are derived from a November 2000 ITA report titled "Costs of Air Transport Delays in Europe", and are significantly higher than the values given from the FAA source.

Other values given in the publication include costs of air traffic delays and distance flown, costs of flight cancellation and diversion, values of avoided fatalities and injuries, and costs of air pollution and noise. The report also includes recommended values to use for a range of operational parameters and statistics, such as the distribution of passenger trip purpose, average flight duration, passenger load factors, rate of fuel burn and price of fuel, and aircraft fleet, traffic and delay statistics.

Sullivan, E., J. Dahlgren, G. Weisbrod, and K. Attaran, "Web-Based Guide to Transportation Benefit-Cost Analysis," *Journal of Transportation Engineering*, Vol. 134, Issue 7, Jul. 2008, pp. 282–286. [Online]. Available: http://cedb.asce.org/cgi/WWWdisplay.cgi?165157, http://www.dot.ca.gov/hq/tpp/offices/ote/benefit_cost/index.html and http://bca.transportationeconomics.org.

The paper describes the development of the web-based guide that can be found on the sites identified above. From the authors' abstract: "Originally begun as an ASCE committee activity, this comprehensive online guide to benefit-cost analysis (BCA) was completed under the sponsorship of the Office of Transportation Economics of the California Department of Transportation. The Web site helps users, step by step, through the process of determining if BCA is an appropriate approach to an investment decision for a particular transportation project and then, if so, of properly conducting the analysis. Although not intended as an instructional aid per se, the site provides elementary guidance on setting up and conducting a BCA, explaining concepts and the basics of appropriate methodologies. It also lets users drill down to detailed technical descriptions of methodologies, analysis tools, and illustrative case studies. The site was developed in order to encourage increased use and proper application of BCA in transportation investment decisions for which this approach is appropriate."

The online guide covers the following topics:

- How to define the problem that the project addresses and set up the analysis
- How to measure and value benefits and costs of transportation projects
- How to calculate benefit-cost measures
- How to interpret and present the results of benefit-cost analysis

- Sample benefit-cost models and links to model sites
- Case studies of benefit-cost analyses for transportation projects
- References

The guide provides guidance and suggestions on how to calculate the various benefits and costs attributable to transportation projects. In particular, it identifies and describes procedures for measuring the following benefits: travel time or delay reductions, accident reduction, emissions reductions, and vehicle operating cost reduction. It also recommends approaches for evaluating effects that are difficult to quantify but may still be considered in BCA: induced travel, noise effects, construction disbenefits, habitat and water quality impacts, economic effects, and community impacts. While the online BCA guide presents applications primarily to ground transportation projects, the methodologies can be adapted to aviation applications, given appropriate data.

This guide has been adopted by the TRB Transportation Economics Committee and is being revised in *Wiki* format.

Transport Canada, *Guide to Benefit-Cost Analysis in Transport Canada*, Transport Canada Report TP 11875E, Sept. 1994. [Online]. Available: http://www.tc.gc.ca/media/documents/corporate-services/bca.pdf.

The guide provides practical guidance to project analysts and managers in Transport Canada on how to evaluate the economic merits of alternative expenditure proposals using BCA. Focusing on transportation projects, the guide provides illustrative applications of BCA in Transport Canada. The guide is divided into three parts:

- Part I describes the BCA framework and approach to the analysis of options.
- Part II provides more specific advice on the estimation of the costs, benefits, and other effects for various options.
- Part III focuses on the analysis and presentation of results.

In the economic evaluation of transportation projects, benefits are primarily related to the efficiency of the transportation system (e.g., reduced travel time and reduced operating costs), safety of the system (e.g., costs of accidents avoided), and efficiency of government operations. Projects may have other unintended effects, which are typically negative (e.g., impact on the environment) and experienced by third parties. They may be either on-going or transitional (i.e. felt only during the implementation of the project). The guide describes the steps involved in the measurement of benefits and other effects.

There is an airport example in this guide.

Treasury Board of Canada Secretariat, *Canadian Cost-Benefit Analysis Guide*, 2007. [Online]. Available: http://www.tbs-sct.gc.ca/ri-qr/documents/gl-ld/analys/analys00-eng.asp.

In November 1999, the Government of Canada instituted the policy that a cost-benefit analysis must be carried out for all significant regulatory proposals to assess their potential impacts on the environment, workers, businesses, consumers, and other sectors of society. In April 2007, the Cabinet Directive on Streamlining Regulation replaced the 1999 Government of Canada Regulatory Policy. One of the key requirements of this new directive is that departments and agencies assess regulatory and non-regulatory options to maximize net benefits to society as a whole. This guide provides guidance to departments and agencies on how to conduct a sound cost-benefit analysis to support regulatory decisions. The guide incorporates the evolution of regulatory policy and developments in the analysis of the impacts of regulations in Canada and elsewhere over the past decade. Such an analysis highlights the importance of identifying and measuring the economic benefits and costs as an essential input into the design process of such regulatory actions.

A guide was first published in 1995. The 1995 guide required updating to reflect the changes in the economy, new regulatory policies, and advances in analytical methods. This guide outlines the analytical methodologies, empirical techniques, and practical approaches to performing analyses of regulatory policies. Efficiency is not the sole criterion for decision making of a regulatory policy. The stakeholder analysis of who gains or loses as a result of a regulation can be critical to decision making and is, therefore, included as part of the overall impact analysis in this guide.

U. S. Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans, *Economic Analysis of Investment and Regulatory Decisions – Revised Guide*, FAA-APO-98-4, Washington, D.C., Jan., 1998.

The document provides basic guidance for conducting economic analysis of investments, including certain Airport Improvement Program (AIP) grants and regulations subject to FAA decision making. It is the third edition of material originally issued in 1976 and revised in 1982. The guidebook is organized as follows:

- Chapter 1 discusses the purpose of economic analysis and the types of economic questions it addresses.
- Chapter 2 provides an overview of economic analysis and the procedures required to evaluate investments and regulations.
- Chapters 3 and 4 provide the conceptual framework for measuring and valuing benefits and costs, and provide practical guidance for estimating benefits and costs in situations which are typical of FAA investments, regulations and grant programs.
- Chapter 5 discusses the multi-period economic decision criteria and the discounting process.

- Chapter 6 deals with variability in benefit-cost estimates due to risk and uncertainty.
- Chapter 7 describes techniques for measuring price level changes and treatment of inflation in benefit-cost analysis.
- Chapter 8 addresses analysis of distributional issues.

The document presents techniques for measuring the following benefit (or cost) categories:

- Safety – defined in terms of the risk of death, personal injury, and property damage resulting from air transportation accidents.
- Capacity increases which reduce congestion related delay – defined in terms of reduction in aircraft delays, which translate into passenger travel time savings and airline operating costs savings.
- Avoided flight disruptions – also defined in terms of reduction in aircraft delays.
- Cost savings – defined in terms of reduction in actual dollar outlays or dollar savings from efficiency gains.
- Other – noise reduction, missed approach benefit, avoided accident investigation costs, regulatory changes in capacity at access capped airports, and construction of a new airport where none currently exists.

U. S. Department of Transportation, Federal Aviation Administration, Policy and Final Guidance Regarding Benefit Cost Analysis on Airport Capacity Projects for FAA Decisions on Airport Improvement Program (AIP) Discretionary Grants and Letters of Intent (LOI), Washington, D.C., Dec. 15, 1999.

This policy requires all airport sponsors to submit BCAs when requesting AIP discretionary grants in excess of $5 million or an LOI to be awarded for capacity projects. For the purpose of this BCA policy, airport capacity projects are those projects that (1) preserve an infrastructure, (2) improve upon an existing infrastructure, or (3) create new infrastructure. Typically, the FAA will not award the discretionary grant or the LOI unless the airport sponsor shows that the project has total discounted benefits that exceed total discounted costs. The BCA policy does not apply to those projects undertaken solely for the objectives of safety, security, conformance with FAA standards, or environmental mitigation.

U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans, *FAA Airport Benefit-Cost Analysis Guidance*, Washington, D.C., Dec. 15, 1999. [Online]. Available: http://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/faabca.pdf.

This document provides guidance to airport sponsors on the conduct of project-level BCA for capacity-related airport projects. It describes the purpose of a BCA and the steps involved in the BCA process. The FAA requires BCA on airport capacity projects for which airport sponsors are seeking AIP discretionary grants of $5 million or more and LOI funding in any amount over the life of the project.

The guidance outlines the following steps in the BCA process:

- Define project objectives
- Specify assumptions
- Identify base case
- Identify and screen reasonable investment alternatives
- Determine appropriate evaluation period
- Establish reasonable level of effort
- Identify, quantify, and evaluate benefits and costs
- Measure impact of alternatives on airport usage (i.e. induced demand)
- Compare benefits and costs of alternatives
- Perform sensitivity analysis
- Make recommendations

While the document is intended to guide BCA for capacity-related airport projects, it addresses the measurement of various categories of benefits (or costs) relevant to a broad range of airport capital investment projects, for example: decrease (increase) in airside delay; improved (diminished) schedule predictability; more (or less) efficient traffic flows; use of faster, larger and/or more efficient aircraft; and compliance with FAA safety, security and design standards.

The guidance recommends the use of economic values established in GRA, Incorporated, Economic *Values for FAA Investment and Regulatory Decisions, A Guide*, Final Report, U.S. Federal Aviation Administration Office of Aviation Policy and Plans, Oct. 3, 2007.

U. S. Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans, *Best Practices Guide: Incorporation of Benefit Cost Analysis (BCA) Procedures into the Airport Planning Process*, Washington, D.C., Draft Oct. 15, 2003.

This document presents a practical "how to" guide for the preparation of BCAs. It is intended to assist FAA airport staff in offering guidance to sponsors on developing BCAs and in reviewing draft BCAs submitted by sponsors. The guidance provides clarification of the BCA process and presents BCA case examples.

U. S. Department of Transportation, Federal Aviation Administration, Investment Analysis and Operations Research, *The Art of Aviation Safety Benefits Analysis,* Jun. 2001.

This report was written to give the less experienced analyst knowledge of, and a feeling for, conducting a real-world safety benefit analysis. In addition to describing a step-by-step approach for conducting a safety benefit analysis, it identifies a number of cautions learned through experience. Also included are a list of "Rules of Conduct" that should be observed in undertaking a predictive safety benefit analysis, and a descriptive "Benefits Universe" to assist the analyst in identifying the potential safety benefit categories of a proposed aviation project. The report also includes an extensive table of data sources and an example illustrating the potential danger in estimating benefits using aggregated data from dissimilar groups (Simpson's Paradox).

U. S. Department of Transportation, Federal Aviation Administration, Investment Analysis and Operations Research, *Investment Analysis Benefit Guidelines: Quantifying Flight Efficiency Benefits*, Version 3.0, Jun. 2001.

This report presents guidelines for quantifying flight efficiency benefits while conducting investment analysis and/or re-baselining acquisitions. These guidelines present a structured methodology for measuring the impact of flight times from expected enhanced capabilities of planned NAS acquisitions. A six-step process is described that walks the analyst through the process of ultimately converting the change in flight times to dollars saved. An illustration of how to baseline and project airborne and block times for three sample cases are presented.

U. S. Environmental Protection Agency, Office of Air Quality, Planning and Standards, "Innovative Strategies and Economics Group," *OAQPS Economic Analysis Resource Document*, 1999.

This document provides a comprehensive guide to the development and presentation of economic assessments for environmental regulations. Three levels of assessment are discussed (in ascending order of complexity and detail): preliminary screening assessment, economic impact assessment, and economic analysis. The required report sections for each type of analysis are provided and discussed. For the most involved of these analyses, the components include:

- Executive summary
- Introduction
- Industry profile
- Need for regulation
- Compliance cost analysis
- Economic impact analysis
- Impacts analysis

- Benefits analysis
- Benefit-cost comparison

The document provides a description of each of these sections, the items that should be included, potential data sources, various methods of analysis, and the like.

Chapter 7 describes the framework for quantitative analysis of the following categories of damages similar to those caused by pollutant emissions from aircraft and vehicles operating at airports:

- Direct damages to humans, including health damages and aesthetic damage.
- Indirect damages to humans through ecosystems, including productivity damages, recreation damages, and intrinsic or nonuse damages.
- Indirect damages to humans through nonliving systems, including damages to materials and structures.

The document describes approaches for quantifying and monetizing the above categories of damages.

Ward, S., R. Massey, A. Feldpaushch, Z. Puchacz, C. Duerksen, E. Heller, N. Miller, R. Gardner, G. Gosling, S. Sarmiento, and R. Lee, *ACRP Report 27: Enhancing Airport Land Use Compatibility*, Transportation Research Board of the National Academies, Washington, D.C., 2010.

This report presents a comprehensive account of issues associated with land uses around airports. Chapter 5: Economic Costs of Airport Land Use Incompatibility in Volume 1 of the report and the working paper on Developing a Framework for the Economic Assessment of the Costs of Airport Land Use Incompatibility in Volume 3 provide a discussion of economic valuation and benefit-cost analysis techniques, as well as economic impact assessment and fiscal impact assessment.

Zerbe, R. and A. Bellas, *A Primer for Benefit-Cost Analysis*, Edward Elgar, Northampton, MA, 2007.

This book provides guidance for conducting proper BCA of public projects. Its discussion of concepts and techniques is not exhaustive, but rather a summary of the important features of BCA. Like other BCA textbooks, it describes what BCA is, the steps involved, the assignment of monetary values, accounting for the timing of costs and benefits, and the performance of sensitivity analysis to consider risk and uncertainty.

Other Methods for Evaluating Airport Capital Investment Decisions

Bierman, H. and S. Smidt, *The Capital Budgeting Decision, Economic Analysis of Investment Projects*, Ninth Edition, Routledge, New York, N.Y., 2006.

This textbook is a guide to capital investment decision making from a corporate perspective. It covers basic topics such as the time value of money and traditional solutions to capital budgeting, as well as more advanced topics in capital investment decision making.

Butler, S. and L. Kiernan, *Estimating the Regional Economic Significance of Airports*, Federal Aviation Administration, Washington, D.C., Sept. 1992.

This document is a revision of the 1986 report, Measuring the Regional Economic Significance of Airports, Report No. DOT/FAA/PP/87-1, which was prepared in response to requests from the airport community for FAA guidelines for estimating measures of the importance of individual airports to their surrounding communities. The original and revised documents provide guidelines primarily for airport managers and planners, particularly of small- and medium-sized public use airports, who are constrained by time and budget to conduct an economic impact study in-house. The document distinguishes between transportation benefit and economic impact, and provides data and describes the steps for arriving at rules-of-thumb estimates. The document outlines procedures for estimating the following measures for each type of benefit:

- Transportation benefit – time saved and cost avoided by travelers
- Economic impact – regional economic activity (output), employment and payroll

Copeland, T. and J. Weston, *Financial Theory and Corporate Policy*, Fourth Edition, Addison Wesley, Reading, 2004.

This textbook in the theory of finance distinguishes itself from others by bridging theory and practice. Modern finance theory originated from a branch of applied microeconomics, and so the concepts, analytical techniques, and investment decision criteria discussed in this book can be applied in both the financial analysis and economic analysis of airport capital investment decisions. In particular, Chapter 2, Investment Decisions: The Certainty Case discusses the theoretical framework of optimal investment decision making and the standard techniques for capital budgeting (i.e. the payback method, the accounting rate of return, net present value, and internal rate of return). The textbook also covers more advanced topics and applications of capital budgeting.

Economic Development Research Group, Inc., *TREDIS® Technical Document: Benefit-Cost Module, Version 3.6.3,* 2 Oliver Street, 9th Floor, Boston, MA, 2010.

TREDIS (Transportation Economic Development Impact System) is a transportation modeling system used for assessing economic impacts, benefits and costs of transportation projects. TREDIS covers all modes of passenger and freight travel, including passenger aviation and air cargo transport. The system represents benefits not only for projects affecting passenger travel time and travel cost, but also for projects affecting airport market access, freight flow patterns, schedule reliability, logistics efficiencies, cargo delivery markets, seasonal or daily congestion periods, and changes in ground access to intermodal transportation ports and terminals. The documentation shows how impacts are calculated for costs savings, productivity and creation of income, jobs and business growth. It then provides a broad set of benefit/ cost measures based on travel efficiency, user benefit, wider economic productivity and net income impacts. Results are broken down by class of impact or benefit, by spatial scale of impact and by affected sector of the economy. Additional detail is provided in a companion article: "A Generalized Approach for Assessing the Direct User Impacts of Multi-Modal Transportation Projects," Transportation Research Record #2079, January 2008.

Karlsson, J., J.R. Ludders, D. Wilde, D. Mochrie, and C. Seymour, *ACRP Synthesis 7: Airport Economic Impact Methods and Models*, Transportation Research Board of the National Academies, Washington, D.C., 2008.

This synthesis documents how airport economic impact studies are currently conducted. It focuses on methods and models used to define and identify, evaluate and measure, and communicate the different facets of the economic impact of airports. The report discusses the various analysis methods, models and tools that are available for local airport economic studies, as well as applicability and trade-offs, limitations, trends, and recent developments. Appendix C of the synthesis provides an annotated literature review of selected completed airport economic impact studies.

Minnesota IMPLAN Group, Inc., *Reference Manual (User's Guide to IMPLAN Version 3.0 Software)*, 1725 Tower Drive West, Suite 140, Stillwater, MN, 2010.

Minnesota IMPLAN Group, Inc. (MIG, Inc.) is the developer of the IMPLAN economic impact modeling system, which is widely used in airport economic impact analysis. The reference manual is an online series of documents to provide up-to-date information on the Version 3.0 software system. It covers all the features of the software and provides precise information on software functions. IMPLAN is useful for estimating job and income impacts of airport investments, but the modeling package is static, so it does not estimate productivity changes from new investments. See http://implan.com/support/knowledgebase.

Nijkamp, P., "Meta-analysis: a methodology for research synthesis," *Research Memorandum*. Universiteit Amsterdam, 2004.

This article explains the benefits of meta-analysis as a method to synthesize results of many previous studies in a comprehensive and systematic way. Meta-analysis is a useful technique to generalize many disparate research findings and combine the results into a more concise form. This technique may be preferable to a more standard literature review. Specific research areas where meta-analysis may be particularly useful are regional economics, transportation, and environmental economics. Several issues must be recognized prior to performing a reasonable meta-analysis. Each study reviewed must evaluate the same issue, outcome measure, population characteristics, and analytical objective. Meta-analysis possibilities are described for nominal, categorical, ordinal, interval, and fuzzy cases.

Regional Economic Models, Inc., *Introduction to PI+: The Next Generation of Policy Insight,* 433 West Street, Amherst, MA, 2010.

The REMI Policy Insight model (PI+) is an economic modeling tool that is used in airport economic impact analysis. PI^+ is used to model economic impacts and simulations policy annual effects of policies, investment and economic changes. PI+ provides estimations of industry cost-response to new investments to estimate changes in productivity. PDF copies of documentation and users guides are available at http://www.remi.com/uploads/File/Documentation/

U. S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, *Regional Multipliers, A User Handbook for the Regional Input-Output Modeling System (RIMS II)*, Third Edition, U.S. Government Printing Office, Washington, D.C., 1997.

This handbook provides guidance on the use of regional multipliers from the Bureau of Economic Analysis' Regional Input-Output Modeling System (RIMS II) for economic impact analysis. RIMS II multipliers are widely used in airport economic impact analysis. The handbook explains the different types of RIMS II multipliers for output, earnings and employment, how they are used, and the type of data input they require. RIMS 2 is useful for estimating job and income impacts of airport investments, but the modeling package is static and does not measure productivity changes due to investments.

U. S. Department of Transportation, Federal Aviation Administration, Investment Planning and Analysis, *Acquisition Management Policy*, Revised Jul. 2010. [Online]. Available: http://fast.faa.gov/index.html.

The Acquisition Management System (AMS) establishes policy and guidance for all aspects of lifecycle acquisition management for the Federal Aviation Administration (FAA). It defines how the FAA manages its resources - money / people / assets - to fulfill its mission. Acquisition management policy applies to all FAA organizations, all appropriations, and all investment programs. This includes all capital investments in the National Airspace System and FAA administrative and mission support systems. The policy does not apply to the Airport Improvement Program, which provides grants to state and local entities as authorized under Title 49, United States Code, Chapter 471. The FAA website (http://fast.faa.gov/index.html) provides guidance on investment analysis.

Miscellaneous Transportation BCA Applications

Cook, A., G. Tanner, and S. Anderson, Evaluating *the True Cost to Airlines of One Minute of Airborne or Ground Delay*, Final Report, Edition 4, Prepared for the Performance Review Unit, EUROCONTROL, Transport Studies Group, University of Westminster, London, England, Feb. 2004.

This report documents the findings of a study that evaluates the full cost of airlines of each minute of airborne or ground delay. The study examines the various components of the costs incurred by airlines when aircraft are delayed, including fuel burn, maintenance costs, flight and cabin crew salaries and expenses, handling agent penalties, airport charges and the costs of passenger delay to airlines. The costs of passenger delay do not include the value of the passenger time, but rather those costs incurred by airlines such as rebooking costs, hotel and meal expenses, and additional baggage handling, as well as consideration of potential loss of future business. The study distinguishes between tactical and strategic costs, where tactical costs are defined as those costs that are incurred when aircraft encounter delays on the day of operations. The study considers both the costs incurrent by an aircraft due to delays incurred on a given flight leg (termed gate-to-gate costs), as well as costs of so-called "knock-on" delays downstream to both that aircraft and other flights, termed network reactionary delays. Strategic costs are those that are incurred when the operating schedule is being planned and arise from buffers that are allowed in the schedule in anticipation of some level of delay. These strategic costs include both opportunity costs and sunk costs that arise from provision in the schedule for delays that do not occur.

DJM Consulting and ECONorthwest, *Benefit-Cost Analysis of the Proposed Monorail Green Line*, Prepared for the Elevated Transportation Company, Revised Aug. 28, 2002. [Online]. Available:
http://courses.umass.edu/pubp606/Of%20interest/BCA_Report_Final_revised.pdf.

The study presents a benefit-cost analysis of the proposed "Green Line" of the Seattle Monorail Project to evaluate whether the returns on the project are sufficient to justify the investment compared to the rates of return on capital in the private economy. All the relevant costs and benefits are identified and quantified to the extent feasible. Quantifiable benefits include value of travel-time savings, parking savings, reduced auto operating/ownership costs, reliability, road capacity for drivers, and reduction in bus-related accidents. Some of these benefits may also be relevant to airport capital investments.

Economic Development Research Group, Inc. and Parametrix, *Economic Comparison of the Alternatives for Tolling Projects*, White Paper, Prepared for Oregon Department of Transportation, Feb. 2009.

This is an application of BCA to the evaluation of tolling alternatives. The paper quantifies user benefits such as value of time saved, lower costs due to increased

safety, and lower vehicle operating costs – benefits that are also relevant airport capital investment projects.

Hogarty, T. Saving Time, Saving Money: The Economics of Unclogging America's Worst Bottlenecks, American Highway Users Alliance, 2000.

Traffic congestion is a worsening problem in many U.S. cities. This study assigns monetary values to the following benefits of improving traffic flow through the 166 worst bottlenecks in the country:

- Save lives and avert injuries by reducing accidents
- Save the environment by reducing greenhouse gases and air pollution
- Save time
- Save fuel

The above benefits also apply to airport capital investment projects.

Landau, S. and G. Weisbrod, *ACRP Synthesis 13: Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis*, Transportation Research Board of the National Academies, Washington, D.C., 2009.

The synthesis provides a summary of 24 completed airport BCA reports submitted to the FAA to support federal grant requests under the Airport Improvement Program.

U. S. Department of Transportation, Federal Aviation Administration, Investment Analysis and Operations Research, *Investment Analysis Report: Airport Surface Movement Enhancement and Runway Incursion Prevention Phase 1 – ASDE-X*, Aug. 15, 2000.

The report presents a detailed economic analysis of the ASDE-X system to determine the number of ASDE-X to acquire, based on costs and calculated monetary benefits. In conducting the economic analysis, the following were developed:

- Forecast of potential accidents at each towered United States airport.
- Rough-order-of-magnitude (ROM) estimate of monetary safety benefits for each airport.
- Detailed life-cycle cost estimate of the ASDE-X system (2003-2026).
- Estimate of monetary benefits versus costs.

The analysis built, as its foundation, a projection of the total number of fatalities (approximately 900) over the 20-year period (2003-2022) that could be attributed to future runway incursion accidents on a National Airspace System (NAS) aggregate basis, as opposed to a per airport basis, if nothing further were done to improve safety on the airport surface.

U. S. Department of Transportation, Federal Aviation Administration, Investment Analysis and Operations Research, *Investment Analysis Report: Next Generation Air/ground Communications System*, Sept. 1998.

The report presents a detailed technical and economic evaluation of alternative architectures for the Next Generation Air/Ground Communication (NEXCOM) program. Economic analysis involves the assessment of user benefits in terms of reduced aircraft delays and safety benefits in terms of the reduction of accidents and incidents.

Value of Time

Value of Travel Time

Cirillo, C., and K. W. Axhausen, "Evidence on the distribution of values of travel time savings from a six-week diary," *Transportation Research Part A*, 40, 2006, pp. 444–457.

The authors estimate mixed logit models that capture the variation across travelers in value of time. They use revealed preference (RP) data from a survey instrument known as Mobidrive, from Karlsruhe and Halle in Germany.

De Borger, B. and M. Fosgerau, "The trade-off between money and travel time: A test of the theory of reference-dependent preferences," *Journal of Urban Economics*, 64, 2008, pp. 101–115.

The authors show that in stated preference (SP) data, people display a loss aversion compared to their base situation, i.e. they value time losses more than time gains.

de Jong, G., M. Kouwenhoven, E. Kroes, P. Rietveld, and P. Warffemius, "Preliminary monetary values for the reliability of travel times in freight transport," *EJTIR*, 92, Jun. 2009, pp. 83–99.

The authors measure the "reliability ratio" – defined as VOR/VOT, where VOR is the value per hour of the standard deviation of travel time, and VOT is the value per hour of average travel time – from Dutch stated preference studies. From the conclusion: "For freight transport by road, without further information, we recommend to use an RR [reliability ratio] of 1.24." The authors stress this is preliminary.

Economic Development Research Group, Inc., "Appendix A-6, Value of Time" in Cambridge Systematics, Inc., Economic Development Research Group, Inc. and ICF Consulting, *Montana Highway Reconfiguration Study*. Montana Department of Transportation, 2005.

Appendix A-6 discusses how different perspectives can be important for value of time because short-term choices of travel route (as observed in toll studies) are usually made by the vehicle driver, and tend to focus mainly on the trade-off between marginal out-of-pocket (toll) cost and marginal difference in travel time. Choices of vehicle type are made by the owner, and tend to focus on average operating costs with a broader definition that also includes fuel and maintenance costs, as well as full wage and overhead costs for vehicle operators. The longer-term choices of transportation service provider include further considerations of reliability and market pricing of the delivery services provided, and that pricing may be determined more by market supply and demand conditions than by operating costs. Finally, the productivity benefit of an on-time arrival for a traveler or freight delivery can be quite different from the market price that is charged for the transportation service. These observations are valid for differentiating between general aviation aircraft owners and commercial passengers, as well as between users of short-distance and long-distance flights.

Fosgerau, M., "The marginal social cost of headway for a scheduled service," *Transportation Research Part B*, 43, 2009, pp. 813–820.

This study is a theoretical investigation of the importance of using a timetable in determining how reliability is valued.

Fosgerau, M., and L. Engelson, "The Value of Travel Time Variance," *Transportation Research, Part B: Methodological*, in press, 2010, DOI:10.1016/j.trb.2010.06.001.

This paper presents a theoretical framework for analyzing the value of travel time variability for a particular formulation of scheduling preferences. While the approach can be applied to any scheduled service, including scheduled air travel, it relies on assumed scheduling preferences of the traveler in which the marginal value of time spent at the origin of the trip changes linearly (in general, decreases) with the departure time, while the marginal value of time spent at the destination changes linearly (in general, increases) with the arrival time. It is also assumed that the rate of change of the marginal value of time spent at the destination is greater than the corresponding rate of change of the marginal value of time spent at the origin, since otherwise the travelers would have no incentive to make the trips. The paper develops a simple expression for the value of travel time variability that does not depend on the shape of the travel time distribution and that can be applied to travelers who can freely choose their departure time, as well as those who use a scheduled service with fixed headways.

The assumptions underlying the basis for the traveler scheduling preferences are quite restrictive and appear rather questionable for air travel. In the case of air travel, it seems quite unlikely that the marginal value of time at the trip destination would change linearly over time with increasing delays, much less that it would increase. The analysis presented in the paper does not include any time-of-day effects on the marginal value of time at either the origin or the destination, which are likely to be significant in the case of air travel.

Gonzales, R. M., “The value of time: a theoretical review,” *Transport Reviews*, Vol. 17, No. 3, 1997, pp. 245–266.

This paper provides a compact review of many models that underlie empirical specifications of studies of value of time.

Gwilliam K., “The Value of Time in Economic Evaluation of Transport Projects: Lessons from Recent Research,” *The World Bank Infrastructure Notes*, World Bank, Washington, D.C., Jan. 1997.

This note reviews research on the valuation of time and suggests an appropriate approach where standard values are not available from government sources. It provides a useful summary of the conceptual basis of time valuation and main research conclusions.

The conceptual model underlying the valuation of travel-time savings is one of consumer welfare maximization. Each individual maximizes the satisfaction or utility he/she gets by consuming and engaging in leisure activities subject to income and time constraints. The value of time can be estimated in two ways: revealed preference (RP) analysis and stated preference (SP) analysis. RP analysis estimates values of time that best explain actual observed choice behavior. SP analysis presents respondents with hypothetical alternatives to choose from and is designed to give numerous credible trade-off possibilities.

Research has shown that the value of travel-time savings varies with respect to the following factors:

- Income
- Categories of journey
- Journey length, small time savings, gains, and losses
- Walking and waiting time
- Time trends
- Transportation modes
- Regional disparities
- Others

Miller, T., *The Value of Time and the Benefit of Time Saving*, National Public Services Research Institute, May 1996.

This paper updates Miller’s 1989 survey that provides time values for use in the Federal Highway Administration – Highway Economic Requirements System (FHWA HERS) model. In his 1989 paper, Miller recommends a value of 60 percent of the wage for auto drivers and 45 percent for auto and transit passengers on personal travel. After reviewing new research in this 1996 update, Miller recommends a downward adjustment to 55 percent for auto drivers and 40 percent for auto and

transit passengers. Miller's findings and recommendations serve as the sources of values for local travel in U.S. Department of Transportation Guidance for the Valuation of Travel Time in Economic Analysis (1997).

Small, K. and E. Verhoef, *The Economics of Urban Transportation*, Routledge, London and New York, 2007.

This book contains a long chapter on travel demand estimation methods, including Section 2.6, "Value of time and reliability", which reviews both theory and empirical measurement of these two values.

The authors describe several theories of time allocation that explain how the value of travel time depends on factors such as wage rate, enjoyment of work, and enjoyment of travel itself. Using these theories, they formulate empirical specifications of travel demand models, in which the value of time in a specific travel activity varies systematically with wage or income. They then review and interpret the results of some empirical studies that measure value of time.

The World Bank, "Valuation of Time Savings," *Notes on the Economic Evaluation of Transport Projects*, Transport Note No. TRN-15, Jan. 2005.

This paper discusses the conceptual basis for valuing time (work and non-work) and the value of time savings to buses and freight. It describes the manner by which the value of time varies with time and between regions, and addresses the treatment of small time savings and the use of standard values of time. It also provides a summary of practical methodologies for estimating the value of travel time savings.

U. S. Department of Transportation, "Revised Departmental Guidance – Valuation of Travel Time in Economic Analysis," *Memorandum*, Feb. 11, 2003.

This guidance publishes revisions to tables presented in the April 9, 1997 Department of Transportation memorandum, "Departmental Guidance for the Valuation of Travel Time in Economic Analysis," to consider more recent information available from several sources used to specify hourly incomes. For air travel, the guidance recommends the following hourly values of travel time by trip purpose in 2000 U.S. dollars per person-hour: personal, $23.30; business, $40.10; and all purposes, $28.60. The guidance also recommends ranges for hourly values of travel time to be used for sensitivity analysis.

U. S. Department of Transportation, "Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis," *Memorandum*, July 9, 2014.

This guidance publishes revisions to tables presented in the 2003 Department of Transportation memorandum, cited above, to consider more recent information on reliability by mode and technology changes, as well as income. This memorandum includes guidance for travelers using both air and surface modes in 2012 U.S. dollars, and equates the value of travel time savings for air and high-speed rail passengers. For air/high speed rail, the guidance recommends the following hourly values of

travel time by trip purpose per person-hour: personal, $32.60; business, $60.00; and all purposes, $43.70. The guidance also recommends ranges for hourly values of travel time to be used for sensitivity analysis. Note that the passenger value of transportation time savings for air passengers is estimated to exceed inflation. Applying the national consumer price index (U.S. Bureau of Labor Statistics) to the values contained in the 2003 memorandum over years 2000 – 2012, show values of $31.10 for personal travelers, $53.50 for business travelers and $38.10 for all travelers. These inflation-adjusted 2000 values are lower than the values in the 2014 memorandum, but fall within the ranges established in the most recent guidance ($28.00-41.90 for personal travelers, $48.00 - $72.00 for business travelers, and $36.10 - $54.10 for all travelers).

Value of Travel Time Reliability

Bates, J., J. Polak, P. Jones, and A. Cook, "The valuation of reliability for personal travel," *Transportation Research Part E: Logistic and Transportation Review*, Vol. 37, No. 2–3, 2001, pp. 191–229.

The authors provide a comprehensive review of the theory of travelers' valuation of travel time reliability and how to apply the theory in empirical research, including data collection, exemplified with stated preference study of rail travel.

Economic Development Research Group, Inc. and Parametrix, *Economic Evaluation of Improved Reliability*, White Paper, Prepared for Oregon Department of Transportation, Feb. 2009.

This paper examines ways to measure reliability; reviews the ways reliability can be included in an economic analysis of pricing and tolling policy; and discusses some practical implications.

Fowkes, A. S., P. E. Firmin, G. Tweddle, and A. E. Whiteing, "How highly does the freight transport industry value journey time reliability – and for what reasons?", *International Journal of Logistics: Research and Applications*, Vol. 7, No. 1, Mar. 2004, pp. 33–43.

The authors present empirical results based on a UK study. From the abstract: "The paper summarizes the findings of the study, which centered on an interview survey of forty shippers, haulers and third party logistics operators."

Lam, T. and K. Small, "The Value of Time and Reliability: Measurement from a Value Pricing Experiment," *Transportation Research E*, Vol. 37, 2001, pp. 231–251.

This is an empirical study of choice of priced versus free lanes on the Riverside Freeway (SR91) in southern California. The authors empirically measure values of both time and reliability from revealed preference data, mostly from commuters. The best model produced average value of time of $22.87 per hour (72% of average wage rate in the sample), and average value of reliability (measured as standard deviation of travel time across weekdays) of $15.12 per hour for men and $31.91 per hour for women (48% and 101% of average wage rate, respectively).

Small, K., C. Winston, and J. Yan, "Uncovering the Distribution of Motorists' Preferences for Travel Time and Reliability," *Econometrica*, Vol. 73, 2005, pp. 1367–1382.

The authors estimate simultaneously values of time and of reliability on SR-91 in Orange County, California, as well as their variation across the population. Reliability is measured as the difference between the 90^{th} percentile and the 50^{th} percentile (i.e. median) travel time across days. The estimation method combines data from RP and SP surveys, including some observations from people who answered both RP and SP questions. The choice of whether or not to invest in a transponder and the associated account for payment is also modeled as part of the system.

The authors find fairly high values from the RP part of the data: median value of time $21.46 per hour with inter-quartile range across the sample of $10.47 per hour; and median value of reliability $19.56 with inter-quartile range of $26.49. Values from the SP part of the data are about half as large.

Brownstone, D., and K. Small, "Valuing Time and Reliability: Assessing the Evidence from Road Pricing Demonstrations," *Transportation Research Part A*, Vol. 39, 2005, pp. 279–293.

The authors review several studies (by same authors with various collaborators) of choice of priced versus free lanes on the Riverside Freeway (SR91) in the Los Angeles region and on Interstate 15 in the San Diego region. These studies, which include Small, Winston, and Yan (2005), empirically measure values of both time and reliability and their variation across individuals, using both revealed preference (RP) data and stated preference (SP) data. The authors reconcile the values obtained on the two different study sections, and also compare the values obtained from RP versus those from SP data, finding the latter to be only about half as large. They suggest this is likely due to misperception of travel time by SP respondents, citing as evidence the systematic over-valuation of the actual time savings that these survey respondents achieve by taking the faster (express) lanes compared to engineering measurements of those same time savings.

Hollander, Y., "Direct versus indirect models for the effects of unreliability," *Transportation Research Part A*, Vol. 40, 2006, pp. 699–711.

The author finds that using a direct measure of unreliability, such as standard deviation of travel time, is inferior to explicitly considering the scheduling costs that lie behind travelers' aversion to unreliable travel times. The analysis is based on a survey of bus users in York, England.

Koster, P., E. Verhoef, and E. Kroes, "Valuing the costs of travel time unreliability," Presented at the Third Kuhmo Nectar Conference on Transportation and Urban Economics, Urbino, Italy, 2007.

The authors show how to calculate the expected cost of a trip when travelers want to arrive at a particular time and have per-minute scheduling cost for being early or late, under several assumed statistical distributions for the uncertain travel time.

Koster, P., E. Verhoef, and E. Kroes, “Travel Time Variability and Airport Accessibility,” Tinbergen Institute Discussion Paper No. TI 2010-061/3, Amsterdam, The Netherlands, June 2010.

> Authors’ abstract: “This paper analyses the cost of access travel time variability for air travelers. Reliable access to airports is important since it is likely that the cost of missing a flight is high. First, the determinants of the preferred arrival times at airports are analyzed, including trip purpose, type of airport, flight characteristics, travel experience, type of check-in, need to check-in luggage. Second, the willingness to pay (WTP) for reduction in access travel time, early and late arrival time at the airport, and the probability to miss a flight is estimated using a stated choice experiment. The results indicate that the WTPs are relatively high, which is partially due to the low cost sensitivity of air travelers. Third, a model is developed to calculate the cost of variable travel times for air travelers going by car, taking into account travel time cost, scheduling cost and the cost of missing a flight. In this model, the value of reliability for air travelers is derived taking 'anticipating departure time choice' into account. Results of the numerical exercise show that the cost of access travel time variability for business travelers are between 3-36% of total access travel cost, and for non-business travelers between 3-30%. These numbers depend strongly on the time of the day.”

Li, Z., D. Hensher, and J. Rose, “Willingness to pay for travel time reliability in passenger transport: A review and some new empirical evidence,” *Transportation Research Part E*, Vol. 46, No. 3, 2010.

> This paper reviews the modeling and estimation approaches used in the literature to obtain willingness to pay (WTP) for improved travel time reliability, suggesting new directions for ongoing research. The authors also estimate models to derive values of reliability, scheduling costs and reliability ratios in the context of Australian toll roads and use the new evidence to highlight the important influence of the way that trip time variability is included in stated preference studies in deriving WTP estimates of reliability in absolute terms, and relative to the value of travel time savings.

Value of Statistical Life

Alberini, A., M. Cropper, A. Krupnick, and N. Simon, “Does the value of a statistical life vary with age and health status? Evidence from the US and Canada,” *Journal of Environmental Economics and Management*, Vol. 48, 2004, pp. 769–792.

> The authors use two contingent valuation studies (a form of stated preference study) from a Hamilton, Ontario sample and from a U.S. national sample. From the abstract: “… we find weak support for the notion that WTP [willingness to pay] declines with age, and then, only for the oldest respondents (aged 70 or above). Furthermore, we find no support for the idea that people with chronic heart of lung

conditions, or cancer, are willing to pay less to reduce their risk of dying…. If anything, people with these illnesses are willing to pay more."

Aldy, J. and W.K. Viscusi, "Age Differences in the Value of Statistical Life: Revealed Preference Evidence," *Review of Environmental Economics and Policy*, Vol. 1, No. 2, Summer 2007, pp. 241–260.

This literature review discusses the need to use age adjustments in analyses using the value of statistical life (VSL). The authors conclude that the basic pattern of VSL is for values to peak in middle age, with lower values found both for younger workers and older workers. Therefore, in analyses where large amounts of benefits accrue for those in older or younger age groups, values may be overstated if discounts are not made. The article cautions against using a single value for all residents.

Aldy, J. and W.K. Viscusi, "Adjusting the Value of a Statistical Life for Age and Cohort Effects," *The Review of Economics and Statistics*, Vol. 90, No. 3, 2008.

Conventional wisdom suggests that VSL declines with age. This article uses a novel, age-dependent fatal risk measure to estimate age-specific hedonic wage regressions. VSL exhibits an inverted-U-shaped relationship with age. In the year 2000 cross section, workers' VSL rises from $3.7 million (ages 18-24) to $9.7 million (35-44), and declines to $3.4 million (55-62). Controlling for birth-year cohort effects in a minimum distance estimator yields a peak VSL of $7.8 million at age 46, and flattens the age-VSL relationship. The value of statistical life-year also follows an inverted-U shape with age.

Ashenfelter, O., "Measuring the Statistical Value of Life: Problems and Prospects," *Economic Journal*, Vol. 116, No. 510, 2006, pages C10-C-23.

Ashenfelter provides an overview of the concept of VSL and its uses in analyses. The idea of VSL relates to the willingness to pay for a decreased risk of fatality, or the requirement for higher wages of an increased risk of fatality. Rather than measuring the value of any specific life, the VSL measures the costs for changes in the probability of death. The use of VSL is common in many types of benefit-cost analysis (BCA), including those of traffic safety decisions, environmental regulations, and medical interventions and technology. Since decisions relating to public policy are supposed to represent the population, it is useful to use the average or median preferences and VSL values for analyses. This is problematic, however, because it is unclear as to whether studies reporting VSL actually represent the appropriate values.

Bellavance, F., G. Dionne, and M. Leabeau, "The Value of a Statistical Life: A Meta-Analysis with a Mixed Effects Regression Model," Canada *Journal of Health Economics*, Vol. 28, No. 2, Mar. 2009, pp. 444–464.

This study presents a meta-analysis of approximately 40 studies to determine the major causes of variability in the estimates of VSL that exist in the literature. The article discusses a number of methodological concerns both for calculating VSL, as well as for meta-analysis. The authors suggest that their analysis is the first to use a mixed effects regression model.

The study concludes that due to the differences in findings among studies carried out in different contexts, different locations, and with different populations, that any benefit-cost analysis (BCA) should be based upon VSLs that are representative of the area being studied. Descriptive statistics show large differences in VSL averages from studies conducted across countries, ranging from $26.1 million in the UK to $1.198 million in South Korea. The overall average across all studies examined was $9.5 million and the median $6.6 million (all figures in $US 2000).

In particular, this study finds that analyses of individuals with higher incomes generally result in higher VSL values and concludes that VSL estimates are higher when risk is treated endogenously.

De Blaeij, A., R. Florax, P. Rietvald, and E. Verhoef, "The Value of Statistical Life in Road Safety: A Meta Analysis," *Accident Analysis and Prevention*, Vol. 23, No. 6, 2003, pp. 973–986.

The authors present an overview of the empirical literature on the value of statistical life in road safety, and use meta-analysis to determine variables that explain the variation in VSL estimates reported in the literature. They find that the magnitude of VSL estimates depends on the value assessment approach (particularly, stated versus revealed preference), and for contingent valuation studies also on the type of payment vehicle and elicitation format. This means that VSL estimates cannot simply be averaged over studies, and the magnitude of VSL is intrinsically linked to the initial level of the risk of being caught up in a fatal traffic accident and to the risk decline implied by the research set-up.

Dionne, G. and P. Lanoie, "How to Make a Public Choice about the Value of a Statistical Life: The Case of Road Safety," École des Hautes Études Commerciales Montréal Working Paper 02-02, 2002.

This article discusses the concept of the value of a statistical life, methods of calculation, and a summary of estimates. It presents a survey of studies on VSL covering more than 85 papers. The goal of the paper is to recommend VSL for the Province of Quebec.

Two major methods are utilized to estimate VSL: revealed preference (based upon the analysis of markets) and contingent valuation (based upon questionnaire data). Revealed preference studies are described as the most useful and often-used methods for determining VSL. After reviewing a number of previous studies, the authors determine that the average VSL for transportation, measured in 2000 Canadian dollars, is $5.183 million (median $5.369 million). It should be noted that there might be differences in various geographic contexts due to the risks of injury present and the willingness to pay for reductions in risk, which likely increase with income.

Dionne, G. and P. Michud, "Statistical Analysis of Value-of-Life Estimates Using Hedonic Wage Method," École des Hautes Études Commerciales Montréal Working Paper 02-01, May 2002.

This paper analyzes the variability of value-of-life estimates, which range from $336,000 to $33.6 million in 2000 Canadian dollars. The paper finds evidence that this variability may in large part be explained by differences in the methodologies used to estimate the value of life. Income elasticity for the value of life is found to be in the 1.07 to 1.72 interval, a result similar to that obtained by Miller (2000) and de Blaeij, et. al. (2000). The authors also analyze the relationship between the value of life and the initial probability of a fatal accident, often used in the literature as a proxy for the variation in the probability of death. Although the willingness to pay may increase with the probability of death, the value of life will decrease with this probability if the initial probability is less than one-half. The authors draw conclusive evidence of such a relationship from a sample of 38 value-of-life estimates based on the hedonic-wage method.

Ehrlich, I., "Uncertain lifetime, life protection, and the value of life saving," *Journal of Health Economics,* Vol. 19, 2000.

The basic objective of this paper is to analyze individuals' demand for life protection and longevity in a life-cycle context, under uncertainty concerning the arrival time of death and alternative insurance options. The analytic innovation is treating life's end as uncertain, and life expectancy as partly the product of individuals' efforts to protect themselves against mortality and morbidity risks. The demand for self-protection is modeled in a stochastic, life-cycle framework under alternative insurance options. The model helps explain the trend and systematic diversity in life expectancies across different population groups, as well as the wide variability in reported "value of life saving" estimates. The analysis yields a close-form solution for individuals' value of life saving that can be estimated empirically. It reflects the impacts of specific personal characteristics and alternative insurance options on both life expectancy and its valuation.

Krupnick, A., "Valuing Health Outcomes: Policy Choices and Technical Issues," Resources for the Future, Mar. 2004.

The paper presents a review of tools and conceptual issues, based on a conference and workshop at Resources for the Future in 2003. It includes a discussion of OMB guidance.

Mrozek, J., and L. Taylor, "What Determines the Value of Life? A Meta-Analysis," *Journal of Policy Analysis and Management*, Vol. 2, No. 2, 2002, pp. 253–270.

The authors estimate a statistical model of the results of many studies, using variables for key methodological choices made in the studies. They find that studies that control for industry (i.e. look only at variations of occupational risk within industries, not across industries) get considerably lower values for Value of Statistical Life (VSL) than others. They conclude that with "best practices" assumptions, the VSL is $1.5 million to $2.5 million in 1998 dollars.

The question of whether one should include an industry control has been debated in the literature, with these authors' preferred assumption disputed by Viscusi and Aldy (2003).

National Safety Council, *Estimating the Costs of Unintentional Injuries*, 2005. [Online]. Available: http://www.nsc.org/resources/issues/estcost.aspx.

The National Safety Council (NCS) provides estimates of VSL and non-fatal injury. While focusing largely on motor vehicle deaths, estimates for costs due other causes are listed as well. The article argues that in BCA, "comprehensive costs" should be utilized. Economic costs include wage and productivity losses, medical costs, administrative costs, etc. Comprehensive costs add the value of "lost quality of life". The values for motor vehicle fatality and injury are estimated as follows:

- Death: $3.84 million
- Incapacitating injury: $193,800
- Non-incapacitating injury: $49,500

For non-motor vehicle injuries, the NSC recommends that costs be estimated based upon the number of fatalities using a rate of $3.5 million per fatality.

Robinson, L., "How US Government Agencies Value Mortality Risk Reductions," *Review of Environmental Economics and Policy*, Vol. 1, No. 2, 2007, pp. 283–299.

The author presents a comprehensive analysis of specific recommendations by OMB and EPA regarding analyses using "quality-adjusted life year" (QALY) or "health-related quality of life" (HROL) as measures that capture how age and health affect value of statistical life. The study is based on findings of an expert committee of the Institute of Medicine, formed at the request of OMB.

U.S. Department of Transportation, "Treatment of the Value of Life and Injuries in Preparing Economic Evaluations," Memorandum, Jan. 8, 1993. [Online]. Available: http://ostpxweb.dot.gov/policy/Data/VSL93guid.pdf.

This guidance presents a revision of the economic values and procedural guidance on the treatment of value of life and injuries in preparing economic evaluations. Some of the key points presented in the guidance are as follows:

- There is a widespread agreement that the DOT uses the collective willingness to pay (WTP) by society for reduced risks of fatalities and injuries as the measure in evaluating regulations and investments that improve transportation safety.
- The DOT recommends a value for the WTP value of a fatality averted – $2.5 million in 1993 – based on a 1988 estimate, updated using the latest available gross domestic product (GDP) deflator. The DOT is to issue a memorandum each year beginning in 1994 to present an updated recommended WTP value for use during the year.
- The guidance also presents estimates for the WTP to avoid injury relative to the WTP value of a fatality averted. These estimates are derived from Miller, Brinkman, and Luchter, "Crash Costs and Safety Investment, 1988. See Miller, et al. (1988).
- There are other costs that result from transportation accidents, namely, costs of emergency services, medical care, and property damage. Savings in these costs likely to result from particular safety measures under consideration should be estimated and reported as a separate benefit. Average or representative direct cost estimates may be used for different types or patterns of accidents.
- The OMB requires the discounting of future costs and benefits to their present value to account for the fact that they are worth less in the future than they are today. Such analysis must use the discount rate specified by the OMB Circular A-94.

U.S. Department of Transportation, "Revision of Departmental Guidance on Treatment of the Value of Life and Injuries," Memorandum, Jan. 23, 2004. [Online]. Available: http://ostpxweb.dot.gov/policy/EconStrat/treatmentof life.htm.

This document provides background information to accompany the updated Department of Transportation guidance memorandum on Treatment of Value of Life and Injuries in Preparing Economic Evaluations. A defined value of life is regarded as an essential element of BCA in the areas of regulation and investment in health and safety. The term "value of statistical life" (VSL) is meant to emphasize that value is placed, not on a particular life, but on safety measures that reduce the statistically expected number of accidental fatalities by one. Past estimates of VSL were commonly based on a concept of human capital, or prospective earning power.

Recent estimates are based on "willingness to pay" (WTP). Three principal methods are used to estimate WTP:

- Wage-risks trade-offs – the wage premiums that must be paid to induce workers to accept riskier employment
- Revealed-preference studies on various forms of consumer behavior – willingness to accept cost or inconvenience in exchange for safety improvements from smoke detectors, automobile seat belts, bicycle helmets, etc.
- Contingent valuation (CV) or stated-preference techniques that rely on verbal responses to carefully structured hypothetical questions

In addition, there are a number of secondary studies that synthesize the results of primary research and draw conclusions on "best practices" or derive a simple mean of estimates. Others are "meta-analyses" that apply statistical techniques to the results of independent studies, accounting for differing results in studies separated by years and national boundaries and for the impact of variables that may not have been estimated directly.

The document summarizes estimates of VSL from the research literature. These estimates range from $1.5 million to $7 million. The January 1993 DOT guidance memorandum recommends a value of $2.5 million, which was increased to $2.7 million in 1996 and to $3 million in 2002.

Viscusi, W.K., "The Value of Life in Legal Contexts: Survey and Critique," *American Law and Economics Review*, Vol. 2, 2000, pp. 195–210.

Value of life issues traditionally pertains to insurance of the losses of accident victims, for which replacement of the economic loss is often an appropriate concept. Deterrence measures of the value of life focus on risk-money trade-offs involving small changes in risk. Using market data for risky jobs and project risk contexts often yields substantial estimates of the value of life in the range of $3 to $9 million. These estimates are useful in providing guidance for regulatory policy and assessment of liability. Use of these values to determine compensation, known as hedonic damages, leads to excessive insurance.

Viscusi, W.K., "The Value of Life: Estimates with Risks by Occupation and Industry," *Economic Inquiry*, Vol. 42, No. 1, Jan. 2004.

Using 1997 CPS data, the authors estimate a value of life of $4.7 million for the full sample, $7.0 million for blue-collar males, and $8.5 million for blue-collar females. From the abstract: "Unlike previous estimates, these values account for the influence of clustering of the job risk variable and compensating differentials for both workers' compensation and nonfatal job risks."

Viscusi, W.K., and J. Aldy, "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World," *The Journal of Risk and Uncertainty*, Vol. 27, No. 1, 2003, pp. 5–76.

> Individuals make choices that reflect how they value health and mortality risks. Many of these choices involve market decisions, such as the purchase of a hazardous product or taking on a risky job. A substantial literature over the past 30 years has evaluated trade-offs between money and fatality risks to arrive at estimates of VSL. These VSL estimates in turn provide governments with a reference point for assessing the benefits of risk reduction efforts.
>
> This article reviews more than 60 studies of mortality risk premiums from 10 countries and approximately 40 studies that present estimates of injury risk premiums. This critical review examines a variety of econometric issues, the role of unionization in risk premiums, and the effects of age on the value of statistical life.
>
> While the trade-off estimates may vary significantly across studies, the VSL for prime-aged workers has a median value of about $7 million in the United States. Other developed countries appear to have comparable VSLs, although some studies of the United Kingdom find much larger risk premiums. Developing countries' labor markets also have significant, but smaller, VSLs. Meta-analysis indicates an income elasticity of the VSL ranging from 0.5 to 0.6. Union members in United States labor markets appear to enjoy greater risk premiums than non-members, while the evidence in other developed countries is rather mixed. The theoretical and empirical literature indicates that VSL decreases with age.
>
> The estimates of the VSL can continue to serve as a critical input in BCA of proposed regulations and policies. Refining VSLs for the specific characteristics of the affected population at risk remains an important priority for future research.

Viscusi, W.K., and J. Aldy, "Labor market estimates of the senior discount for the value of statistical life," *Journal of Environmental Economics and Management*, Vol. 53, 2007, pp. 377–392.

> The authors find an inverted U shape of value of statistical life with age: "estimates … range from $6.4 million for younger workers to a peak of $9.0 million for those aged 35-44, and then a decline to $3.8 million for those aged 55-72."
>
> We note this is in contrast to the results of Alberini, Cropper, Krupnick, and Simon (2004).

Zimmerman, R., "Electricity Case: Economic Cost Estimation Factors for Economic Assessment of Terrorist Attacks," University of Southern California Center for Risk and Economic Analysis of Terrorism Events Report #05-015, Draft May 31, 2005.

> This report sets forth economic factors for quantifying the cost of loss of human life and injuries, business losses (including those to critical infrastructure that supports social and economic activity), and property value losses (usually included in business

losses). Although they are developed for estimating effects of attacks on electric power, these economic factors are broadly applicable to other kinds of events involving deaths, injury or business loss. The report presents a variety of alternative measures and values to provide users flexibility in how they are applied.

Valuation of Noise Impact

Baranzini, A. and J.V. Ramirez, "Paying for quietness: The impact of noise on Geneva rents," *Urban Studies,* Vol. 42, No. 4, pp. 1–14, Apr. 2005.

Using hedonic models, this research estimates the "cost" of noise for Geneva. Using a large sample and detailed database, the authors find that noise is a significant predictor of rents.

Although different measures of noise are employed, the authors do not find major differences in the impact based on the use of these different metrics. An important contribution of the paper is the finding that the impact of noise differs significantly based upon whether the ambient environment of a geographic area is quiet (i.e. non-urban) or noisy (urban). The impacts of noise are greater for quieter regions (0.60 percent/dB versus 0.20 percent/dB).

The paper suggests that GIS be integrated into similar analyses.

Brueckner J. and R. Girvin, "Airport Noise Regulation, Airline Service Quality, and Social Welfare," Unpublished paper, University of California, Irvine, 2006.

Despite continued technological developments making aircraft quieter, noise issues continue to be at the forefront of many airport development decisions. This fact indicates that the lower noise outputs of aircraft are not yet at the level to suit many local regions. This paper investigates the extent to which noise regulations have impacts on airline service quality and fares.

Three scenarios are evaluated: 1) imposed noise constraint – limits per aircraft; 2) imposed noise constraints – airport cumulative; and, 3) noise taxes paid by the airline per unit of noise. The first two are controlled more by local decisions, while the latter is controlled by airline profit maximization.

The analysis results in the following propositions. Cumulative noise reductions result in lower frequency and higher fares – a negative effect on passengers:

- Per-aircraft noise reductions increase fares – frequency remains constant while aircraft size decreases.
- Outcomes of noise taxation schemes can be made equivalent to cumulative noise reduction regulations if the right tax rate is chosen.
- Higher noise taxes reduce frequency, increase aircraft size, and result in higher fares.

Generally, noise regulations will result in higher fares. Cumulative noise reductions are found to have greater overall social welfare than per-aircraft restraints. Since this is likely context dependent, airport-specific limits may be the optimal approach.

Carlsson, F., E. Lampi, and P. Martinsson, "The marginal values of noise disturbance from air traffic: does the time of the day matter?", *Transportation Research Part D*, Vol. 9, 2004, pp. 373–385.

The authors use stated preference data (here called a "choice experiment") to measure willingness to pay for reduced air traffic in the Stockholm area. The value seems to be greatest during the morning and evening hours.

Cohen, Jeffrey P. and Cletus C. Coughlin. "Changing Noise Levels and Housing Prices Near the Atlanta Airport." *Growth and Change*, Vol. 40, No. 2, 2009, pp. 287–313.

The authors use hedonic models to analyze the effects of proximity and noise on housing prices in neighborhoods near Hartsfield-Jackson Atlanta International Airport during 1995–2002. Proximity to the airport is related positively to housing prices. After accounting for proximity, house characteristics, and demographic variables, houses in noisier areas sold for less than houses subjected to less noise.

Cohen, Jeffrey P. and Cletus C. Coughlin. "Spatial Hedonic Models of Airport Noise, Proximity, and Housing Prices." *Journal of Regional Science*, Vol. 48, No. 5, 2008, pp. 859–878.

Incorporating spatial econometric techniques in a hedonic price framework, the authors examine the impact of noise on 2003 housing prices near the Atlanta airport. The study finds that exposure to noise tends to reduce housing prices, while proximity to the airport tends to increase housing prices, after controlling for noise effects.

Feitelson, E., R. Hurd and R. Mudge, "The Impact of Airport Noise on Willingness to Pay for Residences," *Transportation Research 1D*, Vol. 1, No. 1, Sept. 1999, pp. 1–14.

The authors estimate the effects of aircraft noise following airport expansion on the willingness to pay (WTP) for residences using a contingent valuation approach. Their results suggest that noise impact valuations should analyze noise as a multi-attribute externality, rather than by a single composite measure. Household WTP structures are skewed. Beyond a certain disturbance threshold, households are unwilling to pay anything for the residence; yet, different households have different thresholds. This skewed WTP structure helps explain the higher noise premiums obtained in studies relative to hedonic price estimates.

Lane, T., "The Impact of Airport Operations on Land Values: A Case Study of Seattle-Tacoma International Airport," Presented at the Thirty Second Annual Pacific Northwest Regional Economic Conference, 1998

Single family residential values are assessed for a number of neighborhoods in proximity with Seattle-Tacoma International Airport. Ordinary Least Squares Regression (OLS) regression is employed. The modeled structural and locational variables include: lot size, structure size, number of bedrooms, number of bathrooms, distance from flight track, and neighborhood dummy variables.

Results show that property values increase approximately 3.4 percent for each one-fourth-mile increase in distance from the main flight tracks. Most variables are significant, with the exception of number of bedrooms and two neighborhood dummies. The paper indicates that summed across the study area, tax receipts are decreased by about $285,000 per year as a result of the lower property values. The paper suggests that future research should include some variable that models the aircraft flight elevation.

Lipscomb, C., "Small Cities Matter, Too: The Impacts of an Airport and Local Infrastructure on Housing Prices," *Review of Urban & Regional Development Studies*, Vol. 15, No. 3, Nov. 2003, pp. 255–273.

The author applies the hedonic valuation model to a smaller urban area near Atlanta and argues that such smaller cities are generally ignored in previous literature. The literature review indicates that there are discrepancies in the findings of previous research, both in the direction and level of noise impacts.

Three major assumptions are made in the analysis and include: households can be aggregated, households choose particular spaces because of combinations of available public goods, and households make their choices based upon valuation of quality of life. Variables used in the analysis include: parcel size, house size, number of bedrooms, number of bathrooms, community type, most recent sales date, fireplaces, proximity to transit, local amenities, and others. Noise is not found to be a significant factor in house price. Proximity to the airport, however, is a significant and positive predictor of housing prices. In this case, "nearness" appears to be valued by consumers.

Lu, C. and P. Morrell, "Determination and Applications of Environmental Costs at Different Sized Airports–Aircraft Noise and Engine Emissions," *Transportation*, Vol. 33, No. 1, 2006, pp. 45–61.

Social costs of air travel are said to come in two forms: noise and air pollutants. The analysis is based upon hedonic price methods where property values vary in response to neighborhood factors, location, and environmental quality. The annual social cost of noise is then a function of a noise depreciation index (percentage decrease in house value per dB above ambient levels) and the number of houses within each dB region. This is modified by an annoyance function which recognizes that disturbance increases non-linearly with dB increases. The cost of pollutants is a function of emissions from various engine/aircraft types, the number of aircraft movements, the unit costs of pollutants, and flight mode (cruise, take-off, etc.). The two sets of costs are summed to derive an average environmental cost per landing and an annual environmental cost in total for five case study airports, which include Heathrow, Schiphol, Gatwick, Stansted, and Maastricht. Emission cost is higher per landing and on an annual basis for each of the five airports. The societal utility of an airport only increases while the net benefit of additional aircraft movements outweighs their cost. Noise charges are suggested that reflect this relationship.

Morrison, S., C. Winston, and T. Watson, "Fundamental flaws of social regulation: The case of airplane noise," *Journal of Law and Economics*, Vol. 42, 1999, pp. 723–743.

The authors measure value to residents of airport noise reduction, and apply results to analyze the 1990 Airport Noise and Capacity Act. The authors argue that the value to residents was $5 billion less than the cost to airlines of implementing the mandated noise standards.

Morrell, P. and C. Lu, "Aircraft Noise Social Cost and Charge Mechanisms—A Case Study of Amsterdam Airport Schiphol," *Transportation Research D, Transport and Environment*, Vol. 5, No. 4, Jul. 2000, pp. 305–320.

Authors' abstract: "The increasing trend of charging for aircraft noise nuisance to encourage the sustainable development of the air transport industry has resulted in a need to evaluate the real social costs of such externalities for the formulation of effective charge mechanisms. After comparing the current charge mechanisms at world airports, as well as reviewing existing externality measurements, mathematical models are developed to calculate the noise social cost in monetary terms and noise charge mechanisms are subsequently established. The hedonic price method is applied to calculate the annual social cost of aircraft noise during the landing and take-off stages of the flight. This is done by estimating the implicit costs of aircraft noise imposed through a decline in property values in the vicinity of the airport. The empirical results, using Amsterdam Airport Schiphol as the case study, show that the current noise charge level imposed by the Dutch Government is lower than the actual noise social cost resulting from aircraft movements. Several noise charge mechanism scenarios are derived according to the modeling results, as well as the environmental objectives of the airport related authorities."

Navrud, S., *The State-of-the-Art on Economic Valuation of Noise*, Final Report to European Commission DG Environment, Apr. 14, 2002.

This paper reviews the state-of-the-art in economic valuation of noise to provide advice to the European Commission in determining interim values for noise to be used in BCA. The paper addresses the following topics:

- Theoretical basis and valuation techniques

- Review of noise valuation studies
- Potential for benefit transfer of existing studies
- Cut-off point for valuing noise
- Values to use beyond the cut-off point
- Value for noise from different transportation modes
- Should the value be the same for all member states and countries
- Research gaps

Environmental valuation methods, both stated preference (SP) and revealed preference (RP) methods, have been employed to estimate the economic value of changes in noise levels. Most studies apply the RP approach of hedonic pricing (HP) to housing market to analyze how the difference in property prices reflect individuals' willingness to pay (WTP) for lower noise levels. More recently there has been an increased interest in applying SP methods to value noise. Contingent Valuation (CV), Conjoint Analysis (CA), and Choice Experiments (CE) have all been applied to value transportation noise.

Economic valuation techniques are used to set an economic value for a unit of exposure to noise. Two different valuation approaches can be used:

- Transfer estimates from existing valuation studies (using benefit transfer techniques and literature review/databases on noise valuation studies).
- Conduct a new, original study using environmental valuation techniques.

Nelson, J., "Meta-Analysis of Airport Noise and Hedonic Property Values: Problems and Prospects," *Journal of Transport Economics and Policy*, Vol. 38, No. 1, Jan. 2004, pp. 1–27.

The author performs a meta-analysis of 20 hedonic property value studies including 33 estimates. The study finds that the mean cumulative noise discount in the United States (NDI) is 0.58 percent per dB. However, this figure varies by location. Canadian noise discounts are substantially higher at the 0.8 to 0.9 percent range.

The author cites federal studies that indicate that noise levels of greater than 75 dB are not compatible with residential land use and that 65 dB levels are generally considered the maximum noise levels acceptable for residences.

Nijland, H., E. Van Kempen, G. Van Wee, and J. Jabben, "Costs and benefits of noise abatement measures," *Transport Policy*, Vol. 10, No. 2, 2003, pp. 131–140.

This paper describes a cost-benefit analysis of a number of possible noise abatement measures in the Netherlands. Benefits are calculated according to consumer's preferences for dwellings and applied values are derived from two different methodologies (hedonic pricing and contingent valuation). Costs are shown to be surpassed by benefits. The paper identifies weaknesses in valuing noise, particularly where issues of equity, benefit transfer, and embedding are concerned.

Ogren, M., and H. Andersson, "Noise Charges in Railway Infrastructure: A Pricing Schedule Based on the Marginal Cost Principle," *Transport Policy*, Vol. 14, No. 3, May 2007, pp. 204–213.

> From the abstract: "This paper shows that railway-noise charges can be estimated using already obtained knowledge of monetary and acoustical noise evaluation. Most European countries have standardized the calculation methods for total noise level, which can be used to estimate the marginal acoustical effect. Based on a Swedish case study (with a relatively high number of exposed individuals), railway-noise charges are estimated at 0.026, 0.099 and 0.89 €/km for commuter, high-speed and freight trains, respectively."

Salvi, M., Spatial Estimation of the Impact of Airport Noise on Residential Housing Prices, Working Paper, July 2007.

> The author uses a spatial hedonic regression model to measure the impact of airport noise on the price of single-family homes near Zurich International Airport. The hedonic model is specified with an error component for spatial dependence. The paper takes a differentiated approach on the modeling of aircraft noise, using a large database of geo-referenced noise measurements to investigate the reaction of prices to different noise metrics. The paper documents a moderate impact of airport noise on housing prices. In the base model specification, the Noise Discount Index is 0.93% with typical discounts in the range of -2% to -8%. Accounting for the spatiality of the data has little effect on the estimated coefficients and their standard errors.

Tomkins, J., "Noise versus Access: The Impact of an Airport in an Urban Property Market," *Urban Studies*, Vol. 35, No. 2, 1998, pp. 243–258.

> Using hedonic price modeling, this article evaluates the "costs" of Manchester Airport in England. The model uses two sets of variables to accomplish this: property specific variables and external attributes (those outside the control of the property owner).
>
> Two measures of noise nuisance are discussed: Noise and Number Index (NNI) and equivalent continuous sound pressure level (Leq). The NNI is calculated by examining the number of aircraft movements and their peak noise levels. Leq determines an average level of noise above ambient levels over the course of a given time period. Findings show a negative relationship between distance and housing values. However, other factors, such as improved access to the airport as a result of proximity, may overshadow any negative effects. For example, under the 60 dB contour, property values rise by £7493 at a distance of 2.5 km from the airport in comparison with the mean distance of 9.3 km. Thus, the article recognizes that there may also be positive externalities that are associated with close proximity with an airport for employees and consumers of air transport.

Van Praag, B. and B. Baarsma, "Using Happiness Surveys to Value Intangibles: The Case of Airport Noise," *The Economic Journal*, Vol. 115, No. 500, Jan. 2005, pp. 224–246.

The authors estimate the social costs of noise using a method that measures happiness as a function of income, noise, and other variables. The assumption is that if markets are working properly, noise should not be related to happiness because market prices should have already compensated for increased annoyance. Because of high switching costs and market rationing in housing, however, there will be two effects: reductions in house values and residual shadow costs. The authors contend that the case of airport noise fits into a more general set of problems related to the discrimination between private and public costs (residual costs).

A summary of previous studies indicates that the average noise depreciation index (NDI) is approximately 0.6 percent – that is, for every 1 dB increase in noise nuisance, property values fall by about 0.6 percent.

The authors develop a set of models that estimate "well-being" with measures of income, noise, age, family size, and other items. They find that prices in Amsterdam do not relate significantly to noise levels due to the fact that the housing market in the city is not in equilibrium. Residual costs are found to vary with income and are based upon whether the housing stock is insulated.

Valuation of Climate Change and Air Pollution Impacts

Chicago Climate Exchange, 2007. [Online]. Available: http://www.chicagoclimatex.com/.

This is a market website that provides market values for the trade and exchange of CO2 emissions. It provides current estimates of the value of CO2 from aircraft engines.

Davis, M., *Valuation of the Global Warming Impacts of UK Aviation*, Master's thesis, Imperial College of Science, Technology and Medicine, Sept., 2003.

In 2003, the UK Government conducted a BCA of airport capacity expansion. The BCA, however, covers a narrow range of economic impacts and does not provide monetary values for environmental impacts of airport capacity expansion. This thesis seeks to fill some of the gaps in the BCA by valuing the global warming impacts of capacity expansion. This thesis serves as the basis for POSTnote Number 207 published by the Parliamentary Office of Science and Technology in November 2003.

Delucchi, M., and D. McCubbin, "External Costs of Transport in the U.S.," in A. de Palma, R. Lindsey, E. Quinet, and R. Vickerman, eds., *Handbook of Transport Economics*, Edward Elgar, 2010 (forthcoming).

This is a comprehensive review of damage studies from all major sources of both tropospheric (ground-level) and stratospheric (global) air pollution. Reports on three studies of health costs from air transport, with damage costs estimated at 0.39, 0.01, and 0.18 cents per passenger-mile traveled. The first two also include freight, with estimated damages at 1.18 and 0.003 cents per ton-mile. Only the second of these three studies, by Zhang et al. (2004), also includes climate change cost from aviation, obtaining 0.08 cents per passenger-mile and 0.45 cents per ton-mile. The authors also cite six studies providing estimates of the cost of a unit of greenhouse gas emissions, noting the very wide range of results.

Gallagher, K. and R. Taylor, "International Trade and Air Pollution: The Economic Costs of Air Emissions from Waterborne Commerce Vessels in the United States," Tufts University Global Development and Environment Institute Working Paper No. 03-08, 2003.

This paper presents an estimate of the costs of two major pollutants (SOx and NOx), which result from shipping traffic in the United States – pollutants also found in aircraft emissions. The authors implicate the growing international trade regime in the process, since free trade has resulted in additional foreign vessel traffic to the United States. The estimates for the total costs per year are $51 million for SOx and $144 million for NOx. The authors state: "these costs represent abatement costs by private firms equal to the amount of externalities required to be abated under current air regulations." The additional costs of externalities such as health, ecosystems, acid rain, and the like, must be added to the estimate for the total costs for SOx and NOx.

To accomplish this, the authors add social costs, which are derived from previous studies conducted by the EPA and other authors, to their estimates. It should be noted that the estimates for such social costs vary widely: SOx costs range from approximately $1,000/ton to $3,000/ton and NOx costs range from about $1,000/ton to $12,000/ton.

Intergovernmental Panel on Climate Change, *Aviation and the Global Atmosphere*, 1999. [Online]. Available: http://www.grida.no/climate/ipcc/aviation/index.htm.

This article focuses mainly on the global warming impacts of aviation activity and does not discuss local air quality impacts. Approximately two percent of all anthropogenic CO2 is produced by aviation activity and 13 percent of all transportation-related CO2 is a result of air transport. Other major pollutants produced by aviation activity include methane (CH4), nitrogen oxides (NOx), sulfur oxides (SOx), water vapor (H2O), and others. Each of these gases have different atmospheric residence times and, therefore, differing geographic impacts. While the article does not provide economic values, it is useful in identifying the global warming impacts of aviation activity. The article suggests that aircraft are responsible for about three and one-half percent of all radiative forcing. Possibilities for reducing impacts are likely to come from future improvements in aircraft engine technology and more efficient air traffic management.

Muller, N., and R. Mendelsohn, "Measuring the damages of air pollution in the United States," *Journal of Environmental Economics and Management*, Vol. 54, 2007, pp. 1–14.

The study uses an integrated assessment model to measure emissions of 6 tropospheric (ground-level) pollutants and applies valuations to obtain broad annual damage in the United States. The model includes mobile sources, hence, presumably aviation, but aviation is not explicitly identified. It includes methods for relating damage to quantity of emission.

Parliamentary Office of Science and Technology, "The Environmental Costs of Aviation." *POSTnote Number 207*, Nov. 2003. [Online]. Available: http://www.parliament.uk/documents/upload/postpn207.pdf.

This document reviews the key categories of costs that must be considered when conducting an environmental/economic assessment of the overall costs of air-transport activity. Three types of effects are considered: global warming, local air quality and noise. For aviation in the United Kingdom (UK), the costs for 2000 are valued at £1.4b ($2.61 USD), £119-236m ($221.54-$439.36 USD), and £25m ($46.51 USD), respectively.

Several valuation methods are reviewed, including the use of market prices, stated preferences, revealed preferences, and the use of similar estimates from other contexts. Estimates of global warming are derived from a government estimate that each additional ton of CO2 will result in £70 of damage. Because CO2 is only one of the many greenhouse gases emitted by aircraft engines, a multiplying factor of 2.7 was used.

The UK government review of noise studies concludes that house values fall between 0.5 and 1.0 percent for each noise unit (dBA Leq) rise. While techniques to derive these estimates are well-known, there are problems in that some studies actually show that the added value of proximity to an airport outweighs the negative effects of noise, as well as other confounding relationships. The UK government uses an estimate of 0.6 percent per decibel reduction in real estate values for each dB greater than 57 dB.

Regarding local air quality, the report focuses on the effects of particulate matter (PM10) and nitrogen oxides (NOx). The costs related to these items are derived from damage to crops and structures, and impacts on health and to biodiversity. The specific techniques for valuation are not provided. Other potential impacts discussed include "landtake, heritage, wildlife habitat, and water and waste." The claim is also made that aviation is partially responsible for impacts relating to the production of fuel, aircraft, housing, and tourism that occur as a result of air transport. Again, no attempt is made to specifically value these items.

The report warns that several issues must be considered in making valuations, including the recognition of uncertainty, and the fact that policy decisions based upon those valuations will result in those that benefit and those that do not.

Pearce, D., "The Social Cost of Carbon and Its Policy Implications," *Oxford Review of Economic Policy*, Vol. 19, 2003, pp. 362–384.

The study addresses stratospheric air pollution (global). The author reviews evidence from many studies, applies methodological critique, concluding that best assumptions yield a range of damage cost (in British pounds) of GBP 4-27 per metric ton carbon (p. 381, section g; also p. 376). The author argues that valuation used by the UK government is unreasonably high due to certain inappropriate assumptions.

Pearce, B. and D. Pearce, "Setting Environmental Taxes for Aircraft: A Case Study of the UK," CSERGE Working Paper GEC, 2000.

Air transport consumes large amounts of energy per distance traveled per customer. Therefore, the possibility of taxing greenhouse emissions has become a greater possibility. This article discusses the issue in the context of the United Kingdom, where other environmental taxes for land fill deposits, extractive industries, etc., have been considered. The authors argue that market-based approaches are preferable, but that care must be taken to insure that the taxation scheme is efficient and effective in meeting its ultimate goals. In Europe, both Zurich and multiple airports in Sweden have enacted emissions and noise taxes.

The paper suggests an approach for calculating air emissions taxes and noise costs. At Heathrow, noise costs are estimated to range widely depending on the aircraft type (e.g., £168 ($312.75 USD) for a 744; £44 ($81.91 USD) for a 752). Air emission taxes are calculated for a variety of chemicals including CO2, O3, and CH4. Adjustments are made for long-haul, short-haul, and aircraft type, as well as altitude. The overall environmental tax is then the air emission taxes plus the noise costs.

Tol, R.., "The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties," *Energy Policy*, Vo. 33, 2005, pp. 2064–2074.

The study addresses stratospheric air pollution (global). It discusses meta-analysis of 103 estimates from 28 separate studies, put on a common basis of global damage cost per metric ton of carbon content in U.S. dollars ($/tC). With all studies included, the median damage estimate is $14/tC and the mean is $93/tC (abstract). When only peer-reviewed studies are included, the mean falls to $47/tC (p. 2070). Studies that employ "equity weighting" get much higher values. There is a wide range of estimates, mostly due to two assumptions: the discount rate and how impacts are aggregated over countries (p. 2071). This range is smaller in peer-reviewed studies. It also depends on the discount rate assumed: "If we use a pure rate of time preference of 3%—… close to what most western governments use for most long term investments—the combined mean estimate is $16/tC, not exceeding $62/tC with a probability of 95%." (p. 2073)

The overall conclusion from the abstract is: “Using standard assumptions about discounting and aggregation, the marginal damage costs of carbon dioxide emissions are unlikely to exceed $50/tC, and probably much smaller.”

Tol, R., “The economic effects of climate change,” *Journal of Economic Perspectives*, Vol. 23, No. 2, 2009, pp. 29–51.

The review addresses stratospheric air pollution (global) and is aimed mainly at professional economists. Conclusion: “A government that uses the same 3 percent discount rate for climate change as for other decisions should levy a carbon tax of $25 per metric ton of carbon (modal value) to $50/tC (mean value).” (p. 46)

U.S. Department of Transportation, Federal Aviation Administration, Investment Analysis and Operations Research, “Draft Guidelines for Quantifying the Environmental Benefits of An Investment Analysis,” Sept. 29, 2000.

This paper describes techniques to quantify changes in emissions due to technological improvements – a requisite step in economic valuation. The emissions of primary concern included in this study are:

- Carbon Dioxide (CO2)
- Nitrogen Oxides (NOx)
- Carbon Monoxide (CO)
- Hydrocarbons (HC)
- Sulfur Dioxide (SO2)

These gases, in the presence of other chemicals, are the primary sources of:

- Ground-level ozone (O3)
- Particulate matter (PM-10)
- Visibility impairment
- Global warming and climate change
- Acid rain

U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, EPA Report to Congress, Oct. 1997.

Based on a review of 26 studies, the U.S. Environmental Protection Agency suggests that a reasonable estimate of the value of statistical life (VSL) has a mean of $4.8 million with a confidence interval of plus or minus $3.2 million (in 1990 U.S. dollars).

U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1990 to 2010*, EPA Report to Congress, Nov. 1999.

This report to Congress presents the results and conclusions of the analysis of the benefits and costs of the Clean Air Act for the period from 1990 to 2010. This prospective analysis consists of six steps:

- Estimate air pollutant emissions in 1990, 2000, and 2010
- Estimate the cost of emission reductions arising from the Clean Air Act Amendments
- Model air quality based on emissions estimates
- Quantify air quality related health and environmental effects
- Estimate the economic value of cleaner air
- Aggregate results and characterize uncertainties

Estimates of reduction in pollutant emissions serve as the starting point for benefit and cost estimates. The emissions analysis focuses on six major pollutants: volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur dioxide (SOx), carbon monoxide (CO), coarse particulate matter (PM10), and fine particulate matter (PM2.5). The results of the emissions analysis feed into a linked series of models to estimate changes in air quality, human health effects, ecological effects, and, ultimately, the net economic benefits of the Clean Air Act Amendments.

U.S. Environmental Protection Agency, Clean *Air Markets*, 2007, [Online]. Available: http://www.epa.gov/airmarkets/index.html.

The website provides current and historical information on emissions regulations and trading. Information on market prices for nitrogen oxide (NOx) and sulfur dioxide (SOx) allowances are available. This data can be used with aircraft information to determine the economic costs of various pollutants. Results of the most recent auction for SOx allowances indicate a weighted average price of $443.39/allowance (ton of SOx). The Environmental Protection Agency (EPA) conducts auctions for SOx allowances, while those for NOx are handled through private brokers. The March 2007 price for NOx is $1,025, according to http://new.evomarkets.com/.

U.S. Environmental Protection Agency, Clearing *the Air: The Facts about Capping and Trading Emissions* May 2002. [Online]. Available: http://www.epa.gov/airmarkets/presentations/docs/clearingtheair.pdf.

This document provides a layperson's explanation for the trading program in sulfur dioxide (SOx) and nitrogen oxide (NOx). In doing so, it provides an economic rationale for the use of market prices in the valuation of impacts as a result of human activity. SOx and NOx are significant causes of acid rain.

Weisbrod, G., T. Lynch and M. Meyer, "Extending Monetary Values to Broader Performance and Impact Measures: Transportation Applications and Lessons for Other Fields," *Evaluation and Program Planning*, Vol. 32, No. 4, Nov. 2009, pp. 332–341.

This review of benefit monetization factors includes a comparison of methods used in the U.S. and abroad for valuing benefits of air pollution reduction. It discusses valuation of various air pollutants (SO_2, NO_X, PM_{10}, PB) and greenhouse gases (CO and CO_2). It discusses how the emissions valuation factors are affected by setting (urban, rural or metropolitan fringe) and ground transport mode mix, and how values differ when expressed per vehicle-mile (or km) or per ton of emissions. Related values of daily ill health affected by air pollution (including chronic bronchitis, respiratory illness, asthma, etc.) are also discussed.

2 EVALUATING AIRPORT CAPITAL INVESTMENT DECISIONS

This appendix chapter presents four methodologies and associated techniques for evaluating airport capital investment decisions. These methodologies are: (1) economic analysis, (2) financial analysis - investment decision rules, (3) financial analysis - airport financial planning techniques, and (4) economic impact analysis. Analysts can use one or all of these methodologies, each involving different analytical techniques, depending upon the nature and objective of the airport capital investment, the source of funding, and the parties involved in decision making, among other factors. This chapter also discusses approaches to addressing uncertainty in any of the methodologies for evaluating capital investment decisions.

However, note that this chapter is not exhaustive. It focuses on the standard techniques under each methodology—techniques that we believe will be accessible to airport sponsors' staff and have a wider application in considering the types of airport capital projects, airport capital investment decision considerations, FAA project evaluation requirements for Airport Improvement Program (AIP) / Letter of Intent (LOI) funding, and federal guidance for evaluating federal investment and regulatory actions. There are other capital investment evaluation methods and more sophisticated techniques in the literature that are not covered in this chapter.

This Appendix is a primer on airport capital investment decision making. The value of time is one of the most important economic values used in economic analysis to quantify the cost of aircraft and passenger delay, or the benefit of reducing or eliminating such delay. The discussion of methodologies presented below is intended to provide the broad context to the focused research on value of time that is incorporated in the Guidebook.

This Appendix defines what constitutes an airport capital investment, describes different airport capital investment projects, and identifies typical funding sources for airport capital investment. The nature of the project influences the choice of funding source because of funding eligibility considerations. In turn, the choice of funding source influences the choice of methodology and techniques for analyzing the capital investment decision, since certain funding sources require the use of a specific methodology or technique. In particular, the Federal Aviation Administration (FAA) requires airport sponsors[1] to perform benefit-cost

[1] The FAA refers to recipients of AIP grants as "sponsors", and sponsors are public agencies – and in some cases private owners and entities – involved in the planning and development of public-use airports. Airport sponsors must be legally, financially, and otherwise able to carry out the assurances and obligations contained in the project application and grant agreement. Source: FAA, "Overview: What is AIP?" Airport Improvement Program (AIP), 2010 [Online]. Available: http://www.faa.gov/airports/aip/.

analysis (BCA) – an economic analysis technique – to demonstrate a project's economic merit when requesting at least $5 million in discretionary grant funding for airport capacity projects under the Airport Improvement Program (AIP) or any amount of AIP funding under a Letter of Intent (LOI). When airport sponsors sell bonds to finance capital projects, they typically need to present a financial feasibility report prepared by an independent airport consultant to establish the financial feasibility of the airport's capital program and proposed bond financing.

Typically, the responsibility for preparing an analysis to evaluate airport capital investment decisions rests on airport sponsors. Airport sponsors perform the analysis either in-house or with the help of consultants. Therefore, this Appendix addresses airport sponsors, staff and consultants as the primary target audience. Other parties, however, are often involved in airport capital investment decision making, particularly in approving funding, each one with different considerations that can influence what evaluation methodologies and techniques airport sponsors implement. The discussion below identifies some of the considerations in airport capital investment decisions, usually associated with the different funding sources.

The section below, titled "Economic Analysis", describes techniques for the economic analysis of airport capital investment. The discussion focuses on BCA as the recommended technique, with cost-effectiveness analysis (CEA) as a less comprehensive variant. This section also discusses economic valuation and corresponding techniques for assigning monetary values to project benefits and costs in performing BCA. Airport sponsors typically perform BCA for capacity projects for which they need federal grant funding of at least $5 million in AIP discretionary grant or any amount under an LOI to fulfill the FAA grant application requirement. (On October 24, 2011, the discretionary funding threshold was increased from $5 million to $10 million). Hence, the BCA is often prepared in the final stages of project planning. BCA for this purpose used to be performed in-house by the FAA until June 1997, when the FAA issued a policy notice that transferred the responsibility for performing the BCA to the airport sponsor. This was done to encourage airport sponsors to perform BCA early in the airport master planning process – during project formulation and alternatives selection – when it is most useful. The FAA prepared the "FAA Airport Benefit-Cost Analysis Guidance"[2] so that airport sponsors can apply uniform standards in performing BCA of capacity projects. The intention is "to increase the airport sponsor's acceptance of the BCA as one of several useful tools, not merely a requirement imposed from outside."[3,4] While the FAA BCA policy and guidance apply only to capacity projects, economic analysis–BCA and CEA–can be used to evaluate all airport capital projects.

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[2] FAA, Office of Aviation Policy and Plans, *FAA Airport Benefit-Cost Analysis Guidance*, Washington, D.C., Dec. 15, 1999. [Online]. Available: http://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/ faabca.pdf.

[3] FAA, "Policy and Guidance Regarding Benefit Cost Analysis for Airport Capacity Projects Requesting Discretionary Airport Improvement Program Grant Awards and Letters of Intent" (62 FR 34108), *Federal Register*, Vol. 62, No. 121, Jun. 24, 1997.

Techniques for financial analysis are classified into two categories: (1) traditional investment decision rules in capital finance, and (2) techniques used specifically in airport capital investment financial planning.

This Appendix also presents the traditional investment decision rules in capital finance, also known as "capital budgeting techniques", "investment evaluation procedures," and "investment criteria". They include Payback Period, Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost Ratio (B/C Ratio). These are the same investment decision rules for BCA in economic analysis, although the inputs are limited to cash flows to the investment proponent in financial analysis application. Readers should note that there are other, more advanced and sophisticated capital budgeting techniques that are not covered in this working paper—financial analysis techniques for airport capital investment financial planning, which include rates and charges analysis; financial affordability analysis; and financial feasibility analysis. These are the techniques that are widely used by airport sponsors in evaluating the financial feasibility of capital investment decisions. In practice, an airport sponsor typically evaluates the feasibility of its entire Capital Improvement Program (CIP) – a collection of projects that make up a five-year program for planning and development at a particular airport, rather than individual projects. Therefore, the airport financial planning techniques are typically applied to the entire CIP. The application of financial analysis – financial affordability analysis and/or financial feasibility analysis –for an individual project is typically limited to the construction or improvement of a particular facility to be funded from a dedicated revenue stream. Funding is typically supplied through issuance of special facility bonds (e.g., the construction of a consolidated rental car facility to be funded exclusively from user fees collected from rental car customers, the construction of a cargo facility to be funded from a facility's lease revenues or a passenger terminal to be funded by airline terminal rent payments and concession rentals and fees).

Another method used for evaluating capital investments is economic impact analysis—also known as "economic impact assessment" and "economic impact study". Economic impact analysis is different from BCA. It addresses regional economic impacts – typically not included in BCA – that can influence airport capital investment decisions to the extent that airport sponsors need the support of state and local governments and local communities to develop the airport and implement capital projects. Airport sponsors typically conduct an economic impact analysis of overall airport operations; however, they sometimes perform a more focused assessment of the economic impact of its CIP or a specific project.

Evaluations of the potential effects of a capital investment comes with uncertainty. This Appendix also discusses approaches to addressing uncertainty and the use of Monte Carlo simulations and sensitivity analyses in implementing any of the methodologies for evaluating capital investment decisions.

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[4] FAA, "Federal Aviation Administration Policy and Final Guidance Regarding Benefit Cost Analysis (BCA) on Airport Capacity Projects for FAA Decisions on Airport Improvement Program (AIP) Discretionary Grants and Letters of Intent (LOI) (64 FR 70107), *Federal Register*, Vol. 64, No. 240, Dec. 15, 1999.

Airport Capital Investment

What is Capital Investment?

Capital is defined as "accumulated goods devoted to the production of other goods." Investment is defined as "the outlay of money, usually for income or profit."[5]

In the airport context, the term "capital investment" is used less frequently than other terms – such as "airport development" or "capital improvement." Airport development is a statutory term in the context of the AIP – a significant source of funds for airport capital investment. Defined in Section 47102 (3) of Title 49 of the United States Code, airport development refers to activities undertaken by an airport, including, among other things, constructing, repairing or improving a public use airport, acquiring various types of airport equipment, land acquisition for the benefit of the airport and constructing, reconstructing or improving specific airport facilities.[6] In the context of the statute governing AIP, the term airport development is limited to projects or activities that are eligible for AIP funding.

The National Plan of Integrated Airport Systems (NPIAS) Report, an FAA document that estimates airport investment requirements, refers to "airport development needs" or "development requirements" rather than "investment needs."[7] By legislative requirement, the NPIAS Report is confined to estimating AIP-eligible development needs,[8] and the estimates in that report are consequently lower than those included in other studies that take a less restrictive approach to "airport capital development." A Government Accountability Office (GAO) report on planned airport development costs and funding levels similarly refers to "airport capital development."[9]

Considering the purposes of this ACRP 03-19 working paper and its intended audience, "capital investment," as used in this paper, is defined as the expenditure of funds on airport development, in its broadest sense – the expenditure of funds on the construction, repair or improvement of an airport or airport facilities, acquisition of airport equipment, or acquisition of land for the benefit of the airport, regardless of eligibility for AIP grants.

Airport Capital Investment Projects

Airport capital investment projects are primarily divided into two broad categories—airside and landside—following the classification of airport facilities. Airside facilities are those on

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[5] Merriam-Webster's Collegiate Dictionary, 10th Ed., 1994.

[6] 49 USC §47102(3).

[7] FAA, National Plan of Integrated Airport Systems 2009-2013, Report to Congress ("NPIAS Report"), Washington, D.C., Sept. 30, 2008, pages Viii and 61.

[8] 49 USC § 47103(a).

[9] GAO, Observations on Airport Development Costs and Funding Levels and the Administration's Proposed Changes in the Airport Improvement Program GAO 07-885, Washington, D.C., rev. Jul. 5, 2007, pages 2-3.

which aircraft operations are carried out.[10] Therefore, airside projects can include construction of new runways, reconstruction of existing runways, relocation of runways or taxiways, or acquisition of aircraft rescue and firefighting equipment. Landside facilities include parts of the airport serving passengers, including surface transportation.[11] Therefore, landside projects would include construction, expansion and reconstruction of a passenger terminal; construction or reconstruction of ground access facilities; and construction of automobile parking facilities. Terminal reconstruction can also include replacement of terminal components and infrastructure, such as heating, ventilating and air conditioning (HVAC) systems or electrical systems.

Beyond these two categories, there are two other categories under which airport capital investments fall. A third category—miscellaneous airport utility infrastructure projects—may support either airside or land-side facilities and operations. Projects in this category may include electrical distribution and fiber cable, water and sanitation. The cost of these projects are assigned to the airside or the landside depending on the area served by the project. If the project supports both landside and airside operations or facilities, the project cost will be allocated between the two. A fourth category of capital investment projects—environmental projects – cannot be easily categorized as airside or landside. Often these projects occur outside the boundary of the airport, even if the decision to implement the project is driven by a project or operations located on the airport.

Airport capital investment projects typically are intended to meet one or more of the objectives listed below:

- Enhancing capacity – enabling the airport to accommodate a higher volume of traffic or larger aircraft types or to accommodate current volumes with reduced delays[12]
- Preserving capacity – enabling the airport to continue to serve existing traffic
- Safety/security – meeting FAA and Transportation Security Administration (TSA) safety and security requirements, respectively, or enhancing the safety and security of the airport for aircraft operators, passengers and cargo
- Revenue generation – providing facilities and services to enhance airport revenues
- Customer service – providing facilities and services to facilitate passenger movement within the airport or to enhance passenger comfort and experience in the airport
- Standards compliance – projects to adjust the configuration of the airport to meet FAA design standards for the existing aircraft fleet mix

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[10] Wells, A., *Airport Planning & Management*, Third Edition, McGraw Hill, New York, N.Y., 1996, page 100.

[11] *Ibid*, page 101.

[12] Airport sponsors sometimes characterize the objective of a capital project as reducing congestion (i.e. enabling current levels of traffic or operations with reduced delays). For purposes of this report, such projects are considered as capacity enhancing projects because they are evaluated using the same techniques and criteria as projects characterized as enhancing capacity.

- Environmental enhancement or mitigation – projects to satisfy environmental requirements associated with other airport capital investment projects or airport operations, or projects to reduce or mitigate the environmental impacts associated with the airport
- Efficiency improvement – reducing operating costs by replacing old technologies and structures with current systems

In many cases, a project may serve multiple objectives. For example, a runway rehabilitation project preserves capacity and may also enhance safety by reducing the risk that debris from deteriorating pavement will be ingested into an aircraft engine. Table A-1 and Table A-2 below provide a summary of capital investment projects typically undertaken on the airside and landside of an airport, respectively, as well as the objectives those projects typically serve.

Table A-1. Typical Airside Capital Projects and Objectives

Capital Project	Project Objectives
Construct new runways, taxiways and/or aprons	Enhancing capacity
Reconstruct or rehabilitate runways, taxiways and/or aprons	Preserving capacity and safety
Relocate runways, taxiways and/or aprons	Standards compliance and safety
Construct runway safety area	Safety
Acquire land for runway protection zone	Safety
Construct ARFF building	Safety
Construct snow removal equipment building	Safety and enhancing capacity
Construct hangars or commercial general aviation facilities	Revenue generation
Construct aircraft deicing apron	Safety and environmental enhancement
Acquire ARFF equipment	Safety
Acquire snow removal equipment	Safety and enhancing capacity
Acquire aircraft deicing equipment	Safety and environmental enhancement
Acquire and install navigation aids or lighting	Safety and enhancing capacity
Construct Aviation Fuel Farm	Revenue generation

Table A-2. Typical Landside Capital Projects and Objectives

Capital Project	Project Objectives
Construct new terminal/expand existing terminal	Capacity, customer service and efficiency
Replace or reconstruct terminal, including major system replacement	Customer service and efficiency
Construct or expand parking garage	Revenue generation and customer service
Construct consolidated rental car facilities	Revenue generation, customer service and environmental enhancement
Construct, expand or rehabilitate airport access roadways	Customer service and enhancing or preserving capacity
Construct automated passenger movement systems	Customer service, environmental enhancement, and enhancing capacity
Construct or expand cargo facilities	Revenue generation and enhancing or preserving capacity
Construct central heating/refrigeration plant	Customer service and efficiency
Construct electrical substation	Customer service and efficiency

Sources of Funding

A variety of funding sources are available for airport capital investments. Certain funding sources are more suitable for some projects than others. And, certain funding sources call for the application of a particular methodology and technique for evaluating whether a project merits funding and implementation.

The main categories of funding sources are debt instruments, federal grants, passenger facility charges (PFCs), state and local contributions, and airport cash flow:

- For the airport system as a whole, debt instruments constitute the largest source of funds – accounting for 50 percent of funding for capital projects, according to the GAO, based on data for the 2001-2005 period.[13] Debt instruments take a variety of forms. Long-term debt instruments include general airport revenue bonds (GARBs), general obligation (GO) bonds, special facility bonds, and PFC bonds, each distinguished by the type of revenues pledged for debt service. GARBs are backed by a pledge of the general revenues from airport operations (see the discussion of airport cash flow below). Issued by state and local governments, GO bonds are backed by a pledge of the full faith and credit of the issuing government, including the use of its taxing authority as needed to meet the bond obligations. Special facility bonds are backed solely by the revenue stream generated from the facility to be financed – for example, a consolidated rental car facility, terminal, hangar, or cargo facility. PFC bonds are backed by PFC revenues as discussed below. Airport sponsors sometimes use short-term financing devices, such as commercial paper or variable-rate notes, to meet short-term cash needs, and later refinance using GARBs.

[13] GAO, Observations on Airport Development Costs and Funding Levels and the Administration's Proposed Changes in the Airport Improvement Program GAO 07-885, Washington, D.C., revised Jul. 5, 2007, page 8.

- AIP grants are the second largest source of funds at 29 percent of funding for airport capital projects.[14] For smaller airports, however, AIP grants are a more important source of capital funding because access to debt is limited. The bulk of grant funds used to finance airport capital investments come from the AIP administered by the FAA. The AIP statute defines the kinds of projects that are eligible for AIP funding. Airside projects, except hangars and other revenue generating facilities, are generally eligible and get high funding priority. Landside terminal projects, access roads and other ground access projects have limited eligibility and low priority. This is apparent in the distribution of FY 2008[15] AIP funds (Table A-3), with airside projects receiving the largest allocation. Two-thirds of AIP funds are distributed to airports under various apportionment formulae. The remaining one-third, considered "discretionary", is subject to set-asides for the following: planning and implementation of noise compatibility programs; projects at reliever airports;[16] and projects to assist in the conversion of military airfields to civil use. Of the remaining discretionary funds, 75 percent must be applied to AIP-eligible projects at primary and reliever airports, and the balance may be spent on AIP-eligible projects at any eligible airport.[17]

Table A-3. Distribution of AIP Funds for FY 2008

Development Category	Amount
Airside	$2,379,300,000
Landside Terminals	$351,300,000
Landside Access	$39,100,000
Noise	$272,700,000
Unclassified (State Block Grants & Misc.)	$403,900,000

Source: FAA, Airport Improvement Program Fiscal Year 2008, 25th Annual Report of Accomplishments (AIP Annual Report, 2008), April 2010, page E-2.

- PFC revenue accounts for 17 percent of funding for airport capital projects.[18] PFCs are locally imposed airport charges, subject to FAA approval and regulation. Charges can be assessed at the levels of $1.00, $2.00, $3.00, $4.00 or $4.50. Currently all

[14] Ibid.

[15] Federal fiscal year 2008 is the most recent year for which FAA has its comprehensive report on administration of the AIP.

[16] Reliever airports refer to a category of general aviation airports designated by the FAA as relieving congestion at larger primary airports by providing alternative airport access to general aviation flights.

[17] FAA, Airport Improvement Program Fiscal Year 2008, 25th Annual Report of Accomplishments (AIP Annual Report, 2008), April 2010, page 27.

[18] GAO, Observations on Airport Development Costs and Funding Levels and the Administration's Proposed Changes in the Airport Improvement Program GAO 07-885, Washington, D.C., revised Jul. 5, 2007, page 8.

airports collecting PFCs do so at the $3.00 or $4.50 level.[19] The statute authorizing collection of PFCs (49 USC § 40117) also specifies project eligibility and other standards for approval. PFC eligibility is similar but broader than AIP eligibility. First, PFCs can be used to finance components of terminal development that are ineligible for AIP funding. Second, PFCs can be used to pay interest and other financing costs of projects, while only actual project construction or equipment costs are eligible for AIP funding.[20] Additionally, airports can use PFCs to pay for the "local" match for AIP-eligible projects not funded with AIP grants. Airports use PFCs to finance capital investment in two ways. First, PFCs are used on a pay-as-you go ("pay-go") basis – PFC revenues are used directly to pay for project costs as the PFCs are collected. Second, because PFCs can be used to pay interest, PFCs are often leveraged to support issuance of debt, either with a secondary pledge of general airport revenue ("double barrel" bonds), or with the pledged revenue stream defined to include PFCs (GARBs for which PFCs are included in the definition of general airport revenues, which are pledged for the payment of the GARB debt service), or with the PFCs as the sole revenue pledge ("stand alone" bonds).

- State and local contributions account for four percent of funding for airport capital projects.[21] These include state and local grants, loans and matching funds for AIP grants. States derive funds from a variety of sources, including the general fund, aviation fuel taxes, aircraft sales and use taxes, and other sources including hangar rents and other property leases, and tax revenue. Local municipalities provide funds from local taxes and airport cash flow as discussed below.[22]
- Airport cash flow can be used to pay for capital projects directly or to pay debt service on GARBs. Airport cash flow includes current net airport revenues derived from operations. Revenue streams typically include landing fees and rental payments from air carriers; rental payments (and possibly landing fees) from other aviation users; fuel flowage fees; aircraft apron parking and tie-down fees; rental payments and other fees from concession operators; charges to rental car concessions; and automobile parking revenue.[23] For purposes of this report, cash flow also refers to any accumulated cash balances (sometimes referred to as equity) that the airport chooses to apply to capital investment projects. At most airports, rental rates, landing fees and concession charges are established by agreements with the airlines using the airport and concession operators. Depending on the

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[19] FAA, *PFC Approved Locations, Collections, and Expiration Dates*, 2010 (updated monthly). [Online]. Available: http://www.faa.gov/ airports/pfc/monthly_reports/.

[20] 49 USC § 40117.

[21] GAO, *op. cit.*, page 8.

[22] Horonjeff, R., F. McKelvey, W. Sproule, and S. Young, *Planning and Design of Airports*, Fifth Edition, McGraw-Hill, New York, N.Y., 2010, page 558.

[23] Some airports generate additional revenue from other activities, such as farming or mineral extraction, but these activities are not widespread.

airport, the lease and use agreement with carriers may specify the amount of net revenue the airport will generate each year and how that revenue will be distributed or used.

Airport cash flow can be used to fund any type of project listed in Table A-1 and Table A-2. Each of the three other major funding sources is more suitable for certain projects than others, because of eligibility requirements in the case of grant and PFC funding, the availability of an identifiable stream of cash inflow to support debt financing, and the magnitude and timing of a project's funding requirement. Table A-4 and Table A-5 identify the funding sources available for specific airside and landside projects. The less commonly used sources for a particular project are listed in italics.

Table A-4. Typical Airside Projects and Funding Sources

Capital Project	Funding Sources*
Construct new runways, taxiways and/or aprons	AIP grants (including LOIs[24]), PFCs, GARBs, and airport cash flow
Reconstruct or rehabilitate runways, taxiways and/or aprons	AIP grants (including LOIs at small airports), PFCs, GARBs, and airport cash flow
Relocate runways, taxiways and/or aprons	AIP grants (including LOIs), PFCs, GARBs, and airport cash flow
Construct runway safety area	AIP grants, PFCs, GARBs, and airport cash flow
Acquire land for runway protection zone	AIP grants, PFCs, GARBs, and airport cash flow
Construct ARFF building	AIP grants, PFCs, GARBs, and airport cash flow
Construct snow removal equipment building	AIP grants, PFCs, GARBs, and airport cash flow
Construct hangars or commercial general aviation facilities	Special facility bonds, airport cash flow, and *GARBs*
Construct aircraft deicing apron	PFCs, GARBs, airport cash flow, and *AIP grants*
Acquire ARFF equipment	AIP grants, PFCs, GARBs, and airport cash flow
Acquire snow removal equipment	AIP grants, PFCs, GARBs, and airport cash flow
Acquire aircraft deicing equipment	PFCs, GARBs, airport cash flow, and *AIP grants*
Acquire and install navigation aids or lighting	PFCs, GARBs, airport cash flow, and *AIP grants*

**Less commonly used funding source in italics.*

[24] LOI's are not funding sources as such. They are a commitment by the FAA to provide AIP discretionary funds.

Table A-5. Typical Landside Projects and Funding Sources

Capital Project	Funding Sources*
Construct new terminal or expand existing terminal	PFCs, GARBs special facility bonds, airport cash flow, and *AIP grants*
Replace or reconstruct terminal, including major system replacement	PFCs, GARBs special facility bonds, airport cash flow, and *AIP grants*
Construct or expand parking garage	Special facility bonds, airport cash flow, and GARBs
Construct consolidated rental car facilities	Special facility bonds, airport cash flow, and *GARBs*
Construct, expand or rehabilitate airport access roadways	PFCs, GARBs special facility bonds, airport cash flow, and *AIP grants*
Construct automated passenger movement systems	PFCs, GARBs special facility bonds, airport cash flow, and *AIP grants*
Construct or expand cargo facilities	GARBs, special facility bonds, and airport cash flow

**Less commonly used funding source in italics.*

Certain funding sources call for the use of a particular analytical methodology and technique. For example, applications for AIP discretionary grant funding in the amount of $5 million or more, or AIP/LOI funding of any amount to finance AIP-eligible airport capacity projects, must be supported by a BCA, as required by the FAA. Details of the FAA BCA Policy for AIP discretionary grants and LOIs are contained in an official notice published in the Federal Register on Dec. 15, 1999. For the purpose of this BCA policy, airport capacity projects are defined as:

> *Those projects that (1) Preserve an infrastructure, (2) Improve upon an existing infrastructure, or (3) Create a new infrastructure. Capacity projects include airside projects such as runways, taxiways, and aprons but may also include terminal buildings, ground transportation, and other landside projects. Normally, airport capacity projects are located at large air carrier airports where there is existing or projected airfield capacity delay. However, there are also cases they will be located at smaller airports. For the purpose of this BCA policy, airport capacity projects include those projects that significantly change the character of a runway such that the runway is capable of being used by larger or heavier aircraft or such that approach minima are lowered. The BCA policy also covers those projects which will upgrade airport facilities to meet higher design standards and which will allow new classes of aircraft to use the airport.*

The BCA policy does not apply to projects undertaken solely for the objective of safety, security, conformance with FAA standards, or environmental mitigation.[25]

The basis for the FAA BCA requirement is Executive Order 12893, which establishes the guiding principles for federal infrastructure investment, including the systematic analysis of transportation infrastructure project benefits and costs, among others. The Executive

[25] FAA, Policy and Final Guidance Regarding Benefit Cost Analysis (BCA) on Airport Capacity Projects for FAA Decisions on Airport Improvement (AIP) Discretionary Grants and Letters of Intent (LOI), Washington, D.C., Dec. 15, 1999.

Order requires federal agencies to evaluate infrastructure investment at both the program level (e.g., AIP level) and the individual project level. Executive Order 12893 further requires that agency plans to implement the guiding principles be consistent with analytical techniques outlined in Office of Management and Budget (OMB) Circular A-94.[26] The Circular recommends BCA in formal economic analyses of government programs or projects, and CEA, a less comprehensive technique, when the benefits from competing alternatives are the same or when a policy decision has already been made to provide a particular benefit. The Circular prescribes the use of a seven percent discount rate in present value calculations for BCAs, and establishes policy for the treatment of inflation and changes in real costs.[27] The FAA, in turn, published the “FAA Airport Benefit-Cost Analysis Guidance”[28] to provide guidance to airport sponsors in conducting project-level BCA of capacity-related airport projects and “to facilitate the production of consistent, thorough, and comparable analyses that can be used by the Federal Aviation Administration (FAA) in its consideration of airport projects for discretionary funding under the Airport Improvement Program (AIP)”.[29]

The principles of Executive Order 12893 apply to federal spending – direct spending and grants – for infrastructure programs, such as AIP grant funding of airport infrastructure projects. They do not apply to PFC funding. FAA policy, therefore, does not require a BCA in the PFC application and review process, but does not preclude an airport sponsor from submitting a BCA to support its case for adequate justification of proposed PFC projects.[30]

When airport sponsors sell bonds to raise capital funds, they issue an Official Statement – a document or documents prepared by or on behalf of the issuer that contain information relevant to the bonds.[31] Official Statements typically include a *financial feasibility report*, also called *airport consultant report*. The financial feasibility report presents an independent assessment of the ability of the airport sponsor to generate sufficient pledged revenues to cover debt service and associated costs, and is typically prepared by an airport consultant.

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[26] Executive Office of the President, *Principles of Federal Infrastructure Investment*, Executive Order 12893, Jan. 26, 1994.

[27] OMB, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Circular No. A-94, Oct. 29, 1992. [Online] Available: http://www.whitehouse.gov/omb/circulars_default.

[28] FAA, Office of Aviation Policy and Plans, *FAA Airport Benefit-Cost Analysis Guidance*, Washington, D.C., Dec. 15, 1999. [Online]. Available: http://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/faabca.pdf.

[29] *Ibid*, page 1.

[30] FAA, Policy and Final Guidance Regarding Benefit Cost Analysis (BCA) on Airport Capacity Projects for FAA Decisions on Airport Improvement (AIP) Discretionary Grants and Letters of Intent (LOI), Washington, D.C., Dec. 15, 1999.

[31] Municipal Securities Rulemaking Board (MSRB), *Glossary*, Nov. 19, 2010. [Online]. Available: http://www.msrb.org/msrb1/glossary/view_def.asp?param=OFFICIALSTATEMENT.

While airport sponsors – usually with the help of consultants – typically prepare a BCA when applying to the FAA for AIP discretionary or LOI grant funding and a financial feasibility study when issuing bonds, they routinely employ financial planning techniques, such as rates and charges analysis and financial affordability analysis, as part of their CIP planning process. Part of this exercise is the identification of different capital funding sources for the different projects that make up the CIP, and airport sponsors typically perform financial planning for the entire CIP, rather than individual projects.

When airport sponsors seek funding assistance from state and local governments, it helps to demonstrate how airport operations, the CIP, or an individual project contribute to employment, income and output in the state or local economy. Economic impact analysis is useful for this purpose. Airport sponsors typically have economic impact studies prepared for the entire airport operations, not limited to their CIP or particular projects.

Decision Considerations

There are many considerations in airport capital investment decision making because many parties are involved in decision making and in obtaining funding.

Who makes decisions regarding airport capital investments? While airport sponsors and staff are primarily responsible for making decisions regarding airport capital investments, in so doing they often need to obtain the approval or support of local government and community leaders. Airport tenants are involved in decision making to the extent that the capital investment affects particular tenants' operations and will require the tenants to pay higher fees or help collect user fees to finance the capital investment. In particular, certain air carrier lease and use agreements give air carriers approval rights over capital investment decisions or a decision to issue bonds that will be paid for with the fees, rentals and other charges they pay to the airport. The FAA oversees all aspects of civil aviation in the United States including planning and development, reviewing airport master plans, administering the AIP and the PFC program, and approving AIP and PFC funding of specific airport capital projects. Other parties also become involved in decision making to the extent that they provide or approve funding.

Airport capital investment needs and potential funding sources are typically identified during the process of developing airport master plans and CIPs. Airport sponsors make decisions on individual projects within the context of the CIP and the overall CIP funding plan. Before proceeding with the implementation of a particular project, airport sponsors need to consider a variety of issues:

- Will the project meet one or more key objectives of the airport operator?
- Should the project be pursued now or can it be deferred?
- Does the value of the operational benefits of the project exceed the costs that will continue to be incurred if the project is deferred?
- What is the proper scope for the project?

- What is the best alternative for meeting the objective of the project?
- What is the best funding source (or combination of funding sources) for the project?
- Is the project affordable?

Once the airport sponsor decides to proceed with project implementation, the airport sponsor needs to address other considerations specific to the identified funding source(s) and the other parties – air carriers and other airport tenants, the FAA, and parties involved in debt financing –whose approval is needed to obtain funding. Listed below are some of the decision considerations by major funding source.

Debt

- How much of the project costs should be financed with debt?
- What form of debt should be issued and will there be a market for the debt?
- Can the airport sponsor generate sufficient revenue to meet debt service obligations and other financial covenants, such as debt service coverage requirements?
- How will the new debt affect the ability to pay existing debt service obligations?
- How will the new debt affect the bond ratings of existing debt?
- How will the new debt affect air carrier landing fees, rental rates and other charges, and air carrier costs per enplanement (CPE)? (The reasonableness of an airport's rates and charges is usually measured by the projected CPE. This metric is calculated as the amounts charged to the airlines each year, divided by the number of enplanements. An airport's CPE is often compared to the same metric at other similarly sized airports as a gauge of the reasonableness of the airport's rates and charges.)
- How will the new debt affect the airport sponsor's debt capacity (its ability to issue future debt for future capital projects)?
- What factors can introduce risks to the ability of the airport sponsor to meet its debt service obligations?

AIP Grant Funds

- Is the project eligible?
- Is the project a high priority?
- Is the project justified, according to FAA criteria?
- What will be the savings in CPE if AIP funds are obtained?
- Can the airport sponsor generate the funding required to meet the local matching share requirements of AIP?

- Are other statutory and administrative requirements satisfied?[32]

In evaluating AIP grant applications, the FAA will examine the following:

- Whether sufficient funds are available to cover costs not covered by the grant (for all grants)
- The project's effect on system capacity (for LOI requests)
- The project's benefits and costs (for LOI requests and capacity projects seeking more than $5 million in discretionary funds)
- Financial commitments from non-U.S. government sources (for LOI requests and capacity projects)
- Projected passenger or aircraft growth (for LOI requests and capacity projects)

Passenger Facility Charges

- Is the project eligible for PFC funding and consistent with other PFC standards?
- Is the project justified, according to FAA approval criteria?
- If a medium or large hub airport is requesting approval for a $4.00 or $4.50 PFC, does the project make a "significant contribution" to a statutorily defined PFC objective?
- Will the project be implemented within the time-frames required by the FAA?
- Will the airport generate sufficient PFC revenues to finance the new project while continuing to meet existing PFC commitments (including debt-service requirements and PFC pay-as-you-go projects under construction)?
- Are financial resources available to meet any project costs not covered by PFCs?
- Does the amount of PFCs requested exceed the costs of the project after accounting for other sources of funding?
- Are there other capital projects in the pipeline that would represent a better use of PFC revenue?
- How will the project and PFC financing benefit air carrier operations at the airport?
- Is the project – and thus PFC revenue requirements – properly scoped and designed (i.e. does the proposed project reflect reasonable costs)?
- What will be the impact on the CPE of the capital costs not funded with PFCs and of the incremental operations and maintenance costs of the project?

[32] Only those requirements related to the subject matter of this research are listed.

- Have any carrier objections to the project been adequately addressed or mitigated? Is it reasonable to move forward with PFC funding in the face of the objections?

Airport Cash Flow

Funding from current revenues:

- What will be the impact of financing the project on landing fees, rental rates and other charges to carriers and other aeronautical users?
- What will be the impact of financing the project on fees and charges assessed to non-aeronautical users?
- What will be the impact of financing the project on the CPE? How will the change in CPE affect the competitive position of the airport?
- How will the project benefit operations at the airport by air carriers and other tenants? Are there other projects that could be more beneficial to the operations of air carriers and other tenants?
- What will be the impact of financing the project on compliance with financial covenants in existing debt obligations?

Funding from accumulated cash balances:

- What will be the impact of financing the project on compliance with financial covenants in existing debt obligations?
- What will be the impact of financing the project on the airport's liquidity and its ability to survive a downturn in activity and revenue?

Economic Analysis

In practice, airport sponsors perform economic analysis – BCA in particular – because it is a requirement when applying for AIP discretionary grant funding of at least $5 million or any amount of funding under an LOI for airport capacity projects. In the past, BCA, for purposes of meeting the FAA AIP grant funding requirement, was performed by the FAA staff. In June 1997, the FAA issued a policy notice that transferred the responsibility for performing the BCA from the FAA to the airport sponsor, recognizing that BCA is most useful if done early in the airport planning process by the airport sponsor.[33] The policy leaves airport sponsors to decide when to prepare a BCA, but encourages airport sponsors to do so during master planning – during project formulation and alternatives selection – when BCA would be most

[33] FAA, "Policy and Guidance Regarding Benefit Cost Analysis for Airport Capacity Projects Requesting Discretionary Airport Improvement Program Grant Awards and Letters of Intent" (62 FR 34108), *Federal Register*, Vol. 62, No. 121, Jun. 24, 1997.

useful.[34] The FAA prepared guidance to promote uniform standards in performing BCA of airport capacity projects, and "to increase the airport sponsor's acceptance of the BCA as one of several useful methodologies, not merely a requirement imposed from outside."[35]

As presented in Appendix A1, the Annotated Bibliography for this research, the federal requirement, policies and guidance for economic analysis of federal infrastructure investment are contained in the following documents:

- Executive Office of the President, *Principles of Federal Infrastructure Investment*, Executive Order 12893, Jan. 26, 1994. EO 12893 requires that infrastructure investments be based on, among others, a systematic analysis of expected benefits and costs, including both quantitative and qualitative measures.
- OMB, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Circular A-94 Revised, Oct. 29, 1992. OMB Circular A-94 outlines the analytical techniques required to carry out the above principles. It provides general guidance for conducting benefit-cost and cost-effectiveness analyses. It also provides specific guidance on the discount rates to be used in evaluating federal programs.

The FAA final BCA policy is stated in "Policy and Final Guidance Regarding Benefit Cost Analysis on Airport Capacity Projects for FAA Decisions on Airport Improvement Program (AIP) Discretionary Grants and Letters of Intent (LOI)," *Federal Register*, Vol. 64, No. 240, Dec. 15, 1999. The FAA policy requires all airport sponsors to submit BCAs when requesting AIP discretionary grants in excess of $5 million or an LOI to be awarded for capacity projects. For the purpose of this BCA policy, airport capacity projects are those projects that (1) preserve an infrastructure, (2) improve upon an existing infrastructure, or (3) create new infrastructure. The BCA requirement does not apply to those projects undertaken solely for the objectives of safety, security, conformance with FAA standards, or environmental mitigation.

In addition, the following FAA publications, also reviewed in the Annotated Bibliography, provide guidance for performing economic analysis specifically for airport projects:

- FAA, Office of Policy and Plans, *Economic Analysis of Investment and Regulatory Decisions – Revised Guide*, FAA-APO-98-4, Washington, D.C., January 1998. This document gives an overview of economic analysis and describes the process and underlying principles in estimating and comparing benefits and costs.
- FAA, Office of Policy and Plans, *FAA Airport Benefit-Cost Analysis Guidance*, Washington, D.C., Dec. 15, 1999. This document provides detailed guidance to

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[34] FAA, "Federal Aviation Administration Policy and Final Guidance Regarding Benefit Cost Analysis (BCA) on Airport Capacity Projects for FAA Decisions on Airport Improvement Program (AIP) Discretionary Grants and Letters of Intent (LOI) (64 FR 70107), *Federal Register*, Vol. 64, No. 240, Dec. 15, 1999.

[35] Ibid.

airport sponsors for conducting project-level BCA for capacity-related airport projects.

Economic analysis provides a systematic framework for documenting and comparing project costs and benefits, and comparing the net benefits of different project alternatives. Airport sponsors are encouraged to perform economic analysis because: (1) it helps direct resources to their most efficient use; (2) it can be used to determine the optimal timing and scale of projects; and (3) it also provides a transparent documentation of the decision process. Given limited resources, airport sponsors need to decide whether or not to pursue a particular project objective and how best to achieve this objective given alternatives. Within an airport, the results of BCA can be used with other criteria to rank projects and establish priority for funding and implementation in airport CIPs. At the federal level, the FAA uses the results of BCA, along with other criteria, for allocating available federal capital funding.

Whereas financial analysis considers only the cash flows associated with a particular project that accrue to the investment proponent, economic analysis considers all costs and benefits, monetary and non-monetary, not limited to those incurred by the project proponent. In the case of airport investment projects, economic analysis considers costs and benefits to all users, for example, passengers, airlines, shippers, and general aviation (GA) users. It can also consider costs and benefits to non-users, such as those who drop off and pick up passengers, and residents in areas around the airport. This broader treatment of costs and benefits makes economic analysis the recommended methodology for evaluating public investment decisions.

This section describes two techniques for the economic analysis of capital projects: (1) *benefit-cost analysis* (BCA) and (2) *cost-effectiveness analysis* (CEA). BCA is more comprehensive because it evaluates both benefits and costs. BCA can help in deciding whether or not to implement a project, and in selecting among alternative ways of achieving the investment objective. CEA is a less comprehensive technique, whereby the analyst compares either only the costs of alternatives that yield the same benefits (*least cost study*), or only the benefits of alternatives that cost the same (*constant-cost study*).[36] CEA is appropriate when a decision has already been made to meet an investment objective, and there is a choice among alternative means that have either the same benefits or costs.

A third method, *economic valuation,* provides the techniques for expressing economic benefits and costs in monetary units to be used in economic analysis.

BCA, CEA, and economic valuation are described below in a manner that is consistent with the relevant FAA guidance. While the *FAA Airport Benefit-Cost Analysis Guidance* (the FAA

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[36] FAA, Office of Policy and Plans, *Economic Analysis of Investment and Regulatory Decisions – Revised Guide*, FAA-APO-98-4, Washington, D.C., January 1998, page 2-1.

BCA Guidance) addresses the BCA of capacity-related projects for AIP grant funding, economic analysis can be used to evaluate all types of airport capital projects, including those intended for safety, security, conformance with FAA standards, or environmental mitigation. The FAA guide on *Economic Analysis of Investment and Regulatory Decisions* is geared toward a more general application of economic analysis. The FAA guide on *Economic Values for FAA Investment and Regulatory Decisions*[37] provides economic values for the evaluation of airport projects not limited to those addressing capacity.

BCA and economic valuation techniques have been previously discussed in ACRP Report 27 in the context of evaluating the economic costs of land use incompatibility.[38] These techniques are discussed again in this Appendix to provide a complete description of methodologies and techniques for evaluating airport capital investment decisions.

Benefit-Cost Analysis

Benefit-cost analysis, also known as cost-benefit analysis, is a systematic process for evaluating the benefits and costs of a project. It addresses the following questions: (1) Should a particular investment be made, based on whether the benefits justify the costs; and (2) which, among competing alternatives, should be selected? BCA can also help determine the optimal timing for project implementation and scale of the project so that benefits exceed costs. To the extent possible, all benefits and costs should be quantified and expressed in monetary units.

In theory, the assessment of benefits and costs is done from a societal perspective. The objective is to determine whether the investment will yield net benefits to society, and which investment alternative will yield the highest net benefits. It does not matter who bears the costs and who enjoys the benefits.

In practice, whose benefits and costs should be counted depends upon the context of the analysis, and this should be clarified at the outset. According to OMB Circular A-94 Revised, benefit-cost analyses of federal programs and projects that affect private citizens and other levels of government must consider benefits and costs to *society* (specifically the United States), not to the federal government. According to the FAA BCA Guidance, the analysis of airport capacity projects should consider all benefits and costs affecting the *aviation public* or directly attributable to aviation. The rationale for this is that airport investments are funded in whole or in part with federal grants under the AIP, with monies coming from the Airport and Airway Trust Fund. The Airport and Airway Trust Fund has historically received its revenue from taxes imposed on the aviation system users.

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[37] GRA, Incorporated, *Economic Values for FAA Investment and Regulatory Decisions, A Guide*, Final Report, FAA Office of Aviation Policy and Plans, Washington, D.C., Oct. 3, 2007.

[38] Ward, S., R. Massey, A. Feldpausch, C. Duerksen, E. Heller, N. Miller, R. Gardner, G. Gosling, S. Sarmiento, and R. Lee, "Volume 1: Land Use Fundamentals and Implementation Resources, Chapter 5: Economic Costs of Airport Land Use Incompatibility," and "Volume 3: Additional Resources," *ACRP Report 27: Enhancing Airport Land Use Compatibility*, Transportation Research Board, National Research Council, Washington, D.C., 2010.

The BCA Process

The BCA process described here is consistent with the process prescribed in the FAA BCA Guidance and consists of the following steps:

- Define the objective of the proposed project
- Specify the assumptions about future airport and local market conditions
- Identify the base case
- Identify reasonable alternatives
- Determine the evaluation period
- Identify benefits and costs
- Compare benefits and costs
- Perform sensitivity analysis and address risks and uncertainties
- Make recommendations

Define the objective of the proposed project. The objective must be stated in a manner that does not prejudge the means to achieve the objective. The proposed capital investment can have one or more objectives, defined within the context of an identified problem or opportunity. If the BCA is done for the purpose of obtaining AIP funding, a project with multiple objectives must be identified with one principal objective that represents the largest source of project benefits. The BCA requirement applies only to capacity-related projects funded with AIP discretionary grants or issuance of an LOI. Airport capital infrastructure projects can have any of the following objectives, among others:

- Reduce delay associated with airport congestion
- Improve efficiency of airport operations
- Increase the number of aircraft and passengers the airport can serve
- Permit new service by accommodating larger and more efficient aircraft
- Improve or maintain airport safety and security
- Mitigate environmental impacts
- Improve passenger comfort and convenience
- Lower airport operating costs

Specify the assumptions about future airport and local market conditions. The BCA requires numerous assumptions that should be disclosed and explained in the BCA report. These assumptions typically include:

- Projected growth in demand for airport services

- Future changes in airport facilities and capacity that are likely to occur independently of the proposed investment
- Binding constraints on airport capacity that would not be affected by the potential investment
- Improvements in regional air traffic management procedures (for example, anticipated improvements resulting from FAA's implementation of Next Generation Air Transportation System, if any, within the project evaluation period)

Identify the base case. The base case serves as the reference for assessing the incremental benefits and costs of alternatives, and so it is important that the base case is established correctly. According to the FAA BCA Guidance, the base case should not be identified as a "do nothing" scenario. Rather, the base case should represent the best course of action that would be pursued in the absence of a major initiative to obtain specified objectives. The base case must (1) assume optimal use of existing and planned airport infrastructure; (2) incorporate all improvements to airport infrastructure currently underway and/or funded; and (3) incorporate reasonable expectations of corrective actions by airport managers, users and air traffic managers.

Identify reasonable alternatives. The analyst must consider the full range of alternative actions that can be undertaken to achieve the investment objective. The identification of alternatives must consider: (1) if the objective can be addressed to different degrees – leading to alternative scope and timing; and (2) if there are different ways of meeting the objective. Each alternative must represent a reasonable, well-founded, self-contained option. Not all alternatives will require detailed analysis. Certain options can be ruled out quickly through a preliminary screening process – as inadequate, infeasible, or clearly not cost-beneficial. The FAA BCA Guidance states that, at the minimum, the following alternatives for any airport infrastructure project should be identified and discussed:

- Investment in new facilities
- Refurbishment, replacement, and enhancement of existing facilities
- Demand management strategies

Determine the evaluation period. The evaluation period must be long enough to encompass the important benefits and costs of the proposed action. It can be determined based on:

- Requirement life – the period over which benefits will be greater than costs, not to exceed 30 years from a practical standpoint
- Physical life – the period over which the asset is expected to last
- Economic life – the period over which the asset itself can be expected to meet the requirement for which it was acquired in a cost-effective manner, not to exceed requirement life

The FAA generally uses an evaluation period covering at least 20 years beyond the completion of construction for major airport infrastructure projects. The same evaluation period must be used to compare the benefits and costs of mutually exclusive alternatives. There are cases, particularly at smaller airports with lower volumes of activity, when a longer evaluation period may be justified. However, the process of discounting to account for differences in the timing of the occurrence of costs and benefits causes costs and benefits in the later years to have progressively less effect on the overall net benefit. At the same time, uncertainty about the future values of the costs and benefits increases with time. Therefore, extending the evaluation period beyond 30 years may not be worthwhile and may even produce misleading results.

Identify benefits and costs. For each alternative, identify the consequences to all relevant stakeholders over the entire evaluation period. To the extent possible, measure incremental benefits and costs in physical units and express them in monetary terms. The FAA BCA Guidance lists the typical benefits and costs associated with different types of airport capital improvements. As in the case of all transportation investments, many of the associated benefits from airport projects are not directly measured in dollars. Examples include travel time savings, avoided fatalities, avoided injuries, reduced aircraft emissions, and reduced exposure to aircraft noise. There are economic valuation techniques that can be used to assign dollar values to such benefits, and the FAA publishes a guide that contains economic values recommended for use in the benefit-cost analysis of airport projects. There will be benefits and costs that cannot be quantified and evaluated in dollar terms at all. The FAA BCA Guidance refers to these as *hard-to-quantify* benefits and costs, and recommends that they be discussed separately even if they cannot be included in the comparison of benefits and costs.

Compare benefits and costs. Most airport capital projects will generate benefit and cost streams over a multi-year period. Due to discounting, benefits and costs that occur sooner have greater value than the same amount of benefits and costs that occur later. Therefore, benefits and costs must be discounted to control for differences in timing using the appropriate discount rate. The present values of benefits and costs can be compared using the following recommended decision rules: (1) net present value (NPV), which equals the present value of benefits minus the present value of costs; and (2) benefit-cost (B/C) ratio, which is the ratio of the present value of benefits to the present value of costs. The B/C ratio is greater than 1.0 if the NPV is positive. The NPV and the B/C ratio often lead to the same conclusion of whether to accept or reject a project, but they can lead to different rankings of investment alternatives. When comparing mutually exclusive alternatives, select the one that yields the highest NPV. The NPV and the B/C ratio are the same capital investment decision rules used in financial analysis and is described in more detail below.

Address uncertainty. Decisions based on estimates and forecasts will need to consider inherent uncertainty. The analyst should perform a risk analysis to evaluate the effect of uncertainty on the results. There are a number of different approaches to risk analysis, as described in the final section of this Appendix.

Make recommendations. Recommend (1) whether to pursue the proposed investment, and/or (2) which alternative would best meet the investment objective. The recommendation will depend on the comparison of benefits and costs, sensitivity analyses, and consideration of hard-to-quantify benefits and costs.

Underlying Principles and Considerations

Analysts should note the following basic principles and considerations in performing BCA:

- *Economic analysis versus financial analysis.* Economic analysis considers social costs and benefits, while financial analysis considers only the cash benefits and costs accruing to the project proponent. In economic analysis, cost measurement excludes sunk costs, depreciation allowance, and interest expense.
- *Willingness-to-pay (WTP).* The measurement of costs and benefits must be based on the concept of WTP, which measures how much individuals or firms are willing to pay to avoid a particular cost or enjoy a particular benefit. This topic will be addressed further under the section on Economic Valuation below.
- *Life-cycle costs and benefits.* A given project will typically generate costs and benefits over a number of years—over its service life, in the case of infrastructure or equipment. All costs and benefits over the project life-cycle must be evaluated.
- *Treatment of inflation.* Inflation occurs when the prices of goods and services in the economy rise over time. If the values of costs and benefits are expressed in current dollars (with inflation, in *nominal* terms), they must also be discounted using a *nominal* discount rate. Alternatively, analysts can exclude the effects of inflation by expressing future values of costs and benefits in constant base-year dollars (in *real* terms) and discounting them using a *real* discount rate. This approach avoids the need to forecast inflation and reduces analytical complication. In economic analysis of public investment, it is considered best practice to forecast life-cycle costs and benefits without inflation.[39,40]
- *Time value of resources.* Even after controlling for the effects of inflation, a dollar today is worth more than a dollar in the future, because a dollar today can be invested immediately to yield a return. The *time value of resources*, also known as the *opportunity cost of capital*, is measured by the discount rate, which is equal to the economic return that could be earned if the resources were invested in their next best alternative use. OMB Circular No. A-94 recommends using a seven percent real discount rate for federal investment and regulatory analysis. OMB Circular No. A-94 recommends other discount rates for cost-effectiveness, lease-purchase, internal government investment, and asset sales analyses. These discount

[39] Federal Highway Administration, Office of Asset Management, *Economic Analysis Primer*, August 2003, page 10.

[40] FAA, Office of Aviation Policy and Plans, *FAA Airport Benefit-Cost Analysis Guidance*, Washington, D.C., Dec. 15, 1999, page 76.

rates are updated annually and can be obtained from the OMB.[41] BCAs submitted to the FAA to support AIP / LOI funding requests must use the OMB prescribed seven percent discount rate, until the OMB issues an update. The airport sponsor can present sensitivity analyses using other discount rates that might reflect better the long-term opportunity cost of capital under current market conditions.

- *Treatment of transfer payments.* Benefit and cost estimates should exclude transfer payments—resources that are simply transferred from one pocket to another—because they do not result in any economic gain (or loss). The benefits to those who receive the transfer are offset by the costs borne by those who pay it.[42] Tolls, other user charges, taxes, subsidies, and insurance payments are examples of transfer payments.

- *Treatment of regional economic impacts.* The FAA BCA Guidance refers to regional economic impacts as *macroeconomic gains* and treats them as *hard-to-quantify* benefits. According to the FAA BCA Guidance, macroeconomic gains can be treated as benefit only if they were incremental – that is, if they would not have been realized elsewhere in the national economy in the absence of the project.[43] According to OMB Circular A-94, resources should be treated as if they were fully employed so that employment or output multiplier effects should not be counted as benefits or costs.[44] Under full employment conditions, regional economic impacts represent transfers because labor and capital resources could be otherwise employed in another location or industry. Regional economic impacts could also be another representation of transportation benefits already included in the analysis.[45,46] Recent research has identified a few exceptions to this, mainly when a region is subject to strong *agglomeration economies*, by which average productivity is a declining function of aggregate activity and the project promotes such activity.[47,48] Even then, only the "external" part of the economic impacts, the part not realized directly by the individual participants, should be included in BCA.

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[41] OMB, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, Circular A-94 Revised, Oct. 29, 1992.

[42] Ibid.

[43] FAA, Office of Aviation Policy and Plans, *FAA Airport Benefit-Cost Analysis Guidance*, Washington, D.C., Dec. 15, 1999, page 60.

[44] OMB, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, Circular A-94 Revised, Oct. 29, 1992.

[45] Small, K., and E. Verhoef, *The Economics of Urban Transportation*, Routledge, London and New York, 2007.

[46] Lee, D.B. Jr., "Methods for Evaluation of Transportation Projects in the USA," *Transport Policy*, Vol. 7, Issue 1, January 2000, pages 41-50.

[47] Graham, D.J., "Agglomeration, productivity and transport investment," *Journal of Transport Economics and Policy*, Vol. 41, 2007, pages 317-343.

[48] Venables, A.J., "Evaluating urban transport improvements: cost-benefit analysis in the presence of agglomeration and income taxation," *Journal of Transport Economics and Policy*, Vol. 41, 2007, pages 173-188.

- *Treatment of hard-to-quantify benefits and costs.* There may be certain benefits and costs that cannot be measured in dollars. They should be identified and, if possible, expressed in physical units. While hard-to-quantify benefits cannot be incorporated in the BCA, they provide additional basis for evaluating capital investments. They can justify pursuing an investment when the quantified benefits are less than the quantified costs.
- *Treatment of distributional impacts.* From a societal perspective, welfare improves as long as approved projects and regulations have benefits greater than costs. However, those who benefit are not always those who bear the costs. The analyst should identify the gainers and losers, and disclose significant distributional effects.[49,50]

Cost-Effectiveness Analysis [51]

Compared to BCA, CEA is a more limited approach that compares either only the benefits or only the costs of investment alternatives. The objective is to select the alternative that maximizes benefits for a given cost (*constant-cost study*), or minimizes costs for a given output level (*least cost study*). Cost-effectiveness analysis is appropriate in situations where: (1) competing investment alternatives are expected to have either the same costs or the same benefits, (2) benefits cannot be expressed in monetary values, or (3) a policy decision has already been made to provide the benefits. For example, CEA is appropriate for investments involving rehabilitation and replacement of facilities, remediation of environmental impacts, safety and security.

When alternatives have the same costs—such as when a fixed budget is given—but generate different amounts of benefits, the focus is on measuring and comparing benefits to identify which alternative yields the greatest benefits. The FAA refers to this approach as *constant-cost study*.

When the benefits are difficult to express in monetary terms or when they are the same across alternatives, the focus is on comparing costs to identify the least expensive way of achieving the investment objective. The FAA refers to this approach as *least-cost study*.

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[49] OMB, op. cit.

[50] FAA, Office of Policy and Plans, *Economic Analysis of Investment and Regulatory Decisions – Revised Guide*, FAA-APO-98-4, Washington, D.C., January 1998, pages 8-1 to 8-5.

[51] The discussion of cost-effectiveness analysis is based on the following references:

- OMB, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, Circular A-94 Revised, Oct. 29, 1992.
- FAA, Economic Analysis of Investment and Regulatory Decisions – Revised Guide, January 1998.
- Treasury Board of Canada Secretariat, Canadian Cost-Benefit Analysis Guide, Regulatory Proposals, Interim, 2007.
- European Union, Regional Policy, Guide to Cost Benefit Analysis of Investment Projects, July 2008.

The decision rule can also be expressed as a ratio of costs to a nonmonetary quantitative measure of benefits—for example, costs in dollars for each life saved.

For most capital investments, the evaluation period typically spans many years over the investment's life-cycle. Therefore, as in BCA, the comparison of costs among alternatives should consider all the costs to be incurred over the investment's life-cycle—planning and development, construction and equipment acquisition, operations and maintenance, and termination and disposal—and salvage value. The evaluation of costs over an investment's life-cycle is more formally called *life-cycle cost analysis* (LCCA). In economic analysis, LCCA is not limited to financial costs, as it would be in engineering and financial analysis applications. One application of LCCA is in *lease-purchase analysis*, where the discounted present value of lease payments over the term of the lease is compared with the purchase price, if the asset were to be purchased outright rather than leased. Another application is in evaluating decisions to maintain or replace an asset and determining optimal timing for asset replacement.

CEA has essentially the same steps, principles and considerations as BCA. At the minimum, the analyst must clearly identify the project objective, describe all assumptions underlying estimates of benefits and costs, and evaluate alternatives by comparing either costs in least-cost studies or benefits in constant-cost studies. Analyses involving multi-year periods must control for inflation and account for differences in timing of costs and benefits by discounting. The OMB, however, prescribes different discount rates to be used for CEA based on the comparable-maturity Treasury borrowing rate. These discount rates are updated annually and posted on the OMB website.[52]

Economic Valuation

Economic valuation provides the techniques for expressing project benefits (or costs) in monetary units to be used in BCA and CEA. This topic is addressed in more detail in ACRP Report 27. Much of the discussion below is based on the relevant material written by the same author for ACRP Report 27.

Measuring benefits (or costs) is a three-step process: (1) identify the effects of the project and who are affected; (2) measure the effects in physical units; and (3) assign dollar values to the physical units. In economic analysis, the valuation of costs and benefits must be based on the concept of willingness-to-pay (WTP) – the value of something is measured by the maximum amount of other things that people are willing to give up to obtain it. Market prices, under certain conditions,[53] reflect WTP and can be used directly in valuing costs and

[52] OMB, "Appendix C: Discount Rates for Cost-Effectiveness, Lease Purchase and Related Analysis," *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Circular A-94 Revised, updated annually.

[53] Under perfect competition, market prices reflect WTP. Externalities, monopoly power, asymmetric information, taxes or subsidies can distort market prices.

benefits. However, airport capital investment projects, like other transportation projects, often involve benefits (or costs) with no direct market prices, for example:

- For capacity projects - benefits of reduction in aircraft delays, passenger travel time, and shippers' costs; and unintended adverse environmental effects
- For safety projects - benefits of avoidance of accidents and related fatalities, personal injuries, and aircraft damage
- For environmental projects - benefits of reduction in noise, air, and water pollution impacts

And for many of the above benefits, arriving at physical unit measures already presents a challenging task that often requires the application of different fields of expertise.

Economic valuation addresses the final step of assigning dollar values to physical units of project benefits (or costs). Techniques fall under three categories:[54]

- Revealed preference (RP) – RP techniques involve the use of market data, directly or indirectly. When goods and services are traded in the market, actual data on prices and quantities traded can be used. For example, economic value can be measured in terms of the amount people pay, or the cost of actions people take, to: (1) avoid the adverse effects that would occur if certain goods and services were lost (*damage cost avoided*), (2) replace lost goods or services (*replacement cost)*, or (3) provide substitute goods and services (*substitute cost*). When valuing something that is not traded in the market, one can make inferences from observable prices in related markets. For example, the value of reduced noise can be inferred from differences in the prices of houses exposed to different levels of noise, controlling for differences in other attributes. This technique is called *hedonic pricing*.[55]

[54] The following references provide detailed descriptions of these methods, illustrations of their applications, specifications of data requirements, and discussions of advantages and disadvantages:

- Lipton, D., and K. Wellman, "Economic Valuation of Natural Resources, A Handbook for Coastal Resource Policymakers," National Oceanic and Atmospheric Administration Coastal Ocean Program Decision Analysis Series, No. 5, June 1995.
- King, D., and M. Mazzotta, Ecosystem Valuation, 2000. [Online] Available: http://www.ecosystemvaluation.org.
- OMB, *Regulatory Analysis*, Circular A-4, Sept. 17, 2003.

[55] Often a hedonic pricing technique is combined with other information to provide a measure of economic value. For example, investments that reduce air pollution change the likelihood of premature mortality. Researchers have used hedonic studies of labor markets to infer people's willingness to pay for such changes, because different occupations are subject to different levels of occupational mortality; and this information can be combined with epidemiological studies relating levels of air pollution to mortality. Similar techniques have been applied to morbidity (sickness). An example of this approach is the study of air pollution in: Small, K., and C. Kazimi, "On the Costs of Air Pollution from Motor Vehicles," *Journal of Transport Economics and Policy*, Vol. 29, 1995, pages 7-32.

- Stated preference (SP) - When values cannot be inferred from market transactions, economists have devised measurement techniques based on *stated-preference* surveys. The distinguishing feature of SP surveys is that respondents are presented with a hypothetical scenario. One method (the *contingent valuation* method) asks people directly how much they are willing to pay to enjoy a particular benefit, or how much compensation they would be willing to accept to forgo something. Another method (the *contingent choice* method) asks people to make trade-offs among different alternatives, and the analyst can then estimate WTP from these trade-offs.
- Benefit transfer (BT) - Ideally one should conduct an original economic valuation study specific to a particular airport using either RP or SP techniques. However, faced with limited time and money, one can also adopt estimates of economic values from completed studies in similar contexts. This is called the *benefit transfer* method. The choice between conducting airport-specific research and using results from other studies depends on whether the attribute that needs to be valued is likely to vary significantly from airport to airport.

Relevant economic values for many of the types of costs and benefits associated with airport capital investments include the following:

- Value of time to be used in estimating the cost to passengers of travel delays, or the benefits of reducing passenger travel delays
- Aircraft operating and ownership cost to be used in valuing the costs to airlines of aircraft delays, or the benefits of reducing airline costs from aircraft delays
- Value of statistical life to be used in estimating the cost of fatalities and personal injuries from aviation accidents, or the benefits of reducing the risk of fatalities and personal injuries
- Aircraft replacement and restoration costs to be used in valuing damaged aircraft from aviation accidents, or the benefits of avoiding aircraft damage
- Aviation accident investigation costs for valuing costs to the federal government and the private sector of the increased risk of aviation accidents, or the benefits of avoiding these costs
- Value of environmental effects such as noise, climate change and air quality effects

The FAA prescribes values for all of the above except environmental effects in the publication titled *Economic Values for FAA Investment and Regulatory Decisions*.[56] BCAs submitted to the FAA to support AIP discretionary grant and LOI applications must use the FAA prescribed values. However, many of the economic values presented in FAA guidance

[56] GRA, Incorporated, *Economic Values for FAA Investment and Regulatory Decisions, A Guide*, Prepared for FAA Office of Aviation Policy and Plans, Final Report, Revised Oct. 3, 2007.

need periodic updates. In particular the values recommended for passenger travel time were last updated in February 2003, based on guidance from the DOT Office of the Secretary.

Limitations of Economic Analysis

Airport sponsors are encouraged to perform economic analysis – in addition to planning and engineering studies and financial analysis – in evaluating capital investments. In doing so, airport sponsors also need to be aware of the limitations of economic analysis. Economic analysis is geared toward achieving economic efficiency, without consideration for distributive impacts. Sometimes efficient outcomes may not necessarily be “fair” when those who bear the costs are not the ones who enjoy the benefits. When distributive impacts are significant, they should be disclosed in the BCA report for additional consideration.

In addition, economic analysis can be quite involved because airport projects often involve benefits and costs that are not easily measurable in either physical units or dollars, or both. Therefore, economic analysis requires numerous assumptions that can introduce uncertainty into results.

Financial Analysis: Traditional Investment Decision Rules

This section describes the traditional *investment decision rules* used in capital finance budgeting.[57] Investment decision rules are also known as *project evaluation methodologies* or *capital budgeting techniques*.

Readers will find that the investment decision rules in financial analysis are similar to those used in economic analysis. The difference is that financial analysis is concerned only with cash flows to the investment proponent. As explained above, economic analysis is concerned with all types of benefits and costs, not limited to cash flows, and defined more broadly to include those incurred by a larger set of stakeholders (for example, society at large for many public investments or the “aviation public” for airport capital investments).

In this section, we describe the four traditional investment decision rules: *payback period*, *net present value (NPV)*, *internal rate of return (IRR)*, and *benefit-cost (B/C) ratio* (also called *present value index* and *profitability index*).

[57] The discussion of investment decision rules are based on the following sources:

- Bierman, H. Jr., and S. Smidt, *The Capital Budgeting Decision, Economic Analysis of Investment Projects*, Ninth Edition, Routledge, London and New York, 2007.
- Copeland, T., and J.F. Weston, *Financial Theory and Corporate Policy*, Addison-Wesley Publishing Company, Menlo Park, California, 1979.

These techniques are useful in deciding whether to accept or reject a proposed project, establishing investment priorities by ranking projects, and choosing among mutually exclusive alternatives. In airport capital investment, these techniques, applied strictly on cash flows, are appropriate when evaluating projects (1) intended to generate airport revenue, or reduce airport operating and maintenance costs by improving efficiency; (2) to be funded with airport cash flow and/or debt, not federal grants subject to benefit-cost analysis; and (3) the consequences of which are clearly limited to airport cash flows.

According to Copeland and Weston,[58] the best technique should maximize value to stakeholders by satisfying the following criteria:

- All cash flows should be considered. The analysis should include all cash flows from the investment (i.e. *incremental* cash flows), except interest payments on borrowings. Interest represents the cost of capital which is accounted for by discounting.
- The cash flows should be discounted at the opportunity cost of capital. Cash received earlier has more value than the same amount of cash received later, because cash can be invested to earn future returns. The process of discounting takes into account the time value of money. The discount rate to be used depends on the funding source: for example, the borrowing rate in the case of debt financing, the interest return on cash reserve accounts in the case of discretionary cash reserves, the appropriate OMB prescribed rate in the case of federal funding,[59] and the weighted average cost of capital in the case of multiple sources of funding.
- The technique should result in a clear choice from a set of *mutually exclusive projects*. Projects are mutually exclusive when choosing one precludes implementing the others, such as alternative means of achieving the same project objective.
- The technique should also allow decision makers to consider one project independently from all others (known as the *value-additivity principle*). Projects are *independent* when the decision to pursue one does not affect the decision to pursue another. This means the decision maker has the option to pursue any or all of the projects. (In contrast, *contingent projects* are those that have to be carried out together or not at all and, therefore, should be analyzed as a single project.)

Among the four traditional investment evaluation techniques reviewed in this section, NPV is considered by many economists and corporate finance experts to be the best when deciding whether to accept or reject a project and when choosing among mutually exclusive project alternatives, because it is the only one that satisfies all the above criteria for maximizing value to stakeholders. The NPV method always leads to an investment choice

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[58] Copeland, T., and J.F. Weston, *Op. cit.*

[59] OMB, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, Circular A-94 Revised, Oct. 29, 1992.

that will maximize value, whereas the other techniques do not. It is also easy to implement and interpret, especially relative to the internal rate of return (IRR) method. The NPV method, however, has limited use when faced with capital rationing and one needs to rank and choose among independent investments. In this case, a reasonable ranking can be obtained using either the IRR or the B/C ratio. Also, if projects are risky, and risk is not incorporated directly into the analysis, then the IRR or the B/C ratio offers an easier way for a decision-maker to see whether there is a comfortable margin between project costs and benefits.

To illustrate each technique, Table A-6 provides sample annual net cash flows (inflows minus outflows) for four hypothetical projects that are compared using different financial analysis techniques in the following sections.

Table A-6. Sample Cash Flows for Four Mutually Exclusive Projects

Year	Project Cash Flows			
	A	B	C	D
0	(2,000)	(2,000)	(2,000)	(2,000)
1	200	0	200	400
2	1,800	0	400	600
3	200	600	600	1,000
4	(200)	1,400	800	1,000
5	(800)	1,600	1,500	200

Payback Period

The *payback period* is one of the simplest and one of the most frequently used decision rules for capital investment. The payback period is the number of years it takes to recover the initial cash outlay on a project without taking interest (or discounting) into account. For the sample projects in Table A-6, the payback periods are as follows:

- Project A, 2 years
- Project B, 4 years
- Project C, 4 years
- Project D, 3 years

When deciding whether to pursue a project, the decision rule is to accept the project if the payback period is less than or equal to an acceptable time limit. For example, if the acceptable payback period were three years, Projects A and D can be pursued. When comparing mutually exclusive alternatives, the decision maker would choose the one with the shortest payback period – Project A.

The main advantage of the payback period is that it is easy to calculate. Setting an acceptable time limit for payback to decide whether to accept a project, however, is arbitrary. When comparing alternatives, the payback period can lead to a wrong decision because: (1) it does not consider cash flows beyond the payback period; and (2) it does not discount cash flows to account for differences in the timing of cash flows. It does serve as an approximate measure of risk: for example, all other things equal, a project with a two-year payback is less risky than one with a much longer payback.

To account for the time value of money, the payback period can be calculated based on discounted cash flows. The *discounted payback period* is recommended over the undiscounted payback period, but it still does not consider cash flows beyond the payback period.

Net Present Value

The *net present value* method discounts cash flows to take into account the time value of money. Its computation requires the following steps: (1) choose an appropriate discount rate; (2) compute the present value of the cash proceeds expected from the investment; (3) compute the present value of the cash outlays required by the investment; and (4) subtract the present value of the cash outlays from the present value of the cash proceeds to obtain the NPV. The mathematical representation of NPV is as follows:

$$NPV = \sum_{t=1}^{N} \frac{Net\ cash\ flow_t}{(1+r)^t} - Initial\ outlay$$

Or

$$NPV = \sum_{t=1}^{N} \frac{Cash\ proceeds_t}{(1+r)^t} - \sum_{t=1}^{N} \frac{Cash\ outlays_t}{(1+r)^t}$$

where N is the number of years in the project's evaluation period and r is the discount rate (or opportunity cost of capital).

Assuming a five-year evaluation period and a discount rate of seven percent, the NPVs of the sample projects in Table A-6 are as follows:

- Project A, -$801
- Project B, $699
- Project C, $706
- Project D, $620

The decision rules are as follows:

- Accept a project if its NPV is greater than zero. In the example, all but Project A pass this rule.
- When comparing mutually exclusive alternatives, choose the one with the highest NPV. This is Project C in the example above.

As explained above, the NPV method is the only one among the four investment decision rules that always leads to an investment choice that will maximize value. The NPV method, however, has limited effectiveness when faced with capital rationing.

Internal Rate of Return

Many different terms are used to refer to the concept of *internal rate of return (IRR)*: *yield*, *yield to maturity*, *interest rate of return*, *rate of return, return on investment*, *present value return on investment*, *time-adjusted rate of return*, and *marginal efficiency of capital*.[60] The IRR is the discount rate that makes the present value of annual net cash flows equal to the initial outlay. Put differently, the IRR is the discount rate that makes the project's NPV equal to zero. Certain calculators and computer software have built-in functions to readily solve for the IRR. The IRRs of the sample projects in Table A-6 are as follows:

- Project A, none (no solution)
- Project B, 15%
- Project C, 16%
- Project D, 18%

The decision rules are as follows:

- Accept a project if the IRR is greater than the required rate of return (i.e. the opportunity cost of capital). Assuming that the required rate of return is seven percent, all but Project A pass the rule.
- Faced with mutually exclusive alternatives, choose the one with the highest IRR. This is Project D in the example above.

The IRR method is superior to the discounted payback period because it considers all cash flows. Unlike the NPV method, the IRR method does not show the dollar value of the net financial payoff resulting from the investment. Given "normal" cash flows–that is, negative in the first period and positive in subsequent period, as in the cases of Projects B, C and D in Table A-6, the IRR method leads to the same investment evaluation as the NPV method. When the cash flows are not "normal", the IRR method is not reliable for a number of reasons: (1) the IRR may not be computable as in the case of Project A, (2) it can lead to a wrong evaluation when the cash flows are reversed–that is, positive initially and negative subsequently, and (3) projects can have multiple IRRs when the cash flows switch signs from year to year (switching from positive to negative and vice versa). The IRR method can also lead to wrong or ambiguous evaluation in the following cases: (1) when the investment has a non-uniform term structure, (2) when considering mutually exclusive projects with

[60] Bierman and Smidt (2007), page 51.

significant scale differences, and (3) when considering mutually exclusive projects with significant differences in the timing of cash flows.[61]

Benefit/Cost Ratio

The *benefit/cost ratio (*also known as *profitability index* or *present value index)* is calculated by taking the present value of cash inflows divided by the present value of cash outflows. The resulting ratio gives the return in present value terms per unit invested. The decision rule is to implement a project if its B/C ratio is greater than one. When comparing mutually exclusive projects, the decision rule is to choose the one with the highest B/C ratio. There are two problems with the B/C ratio: (1) the option with the highest ratio may not yield the largest return in absolute value, and (2) the analyst can influence the resulting ranking of alternatives by changing the assignment of cash flows into the numerator and the denominator. An example of this being the somewhat arbitrary decision on whether to count labor savings as a benefit (cash inflow) or an offset to costs (a negative cash outflow) will change the B/C ratio. The analyst can also influence the resulting ranking by including or excluding certain costs or benefits that are constant across alternatives (and thus should not affect the decision).

Limitation of Traditional Investment Rules in Financial Analysis of Airport Capital Investments

Traditional investment rules have limited applications in financial analysis of airport capital investments. As mentioned above, these techniques consider cash flows and, therefore, can be used only for projects that will either directly generate airport revenue, or reduce financial costs, such as airport operating and maintenance costs. Many airport capital projects do not directly generate cash flows–especially revenues–that are clearly identifiable. Also, many airport capital projects have consequences not limited to cash flows and not limited to the airport sponsor, so that the financial analysis application of traditional investment rules alone can lead to flawed investment decisions.

There are other capital investment evaluation methods and more sophisticated techniques that are not covered in this paper. For a more exhaustive discussion, readers should consider the following references:

- "Capital Budgeting Techniques: Certainty, Risk, and Some Refinements" in http://www.uni.edu/isakson/CHAP09/index.htm.
- Jonathan Mun, *Real Options Analysis: Tools and Techniques for Valuing Strategic Investment and Decisions*, 2nd Edition (Wiley Finance), 2006.

[61] See the lecture notes on Project Evaluation by C. Harvey at Duke University posted on-line at http://www.duke.edu/~charvey/Classes/ba350/project/project.htm for illustrations of the shortcomings of the IRR method.

Financial Analysis: Airport CIP Financial Planning Techniques

This section describes techniques of financial analysis with specific application to airport CIP financial planning–techniques that are widely and routinely used by airport sponsors in evaluating airport capital investment decisions. These techniques address questions of financial affordability and feasibility in terms of how the project and its financing will affect the airport's rates and charges, cost per enplanement, and other financial performance metrics. Most airport capital investments will require some form of one or more of the following techniques: (1) *airline rates and charges analysis*, (2) *financial affordability analysis*, and (3) *financial feasibility analysis*. Projects to be funded with bond financing secured by general airport or special facility revenue issue will require financial feasibility analysis–the most detailed and comprehensive of the three airport financial planning methodologies.

Airline Rates and Charges Analysis – For Commercial Airports

The purpose of airline rates and charges analysis is to evaluate the potential effect of alternate airline rate-making methodologies on an airport's ability to fund capital projects. The results of airline rates and charges analysis are used by airport management to determine if it would be advantageous for the airport to revise or change its airline rate-making methodology and, if so, what revisions or changes would best help the airport achieve the financial goals for its capital program. This method primarily applies to capital improvements to facilities used by the airlines (such as airfield and terminal facilities). Airline rates and charges, however, can be used for all types of capital projects, since the financial operations of an airport are inter-related between all airport facilities, whether directly used by the airlines or not. Airline rates and charges analysis is best performed as soon as potential capital costs are known, in order to assist airport management in the development of the capital program funding plan.

The airlines' use of facilities at an airport is usually governed by a lease agreement between each airline and the airport. The lease agreement specifies the airline's permitted uses of airport facilities and the rates and charges the airline will pay for their use of airport facilities. Although it is most common for airports to charge the airlines based on the methodology specified in the lease agreement, in some instances, an airport will impose airline rates and charges by ordinance. The airlines generally prefer having a lease agreement, since such an agreement usually reflects the results of a good faith negotiation of all parties involved and is usually viewed by the airlines as providing safeguards against excessive rates and charges.

The revenues generated by an airport are typically classified into two categories: (1) airline revenues and (2) non-airline revenues. Airline revenues are principally composed of landing fees, aircraft apron fees, and terminal rents. Non-airline revenues include revenues generated from public parking facilities; rental car concession fees; terminal concession fees; revenues generated from general aviation users, including fixed base operators (FBOs); revenues generated from air cargo facilities; and other sources, such as land and non-terminal building rents.

Airlines are typically charged for their use of the terminal and airfield facilities. Some airports include charges for aircraft aprons in the airfield charges, while other airports charge separate apron fees. Most airports classify costs into cost centers in order to separate the costs to be charged to the airlines. The following are typical cost centers:

- Airfield
- Aircraft Apron (if not included in the Airfield cost center)
- Terminal
- Parking and Roadways
- General Aviation
- Cargo
- Indirect cost centers, such as Administration, Maintenance, Marketing, etc.

Depending on the airport's rates and charges methodology, certain costs are allocated to the airline rate cost centers (Airfield, Aircraft Apron, and Terminal), and the non-airline cost centers, including the following:

- **Operation and Maintenance (O&M) expenses**, which are the expenses incurred for the on-going operation and maintenance of the airport. Some expenses are directly attributable to specific areas of the airport, such as the airfield, the terminal, and the parking facilities. Other expenses, such as administrative expenses, must be allocated to the direct cost centers using a reasonable allocation methodology, which is usually specified in the airline lease agreement.
- **Capital costs**, which can be recognized in the form of bond debt service (annual principal and interest payments), amortization charges, or other capital recovery charges. The allocation methodology is usually specified in the airline lease agreement. Bond debt service costs are typically allocated to the various cost centers based on the use of bond proceeds. Capital costs for support facilities such as: access roads; service roads; sewer systems; and electrical, mechanical, communication, and security systems should be allocated to the appropriate cost centers.
- **Deposits** to reserve funds established pursuant to the bond indenture or other legal documents.

Planned airport capital programs should be evaluated in terms of the projected effect on airline rates and charges. Capital program expenditures for certain types of projects, such as airfield and terminal projects, often are included in the airline rate base. The extent of capital expenditures that will be included in the airline rate base depends on the airline rate methodology – specified in the lease agreement, or decreed through ordinance – and the capital program funding plan. It is usually best for an airport to maximize the amount of FAA AIP funds used for airfield projects, in order to minimize the impact of airfield capital project expenditures on the airline rates and charges. Many airports also maximize the use of Passenger Facility Charges (PFCs) for airfield and terminal projects.

Many airports have a lease agreement containing a Majority-In-Interest (MII) provision. An MII provision requires that the airport sponsor obtain the approval of a majority of the airlines (in terms of landed weight, market share, or both) in order for the airport sponsor to proceed with a capital project or a group of capital projects. If the airlines believe that a capital program will subject them to undue increases in their rates and charges, the airlines will be reluctant to grant approval under the MII provision.

There are two main types of airline rates and charges methodologies: *residual* and *compensatory*. Under a residual methodology, the airlines are responsible for paying the residual amount (i.e. the amount left over after nonairline revenues[62] have been applied to the costs allocated to the airline cost centers). Under this methodology, the airlines assume the risk of covering any operating and capital deficits. However, the airport's ability to generate discretionary cash for capital expenditures is limited. Non-airline revenue is subtracted from the costs allocated to the airline cost centers to arrive at the net amount to be recovered from the airline rates and charges. The net amount to be recovered from the airlines in each airline cost center is divided by the appropriate units: landed weight for the airfield to calculate the landing fee rate; aircraft parking positions to calculate the apron parking position charge; and total terminal leasable square footage to calculate the terminal rental rate.

Under the compensatory methodology, the airlines pay for the percentage of costs based on their usage of the facilities. The airport assumes the risk of generating sufficient non-airline revenues to pay costs not covered by airline revenues. Under this methodology, the airport typically has a greater ability to generate discretionary cash for capital expenditures.

Under the compensatory methodology, costs are allocated to the airlines based on (1) their collective share of landed weight (for the calculation of the landing fee rate) and (2) their collective share of terminal space (for the calculation of the terminal rental rate). If an airport has an aircraft apron cost center, all of the costs of that cost center are usually charged to the airlines. The amount to be recovered from the airlines in each airline cost center is divided by the appropriate units: landed weight for the airfield to calculate the landing fee rate; aircraft parking positions to calculate the parking position charge; and total terminal square footage or total terminal leasable square footage to calculate the terminal rental rate. If airline leasable square footage is used as the denominator, the methodology is called "commercial compensatory."

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[62] Non-airline revenues generally include public parking revenues, rental car revenues, terminal concession revenues, general aviation revenues, etc.

Sample calculations of terminal and airfield rates and charges, under residual and compensatory methodologies, are presented in Table A-7 through Table A-10.

Table A-7. Sample Terminal Rental Rate Calculation – Residual Methodology

Passenger Terminal Costs	$30,000,000
Debt Service	$6,000,000
Amortization	$2,000,000
Reserve Fund Deposits	$1,000,000
Total Terminal Costs	*$39,000,000*
Less Non-airline Revenue:	
Parking Revenue	$16,000,000
Rental Car Concession Revenue	$9,000,000
Food & Beverage Concession Revenue	$3,000,000
Retail Concession Revenue	$2,800,000
Other Terminal Concession Revenue	$3,000,000
Total Non-airline Revenue	*$33,800,000*
Net Airline Requirement	**$5,200,000**
Divided by total leasable square footage[1]	200,000
Rate per square foot	***$26.00***

[1] Total leasable area in the passenger terminal.

Table A-8. Sample Landing Fee Calculation – Airport-Wide Residual Methodology

Airfield Costs:	
O&M Expenses	$15,000,000
Debt Service	$1,000,000
Amortization	$1,000,000
Reserve Fund Deposits	$250,000
Total Airfield Costs	*$17,250,000*
Less Non-airline Airfield Revenue:	
General Aviation Revenue	$1,250,000
Air Cargo Rentals	$500,000
Non-signatory Landing Fees	$1,500,000
Other Non-airline Revenues	$750,000
Total Non-airline Revenue	*$4,000,000*
Net Airfield Costs[1]	***$13,250,000***
Plus: Residual Costs[2]	$23,750,000
Net Airline Requirement	*$37,000,000*
Divided by landed weight (000 lbs.)	7,000,000
Landing Fee	**$5.29**

[1] Airfield Costs minus non-airline airfield revenue

[2] Airport costs in excess of Airport revenues from cost centers other than the Airfield

Table A-9. Sample Terminal Rental Rate Calculation – Compensatory Methodology

	Regular Compensatory	Commercial Compensatory
Passenger Terminal Costs	$30,000,000	$22,500,000
Debt Service	$6,000,000	$4,500,000
Amortization	$2,000,000	$1,500,000
Reserve Fund Deposits	$1,000,000	$750,000
Total Terminal Costs	*$39,000,000*	*$29,250,000*
Divided by:		
Total Leasable sqft.	200,000	—
Airline Leasable sqft.	—	150,000
Terminal Rental Rate per sqft.	$195.00	$195.00
Airline Leasable sqft.	150,000	150,000
Airline Rent	**$29,250,000**	**$29,250,000**

Table A-10. Sample Landing Fee Calculation – Compensatory Methodology

Airfield Costs	$15,000,000
Debt Service	$1,000,000
Amortization	$1,000,000
Reserve Fund Deposits	$250,000
Total Airfield Costs	**$17,250,000**
Divided by Landed Weight	*7,000,000*
Landing Fee	***$2.46***

Various hybrid methodologies are in use at a number of airports. Examples include:

- Compensatory for the terminal and residual for the airfield
- Compensatory for the terminal and airport-wide residual
- Compensatory with credits for some non-airline revenues
- Compensatory, but the airport shares the “bottom line” with the airlines

Changes in the airline rate methodology can be explored, or entirely new methodologies can be evaluated, depending on the goal and the need of the airport. For example, if the airport has a fully residual rate making methodology, one goal of the airport may be to develop a modified or new methodology to enable the airport to generate additional discretionary cash to fund capital project expenditures. If, on the other hand, an airport has a fully compensatory rate making methodology, the airport may want to seek ways to reduce the airline rates and charges without adversely impacting the airport’s ability to fund capital project expenditures.

Sample calculations of Terminal and Airfield rates and charges, under hybrid methodologies, are presented in Table A-11 and Table A-12.

Table A-11. Sample Terminal Rental Rate Calculation – Hybrid Methodology

Passenger Terminal Costs	$30,000,000
Debt Service	$6,000,000
Amortization	$2,000,000
Reserve Fund Deposits	$1,000,000
Total Terminal Costs	**$39,000,000**
Less Credits (50%):[1]	
Parking Revenue	$8,000,000
Rental Car Concession Revenue	$4,500,000
Food & Beverage Concession Revenue	$1,500,000
Retail Concession Revenue	$1,400,000
Other Terminal Concession Revenue	$1,500,000
Total Non-airline Revenue	**$16,900,000**
Net Leased Space Requirement	*$22,100,000*
Divided by leasable sqft.	*200,000*
Rate per square foot	***$110.50***

[1] For this illustrative table, 50% is used as an example. The Airport and the airlines typically negotiate the applicable percentage that is specified in the airline use and lease agreement

Table A-12. Sample Landing Fee Calculation – Hybrid Methodology

Airfield Costs	$15,000,000
Debt Service	$1,000,000
Amortization	$1,000,000
Reserve Fund Deposits	$250,000
Total Airfield Costs	**$17,250,000**
Less Non-airline Revenue:	
Parking Revenue (25%)	$4,000,000
General Aviation Revenue	$1,250,000
Air Cargo Rentals	$500,000
Non-signatory Landing Fees	$1,500,000
Other Non-airline Revenue	$750,000
Total Non-airline Revenue	**$8,000,000**
Net Airline Requirement	*$9,250,000*
Divided by landed weight (000 lbs.)	*7,000,000*
Landing Fee	***$1.32***

[1] For this illustrative table, 25% is used as an example. The Airport and the airlines typically negotiate the applicable percentage that is specified in the airline use and lease agreement

To illustrate a sample rates and charges analysis, we assume that an airport has a fully residual airline rate making methodology, whereby the terminal rental rate is calculated based on a terminal cost center residual methodology and the landing fee calculation is based on an airport-wide residual methodology, as presented in Table A-7 and Table A-8 above. Although the terminal rental rate is lower under the hypothetical residual methodology (compare the sample compensatory rate shown in Table A-7 with the sample residual rate shown in Table A-9), the landing fee would be higher under the residual methodology (see Table A-8) than under the compensatory methodology (see Table A-10). This is because under the residual landing fee methodology, the residual costs of the airport are included in the calculation of the landing fee rate. Additionally, the airport would be unable to generate discretionary cash for capital project expenditures under the residual methodology. The illustrative cash flows under the assumed residual and compensatory methodologies are shown in Table A-13. In the illustration, the net cash flow of $3.0 million represents the 25 percent debt service coverage amount assumed to be collected each year. That amount would be the total discretionary cash collected under the sample residual rate methodology. Such a limited discretionary cash flow would limit the airport's ability to fund capital project expenditures. Therefore, the airport might decide to negotiate with the airlines to move toward a compensatory rate methodology, or at least a hybrid methodology, in order to enhance the airport's ability to generate discretionary cash for its capital program funding plan.

Table A-13. Illustrative Cash Flow – Residual and Compensatory Rate Methodologies

	Residual	Compensatory
Airline Revenue		
Airline Rent	$5,200,000	$29,250,000
Landing Fees	$37,000,000	$17,250,000
Total Airline Revenue	**$42,200,000**	**$46,500,000**
Non-airline Revenue		
Parking Revenue	$16,000,000	$16,000,000
Rental Car Concession Revenue	$9,000,000	$9,000,000
Food & Beverage Concession Revenue	$3,000,000	$3,000,000
Retail Concession Revenue	$2,800,000	$2,800,000
Other Terminal Concession Revenue	$3,000,000	$3,000,000
General Aviation Revenue	$1,250,000	$1,250,000
Air Cargo Rentals	$500,000	$500,000
Non-signatory Landing Fees	$1,500,000	$1,500,000
Other Non-airline Revenue	$750,000	$750,000
Total Non-airline Revenue	**$37,800,000**	**$37,800,000**
Total Revenues	**$80,000,000**	**$84,300,000**
O&M Expenses		
Terminal	$30,000,000	$30,000,000
Airfield	$15,000,000	$15,000,000
Other	$20,000,000	$20,000,000
Total O&M Expenses	**$65,000,000**	**$65,000,000**
Net Revenues	***$15,000,000***	***$19,300,000***
Debt Service	*$12,000,000*	*$12,000,000*
Net Cash Flow	*$3,000,000*	*$7,300,000*
Debt Service Coverage	***1.25***	***1.61***

Financial Affordability Analysis and Financial Feasibility Analysis

A key question to answer in the early stages of the capital program planning process is: How much can the airport afford to build? In other words: How much capital project expenditures can the airport reasonably afford? This question is answered through a financial affordability analysis. Financial feasibility analysis is an extension of the financial affordability analysis. In the financial feasibility analysis, the airport analyzes whether the preferred capital program and funding plan are financially feasible.

Financial Affordability Analysis

The amount of capital improvement costs an airport can afford depends, in part, upon the airport's rates and charges methodology, as discussed above, which affects the amount of discretionary cash the airport can generate, and the level of airline rates and charges (expressed in terms of the airline cost per enplanement).

Another key consideration in financial affordability analysis is the airport's debt capacity. What is the maximum amount of debt the airport can issue and still maintain its minimum required debt service coverage level? The minimum required debt service coverage is usually specified in the governing bond documents, such as the bond indenture. The bond indenture is a legal document that specifies the revenues generated by the airport that will be pledged to the bond holders for the payment of debt service on the bonds. Usually, the bond indenture also includes a requirement for the airport to establish and charge fees and rents that will generate pledged revenues at a minimum level in excess of annual debt service requirements. This provision is called the "rate covenant." The purpose of the rate covenant is to ensure that pledged revenues will exceed the debt service requirements. The most common level of required debt service coverage is 125 percent of annual debt service requirements.

Airport management may set a target debt service coverage level higher than the minimum level specified in the bond indenture. The target debt service coverage level will affect the amount of debt that the airport can issue. That amount of debt, combined with the other anticipated sources of funding, will determine the maximum affordable project costs.

The financial affordability analysis is developed further in the financial feasibility analysis process. Financial affordability analysis takes a broad look at the amount of capital costs an airport can afford, whereas the financial feasibility analysis takes a more detailed look at the feasibility of the proposed capital program and the associated funding plan.

An illustrative affordability analysis is shown in Table A-14. In this example, the airport cash flow for a sample compensatory rate methodology shown on Table A-13 was revised to include additional debt. Although a thorough affordability analysis would involve much more detailed analysis, this illustration shows that the airport could increase its annual debt service by approximately $9.0 million and still maintain its minimum debt service coverage ratio of 1.25 times annual debt service. In practice, most airports set a goal of maintaining a debt service coverage ratio above 1.25 times the annual debt service; however, this illustration demonstrates the maximum additional debt this sample airport could afford. The example assumes that the additional debt will be issued to fund passenger terminal capital expenditures and, therefore, the additional debt service will be included in the calculation of the terminal rental rate. The analysis also assumes that the additional terminal facilities will result in a 10.0 percent increase in annual O&M expenses for the terminal cost center.

Assuming an annual bond rate of approximately 6.0 percent, a 30-year bond amortization period, bond issue costs of 2.0 percent, and a 2-year capitalized interest period to correspond with the anticipated construction period, the $9.0 million in additional annual debt service would mean the airport could fund a maximum of approximately $96.0 million in capital costs. The airport would also review its entire capital program, evaluate its ability to generate discretionary cash flow, PFCs, and AIP grant receipts, and develop an estimate of the entire CIP cost it could afford, based on the assumed funding sources and amounts. Once this affordability analysis has been performed, the airport would proceed with a bond financing strategy, which would include the commissioning of a financial feasibility analysis.

Table A-14. Sample Cash Flow for Affordability Analysis

Airline Revenue	
Airline Rent	$38,250,000
Landing Fees	$18,300,525
Total Airline Revenue	**$56,550,525**
Non-airline Revenue	
Parking Revenue	$16,000,000
Rental Car Concession Revenue	$9,000,000
Food & Beverage Concession Revenue	$3,000,000
Retail Concession Revenue	$2,800,000
Other Terminal Concession Revenue	$3,000,000
General Aviation Revenue	$1,250,000
Air Cargo Rentals	$500,000
Non-signatory Landing Fees	$1,500,000
Other Non-airline Revenue	$750,000
Total Non-airline Revenue	**$37,800,000**
Total Revenues	**$94,350,525**
O&M Expenses[1]	*$68,000,000*
Net Revenues	**$26,350,525**
Debt Service	*$21,000,000*
Net Cash Flow	***$5,350,525***
Debt Service Coverage	1.25

[1] *Assumes a 10% increase in Terminal O&M Expense (from $30 Million to $33 Million) due to expanded facilities.*

Financial Feasibility Analysis

Typically, financial feasibility analysis is performed when the airport is ready to issue bonds or other forms of debt financing. The bond financing process includes the preparation of a Preliminary Official Statement (POS) and a final Official Statement (OS). The POS and OS inform potential investors about the pending bond financing. These statements include pertinent legal and financial documents as appendices, one of which is the *financial feasibility report*, also called the *airport consultant report*.

The main purpose of the financial feasibility report is to address the following question: Will the airport generate sufficient pledged revenues for the bond financing to meet debt service requirements and any associated financial obligations? The financial feasibility report provides an independent assessment of the airport's ability to repay the debt, based on certain conditions. It provides information essential to interested parties—particularly bond underwriters, bond insurers, rating agencies, and prospective bondholders by evaluating the credit-worthiness of the bonds. If the various interested parties are not convinced of the credit-worthiness of the bonds, the airport will not be able to sell the bonds or will have to pay a higher interest rate to do so and, thus, will be unable to fund its capital program. Therefore, the evaluation of the bond underwriters, bond insurers, rating agencies, and prospective bondholders is crucial for the viability of the capital program funding plan. The information presented in the financial feasibility report includes the following:

- *Existing Airport facilities, governance and key management team* — The discussion of the airport's governance and key management team is intended to demonstrate that airport management is stable and the team consists of highly qualified and experienced professionals.
- *Airport's CIP, the financial plan, and the specific projects to be financed by the bond proceeds* — The discussion will show how the specific projects to be financed with the bond proceeds fit within the airport's Capital Improvement Program. It will also provide an evaluation of the overall funding plan for the airport's capital program. Projected AIP grants must be sufficient to support the planned AIP funding for the capital program. Likewise, projected PFC collections must be sufficient to support the planned PFC funding for the capital program. Projected airport cash flow must be sufficient to cover the amount of capital expenditures planned to be funded with the airport discretionary cash.
- *Demographic and economic attributes of the airport's service area* — The airport's service area provides the population and economic base for local air travel demand. The discussion of the demographic and economic attributes of the airport's service area provides the context for understanding historical trends and evaluating the reasonableness of forecast trends in aviation activity.
- *Historical and forecast aviation activity* — Forecast aviation activity determines the components and the timing of the implementation of an airport's Capital Improvement Program. Much of an airport's revenue stream is directly related to the volume of passenger traffic and the number of aircraft operations at the airport. Landing fee revenue is dependent on aircraft landed weight; terminal rental revenue is a function of the amount of space leased by the airlines, which is dependent on passenger activity; public parking and rental car revenue is dependent on the number of origin and destination (O&D) passengers; and terminal concession revenues are dependent on the airport's passenger activity. This section of the financial feasibility report will review trends in historical activity, and present credible forecast methodology and results.
- *Financial analysis of airport operations* — This section involves the analysis of the airport's historical financial results and the development of a financial model for projecting revenues (airline, non-airline, and PFC, if applicable), landing fee and

terminal rental rates, O&M expenses, debt service, cash flow, cost per enplanement, and debt service coverage.

The financial analysis is structured to simulate the financial operations of the airport. This involves setting up a financial model that incorporates the airport's airline rates and charges methodology, including the cost center allocation methodology. The financial model is used to develop financial projections, based on the airport's projected operations. O&M expenses are projected based on historical trends and anticipated future conditions. Changes in future conditions, such as the expansion of existing facilities or the construction of new facilities, are normally expected to impact future O&M expenses. O&M expense projections are allocated to the various cost centers based on the airport's methodology. Capital costs are also allocated to cost centers in the form of annual debt service and/or amortization charges. The projected effect of the proposed capital program (and the related funding plan), including future debt service requirements, are incorporated into the analysis.

The projections of O&M expenses and capital costs feed into the calculation of projected airline revenues, based on the airport's airline rates and charges methodology. The projections of airline derived revenues involve projections of the landing fee rate, aircraft apron rent, and airline terminal rents.

Non-airline revenue projections are primarily driven by the enplanement forecast applied to recent trends in non-airline revenues, adjusted for anticipated changes in conditions. For example, historical terminal concession revenue can be analyzed on a per-enplanement basis. Recent public parking revenue trends can be analyzed in terms of revenue per vehicle exit, parking duration, and other metrics in order to establish a basis for future projections. Similar analyses can be performed for rental car revenues, general aviation revenues, air cargo facility revenues, and other types of non-airline revenues.

If PFCs are a source of funding for the capital program, the financial analysis should include an analysis of historical PFC collections, projections of future PFC collections and how these will be applied, and PFC cash flow projections.

As mentioned above, an airport's bond indenture typically includes a rate covenant, whereby the airport covenants to establish, charge, and collect rates and fees that generate annual pledged revenues in excess of the annual bond debt service requirements. A key component of the financial feasibility report is the projection of debt service coverage, based on the projections of O&M expenses, debt service requirements, airline revenues, non-airline revenues, and other financial variables.

Also included in the financial analysis are projections of the anticipated rates and charges expressed on a per-enplanement basis (the airline CPE). This metric is widely used in the industry as a measure of the reasonableness of the projected airline rates and charges. The metric should be used with caution, however, because there are wide variances among airports regarding how much of the operating and capital costs are (1) borne by the airport (and then charged to the airlines) and (2) paid directly by the airlines. At some airports, such as Hartsfield-Jackson Atlanta International Airport, the airline lease agreement specifies that the airlines will pay janitorial and other operating expenses directly to private vendors, which means that those expenses are not reflected in the airport's airline cost per enplanement. Similarly, because the airlines have financed terminal facilities at some airports, the associated capital costs are not reflected in the airline cost per enplanement for those airports. Also, the projected airline cost per enplanement includes the effect of the airport's capital program expenditures. So, the airline cost per enplanement metric for the most recent year at comparable airports would not include the effect of future capital expenditures. However, the comparison can be made to airports that have recently completed a capital program of comparable magnitude.

Table A-15 presents an illustration of a summary table for a financial feasibility report. The illustrative table includes projections of airline revenues, non-airline revenues, O&M expenses, debt service, and net cash flow. The table also includes projections of debt service coverage and airline cost per enplanement. For purposes of the illustration, it is assumed that O&M expenses will increase 3.0 percent per year. Consistent with the affordability analysis illustration presented above, it is assumed that the bonds will have a two-year capitalized interest period. Therefore, debt service coverage is projected to decrease in Year 3, when the full annual debt service requirements become due. The airline cost per enplanement is projected to increase in Year 3, reflecting the end of the capitalized interest period.

Table A-15. Illustrative Summary Table – Financial Feasibility Report

	Year 1	Year 2	Year 3	Year 4	Year 5
Airline Revenue					
Airline Rent	$29,250,000	$30,127,500	$38,250,000	$39,397,500	$40,579,425
Landing Fees	$17,250,000	$17,767,500	$18,300,525	$18,849,541	$19,415,027
Total Airline Revenue	**$46,500,000**	**$47,895,000**	**$56,550,525**	**$58,247,041**	**$59,994,452**
Non-airline Revenue					
Parking Revenue	$16,000,000	$16,480,000	$16,974,400	$17,483,632	$18,008,141
Rental Car Concession Revenue	$9,000,000	$9,270,000	$9,548,100	$9,834,543	$10,129,579
Food & Beverage Concession Revenue	$3,000,000	$3,090,000	$3,182,700	$3,278,181	$3,376,526
Retail Concession Revenue	$2,800,000	$2,884,000	$2,970,520	$3,059,636	$3,151,425
Other Terminal Concession Revenue	$3,000,000	$3,090,000	$3,182,700	$3,278,181	$3,376,526
General Aviation Revenue	$1,250,000	$1,287,500	$1,326,125	$1,365,909	$1,406,886
Air Cargo Rentals	$500,000	$515,000	$530,450	$546,364	$562,754
Non-signatory Landing Fees	$1,500,000	$1,545,000	$1,591,350	$1,639,091	$1,688,263
Other Non-airline Revenue	$750,000	$772,500	$795,675	$819,545	$844,132
Total Non-airline Revenue	**37,800,000**	**$38,934,000**	**$40,102,020**	**$41,305,081**	**$42,544,233**
Total Revenues	**$84,300,000**	**$86,829,000**	**$96,652,545**	**$99,552,121**	**$102,538,685**
O&M Expenses	*$65,000,000*	*$66,950,000*	*$68,000,000*	*$70,040,000*	*$72,141,200*
Net Revenues	**$19,300,000**	**$19,879,000**	**$28,652,545**	**$29,512,121**	**$30,397,485**
Debt Service	*$12,000,000*	*$12,000,000*	*$21,000,000*	*$21,000,000*	*$21,000,000*
Net Cash Flow	**$7,300,000**	**$7,879,000**	**$7,652,545**	**$8,512,121**	**$9,397,485**
Debt Service Coverage	1.61	1.66	1.36	1.41	1.45
Forecast Enplanements	7,500,000	7,650,000	7,803,000	7,959,060	8,118,241
Airline Cost per Enplanement	$6.20	$626	$7.25	$7.32	$7.39

Limitations of Airport CIP Financial Planning

The airport CIP financial planning techniques described above are an intrinsic part of airport capital investment planning because they address the questions of how capital investments can be funded, how they will affect rates and charges, whether the airport sponsor can afford them, and whether they are financially feasible based on a variety of airport financial considerations. However, they do not address the questions of whether capital investments under consideration maximize value to stakeholders or represent the most efficient use of resources. They are necessary but not sufficient in evaluating airport capital investment decisions, and need to be complemented with economic analysis as discussed above.

Economic Impact Analysis

Economic impact analysis[63] estimates regional economic impacts. Though typically not included in BCA, economic impact analysis can influence airport capital investment decisions to the extent that airport sponsors need the support of state and local governments and local communities to develop the airport and implement capital projects.

Economic impacts refer to employment, income and output generated by an economic activity. Airport sponsors conduct economic impact studies to educate the public about the significant economic contributions of airport operations. Economic impact studies are often used as public information tools to gain community and local government support for airport development. Airport sponsors typically conduct an economic impact analysis of overall airport operations. Sometimes airport sponsors perform a more focused assessment of the economic impact of its CIP or a specific project to provide additional justification for the capital investment. The topic of economic impact analysis has also been addressed in ACRP Report 27. Some of the discussion below is similar to the relevant material written by the same author for ACRP Report 27.

Economic impact analysis is a methodology for determining how a change in regulation, policy, or activity in a particular industry affects regional income and other economic activities including revenues, expenditures, and employment. It provides measures of economic activity, not measures of economic or social value.[64]

Theoretical Framework

Economic impact analysis estimates the economic repercussions of changes in final demand—purchases of goods and services by final users—arising from an economic activity via the concept of the multiplier. The multiplier accounts for the economic effects of subsequent rounds of spending resulting from an initial expenditure. Therefore, there are two key inputs to economic impact analysis: an estimate of the exogenous economic stimulus—the initial change in final demand—and a model of the economy that produces estimates of the multiplier effects.

[63] Also known as "economic impact assessment" and "economic impact study."

[64] Lipton, D., and K. Wellman, "Economic Valuation of Natural Resources, A Handbook for Coastal Resource Policymakers," National Oceanic and Atmospheric Administration Coastal Ocean Program Decision Analysis Series, No. 5, June 1995.

There are three basic categories of models used to derive regional multipliers for estimating total economic impact: (1) economic base models, (2) econometric models, and (3) input-output models.[65,66,67] The models are described as follows:

- *Economic base models* divide local industries between export and service, and consider regional trade as the primary driver of growth.
- *Econometric models* involve estimating multiple-equation systems that attempt to describe the structure of a local economy and forecast aggregate variables such as income, employment, and output.
- *Input-output (I-O) models* are based on an accounting framework called an I-O table, which shows the distribution of inputs purchased and outputs sold for each industry. They are widely used because they provide details on how the impact of one sector spreads throughout other sectors in the economy.

Components and Sources of Airport Economic Impact

Total economic impact consists of the *direct impact* of the initial change in final demand generated by an economic activity and the *multiplier effects* on the local economy. Multiplier effects arise when businesses buy inputs from each other (*indirect impact*) and when workers and their households spend their income on various purchases (*induced impact*). In estimating an airport's economic impact, there are three sources of initial changes in final demand: (1) the provision of aviation and related services to passengers and other airport users (*aviation provision*), (2) local spending by non-local passengers using the airport (*aviation use*), and (3) outlays associated with airport capital improvement projects and other economic development projects (*capital outlays*). The initial changes in final demand from these three sources, along with their corresponding multiplier effects (indirect and induced impacts), constitute the total economic impact of an airport.

Aviation Provision Impact. Aviation provision impact refers to the output, earnings and employment generated by business and government entities engaged in providing aviation and aviation-support services at an airport. Sources of aviation provision impact include the airport administration, airlines, retail concessionaires, general aviation and corporate aviation tenants, fixed base operators, ground transportation providers, and other government agencies that provide aviation and support services. These entities are

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[65] DiPasquale, D., and K. Polenske, "Output, Income, and Employment Input-Output Multipliers," in Pleeter, S. ed., *Economic Impact Analysis: Methodology and Applications, Studies in Applied Regional Science*, Vol. 19, Martinus Nijhoff Publishing, Boston, Mass., 1980, pages 85-113.

[66] Pleeter, S., "Methodologies of Economic Impact Analysis: An Overview," in Pleeter, S. ed., *Economic Impact Analysis: Methodology and Applications, Studies in Applied Regional Science*, Vol. 19, Martinus Nijhoff Publishing, Boston, Mass., 1980, pages 7-31.

[67] Richardson, H., *Input-Output and Regional Economics*, Redwood Press Limited, Trowbridge, Wiltshire, Great Britain, 1972.

engaged in a broad range of business activities and employ workers in various occupations in order to provide aviation and related services at airports.

Aviation Use Impact. Aviation use impact refers to the output, earnings, and employment generated by businesses located off-airport by providing goods and services to users of aviation services. Visiting passengers who arrive through the airport spend money on lodging, food, retail merchandise, ground transportation, and recreation, supporting various local businesses.

Capital Outlays Impact. In addition to the day-to-day provision and use of service at airports, airport capital outlays (construction spending) also create economic impacts in terms of business revenues, jobs and income.

Multiplier Effects. The initial changes in final demand from aviation provision, aviation use and capital outlays stimulate further economic activity in the region, as workers spend their income on local goods and services, and local businesses purchase goods and services from other local businesses. The additional economic activity generated by successive rounds of spending in the local economy, called the multiplier impact, is estimated using input-output models.

Measures of Economic Impact

The three most widely used measures of economic impact are *employment*, *earnings*, and *output*. *Employment* refers to the number of jobs generated by an economic activity. *Earnings* refer to employee compensation, measured by payroll costs of employees whose jobs depend directly and indirectly on the presence of the airport. *Output* is the broadest measure of economic impact. Typically measured by sales or business revenue, output refers to the value of goods and services produced by an economic activity. Another measure is *value-added*, which is similar in concept to gross domestic product and measures the sum of wage income and corporate profit generated in the study region.

Limitations of Economic Impact Analysis

Economic impact analysis can be used to provide additional justification for airport capital investment decisions, especially when airport sponsors need the support of state and local governments and local communities to develop the airport and implement capital projects. Regional economic impacts, however, provide measures of economic activity, not economic value. Therefore, economic impact analysis should not guide decisions intended to achieve efficient resource allocation or welfare improvement.

Addressing Uncertainty

The implementation of any of the techniques for evaluating capital investments requires numerous assumptions and forecasts for many variables. Analysts need to consider the effect of the uncertainty surrounding estimates and forecasts, which variables have the greatest effect on the results, and how the results will change if the values of these variables change.

The analyst needs to identify those variables that have the greatest effect on the decision outcome and perform *sensitivity analysis* to evaluate how the results would change if these variables change. Sensitivity analysis can be carried out by changing the value of one variable at a time, or two or more variables at a time. Sensitivity analysis that is carried out by changing two or more variables at a time is also called *scenario analysis*.

Another approach is *risk analysis* using *Monte Carlo simulation*, in which the analyst assigns probability distributions to the critical input variables. In Monte Carlo simulation, different values for the critical variables are drawn randomly from the corresponding probability distributions to recalculate the decision rule, for example, NPV. This process is repeated many times—typically at least 100 times—producing a distribution of NPV results for each investment alternative. The analyst then compares alternatives based on the mean values and distributions of the NPV results. There is commercially available software for performing Monte Carlo simulation.

The biggest challenge in performing Monte Carlo simulation is the assignment of probability distributions. The analyst can examine historical or experimental data if available, research the literature for probability distributions used for similar variables in other studies, or consult experts. Many variables follow a normal distribution, and so a normal distribution presents a convenient and reasonable assumption in many cases. A simple triangular or three-point distribution—described by a "high" value, a "low" value and a "best guess" value—can also be used when there is little or no information about a variable's past behavior.[68]

Between the two approaches, sensitivity analysis is more widely used in airport financial and economic analyses because it is a well-known approach and, therefore, easy to explain to decision makers. It is adequate in most cases when only a few variables need to be changed and the analyst has reasonable basis—such as historical data, official guidance, or other studies—for assigning alternative values to these variables. However, sensitivity analysis can become intractable when the analyst needs to evaluate too many alternative values for each variable and when many variables need to be changed simultaneously. In these cases, risk analysis using Monte Carlo simulation would be a better approach. The choice between sensitivity analysis and Monte Carlo simulation also depends on both the size of the investment and the potential consequences of making the wrong investment choice by failing to adequately account for the risks involved.

FAA guidance recommends Monte Carlo simulation for risk analysis in performing BCA. Monte Carlo simulation has many other potential applications in airport capital planning

[68] European Union Regional Policy, *Guide to Cost Benefit Analysis of Investment Projects*, July 2008, page 236-237.

and budgeting, beyond BCA risk analysis. Any type of planning and analysis that involves estimates and projections about input variables is a potential application. Risk analysis, using Monte Carlo simulation, can be used with any of the capital investment evaluation techniques described in Sections 3-5. It is used in real options analysis, a technique for evaluating capital investment strategies under uncertainty. Other applications include CIP program management and project scheduling.

Summary

Depending on the nature and objective of an airport capital investment, the source of funding and the parties involved in decision making, the following methodologies and associated techniques or techniques can be used to aid in decision making:

- Economic analysis (benefit-cost analysis, cost-effectiveness analysis and economic valuation)
- Financial analysis using traditional investment decision rules (payback period, net present value, internal rate of return, and benefit/cost ratio)
- Airport financial planning (rates and charges analysis, financial affordability analysis, and financial feasibility analysis)
- Economic impact analysis

All of the above methodologies play a role in airport capital investment decision making. From a public investment perspective, economic analysis is recommended for addressing the objectives of efficient resource allocation and maximization of returns. Airport sponsors are encouraged to perform economic analysis as part of the master planning and CIP planning process—especially in the early stages of project formulation and alternatives selection when it would be most useful. In particular, benefit-cost analysis is a requirement for applications for AIP discretionary grant funding of $5 million or more and any amount of LOI funding. Financial analysis using traditional investment rules, which evaluate cash flows, can be applied to projects that will either directly generate airport revenue, or reduce financial costs, such as airport operating and maintenance costs. Airport CIP financial planning techniques address considerations of financial affordability and financial feasibility, and these techniques are widely used by airport sponsors. Economic impact analysis is useful to understand the wider impacts of airport capital investment decisions and as a public information tool for gaining community and local government support to airport development.

In implementing any of the techniques and techniques for evaluating capital investments, analysts need to consider the effect of the uncertainty surrounding estimates and forecasts. Two approaches to assess the potential effect of uncertainty are sensitivity analysis and risk analysis using Monte Carlo simulation. Choosing the appropriate approach depends on both the size of the investment and the potential consequences of making the wrong investment choice by failing to adequately account for the risks involved.

3 EVALUATING AIRPORT CAPITAL INVESTMENT DECISIONS: SUMMARY TABLES

This synopsis presents five reference tables that (1) summarize methodologies and techniques for use in evaluating airport capital investment decisions; and (2) provide guidance for identifying, measuring and valuing benefits in airport benefit-cost analysis.

The first two tables provide quick references on the use of each of the following methodologies and associated techniques: (1) economic analysis, (2) financial analysis – investment decision rules, (3) financial planning – airport financial planning, and (4) economic impact analysis. The last three tables present relevant information from the Federal Aviation Administration (FAA) Airport Benefit-Cost Analysis (BCA) Guidance – with updates to certain source references – on the types, measurement and valuation of benefits for airport capital projects in benefit-cost analyses submitted to the FAA to support requests for Airport Improvement Program (AIP) discretionary grants and Letters of Intent (LOIs). This guidance document is described in the literature review submitted in Appendix A.1.

The five reference tables are as follows:

<u>Summary Tables on Methodologies and Techniques for Evaluating Airport Capital Investment Decisions</u>

- Summary Tables on Methodologies and Techniques for Evaluation of Airport Capital Investment Decisions
- Table A-16. Methodologies and Techniques for Evaluating Airport Capital Investment Decisions
- Table A-17. Methodologies and Techniques for Evaluating Airport Capital Investment Decisions: Measurements and Decision Rules

<u>Summary Tables on the Identification, Measurement and Valuation of Benefits for Airport Benefit-Cost Analysis</u>

- Table A-18. Airport Benefit-Cost Analysis: Airport Capital Projects and Benefits
- Table A-19. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefits and Measurement Units
- Table A-20. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefit Measurement Units, Relevant Economic Values and Data Sources

Summary Tables on Methodologies and Techniques for Evaluation of Airport Capital Investment Decisions

Table A-16. Methodologies and Techniques for Evaluating Airport Capital Investment Decisions

(Page 1 of 2)

Methodology	Purpose	Technique	Application
Economic analysis	To determine whether proposed projects maximize value to society and represent the most efficient use of public resources.	Evaluate economic benefits and economic costs using: • Benefit-cost analysis (BCA) (applying the NPV and B/C ratio decision rules) • Cost-effectiveness analysis (CEA)	• Typically applied at project level. • Applicable to any airport capital project with consequences not limited to cash flow. • Required for all public investment projects that are federally funded. • BCA is the more comprehensive and recommended technique for deciding whether or not to pursue a project and choosing among project alternatives with different cost and benefit streams. • BCA is required by the FAA for applications for an AIP discretionary grant of at least $5 million and any amount of LOI for airport capacity projects. • CEA is appropriate when a policy decision has been made to meet an investment objective and there is a choice among alternative means that: (1) yield the same level of benefits but have different costs, (2) cost the same but yield different levels of benefits, (3) have benefits that are hard to measure. Examples: projects intended to comply with FAA safety, security and design standards; and FAA environmental order.
Financial analysis-investment decision rules	To determine whether proposed projects maximize cash returns and represent the most efficient use of cash to the proponent.	Evaluate cash inflow and outflow using: • Payback period • Net present value • Internal rate of return • Benefit-cost ratio	• Typically applied at project level. • Applicable to airport capital projects that are either revenue-generating or cost saving, with consequences limited to airport cash flow.

Table A-16. Methodologies and Techniques for Evaluating Airport Capital Investment Decisions

(Page 2 of 2)

Methodology	Purpose	Technique	Application
Financial analysis – airport CIP financial planning	To determine whether proposed projects are affordable and financially feasible.	Evaluate cash inflow and outflow using: • Rates and charges analysis • Financial affordability analysis • Financial feasibility analysis	• Typically applied at CIP level and sometimes at project level. • Required for all airport capital projects. • Rates and charges analysis is appropriate when an airport sponsor is considering a change in its rates and charges methodology to finance capital projects. • Financial affordability analysis is appropriate for deciding how much capital expenditures an airport sponsor can afford. • Financial feasibility analysis is a more detailed extension to determine whether the CIP, or a specific project, is financially feasible based on a variety of airport financial considerations. • Financial feasibility analysis is often required for bond sales.
Economic impact analysis	To estimate the project's regional economic contributions in terms of employment, earnings and output.	Estimate jobs, earnings and output generated using: • Economic base model • Econometric model • Input-output model (the most widely used in airport applications)	• Typically applied on entire airport operations and sometimes on the CIP or a specific project. • Typically used for public information to gain community and local government support for airport development. • Sometimes used to provide additional justification for funding the CIP or a specific project.

Source: ACRP 03-19 Task 1B Working Paper on Evaluating Airport Capital Investment Decisions.

Table A-17. Methodologies and Techniques for Evaluating Airport Capital Investment Decisions: Measurements and Decision Rules
(Page 1 of 2)

Methodology	Technique	Measurements	Decision Rules
Economic analysis*	• Benefit-cost analysis (BCA)	• Discounted economic benefits, and • Discounted economic costs	• Implement a project if: – net present value is greater than zero – benefit/cost ratio is greater than one • When choosing among mutually exclusive projects, select the project with the higher benefit/cost ratio.
	• Cost-effectiveness analysis (CEA)	• Discounted economic benefits, or • Discounted economic costs	• When choosing among mutually exclusive project alternatives that cost the same, select the alternative with the highest benefits. • When choosing among mutually exclusive project alternatives that yield the same level of benefits, select the alternative with the lowest cost.
Financial analysis - Airport CIP financial planning	• Rates and charges analysis	• Nominal cash inflows (revenues) • Nominal cash outflows (expenses)	• Consider a change in rates and charges methodology if the change enhances an airport's ability to generate discretionary cash for capital funding.
	• Financial affordability analysis	• Nominal cash inflows (revenues) • Nominal cash outflows (expenses)	• Determine how much capital costs an airport can afford to pay while: – keeping the airline cost per enplanement at a reasonable level – meeting the debt service coverage requirement (typically 125% of annual debt service requirements).

**Financial analysis involves the application of similar techniques and decision rules to cash inflows and outflows incurred by the investment proponent.*

Table A-17. Methodologies and Techniques for Evaluating Airport Capital Investment Decisions: Measurements and Decision Rules
(Page 2 of 2)

Methodology	Technique	Measurements	Decision Rules
Financial analysis - Airport CIP financial planning	• Financial feasibility analysis	• Nominal cash inflows (revenues) • Nominal cash outflows (expenses)	• An individual project or an airport's CIP is considered financially feasible if an airport can raise capital finance while: – keeping the airline cost per enplanement at a reasonable level – meeting the debt service coverage requirement (typically 125% of annual debt service requirements). • Airports typically target maintaining a debt service coverage that is higher than the requirement.
Economic impact analysis	• Input-output model • Economic base model • Econometric model	• Employment (number of jobs) • Earnings • Output • Value-added	• Support an investment that generates business activity, creates jobs, and brings income to households in the regional economy.

Source: ACRP 03-19 Task 1B Working Paper on Evaluating Airport Capital Investment Decisions.

Summary Tables on the Identification, Measurement and Valuation of Benefits for Airport Benefit-Cost Analysis

Table A-18. Airport Benefit-Cost Analysis: Airport Capital Projects and Benefits

(Page 1 of 2)

Project	Benefit
AIRSIDE **Airside Capacity Projects**	
• New or extended runway, taxiway, apron, or hold pad	• Reduced aircraft, passenger, and cargo delay during normal airport operations • Reduced aircraft, passenger, and cargo delay during reconstruction of other airport facilities • Greater schedule predictability: o Aircraft operator able to make more efficient use of equipment and personnel o Passenger able to take later flight and arrive at destination on-time • Improved efficiency of traffic flows (reduced vectoring and taxiing distances) • Reduced aircraft operating costs and passenger travel times due to airport's ability to accommodate faster, larger, and/or more efficient aircraft • Bringing existing infrastructure into compliance with FAA safety and security standards • Safety improvements • Noise abatement • Reduction of aircraft emissions
• Reconstruction of runway, taxiway, apron, or hold pad	• Lower facility maintenance costs • Avoided loss of capacity benefits associated with facility failure
• Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment)	• Reduced aircraft, passenger, and cargo delay during normal airport operations • Greater schedule predictability • Improved safety • Lower facility maintenance costs
Airside Safety, Security, and Design Standards Projects	
• Installation of signage and lighting • Expansion of runway safety areas • Removal of obstructions from existing approaches • Fencing • Acquisition of rescue and firefighting equipment	• Compliance with FAA safety, security, and design standards to reduce accidents and incidents causing travel delay, and facilitate speedy response to accidents and other incidents Note: Compliance is mandatory and not subject to the FAA BCA requirement. However, compliance must be done in the most cost-effective manner acceptable to FAA.
Airside Environmental Projects	
• Noise mitigation for existing infrastructure (noise insulation, structure removal) • Fuel and chemical containment for existing infrastructure	• Compliance with FAA requirements to mitigate adverse environmental and health impacts Note: Compliance is mandatory and not subject to the FAA BCA requirement. However, compliance must be done in the most cost-effective manner acceptable to FAA.

Table A-18. Airport Benefit-Cost Analysis: Airport Capital Projects and Benefits

(Page 2 of 2)

Project	Benefit
LANDSIDE - AIRPORT TERMINAL BUILDING (ATB) **ATB Capacity Projects**	
• Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding)	• Reduced aircraft, passenger, cargo, and well-wisher/greeter delay (attributable to more gates and faster passenger transfers to connecting flights) • Improved passenger schedule predictability (ability to allow less time for potential delays at ATB) • More efficient traffic flows (shortened pedestrian traffic distances) • Improved passenger comfort • Lower ATB operating and maintenance costs
• Baggage Handling Systems	• Reduced passenger and cargo delay • More efficient baggage distribution • Lower operating and maintenance costs
ATB Security Projects	
• Passenger, baggage, and freight security systems	• Compliance with FAA and TSA standards to ensure safety for people and property Note: Compliance is mandatory and not subject to the FAA BCA requirement. However, compliance must be done in the most cost-effective manner acceptable to FAA.
• Security fencing and gates	• Compliance with FAA and TSA standards to ensure safety for people, aircraft and property Note: Compliance is mandatory and not subject to the FAA BCA requirement. However, compliance must be done in the most cost-effective manner acceptable to FAA.
LANDSIDE-OTHER **Inter-Terminal Transportation**	
• Fixed guideway people mover • Bus • Other inter-terminal transportation investments*	• Reduced aircraft, passenger, and cargo delay (attributable to faster passenger transfers to connecting flights) • Improved passenger comfort • Lower operating and maintenance costs
Landside Access Projects *	
• Airport access roads • Passenger pick-up/drop-off areas • Transit areas • Other landside facility improvements*	• Reduced passenger, cargo, and airport and airline employee delay in getting to airport • Improved schedule predictability (ability to leave later for airport and arrive on-time for check-in) • Lower operating and maintenance costs • Improved safety • Reduced automobile emissions

Source: FAA Office of Aviation Policy and Plans, "Table 10.1: Benefits of Airport Projects," FAA Airport Benefit-Cost Analysis Guidance, Dec. 15, 1999, pp. 26-27.

** Note: Landside access projects can include terminal curbfront and roadways, other on-airport roads, people-mover links, intermodal terminals, parking facilities, rental car facilities, express bus services to remote terminals, and rail access projects.*

Table A-19. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefits and Measurement Units
(Page 1 of 5)

Airport Capital Project	Benefit	Measurement Unit
Reduced Delay/Reduced travel time		
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding)	• Reduced aircraft delay or travel time	• Reduced hours of aircraft delay or travel time by airborne, taxi, or gate status for each aircraft class (air carrier, commuter, GA, military)
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems • Fixed guideway people mover • Bus • Other inter-terminal transportation investments • Airport access roads • Passenger pick-up/drop-off areas • Transit areas • Other landside facility improvements	• Reduced passenger delay or travel time	• Reduced hours passenger delay or travel time by airside, ATB, and landside status • Reduced hours of passenger vehicle delay or travel time in landside access
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Freight handling systems • Airport access roads	• Reduced cargo delay or shipping time	• Reduced units of express cargo arriving at/departing from airport after time required to make guaranteed delivery time • Reduced air freight ton shipping time or delay hours by airside, ATB, and landside status • Reduced truck delay hours in landside access • Increased cargo throughput • Improved reliability

Table A-19. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefits and Measurement Units
(Page 2 of 5)

Airport Capital Project	Benefit	Measurement Unit
Improved Schedule Predictability		
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Airport access roads • Passenger pick-up/drop-off areas • Transit areas • Other landside improvements	• Aircraft operator ability to make more efficient use of equipment and personnel due to more predictable schedules	• Reduced numbers of aircraft and crew required to accommodate posted schedules
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Airport access roads • Passenger pick-up/drop-off areas • Transit areas • Other landside improvements	• Passenger confidence to take later flight with expectation of arriving at destination on-time • Passenger confidence to arrive at ATB closer to flight time with expectation of making flight • Passenger confidence to leave residence or business later for airport with expectation of arrival at ATB in time for check-in	• Reduced hours of passenger travel time scheduled to accommodate potential delay by airside, ATB, and landside components (less the amount of reduced delay associated with the project)
More Efficient Traffic Flows		
• New or extended runway, taxiway, apron, or hold pad	• Reduced aircraft vectoring and taxiing	• Reduced aircraft and passenger hours due to more efficient layout of runways, taxiways, hold pads, and aprons
• Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding)	• Shortened pedestrian traffic distances	• Reduced passenger time required to walk or travel within ATB (not attributable to reduced ATB congestion)

Table A-19. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefits and Measurement Units

(Page 3 of 5)

Airport Capital Project	Benefit	Measurement Unit
Use of Larger, Faster and/or More Efficient Aircraft		
• New or extended runway, taxiway, apron, or hold pad	• Reduced aircraft operation costs and shorter passenger travel times due to service by larger, faster, and/or more efficient aircraft	• Lower cost/fare per revenue passenger mile • Lower cost/charge per revenue cargo ton mile • Reduced passenger hours associated with new direct flights • Reduced passenger hours associated with new jet flights • Reduced cargo ton hours associated with new direct flights
Safety, Security, and Design Standard Benefits Associated With Capacity Projects		
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Installation of signage and lighting • Expansion of runway safety areas • Airside fencing • Acquisition of rescue and firefighting equipment • Passenger, baggage, and freight security systems • ATB security fencing and gates • Airport access roads • Passenger pick-up/drop-off areas • Transit areas	• New capacity project complies with FAA safety, security, and design standards	No benefits can be applied. All new capacity projects must be built to FAA safety, security, and design standards to qualify for AIP funds.

Table A-19. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefits and Measurement Units

(Page 4 of 5)

Airport Capital Project	Benefit	Measurement Unit
Safety, Security, and Design Standard Benefits Associated With Capacity Projects		
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Installation of signage and lighting • Expansion of runway safety areas • Removal of obstructions from existing approaches • Airside fencing • Acquisition of rescue and firefighting equipment • Passenger, baggage, and freight security systems • ATB security fencing and gates • Airport access roads • Passenger pick-up/drop-off areas • Transit areas • Other landside facility improvements	• New capacity project enables compliance of pre-existing infrastructure within FAA safety, security, and design standards	• Value of most cost-effective alternative means to bring pre-existing infrastructure into compliance with FAA safety, security, and design standards (if new project were not built)
• Acquisition of airside equipment to support capacity objectives (navigational aids)	• Increased safety associated with precision approaches	• Number of precision approaches flown with new landing system (will be calculated by FAA)
Environmental Benefits		
• New or extended runway, taxiway, apron, or hold pad	• New capacity project complies with federal environmental requirements	No benefits can be applied. All new projects must be built to federal environmental requirements
• New or extended runway, taxiway, apron, or hold pad • Noise mitigation for existing infrastructure (noise insulation, structure removal)	• New capacity project brings existing infrastructure into compliance with federal environmental requirements	• Value of most cost-effective alternative means to accommodate federal environmental requirements (if the new project were not built)

Table A-19. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefits and Measurement Units

(Page 5 of 5)

Airport Capital Project	Benefit	Measurement Unit
Airport Operating and Maintenance Benefits		
• Reconstruction of runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems • Fixed guideway people mover • Bus • Airport access roads • Passenger pick-up/drop-off areas • Transit areas • Other landside facility improvements	• Lower operating and maintenance costs	• Reduced employees, power, fuel, and maintenance materials per passenger

Source: FAA Office of Aviation Policy and Plans, "Table 10.2: Measures of Airport Project Benefits," FAA Airport Benefit-Cost Analysis Guidance, Washington, D.C., Dec. 15, 1999, pages 34-35.

Table A-20. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefit Measurement Units, Relevant Economic Values and Data Sources
(Page 1 of 6)

Airport Capital Projects	Benefit Measurement Unit	Relevant Economic Values	Data Source
Reduced Aircraft Delay Hours			
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems	Reduced aircraft delay hours by airborne, taxi, or gate status for each aircraft class (air carrier, regional/commuter, GA, and military)	Operating cost per aircraft hour, adjusted for aircraft class and delay location status. In limited cases, saved aircraft capital cost may be considered.	FAA Guide on Economic Values*
Reduced Passenger Delay Hours			
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems • Fixed guideway people mover • Bus • Airport access roads • Passenger pick-up/drop-off areas • Transit areas	Reduced business and non-business passenger delay hours by airside, ATB, and landside status	Passenger willingness to pay to avoid one hour of travel delay	FAA Guide on Economic Values*
• Airport access roads • Passenger pick-up/drop-off areas	Reduced passenger vehicle hours in landside access	Passenger vehicle operating costs	Current FHWA estimates

Table A-20. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefit Measurement Units, Relevant Economic Values and Data Sources

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Airport Capital Projects	Benefit Measurement Unit	Relevant Economic Values	Data Source
Reduced Air Cargo Delay Hours			
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems • Airport access roads	Reduced air cargo ton hours by airside, ATB, and landside status	Opportunity cost of cargo delayed in transit/spoilage of time-sensitive cargo	Documented data on value of cargo provided by operators (if available). Apply 7 percent real opportunity cost (annual basis) to the value of cargo for period delayed.
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems • Airport access roads	Units of express cargo arriving late at airport after time required to make guaranteed delivery time	Refunded shipping revenue for late package delivery or greater resource costs expended to compensate for airport delays	Documented data provided by operators
• Airport access roads	Reduced trucking hours in landside access	Cargo vehicle operating costs	Current FHWA estimates for light trucks (including driver costs)

Table A-20. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefit Measurement Units, Relevant Economic Values and Data Sources

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Airport Capital Projects	Benefit Measurement Unit	Relevant Economic Values	Data Source
Reduced Meeter/Greeter Delay Hours			
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems • Fixed guideway people mover • Bus • Airport access roads • Passenger pick-up/drop-off areas • Transit areas	Reduced meeter/greeter delay hours by airside, ATB, and landside status	Meeter/greeter willingness to pay to avoid one hour of delay	FAA has not assigned a value to meeter/greeter time. Sensitivity analysis should assume half the values applied to passenger time in FAA Guide on Economic Values*.
Improved Schedule Predictability			
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding)	Reduced resources needed to meet flight schedules	Cost of resources allocated to accommodate potential delays	Documented aircraft operator cost data in FAA Guide on Economic Values*

Table A-20. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefit Measurement Units, Relevant Economic Values and Data Sources

(Page 4 of 6)

Airport Capital Projects	Benefit Measurement Unit	Relevant Economic Values	Data Source
Improved Schedule Predictability			
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding)	Reduced hours of passenger travel time scheduled to accommodate potential delay, less reduced actual delay, by airside, ATB, and landside status	Passenger willingness to pay to avoid one hour of scheduled travel time	Passenger travel time values in FAA Guide on Economic Values*
More Efficient Traffic Flows			
• New or extended runway, taxiway, apron, or hold pad	Reduced aircraft hours in airspace and on ground due to more efficient layout of runways, taxiways, and aprons	Operating cost per aircraft hour, adjusted for aircraft class and airborne, taxi, or gate status (if available).	See Reduced Aircraft Delay
• New or extended runway, taxiway, apron, or hold pad • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Fixed guideway people mover • Bus • Airport access roads • Passenger pick-up/drop-off areas • Transit areas	Reduced passenger hours due to more efficient airside, ATB, and landside traffic flows	Passenger willingness to pay to avoid one hour of scheduled travel time	See Improved Schedule Predictability/Reduced Hours of Scheduled Passenger Time

Table A-20. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefit Measurement Units, Relevant Economic Values and Data Sources
(Page 5 of 6)

Airport Capital Projects	Benefit Measurement Unit	Relevant Economic Values	Data Source
Use of Larger, Faster and/or More Efficient Aircraft			
• New or extended runway, taxiway, apron, or hold pad	Lower cost due to more efficient aircraft	Cost or fare reduction per passenger/cargo unit	Aircraft operator cost data in FAA Guide on Economic Values*. Commercially available data on average yield, destinations, and trip distance at subject and comparison airports.
• New or extended runway, taxiway, apron, or hold pad	Reduced passenger hours on direct flights or jet flights	Passenger willingness to pay to avoid scheduled travel hour	See Improved Schedule Predictability/Reduced Hours of Scheduled Passenger Time for valuation of reduced trip hours.
• New or extended runway, taxiway, apron, or hold pad	Reduced cargo hours on direct or jet flights	Opportunity cost of cargo in transit/Reduction in resources to meet guaranteed delivery times	See Reduced Air Cargo Delay
Safety, Security, and Design Standard Benefits Associated With Capacity Projects			
• New or extended runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Installation of signage and lighting • Expansion of runway safety areas • Removal of obstructions from existing approaches • Airside fencing • Acquisition of rescue and firefighting equipment • Passenger, baggage, and freight security systems • ATB security fencing and gates • Airport access roads • Passenger pick-up/drop-off areas • Transit areas	Accommodation of safety, security, and design standards of pre-existing airport infrastructure	Lowest-cost alternative means to achieve compliance of pre-existing infrastructure with FAA standards	Engineering cost estimates of alternative project designed specifically to correct substandard conditions. Compare to delay cost imposed by an operating restriction to accomplish same objective.

Table A-20. Airport Benefit-Cost Analysis: Airport Capital Projects, Benefit Measurement Units, Relevant Economic Values and Data Sources

(Page 6 of 6)

Airport Capital Projects	Benefit Measurement Unit	Relevant Economic Values	Data Source
Safety Benefits of Capacity Projects			
• Acquisition of airside equipment to support capacity objectives (navigational aids)	Precision approaches enabled by new landing system	Reduced fatalities, injuries, and property damage per precision approach	Benefits calculated by FAA
Environmental Benefits of Capacity Projects			
• New or extended runway, taxiway, apron, or hold pad • Noise mitigation for existing infrastructure (noise insulation, structure removal)	Accommodation of environmental standards for pre-existing airport operations	Lowest-cost alternative means to attain compliance with standards	Engineering cost estimates of project designed specifically to correct sub-standard environmental compliance. Compare to delay cost imposed by an operating restriction to accomplish same objective.
Airport Operating and Maintenance Benefits			
• Reconstruction of runway, taxiway, apron, or hold pad • Acquisition of airside equipment to support capacity objectives (navigational aids, snow removal and maintenance equipment) • Reconstruction, expansion, and/or modernization of ATBs (excluding concession areas which are not eligible for AIP funding) • Baggage handling systems • Fixed guideway people mover • Bus • Airport access roads • Passenger pick-up/drop-off areas • Transit areas	Reduced employee, power, fuel, and maintenance per passenger	Cost reduction in personnel, energy, and supplies. To be treated as cost element	Airport accounting records and management cost estimates.

**GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Final Report, FAA Office of Aviation Policy and Plans, Oct. 3, 2007.*

Source: FAA Office of Aviation Policy and Plans, "Table 10.4: Valuation of Airport Project Benefits," FAA Airport Benefit-Cost Analysis Guidance, Dec. 1999, pp. 52-54.

4 IDENTIFYING CASE STUDIES

The Research Team identified five cases for review of how airports make capital investment decisions. In the course of selecting the Research Team identified and screened multiple capital projects. Airport officials were contacted to determine if there were viable value of time aspects to the projects; if tools identified in Task 2 (Appendix A.2) were used during project planning; and to solicit the cooperation from the airports. Airport officials for each case below gave their assent for these projects to be used as case studies for the ACRP 03-19 research effort, and offered to cooperate with the Research Team in the preparation of the cases.

Case Study Overviews

The selected case study projects encompass both capacity enhancement projects and non-capacity-related investments, and a variety of analysis techniques used to guide airport owners and operators and other stakeholders in making decisions. The key issues addressed in these case studies are how airport operators and other stakeholders apply recognizable and replicable techniques to guide decision making. Table A-21 summarizes the case studies. The case studies were ordered to first show the three projects that used passenger value of time to evaluate proposed capital investments (Boston Logan Airport, Dallas Love Field and Lambert-St. Louis Airport) and then the two projects that did not use passenger value of time (Hartsfield-Jackson Atlanta International Airport and Birmingham-Shuttlesworth International Airport).

Table A-21. Profile of Case Study Projects

Airport	Project(s)	Key Features
Boston Logan International Airport	Airfield Delay Reduction	Construction of Runway 14/32, a 5,000-foot unidirectional runway that also included a new taxiway and improvements to existing taxiways.
Dallas – Love Field Airport	Air and Groundside Capital Development Program	Terminal improvements and expansion, including 20 new gates, airfield improvements and Automated People Mover to connect airport to Dallas Area Rapid Transit
Lambert – St. Louis International Airport	Airport Development Program	New 9,000-foot parallel runway (11-29) to allow the airport to accommodate dual independent aircraft arrivals during IFR or bad weather conditions.
Hartsfield-Jackson Atlanta International Airport	Runway 8R End-Around Taxiway	Allows aircraft landing on Runway 26R to taxi around 26L instead of crossing the runway. A primary benefit of the project is the reduction in passenger delay due to the end-around routing.
Birmingham-Shuttlesworth International Airport	Terminal Modernization	Improve passenger movement in terminal and speed up security procedures. Note that this case study also includes a cargo component.

Documentation of the methodologies and techniques (e.g., benefit-cost studies and financial analyses) used for each proposed case are available. In addition, airport staff and consultants who worked on the projects have been identified and are willing to be interviewed.

Each of these five projects has implications for time savings for passengers. The terminal modernization program at Birmingham-Shuttlesworth International Airport and the capital development program at Dallas Love Field Airport were conceived, in part, to relieve terminal congestion and improve passenger comfort in terminals; thus, affecting both the length of time passengers are in the terminals and enhancing productivity when in the facilities. In addition, part of the Dallas Love Field program is designed to enhance ground access.

New runways are the focus of the case studies proposed for Boston Logan International Airport and Lambert-St. Louis International Airport. The Logan Airport project (5,000-foot runway 14/32) was conceived to relieve major aviation delays by separating smaller aircraft from large air carriers for take-offs and landings and, thereby, improving reliability. The 9,000-foot Lambert-St. Louis runway was designed to allow the airport to accommodate dual, independent aircraft arrivals during IFR or bad weather conditions, to substantially improve reliability, reduce delays in landings and increase capacity of the airport.

The primary objective for developing the end-around taxiway (EAT) at the Hartsfield-Jackson Atlanta International Airport (ATL) was to provide delay reduction for Runway 26L departing aircraft by requiring Runway 26R arrivals to taxi around the approach end of Runway 8R and avoid crossing Runway 26L. The EAT increased the departure rate of 26L due to fewer runway crossings, and reducing departure delays.

Research Objective

The case studies were used to examine the tools used for capital decision making and relevance of the tolls to estimate benefits concerning the passengers' value of time. The cases describe the context of capital investment decisions, the evaluation techniques used by airports, and factors considered by airports to make decisions. However, the case studies **<u>are not used</u>** to evaluate how well the evaluation techniques were applied or if they are good or bad projects. The case studies were conducted from the perspectives of decision makers, who confronted "invest/don't invest" decisions and choices among project alternatives.

Following completion of the case studies, the Research Team combined the studies with findings of Appendix A.2 and examined gaps in available data or techniques that prevented a full examination of capital investment under question (reported in Chapter 4, below). For this analysis, gaps include a lack of data or suitable analytical tools, or data and/or methodologies/techniques that are difficult to understand or are contradictory.

Case Study Outline

As part of the project, the Research Team developed case studies to illustrate how airports make capital investment decisions using benefit-cost analysis, financial analysis, capital investment financial planning, and economic impact analysis.

To complete a case study, the Research Team interviewed airport management staff, consultants, FAA representatives and other parties involved in the decision process, and reviewed available reports to document the following:

1. Airport overview
    a. Airport name and location
    b. Governance
    c. FAA hub designation (large, medium, small or non-hub)
    d. Key activity measures in 2010 (enplanements, cargo and aircraft operations)
2. Proposed capital improvement (individual project or entire Capital Improvement Program [CIP])
    a. Problem statement and investment objective
    b. Description of project or CIP
    c. Description of alternatives considered, if any
    d. Description of how passenger time (at the airport, arriving or exiting the airport) factored into the proposed projects, directly or indirectly
3. Funding plan (sources and uses of funds)
4. Capital investment decision process
    a. Overview of the process
        i. Identification of the parties involved in the decision
        ii. Description of the process
        iii. Highlight of any major issue or consideration and how it was addressed
    b. Specific evaluation methodologies and techniques used
        i. Identification of methodology and technique
        ii. Summary of approach, results and recommendations
        iii. Obtaining of a copy of any documentation (e.g., LOI application, BCA report, financial feasibility study, or financial plan)
        iv. Description of how the passenger value of time factored into the analysis
    c. Decision outcome
        i. Was the decision consistent with the evaluation recommendation? If not, what were the other considerations for the decision?
        ii. Report on the status of project or CIP financing and implementation
5. Appendices
    a. Persons interviewed (name, title, role in analysis or decision making)

b. Documents reviewed

Case Study Summaries

Boston Logan International Airport - Construction of Runway 14/32

Runway 14/32 is a 5,000-foot unidirectional runway, with departures conducted from Runway 14 and landings on Runway 32 (see Figure A-1). The runway was designed as part of an overall airfield delay reduction program that also included a new taxiway, improvements to existing taxiways, reductions in runway minimums including upgrading a second runway to CAT (ILS Category) II/III, and a peak period surcharge triggered when VFR (Visual Flight Rules) delays become excessive. As the project was being conceived, modeling indicated that the runway would reduce clear weather delays by 68 percent and reduce total delays by nearly one-third.[69] The goal of the airfield portion of the overall Logan Modernization Program was to reduce current and projected levels of aircraft delay and enhance operational safety at the airport.

The primary benefit of Runway 14/32 occurs during high to moderate northwest wind conditions. In these situations, airfield capacity declined sharply as operations shifted from Logan's normal three-runway configurations to current lower capacity configurations using Runways 33L and 27 or (during very strong wind conditions) Runway 33L alone. With Runway 14/32, air traffic controllers have the opportunity to avoid this decline in capacity, thereby reducing delays. As a condition of its environmental approval, the new runway is wind restricted (i.e. it can only be used by the FAA Tower when winds are from the northwest or southeast).

[69] Leo, Flavio; Planning Constructing and Integrating a New Runway at Boston Logan International Airport; December, 2010.

The new runway became operational in November of 2006. (See Figure A-2.) The runway is used by small aircraft, including CRJ1, CRJ2, CRJ7, E135, E145, E190, B190, SF34, DH8, and non-large jet aircraft. It is also designed for next generation regional jets.[70]

Since it was placed into service, the new runway has significantly reduced congestion/delays during northwest wind conditions by allowing the Air Traffic Control Tower to separate smaller aircraft from Runway 15/33 (the primary runway in the northwest flow), thus freeing up the 10,000-foot runway to service larger air carrier jets.

Background

The purpose of the airport's Airside Projects is to reduce delays caused by these conditions and improve runway reliability. Logan International Airport is the largest airport in the six-state New England region and also operates as a regional hub for connecting passengers. Prior to construction of Runway 14/32, the airport oversaw 488,000 landings and take-offs in 2000, which served 27.4 million passengers. In 2000, Logan was the 6th most delayed airport nationally, and recorded the second highest amount of arrival delays among U.S. airports; yet it ranked 11th in terms of total aircraft operations. Moreover, in 1998, airlines and passengers experienced approximately 142,000 hours of delay.

Analysis conducted when Runway 14/32 was being planned indicated that, had the runway been available in 1998, annual runway delays would have been reduced by 32 percent and Visual Flight Rules (good weather) delays occurring during northwest winds would have been reduced by 87 percent. As airport activity was projected to grow over time, delay reduction benefits also were projected to increase. Table A-22 shows the project budget.

[70] Ibid

Table A-22. Project Budget for Runway 14/32

Item	Cost
Property Acquisition	$9,237,000
Design	$2,561,000
Construction & Construction Related	$56,837,000
Legal & Environmental	$14,373,000
OCIP (Owner Controlled Insurance Program)	$1,570,000
Other	$845,000
Contingency	$14,325,000
Total	**$99,748,000**

Source: Leo, December 2010

Dallas – Love Field Airport Development Program

In 2008, the City of Dallas Airport Authority began a major capital program to reconstruct and renovate Love Field Airport. This Capital Development Program (CDP) consists of three major elements: 1) the Love Field Modernization Program (LFMP); 2) The Capital Improvement Program (CIP); and 3) The Automated People Mover (APM). The LFMP is a direct result of the Five Party Agreement to repeal the Wright Amendment in 2014 (for discussion of the Wright Amendment, please see the case study in Chapter 5, below). Combined, the CIP and the APM programs will enhance capacity, safety and access to the airport.

The LFMP and the CIP are separate complementary programs consisting of distinct project elements. The LFMP carries out the City's commitment under the Five-Party Agreement to make a significant capital investment to modernize the terminal, while the CIP consists of improvements that are needed independent of the LFMP.

The LFMP includes the replacement of the apron, roadways, and support buildings. It will also replace the original ticketing hall (constructed in the 1950s and abandoned in the 1970s) with a new modern ticketing hall for all airlines. The baggage claim hall will be expanded to accommodate future demand levels, and the main lobby will be renovated and expanded. The primary component of the program is the complete replacement of the three existing concourses with one single concourse. The final facility will be approximately 800,000 square feet and include 20 narrow body gates for three carriers.

The funding plan for the LFMP is complex and includes federal grants, TSA and ASP grants, bond funds, Southwest Airlines funds, PFCs and airport equity. The original sources and uses of funds are shown on Table A-23.

Table A-23. Sources and Uses of Funds for the LFMP

LFMP			
Source of Funds (in millions)		Use of Funds (in millions)	
Bond Proceeds	$377.2	Terminal	$288.2
PFCs	$29.2	Apron	$93.8
FAA Grants	$59.0	Airfield	$7.0
TSA Grant	$19.5	Parking & Ground Transport	$20.7
ASP Grant	$3.6	Other Facilities	$29.5
Southwest Airlines	$10.2	Enabling	$34.2
Aviation Capital Funds	$20.3	PMT & Indirects	$45.8
Total Sources	**$519.1**	**Total Uses**	**$519.1**

Note: The primary source of funding for the PMT and other indirect costs are bonds, i.e. debt service.

The CIP program consists of projects that rebuild and rehabilitate taxiways, build new taxiways, rebuild holding pads, and service roads, airfield drainage improvements, a new parking garage, enhanced security, runway rehabilitation and repair, RSA (Runway Safety Area), repair the Vertiport, replace ARFF (Aircraft Rescue and Fire Fighting) equipment and build a new ARFF Facility. The CIP addresses improvements to access roads into the airport. The funding sources of all of the projects are as follows on Table A-24.

Table A-24. Sources and Uses of Funds for the CIP

CIP			
Source of Funds (in millions)		Use of Funds (in millions)	
FAA Grants	$38.7	Drainage	$118.4
PFCs	$74.1	Buildings	$76.9
Aviation Capital Funds	$53.1	Airfield	$67.6
GARBS	$157.0	Roadways/Parking	$52.1
Other	$22.5	Program Management	$17.7
		ARFF	$7.9
		Land Acquisition	$2.0
		Equipment Purchases	$1.2
		Misc. Aesthetic Improvements	$1.0
		Miscellaneous Studies	$0.7
Total Sources	**$345.5**	**Total Uses**	**$345.5**

Source: Dallas Airport System, CIP Projects by Year: 2007-2014

The APM project will connect the Dallas Area Rapid Transit (DART) system to the airport via a connector from a local station. At this writing, the APM project is considering various options and locations. The project is estimated to cost $150 million to $250 million, and will be funded though bonds, local funds and PFCs.

Lambert-St. Louis International Airport – Airport Development Program

In 1999, the City of St. Louis Airport Authority embarked on a major capital program to expand and improve Lambert-St. Louis International Airport. The program, referred to as the Airport Development Program (the ADP), was based on recommendations of the Airport's 1996 Master Plan Supplement. The Master Plan Supplement included recommendations for airport development over a 20-year planning period, to be accomplished in phases. The major elements of Phase I included land acquisition for the runway and support facilities, the planning, design and construction of a new 9,000-foot parallel runway, relocation of the Missouri Air National Guard (MOANG) and infrastructure for the redevelopment of the northeast quadrant of the airport. The airport also retained the option to finance certain replacement facilities for airport tenants which would be paid for entirely by those tenants.

Prior to the ADP, the airport's two primary runways were separated by only 1,300 feet and the airport was reduced to one precision instrument approach during adverse weather conditions. The new runway was designed to allow the airport to accommodate dual independent aircraft arrivals during IFR or bad weather conditions; thereby, substantially increasing capacity. Previous studies indicated the new runway should result in savings to airlines and passengers from a reduction in aircraft delay of approximately $50 million a year and have a benefit/cost ratio of greater than 2:1.[71] In addition, the project was expected to reduce air traffic delays in the national air transportation system.

The funding plan for the ADP was complex and included federal grants, bond funds, local sources and airport equity. The original sources and uses of funds are shown in Table A-25.

Table A-25. Sources and Uses of Funds for the Airport Development Program

Original Sources of Funds (in millions)		Original Uses of Funds (in millions)	
Airport Development Fund	$79,520	Program Mgmt/Prof. Services	$110,922
AIP Funding (through LOI)	$106,568	Land Acquisition	$437,473
FHWA Grant	$14,436	Northwest Land Acquisition	$50,000
PFC Pay-As-You-Go	$400,118	New Runway	$370,784
GARBS	$508,879	Northeast Quadrant Infrastructure	$27,343
		Relocation of MOANG	$35,000
		Contingency	$78,000
TOTAL SOURCES	**$1,109,522**	**TOTAL USES**	**$1,109,522**

Three years into the ADP, the airline industry was severely affected by the September 11th terrorist attacks, a weakened economy and the Iraq war. Less than two years later, American Airlines, the largest carrier at the airport at that time, announced plans to reduce

[71] Source: FAA Benefit-Cost Analysis for Lambert-St. Louis International Airport Capacity Enhancement Project, July 31, 1997.

its service by approximately 50 percent, lowering total enplanements by over 30 percent. The airport responded to these challenges by reducing the scope of the program and adjusting the funding sources. These changes resulted in fewer costs of the project being charged to the airlines. The FAA was instrumental in this process and assisted by increasing the LOI by $50 million, accelerating the LOI schedule and providing more than $30 million in noise grants for property that was purchased for acquisition. The final sources and uses of funds are shown in Table A-26.

Table A-26. Final Sources and Uses of Funds

Final Sources of Funds (in millions)		Final Uses of Funds (in millions)	
Airport Development Fund	$12,213	Program Mgmt/Prof. Services	$164,876
AIP Funding (through LOI)	$153,228	Land Acquisition	$482,959
FHWA Grant	$14,436	Northwest Land Acquisition	$50,000
PFC Pay-As-You-Go	$330,061	New Runway	$354,234
GARBS	$516,414	Northeast Quadrant Infrastructure	$603
Noise Grants	$31,182	Relocation of MOANG	$0
		Toolbox Contracts	$966
		Contingency	$3,897
TOTAL SOURCES	**$1,057,535**	**TOTAL USES**	**$1,057,535**

Hartsfield-Jackson Atlanta International Airport – Runway 8R End-Around Taxiway (EAT)

Hartsfield-Jackson Atlanta International Airport constructed a taxiway that allows aircraft landing on Runway 26R to taxi around the 8R end or Runway 8R/ 26L instead of crossing Runway 26L. Figure A-3 illustrates the connections of 26R, 8R and 26L. The primary objective behind the taxiway is to reduce runway crossings of Runway 26L, thereby increasing the Runway 26L departure rate and reducing departure delay for both departure runways (Runway 26L and 27R). Thus, the primary benefits of the project are to reduce variable aircraft operational costs by reducing aircraft departure delay and to provide passenger delay reduction. Objectives of the EAT (end-around taxiway) are summarized in Table A-27.

Table A-27. Project Objectives

Number	Primary Objective	Other Project Benefits
1	Reduce Runway 26L departure delay	Reduction of Runway 27R departure delay
2	Reduce crossings of Runway 26L and exposure to incursions	Reduced aircraft engine emissions
3	Clear up Runway 8R queueing problems at Ramp 1, 2, and 3 throats	Greater controller flexibility
4	Expedite DAL Supertug	Repositioning of aircraft from CPTC to TOC North and vice versa

DAL = Delta Airlines; CPTC = Central Passenger Terminal Complex; TOC = Technical Operations Center (an existing airplane maintenance complex)

Source: Atlanta Department of Aviation, Runway 8R End-Around Benefit-Cost Analysis Report

A key feature of the four-runway system and the Atlanta departure airspace is the capability to swap some departing aircraft from Runway 27R to 26L, and vice versa, when it is operationally advantageous to do so. Approximately 25-50 aircraft are swapped on a typical day. For example, some departures assigned to Runway 27R are reassigned to Runway 26L. The opposite also occurs.

With the 8R EAT in place, Runway 26L is capable of producing a greater departure rate than 27R. Thus, additional aircraft are reassigned to 26L from 27R. Fewer Runway 27R departures also provide delay reduction for those aircraft still assigned to depart from Runway 27R. Additionally, eastern departures from Runway 8R are able to queue on both sides of Runway 8R by using the EAT in the reverse direction. Queueing some aircraft on the runway's north side helps relieve the blockage of the Ramp 1 North, 2 North, and 3 North throats that occurs during an east operation.

For calendar year 2004, FAA Aviation System Performance Metrics (ASPM) data showed that Hartsfield-Jackson was ranked second nationally in aggregate taxi-out delay with an approximate total of 4.2 million minutes of delay (Chicago O'Hare International Airport was ranked first). While the new Runway 10/28 provides departure delay reduction, the end-around taxiway further reduces departure delay; thereby, reducing airline operating expenses, enhancing airline schedule integrity locally and nationally, providing a more reliable ATL operation, and providing a greater passenger level of service both locally and across the NAS (National Aviation System).

The program cost (construction and all soft costs) was estimated at $42.1 million prior to implementation, as shown in Table A-28.

Table A-28. Estimated EAT Budget Prior to Development

Item	Estimated Cost
Planning	$548,182
Design	$1,230,099
Construction	$37,331,689
Construction Management	$972,675
Program Management	$1,035,861
Insurance	$732,169
Testing	$244,056
Total	**$42,094,731**

Birmingham-Shuttlesworth International Airport Terminal Modernization Project

In February of 2006, the Birmingham Airport Authority commissioned a study to determine the future viability of the Birmingham-Shuttlesworth International Airport Main Terminal Building. The study, "Birmingham International Airport Terminal Modernization Program Criteria Document", reported that the main terminal had several problems including: (1) the roof no longer protected the building; (2) the exterior walls leaked and were not properly insulated; (3) the primary building systems (electrical, mechanical, and fire protection) were at the end of their useful lives and some did not meet current codes; (4) the central plant needed upgrades; and (5) the functional layout of the main terminal was not conducive to the current needs of airline operations, passenger security screening, concessions operations, and baggage screening.

On November 29, 2010, the Authority executed a construction contract with a guaranteed maximum price of $201.649 million. The project involves the complete modernization and expansion of the main terminal building, expanding the building from 244,000 square feet to 424,000 square feet. In addition to the overall expansion, the project will also include: (1) the construction of new facilities for passenger screening; (2) the implementation of a new access control system; (3) the construction of a secured loading dock; (4) the implementation of other security projects; (5) the addition of improved baggage screening devices and a baggage make-up area; (6) the implementation of an integrated outbound baggage handling system; (7) the purchase and installation of 19 jet bridges; (8) the construction of upgraded food and retail concession areas; (9) improvements to the baggage claim area; (10) an upgraded central plant and HVAC system; (11) the construction of a FIS (Federal Inspection Services) facility; (12) improved elevators in the parking deck; (13) construction of a pedestrian ramp; and (14) the relocation of tenants from the old cargo building to the new cargo building. Table A-29 displays the funding plan for the terminal modernization.

Table A-29. Terminal Modernization Source of Funds

Source	Amount
Series 2010 GARBs	$116,075,430
PFC Pay-As-You-Go	15,603,206
AIP Entitlements Grants	22,337,976
AIP Discretionary Grants	18,386,540
VALE Grants	8,773,988
TSA Grants	14,303,230
Airport Discretionary Revenue	6,168,781
Total Sources of Funds	**$201,649,150**

A financial feasibility study was prepared to support the recently issued Series 2010 GARBs, which account for nearly 58 percent of total capital funding requirements.

5 CASE STUDIES

Purpose of Case Studies

Airport capital investment decisions may be conceived and implemented for either of two overarching reasons:

- An airport may require more capacity to address congestion and delays, or
- There may be a need to improve safety or environmental factors or passenger convenience.

Because funding for projects is competitive, decision makers must evaluate projects on a number of factors when deciding what to fund, including a project's return on investment and the ratio of the project benefits to project costs. Case studies provide key information for understanding the tools and measures decision makers use to evaluate airport capital investments. For this project, five case studies of airport investments were conducted to identify what tools were used in decision making, how tools varied based on the project motivation and funding sources being sought, what important factors were considered in the process, and, in particular, how the passenger value of time factored into the investment decision. The case study projects encompass both capacity enhancement and non-capacity-related investments. The case studies did *not* assess how well the evaluation techniques were applied or if these are worthwhile projects.

As documented Appendices A.1 and A.2, the value of travel time is a central element in assessing the benefit of capacity projects that are designed specifically to reduce delay. Delay is important to both the airline operators, whose operating costs increase with delay, and to business and non-business passengers, who place a value on their time. Even projects designed to address safety or environmental issues may have effects on travel time, such as when an investment is made in new security screening facilities, allowing passengers to pass through checkpoints more rapidly. The case studies help to illustrate the importance of value of time for both operators and passengers in investment decision making.

Summary of Results

Table A-30 provides an overview of the case study airports and the investments highlighted in each case. The projects include:

- Terminal modernization at the Birmingham-Shuttlesworth International Airport
- A new end-around taxiway at the Hartsfield-Jackson Atlanta International Airport
- A new runway, a taxiway extension, and reconfiguration of additional taxiways at Boston Logan International Airport

- A modernized terminal building, together with construction or reconstruction of runways, taxiways, and other infrastructure, at Dallas Love Field Airport (an automated people mover was considered but subsequently found to be infeasible due to cost)
- A new parallel runway at Lambert-St. Louis International Airport

The case study airports include one small hub, two medium hubs, and two large hubs. The terminal modernization projects are intended to improve passenger flow and airport safety, and accommodate more aircraft at the terminal buildings. The runway improvements and taxiways are intended to add capacity for more flights, reduce delays, and increase safety. As of the date of finalizing this appendix, three of the projects have been completed for several years and two are essentially completed.

Table A-30. Overview of Case Studies

Airport	Airport Designation	Project Description	Date Completed	Project Purpose
Birmingham-Shuttlesworth International Airport	Small Hub	Main terminal building modernization	Largely Complete	Terminal modernization to update systems, make building improvements and improve passenger flow. Passenger flow improvements include new central screening area that can handle more passengers, post-screening concessions, improved baggage screening devices, baggage make-up area and baggage claim area, upgraded elevators in garage, pedestrian ramp from garage to terminal building, and improved signage.
Hartsfield-Jackson Atlanta International Airport	Large Hub	Runway 8R end-around taxiway	2007	Reduce delays on existing runways and reduce congestion at terminal apron entrance and exit taxiways. Improve safety by reducing chances for runway incursions.
Boston Logan International Airport Runway Extension	Large Hub	New runway 14-32; extension of taxiway D; reconfiguring a group of taxiways	2006	Reduce operational delays caused by strong northwest winds.
Dallas Love Field Airport	Medium Hub	Air and groundside capital development program, including revamped terminal, runways, taxiways, and other infrastructure. Automated people mover considered but found infeasible.	Largely Complete	Provide additional airport capacity in the Dallas region.
Lambert-St Louis International Airport	Medium Hub	Phase I of Airport Development Plan: new 9,000 foot parallel runway	2006	Increase capacity during instrument flight rule conditions.

Overview of Approaches to Decision Making and Passenger Value of Time

Analysis methodologies and techniques used by the project sponsors for each of the case study projects followed the requirements of funding agencies and programs. Employment of methodologies was undertaken in part to promote the projects to potential funding sources. While initial discussions indicated that saving passenger time was an important consideration for all the cases, the research revealed that, in fact, only three of the five projects used passenger value of time as a formal part of project evaluation. Notably, while a goal of the Birmingham-Shuttlesworth project is to save passenger time in going through security and in the baggage area, the value of the time savings for these improvements was not calculated. Furthermore, current guidance on benefit-cost analyses for airport projects is limited in how the value of time for specialized segments of passengers' experiences can be consistently measured across airports. Also, while there is no dispute that the EAT at Hartsfield-Jackson Atlanta International Airport (ATL) has significant value of time implications for passengers, these travel time savings were not included in the analysis. When the project was initially presented to the airlines at ATL, the airport management did not believe that airline decision makers were as concerned about the passenger value of time savings as they were about the reduction in their operating costs of reduced aircraft delay. Therefore, the initial benefit-cost analysis (BCA) focused exclusively on the likely benefits and costs to airlines. Regardless, the airlines chose not to fund the project, possibly because airline executives realized that FAA funding was available. In addition, the BCA developed for the airline executives demonstrated robust results without requiring the passenger value of time savings to be added for submittal to the FAA for funding under the Airport Improvement Program.

The case studies that addressed the value of passenger travel time savings did not include the value of any travel time savings that could be attributed to access to, or egress from, the airport. Such time savings can result from major airport improvements that persuade users of other airports to make a shorter trip to the improved facility. FAA benefit-cost guidance is distinct from other agencies because it recognizes the multi-modal aspects of airport access/egress. FAA guidance, however, does not differentiate the value of travel time between modes. Therefore, had savings of ground access/egress travel time been calculated, the value of time used most likely would have been the same as that used for savings in flight delay.

The planning studies shown in Table A-31 displays how each of the projects profiled in the case studies are incorporated in airport improvement programs. These planning studies range from master plans and capital plans, where projects are often first introduced, to environmental impact studies. The number of studies undertaken is often proportional to either the level of controversy provoked by the proposal or the feasibility of the project and/or alternatives.

Table A-31. Studies Used to Define Capital Investment Programs

Airport	Terminal Modernization Plan	Airport Master Plan	Capital Improvement Plan/ Capital Development Plan	Airport Development Plan	Environmental Impact Statement	Project Definition Report
Birmingham-Shuttlesworth International Airport	X					
Hartsfield-Jackson Atlanta International Airport		X	X			X
Boston Logan International Airport				X	X	
Dallas Love Field Airport	X					
Lambert-St Louis International Airport		X		X	X	

Table A-32 lists the analytical tools used to evaluate the feasibility of each case study project. These methodologies include financial techniques and benefit-cost analyses, which are often employed after numerous scenarios have been vetted in the processes listed in Table A-31. These analyses are applied to alternatives that best meet project objectives. The number of methodologies employed for evaluation purposes increases with project complexity, as well as with the requirements of funding sources being sought.

Table A-32. Types of Analyses Used to Evaluate Capital Investment Projects

Airport	Alternatives Analysis	Financial Feasibility Analysis	Passenger Facility Charge Financial Plan	Benefit-Cost Analysis
Birmingham-Shuttlesworth International Airport		X	X	
Hartsfield-Jackson Atlanta International Airport			X	X
Boston Logan International Airport	X			X
Dallas Love Field Airport	X	X	X	X
Lambert-St Louis International Airport	X	X	X	X

Table A-33 shows the techniques used to evaluate projects and alternatives and Table A-34 lists funding sources for the case study projects. In addition, some funding sources require specific requirements as part of the project evaluation. For example, project sponsors that intend to use Pay-As-You-Go Passenger Facility Charges (PFCs) or General Airport Revenue Bonds (GARBs) must complete a financial plan. These plans require the applicant to demonstrate that the PFCs will cover the portion of the project they are intended to fund.

Two airports also reported data on the cost per enplanement both before and after the improvement, and the debt coverage ratio before and after the improvement, as shown in Table A-33. These are common measures for assessing the ability of an airport to repay the debt incurred for capital investments. Moreover, this type of sensitivity analysis is part of the application process to show how the funding might change under different airport usage scenarios.

Table A-33. Project Evaluation Techniques

	Analysis Measures					
Airport	**Benefit-Cost Ratio**	**Net Present Value**	**Value of Time**	**Other factors included in Benefit-Cost Analysis**	**Cost per Enplanement After Improvement**	**Debt Coverage Ratio After Improvement**
Birmingham-Shuttlesworth International Airport	NA	NA	NA	NA	$7.72 prior to project; $11.91 after project	1.96 prior to project; 1.68 after project
Hartsfield-Jackson Atlanta International Airport	3.6-6.4	$91.5m - $194.3m net	$26.70/hr for passenger time did not included value of time to insure a conservative estimate	Capital costs, aircraft activity, and aircraft operating costs	NA	NA
Boston Logan International Airport	5.0-7.5, for scenarios that cap delay at 20 min.	$439m-$705.9m, for scenarios that cap delay at 20 min.	$34.50/hr business; $19.50/hr non-business; $26.70/hr mix business and non-business	Capital costs, aircraft activity assumptions, aircraft operating costs	NA	NA
Dallas Love Field Airport	Range for 15 scenarios based only on portion of project requiring AIP funds: 0.85-3.92	Study reported PVs for 5 benefit scenarios ($81.6m - $184.8m) and 3 cost scenarios ($47.1m - $96.6m)	Base value for all-purpose airline travel of $28.60/hr; low of $23.80/hr, high of $35.60/hr used for sensitivity analysis	Capital costs, other	NA	NA
Lambert-St Louis International Airport	2.2-2.6	$483m - $966 m	$45.50/hr all passengers in screening study and $27.90/hr all passengers in official BCA	$1,800/hr cost of aircraft operations; capital costs; design, land acquisition	$3.50 prior to investment; $10.12 after investment	1.47 prior to investment; 1.37 after investment

NA (not applicable) indicates that technique was not used.

Table A-34. Funding Mechanisms for Airport Improvements

	Funding Mechanisms											
Airport	**GARBs**	**PFCs**	**AIP grants**	**TSA grants**	**VALE Program grants**	**Municipal Funds**	**FAA Facilities & Equipment Fund**		**Airline Funding**	**SFB**	**Interest Income**	**Other Airport Revenues**
Birmingham-Shuttlesworth International Airport	X	X	X	X	X							X
Hartsfield-Jackson Atlanta International Airport		X	X			X						
Boston Logan International Airport			X			X						X
Dallas Love Field Airport		X	X	X					X	X		X
Lambert-St Louis International Airport	X	X	X				X				X	X

<u>Funding Mechanisms:</u>

GARB - General Airport Revenue Bonds

PFC - Passenger Facility Charge

AIP - Airport Improvement Program

TSA - Transportation Security Administration

VALE - Voluntary Airport Low Emissions Program

SFB - Special Facility Bonds. In the case of Dallas Love Field, the SFBs were approved the city of Dallas and guaranteed by Southwest Airlines

All of the airports except Boston Logan applied for and received permission to increase PFCs to help fund their projects. Two of the airports used GARBs to help fund their projects. A debt coverage ratio greater than 1.25 is typically required for projects seeking GARB funding. Any project sponsor that seeks funding through the Airport Improvement Program may be required to conduct a benefit-cost analysis (BCA), depending on the specifics of the funding request. The purpose of the BCA is to demonstrate that the benefits generated from the project, measured in dollars, outweigh the costs of the project. Benefits often are measured in terms of reduced airline operating costs (such as labor, maintenance and fuel savings) and reduced passenger travel time expressed in dollars reflecting the value of time saved by travelers. In 1997, the FAA established, and has since updated, guidelines for BCAs, including appropriate dollar values for the time of business passengers, those travelling on personal time, and a blended rate to cover both classes of passengers.

All of the case study projects applied for FAA Airport Improvement Program (AIP) entitlement or discretionary funds. Benefit-cost ratios and net present values (NPVs) of the projects were reported for four of the five projects, as shown in Table A-33. For Birmingham-Shuttlesworth, a BCA was contemplated when the airport and the FAA were considering whether to request and issue a Letter of Intent (LOI) for AIP funds. The decision was made not to pursue LOI funding, but request regular discretionary AIP funds in a three-year phased funding plan. The FAA also determined that the project could be categorized as a project to comply with FAA airport design standards, which does not require a BCA.

Table A-33 reports the passenger value of time used or considered in each BCA. The value used for passenger travel time varied considerably, ranging from $19.50 for non-business travel time in the Boston Logan case study, to $45.50 for all passenger travel time in the Lambert-St. Louis case study, which predated the 1997 published FAA guidance.[72] Three of the airports – Boston Logan, Dallas Love Field, and Lambert-St. Louis – used passenger value of time in their BCA. For the Hartsfield-Jackson Atlanta project, the airport chose to omit passenger value of time from the BCA, noting that this omission led to a conservative (yet still quite positive) benefit-cost estimate. The Hartsfield-Jackson Atlanta airport management chose not to include passenger value of time in the BCA in large part because the analysis was being used to convince the airlines to support the investment in the end-around taxiway, and management felt that the airlines would not take account of passenger value of time in their decisions.

Table A-33 also lists the factors included in the benefit-cost analysis for each project. Each of the projects included the capital costs of the project on the cost side of the equation, and

[72] See "Paying for Highways, Airways and Waterways: How Can Users be Charged", Congressional Budget Office, 1992. The CBO study shows 1987 values of time of $37.06 and $31.86 for business and non-business travel, respectively, and quotes the FAA as approving 1991 values of $44.24 for business travel and $38.03 for non-business travel based on applying the CPI to the 1987 values.

airline operating cost reductions resulting from reduced delays on the benefit side of the equation.

The sensitivity analyses for the various projects diverged on several factors to arrive at a range of benefit/cost ratios and net present values (NPVs). Some of these factors included the discount rate used, the payback period, the split between new and existing passengers affected by the project, and various caps on the amount of delay that is reasonable to assume before airlines choose not to use an airport. For example, in the Boston Logan case, the analyses were run using delays as long as 40 minutes, which resulted in a benefit/cost ratio of over 15. However, the analysts, in conjunction with the FAA, decided that delay should be capped at 20 minutes for the analysis, assuming that airlines would not choose to use Boston Logan if delays exceeded 20 minutes.

Overall, benefit/cost ratios and NPV appear to be important in the decision making process. One important reason is that many of the federal grants available to help pay for projects rely on these measures for evaluating the merit of each project. In addition, these measures are important to stakeholders, such as the airlines, for understanding the value of capital investments to operations. These measures have also proved useful in garnering support from other stakeholders, such as city council members and business leaders.

Other factors important to the decision making process varied among projects, and were driven by local considerations. In the Birmingham-Shuttlesworth case, the airport was very concerned about how the terminal modernization would affect its price competitiveness with similarly sized airports, leading to many adjustments to the terminal design to prevent costs becoming prohibitive. To ensure that the cost was capped, the airport authority executed a construction contract with a guaranteed maximum price. In the case of Dallas Love Field, the parameters of the project were driven by “The Five Party Agreement”, an agreement between the cities of Dallas and Fort Worth, the Dallas/Fort Worth International Airport (DFW) Board, American Airlines and Southwest Airlines. These parties had to agree to repeal a 1979 law that forbade certain types of air travel through Love Field in an effort to protect DFW. The law was repealed due to congestion issues at DFW, but all five parties needed to agree on new restrictions for air travel through Love Field. The elements included in the capital improvement plan were driven by safety and maintenance concerns, not financial concerns, although a benefit-cost analysis was still required for AIP funding.

The airport operator decision making for the Hartsfield-Jackson Atlanta EAT project was based on meeting a critical need for reduced delay. While support from the airlines was sought, the project went forward without their support. Roadblocks in getting the project approved did not arise at the local level. Instead, it was the FAA that initially balked at the project, primarily because the EAT solution to delay was a new concept. The FAA decided to support the project after considerable debate.

The Lambert-St. Louis project construction followed a long process that included substantial stakeholder involvement from a wide range of players, including the City of St. Louis, the airport, the airport's consultant, the FAA, a St. Louis business association, labor unions, congressional members, local governments and the public. After the FAA approved the project's Environmental Impact Statement (EIS), its construction was delayed for several years by lawsuits from nearby cities and opposition from the Air Line Pilots Association, the National Air Traffic Controllers Association, and a citizens group opposed to noise. Finally, the impacts of September 11, 2001, a general economic downturn, and American Airline's acquisition of TWA all impacted demand at the airport and required a revision to the improvement plan.

Boston Logan Airport's airside planning was intended to reduce delays by developing ways to maintain runway capacity at the airport during certain wind conditions. Like Lambert-St. Louis, the planning process involved stakeholders from the relevant agencies, the City, the FAA, businesses, airlines, the Commonwealth, permitting agencies, the U.S. Environmental Protection Agency (EPA), and the public. After the FAA approved the plans, neighborhoods affected by the plans sued to prohibit flights over South Boston and won, requiring revisions to the plan before it could go forward.

The remainder of this report provides a detailed description of each case study and how evaluation tools and the passenger value of time factored into the decision-making process.

Boston Logan International Airport – Runway Extension

Airport Overview

The General Edward Lawrence Logan International Airport (also known as Boston Logan International Airport, or commonly as "Logan") is located in the East Boston neighborhood of Boston, Massachusetts. It is operated by the Massachusetts Port Authority (Massport), an independent public authority which develops, promotes and manages airports, the seaport and transportation infrastructure in the Commonwealth. Logan is designated by the FAA as a large hub.[73] In 2010, Logan had 352,643 aircraft operations, 27 million passengers, and moved 247,833 metric tons of cargo.

Problem Statement and Investment Objective

Operational delays at Boston Logan International Airport (BOS) had occurred since the early 1990's which prompted the FAA and Massport to work together to identify policies that would meet existing and future demand for aviation in metro-Boston and the Greater New England area. Delay statistics from the FAA's Operations database showed that the airport

[73] http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

ranked as one of the top 10 most delayed airports in the U.S. from 1990 through 2001.[74] The delays were caused by a variety of factors, the most significant being the loss of airfield capacity associated with moderate to high northwest winds. Winds from the northwest occur an estimated 37 percent of the time and under these conditions controllers had to restrict operations to only one or two runways. This cut the runway capacity by 25-50 percent, from approximately 120 operations per hour to 60-90 operations per hour.

The taxiway system at Logan has evolved over the 80-year history of the airport and consists of intersecting taxiways which reduce operational efficiencies on the ground. The complex system has led to numerous runway incursions creating a safety issue which added to air traffic control workload. In addition, 40 percent of aircraft landing at Logan in 1992 were Class 1 and 2 aircraft,[75] used by commuter airlines and general aviation.[76] The configuration of runways at the Airport, including Runway 14/32, is illustrated by Figure A-3.

The combination of wind-related delays and the proportion of Class 1 and 2 aircraft using the airport had adverse effects on passengers, airlines, the airport, and supporting services. With passenger growth increasing each year, the average delay at Logan was expected to eventually reach a twenty-minute threshold. According to the FAA, a twenty-minute delay is "…the highest recorded average delay per operation known to the FAA at an airport in the U.S." The delay analysis indicated that, with passenger forecasts, an increase in delay beyond twenty minutes would be expected; however, the FAA believed that this prediction was unrealistic since airlines would likely refrain from adding additional flights to Boston Logan once the 20-minute delay threshold was reached.[77] This would essentially hamper future airline growth and would limit business-related travel and other tourism, which are important to the Boston metro area economy. Capping the delay by limiting the number of flights was one of the scenarios included in the benefit-costs analysis. . Complicating the development and use of the runway was a strong opposition to its construction and operation, which was spearheaded by community groups from Boston neighborhoods and the other cities and towns surrounding the airport. These groups cited a variety of issues as reasons for opposition,

[74] Leigh Fisher (2003) p. 3

[75] Class 1 aircraft have a wingspan of less than 49 feet and Class 2 aircraft have between a 49-78 feet wingspan.

[76] Federal Aviation Administration (1992)

[77] Leigh Fisher Associates (2003) p.ES-4

including increases in noise and emissions, detriments to economic growth and threats to endangered species.[78]

Project Description

After evaluating several recommended solutions from numerous studies, the FAA issued their Record of Decision (ROD) in 2002, which approved three proposed recommendations to reduce travel delay: (1) a unidirectional Runway 14/32, (2) an extension of Taxiway D, and (3) optimization of the Southwest Corner Taxiway complex.

Runway 14-32

This new runway was designed for use by commuter jets and general aviation (GA) aircraft, in order to free up longer runways for larger aircraft. Runway 14/32 would only be operated when winds were above 10 knots in a northwest/southeast wind direction. Runway 14 would be used exclusively for departures while Runway 32 would be used only for arrivals. The project also included taxiway improvements necessary to provide access to the new runway.

Extension of Taxiway D

This project extended Taxiway D by 2,000 feet. It was designed to facilitate more efficient and less confusing taxiing routes for certain aircraft that use Runways 4R/22L and 33L.

Southwest Corner Taxiway Complex

This project included reconfiguring a group of taxiways near the ends of Runways 4L, 4R, and 9 to improve taxiway flows, reduce taxiway complexity, and reduce the potential for runway incursions.

Alternatives

These airside improvements were the result of several studies conducted by Massport and the FAA to improve airfield operational efficiency, reduce aircraft delays, and enhance airfield capacity. One of the first alternative solutions evaluated was the feasibility of building another airport. In 1991, the Massachusetts Aeronautics Commission conducted a study to evaluate a second major air carrier airport in the vicinity of Boston. The study found that developing a second airport would require a significant amount of time and would likely encounter significant political and popular opposition. It ultimately concluded that a second airport would not serve Boston's core markets effectively.

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[78] U.S. General Accounting Office, Report to the Subcommittee on Aviation, House Committee on Transportation and Infrastructure, *Challenges Related to Building Runways and Actions to Address Them By United States,* 2003.

Other studies from 1992-1995 included the following recommendations, in addition to ones accepted by the FAA in their 2002 Record of Decision (ROD). Ultimately, these components were not implemented, but are listed below to show the magnitude of Massport's capital improvement strategy for Logan Airport:

1) Develop high speed rail to accommodate forecast air traffic growth
2) Increase airport infrastructure development and commercial aviation service at other airports (e.g., Manchester, T.F. Green in Providence, Rhode Island, and Worcester)
3) Build a centerfield taxiway between Runways 4L/22R and 4R/22L
4) Reduce approach minimums for Runways 15R, 22L, 27, and 33L
5) Realign Taxiway N
6) Implement peak period pricing and other demand management strategies to optimize scheduling and operations

Passenger Value of Time

The benefits of the airside improvements were primarily measured in (1) reduction in aircraft delays and (2) reduced passenger delays. An average aircraft direct operating cost, reported in the Final Environmental Impact Statement (FEIS), was used to monetize the estimated delay reductions in dollars. Passenger delay was valued using guidance from the FAA Office of Aviation Policy and Plans (APO) report "Treatment of Values of Passenger Time in Economic Analysis" (APO 97-1) which contains the following values:[79]

1) $34.50 per hour for business travelers
2) $19.50 per hour for non-business travelers
3) $26.70 per hour for a mix of business and non-business travelers

These values were stated in 1995 dollars, not escalated to 2002 dollars (the date of the ROD) per FAA and Government Accountability Office (GAO) policy and guidance

These values of time were used to monetize the value of reducing passenger delay by implementing the projects. Different values of time for passengers arriving at, departing from, or waiting at the airport were not used.

Funding Plan

The total cost of the project was estimated to be $109 million which included allowances for engineering, design, mobilization, and contingencies, but excluding financing and

[79] If escalated using the CPI to 2002 dollars, the rates would be represented as $40.73 for business, $23.02 for non-business, and $31.52 for a mix of business and non-business.

escalation for inflation in accordance with FAA BCA guidance. The actual cost of the project was $100 million dollars, which is listed in Table A-35 by component.

Table A-35. Project Cost

Item	Cost
Property Acquisition	$9,237,000
Design	$2,561,000
Construction & Construction Related	$56,837,000
Legal & Environmental	$14,373,000
Owner Controlled Insurance Program (OCIP)	$1,570,000
Other	$845,000
Contingency	$14,325,000
Total	**$99,748,000**

Source: Leo Flavio, Massport Department of Aviation, December 2010

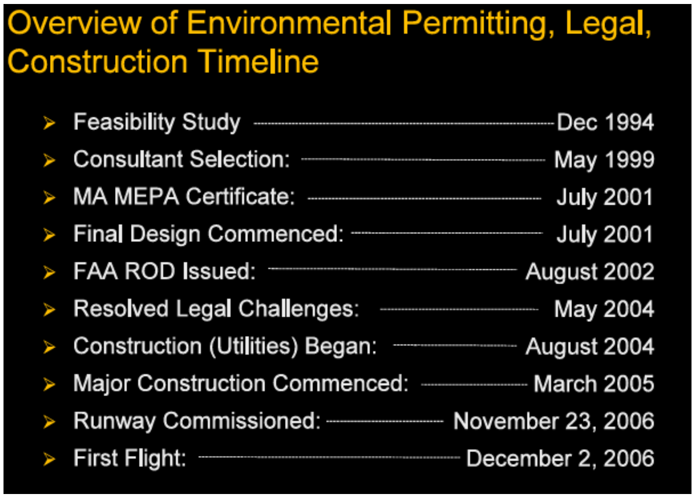
Massport requested $91.2 million in federal Airport Improvement Program funds, with the assumption that Massport would provide the remaining portion of the funds.

Capital Investment Decision Process

The decision process to fund the airside improvements came from a collective group of organizations, each viewed as a stakeholder in the process. These included: Massport, the FAA, The Commonwealth of Massachusetts, local business communities, the airlines, community and political leaders, permitting agencies, and the federal and state Environmental Protection Agencies.

As a part of efforts to address delays at Boston Logan International Airport, Massport and the FAA conducted a number of planning studies from the late 1990's to the early 2000's. These studies evaluated in detail a series of recommended projects, three of which were ultimately accepted by the FAA and were constructed at the airport. It was not until 2002 that the ROD was issued and major construction followed two years later in 2004 (Figure A-4 presents the timeline for this process).

Figure A-4. Project Timeline



Note: MEPA stands for the Massachusetts Environmental Protection Plan

Source: Leo, Flavio; Planning, Constructing and Integrating a New Runway at Boston Logan International Airport; Dec. 2010

Major Issues

After the FAA's approval, litigation resulted in a court order that restricted the use of Runway 14/32 to aircraft taking off and landing over Boston Harbor. Due to this court order, Massport was legally forbidden – except in emergencies – from using the runway to let planes take-off or land over South Boston and downtown Boston and could only use it during about one-third of the year when winds are from the northwest or southeast and speeds are at 10 knots or higher. As an additional measure to prevent Massport from extending Runway 14/32 or using it for planes flying over the city, former transportation secretary and Massport board member Frederick P. Salvucci engineered the construction of the 270-room Hyatt Harborside Hotel in close proximity to the end of the new runway, in the 1990s, to ensure that no flights would take-off or land over South Boston.[80]

Methodologies and Techniques Used

The primary methodology used was a BCA), which is required by the FAA when submitting a request for a Letter of Intent for Airport Improvement Project funding. The BCA report outlined the primary benefits as reduction in aircraft delay and savings in passenger travel time. Estimates of delay reduction were developed using capacity and aircraft delay simulation models to evaluate the average annual delays associated with the project and the base case. These estimates indicated that the new runway and reconfigured taxiways were expected to reduce delays by approximately 2 minutes per operation in the first year of the runway's operation and by 9 minutes per operation in 2018.

[80] Howe, Peter J. (November 19, 2006). "The 30-year saga of 14/32". *The Boston Globe*. http://www.boston.com/business/globe/articles/2006/11/19/the_30_year_saga_of_1432/.

Massport's 2002 planning forecasts were used to estimate future passenger growth and activity and a 7 percent real discount rate was used to calculate the present value of benefits and cost (in 2002 dollars). The project was also assumed to have a 20-year economic life beginning the first full year the runway would become operational (2006). Based on the FAA's statement that a 20-minute operational delay is a threshold limit for airlines to add capacity, a scenario was developed in which the number of aircraft operations was "capped" for both the project and the base case when average annual delays reached 20 minutes per operation.[81]

Sensitivity tests were also conducted to determine if the project would retain a positive NPV over a range of activity, project cost, and project benefit scenarios. These tests were performed under the assumption that aviation delay would be capped at 20 minutes per operation. Based on different scenarios, the NPV ranged from a high of $705.9 million to a low of $439 million. Activity growth was modeled using the 2003 FAA Terminal Area Forecasts (TAF) which had lower levels of aircraft and passenger activity than Massport's planning forecast. Using the TAF projections rather than the Massport forecast is the reason that the projected NPV was $267 million less in the low scenario than in the high scenario, providing a more conservative estimate. In this scenario, the discounted benefits due to savings in passenger value of time were 53-56 percent of the total discounted benefits over the life of the project.[82] The benefit/cost ratio ranged from 5.0 to 7.5 for the scenarios that capped delay at 20 minutes.

Economic justification for constructing Runway 14/32 and the taxiways did not depend on the calculated benefit of passenger value of time, and the project could have shown a positive net present value based on aircraft savings alone, as shown in Table A-36. Without including the passenger value of time savings, the capped alternatives would have returned benefit/cost ratios between 2.2 and 3.5, and the benefit/cost ratio of the uncapped alternative would have been 6.9.

Table A-36. BCA Excluding Passenger Value of Time Savings

Alternatives	Net Present Value of Aircraft Savings Only	Benefit-Cost Ratio
Uncapped	$750.6 Million	6.91
Capped Delays at 20 minutes	$241.6 Million to $377.7 Million	2.22 to 3.47

Source: Leigh Fisher Associates (2003). Benefit-Cost analysis of airside improvements – Boston-Logan International airport

Overall costs were increased by increments of 10 percent (to $119 million) and 20 percent (to $130 million) to reflect potential increases in project implementation costs. Delays in

[81] The costs to passengers (and potential passengers) of limiting airport capacity in this way were not considered.

[82] For the TAF capped delay scenario, the percentage of discounted benefits provided by passenger time value ranges from 53-58 percent of the total discounted benefits.

project implementation were postponed by 1, 3, and 5 years. Benefits were also reduced by 10 percent and 20 percent to model the potential variation in delay reduction.

Aside from the more tangible and measureable benefits, there are recognized benefits that are difficult to quantify. Although not included in the analysis, the following project benefits were recognized in the BCA report:

1) Enhancing capacity of National Airspace System
2) Increasing margins of safety and reducing potential for runway incursions
3) Improving taxiway flows
4) Reducing air traffic controller workload
5) Macroeconomic impacts

Decision Outcome

The FAA ROD provided the approval to implement the three projects (because FAA approval is required for AIP funds). Construction began in 2004 and the new runway became operational in November of 2006. The new runway has significantly reduced congestion at the airport by allowing 75,000 more flights each year, effectively doubling the number handled at the airport. The wind restrictions on the use of the facility are being monitored quarterly by the FAA.

Sources

The following documents and/or sources were used as resources for this report:

- Leigh Fisher Associates *Benefit Cost Analysis of Airside Improvements – Boston-Logan International Airport*. Prepared for the Massachusetts Port Authority, 2003
- Federal Aviation Administration. *Boston Logan International Airport Capacity Enhancement Plan*. October, 1992.
- Leo, Flavio, "Planning, Constructing and Integrating a New Runway at Boston Logan International Airport," Presentation at the ALACPA and FAA Airport Pavement Seminar and Workshop, Miami International Airport, Dec 6-9. Massport – Aviation Planning. 2010. http://alacpa.org/index_archivos/Dia2_New%20Runway%20and%20Safety_LEO.pdf

The following persons were interviewed in conjunction with this report:

- Flavio Leo – Massport Department of Aviation (Manager of project)
- Ralph Nicosia-Rusin – Airport Capacity Planner, FAA New England Region (Capacity Enhancement Team)

Birmingham-Shuttlesworth International Airport – Terminal Modernization Program

In February of 2006, the Birmingham Airport Authority (the Authority) commissioned a study to determine the future viability of the Birmingham-Shuttlesworth International Airport (BHM) main terminal building. The study listed several areas that needed to be addressed by either replacement or improvement. Consequently, the Authority began to plan to modernize the main terminal building, which would ultimately improve the passenger experience at BHM. An updated main terminal building would improve passenger flow throughout the airport, improve security at the TSA checkpoints, reduce maintenance costs, and allow the development of better concessions post security.

While no formal analysis of passenger time savings was done, passenger time savings clearly motivated many of the elements of the Terminal Modernization Program (TMP). The new terminal layout includes improvements that will improve passenger flow throughout the terminal by speeding up passenger security screening, passenger flow in baggage claim, passenger access between the parking facility and the main terminal, and passenger way-finding by improved signage throughout the terminal. The new terminal layout will include a new passenger screening area. The new area will serve as the single security checkpoint, which will have a minimum of five screening lanes. The old terminal has two separate security checkpoints, each with two screening lanes. Also as part of the TMP, screening will no longer be in the lobby of the terminal, creating more space for the passengers to move throughout the lobby. In addition, there will be improvements made to the parking facility to improve passenger flow. These improvements will include the replacement of the elevators and the construction of a pedestrian ramp from the parking facility to the terminal. Finally, passenger flow will improve from additional signage that will be added throughout the terminal and along the terminal roadways. Improved signage should reduce passenger time and confusion as passengers move throughout the airport.

The Authority worked to make the necessary improvements while remaining financially sound and maintaining a competitive cost structure for the airlines that serve BHM.

Airport Overview

Birmingham-Shuttlesworth International Airport is located in Birmingham, Alabama. It is operated by the Birmingham Airport Authority pursuant to a 50-year lease effective

September 16, 1986. The Authority is an independent authority of the City of Birmingham, governed by an eight-member Board of Directors (the board). The members of the board are nominated by the mayor of the city and elected by the city council. The board appoints the authority president and chief executive officer, who has overall responsibility for the management, administration, and planning of the authority.

The Birmingham Airport is a small hub airport based on the FAA's hub designation. Airports Council International (ACI) traffic data for calendar year (CY) 2010 shows the airport ranked 70th in total passengers, 79th in total aircraft operations, and 78th in total air cargo among U.S. airports. The airport had 3.0 million passengers, 109,867 aircraft operations, and 24,989 metric tons of air cargo in CY 2010.

Proposed Capital Improvement

As of October, 2011, the airport facilities include a main terminal building with two concourses (B and C). The main terminal building has 19 aircraft gate positions. In addition, there is Terminal A which is no longer in use (and will be demolished as part of the project discussed below). The airport also has a seven-level parking deck (parking structure) across the terminal access roadway. The parking deck contains 5,103 public parking spaces and 349 ready-return spaces for rental cars. The airfield includes two air carrier runways. Runway 6/24 is 12,000 feet long and can accommodate a fully loaded and fully fueled 747 aircraft, and Runway 18/36 is 7,100 feet long.

A study performed in February of 2006[83] reported that the main terminal had several problems including: (1) the roof no longer protected the building; (2) the exterior walls leaked and were not properly insulated; (3) the primary building systems (electrical, mechanical, and fire protection) were at the end of their useful lives and some did not meet current codes; (4) the central plant needed upgrades; and (5) the functional layout of the main terminal was not conducive to the current needs of airline operations, passenger screening, concessions operations, and baggage screening.

On November 29, 2010, the Authority executed a construction contract with a guaranteed maximum price of $201,649,000. As described earlier, the Terminal Modernization Project involves the complete modernization and expansion of the main terminal building. The project will expand the main terminal building from 244,000 square feet to 424,000 square feet. In addition to the overall expansion, the project includes: (1) the construction of a new passenger screening area; (2) the implementation of a new access control system; (3) the construction of a secured loading dock; (4) the implementation of other security projects; (5) the addition of improved baggage screening devices and a baggage make-up area; (6) the implementation of an integrated outbound baggage handling system; (7) the purchase and installation of 19 jet bridges; (8) the construction of upgraded food and retail concession areas; (9) an improved baggage claim area; (10) upgraded central plant and

[83] Birmingham International Airport Terminal Modernization Program Criteria Document.

HVAC system; (11) the construction of a Federal Inspection Service (FIS) facility; (12) improved elevators in the parking garage; (13) construction of a pedestrian ramp from the parking garage to the terminal; and (14) the relocation of tenants from the old cargo building to the new cargo building.

The Terminal Modernization Project (TMP) was undertaken for multiple reasons, including updating systems, upgrading mechanical systems, making building improvements, and improving passenger flow at the airport.

Passenger flow will be improved by the construction of a central passenger screening area, construction of post security concessions, the construction of an improved baggage screening facility and baggage make-up area, an improved baggage claim area, upgraded elevators in the parking deck, construction of a pedestrian ramp, and improved signage around the terminal and landside.

In the old terminal building, there were two screening areas (one per concourse), each with two lanes for passenger screening. The layout of the old terminal building did not allow for expansion. There were often long lines waiting to pass through security screening as a result of only having two lanes and such a small area. This obviously had an impact on passenger travel times and on the overall passenger experience. In addition to the passenger experience, this impacted the concession program because passengers did not have time to take advantage of the pre- or post-security concessions. The TMP created one central passenger screening area. This screening area is much larger and initially included five lanes with the ability and space to expand to a maximum of eight lanes. This should increase passenger flow and efficiency, especially during heavy travel times. It also provides flexibility to the Authority and TSA by giving additional space to open additional lanes.

The TMP will also improve the passenger experience with the construction of more post-security concessions. In the old terminal building, there was a limited amount of post-security concessions, and three fast food concessions before security. With better flow through security and more concession options, passengers should have faster access to the concessions and more time to enjoy the airport's concession options.

The TMP includes the construction of a new baggage make-up area and baggage screening areas. These new areas will provide passengers more space to pass through the terminal. In the old terminal, the baggage screening areas were set up in the ticket lobby and restricted passenger flow. The new baggage make-up and baggage screening areas will not be in the public area of the terminal and this will provide more space for passenger circulation.

Improvements to the parking deck provide better passenger access to and from the main terminal. Prior to the TMP, the parking deck had old, inefficient elevators that slowed down the passengers. In addition, there could have been safety concerns in the future if the elevators had not been improved. As part of the TMP, the parking deck elevators were replaced with new, efficient elevators. These elevators will enhance the passenger experience and eliminate or reduce the safety concerns. Also, the TMP included building a pedestrian ramp from the third level of the parking deck to the second level of the new terminal. This allows passengers to take the ramp across and check-in for flights and go through security without needing to go to the first floor of the parking garage, cross over to the terminal, and then go to the second floor of the terminal.

As part of the TMP, the Authority has also been improving and increasing the signage and informational displays inside the terminal and along the access and terminal area roadways. More signage will help vehicle flow on the roadways and passenger flow in the terminal. The new terminal required regular passengers to learn the new layout of the terminal and the increased signage helped facilitate the adjustment to the redesigned terminal. Furthermore, the improved displays and signs also enhanced the passenger experience and the passenger flow throughout the airport.

Funding Plan

The funding plan for the Terminal Modernization Project includes GARBs, PFCs, federal grants, and airport discretionary revenue. The amounts of funding from each source are shown in Table A-37.

Table A-37. Birmingham-Shuttlesworth International Airport Terminal Modernization Program Budget and Sources of Funds

Source	Amount
Series 2010 GARBs	$116,075,430
PFC Pay-As-You-Go	15,603,206
AIP Entitlement Grants	22,337,976
AIP Discretionary Grants	18,386,540
TSA Grants	14,303,230
VALE Grants[1]	8,773,988
Airport Discretionary Revenue	6,168,781
Total	**$201,649,150**

[1] Voluntary Airport Low Emissions (VALE) Program, an FAA program that funds airport investments to reduce on-airport emissions

Capital Investment Decision Process

Overview of the Process

In February 2006, the Birmingham Airport Authority commissioned a study to determine the future viability of the BHM main terminal building, which identified a large number of issues that needed to be addressed and resulted in the “Birmingham International Airport Terminal Modernization Program Criteria Document.”

In response to the study, the Authority began working with the architecture firm KPS Group to design an improved terminal building that would address these issues. The airlines that serve BHM were involved in the planning process through their participation in several technical committees. The Authority desired to maintain a competitive cost structure at BHM, and this led to many adjustments to the terminal design and many iterations of the funding plan. The initial cost of the TMP would have resulted in an airline cost structure that was not competitive with other similarly sized airports. It became a priority of the Authority to complete the TMP at a price that would maintain the airport's competitiveness. As a result of the planning and the terminal designed by KPS, on November 29, 2010, the Authority executed a construction contract with a guaranteed maximum price of $201,649,000.

Beginning January 1, 2006, the airlines operated at the airport without an agreement in place. From January 1, 2006 to February 28, 2009, the rate methodology from the expired Airline Use and Lease Agreement was used to set rates. On March 1, 2009, the Authority changed its rate setting approach. The Authority and the airlines were negotiating a new Airline Use and Lease Agreement while the Authority was completing the funding plan for the TMP. The authority worked very hard to limit the increase in the airlines' cost structure. The Authority made a pledge to the airlines that any cost over $201.6 million would result in some parts of the project being eliminated or reduced, or the excess cost being covered by Authority funds and/or government grants. As a result of the Authority's efforts, the Authority was able to obtain about $64 million or 32 percent of the project cost in grants. In addition to the grants, the Authority also leveraged PFC revenue and pledged about $6 million in Authority revenue. A financial feasibility study was prepared to support the issuance of Series 2010 General Airport Revenue Bonds (GARBs) in the total amount of $116 million, accounting for nearly 58 percent of total capital funding requirements.

In addition, the Authority also wanted to implement a three part phasing of the construction of the new terminal. The Authority's goal was to remain operational during the entire construction period. This goal would require all air carriers to temporarily relocate at least once and some airlines to relocate twice during the construction period.

As part of the TMP, the Authority planned to construct a Federal Inspection Service facility in order to have the ability to serve international passengers. The air carriers were not in support of the FIS facility because they did not anticipate using the facility regularly. The Airport Director, Mr. Al Denson, decided to move forward with the construction of the facility. However, the Authority agreed to not include the costs associated with the construction or the daily operation of the facility in the airlines' cost structure. Instead, the funding of the facility would come from airport revenue. In addition, the facility would have a use fee for any airline that chose to use the facility.

Finally, the TMP included construction of additional gates for the terminal. With a decline in enplanements over the preceding two years, the airlines did not see the need for additional gates. Mr. Denson decided to build the space for the additional gates, but the

Authority would not fit out the gates. The gates would be blocked from the rest of the terminal and would not become operational until the passenger traffic is anticipated to increase to a sufficient level to need them.

Evaluation Methodologies and Techniques

Financial Feasibility Report. As a requirement to issuing GARBs, the Authority retained Unison Consulting, Inc., to conduct an independent Financial Feasibility Study (FS) to determine the viability of the project at the airport. The FS contained information about the following:

- The Birmingham Airport Authority
- The Capital Improvement Program (CIP)
    - The TMP
    - Other Projects
- CIP Funding Plan
- Local Economic Base
- Aviation Activity Analysis and Forecasts
    - Historical Aviation Activity
    - Forecast Aviation Activity
    - Forecast Uncertainty and Risk Factors
- Airline Rates and Charges
- Financial Analysis
    - Financial Framework
    - Current Expenses
    - Debt Service and Amortization Charges
    - Revenues
    - Key Financial Indicators

The analysis indicated that cost per enplanement, a widely used metric at airports, would increase from $7.72 in 2011 to $11.91 in 2015, the estimated first full year after the completion of the terminal. The plan also estimated that the debt coverage ratio (net revenues divided by debt service) would decline from 1.96 in 2011 to 1.68 in 2015. Based on these findings, the FS determined that the project was financially feasible.

Passenger Facility Charge Applications. The Authority submitted applications to the FAA in 2009 and 2010 for authority to collect PFCs and each of the applications were approved by the FAA. Each PFC application also included a financial plan that presented passenger projections and forecasted PFC revenue. Specifically, the analyses showed the projected PFC collections and uses in order to show that the resources would be sufficient to pay for that portion of the project.

Decision Outcome

On February 10, 2011, construction officially began on the project and the first phase of airline moves was subsequently completed. In June 2011, the Authority completed negotiations with the airlines to complete a new Airline Use and Lease Agreement (AUA). The new AUA had a one-year term with mutual options for extensions. Agreeing to the new AUA showed the airlines' support for the TMP. The first phase of the terminal modernization was completed in February 2013 with the opening of Concourses A and B and the centralized security screening facility. The remainder of the TMP was completed in August 2014 with the opening of Concourse C.

The funding plan for the TMP continued to evolve during the construction. By February 2012, the amount of funding from PFCs had increased to $81,603,272 and the amount from GARBs had been reduced to $55,075,430. The funding from AIP and TSA grants was unchanged but the VALE grant was no longer expected and the balance of the funding would come from Authority funds.[84] In September 2013, it was announce that the Authority would receive a VALE grant of $2,847, 790 (rather than the $8,773,998 originally requested) but an additional grant of $6,001,875 for terminal security enhancements,[85] reducing the contribution of Authority funds to the project.

Sources

The following documents and/or sources were used as resources for this report:

- Birmingham-Shuttlesworth International Airport, *Passenger Facility Charge Application #8*, December 2009.
- Birmingham-Shuttlesworth International Airport, *Passenger Facility Charge Application #9*, September 2010.
- Unison Consulting, Inc., *Financial Feasibility Report – Birmingham Airport Authority Airport Revenue Bonds, Series 2010*, December 10, 2010.

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[84] http://www.flybirmingham.com/terminal-modernization-project/funding.html (Archived by www.archive.org on Feb. 14, 2012).

[85] Birmingham Airport Authority, "Birmingham Airport Authority receives update on terminal modernization," Press release, September 16, 2013 (At www.flybirmingham.com/terminal-modernization-project/public-relations.aspx, Accessed Feb. 19. 2015).

In addition, the Research Team interviewed:

J. Walker Johnson, Vice President of Finance, Birmingham-Shuttlesworth International Airport. Mr. Johnson worked with the Airport Director, Mr. Al Denson, the airlines, the consultants, and the architects. Mr. Johnson provided detailed information to the architects and consultants, and helped to make sure the TMP conformed to Mr. Denson's intent.

Hartsfield-Jackson Atlanta International Airport - Runway 8R End-Around Taxiway

Airport Overview

Hartsfield-Jackson Atlanta International Airport (ATL) is located 10 miles south of the central business district of Atlanta, Georgia, primarily within unincorporated areas of Fulton and Clayton Counties. It is owned and operated by the City of Atlanta through its Department of Aviation. The airport covers 4,700 acres, 130 of which are occupied by the 5.6 million square feet terminal complex. The airport has five runways ranging from 9,000 to 11,899 feet in length, which are shown by Figure A-6.

Hartsfield-Jackson Atlanta International Airport has been the busiest passenger airport in the world since 1998, and had the highest number of aircraft operations in the world since 2005. In 2010, the airport had aircraft operations totaling 950,119, including domestic and international air carriers, air taxi, general aviation and military aircraft. It serves as the principal hub for Delta Airlines, and in 2011 had service from an additional 16 mainline airlines, 19 regional airlines, and three charter airlines. In 2010, more than 89.3 million passengers passed through the airport, averaging 240,000 passengers per day. Fifteen mainline and five charter cargo companies serve the airport. A total of 659,129 metric tons of cargo were handled at the airport in 2010, including freight and express cargo and mail.[86] The airport is designated as a large hub by the Federal Aviation Administration.

Proposed Capital Improvement

Hartsfield-Jackson proposed a new end-around taxiway (EAT) that would allow aircraft landing on Runway 26R to taxi around the arrival end of Runway 8R, eliminating the need

[86] City of Atlanta Department of Aviation, *Monthly Airport Traffic Report*, December 2010. http://www.atlanta-airport.com/Airport/ATL/operation_statistics.aspx

for landing aircraft to cross Runway 26L in order to access the terminal. The primary purpose of the EAT is to decrease delays caused by aircraft crossing Runway 26L, thus increasing the Runway 26L departure rate and reducing departure delays. The EAT not only reduces departure delays on Runway 26L, but also on Runway 27R, as aircraft that would normally be assigned to depart Runway 27R can be rerouted to 26L. The project further reduces Runway 8R queueing problems at Ramp 1, 2 and 3 throat taxiways. By using the EAT in the reverse direction, aircraft can queue on both sides of Runway 8R. This relieves the blockage of the Ramp 1 North, Ramp 2 North, and Ramp 3 North throats that occurs during an east flow operation.

A benefit-cost analysis was conducted for the project that identified three primary project objectives and four additional objectives, as listed in Table A-39. Reducing passenger delay is not explicitly mentioned in the table. However, the report does state that "the primary *benefits* [emphasis added] of the project are to reduce variable aircraft operational costs by reducing aircraft departure delay and to provide passenger delay reduction."[87] By reducing departure delays, the project will "reduce airfield congestion thus increasing capacity."[88] The application to allow PFC funding for the project noted that "in visual meteorological conditions (VMC), approximately 48 aircraft depart per hour on runway 26L. With the implementation of the Runway 8R End-Around Taxiway, this departure rate will increase to 58 per hour.

Table A-38. ATL EAT Project Objectives

Primary Objectives	Other Project Benefits
Reduce Runway 26L departure delay	Reduction of Runway 27R departure delay
Reduce crossings of Runway 26L and exposure to incursions	Reduced aircraft engine emissions
Clear up Runway 8R queueing problems at Ramp 1, 2, and 3 throats	Greater controller flexibility
	Expedite DAL Superbug repositioning of aircraft from CPTC to TOC North and vice versa

DAL = Delta Airlines; CPTC = Central Passenger Terminal Complex; TOC = Technical Operations Center (an existing airplane maintenance complex)

Source: Department of Aviation, as reported in Runway 8R End-Around Taxiway Benefit Cots Analysis Report, City of Atlanta Department of Aviation, p. 3

The EAT was first proposed as part of the Airport Master Plan, prepared in 1999. Originally expected to cost $20-25 million, it was one of many capital improvements identified in the more than $5 billion master plan. The master plan included general guidelines for the project. The project was then included in the airport's Capital Development Program. Next, a Project Definition Report was completed to look at different concepts for the EAT.

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[87] City of Atlanta Department of Aviation, Runway 8R End-Around Taxiway Benefit-Cost Analysis Report, p.1

[88] "Attachment B: Project Information", part of Application number 02-03-C-00-ATL to the FAA to allow the imposition of a passenger facility charge (PFC) at the Hartsfield Atlanta International Airport, August 2002, p 2.

The final project differed from the concept in the Master Plan in several ways. The master plan concept did not anticipate that the EAT would be able to handle the largest categories of aircraft and assumed that the existing lighting system would be retained. The Project Definition Report evaluated alternatives, including building the EAT 1,400 feet or 1,800 feet from the centerline of Runway 26L. The longer distance would allow all aircraft, including Group V, which have taller tails, to use the EAT. The shorter distance would accommodate all categories of aircraft except Group V. The airport modeled representative alignments of both alternatives, and determined that the additional departure delay reduction that resulted from the longer distance did not justify the additional cost associated with that alternative. The ultimate design located the 2,900-foot long EAT 1,520 feet from the Runway 26L departure threshold. There is an elevation difference of 29 feet between the runway and the EAT, which allows for clearance of departing aircraft over the aircraft using the taxiway.

The construction of the EAT required “the relocation of the Terminal North airport exit road, approximately 700 North Economy Lot parking spots, a non-licensed vehicle roadway inside the security identification display area, and the removal of approximately 1.5 cubic yards of embankment.”[89] In addition, the Runway 26L localizer and numerous utilities, including Georgia Power lines and fiber optic cable, needed to be relocated.

The EAT was justified solely on its operational cost savings, with a strong acknowledgement of safety benefits (i.e. reduction in potential incursions between aircraft). The latter were not factored into the benefit-cost calculation. The Benefit-Cost Analysis (BCA) report notes that the benefit/cost ratio is conservative because it does *not* include any assessment of passenger value of time. No value was ever assigned to reduced passenger delay, and none of the alternative benefit-cost scenarios evaluated included a value for passenger time. The Assistant Director of Planning for the airport noted that the Airport General Manager at the time the BCA was done elected not to include passenger travel time savings in the analysis.

The then-General Manager wanted to use the analysis to convince the airlines at ATL to pay for the EAT.[90] When constructing his argument, he believed the airlines to be indifferent to the passenger value of time savings, and he wanted the BCA to reflect costs and benefits meaningful to the airline decision makers. Therefore, the BCA focused on aircraft delay and fuel burn reductions on the benefit side of the equation, which were factors important to the airline executives. The analysis provided to the airlines demonstrated a payback in less than two years. Airlines representing at least 90 percent of landed weight at ATL had to

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[89] City of Atlanta Department of Aviation*, Op. Cit.*, p. 3.

[90] Benjamin R. DeCosta, DeCosta Consulting, LLC and former General Manager of ATL. Phone interview July 22, 2011.

approve the proposed expenditure for the EAT.[91] However, the airlines voted to deny the expenditure.[92]

The Assistant Director of Planning noted that if the benefit-cost had not been positive based on the inclusion of only operational cost savings in the BCA, the airport would not have pursued the EAT (at least not for funding by the airlines, according to the former general manager). No new analysis would have been done to see if including passenger value of time would make the benefit-cost positive.[93]

The initial BCA for the airlines was conducted with various assumptions about the operating cost savings at the airport (primarily related to variations in operations levels). The benefit/cost ratio under alternative assumptions about the actual delay reduction achieved ranged from 3.6 to 6.4 based solely on operational cost savings. Thus, even though the airline support was not forthcoming, the initial BCA met the test for a discretionary grant through the FAA's Airport Improvement Program (AIP) without airline support, and there was no need to augment the analysis by adding calculations to demonstrate the value of time savings that passengers would experience. The net present value (NPV) for the project ranged from $91.5 million to $194.3 million among the alternative scenarios.

Funding Plan

The Department of Aviation initially assumed that the EAT would be paid for with Passenger Facility Charges (PFCs). The airport prepared an application to the FAA to impose a passenger facility charge at Hartsfield-Jackson at the $4.50 level. The EAT was just one of several capital improvements that would be funded through the PFC, which was projected to generate net revenue of almost $1.3 billion over a seven to eight year period. The anticipated cost of the EAT at the time of the PFC application was $33.4 million, of which $30.7 million would be provided through pay-as-you-go PFC funds (thus eliminating the need for bonding.) The remainder of the cost, almost $2.7 million, would be paid for from the city's Renewal and Extension Fund. The Renewal and Extension funds were proposed for replacing the parking taken by the project, which the city believed would not be eligible for PFC funding.[94]

The FAA issued a Final Agency Decision in support of the PFC application on October 10, 2002. In April 2005, the airport applied to the FAA for a Letter of Intent (LOI) for partial funding of the project with FAA discretionary AIP funds. On March 1, 2006, the FAA,

[91] This is the majority in interest clause at ATL,

[92] It was believed the vote could not achieve the necessary 90% threshold because airline executives knew that alternative sources of funding were available.

[93] Matt Davis, Assistant Planning Director, City of Atlanta Department of Aviation. Telephone interview on May 17, 2011.

[94] The end around taxiway displaced public parking at the airport, and the $2.6 million funded replacement parking. Despite initial expectations, the replaced parking was paid for by PFCs.

through an LOI, awarded the airport $26 million for construction of the EAT, to be paid as follows:

FY06	$7m
FY07	$7m
FY08	$2.5m
FY09	$7m
FY10	$2.5m
Total	**$26m**

As the project unfolded, the total cost of the project increased to $44.8 million. It was also determined that the parking dislocation costs could be paid for by PFCs. Therefore, PFCs were used to fund the $18.8 million in costs not covered by the LOI. The EAT was constructed over a one-year period, and opened on April 26, 2007.

Capital Investment Decision Process

The design, planning and engineering for the EAT were developed by the Department of Aviation's Planning and Development Division. The Department's Finance Department developed the detailed financial plans, including the Benefit-Cost Analysis (BCA), and applications for PFC approval and for discretionary FAA funds. The Capital Development Program, which included the EAT, was vetted and approved by an executive committee of senior airport managers and senior airlines management. Both the General Manager for the airport and the Executive Senior Vice President of Properties for Delta Airlines were part of the Executive Committee. The airport initially assumed that the costs of the project would be paid using PFCs and prepared an application to the FAA for imposing such fees in 2002. At the same time, the airport chose to pursue FAA AIP discretionary funding to help pay for the EAT. In early 2002, the Department of Aviation developed an initial benefit/cost analysis using a forecast year of 2005. The application was prepared in accordance with the FAA's Airport Benefit-Cost Analysis Guidelines published December 15, 1999, in anticipation of applying for FAA discretionary funds. The BCA was updated in 2005 with new assumptions about the reduced departure delay that would be achieved, based on changes in operational levels at the airport. The BCA was deemed to be conservative because the only benefits calculated were aircraft variable costs due to reduced departure delay. The BCA Report states, "Neither passenger value of time nor other aircraft operational benefits are included."[95]

The airport's General Manager at the time chose not to include passenger value of time in the benefit-cost in proposing that airlines support the project through the expenditure of airfield funds because he felt it was important to base the analysis on factors relevant to airline executives. Airlines make decisions based on what benefits their shareholders, not customers, unless customers "vote with their feet" to use another airline. The BCA prepared for the airlines showed a strong positive result, so there was never any

[95] City of Atlanta Department of Aviation, *Op. Cit.*, p. 1.

consideration of adding passenger value of time in the benefit-cost calculation when preparing it for FAA review after the airlines turned down the EAT funding request.

The Capital Development Program proposed for the airport was considered necessary, was not controversial within the Executive Committee, and was approved. The funding for the EAT *was* controversial within the FAA, primarily because it was a new concept – an end-around taxiway had never been built in the United States. The airport was required to prepare an FAA Form 7460 – Notice of Proposed Construction or Alternation submission, which is required whenever there is any alteration or construction of operational facilities at an airport. The FAA did eventually approve the EAT, provided discretionary funding, and used the Atlanta project as the impetus to modify its design guidelines on how to design an EAT.

The decision to build the EAT was supported by the findings of the BCA. The original funding plan for the EAT relied solely on pay-as-you-go PFC's. Procedurally, the city council required that the funding source be identified in the legislation authorizing the project, and the funds encumbered. The pay-as-you-go PFCs were identified in the legislation authorizing the main construction contract before the airport was notified that AIP funds would be forthcoming. The project was essentially funded from the PFC fund and the city Renewal and Extension fund (for soft costs). Later, when the airport received the AIP discretionary funds committed by the LOI, it reimbursed the PFC fund and city Renewal and Extension fund. After all reimbursements were complete, the project was funded with a combination of pay-as-you-go PFCs and the AIP discretionary funds authorized with the LOI. The EAT opened in April 2007.

Eleven months before opening the EAT, ATL opened Runway 10/28 in May 2006. Although beyond the scope of this case study, it may be a worthwhile topic for future research to analyze the relative benefits resulting from the EAT and Runway 10/28 and how each project influenced the benefits from the other.

Sources

The following documents and/or sources were used as resources for this report:

- City of Atlanta Department of Aviation, *Monthly Airport Traffic Report*, December 2010. http://www.atlanta-airport.com/Airport/ATL/operation_statistics.aspx
- City of Atlanta Department of Aviation, *Runway 8R End-Around Taxiway Benefit-Cost Analysis*, 2005.
- Federal Aviation Administration, *Final Agency Decision, City of Atlanta, Atlanta, Georgia*, October 10, 2002.
- Federal Aviation Administration, *Final Agency Decision, City of Atlanta, Atlanta, Georgia*, *Attachment B: Project Information,* October 10, 2002.

- Federal Aviation Administration, *Letter of Intent, ASO-06-01, Atlanta Hartsfield-Jackson International Airport, Atlanta, Georgia*, March 1, 2006.

The following persons were interviewed for this case study:

- Matt Davis, Assistant Director of Planning, Department of Aviation, City of Atlanta
- Cathy Donato, Key Financial Strategist, Capital Finance Manager, Hartsfield-Jackson Atlanta International Airport, Hartsfield-Jackson Development Program
- Tina Wilson, Financial Strategist, Hartsfield-Jackson Atlanta International Airport, Hartsfield-Jackson Development Program
- Troy Butler, AIP/PFC Program Manager, FAA Southern Region, Airports Division, ASO-610B
- Benjamin DeCosta, former General Manager, Hartsfield-Jackson Atlanta International Airport

Dallas Love Field – Capital Development Program

Dallas Love Field (DAL) is an FAA designated medium hub airport located seven miles northwest of downtown Dallas. It is owned by the City of Dallas and managed by the city's Department of Aviation. In 2010, DAL had 168,554 aircraft operations with 3,998,271 passenger enplanements.

Proposed Capital Improvement

Problem Statement and Investment Objective

Aviation activity at DAL was statutorily constrained by the 1979 "Wright Amendment", passed in response to the 1978 Airline Deregulation Act to protect Dallas/Fort Worth International (then Regional) Airport (DFW) from competition. The Wright Amendment applied to all aircraft with 56 seats or more, and limited non-stop service from DAL to other points in Texas and cities in the four adjacent states, Louisiana, Arkansas, Oklahoma and New Mexico ("Dallas Love Field Service Area").[96] The Amendment also barred through flights, through tickets and through fares between DAL and points outside the Love Field Service Area.

As DFW approached maturity, the need for additional airport capacity grew and concerns over competition from DAL diminished. In 2006, the cities of Dallas and Fort Worth, the DFW International Airport Board, American Airlines and Southwest Airlines entered into

[96] Subsequent amendments to the Wright Amendment expanded the L
in Alabama, Mississippi, Missouri and Kansas.

what is called the "Five Party Agreement," which formed the basis for the repeal of Wright Amendment restrictions by 2014. As concessions, the agreement also limits DAL to 20 gates (requiring demolition of 16 existing gates beyond that limit) and obligates the City of Dallas to spend between $150 and $200 million to improve and modernize terminal facilities.[97]

The lifting of Wright Amendment restrictions would allow the airport much higher levels of activity. Under the Wright Amendment, the FAA had expected commercial operations growth of about one percent per year between 2006 and 2020. Despite the reduction in gates from 36 to 20 under the Five Party Agreement, in the absence of Wright Amendment restrictions, operations are expected to exceed FAA forecasts by 39 percent in 2020.

Prior to the repeal of the Wright Amendment, the City of Dallas Department of Aviation contracted for a review of its 2001 Master Plan; this resulted in the 2004 Terminal Area Redevelopment Program Study (TARPS). Following the Five Party Agreement, in 2008 the TARPS was updated to respond to the repeal of the Wright Amendment and to meet the terms of the Five Party Agreement.

Project Description

The DAL Capital Development Program comprised three elements:

1) **Love Field Modernization Program (LFMP)** – Addressed the city's statutory obligations under the Five Party Agreement and repeal of the Wright Amendment and meets resulting demands for increased capacity;
2) **Capital Improvement Program (CIP)** – Intended to resolves safety and ongoing maintenance issues; and
3) **Automated People Mover (APM) –** Would provide a passenger connection to the regional transit system, Dallas Area Rapid Transit (DART), which would be needed to accommodate future airport passenger and employee activity.

The LFMP included the replacement of the apron, roadways, and support buildings, and replacement of the original ticketing hall – constructed in the 1950s and abandoned in the 1970s – with a new modern ticketing hall for all airlines. The baggage claim area would be expanded to accommodate future demand levels, and the main lobby would be renovated and expanded. The primary component of the program was the complete replacement of the three existing concourses with a single concourse. The final facility is approximately 800,000 square feet and includes 20 narrow body gates (rather than the existing 36 gates) for three carriers.

The major elements of the CIP were: (1) roadway and parking facility improvements; (2) taxiway modifications and reconstructions; (3) runway safety area enhancements; (4) an extension of Taxiway M; (5) a new aircraft rescue and firefighting (ARFF) building and new

[97] The Wright Amendment Reform Act of 2006 codified the Five Party Agreement into Federal law.

ARFF equipment; (6) drainage and storm water projects; (7) the demolition of the Lemon Avenue facility (former Braniff headquarters); (8) land acquisition; and (9) program management costs.

The APM project was planned to connect the DART system to the airport via a people mover from a nearby station. Various alternatives for the APM project were studied. However, they all proved cost-prohibitive and eventually the project was abandoned.

Selection of Preferred Alternatives

Love Field Modernization Program. Multiple alternative concepts for the LFMP were developed with the aim of meeting future passenger demand at DAL within the constraints of the existing terminal facilities area and the terms of the Five Party Agreement. A set of facility requirements were established (Table A-39), and alternatives developed to meet these criteria.

Table A-39. TARPS Facility Requirements

Facility	Existing Facilities	TARPS Requirements
Passenger Processing		
Ticketing Agent Positions	*24*	*15*
Ticketing Curbside Positions	*10*	*12*
Ticketing Self-Service Device (SSDs) Positions	*14*	*50*
Total Ticketing Positions	48	77
Baggage Claim (linear feet)	450	729
Baggage Claim Devices	4	5
Security Processing		
Security Checkpoint Lanes	7	14
Explosive Detection System (EDS Devices)	9	10
Concession Space		
Concession Space (square feet)	20,400	72,719
Curbside Facilities (linear feet)		
Arrivals Curb	820	1,043
Departures Curb	690	992
Commercial Curb	110	568
Employee Parking Spaces (Option C only)		
Employee Parking Spaces		1,000
Department of Public Safety (Option C only)		
Department of Public Safety (square feet)		15,000

Source: Five Party Agreement TARPS for Dallas Love Field (June, 2008).

Note: Assumes 20 gates and 10 turns per gate per day.

The following three alternatives were selected for refined analysis:

- **Alternative A ("minimal impact" concept , utilize existing facilities as much as possible)**

- Renovate the existing West Concourse for Southwest Airlines (16 gates)
- Renovate the existing North Concourse for American and Continental (4 gates)
- Enlarge concession space
- Enhance ticketing and security screening
- Minimally enhance terminal building, bag claim, curbside and roadway
- Lowest cost option: $357 million

- **Alternative B (hybrid concept of minimal impact and efficiency, focus on efficiency gains while maintaining existing structures where possible)**
  - Renovate and expand West Concourse for Southwest (12 gates)
  - Demolish North and East Concourses and rebuild in new location for Southwest, American and Continental (8 Gates)
  - Build New Ticket Hall
  - Renovate Terminal
  - Expand Bag Claim and Curbside
  - Highest cost option: $608 million
- **Alternative C ("maximize efficiency" concept)**
  - Demolish East, North and West Concourses and replace with one double-loaded concourse (20 gates)
  - Build New Ticket Hall
  - Expand Bag Claim and Curbside
  - Renovate Terminal
  - Cost: $571 million

Each of the three alternatives was then compared to the performance targets shown below in Table A-40. Alternative A met or exceeded 3 of the 12 terminal performance requirements, Alternative B met or exceeded 7 of the 12 old Braniff Headquarters requirements and Alternative C met or exceeded 8 of the 12 requirements.

Table A-40. Concept Development Performance Matrix

Performance Requirements	Performance Target	Existing	Option A	Option B	Option C
Terminal Facilities					
Ticketing Counter Position	15	14	14	14	14
Self-Service Devices	50	24	49	49	49
Ticketing Curbside Positions	12	10	10	10	12
Bag Claim (area – square feet	12,500	19,000	19,000	23,400	23,400
Bag Claim (frontage – linear feet)	729	450	450	1000	1000
Passenger Security Checkpoints	14	7	12-14	12-14	12-14
EDS Screening Devices	10	9	8-9	10	10
Concessions (square feet)	72,719	20,400	29,100	73,000	75,000

Gate Holdroom (avg. sq. ft./gate)	2,250	1,835	1,835	2,250	2,250
Landside Facilities.					
Arrivals Curb	1,043	660	300	600	600
Departures Curb	992	530	400	600	600
Commercial Curb	568	100	600	1,000	1,000

Source: Five Party Agreement TARPS for Dallas Love Field (June, 2008).

Finally, the three alternatives were compared using an evaluation matrix based on criteria set forth by the city, project stakeholders and the planning team (Table A-41)[98]. Of the three alternatives, Alternative C satisfied the most facility requirements and ranked the highest with respect to performance criteria.

Table A-41. Performance Evaluation Matrix

	Option A	Option B	Option C
Implementation			
Time to Implement	5	2	3
Operational Complexity	2	1	4
Customer Inconvenience	2	1	4
Cost of Overall Program	5	2	3
Operations			
Operational Efficiency	4	3	5
Estimated Relative O&M Cost	2	4	5
Customer Convenience			
Curbside	2	4	4
Ticketing	2	4	4
SSCP	2	4	4
Holdrooms	2	5	5
Concessions and Amenities	2	5	5
Baggage Claim	4	4	4
Walk Distance	3	4	4
SUMMARY	**37**	**43**	**54**

Score Range is 1-5; 1 is "least desirable" and 5 is "most desirable"

Source: Five Party Agreement TARPS for Dallas Love Field (June, 2008).

Capital Improvement Program. The CIP was not developed based on BCA because it was focused on safety, and safety projects are not subject to benefit-cost analysis to justify funding.

[98] The performance evaluation matrix was developed by Gresham, Smith and Partners as part of the original TARPS in 2004. Unfortunately, no further information is available regarding the methodology used to assign scores to each element.

Automated People Mover. A 2008 feasibility study for the APM analyzed eight options for the DART Love Field station and ten options for the corresponding DAL terminal station. The stations were first analyzed individually (rather than as DART Love Field-DAL Terminal pairs), based on a number of qualitative factors, as well as cost, including:

- Perception of level of service ("seamless integration" between DART and the terminal; perception of a public entrance to the airport; overall image/aesthetics);
- Performance level of service (comfort/convenience/ease of use including visibility of stations, accessibility, maintainability);
- Ease of construction;
- Phasing;
- Operational impacts to terminal area;
- Expandability;
- Right-of-way acquisition; and
- Relative cost.

This alternatives screening process resulted in two preferred alternative locations for the DART Love Field station and two preferred alternative locations for the DAL terminal station. These alternatives were analyzed based on system performance (trip times, travel times, capacity and expansion), maintenance and storage facility, tunneling requirements, station locations and order of magnitude cost. The 2008 report identified a feasible alternative at a cost of $330 million (2010 dollars). However, subsequent analysis determined that the alternative was cost prohibitive and in 2011 the City of Dallas decided to reprogram much of the money that had been set aside for the APM to a different use, which caused the project to be deferred indefinitely.[99]

Funding Plan - Sources and Uses of Funds

The LFMP is funded through multiple sources (Table A-42):

1) **Airport Improvement Program Grants (AIP)** –This includes AIP entitlements based on the FAA AIP entitlement formula and represents the full 75 percent federal share of the estimated costs of the portion of the LFMP covered by an FAA Letter of Intent. (The LOI also included alternative AIP funding levels representing 65 percent federal share and 50 percent federal share).
2) **Passenger Facility Charge (PFCs) –** DAL increased the PFC from $3.00 to the maximum allowed of $4.50, to generate an increase in revenues from $11.3 million/year in 2009 to $16.5 million/year in 2010, growing to $29 million in

[99] Formby, Brandon, "Airport DART station is one direct connection Dallas Love Field doesn't have," *The Dallas Morning News*, Oct. 12, 2014.

2018. With the exception of PFC revenues obligated to prior projects, all PFC revenues are applied to the PFC-eligible projects in the LFMP, CIP, and potentially the APM.

3) **TSA Grant -** (including Advanced Surveillance Program grant funds) cover facilities and systems associated with explosives detection.
4) **City Funds -** The city's Aviation Capital Fund cover city project elements.
5) **Southwest Airline Funding -**
6) **Special Facility Bond Proceeds –** Issued to cover the balance of LFMP not covered by the funding sources described above.

Table A-42. Summary of Dallas Love Field LFMP Project Costs by Category and Funding Sources (millions)

		ESTIMATED FUNDING SOURCES								
Project Category	ESTIMATED COST	AIP Entitlement Grants	AIP Discretionary Grants	PFCs (PAYGO)	Aviation Fund	TSA Funding	ASP Grant Funding	SWA Funding	Special Facility Bond	Total Estimated Funding
Enabling Projects	$34.2							$10.2	$24.0	$34.2
Other Facilities	$29.6				$12.5				$17.1	$29.6
Parking/Ground Trans.	$21.6								$21.6	$21.6
Terminal Area Projects	$275.5					$14.9	$3.6		$257.0	$275.5
Airfield Area Projects	$7.0	$2.7		$0.9	$0.3				$3.1	$7.0
Apron Projects	$94.9		$56.3	$28.2					$10.5	$94.9
Other Costs	$45.3				$7.6	$4.6			$33.2	$45.3
LFMP Total	**$508.1**	**$2.7**	**$56.3**	**$29.1**	**$20.3**	**$19.5**	**$3.6**	**$10.2**	**$366.5**	**$508.1**

Source: Construction Document Baseline Budget (6/21/2010).

The 2007-2014 CIP totaled approximately $345.5 million and was funded by FAA AIP entitlement ($22.4 million) and discretionary ($16.3 million) funds, PFCs ($74.1 million), GARBs ($157 million), the Aviation Capital Fund ($53.1 million), and other sources ($22.5 million, sources not yet determined as of this writing, but likely some combination of Dallas Area Rapid Transit and the Aviation Capital Fund).

The airport's share of the APM project was envisaged as being funded through PFCs, while the remaining shares would be funded by DART and the city. The amounts were to be determined based on the final program design.

Capital Investment Decision Process

For the LFMP, the capital investment decision process was ultimately driven by the statutory obligations set forth in the Five Party Agreement and the need for airport capacity to meet ensuing activity demand. Once an alternative that best met those obligations was identified (through the process described above), the airport and City of Dallas, with analytical support and advice from Unison Consulting, were responsible for identifying available funding sources for each program element.

CIP items were identified based primarily on safety and ongoing maintenance issues and were not selected for inclusion based on financial or benefit-cost analysis.

Evaluation Methodologies and Techniques Used

As part of the project evaluation process, a financial analysis was conducted first to determine the cost of each program element, including the costs of project phasing. Next, possible funding sources were identified and investigated. For the portion of the program eligible for AIP grant funds, an LOI application was filed, which contained a required benefit-cost analysis.

The initial benefit-cost analysis calculated the Net Present Value (NPV) and Benefit-Cost Ratio for the preferred alternative compared to the no-action, or base case, scenario. A number of sensitivity scenarios were also analyzed, representing different values in benefit estimation (forecast enplanements, passenger travel time, discount rate, and split of new passengers and diverted traffic) and net and total outlay cost estimates. The component of the LFMP covered by the LOI represented only part of the total program. Therefore, the BCA allocated only 20.9 percent of the total benefits attributable to the entire LFMP to the LOI component (the LOI component represented $108.3 million of the total $508.1 million cost for the LFMP).

The FAA reviewed the LOI application and provided feedback that resulted in submission of supplemental information,[100] which included revised calculations of benefits (for three scenarios) and costs (for five scenarios) for a total of 15 scenarios. Present value and benefit-cost calculations for these 15 scenarios addressed the following FAA concerns: isolation of delay benefits associated with the LOI component, benefit categories properly recognized in the BCA to exclude transfer payments, and definition of incremental project costs limited to the LOI component net of avoided cost. Based on these revisions, present values of the benefits for the LOI component ranged from $81.7 million to $184.8 million, while present values of costs ranged from $47.1 million to $96.6 million. Benefit-cost ratios ranged from 0.85 to 3.92, with 13 of the 15 scenarios presenting benefit/cost ratios greater than 1.0.

For this project, the BCA was not used to choose among various alternatives, but rather to demonstrate that the project would have a favorable benefit-cost ratio under all but the most conservative assumptions.

Passenger Value of Time

The BCA that was done to fulfill the FAA requirement for AIP funds was the only element of the development plan that formally quantified passenger value of time.

The BCA calculations included three sensitivity scenarios that varied the passenger value of time. The base value of time was $28.60 per hour, the low value of time was $23.80 per hour and the high value of time was $35.60 per hour. The base value represents the recommended passenger value of time for "all purpose" air carrier travel as recommended by the FAA.[101] The low and high values represent the sensitivity range recommended by the FAA.

The benefit-cost analysis accounted for seven benefit streams, four of which represented passenger value of time for different travel activities, as follows:

- Current passengers' benefits from through ticketing – time savings from not having to check luggage twice;
- Current passengers' travel time savings from the availability of non-stop flights beginning in 2014;
- Diverted passengers' airport ground access travel time savings, assuming only 50 percent of diverted passengers enjoy the savings; and
- Passenger travel time savings from reduction in ramp delay.

[100] Supplemental information was provided first on October 23, 2009 (October 2009 Study), then following further communications with the FAA, additional supplemental information was provided on January 19, 2010.

[101] GRA Incorporated, Economic Values for FAA Investment and Regulatory Decisions: A Guide, Final Report, Revised Oct. 3, 2007.

The first two benefits listed above result directly from the removal of the Wright Amendment, while the second two are the result of program construction and renovations. The other three benefit streams not related to passenger value of time were (a) producer surplus from induced traffic (assuming equal to 50 percent of new passengers); (b) consumer surplus; and (c) passenger aircraft operating savings from reduction in ramp delay.

The benefit-cost analysis considered five benefits scenarios, which calculated benefits assuming different levels of producer and consumer surplus described above. These range from Scenario 1, which included 100 percent of these items, decreasing by 25 percent for each scenario through Scenario 5, which included zero percent of the two items. The passenger value of time was held constant among all scenarios. Due to changes assumed from induced traffic and consumer surplus, the total benefits decreased from a total of $184.8 million to $81.7 million from Scenarios 1 through 5 (see Table A-43). As a result, the passenger value of time assumes an increasing share of total benefits across the scenarios, starting at 41.6 percent for Scenario 1 and increasing to 94.1 percent for Scenario 5.

Table A-43. Passenger Value of Time as a Percent of Total Benefit by Scenario

Benefit Scenario	Passenger Value of Time (millions)	Total Benefits (millions)	PVT as Share of Total Benefits
Scenario 1	$76.9	$184.8	41.6%
Scenario 2	$76.9	$159.0	48.3%
Scenario 3	$76.9	$133.2	57.7%
Scenario 4	$76.9	$107.4	71.5%
Scenario 5	$76.9	$81.7	94.1%

Source: Dallas Love Field LOI Application Benefit-Cost Analysis Supplemental Information II (Jan. 19, 2010).

As previously discussed, the benefit-cost analysis considered each of the five benefits scenarios against three separate cost scenarios. Table A-44 illustrates the role of passenger value of time in the resulting benefit/cost ratios by showing what the benefit/cost ratio would have been without passenger value of time. The inclusion of the passenger value of time in the BCA was instrumental in demonstrating that the LFMP would likely return a positive net present value. Table A-44 shows that without passenger value of time, ten of the 15 combinations of cost and benefit scenarios fail to achieve benefit/cost ratios of 1.0. This stands in contrast to the official benefit/cost ratios calculated with passenger value of time, among which only two of the 15 failed to meet the 1.0 threshold.

Table A-44. Benefit-Cost Analysis Excluding Passenger Value of Time

Benefit Scenario	Benefits Excluding Passenger Value of Time	Benefit/Cost Ratio		
		Cost Scenario 1 ($47.1 million)	Cost Scenario 2 ($96.6 million)	Cost Scenario 3 ($87.8 million)
Scenario 1	$107,924,285	2.3	1.1	1.2
Scenario 2	$82,138,534	1.7	0.9	0.9
Scenario 3	$56,352,783	1.2	0.6	0.6
Scenario 4	$30,567,033	0.6	0.3	0.3
Scenario 5	$4,781,282	0.1	0.0	0.1

Source: Dallas Love Field LOI Application Benefit-Cost Analysis Supplemental Information II (Jan. 19, 2010).

Though passenger value of time was not formally quantified as part of the LFMP alternative development and selection process, many of the facility requirements and evaluation criteria favored efficiency gains that would reduce passenger travel time. Ultimately, the alternative selected was the one based on the concept of maximum operational efficiency.

Outcome

Construction in the LFMP began in 2009 with the construction of a new General Use Building for Southwest Airlines. This was followed in 2010 with the start of work on the new terminal. The new ticketing and check-in hall opened on November 1, 2012 and the first phase gates in the new concourse opened on April 16, 2013. The new baggage claim hall opened in September 2014, with the remaining gates in the second phase of the new concourse opening on October 1, 2014. The ending of the Wright Amendment restrictions on October 13, 2014 saw an increase in flight departures from 118 on October 12 to 140 on October 13.

With the incipient completion of the new terminal in 2014, planning resumed to explore a new and less costly alignment for the APM.[102]

Sources

The following documents and/or sources were used as resources for this report:

- Five Party Agreement TARPS for Dallas Love Field, Final Report, June, 25, 2008.
- Dallas Love Field People Mover Connector Feasibility Study, July 2008.
- Application for Letter of Intent for Dallas Love Field, presented to Federal Aviation Administration April 30, 2009.

[102] Rincón, Diego, "Love Field Modernization Program," Presentation to North Central Texas Council of Governments, People Mover Planning Luncheon, Jun. 27, 2014. (Available at http://www.nctcog.org/TRANS/presentations/documents/PeopleMoverPlanning.pdf, accessed Feb. 20, 2015).

- Dallas Love Field LOI Application Benefit-Cost Analysis Supplemental Information II, January 19, 2010.
- Dallas Love Field Impact Analysis Update: In the Absence of the Wright Agreement, May 31, 2006.

The following persons were interviewed for the case study:

- Manoj Patel, Former Finance Consultant at Dallas Love Field Airport

Lambert-St. Louis International Airport – Airport Development Program

Introduction

In 1992, the City of St. Louis Airport Authority (the Authority) completed a comprehensive Master Plan Study of the Lambert-St. Louis International Airport (STL) to determine the airport's future demand and infrastructure requirements. The study recommended a development plan known as Alternative F-4, which called for reconfiguring and expanding the airfield by rotating the alignment of the main runway system by approximately 10 degrees. In 1993, the airport completed a more thorough review of Alternative F-4 and determined that the plan was not feasible due to higher than anticipated costs and the difficulty of reconfiguring the airfield while maintaining 24-hour operations. The Authority re-evaluated the plan and, in 1994, began working on the Master Plan Supplement Study. Completed in 1996, the Supplement Study recommended a plan of development called Alternative W-1W, consisting of three phases. In 1999, the authority began implementing Phase I, also known as the Airport Development Program (ADP), which included the construction of a new 9,000-foot parallel runway. Figure A-8 illustrates the runway configuration of STL.

Prior to the ADP, because the airport's two primary runways were separated by only 1,300 feet the airport was reduced to one precision instrument approach during adverse weather conditions. The new runway allows dual independent aircraft arrivals during instrument flight rule (IFR) (bad weather) conditions, thereby substantially increasing capacity. Studies indicated the new runway would result in operating cost savings to airlines and travel time savings to passengers, and that the present value of these savings over 20 years exceeded the present value of costs, yielding a benefit/cost ratio greater than 2:1.[103] Additionally, the project was expected to reduce air traffic delays in the national air transportation system.

At the time of the Master Plan and subsequent initial work to implement the ADP, STL had become the primary hub for Trans World Airlines (TWA) and the delays that resulted from the loss of runway capacity during bad weather had a serious adverse impact on the reliability of TWA's flight network. During the 1990s, TWA experienced continuing financial difficulties leading to two declarations of bankruptcy, in 1992 and 1995. In April 2001, American Airlines acquired TWA and subsequently began merging its operations into its own network, but continuing to operate the St. Louis hub.

Three years into the ADP, the airline industry was severely affected by the September 11, 2001 terrorist attacks, a weakened economy and the Iraq war. Less than two years later, American Airlines, the largest carrier at the airport at that time, announced plans to reduce its service by approximately 50 percent, which would lower total enplanements by over 30 percent. The airport management responded by reducing the scope of the ADP[104] and adjusting the funding sources, resulting in fewer project cost elements charged to the airlines. The runway was completed and became operational in April 2006.

Airport Overview

The airport is located in St. Louis County, approximately 15 miles northwest of downtown St. Louis and within the St. Louis metropolitan area.[105] The airport occupies approximately 3,600 acres of land, with four runways and an extensive taxiway system. The largest commercial aircraft can use the primary runways (12R-30L, 12L-30R and 11-29) without restrictions. The newest runway (Runway 11-29), completed in April 2006, allows simultaneous take-offs and landings with Runway 12L-30R during IFR conditions.

The airport is owned by the City of St. Louis and is managed by the Airport Authority, which was created by an ordinance enacted by the city's legislative body, the Board of Aldermen. The Director of Airports serves as the Chief Executive Officer of the Authority. The Airport Commission is the governing board of the Airport Authority and is responsible for overseeing the planning, development, management and operation of the airport. The Airport Commission has 17 members: the Director of Airports (Chairman of the

[103] Federal Aviation Administration, Benefit-Cost Analysis for Lambert-St. Louis International Airport Capacity Enhancement Project, July 31, 1997.

[104] Described below in the section, Revised ADP

[105] The overview is drawn from: Unison Consulting, Inc., Review of the Airport Consultant for the City of St. Louis, MO Airport Revenue Bonds, Series 2009 A-1 and 2009 A-2, $129,970,000, June 30, 2009.

Commission), the City Comptroller (Chief Fiscal Officer), the President of the Board, the Chairman of the Transportation and Commerce Committee of the Board, six members appointed by the Mayor of the city, five members appointed by the St. Louis County Executive, one member appointed by the County Executive of St. Charles, Missouri, and one by the Chairman of the County Board of St. Clair County, Illinois. The Director of Airports is supported by three Deputy Directors: a Senior Deputy Director of Airports, a Deputy Director of Finance, and a Deputy Director of Planning and Development.

The Director of Airports, with approval from the Airport Commission and the Board of Estimate and Apportionment of the city, has the power to enter into contracts, leases and agreements. Any contracts, leases and agreements with a term of more than three years must be authorized by the Board and, if such contract, lease or agreement relates to the construction of public works, by the city's Board of Public Works. The Director of Airports, with the approval of the Airport Commission, has the power to establish schedules fixing all other fees and charges.

The Federal Administration (FAA) classifies the St. Louis Airport as a medium hub airport, defined as an airport that enplanes between 0.25 and 1.0 percent of the total enplanements in the United States in a calendar year. In calendar year (CY) 2010, STL enplaned nearly 6.2 million passengers, which accounted for 0.85 percent of total U.S. enplanements. Airports Council International (ACI) ranked STL 34th in total passengers, 47th in total operations and 39th in total cargo metric tons for CY 2010, among North American airports. Total aircraft operations were 185,720 and total air cargo volume was 103,742 metric tons in CY 2010, according to ACI traffic data.

Proposed Capital Improvement

The Airport Development Plan (ADP) was developed to implement the Phase I development recommendations from the 1996 Master Plan Supplement Study. The major elements of the Phase I development included land acquisition for a new runway and support facilities; planning, design and construction of a new 9,000-foot parallel runway; relocation of the Missouri Air National Guard (MOANG); and infrastructure for the redevelopment of the northeast quadrant of the airport. The St. Louis Airport also retained the option to finance certain replacement facilities for airport tenants, to be paid for entirely by those tenants.

In 1996, STL served more than 13.6 million enplanements and 514,000 aircraft operations. Based upon these statistics, the airport was the 14th busiest in the United States in terms of enplanements and the 8th busiest in terms of aircraft operations. Due to significant traffic growth beginning in 1992, STL's airfield was operating near capacity and future growth was forecast to create significant increases in air traffic delays. The 1996 Master Plan

Supplement Study recommended that the airport construct a new runway to increase airfield capacity and reduce air traffic delays.[106]

Table A-45 presents the historical and forecast traffic data for STL in the 1996 Master Plan Supplement Study.

Table A-45. Passenger Enplanements and Aircraft Operations Historical (1985-1996) and Master Plan Projections (2000-2015)

Year	Enplanements	Percentage Change	Aircraft Operations (000)	Percentage Change
1985	9,952		428	
1986	10,149	2.0%	458	7.1%
1987	10,172	0.2%	419	-8.5%
1988	10,071	-1.0%	433	3.2%
1989	9,997	-0.7%	429	-0.8%
1990	10,020	0.2%	439	2.4%
1991	9,556	-4.6%	413	-5.9%
1992	10,479	9.7%	428	3.5%
1993	9,942	-5.1%	453	6.0%
1994	11,667	17.3%	480	5.9%
1995	12,848	10.1%	519	8.2%
1996	13,644	6.2%	514	-1.0%
2000	13,933		513	
2005	16,418		558	
2015	20,901		632	
Average Annual Growth Rate				
1985-1990	0.1%		0.5%	
1991-1996	7.4%		4.5%	
1996-2000	0.5%		0.0%	
2000-2015	2.7%		1.4%	

Sources: Airport management records for historical statistics; Leigh Fisher Associates, Master Plan Supplement Study for Lambert-St. Louis International Airport, Table 6, January 1996; Forecasts were developed on September 30, 1994.

In 1995, the average annual delay per aircraft operation at the St. Louis Airport was approximately eight minutes. If no improvements were made to the airfield capacity, the average annual delay per aircraft operation was projected to exceed 34 minutes in 2015. As of 1995, STL ranked second among 51 U.S. airports in the number of operations that were delayed by 15 minutes or more. The St. Louis Airport was a critical component of the national air transportation system, and travel delays at STL contributed to delays system-wide.

[106] Lambert-St. Louis International Airport, Application for Letter of Intent to provide a Multi-Year Commitment of Airport Improving Program Grant-in-Aid Funding, Feb. 28, 1998.

Investment Objective

The objective of the ADP was to mitigate runway congestion and reduce aircraft delays at STL while providing capacity to accommodate forecast growth in aviation activity. This was perceived as necessary at that time to maintain the viability and attractiveness of STL as an airline hub airport and as an important link in the national aviation system.[107]

In 1997, the William J. Hughes FAA Technical Center Aviation System Analysis and Modeling Branch conducted a study to review the alternatives proposed in the Master Plan Supplement Study.[108] The study concluded that "the major constraint on the operation of Lambert is during marginal Visual Flight Rules (VFR) and IFR conditions, which occur approximately 14% of the time, but contribute to more than half of the total annual delay…". The study also found that "any improvement to Lambert which would increase IFR and marginal VFR capabilities … would result in a significant increase in airfield capacities during adverse weather conditions." As shown in Table A-46, the ADP was projected to result in significant reduction in operational and passenger delays at STL and in the national aviation system (NAS).

Table A-46. STL ADP – Reduction in Operational and Passenger Delay at the Airport and in the National Aviation System

Delay	2005		2010		2015	
	STL	NAS	STL	NAS	STL	NAS
Operational	63%	5%	65%	8%	66%	14%
Passenger	55%	7%	52%	9%	57%	18%

Source: FAA, National Airspace System Performance Analysis Capacity Study, June 1997

Project Description

Alternative W-1W was the recommended development plan from the 1996 Master Plan Supplement Study. The original plan was divided into three phases.[109] Traffic forecasts from the Supplement Study indicated that Phase I (1996-2002), which included the construction of a new 9,000 foot runway (Runway 11/29), laterally separated by 4,100 feet from the existing runway to allow for simultaneous operations in IFR conditions, was needed immediately to accommodate expected growth. Phase II (2002-2015), and potentially Phase III (after 2015), would not be undertaken until warranted by demand.

[107] Lambert-St. Louis International Airport, Application for Letter of Intent to provide a Multi-Year Commitment of Airport Improving Program Grant-in-Aid Funding, Feb. 28, 1998.

[108] Richie, Joseph, and Doug Baart, *Evaluation of the Proposed Lambert-St. Louis International Airport Expansion*, FAA William J. Hughes Technical Center, Atlantic City, New Jersey, June 1997.

[109] Federal Aviation Administration, EIS Record of Decision for Lambert-St. Louis International Airport, September 30, 1998.

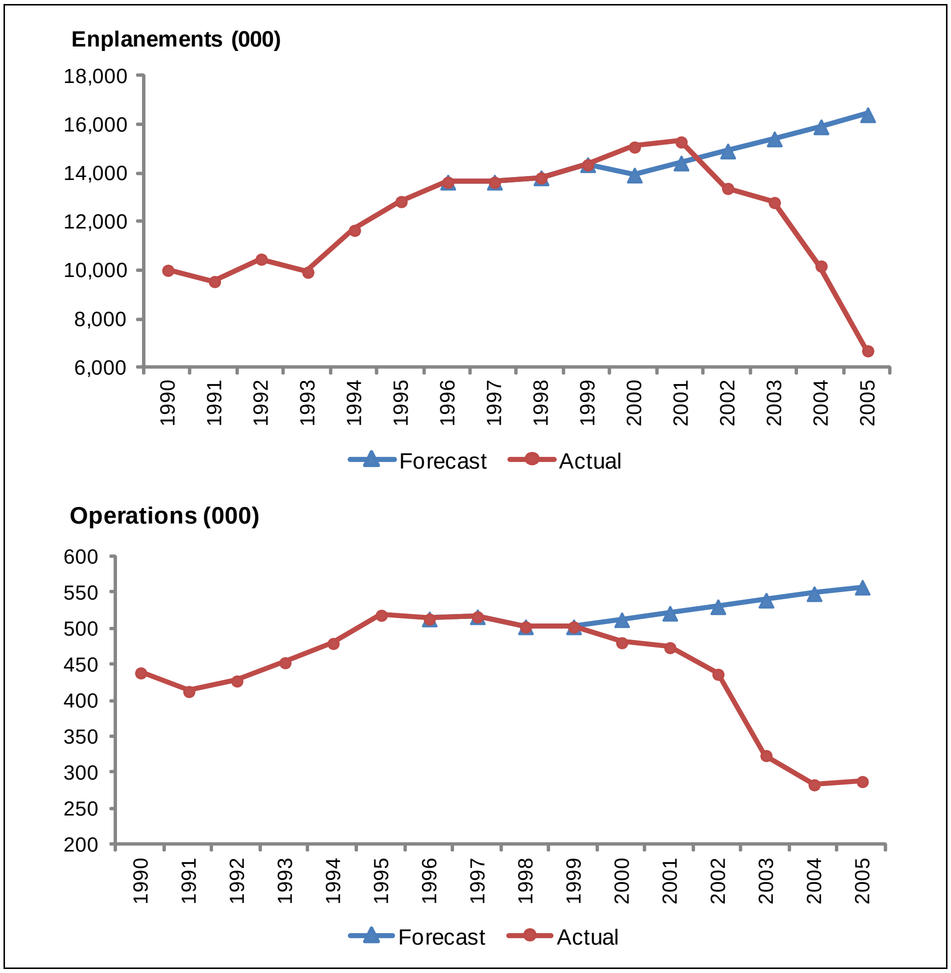
Phase III projects were beyond the 20-year planning period and were not programmed for implementation.

Original ADP. In 1999, the airport authority began implementing the ADP based on the 1996 Master Plan Supplement Study recommendations for Phase I of W-1W. Initial plans for the ADP included the following major elements:

- *Program management / professional services.* Program management services, general planning, project design, financial consulting services, information technology and systems management services, geotechnical consulting services, environmental consulting and mitigation measures, surveying and materials testing.
- *Land acquisition for new runway.* Acquisition of 1,903 parcels of single-family residences, multi-family dwellings, commercial properties and other facilities, located to the west of the existing airport in the City of Bridgeton, Missouri, – encompassing approximately 11.4 percent of Bridgeton, or 1.36 square miles.
- *Northwest land acquisition.* Acquisition of a 76-acre parcel, which included the Boeing Company's aircraft manufacturing facilities (around 20 buildings), on the northern boundary of the airport immediately west of the crosswind runway, to be redeveloped for airport support facilities.
- *New runway.* Design, site utilities, site preparation, roadway relocations, facility relocations, and the construction of a new 9,000-foot air carrier runway, together with associated lighting, instrument landing systems, navigational aids and facility demolitions and relocations.
- *Northeast quadrant infrastructure.* Redevelopment of the existing northeast quadrant of the airport to facilitate the relocation of certain tenant facilities, as well as the construction of new cargo and airline maintenance facilities.
- *Relocation of MOANG.* Relocation of existing Missouri Air National Guard (MOANG) facilities – deemed an airspace obstruction to the new runway – to the northwest land acquisition area.
- *Program contingency.* Overall program contingency for Phase I in the amount of $78 million to cover potential program scope changes and unanticipated cost increases.
- *Replacement tenant facilities.* Relocation to the northeast quadrant of certain tenant facilities, which posed airspace obstruction to the new runway.
- *Navigational aids.* Navigational aids (navaids) for the new runway to be funded by the FAA and not included in the airport's ADP budget.

Revised ADP. While the ADP implementation was underway, several events caused a significant decline in traffic at STL – the 2001 economic recession, the September 11, 2001 terrorist attacks, and the acquisition of TWA by American Airlines that led to significant cuts in the airline's operations at STL and, ultimately, the de-hubbing of STL. On July 16, 2003, American Airlines, the largest carrier at the airport, announced a 51 percent reduction in service to and from St. Louis effective November 1, 2003. Other events, such as the severe acute respiratory syndrome (SARS) epidemic and the Iraq war in 2003, contributed to the overall decline in traffic. Figure A-9 shows how actual enplanements and aircraft operations had fallen significantly below the Master Plan Supplement Study forecasts since 2001.

Figure A-9. Forecast and Actual Enplanements and Aircraft Operations at the Airport



Sources: Airport management reports for actuals; Leigh Fisher Associates, "Master Plan Supplemental Study for Lambert-St. Louis Airport", January 1996, for forecasts for Lambert-St. Louis International Airport. Forecasts were developed on September 30, 1994.

In response, the airport management took dramatic steps to reduce the impact of the service reduction on the air carriers operating at the airport, including cuts in the scope and budget of the ADP. The holding pad and deicing pad associated with the runway were deleted from the ADP, the relocation of Missouri Air National Guard, American Airlines' St. Louis Ground Operations Center (SGOC) and the airfield maintenance facility were deferred indefinitely, and the infrastructure projects in the northeast quadrant were put on hold. While the runway was planned to be ultimately programmed for a CAT III approach, the airport management decided to keep the American Airlines hangar facility in the interim, and, with the approval of the FAA, the new runway was constructed and to be operated on an interim basis with a CAT I approach to the west. This eliminated the need to relocate the hangar, as well as the MOANG munitions bunker and a U.S. Navy vehicle maintenance facility, which were initially deemed airspace obstructions to the new runway. However, to avoid closure of the new runway in the future, the FAA installed the necessary CAT III Instrument Landing System (ILS) equipment during construction.

Alternatives Considered

The airport management initially considered more than 40 potential airfield development concepts, including new parallel runways, new parallel runways in different orientations, and extensions to the existing runways.[110] After a lengthy process that included capacity and delay studies, environmental impact assessments, cost evaluation, and public consultation, the list was reduced to a "do-nothing" alternative and eight build alternatives that were more fully developed. The nine alternatives were then evaluated further based on the following criteria: (1) airport and metropolitan area goals; (2) operational safety; (3) operational efficiency; (4) environmental factors; (5) constructability; and (6) affordability. Based on this evaluation, Alternative W-1W was selected as the preferred alternative.

Alternative W-1W included the construction of a new 9,000 foot runway (12W/30W, later designated 11/29) parallel to and southwest of existing runways 12L/30R and 12R/30L. The new parallel runway was to be separated by 4,100 feet from existing Runway 12L/30R and located south and west of existing crosswind Runway 6/24. It also required the construction of a runway/taxiway bridge across Lindbergh Boulevard.

The other seven build alternatives identified capital investments that were rejected by airport management based on the six criteria listed above. These investments included:

- Construction of a new 9,000-foot parallel northwest-southeast runway at least 1,200 feet north of existing Runway 12L/30R.
- Construction of a new 9,000-foot parallel northwest-southeast at least 1,000 feet south of existing Runway 12R-30L.
- Decommissioning of Runway 12L-30R to accommodate a new terminal between the new north parallel runway and the existing Runway 12R-30L.
- A new south parallel runway at least 4,200 feet from the existing Runway 12R-30L.
- Two dual taxiway bridges to cross Interstate 70.
- Relocation of Interstate 70.
- Construction of three new parallel runways rotated approximately 10 degrees clockwise from the current orientation of the existing parallel runways. The runways

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[110] Leigh Fisher Associates, Master Plan Supplement Study for Lambert-St. Louis International Airport, January 1996.

would be completed sequentially—one parallel runway to the west of the existing terminal, and then two parallel runways to the north of the existing terminal.

- Programs of property acquisition more aggressive than Alternative W-1W required for three of the other seven build alternatives.

Also rejected were two options that added capacity away from Lambert Field:

- Supplement STL with services at another existing airport.
- Replace STL with a new airport.

Passenger Value of Time

Passenger time lost due to operational delays was a major factor in the airport management's decision to implement the ADP. Estimated passenger time savings accounted for a significant portion of the project benefits that justified federal funding and project implementation.

The FAA study team from the FAA William J. Hughes Technical Center used the National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System to represent the essential elements of the Master Plan Supplement Study and to estimate their impact on the performance of the National Airspace System. This study was sponsored by the FAA Investment Analysis and Operations Research Division. [111]

The NASPAC simulations were used to estimate delays at STL and nationwide, with and without the proposed projects. The delay estimates provided the basis for estimates of savings in aircraft operating costs and passenger travel time attributable to the ADP. The FAA study assumed $1,800 per hour for the cost of operating an aircraft, including crew salaries, aircraft maintenance, fuel, depreciation and amortization, and $45.50 per hour for the value of passenger travel time.

As shown on Table A-47, cumulative operational delay savings between 2005 and 2015 were estimated to amount to $1.9 billion at STL and $5.1 billion for the NAS, in constant 1996 dollars. The cumulative value of travel time savings to passengers was estimated at $1.4 billion at the airport and $9.5 billion nationwide, in constant 1996 dollars. Table A-48 and Table A-49 show the annual estimates of operating cost and passenger time savings between 2005 and 2015 at STL and for the NAS, respectively.

[111] Federal Aviation Administration William J. Hughes Technical Center, *Draft Evaluation of the Proposed Lambert-St. Louis International Airport Expansion*, June 1997. This was not the BCA. The BCA for the project dated July 31, 1997, conducted by FAA Systems Analysis and Policy Division was the official document used to justify AIP funding.

Table A-47. Cumulative Delay Savings at the Airport and the National Airspace System (in 1996 dollars); 2005-2015

Location	Operational Delay Savings	Passenger Delay Savings
STL	$1.9 billion	$1.4 billion
NAS	$5.1 billion	$9.5 billion

Source: FAA, National Airspace System Performance Analysis Capacity Study, June 1997

Table A-48. Annual Operational and Passenger Delay Savings at STL (2005-2015)

Years	Operating Delay		Passenger Delay	
	Hours	Savings[1]	Hours	Savings[1]
2005	80,486	$141,350,000	51,778	$103,943,000
2006	83,634	$146,063,000	53129	$105,834,600
2007	86,782	$150,772,000	54,480	$107,726,200
2008	89,930	$155,481,000	55,831	$109,617,800
2009	93,078	$160,190,000	57,182	$111,509,400
2010	96,227	$164,900,000	58,534	$113,401,000
2011	100,216	$176,838,000	63,516	$128,546,000
2012	104,205	$188,776,000	68,498	$143,691,000
2013	108,194	$200,714,000	73,480	$158,836,000
2014	112,183	$212,652,000	78,462	$173,981,000
2015	116,170	$224,590,000	83,445	$189,126,000
Totals	**1,071,105**	**$1,922,326,000**	**698,335**	**$1,446,212,000**

[1] In 1996 dollars

Source: FAA, Draft Evaluation of the Proposed Lambert-St. Louis International Airport Expansion, June 1997

Table A-49. Annual Operational and Passenger Delay Savings in the NAS (2005-2015)

Years	Operating Delay		Passenger Delay	
	Hours	Savings[1]	Hours	Savings[1]
2005	96,247	$169,543,000	163,123	$340,679,000
2006	123,649	$210,673,400	192,534	$376,697,600
2007	151,051	$251,803,800	221,945	$412,716,200
2008	178,453	$292,934,200	251,356	$448,734,800
2009	205,855	$334,064,600	280,767	$484,753,400
2010	233,259	$375,195,000	310,176	$520,772,000
2011	285,086	$482,437,400	416,380	$806,603,600
2012	336,913	$589,679,800	522,584	$1,092,489,200
2013	388,740	$696,922,200	628,788	$1,378,347,800
2014	440,567	$804,164,600	734,992	$1,664,206,400
2015	492,395	$911,407,000	841,197	$1,950,065,000
Totals	**2,932,215**	**$5,118,825,000**	**4,563,842**	**$9,476,065,000**

[1] In 1996 dollars

Source: FAA, Draft Evaluation of the Proposed Lambert-St. Louis International Airport Expansion, June 1997

Funding Plan

Cost estimates for Phases I and II (1996-2015) of Alternative W-1W, as shown on The Master Plan Supplement Study identified sources and uses of funds for W-1W, as presented on Table A-51**.** The sources of funds, in descending order of magnitude, were as follows:

- General Airport Revenue Bonds (GARBs);
- STL Airport Development Fund (ADF);
- Pay-As-You-Go Passenger Facility Charges (PAYGO PFC);
- Airport Improvement Program (AIP) Grants;
- Interest Income; and
- FAA Facilities and Equipment (F&E) Funds.

Table A-50**,** were originally developed in 1995 by Intercontinental Management Controls, Inc. They included a 15 percent allowance for engineering, design and program management, and a 15 percent contingency factor. They were escalated from 1995 to the midpoint of construction at an inflation rate of 3.5 percent per year.

The Master Plan Supplement Study identified sources and uses of funds for W-1W, as presented on Table A-51**.** The sources of funds, in descending order of magnitude, were as follows:

- General Airport Revenue Bonds (GARBs);
- STL Airport Development Fund (ADF);
- Pay-As-You-Go Passenger Facility Charges (PAYGO PFC);
- Airport Improvement Program (AIP) Grants;
- Interest Income; and
- FAA Facilities and Equipment (F&E) Funds.

Table A-50. Lambert-St. Louis International Airport Master Plan Supplement Study – Original Cost Estimates

	Total (000)
Land Acquisition Program	
Land Acquisition and Noise Mitigation	$322,229
Replacement of On-Airport Facilities and Relocation Costs	$101,431
Roadway Improvements	$174,749
	$598,409
Airfield Construction Projects	
New West Runway and Related Taxiways	$168,275
Aircraft Parking Aprons	$19,620
Airside Service Roads	$6,159
Aircraft Fuel and Glycol Systems	$32,500
Airline Support Facilities	$66,003
Airfield Rescue and Firefighting Facilities	$5,668
Airfield Lighting, Signage and Navigational Aids	$33,338
Utility Relocations	$30,916
General Allowances for Repair and Improvement	$80,421
	$442,900
Terminal Building Complex	
Renovation of Existing Terminal Complex	$100,877
Construction of New Terminal and Concourse Facilities	$380,777
Ground Support Systems for New Aircraft Gates	$1,811
Connector Tunnel to West Terminal Complex	$70,463
People Mover System	$25,901
	$579,829
Cargo and Other Leasable Projects	
	$22,159
Parking Structures and At-Grade Parking	
	$35,643
Landside Roads and Utilities	
Reroute Lambert International Drive	$10,955
Drainage Improvements	$9,857
New Terminal Freeway Interchange	$50,664
	$71,476
TOTAL PROJECT COSTS	**$1,750,416**

Project costs in 1995 dollars, escalated through 2005.

Source: Intercontinental Management Controls, Inc.

Table A-51. Lambert-St. Louis International Airport Master Plan Supplement Study – Original Plan of Finance-Sources and Uses of Funds

Sources of Funds	(000's)
GARBs (Principal)	$1,660,229
AIP Grants	$81,045
FAA F&E Funds	$19,990
PAYGO PFC	$119,474
ADF	$266,487
Interest Income	
Construction Fund	$33,157
Capitalized Interest	$24,565
Total	**$2,204,947**
Uses of Funds	**(000's)**
Project Costs	
Land Acquisition Program	$598,409
Airfield Construction Projects	$442,900
Terminal Building Complex	$579,829
Cargo and Other Leasable Projects	$22,159
Parking Structures and At-Grade Parking	$35,643
Landside Roads and Utilities	$71,476
Financing Costs	
Issuance Expenses	$24,903
Capitalized Interest	$287,165
Bond Reserve Fund	$142,463
Total	**$2,204,947**

Source: Leigh Fisher Associates, Master Plan Supplemental Study for Lambert-St. Louis Airport, January 1996.

The budget and components of the ADP changed a number of times during the course of the project. As discussed above, the scope of the project was reduced to reflect the decline in traffic the airport experienced beginning in 2001. Table A-52 shows the plan for the final ADP budget**.** There are major differences between the initial and final financial plans. GARBs remained the largest funding source, but the ADF ended up as the smallest source – from the second largest – due to the significant service cutbacks and the change in the airport's status as a hub airport. The changes in the funding sources reflected greater support from the FAA and lower impact to the airlines' rates and charges. The percentages of the budget funded via PAYGO PFC and AIP grants increased by 24 and 10 percentage points, respectively. The FAA also contributed additional monies in the form of noise grants, which were not anticipated when the project began.

Table A-52. Lambert-St. Louis International Airport - Airport Development Project: Final Budget and Funding Sources

Major Project Elements	Project Funding Sources (000)						
	Airport Equity	FHWA Grant	GARBs	AIP Grants (through LOI)	Noise Grants	PAYGO PFC	Total Sources
Program Management / Professional Services	$2,872	$ —	$81,354	$24,929	$31,182	$55,721	$196,058
Land Acquisition	$ —	$ —	$225,406	$50,993	$ —	$175,378	$451,777
Northwest Land Acquisition	$ —	$ —	$50,000	$ —	$ —	$ —	$50,000
New runway							
Design Services	$1,891	$4,734	$3,211	$6,119	$ —	$7,814	$23,769
Site Preparation	$312	$ —	$59,281	$38,546	$ —	$27,947	$126,086
Construction							$0
Construction Staging Areas	*$ —*	*$ —*	*$ —*	*$ —*	*$ —*	*$407*	$407
Roads	*$118*	*$9,702*	*$75,311*	*$ —*	*$ —*	*$4,195*	$89,326
Site Utilities	$ —	$ —	$7,992	$6,338	$ —	$7,520	$21,850
Runway / Deicing Pads	$ —	$ —	$9,966	$26,166	$ —	$41,913	$78,045
Navigational Aids	$272	$ —	$1,728	$ —	$ —	$ —	$2,000
Relocations / Demolitions	$5,353	$ —	$2,160	$ —	$ —	$5,240	$12,753
Northeast Quadrant	$429	$ —	$6	$139	$ —	$29	$603
Miscellaneous	$966	$ —	$ —	$ —	$ —	$3,897	$4,863
Total	$12,213	$14,436	$516,415	$153,230	$31,182	$330,061	$1,057,537

Source: Unison Consulting, Inc., Calculation of Rates and Charges for Lambert-St. Louis International Airport, FY2011.

Capital Investment Decision Process

The decision to increase the airfield capacity of the airport was not reached through a linear decision-making process, but rather as "a given" following the completion of the 1992 Master Plan. The city initially investigated Alternative F-4, but determined that it was not feasible. A few years later, the 1996 Master Plan Supplement Study confirmed the findings of the 1992 Master Plan and predicted that average delays at STL would increase from 8 minutes in 1995 to 34 minutes in 2015. This forecast solidified the decision to proceed with a major capital investment to expand capacity to accommodate forecast demand.

Overview of the Process

On July 6, 1995, Mayor Freeman Bosley, Jr. and Airport Director Col. Leonard Griggs announced that the City of St. Louis had selected Alternative W-1W as the preferred development concept for the airport. This public announcement was the first step of a lengthy process to obtain approval for W-1W and, ultimately, implementation of the ADP, from interested stakeholders and the public. The participants in the discussions and meetings included the City of St. Louis, the St. Louis Airport, the airport's consultants, tenant airlines, the FAA, St. Louis Regional Commerce and Growth Association (representing St. Louis area businesses), labor union officials, Missouri congressional members, local governments, agencies, and the public.

The city officially began funding the ADP on November 1, 1996 when Ordinance 63873 was passed by the City of St. Louis Board of Aldermen, authorizing $40 million to be spent for the pre-design, pre-program management and final processing of the Airport Layout Plan. This pre-funding occurred before the project was approved by the FAA.

There were many steps in the W-1W approval process, and it took three years to obtain the final FAA approval. In 1995, the FAA began the public phase of the process to approve the Environmental Impact Statement (EIS). After evaluating the EIS and reviewing substantive comments from public agencies, local governments, community groups and individual citizens, the FAA approved the Final Environmental Impact Statement on December 19, 1997. This was followed by the EIS Record of Decision (ROD) which was issued on September 30, 1998. The ROD was the final approval needed to begin the project in earnest.

Despite having approval from city officials and the FAA, the airport authority had to overcome a major hurdle: the cities of Bridgeton and St. Charles, and St. Charles County sued the City of St. Louis in an attempt to stop the ADP shortly after the ROD was issued. Bridgeton filed two lawsuits, one in state court and the other in federal court. The state lawsuit alleged that the airport was violating Bridgeton's zoning ordinance. Bridgeton, St. Charles and St. Charles County filed a suit in federal court alleging that the FAA had failed to consider W-1W's harmful effects on the surrounding communities and did not consider other, less-disruptive alternatives. The project also faced strong opposition from the Air Line Pilots Association, the National Air Traffic Controllers Association, and a local group, Citizens Against Airport Noise. The legal challenges delayed the land acquisition process, which then impacted the construction schedule. During this time, the Authority assembled the program management team, began the design process and developed the project's labor agreement. In 2000, both lawsuits were dismissed and the project was allowed to continue.

Evaluation Methodologies and Techniques

The ADP underwent several evaluations before it was completed. Beginning with the Master Plan Supplement Study and continuing throughout the funding process, various methodologies were utilized to determine the viability of the project.

Financial Feasibility Analysis. The first financial evaluation occurred in the Master Plan Supplement Study as a part of the master plan process. Master plans are required to include a financial feasibility analysis that demonstrates the airport's ability to fund recommended projects. The Master Plan Supplement Study included a financial plan presenting sources and uses of funds, projections for operational and maintenance expenses, airline rates and charges, debt coverage ratio (net revenues divided by debt service), and fund balances. The analysis indicated that cost per enplanement, a widely used metric at airports, would increase from $3.50 in 1995 to $10.12 in 2002, the estimated first year after the completion of the runway. The plan also estimated that the debt coverage ratio would decline from 1.47 in 1995 to 1.37 in 2002.

The ADP funding included two bond issues, one in 2000 and one in 2001. As is typical with GARBs, the official statements for the bond issues included financial feasibility studies conducted by an independent airport consultant.[112,113] The purpose of financial feasibility studies is to demonstrate to potential bondholders that the airport has the ability to repay the debt. The feasibility studies contained the following information about the airport and the ADP:

- Airport facilities
- Airport governance
- Airport management
- Summary of the Trust Indenture
- Overview of the capital program and the projects being financed
- Plan of finance
    - Funding sources
    - Financing plan for the ADP
    - Debt service requirements
- Economic base of the airport
- Analysis and forecast of aviation activity
- Financial analysis
    - Airport financial framework
    - Revenues
    - Operations and maintenance expenses
    - Application of revenues
    - Debt service coverage
    - Sensitivity analyses

The finance plan presented all the sources and uses of funds associated with the project and its budget. The financial analysis simulated the financial operations of the airport and analyzed the airport's historical financial results and projected revenues, landing fees,

[112] Unison-Maximus, Inc., Report of the Airport Consultant Concerning the Financial Feasibility of Issuing The City of St. Louis, Missouri Letter of Intent Double Barrel Revenue Bonds, Series 2000 (Lambert-St. Louis International Airport Project), Jul. 14, 2000.

[113] Unison-Maximus, Inc., Financial Feasibility Report—City of St. Louis, Missouri, Airport Revenue Bonds, Series 2001A (Airport Development Program), Apr. 13, 2001.

terminal rental rates, O&M expenses, debt service, cash flow, cost per enplanement, and debt service coverage. In 2001, cost per enplanement was projected to increase from $3.99 in fiscal year (FY) 2001 to $6.04 in FY 2007, the actual first full year following the completion of the runway. The landing fee was projected to grow from $1.66 per 1,000 pounds of landed weight to $3.12 per 1,000 pounds during the same time period. The debt service coverage was forecast to improve from 1.34 in FY 2001 to 1.78 in FY 2007.

PFCs (PAYGO and those used to pay debt service) accounted for almost 60 percent of the final ADP budget. The airport submitted and received FAA approval for PFC applications in 1998, 2000 and 2002. Each PFC application also included a financial plan that presented passenger projections and forecast PFC revenue. Specifically, the analyses show the projected PFC collections and uses in order to establish that the resources are sufficient to pay for that portion of the project.

Benefit-Cost Analysis. The airport authority requested AIP funding for the ADP under an FAA Letter of Intent, and, therefore, was required to prepare a benefit-cost analysis. As described elsewhere in this appendix, the AIP is a grant program administered by the FAA to fund certain types of airport projects. The AIP LOI program helps fund large-scale capacity projects at primary or reliever airports. LOIs state that the FAA intends to obligate future AIP discretionary and entitlement funds to fund a portion of allowable costs of an approved project. The LOI also includes a schedule that will be used to reimburse the airport for the FAA funded portion of the project.

The FAA requires airport sponsors to submit a BCA to support applications for AIP grant discretionary funding in excess of $5 million for airport capacity projects or for any amount of LOI funding for airport capacity projects.[114] On June 2, 1997, the FAA's Office of Aviation Policy and Plans specified the manner and methodology that must be used for an LOI BCA in "FAA Airport Benefit-Cost Analysis Guidance". A BCA evaluates the economic viability of a capital project and determines: (1) if the benefits of a particular investment justify the costs; and (2) which among competing alternatives is the best alternative.

There were three BCAs done in conjunction with the project. The first BCA was prepared as part of the 1996 Master Plan Supplement Study. It evaluated eight alternatives against the ninth "do nothing" alternative, and compared the benefits of aircraft operating cost (aircraft travel time and delay savings) with the estimated construction costs between 1996 and 2015. The analysis concluded that the preferred alternative, W-1W, had aircraft operating cost savings of $885 million and total capital costs of $402 million. This resulted in a net present value (NPV) of $483 million, the highest NPV of eight alternatives, and a benefit/cost ratio of 2.2, the second highest of eight alternatives.

The Systems and Policy Analysis Division of the FAA Office of Aviation Policy and Plans completed the second BCA, dated July 31, 1997, as a supplement to the analysis of W-1W

[114] On October 24, 2011, the discretionary funding threshold was increased from $5 million to $10 million.

for the Final EIS, in anticipation of a request for AIP funding.[115] This BCA evaluated only one alternative, W-1W, against the no-action alternative. The initial BCA that narrowed the alternatives from eight to the preferred W-1W alternative did not explicitly consider passenger value of time as a project benefit. This second BCA, conducted by the FAA, however, included passenger value of time. The July 1997 BCA also acknowledged that the earlier study by the FAA Technical Center had used a value of time of $45.50 per hour, but the BCA used the "rate recently revised downward by the Office of the Secretary of Transportation" of $27.90 (the blended business and personal rate). The projections and results of the second BCA are presented in Table A-53.

Table A-53. Lambert-St. Louis International Airport—Airport Development Project: FAA BCA Costs and Benefits

Benefits		Costs	
Operations Delay Savings	$908	Investment Cost	$537
Passenger Delay Savings	$661	Recurring Cost	$142
		Disposal Value	($76)
Total Delay Savings	**$1,569**	**Total Life-Cycle Cost**	**$603**
Net Present Value		**B/C Ratio**	
Total Delay Savings	$1,569	Benefits	$1,569
Less: Total Life-Cycle Cost	$603	Costs	$603
W-1W Net Present Value	**$966**	**B/C Ratio**	**2.6**

Note: Dollars in millions, discounted back to August 1997.

The FAA BCA found that W-1W would result in an NPV of $966 million and a benefit/cost ratio of 2.6. The FAA study also included a risk analysis that calculated the effect of cost overruns, delays in the schedule, variances in traffic growth and a combination of those variables. The analysis indicated that W-1W had a high probability of maintaining a benefit/cost ratio of more than 1.0 under various scenarios.

According to both the FAA Technical Center study and the July 1997 BCA report, passenger costs were derived from the expected number of passengers on a flight multiplied by the FAA-endorsed value per hour of delay ($45.50 for the Technical Center study and $27.90 for the July 1997 BCA) multiplied by hours of delay. The number of passengers per flight was based on the passenger enplanements and aircraft operations projected in the FAA Terminal Area Forecast for STL.

A third BCA was conducted by Unison Consulting as part of the 1998 LOI application process for the ADP and was prepared in accordance with the then recently issued 1997 BCA guidance. Unison's analysis validated the findings of the FAA BCA, which was used to

[115] FAA conducted BCAs before the 1997 guidance that shifted the responsibility to the sponsor (airport).

support the airport authority's LOI application, also prepared by Unison Consulting.[116] This BCA calculated a total present value benefit of $4.967 billion, of which airline savings accounted for 39 percent and passenger value of time accounted for 61 percent. In this BCA, passenger value of time was set at $30.75 per hour, based on inflating the FAA's recommended values of passenger value of time from 1995 dollars to 1997 rates. At the time of the analysis, STL's passenger profile was 35 percent personal travel and 65 percent business travel, and the adjusted FAA rates for personal and business travel were weighted accordingly.

Prior to the LOI application deadline, a decision was made to use the results of the July 1997 FAA BCA in the application.

Decision Outcome

Alternative W-1W and the ADP were assessed several times utilizing financial and economic evaluation methodologies. In each case, the project was found to be financially feasible and economically justifiable. In 1999, the St. Louis Airport proceeded with the ADP implementation based on the results of these evaluations. The new runway, designated 11/29, was completed and became operational in April 2006.

Sources

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[116] Lambert-St. Louis International Airport, Application for Letter of Intent to provide a Multi-Year Commitment of Airport Improving Program Grant-in-Aid Funding, Feb. 28, 1998.

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- Saint Louis Public Library, *St. Louis City Ordinance 63873*, Nov. 1, 1996.
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- Unison-Maximus, Inc., *Financial Feasibility Report—City of St. Louis, Missouri, Airport Revenue Bonds, Series 2001A (Airport Development Program)*, Apr. 13, 2001.

The following persons were interviewed for this case study:

- **Colonel Leonard Griggs, former Airport Director, Lambert-St. Louis International Airport.** Col. Griggs served as the Airport Director during two separate periods. The second period, from 1993 to 2005, was primarily focused on solving the St. Louis Airport's airfield capacity issues. In 1993, he began the process of thoroughly reviewing the F-4 alternative which eventually led to the implementation of W-1W. Col. Griggs previously worked for the FAA and was instrumental in utilizing his connections at the FAA and among Missouri politicians to obtain approval for the ADP.
- **Robert (Bob) Dopuch, General Manager of the STL Program Management Office for the Airport Development Program.** Mr. Dopuch served as the St. Louis Airport's Executive Program Manager in 1992 and as the Assistant Director, Airport Planning & Development between 1993 and 1996. He has a long history with the airport and was intimately involved in the 1992 and 1996 master plans and the planning, design and implementation of the ADP. In 1997, Mr. Dopuch joined Unison Consulting as Vice President and General Manager of the STL Program Management Office. As General Manager, Mr. Dopuch was responsible for overseeing the design, construction, budget, and day to day issues surrounding the ADP.

Conclusion

The ACRP research project for which these case studies were performed is focused on evaluating how airports make capital investment decisions and how the passenger value of time is used to influence those decisions. The case studies examined capital investment decisions from a real-world perspective, and found that the tools and methodologies used were based on what was necessary to reach a decision. Therefore, for two of the five investment programs reviewed, airport management chose not to include passenger value of time in the decision-making process. At Hartsfield-Jackson Atlanta International Airport, funding for the EAT was being solicited from airlines and airlines are concerned with aircraft operating expenses, not savings that accrue to passengers. Although the airlines did not agree to fund the EAT, the BCA developed for the EAT showed a B/C ratio significantly greater than 1.0, and the airport manager saw no need to incur the additional expense to add a passenger value of time analysis to the BCA. At Birmingham-Shuttlesworth International Airport, detailed financial analyses were performed to determine if the project was feasible to build. At that point, a BCA was contemplated when the airport was considering requesting an LOI as part of the funding plan. The airport ultimately realized that financing was feasible from regular discretionary AIP funding and that the project could be categorized as an airport standards project, which does not require BCAs under FAA policy. Thus, financial viability (using the AIP grants for work that could be treated as a standards project) led to the decision to proceed with the proposed terminal modernization, and the effort and cost of preparing a BCA was avoided.

BCAs were required to secure FAA AIP funding for the runway and associated improvements at Boston Logan International Airport, improvements at Dallas Love Field, and the airport development program implemented at St. Louis Lambert Field. The passenger value of time used for the runway project at Logan International Airport and improvements at Dallas Love Field were obtained directly from blended values provided by FAA guidance. The passenger value of time accounted for 53-54 percent of the present value estimated for the Logan project, and 41-94 percent of the present value for the Dallas Love Field improvements, depending on the scenario under consideration.

The initial FAA analysis of the STL Airport Development Program was developed prior to publication of 1997 FAA BCA guidance, and the values used were significantly higher than the values of time published in the guidance, and used $45.50 per hour as the passenger value of time. Two subsequent BCAs used the blended rate from FAA guidance of $27.90 per hour and a calculated blend of $30.75 based on the STL passenger profile (35 percent personal travel and 65 percent business travel) and adjusted the values in the FAA guidance to account for two years of inflation. For the initial FAA study, the value of passenger travel time savings amounted to 43 percent of the total project benefits at STL and 65 percent of the total benefits across the National Aviation System. Subsequently, the July 1997 BCA attributed 42 percent of total benefits to cumulative passenger value of time, and the final

BCA (which was not submitted to the FAA) attributed 61 percent of all benefits to the passenger value of time.

Similar to the EAT at ATL, the new runway at BOS would have achieved a BCA ratio greater than 1.0 even without including the value of passenger time savings. The scenarios that did not include passenger value of time, for which delays were capped at 20 minutes, achieved BCAs between 2.2 and 3.5. With value of time included, the BCAs ranged from 5.0 to 7.5, with the variation resulting from alternative assumptions in each scenario. The benefit/cost ratio for the scenario not capping delay time was 6.9 without the passenger value of time component, compared to 17.5 with passenger time. Ultimately, the BCAs for both Logan and Hartsfield-Jackson airports were targeted to multiple audiences. ATL first presented its BCA to airlines, which were assumed to be indifferent about the value of passenger benefits, and the ATL General Manager saw no need to expand the BCA to include value of time when it was subsequently submitted to the FAA. The Logan analysis was aimed at multiple audiences: the FAA, for which a benefit/cost ratio greater than 1.0 was required for AIP funding, and a skeptical public and their elected representatives. For the latter two, a substantial demonstration of passenger benefit was important.

The STL BCA study dated July 31, 1997 (the second study) showed $1.569 billion in discounted benefits, of which 42 percent ($661 million) was accounted for by the value of passenger time savings. Overall, the B/C ratio was 2.60. However, without considering the passenger value of time, the benefit/cost ratio would have been 1.51. The analysis indicated that the Airport Development Plan (Alternative W-1W) had a high probability of maintaining a B/C ratio greater than 1.0 under various scenarios.

For Dallas Love Field, passenger value of time proved instrumental in establishing the likelihood that there would be a positive net present value for the Love Field Modernization Program. The BCA showed 13 of 15 scenarios with a positive NPV. Without the passenger value of time, however, only 5 of 15 scenarios were positive.

Airport capital investment decision making is a practical exercise. Paramount for the decision-making process is the affordability of project alternatives, financing techniques, and the sources of sufficient capital to build the projects. Methodologies and techniques used and analyses conducted to evaluate projects are based on the interests of airports and project stakeholders and the requirements of potential funding sources.

Methodologies used to evaluate projects include cost-effectiveness analysis, life-cycle cost analysis and financial analysis, as well as benefit-cost analysis. Economic impact analysis was not used in any of the five case studies.

The process followed in each of the case study projects was:

1) Identification of a problem.
2) Development of alternative capital investment projects to address the problem.

3) Performance and financial evaluation of project alternatives to reduce the number of alternatives for more detailed analysis.
4) Preparation of analyses mandated by funding sources for viable alternatives. Methodologies used, such as benefit-cost analysis, are mandated by funding sources such as the FAA, but also are used to convince other audiences or funding sources of the importance of projects.
5) Calculation of passenger value of time when needed to support a positive net present value and B/C ratio greater than 1.0, or to convince stakeholders that a proposed project provides robust benefits that justify the costs involved.

6 Identification of Gaps in Analytical Techniques and Required Steps to Fill Gaps

This appendix examines the extent to which gaps exist in the available guidance and information on how to apply the techniques for evaluating airport capital investments, as well as the steps required to fill those gaps. These gaps can take one of two forms. The first is a lack of adequate guidance on how to address particular aspects of benefit-cost or other capital investment analysis. An example of the first type of gap is inadequate guidance on how to address uncertainty in evaluating particular projects. The second is a lack of data or other information needed to effectively address particular issues in applying analytical techniques to airport capital investment decisions. An example of the second type of gap is the lack of available information on how air travelers value the different components of their total trip, such as differences in the perceived disutility of time spent waiting in security screening queues and that spent waiting at the gate.

Some issues involve both types of gap, where there is not only a lack of guidance on how to address the issue but also a lack of the underlying data needed to adequately address the issue. An example of such an issue is the likely non-linearity of the cost to air travelers and airlines of flight delays. While most travelers make some allowance for delays in their travel plans and airlines build some margin into their flight schedules so that fairly short delays can be handled without disrupting the rest of their operations, as delays increase the impacts become proportionally much more costly. As delays become longer, passengers may miss connections or arrive too late for meetings or other events that were the whole point of the trip. Aircraft and flight crew held on the ground for an extended time due to arrival delays at their destination airport may not be available to operate subsequent flights later that day, resulting in a propagation of delays throughout the system.

It follows that the distribution of delays by length of delay is likely to have a major effect on the cost of those delays to both air travelers and airlines. The cost of delaying one flight by three hours is not likely to be the same as the cost of delaying 12 flights by 15 minutes, even though the total aircraft-minutes of delay are the same in both cases. Failure to properly account for this effect could significantly understate or overstate justifications for projects to increase airport airside capacity. However, not only is there currently a lack of guidance on how to address this issue, but there is also a lack of data on how the costs of a given delay increase with the duration of the delay.

This appendix is based on a review of the findings of research on benefit-cost analysis and related analytical techniques documented in the annotated bibliography presented in

Appendix A.1 and the description of analytical techniques for airport capital investment decisions and associated guidance in Appendix A.2. The review examined four aspects of the application of analytical techniques to airport capital investment decisions, distinguishing between:

- Procedural issues
- Methodological issues
- Treatment of non-linear factors, and
- Data and information issues

Procedural issues address which analytical techniques are used for given types of decisions, what constraints are placed on how those techniques are used, and what factors can or should be considered in the analysis. In practice, these issues are addressed by the published guidance issued by agencies with approval authority over projects or funding, as well as how that guidance is interpreted by agencies reviewing the results of the application of analytical techniques in a given situation. Even if in principle the analytical techniques can address a specific issue, unclear or ambiguous guidance can limit how effectively the issue is addressed, while guidance or regulations that exclude consideration of a specific aspect can result in an incomplete evaluation of the merits of a project.

Methodological issues address the way in which a particular analytical technique is applied and the ability of the existing analytical techniques to meet the needs of decision-makers. An example of a methodological issue is how uncertainty is addressed in applying particular techniques. Uncertainty is inherent in any prediction about how a particular project will perform in the future. However, uncertainty is often ignored or approached in a very simplistic way when evaluating the merits of a given project. At the same time, techniques for explicitly addressing uncertainty can significantly increase the complexity of the analytical task.

Non-linear factors. Apart from these general issues, there is the practical consideration of how to calculate the various costs and benefits involved in a specific project alternative. This can become a critical issue if, for example, long delays are considered to have a higher cost to air passengers or airlines than the same number of minutes of delay spread across a large number of relatively short delays. A related issue is how to account for flight cancellations. Traditionally, capacity and delay calculations are based on the assumption that all the scheduled flights continue to operate during periods of reduced capacity. In reality, airlines will start canceling flights as delays increase in order to protect the schedule integrity in the rest of their network. While a cancelled flight does not incur any delay, and indeed reduces the delay experienced by other flights, this is not without a cost to either the airline or the passengers booked on that flight. Depending how quickly passengers on cancelled flights can be accommodated on other flights, the resulting delay cost to those passengers may be much greater than if the flights had in fact continued to operate and incurred a significant delay.

Similarly, the impact of delays on aircraft operating costs can vary with the way in which the delay is incurred. An aircraft that is held at the gate as part of a traffic flow management program is not incurring costs at the average operating cost per block hour, since it is not burning fuel and the flight crews are typically paid at a lower rate for time spent on duty but not flying. However, just as with passengers, there may be downstream costs that increase non-linearly as the length of the delay increases. As noted above, aircraft and crews may not be available to operate later flights that day, and flight crews may run up against limits on how many hours they can be on duty, requiring the use of a new crew to complete their assigned flights.

Data and information issues address the input assumptions and values used in the application of specific analytical techniques, such as the value of air passenger travel time to adopt for a given analysis or the appropriate cost to assign to a given amount of aircraft delay.

As indicated in the above discussion, the appropriate value to assign to air passenger travel time is likely to depend on the circumstances under which the time is spent, as well as the total length of any delay. In addition to it being likely that delay costs are highly non-linear with the duration of the delay, the consequences of a given delay may also vary by time of day, with a high proportion of passengers on early morning flights heading to meetings or other events later that morning where a delay could have very high adverse consequences. In contrast, passengers on late afternoon or evening flights are more likely to be returning home or going to a hotel on arrival and, thus, less adversely affected by delays.

Whether such differences matter from the perspective of comparing the costs and benefits of alternative projects depends on the specific circumstances of the situation being analyzed. Because delays tend to increase cumulatively during the day, particularly when bad weather reduces airport capacity for most of the day, using the same value of travel delay throughout the day may overstate the benefits of reducing delays in cases where travelers view evening delays as having less serious consequences than morning delays.

Required Steps to Fill Gaps

In addition to identifying current gaps in the analytical techniques used to evaluate airport capital investment projects, the research or other steps that are required to address or fill those gaps are discussed below. Since these steps will, in general, depend on the details of each specific gap, they are part of the discussion of each gap.

Some of the required research steps are addressed as part of the survey and data collection on the value of air traveler time presented in Chapter 3 of the research report, and in Appendix B of the report. Also, some of the procedural and methodological issues are addressed in the *Guidebook for Valuing User Time savings in Airport Capital Investment Decision Analysis* prepared as part of the current research. Beyond these steps, additional needs for further research can be addressed further in the recommendations found in Chapter 4 of the research report.

However, many of the current gaps in information and analytical techniques identified in this appendix will require a sustained program of research to improve the understanding of the issues involved and acquire the necessary empirical data, as well as expansion and updating of the guidance on evaluating airport capital investment projects published by the Federal Aviation Administration (FAA) and other governmental agencies. Although the current ACRP project serves to begin this process and to help define the further research needs, it had neither the resources nor the time that will be required to adequately address all the gaps identified in the research undertaken to date.

A better understanding of the comparative economic performance of the various airport capital investments funded under the current program structure and the distribution of the revenues that fund those programs could help inform future changes to federal programs that support airport capital investments to increase the effectiveness of those programs.

Structure of this Appendix

The remainder of this appendix consists of five sections. The following two sections address procedural and methodological gaps respectively, including the treatment of uncertainty and reliability in the analysis of airport capital investment projects. The third of the subsequent sections discusses gaps in guidance addressing the potential non-linear nature of some perceived costs, particularly costs associated with flight delays. The following section addresses gaps in available data and information needed to define appropriate input values to use in benefit-cost analysis in order to adequately consider specific types of benefit and cost, such as environmental costs. The fifth and final section provides summarized findings and presents some conclusions on how best to fill the gaps in guidance and available data and information.

Procedural Issues

Procedural issues address which analytical techniques are used for certain types of decisions, what constraints are placed on how those techniques are used, and what factors can or should be considered in the analysis. Even if the analytical techniques can, in principle, address a specific issue, unclear or ambiguous guidance can limit how effectively the issue is addressed, while guidance or regulations that exclude consideration of a specific aspect can result in an incomplete evaluation of the merits of a project.

Research undertaken as part of ACRP Synthesis 13 (Landau & Weisbrod, 2009) identified a number of procedural issues arising from current FAA guidance on performing benefit-cost analysis:

- Appropriate specification and treatment of the base case against which project alternatives are compared:
- How to account for benefits accruing to aviation-dependent activities that are not themselves direct users of the facility in question, or benefits or costs incurred by

users of other modal facilities that result from changes in the use of aviation for travel; and

- How to include local and regional economic development benefits of airport investments.

In addition, several of the case studies of airport capital investment analysis undertaken as part of the current research project found that these analyses were scoped in a way that deliberately excluded some of the benefits of the project. In the case of the end-around taxiway at Hartsfield-Jackson Atlanta International Airport, the time savings to airline passengers from reduced delays were not considered because initially the analysis was prepared to justify the project to the airlines in terms of direct airline cost savings. Since the project showed a positive benefit- cost ratio without considering passenger time savings, the benefits were not recalculated when the project was submitted to the FAA for funding. In the case of the passenger terminal modernization program at Birmingham-Shuttlesworth International Airport, no analysis of travel time savings to air passengers was undertaken, although many of the elements of the terminal modernization program were designed to improve the passenger experience while using the terminal.

If the only purpose of a BCA is to show that the benefits of a project exceed the costs, then it may not matter if some benefits are not considered so long as those that are considered exceed the costs. Similarly, if a project is being undertaken for reasons other than the user benefits or it is felt that the user benefits are so obvious that they do not need to be quantified, it may be felt appropriate for the evaluation to ignore those benefits. Where the evaluation of the project primarily addresses financial aspects (e.g., whether the airport authority can afford to implement the project), then the absence of a benefit-cost analysis may not matter to the decision-makers. However, these arguments ignore two important considerations. The first is whether a modified project might have had even greater net benefits than the project that was chosen. This cannot be known without evaluating a reasonable range of project alternatives and considering all the benefits given by each alternative. The second consideration is how the economic performance of the project compares to that of similar projects at other airports. This provides useful information to the airport authority about whether the project is appropriately scoped and designed, and, in the case of a project that will be funded in part using FAA discretionary funds, helps the FAA prioritize the project relative to other projects requesting discretionary funds. Of course, similar considerations of comparative economic performance arise when evaluating multiple projects at a single airport, as may occur in a master planning process, or evaluating multiple projects across different airports in the context of an airport system plan.

Therefore, all major projects should be subject to both a benefit-cost analysis and an alternatives analysis, whether or not these are required by the FAA or other funding agencies, and these analyses should consider all categories of benefit.

Specification and Analysis of Base Case

Typically, the benefit-cost analysis of a proposed project or set of project alternatives will compare the benefits and costs of the project or each alternative to a base case or no-project alternative (often referred to as the no-action alternative). However, care is needed in specifying the details of the base case and analyzing the associated benefits and costs if the comparison is to be valid.

The analysis of each proposed project alternative will include the anticipated future streams of benefits and costs over the selected analysis period. Therefore, the analysis of the base case should include the corresponding streams of benefits and costs over the same period in the absence of the proposed project alternative. The base case should assume that prudent actions are taken to maintain and manage the facility over the analysis period, including normal replacement of obsolete or worn out components and appropriate measures to manage congestion that results from shortfalls in airport capacity to handle increasing demand. This will generally require some thought as to what sort of measures could be implemented to manage congestion short of the type of capital development implied by the project alternatives.

However, one gap in current procedural guidance is how to define appropriate assumptions about likely airline and passenger response to increased delays. Since delays increase rapidly as demand approaches capacity, assuming that the unconstrained forecast demand occurs without any significant increase in capacity will generally result in unrealistic levels of delay. In practice, before such levels of delay occur, the airlines will take actions to reduce the delays that they are experiencing, since extremely high levels of delay would be very disruptive to their operations in the rest of their network. As delays increase, a point will be reached at which the airlines decide to stop adding flights to accommodate increased demand. As a result, load factors will increase and the airline yield management systems will compensate for the lack of available capacity by restricting the availability of more deeply discounted fares, thereby raising average fares and reducing the demand to a level that can be served with tolerable levels of delay. Of course, airlines may also raise the overall fares, as well as restrict the availability of discounted fares. Indeed, such actions may be necessary to reduce demand to a level that can be accommodated by the available seat capacity.

Airport management may also take actions to manage demand in order to reduce delays, such as working with the airlines to encourage them to shift some flights to off-peak times or increase the size of aircraft they use to serve the airport, or by instituting some form of peak-period pricing. The FAA guidance on benefit-cost analysis of airport projects (FAA, 1999) states that the base case used in the analysis should "incorporate reasonable expectations of corrective actions by airport managers, users, and air traffic managers in response to build-ups in delay and other problems as airport traffic grows" (Section 6.2), but does not provide any further guidance on how to decide what are reasonable assumptions.

The report on ACRP Synthesis 13 (Landau & Weisbrod, 2009) identifies a separate issue with the specification and analysis of the base case in performing a BCA of proposed airport capital projects, namely the appropriate treatment of avoided costs if the proposed project is constructed. For example, constructing a new runway may eliminate the need for improvements to an existing runway that would otherwise be required in the base case. The issue is whether to treat these avoided costs as benefits of the project or to reduce the costs of the project assumed in the BCA by the amount of the avoided costs. While the choice between these two approaches does not make any difference to the net present value (NPV) calculated for the project, it will in general change the calculated benefit/cost ratio (B/C ratio), except in the case where the B/C ratio is exactly 1.0. For projects where the B/C ratio is greater than 1.0, counting any avoided costs as project benefits will reduce the B/C ratio compared to reducing the project costs assumed in the BCA by the amount of the avoided costs.

Therefore, in order to compare the B/C ratio of different projects on a consistent basis, guidance is needed on whether to treat avoided costs as a project benefit or as a reduction in the project costs used in the BCA. The FAA guidance on benefit-cost analysis of airport projects (FAA, 1999) does not address how to include avoided costs in a BCA, although discussions with FAA staff undertaken as part of the research for ACRP Synthesis 13 and summarized in the Synthesis report indicate that the FAA would generally expect that avoided costs would be deducted from the costs assumed for implementing the proposed project.

Required Steps to Address Gaps

Identifying likely airline response to increasing flight delays or demand management measures instituted by airport management would be a major research project in its own right. Some insights can undoubtedly be obtained from empirical experience at congested airports with high levels of delay, such as New York LaGuardia and Chicago O'Hare, although the presence of slot controls at those airports in the past will complicate any analysis. In principle, airlines can be expected to make economically rational decisions when faced with increasing congestion or airport demand management measures. However, these decisions are likely to be very situation dependent and may involve proprietary information and considerations that an airline is not willing to discuss publicly. Even so, a detailed analysis of the economics underlying potential airline response to increasing congestion will help identify unrealistic expectations or implausible assumptions. Furthermore, conducting such an effort could provide significant benefits to a broad range of aviation system planning studies, in addition to helping identify appropriate assumptions for use in airport BCA studies.

Developing more detailed guidance on how to account for avoided costs in airport BCA studies is a more straightforward issue, because in all cases of projects that have a favorable B/C ratio (i.e., greater than 1.0) the default approach of reducing project costs by the avoided costs gives a higher B/C ratio, so there is no reason for a project sponsor to treat the avoided costs as a project benefit instead.

Non-User Benefits and Costs

Accounting for benefits accruing to aviation-dependent activities that are not direct users of the facility in question or benefits and costs incurred by users of other modal facilities that result from changes in the use of aviation resulting from the project in question involves two challenges. The first is identifying those activities and users and the second is determining the benefits and costs that result from the project. In addition, considerable care must be taken to avoid double-counting benefits with those assumed for the users of the facility or project.

There is obviously some potential overlap between non-user benefits accruing to aviation-dependent activities and the wider economic development benefits discussed in the next section. Thus, for the purpose of this section, non-user benefits are considered to be those that can be quantified well enough to be included in a formal BCA assessment of a proposed project. An example of such non-user benefits could arise in the case of a project involving construction of an automated people-mover link between an airport terminal and a nearby rail station. Airport travelers not using the people-mover could derive travel time benefits from the project if the improved intermodal connectivity diverts some air passengers or airport employees to the new link from other modes, thereby reducing congestion on those modes. Also, non-users may derive benefits from the perception of enhanced system reliability arising from the availability of alternative access pathways that provide a hedge against breakdowns and unusually congested conditions.

An example in the reverse direction would be the increase in travel times of non-airport travelers on the highway or arterial street system in the vicinity of the airport as a result of increased airport ground access traffic arising from a runway expansion project that allows a greater number of air passengers to use the airport. Development of a new runway could also generate both benefits and costs to communities off the ends of both the new runway and the existing runways due to the changed levels and pattern of aircraft noise resulting from changes in the runway utilization and flight patterns at the airport.

A major challenge in quantifying non-user travel time benefits and costs is estimating the very small time savings involved due to reduced or increased congestion. While traditional traffic engineering models or analysis tools can develop such estimates, they are very dependent on the assumed shift of mode due to the project. Existing airport ground access mode choice models are typically not well structured to accurately reflect small changes in travel times and do not usually consider travel time reliability. They are generally designed to capture the effect on mode choice of fairly large travel time differences between modes, rather than small time differences on a given mode. Thus, it would be desirable to develop mode choice models or other analytical techniques that are specifically designed to reflect the effect of small changes in access times. In addition, the valuation of travel time savings (or increased travel times) by non-airport traffic should use the appropriate values of time used in evaluating other highway or street projects, rather than the unit values used for air passengers.

Required Steps to Address Gaps

Assessing the travel time savings of airport landside projects to both users and non-users is usually fairly complex and involves the use of fairly sophisticated modeling techniques. Since these are generally the principal benefits of such projects, more detailed guidance on the use of the analytical tools involved would be helpful in achieving a consistent approach to evaluating such projects.

In addition, there is need for further research into airport ground access mode choice models to define clearer standards of practice for developing and using such models, and identifying model specifications that can better reflect the effect of small changes in travel times. In addition to using established modeling tools for surface transportation, additional research may provide guidance for constructing spreadsheet models to measure benefits and costs of small time differences.

Wider Economic Development Benefits

Investments in new or improved airport facilities are generally believed to generate wider economic development benefits through enhanced air travel opportunities and improvements in air freight logistics, although assessing the extent of such benefits is not easy. As part of the 2030 Master Plan for Hong Kong International Airport (HKIA), the Airport Authority Hong Kong (AAHK) commissioned a study of the relative economic benefits to the Hong Kong region of two alternative airport development plans for HKIA based on an assessment of the economic value added that would result from the aviation activity that would occur under each development plan (AAHK, 2011). However, the details of the analysis are not substantively different from a more conventional economic impact study. Both HKIA and conventional economic impact studies attempt to measure the employment and economic activity that results from an airport's operations, and each uses a similar approach that distinguishes between direct, indirect and induced employment and spending.

The HKIA Master Plan analysis concluded that the alternative that included a new runway would generate significantly more economic value added for the region because it would allow traffic to grow to higher levels in the future. In turn, the higher levels of air traffic activity would require more direct employment and spending, which in turn would generate more indirect and induced employment and value added. It seems reasonable that rising levels of congestion at the airport due to insufficient runway capacity to serve the future growth in demand would adversely impact economic growth in Hong Kong.

It is almost impossible to anticipate how changes in congestion levels will affect economic growth without a better understanding of how different components of aviation activity contribute to economic growth in the region served by an airport and how the composition of aviation activity will change in response to growing levels of congestion. For example, as congestion increases, it is likely that airlines will raise fares, discontinue flights in less profitable markets, and shift connecting traffic to other routes in order to free up capacity to serve trips with an origin or destination in the region served by the airport. In the case of Hong Kong, what effect would this have on the tourist industry in Hong Kong? How would it affect decisions by different sectors of the business community to shift activity to other cities? To what extent would the reduced level of employment at the airport be offset by growth of employment in other sectors of the Hong Kong economy?

These are complex questions that the current state of knowledge about the relationship between air services and economic growth in a region do not clearly answer. However, one thing is clear. If the growth in air traffic handled by an airport is constrained by inadequate capacity, the future contribution of aviation to the regional economy is most unlikely to be simply given by the current contribution pro-rated by the change in traffic level.

Other approaches also incorporate wider benefits into BCA. For example, the Multiple Analysis Framework used in the United Kingdom and Canada attempts to provide a "holistic" look at projects, combining traditional BCA, economic impacts, land use analysis, environmental impacts, and fiscal analysis.[117] Modeling tools such as the Transportation Economic Development Impact System (TREDIS) layer different analytical techniques, such as a BCA assessment of user benefits, with measures of non-user benefits (e.g., environmental benefits), and discounted direct value added expected to be gained due to a project.[118]

The FAA guidance on benefit-cost analysis of airport projects (FAA, 1999) recognizes two different types of what it terms non-aviation impacts and classifies as "hard-to-quantify:" macroeconomic gains and productivity gains (Section 10.6.3). Macroeconomic gains include expansion of employment and income as a result of the investment in the facility or project that would not have occurred in the absence of the project. Productivity gains arise when improvements in air services allow businesses to perform their activities more efficiently, such as by restructuring their logistics systems. The guidance notes that a project must result in a fundamental change in the cost of doing business to result in productivity gains, although it is not obvious why this should be so. Productivity gains arise whenever the cost of producing a given level of output is reduced. Such cost reductions can result from a large number of relatively modest cost reductions across a range of activities that would not normally be considered a fundamental change in the cost of doing business.

The guidance indicates that the FAA is receptive to having information on both types of benefit submitted in support of a particular project, but that such benefits need to be carefully documented and should not be included in the formal BCA. The guidance stresses that only incremental benefits should be considered and cautions that the extent of employment and income multiplier effects may depend on the existence of an unemployed labor pool sufficiently large to provide the necessary labor. Multiplier effects in input-

[117] See, for example, *Improved Decision-Aid Methods and Tools to Support Evaluation of Investment for Transport and Energy Networks in Europe*, published by the European Commission, Dec., 2008.
[118] TREDIS Software Group, *User's Manual, Version 4.0*, Economic Development Research Group, 2014.

output models that arise from transfer of economic activity between regions should not be included in analysis prepared for consideration by the FAA, because such transfers generally provide no net benefit to society as a whole.

Unfortunately, while the FAA guidance provides a number of cautions about aspects that should not be included in an analysis of non-aviation impacts, it provides very little guidance on what should (or could) be included and how to assess those impacts.

Required Steps to Address Gaps

Developing a better understanding of the relationship between changes in the nature and cost of air services available at an airport and measures of economic growth in the region served by the airport will require a major research effort that is well beyond the scope of the current project. Given the importance of this question to understanding the economic impacts of aviation in general and the economic justification for continued future development of the airport system, it is surprising that it has received so little attention to date. The fact that the FAA classifies wider economic benefits of airport investments as "hard-to-quantify" and excludes them from formal BCA assessment of airport projects demonstrates how poorly this topic is currently understood. Yet, quantifying the relationship between airport development and growth in regional economic activity is fundamental to the formulation of rational airport development policies. After all, if airport congestion does not in fact have a significant impact on regional economic growth, why spend the billions of dollars that will be required to provide the airport capacity enhancements needed to reduce future congestion levels? Would the money not be better spent, say, improving the education system?

Such questions rarely get asked because of the compartmentalized way that our society makes its investment and funding decisions. Aviation taxes get put into a trust fund that can only be used for aviation purposes, including investments in airport infrastructure. Airports generate revenues from passengers using the airport through car parking charges and other concession fees, as well as passenger facility charges added to the airline passenger tickets and are restricted to using those revenues for airport operations and capital costs. While this helps ensure an adequate stream of revenue to support the ongoing operation and development of the nation's airport system, it tends to avoid the question of whether there has been an over-investment or under-investment in the airport system.

Clearly there is a connection between the value of time savings from improvements in airport infrastructure and economic growth. Air passengers value their travel time because the less time they have to spend traveling the more time they have for other things, including work activities that contribute to economic production. Similarly, if air travelers have to pay more to make a given air trip because air fares have increased due to inadequate airport capacity limiting the supply of seats offered in a given market, they will have less money to spend on other things, which will impact economic activity in the region.

However, while these effects can be described in qualitative terms, quantifying them is another matter entirely.

This point brings up the reality that BCA does not recognize geography (in the sense that transfer payments are excluded from the analysis) while economic impact analysis does consider which region is being impacted. Thus, economic impacts in a particular city may not be positive impacts at the state level if based on spending by firms or residents from elsewhere in the state. In terms of visitor spending, it would seem that only international visitors bring new visitor spending impacts to the U.S. Other spending by domestic visitors is simply redistributive. Furthermore, while visitor spending in a region is typically counted in economic impact studies, such studies almost always ignore spending by residents of the region when they visit other regions, which of course reduces the spending by residents that contributes to local economic activity.

While the current research project is limited in what it can do to begin to answer these questions, there is clearly a need to develop recommendations for a simplified analytical framework to express how the user benefits typically quantified in traditional BCA assessments of airport projects might in turn influence regional economic activity. A separate ACRP research project (Project 03-28 *Economic Impacts of U.S. Airports*), publication pending, addresses some of these issues. This research, together with the findings of the current project, could serve as the starting point for a subsequent workshop that would bring together selected economists and aviation experts to critique the current approach to measuring economic impacts and incorporating them in airport capital investment analysis and define a research agenda that would be needed to develop a more comprehensive framework, as well as to quantify the relationships involved so that the framework could be applied in different situations. This workshop could be funded in a number of ways, including the ACRP, FAA research funds, or foundations interested in economic development issues.

Methodological Issues

Methodological issues address the way in which a particular analytical technique is applied to airport capital investment projects and the ability of the existing analytical techniques to meet the needs of decision-makers. Two methodological issues that are not well addressed in current guidance on how to perform benefit-cost analysis of airport capital investment projects are how uncertainty should be addressed in applying particular techniques and how to account for the reliability of travel times experienced by users of the system.

While these may at first appear to be related issues, they are in fact quite distinct and need to be considered separately. Uncertainty is inherent in any prediction about how a particular project will perform in the future, yet is often ignored or addressed in a fairly simplistic way when evaluating the benefits and costs of a given project. At the same time, techniques for explicitly addressing uncertainty in the projections of future benefits and costs can significantly increase the complexity of the analytical task.

The reliability of travel times experienced by users of a project relates to the ability of those users to anticipate the time that a given trip will require. An obvious example is the effect of weather on flight delays. Air travelers will generally not know the weather that will prevail during their trip at the time they make their travel plans. Secondly, they may not know weather conditions (other than at their point of take-off and possibly their point of destination) that will prevail during the trip. Thirdly, they will typically not know the full extent of any flight delays that they will experience as a result of the weather conditions, since these delays are often influenced by factors that may change in the course of the trip or that depend on information that the travelers cannot access. Moreover, weather delays at a flight's point of origin affect travelers who are preparing to board the aircraft when it arrives at successive airports hundreds, or thousands, of miles away from the point of origin.

It has become common in the U.S. to express the schedule reliability of a given flight (i.e., the same flight number) on successive days in terms of the percent of operations of that flight that incur arrival delays of 15 minutes or more. While this information may be available to the traveler at the time they make their travel plans, they cannot know whether the flight they select will be one of those delayed by 15 minutes or more, nor how long the delay will be if it is delayed more than 15 minutes.

Another source of unpredictable delays is the length of queues for security screening. While these may be broadly predictable by airport and time of day, there is also a random component due to such factors as equipment problems, personnel scheduling constraints, and other unexpected events that can significantly reduce the throughput. Furthermore, while regular users of a given airport may have a sense of likely security screening times, there is no readily available source of data that travelers can refer to that reports expected security screening times by time of day at a given airport.[119] This requires passengers to allot extra time, in case they face unexpectedly long lines at the security screening checkpoints. Time spent in the boarding security queue is also dead time for travelers, regardless of predictability.

Where an airport capital investment project is likely to improve the schedule reliability of flights using that airport, such as by increasing runway capacity during poor weather conditions, it would be important in assessing the benefits of the project to account for the

[119] The U.S. Transportation Security Administration website provides reports on wait times by screening checkpoint and airport. However, these data are collected from user reports made using a mobile phone app and are often several days old. Although the reports are time-stamped, there is no way to request information for a specific time or a future day and time. Some airports report current security checkpoint wait times on their websites, but this is of limited use for trip planning.

improvement in flight schedule reliability, as well the reduction in average delays. These benefits are likely to be valued differently by airport users.

The report on ACRP Synthesis 13 (Landau & Weisbrod, 2009) identifies a number of other methodological issues, including:

- The discount rate to be used in adjusting future costs and benefits to present values.
- Whether to adjust the assumed value of air passenger travel time for future changes in real income levels or use a constant value over time.
- How to account for salvage or residual value of equipment or infrastructure at the end of the analysis period.
- How to account for environmental externalities such as noise, air quality emissions or water quality.
- Consideration of interactions among airports, particularly in multi-airport metropolitan regions or as part of state airport system plans.

Handling Uncertainty

Because BCA assessments of airport capital investment projects are based on projections of future benefit and cost streams they necessarily involve a considerable degree of uncertainty. The FAA guidance on benefit-cost analysis of airport projects (FAA, 1999) suggests that uncertainty be addressed through a combination of techniques depending on whether probability distributions are known for key assumptions. In the absence of information about the probability of key variables taking particular future values, sensitivity analysis can be performed, either on each variable at a time or on combinations of variables (typically two, since combinations of more than two variables quickly generate more outcomes than decision-makers can process). When probability distributions are available for key variables, a risk analysis can be performed using Monte Carlo simulation techniques (simulations based on generating random numbers that are used to select values for each variable from the probability distribution for that variable).

The FAA guidance refers to each combination of values generated in a Monte Carlo simulation as an alternative scenario. While this is semantically correct, scenario analysis more generally refers to defining a combination of analysis assumptions that are internally consistent but are based on a reasonable (i.e., fairly small) number of different views of the future. For example, an analysis might include a scenario of strong economic growth and another scenario of economic stagnation, with each scenario associated with different projections of future growth in air traffic. Assumptions for the values of other variables in each scenario, such as future increases in operating and maintenance costs would be consistent with the economic growth assumptions. Thus, one would expect real operating and maintenance costs to rise more rapidly in a strong economic growth scenario because the airport would be competing with other economic sectors for resources. Conversely, real operating and maintenance costs would tend to grow more slowly or even decline if the larger economy is stagnating.

Unfortunately, the FAA guidance is silent on how an analyst might develop or obtain probability distributions for key variables in a BCA of an airport capital investment project. This is the most challenging aspect of a risk analysis and critically affects the credibility and usefulness of the result. The choice of unreasonable probability distributions will generate meaningless results, dressed up as a sophisticated analysis. Therefore, much more detailed practical guidance is needed in applying this technique.

One obvious limitation of sensitivity analysis is that, while it does not require assumptions about the probability distributions of future values of key variables and is useful for identifying those variable that are likely to have the most effect on the outcome of the analysis, it provides decision-makers with no information about the likelihood of any particular outcome. Thus, a two-variable sensitivity test may show the effect of a range of assumptions regarding construction costs and a range of assumptions regarding the future growth in air traffic on the net present value of a proposed new runway project, but so what? Without some indication of the likelihood of experiencing different construction costs and the likelihood of different air traffic growth rates occurring, the results of the sensitivity analysis become meaningless as a decision tool. Of course, individual decision-makers may have their own subjective opinion of the likelihood of particular values of key assumptions and, hence, use the results of the analysis to inform their impression of the worth of the project. However, each decision-maker may have different views on these likelihoods and, therefore, interpret the analysis in very different ways.

A major issue with both sensitivity analysis and more formal risk analysis is the fact that values of key assumptions may vary from the baseline case in different ways over time. Thus, growth in air traffic is not only likely to deviate from the baseline growth assumption over the life of the project, but may be below the assumed baseline growth in the early years of the project, but above the assumed baseline growth in the later years. This will produce a very different outcome from the reverse case where the air traffic growth is above the assumed baseline growth in the early years, but below the assumed baseline growth in later years, since the discounting of future benefits will reduce the effect of traffic growth in the later years of the analysis period compared to growth in the early years.

Another critical issue in Monte Carlo simulation that is often overlooked is the potential correlation between the probability distributions of key variables, as indicated in the example given above regarding the effect of economic growth rates on operating and maintenance costs. What is needed are joint probability distributions that show how the likelihood of one variable taking a particular value is affected by the values taken by other variables. This greatly complicates the task of developing reasonable probability distributions. However, ignoring this can result in the analysis assigning non-trivial probabilities to outcomes that are quite implausible, thereby distorting the results of the analysis.

Required Steps to Address Gaps

The future will almost certainly evolve in ways that are quite different from what is expected and once a capital investment has been made in constructing airport facilities, that decision cannot usually be reversed without a great deal of additional expense. One of the most important functions of performing BCA assessment of airport capital investment projects is to inform decision-makers of the economic risks inherent in a particular decision. This requires a sophisticated approach to handling uncertainty in BCA assessments.

While risk analysis will significantly increase the level of effort required in a BCA analysis, this effort is still likely to be fairly modest compared to the costs of making a bad decision. In addition to much more detailed guidance, there is a need for research into developing appropriate procedures and information to define probability distributions for future values of key variables for use in the application of risk analysis to BCA assessments. This needed research goes well beyond the scope of the current project.

Travel Time Reliability

Travel time reliability refers to the variation in travel times that travelers experience on a given trip compared to the time that they expected the various components of the trip to take. The access trip to the airport may take longer than expected, the time required at the airport to check-in and clear security screening may take more or less time than expected, and the flight may be delayed from its published schedule (or, less commonly, arrive early). The larger these variations in travel time are, the lower the travel time reliability provided by the system becomes and, hence, the greater the provision that travelers have to make in their travel plans for unanticipated delays.

It is increasingly recognized in the literature on the value of travel time that travelers value reliability, as well as reductions in the actual time spent traveling (Fosgerau & Karlström, 2010), and that empirical evidence suggests that the unit values are typically different (Brownstone & Small, 2005). In the case of air travel, this is particularly clear, because unexpected delays may cause travelers to miss connecting flights or arrive at their destination too late for a meeting or other event that was the purpose of the trip. To avoid such a situation, travelers usually make allowances for delays in their planned travel schedule, such as taking an earlier flight than strictly necessary from the published flight schedule, selecting routes for connecting flights that avoid airports with a high frequency of delays (if possible), or other trip planning strategies designed to reduce uncertainty associated with expected travel time. There are costs for these “hedging” strategies in that if the flight is on-time (or arrives early) then travelers end up having to spend more time than necessary waiting for their connecting flight or for their meeting or event to begin. Depending on the circumstances, this time may not be entirely unproductive (for example, they may be able to spend it getting some work done or sightseeing) and, thus, they may value the time involved differently from time spent actually traveling.

To date, most of the empirical studies of the value assigned by travelers to travel time reliability have addressed urban commuting trips (e.g., Noland & Small, 1995; Small, Winston & Yan, 2005; Fosgerau & Fukuda, 2010). However, there have been a number of recent studies that have examined the role of connecting times in airline itinerary choice (Adler, Falzarano & Spitz, 2005; Theis, et al., 2006; Warburg, Bhat & Adler, 2006) and airport accessibility (Koster, Kroes & Verhoef, 2011).

Two critical issues in valuing travel time reliability are how to measure the variability in travel times and how to distinguish between expected and unexpected delay. Two approaches to measuring the variability in travel time that have been used in urban travel are to use the standard deviation of the travel time (Fosgerau & Karlström, 2010) or a specified percentile range such as the difference between the 50th and 90th percentile (Lam & Small, 2001). The latter approach recognizes that being late is generally of much greater concern than being early. However, air travel information on travel time reliability has typically been expressed in terms of the percentage of flights that operate within 15 minutes of their schedule ("on-time"). There are two separate issues that arise from this. The first is the distinction between departure delays and arrival delays. While flight arrival delays are generally what matter to air travelers in terms of their ability to make connecting flights or scheduled events at their destination, air travelers on delayed flights arriving at a connecting airport later than the scheduled departure time of their onward flights may still be able to make their connections if the departures of their onward flights are also delayed (either to wait for connecting passengers or for other reasons). Except for a few airlines and some special websites that cater to frequent travelers, published information on the on-time performance of specific flights generally provides no information on the occurrence of long delays and may not clearly distinguish between departure and arrival delays. This is a significant limitation because airlines add some margin or buffer time to scheduled flight times to allow for a certain level of delays. Thus, a flight may depart late but still arrive on time or even early if the departure delay is less than the buffer time allowed in the schedule and no further delays are experienced enroute.

The second and more significant issue is that the percentage of flights that operate within 15 minutes of schedule (or any other on-time performance threshold) provides no explicit information about the distribution of longer delays. While in general, the lower the percentage of flights that operate on-time, the higher the percentage of flights experiencing a delay greater than any particular amount. However, air travelers may not be aware of this relationship, or may have an incorrect impression of the relationship. Therefore, empirical studies to measure the value that air travelers assign to schedule reliability need to give careful thought to how reliability is measured. While assigning a value to on-time performance expressed as the percentage of flights that operate on-time, as done by Adler, Falzarano & Spitz (2005) and Theis et al. (2006), provides a way to measure the trade-off between on-time performance and other attributes of a flight itinerary, this assumes that travelers value a given percentage change in on-time performance equally, irrespective of the change. However, a change in on-time performance from 90% of flights being on-time to 80% of flights being on-time is likely to imply a very different level of longer delays than a change in on-time performance from 60% of flights being on-time to 50% of flights being on-time.

Required Steps to Address Gaps

There are two aspects to the foregoing discussion that should be addressed in future research.[120] The first is the inclusion of meaningful measures of travel time reliability in air traveler stated preference surveys performed as part of future research that can capture the asymmetry of travel time reliability as currently measured by aviation statistics. This would allow some analysis of both how travelers value the avoidance of long delays, as well as their perception of the relationship between traditional measures of on-time performance and the likelihood of experiencing long delays.

The second area of potential research would compare the relationship between the published measures of on-time performance (standard delay measures as described above, such as the number of flights with delays of 15 minutes or more) and the distribution of actual flight delays from the data on on-time performance reported to the U.S. Department of Transportation (DOT) by the airlines. This would be helpful in relating air travelers' valuation of on-time performance measures to other measures of the value of travel time savings or other measures of travel time reliability, and in relating measures of on-time performance to the distribution of longer delays. It could also provide information – if associated with connections and contingent delays – on the effect of long delays on total travel time.

Discount Rate

A critical issue in performing BCA assessments is the choice of the discount rate used to adjust future costs and benefits to present values. Most airport capital investment projects involve high costs in the first few years while the project is under construction, with the benefits spread over future years and tending to increase with growth in traffic. Thus, the higher the discount rate used, the less favorable the project will appear when the costs and benefits are discounted to present values. The FAA guidance on benefit-cost analysis of airport projects (FAA, 1999) specifies the use of a 7% discount rate for airport projects funded with federal grant funds, based on the discount rate specified in the Office of Management and Budget (OMB) Circular No. A-94 issued in October 1992 (OMB, 1992). This circular states that this rate "approximates the marginal pretax rate of return on an average investment in the private sector in recent years" (at the time) and that any significant changes in this rate will be reflected in updates to the circular. However, to date, no such updates have been issued.

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[120] The Research Team had intended to address both issues in the course of the project. The percent of flights that were assumed to be on-time, and the expected delays for delayed flights were both included in the initial drafts of the stated preference experiments. However, the subsequent decision to combine both measures into an expected delay to minimize the survey length prevented analysis of any nonlinear effects in the value of on-time performance or the cost of delays.

Many other federal agencies, including other modal administrations in the U.S. Department of Transportation, have since revised their recommended discount rates, reflecting changes in macroeconomic conditions and evolving thinking on appropriate discount rates for publicly funded projects. While it makes sense that all BCA assessments of airport projects should use the same discount rate so that the B/C ratio of different projects are calculated on a consistent basis, using different discount rates for airport projects compared to projects in other modes makes it impossible to compare the payoff obtained from increasing investment levels in airport infrastructure compared to increasing investment in other modes. This has become a particularly pressing issue as many states and the federal government are considering making major capital investments in developing high-speed rail projects.

The general effect of changing the discount rate used for BCA assessment of airport capital investment projects is well understood (although not necessarily how this would play out in the case of a specific project or how it might change the relative ranking of different projects). The OMB circular states that analyses of net present values or other measures of economic outcome of proposed investments should include a sensitivity analysis of the effect of varying the discount rate. However, this is not mentioned in the FAA guidance on BCA assessments of airport capital investment projects.

Required Steps to Address Gaps

The selection of the appropriate discount rate to use for analyzing the expected economic performance of proposed capital investments is a question of policy, rather than an issue of analytical techniques or information. Based on the statements in the FAA guidance on BCA assessments of airport capital investment projects, the FAA appears to believe that any changes in the discount rate used in BCA is dependent on revised direction from the OMB, although other modal administrations do not appear to feel that the situation is so definitive (Landau, Weisbrod & Alstadt, 2010).

Changes in Income Levels

Current FAA guidance on the appropriate values of air passenger travel time to be used in BCA of airport capital investment projects (GRA, 2007) are based on U.S. Department of Transportation (U.S. DOT) guidance on the valuation of travel time in economic analysis (U.S. DOT, 1997; U.S. DOT, 2003). This guidance specifies values of time in constant year 2000 dollars per person-hour. While the use of constant dollars corrects for inflation, as household and individual income levels rise in real terms it would be reasonable to assume that the value of time would also rise. In the case of business travel, if the costs of employee compensation and benefits increase in real terms, then the opportunity cost of time spent in travel will also rise in real terms. Of course, it is possible that improvements in the ability to use travel time productively (through increased availability of wireless internet connections) or enjoyably (from improved in-flight entertainment systems) could offset the effect of increased compensation or income levels, at least for a time.

In July 2014, the U.S. DOT revised their recommended guidance on the valuation of travel time in economic analysis (U.S. DOT, 2014) that not only increased the recommended values of travel time savings for air travel, but provided a methodology to account for the growth in real incomes in assuming future values of travel time savings for economic analysis. As of the date of writing this appendix, the FAA has not yet reflected this revised guidance in own guidance on the appropriate values of passenger travel time to be used in BCA analysis, although the FAA guidance refers to the U.S. DOT guidance, so by implication those preparing airport BCA studies should use the revised U.S. DOT values. However clarification in this aspect would be helpful, particularly since those using the FAA guidance may not be aware of the revised U.S. DOT guidance.

Apart from the question of whether the values of travel time in the current FAA guidance are still valid, there is the issue of whether assumed future values of travel time in BCA of capital investment projects should be held constant in real terms. While future increases in real income levels may be conjectural, so are all estimates of future costs. In many cases, forecasts of future traffic levels on which BCA estimates are based are derived from econometric modeling that explicitly or implicitly assumes rising real income levels in the future. Similarly, a good deal of economic planning is based on projections of rising future levels of gross domestic product (GDP) per capita and associated household income levels. It makes little sense to assume rising real household income levels in one part of the analysis, or for some aspects of economic planning, but assume constant real household incomes (and associated values of time) in another part of the analysis or for other aspects of economic planning. This issue has been addressed in the latest U.S. DOT guidance on the value of travel time savings, but not in the current FAA guidance.

Required Steps to Address Gaps

The analysis of perceived values of travel time for different types of air travel that was performed in this project and reported in Chapter 3 of the research report is informative of how perceived values of air passenger travel time appear to have increased since the FAA guidance was formulated. These findings could inform future recommendations and departmental guidance on the value of travel time savings, both in absolute levels, as well as recommendations on how to incorporate expected future increases in real income levels into BCA.

Salvage and Residual Values

Since BCA assessment of airport capital investment projects generally considers the flows of benefits and costs over a finite time period (often 30 years), it is necessary to address how to incorporate the salvage and residual value of infrastructure and equipment at the end of the period. These values will, of course, be discounted to present values in the analysis, so the issue becomes one of determining their value at the end of the analysis period in constant dollars. If it is expected that a particular facility will no longer be required at some point in the future within the usual time frame for performing BCA, then the analysis period will extend to the date at which the facility is no longer required, when benefits from the use of the facility cease.

The FAA guidance on BCA assessments of airport capital investment projects (FAA, 1999) recognizes three different types of cost that can occur at the end of a facility's life or the end of the analysis period: (1) termination costs involved in disassembling and removing old facilities and equipment that are no longer required, (2) site restoration costs involved in returning a project site to its former condition, and (3) the salvage value of the facilities and equipment at the end of the project's life or the end of the analysis period. In many cases, facilities and equipment will continue to be used beyond the end of the analysis period and, so, will have residual value. If equipment is well-maintained and replaced as it becomes functionally obsolete (the costs for which should be included in the cost stream for the project), the equipment in place at the end of the analysis period may well be able to continue to be used for a considerable time and, thus, have significant residual value.

In cases where a facility has come to the end of its useful life, it is not obvious that the site would need to be restored to its former condition before the facility was built. The site will presumably have other uses and thus would only need to be restored to a suitable condition to implement those uses. This may involve little more than leaving the site in a fairly clean state, ensuring adequate drainage, and possibly installing grass or other vegetation to prevent erosion until work can commence on the subsequent uses of the site.

The FAA guidance suggests that salvage value could be treated as an offset to termination costs or as a project benefit, but provides no guidance on when to use each approach. If the facility will continue to be in use and, hence, the salvage value reflects the benefits of that future use, then it would seem most appropriate to treat the salvage value as a benefit. On the other hand, if the facility or equipment will no longer be used for its original purpose but salvageable components will (or could) be sold, then it seems most appropriate to treat the salvage value as an offset against terminal costs.

Required Steps to Address Gaps

Although developing estimates of the residual or salvage value of airport facilities and equipment at the end of the analysis period many years in the future may be difficult, this is in principle no different from the challenge of estimating maintenance and operating costs far into the future.

It would be helpful for ACRP or others to sponsor an empirical study that examines a sample of airport facilities and equipment that have come to the end of their operational lives in recent years and documents how their salvage value was assessed.

Environmental Externalities

Environmental externalities form an important component of the societal benefits and costs of airport capital investments. While some capital investment projects – such as provision of preconditioned air and aircraft electrical power at terminal gates, treatment facilities for runoff from airfield pavements, or residential sound insulation programs – are designed explicitly to reduce airport environmental impacts, other projects may change the environmental impacts of airport activity, although that is not their intended purpose. The FAA guidance on BCA assessments of airport capital investment projects (FAA, 1999) provides general guidance on the treatment of environmental impacts. The guidance stresses that, while no benefit can be claimed for compliance of capacity projects with federal environmental standards, reductions in adverse environmental impacts should be included in project benefits in BCA assessments, while increases in adverse environmental impacts should be included in project costs (Section 10.4.8).

The FAA guidance describes the modeling tools that can be used to quantify the extent of aircraft noise or air quality impacts, but provides no guidance on how to value the physical changes in the estimated impacts. More recent guidance on economic values for use in FAA investment and regulatory decisions (GRA, 2007) does not address environmental externalities. Thus, there is a need for more specific guidance on what values to use for environmental impacts.

Required Steps to Address Gaps

Developing recommended values for environmental externalities, or at least defining a methodology that could be applied in specific cases, seems an appropriate topic for an ACRP research project. Such a project could summarize the extensive literature on the topic and review values used to date in BCA assessments submitted to the FAA. The project could also address the values used by the FAA itself in its own BCA of regulatory decisions and guidance prepared by other federal agencies. Given the scope and complexity of the issues involved, this would be a major research undertaking and might need to be divided into several smaller projects.

Interactions between Airports

Interactions between airports in a multi-airport system can complicate the assessment of benefits and costs for projects at a single airport in that system, due to spill-over effects on other airports. For example, a runway capacity expansion project at one airport in a multi-airport region could facilitate an expansion of air service at that airport that attracts traffic that would otherwise use other airports in the region. Conversely, the base case for such a project would generally imply an increase in congestion and delays that would cause some of the projected future traffic to divert to other airports.

Determining the costs and benefits of the resulting changes in traffic at each airport is no different from the assessment of costs and benefits in the case of a single airport. However, this requires a way to determine how the total demand for aviation activity (air travel, air cargo, or general aviation activity--as the case may be) in the region served by the airport system will distribute itself among the airports in the system. The FAA guidance on BCA assessments of airport capital investment projects (FAA, 1999) discusses some of the issues that need to be considered in performing a BCA for a new airport (Section 10.7), including the effect of changes in airport accessibility on the resulting air traffic demand. While the guidance discusses how to account for the effects of induced demand in some detail (in Appendix C of the FAA guidance), this discussion assumes that both demand and supply curves are known (and the effect of the proposed project on the supply curve). The FAA guidance notes that the elasticity of demand with respect to various components of the cost of travel is likely to be highly specific to the characteristics and location of a particular airport (Section C.3.4.1) and suggests some ways in which these elasticities can be estimated. However, the concept of elasticity of demand is of limited use in the case of multi-airport systems, since a given shift in traffic from one airport to another will represent a different percentage change in traffic (and, hence, different elasticity) at each airport.

In fact, what is needed is a demand forecasting and allocation model or procedure that reflects the effect on both total demand and its distribution between the airports of varying congestion levels and other cost factors at each airport. While such models have been developed in the past for a few selected regions, a generic model that can be adapted for any given region is not currently available.

Accounting for interactions between multiple airports in a system is an important consideration in state aviation system planning processes (SASP). Often in a SASP, lists of capital improvements are developed and, sometimes, although not always, projects are prioritized based on some criterion, such as a BCA assessment or some expression of need. However, these plans do not commonly attempt to assess how improvements at a specific airport will affect nearby airports or the overall state system.

Required Steps to Address Gaps

ACRP Report 98 *Understanding Airline and Passenger Choice in Regions with Multiple Airports* reviewed the dynamics of airline and passenger decision making in multi-airport regions. The objective of that project was to assist airports and their stakeholders better understand the factors that drive airline service decisions and passenger choice in multi-airport regions, and the project did not develop any formal demand allocation models. However, the findings of the research may be helpful to the development of an analytical model that can be used to predict air traffic demand and its distribution among airports in such a region.

However, developing such a model would require a significant commitment of resources. In addition to adequately reflecting the different factors that influence airline service decisions and air passenger choice of airport, there is the challenge of predicting how those factors will evolve in the future in a given region. Over the past few years the FAA has developed a flow-based passenger demand forecasting framework, termed Terminal Area Forecast – Modernization (TAF-M) (FAA, 2012), that may be able to serve as one component of a regional modeling approach.

Non-Linear Factors

The current state of practice of valuing air passenger travel time and the cost to the airlines of aircraft delay implicitly assumes that each minute of delay is equally costly and that delays can, therefore, be measured in terms of the total minutes of delay rather than considering the distribution of the length of the individual delays.

Most airlines provide some margin in their flight schedules for expected delays. Thus, a flight may leave several minutes late, or incur delays enroute to its destination, but still arrive on-time. Similarly, most travelers will allow some margin in their travel plans for potential delays, so even if their flight arrives several minutes late, they will not miss a connecting flight, meeting or other event. However, as the length of the delay increases, the likelihood of highly inconvenient or costly consequences increases disproportionately. In the case of airlines, unexpectedly long delays can cause flight crews to exceed their allowable duty times, requiring additional crews to be brought in to operate later flights that the original crews were scheduled to operate. On the other hand, if the delay is experienced as a ground hold, then the operating cost of the aircraft will be much less than its usual cost per block hour because no fuel is being burned other than perhaps a small amount to run the aircraft's auxiliary power unit.

Thus, the value that passengers assign to fairly short flight delays is likely to be fairly small, since they have already made some allowance for delays in their travel plans and so the consequences are not particularly troubling or costly. As the length of the delay increases, so the perceived cost of each additional minute becomes greater as the consequences of the delay become more serious. Of course, the consequences of a given delay will vary from passenger to passenger and may well vary by market and other flight characteristics, such as the time of day. Once the length of the delay exceeds a certain amount, the perceived cost of each additional minute may become relatively low again as the adverse consequences of the delay do not get any worse. Once a connecting flight has been missed, the next flight may not be for several hours and it may not matter much how long the delay lasts so long as the flight arrives in time to make the next connecting flight. Similarly, once a planned meeting or other event has been missed, it may not matter how long the delay lasts since this does not change the perceived cost of missing the meeting or event.

The time of day may also have a significant impact on the value that passengers assign to delays. Passengers on flights arriving in the late afternoon or evening are likely returning home or going to a hotel and, therefore, the consequence of a given delay may not be a great as it would be earlier in the day when they are planning to arrive in time for a meeting or other event. However, delays that result in passengers arriving very late in the evening may have other adverse consequences if they miss the last departure of a ground transportation service that they were planning to use to reach their final destination and end up having to use a much more expensive service, such as a taxi. Similarly, delays to flights arriving later in the day may result in passengers who need to make a connecting flight missing the last connecting flight of the day and having to spend the night in a hotel. Even if the airline covers the cost of the hotel, the additional travel time involved can be greatly disruptive.

However, from the perspective of the airline operations, delays to flights scheduled to arrive later in the day will generally result in less downstream disruption to other flights simply because there is less opportunity for delays to propagate to other flights, whereas delays to flights earlier in the day may continue to ripple through the network for the rest of the day, unless there is sufficient buffer time in the flight schedule to recover from the delays.

Whether these effects will tend to cancel each other out for a given project or result in a pattern of delays where the costs of the delays to the passengers and the airlines are very dependent on the distribution and timing of the delays is likely to be very situation specific. Accounting for any such non-linear effects in estimating the benefits and costs of a project will require both an analysis of the occurrence of delays that can generate a distribution of the individual flight delays by time of day, as well as an understanding of how the cost of the delays to the passengers and airlines varies by the duration of the delay and time of day.

Required Steps to Address Gaps

Estimating the distribution of individual flight delays by time of day can generally be done fairly easily using standard airport capacity and delay simulation software, although this may require rather more effort than is usually done for such analyses. Further research may be needed to develop appropriate procedures to properly account for the effect of flight delays that originate elsewhere in the system and for the downstream consequences of delayed departures. While simulation tools exist to model delay propagation at the level of the National Airspace System (NAS), these are generally too complex and data intensive to use for the evaluation of a project at a specific airport. What is needed is guidance on appropriate assumptions for the effects of downstream delay propagation in the system and for delays that arise elsewhere in the system and propagate to the airport in question so that these can be reflected in the simulation input.

Assessing the effect of delays of varying length and time of day on airline operating costs is a significant research topic in its own right and could form an appropriate future research project for the ACRP or FAA. In the meantime, some general indication of the likely relationships can be derived from an analysis of the components of airline operating costs, typical flight crew duty rules, and prior simulation studies of delay propagation in the NAS by the FAA and researchers at the National Aeronautics and Space Administration.

Data and Information Issues

Data and information issues address the input assumptions and values used in the application of specific analytical techniques to evaluating airport capital investment decisions. These include such factors as the passenger value of time to adopt for a given analysis, the appropriate cost to assign to a given amount of aircraft delay, and the values to assign to environmental externalities where these are included in the analysis.

Many of the aspects of airport capital investment decisions, where there are currently data and information gaps in current practice, have been identified in the previous discussions on procedural issues, methodological issues, and accounting for non-linear aspects of the values to be assigned to passenger and aircraft delay. This section addresses two additional aspects where there are significant data and information gaps that limit the current state of practice of BCA assessment of airport capital investment decision:

- Differences in the value of air passenger travel time for different components of the overall trip.
- Accounting for sustainability and climate change in airport capital investment decision.

Travel Time Components

The values of passenger travel time included in current FAA guidance on performing BCA assessments for airport capital investment decisions (GRA, 2007) distinguish between business and personal travel, and between trips using air carriers and general aviation, but assume the same value of travel time for all components of a given trip. Chapter 2 of the Research Report reviews the theory underlying empirical estimates of the values of travel time and travel time reliability and explores the factors that are likely to influence the values of travel time for different components of a given trip. These components include:

- Ground-side access and egress time
- Time spent in flight check-in, security screening, and walking to the gate
- Time spent in the gate area or airport concessions
- Time on board the aircraft
- Time involved in making flight connections at an intermediate airport
- Baggage claim and terminal egress time

Because the circumstances under which the time involved in these different components of a given air trip differ in terms of such aspects as the level of comfort or effort, the level of anxiety, and the opportunities for productive or enjoyable use of the time, it appears reasonable that air passengers would value their time differently in each case. Since different airport capital investment projects affect the various time components of a trip to a different extent, it would seem appropriate to use different values of travel time for each component.

Changing communication technology is increasingly important in how travelers value the time spent in different components of their trip, particularly business travelers, due to the opportunities that such capabilities as wireless Internet access and cellular or smart telephones provide for spending time productively or more enjoyably. Since the time spent on the aircraft is often the largest single component of an air trip, comprising a significant block of uninterrupted time, the increasing availability of these technologies on flights is likely to affect how travelers value the travel time involved in this component of the trip.

Another important reason for distinguishing the value of time spent in different components of the total air trip is that capital investment projects may change the proportion of the total trip time that passengers spend in different components, rather than reduce the total time. For example, an automated people-mover project may reduce the time that passengers need to spend walking to their gate or riding a shuttle bus. However, if passengers arrive at the airport at the same time before their scheduled flight departure, then the walking time saved by the people-mover will be spent waiting at the gate or in airport concessions.

Similarly, measures to reduce the time that passengers have to spend in security screening, or any other passenger processing step, may not change the total time spent in the terminal building, but may allow passengers to spend more of the time in more pleasant or productive circumstances. Therefore, the analysis techniques need to be able to account for the amount of time spent in various steps of the process between arriving at the terminal curb and boarding the aircraft, as well as the varying value of time spent in the various steps.

However, to the extent that changes in the time required to clear security screening may cause passengers to change how soon before flight departure time they arrive at the airport, this will impact both total travel time, as well as the time spent in the various steps of the process. Therefore, the analysis techniques need to account for appropriate feedback effects, to the extent that these are known. As with aircraft delay, the variance in the time required may be more important than the average time. Even if, on average, passengers only spend five minutes in security screening, if the process can take up to a half-hour at times, and particularly if the times when this occurs are not predictable or not widely known, then most travelers will allow more time than strictly needed, since the cost of missing their flight is usually very high. This, in turn, implies that the analytical tools used to determine the effect of a proposed project on passenger processing times need to be able to measure the distribution of processing times, rather than simply the average.

Required Steps to Address Gaps

This issue formed the focus of the analysis presented in Chapter 3 of the Research Report and is discussed in more detail in Appendix B. A stated preference survey of a sample of air travelers was undertaken to develop updated measures of the value of air passenger travel time, structured in a way that allowed different values of time to be estimated for different components of the air trip.

Sustainability and Climate Change

In the past few years, there has been a growing awareness in the airport community of the need to give greater attention to issues of sustainability in making airport development, equipment acquisition, and operational decisions. A major driver for this thinking has been the recognition of the need to take action to reduce emission of greenhouse gases by all types of aviation activity, including the development and operation of airports. Although the federal government in the U.S. has been slow to take action on climate change, some state governments, in particular California, have started to take more aggressive action and, at a local level, concerned citizens, environmental groups, and some elected officials have started to press airport management to incorporate sustainability into their decision making.

It is not surprising that the FAA guidance on BCA assessment of airport capital investment projects, last updated in 1999, is silent on the issue of sustainability and climate change. In 1999, these were not yet issues to which the aviation community paid much, if any, attention. However, these are concerns which any environmental impact documentation prepared today must at least recognize, if not address, in detail. A growing number of ACRP reports are providing guidance to airport operators on strategies to address these concerns (Kim et al., 2009; Ritter, Bertelsen & Haseman, 2011; CDM & Synergy Consultants, Inc., 2012).

Thus, even if the FAA does not require these concerns to be addressed in BCA assessments submitted in support of applications for federal funding of airport capacity projects, an increasing number of airport operators are beginning to address these issues in their capital investment decision making. So there is a need for data and information to support inclusion of these issues into BCA assessments and capital investment decisions.

Required Steps to Address Gaps

Two recently completed ACRP research projects explore airport sustainability issues:

- ACRP Report 80, *Incorporating Sustainability into Traditional Airport Projects* is a guidebook for airports to use in evaluating sustainable design and technology alternatives during the planning and design phases of airport project development.
- ACRP Report 119, *Airport Sustainability Practices: Tools for Evaluating, Measuring and Implementing* developed a decision tool for airports to identify, evaluate, prioritize, and select sustainability practices; developing a prototype sustainability rating system; and evaluating the viability of implementing the rating system and a voluntary airport sustainability certification program.

Examining the joint outcomes of these two research projects, and considering them in conjunction with other on-going efforts by industry groups to address sustainability issues, will indicate if there is a need for additional research to explore how to incorporate sustainability and climate change concerns into project evaluation for airport capital investment decisions and to develop the necessary data and information to support these evaluation techniques.

Summary and Conclusions

The application of benefit-cost analysis (BCA) techniques to airport capital investment projects involves addressing a number of relatively complicated analytical issues and defining appropriate assumptions. Of the various analytical steps, calculating present values of the expected stream of future benefits and costs and expressing these in terms of widely recognized metrics, such as net present value and benefit/cost ratio, are perhaps the easiest part of the analysis. In spite of the fairly detailed guidance published by the FAA on performing benefit-cost analysis to airport capital investment projects (FAA, 1999; GRA, 2007), there are many gaps in the current procedures, methodology, and information that make performing such analysis extremely challenging and lead to considerable divergence on how these issues are handled in the case of different projects.

Perhaps the most significant gap in current procedures and methodology relates to guidance and supporting information on handling uncertainty in BCA assessment. While the FAA guidance stresses the importance of addressing uncertainty and suggests a number of ways to do this, it provides very few details of how to actually apply these techniques, aside from a couple of fairly simple examples of sensitivity analysis. The guidance mentions the use of risk analysis, which is, in fact, the only technique of those discussed in the guidance that offers a meaningful assessment of the likely variability of the project economic outcome (i.e., whether the present value of project benefits will exceed that of the project costs and by how much) over the range of likely future values of key factors that will influence the project outcome, but provides no real guidance on how to apply this.

This appendix discusses a number of additional gaps in methodology and information needs in the current state of practice of performing BCA of airport capital investment projects, and identifies steps that can be taken in the course of subsequent research.

It is clear from the discussion in this appendix that many of the gaps in methodology and information are likely to have a significant effect on the results of BCA assessments of airport projects when these issues are ignored in the analysis. It is less clear if accounting for these issues would change the resulting decision on whether to proceed with a project or the relative priorities of alternative or competing projects and it would obviously vary from case to case. However, it seems unlikely that the significant changes in BCA methodology and assumptions implied by addressing the gaps and information needs would have no effect on the relative priorities of alternative or competing projects. Therefore, failing to address these issues in performing economic assessment of proposed projects is almost certain to lead to sub-optimal capital investment decisions and less productive use of limited public funds.

To the extent that resources for capital investments in transportation infrastructure across all modes are constrained, it is clearly desirable that a consistent methodology for economic assessment of transportation projects be used across different modes.

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7 ACRONYMS AND DEFINITION OF FINANCIAL TERMS

Acronyms

AIP	Airport Improvement Program
ASP	Advanced Surveillance Program[1]
BCA	Benefit-cost Analysis
B/C Ratio	Benefit-cost Ratio
CEA	Cost-effectiveness Analysis
CFC	Customer Facility Charges
CIP	Capital Improvement Program
CPE	Costs per Enplanement
FAA	Federal Aviation Administration
FBO	Fixed Base Operator
FHWA	Federal Highway Administration
GA	General Aviation
GAO	Government Accountability Office
GARB	General Airport Revenue Bond
GO Bond	General Obligation bond
HVAC	Heating, ventilating and air conditioning
I-O	Input-Output
IRR	Internal Rate of Return
LCCA	Life-cycle Cost Analysis
LOI	Letter of Intent[2]
MII	Majority-in-interest
NPIAS	National Plan of Integrated Airport Systems
NPV	Net present value
OMB	Office of Management and Budget
O&M	Operation and maintenance
O&D	Origin and destination
PFC	Passenger Facility Charges (Also known as Pay-As-You-Go)[3]
PMT	Program Management Team
SFRB	Special Facility Revenue Bonds
TSA	Transportation Security Agency[1]
VALE	Voluntary Airport Low Emissions Program
WTP	Willingness-to-pay

[1]ASP and TSA grants are separate and have separate departments within TSA that are responsible for them.

[2]A FAA Letter of Intent (LOI) is a commitment of future Airport Improvement Program grants that allows grant recipients to proceed with multi-year projects with an assurance of AIP grants in subsequent years.

[3] The use of Pay-As-You-Go funds is generally for a big project that is constructed in phases and over several years. In that way, the airport authority can collect PFC funds from the airlines to pay for the construction on said project.

Definition of Financial Terms

- *Airport Development Fund (ADF).* Airports generate cash flow from operations. Each year, revenues generated after payment of operating expenses, debt service on outstanding bonds, and the replenishment of certain reserves, flows to the ADF where they can be appropriated for capital projects.
- *Airport Improvement Program (AIP) Grants[121].* AIP grants assist sponsors, owners, or operators of public-use airports in airport master planning, construction, or rehabilitation at a public-use airport. AIP Entitlement Grants are apportioned by formula each year to individual airports. AIP Discretionary Grants are awarded by the FAA based on eligible projects' priority as determined by the FAA and its National Priority System. The highest priority is typically given to projects that will enhance airport safety and security.
- *FAA Facilities and Equipment (F&E) Funds*. The FAA maintains an F&E budget to provide for the deployment of communications, navigation, and surveillance equipment, and related capabilities within the NAS.
- *General Airport Revenue Bonds (GARBs).* GARBs are tax exempt bonds issued by the authority that are payable from airport revenues and PFCs (for the PFC eligible costs). The Authority can issue these bonds as long as it can meet an additional bonds test. The Trust Indenture (a legal document governing the bond sale) requires the debt service coverage[122] to be 1.25 or higher and the PFC debt service coverage to be 1.00 or higher in every year.
- *Interest Income.* The proceeds from the sale of GARBs are placed in various accounts, including the construction and capitalized interest accounts. The interest earned in these accounts can be used to pay costs of the project.
- *Pay-As-You-Go Passenger Facility Charges (PFC Paygo).* In 1990, Congress authorized public airport operators to impose passenger facility charges (PFCs) of up to $3.00 per eligible enplaned passenger and use the proceeds of such charges to fund certain airport capital improvements—specifically projects that improve airport capacity, mitigate noise, or enhance airline competition. On April 5, 2000, the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century became

[121] A BCA was contemplated when the airport and the FAA was considering an LOI as a funding vehicle for AIP. At some point, the decision was made not to pursue LOI funding, but regular discretionary AIP in a three-year phased funding plan. The FAA also determined that the project could be categorized as a standards project. Standards projects do not require BCAs under FAA policy.

[122] Debt service coverage per bond ordinance refers to net revenues as defined in an airport bond ordinance divided by principal and interest requirements for the fiscal year.

public law and amended the PFC guidelines and allowed airports to request authority to charge a PFC of $1, $2, $3, $4 or $4.50 on all eligible passengers enplaned at their airport. On July 7, 2008, the Authority's application was approved, which allowed the Authority to begin assessing a $4.50 PFC charge.

- *Transportation Security Administration (TSA) Grants.* The TSA provides funding to airports to support the installation of in-line checked baggage explosive detection systems (EDSs). Eligible projects include EDS equipment, facility modification and installation of EDSs included in an in-line baggage system.
- *Voluntary Airport Low Emission (VALE) Program Grants.* VALE Grants are provided by the FAA from a special AIP budget. The funds are provided for infrastructure

Appendix B:
Stated Preference Survey

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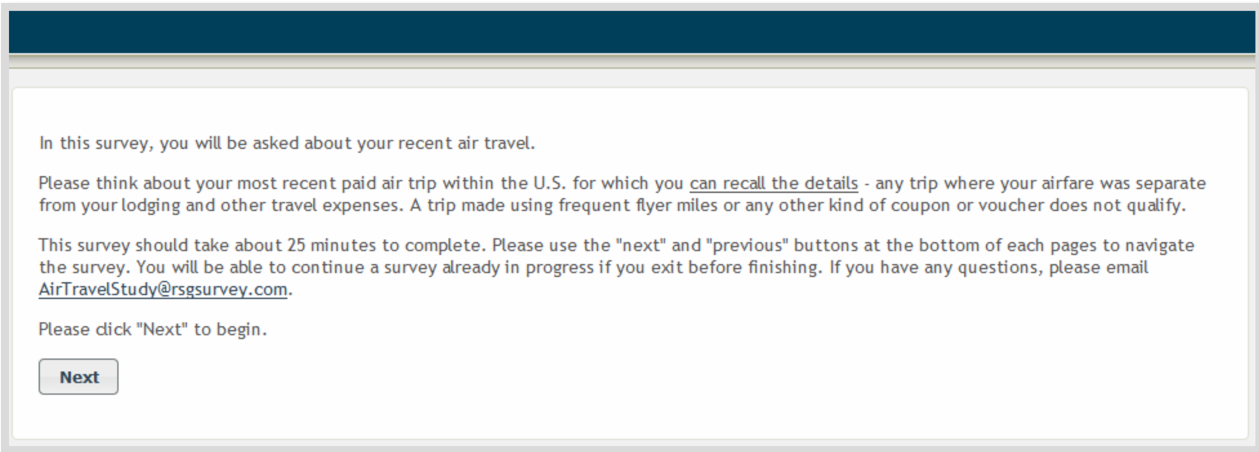
Screening and Trip Characteristics Questions

Survey Introduction


In this survey, you will be asked about your recent air travel.

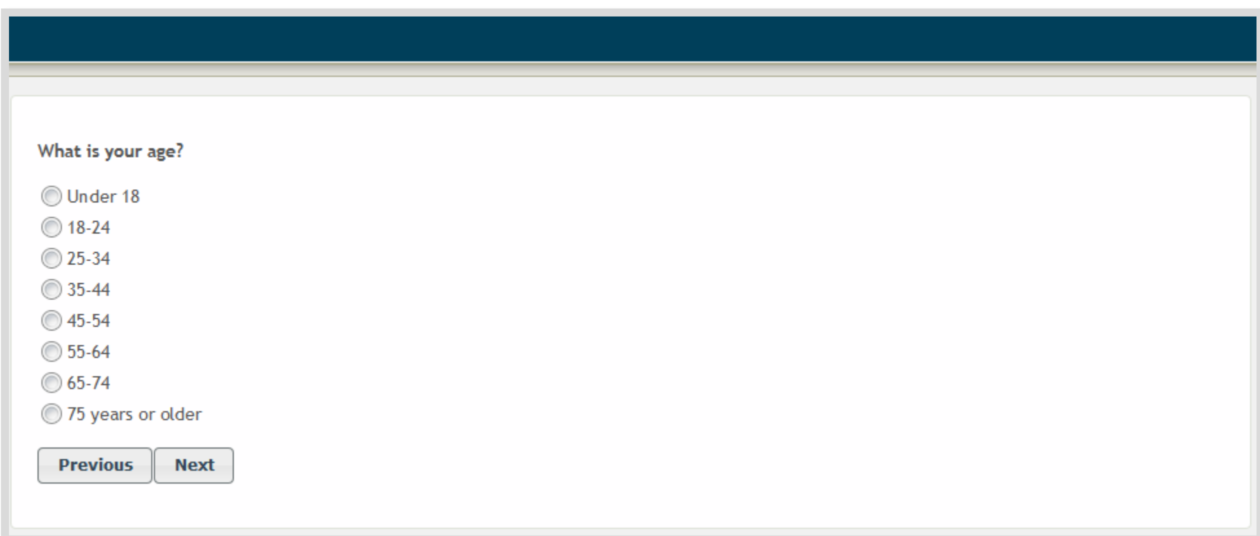
Please think about your most recent paid air trip within the U.S. for which you can recall the details - any trip where your airfare was separate from your lodging and other travel expenses. A trip made using frequent flyer miles or any other kind of coupon or voucher does not qualify.

This survey should take about 25 minutes to complete. Please use the "next" and "previous" buttons at the bottom of each pages to navigate the survey. You will be able to continue a survey already in progress if you exit before finishing. If you have any questions, please email AirTravelStudy@rsgsurvey.com.

Please click "Next" to begin.

Next

Age


What is your age?

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65-74
- 75 years or older

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Industry

Which of the following best describes the industry that you work in?

- ◯ Airline
- ◯ Arts
- ◯ Communications
- ◯ Construction
- ◯ Education
- ◯ Finance/insurance
- ◯ Government
- ◯ Health/medical
- ◯ Manufacturing
- ◯ Marketing/market research
- ◯ Professional services
- ◯ Retail trade
- ◯ Technology
- ◯ Transportation
- ◯ Wholesale trade
- ◯ Other, please specify: ________

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Recent Trip

Please think about the most recent air trip you made in the U.S. that you can also recall the details of, and that you made using a PURCHASED TICKET.[1]

When did you make this trip?

- ◯ In the past month
- ◯ 1-2 months ago
- ◯ 3-6 months ago
- ◯ 7-12 months ago
- ◯ More than 1 year ago
- ◯ I have never flown before

[1] Note: A purchased airline ticket is one in which you or your employer paid for the airline fare. A purchased ticket does not include any flights for which you received a frequent flyer award ticket, an airline voucher and/or a free flight - even if you paid taxes or fees associated with that flight.

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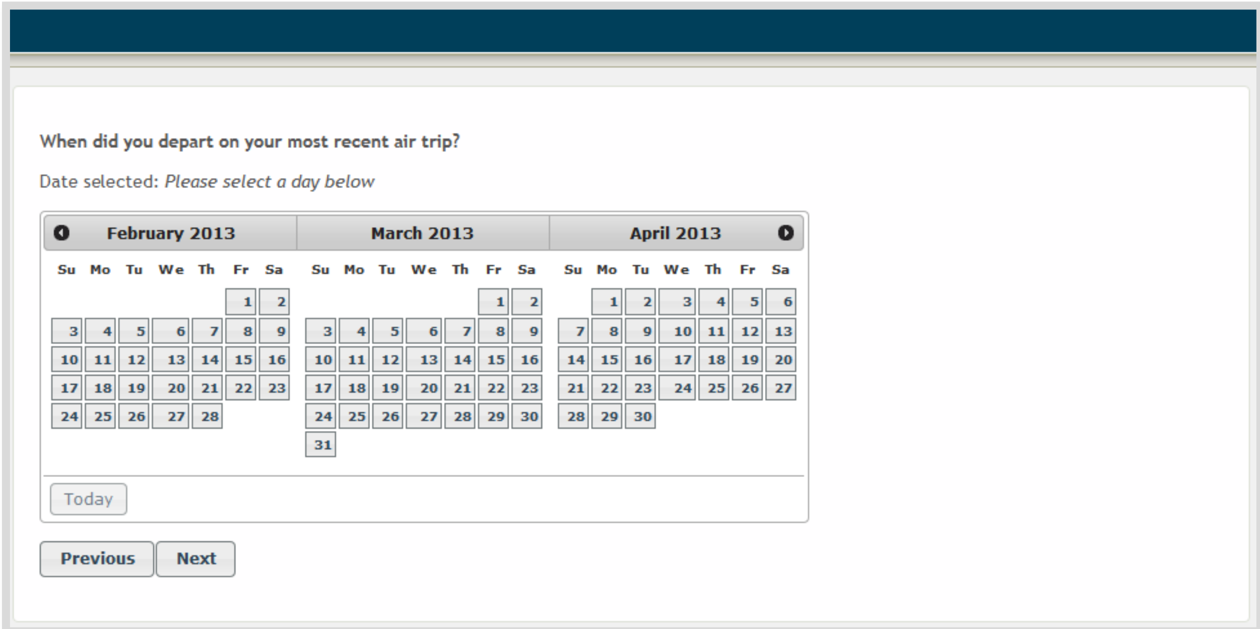
Trip Date


When did you depart on your most recent air trip?

Date selected: *Please select a day below*

February 2013

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

March 2013

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

April 2013

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Today

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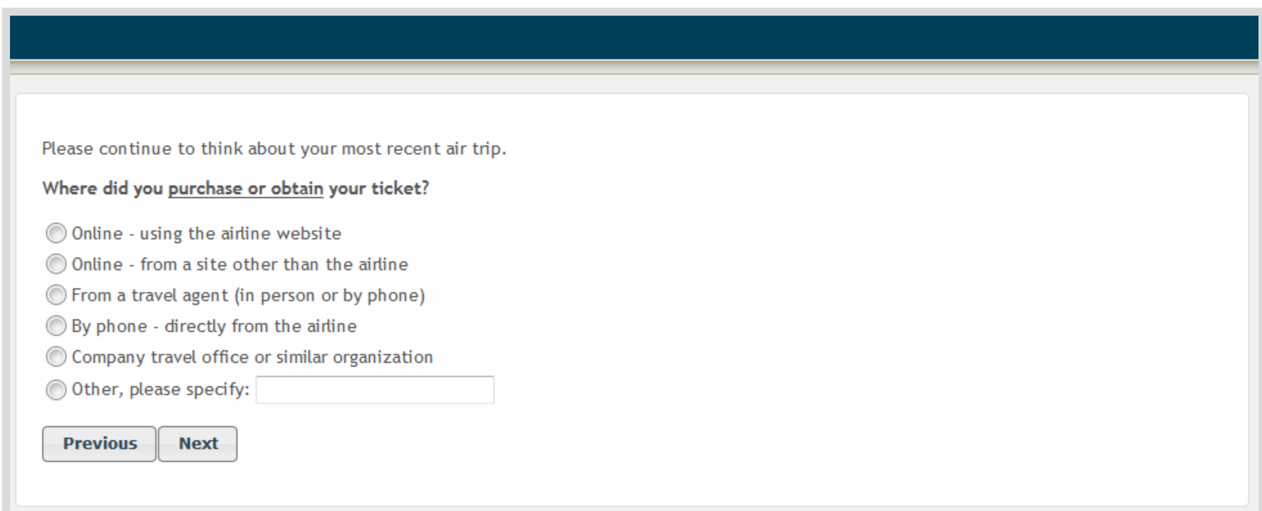
Ticket Acquisition


Please continue to think about your most recent air trip.

Where did you purchase or obtain your ticket?

- Online - using the airline website
- Online - from a site other than the airline
- From a travel agent (in person or by phone)
- By phone - directly from the airline
- Company travel office or similar organization
- Other, please specify:

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Ticket Payment

Who paid for your ticket?

- ◯ I paid personally
- ◯ My company paid or reimbursed me
- ◯ It was free through the airline (either through a frequent flyer program, a voucher or from getting bumped)
- ◯ Family or friend
- ◯ Other, please specify: ______

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Travel Rules – if company paid or reimbursed

Did you have to follow company rules when choosing the itinerary for your trip?

Please select all that apply.

- ☐ No
- ☐ I had to use the company's preferred airline
- ☐ I had to choose the lowest price
- ☐ I had to follow other company rules, please specify: ______

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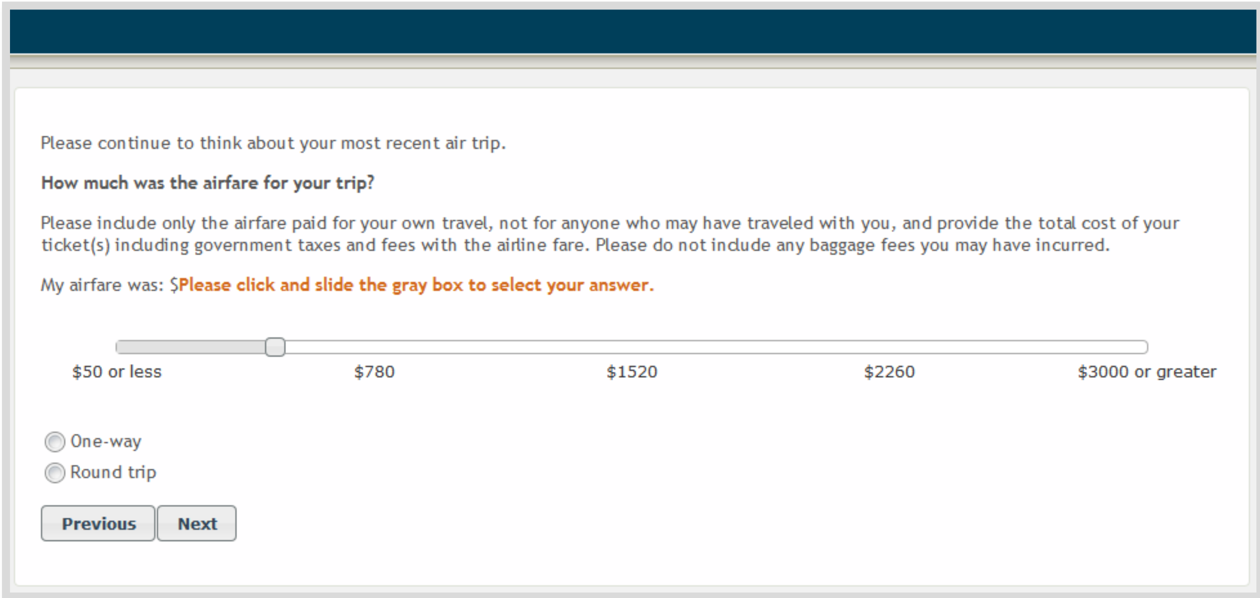
Airfare


Please continue to think about your most recent air trip.

How much was the airfare for your trip?

Please include only the airfare paid for your own travel, not for anyone who may have traveled with you, and provide the total cost of your ticket(s) including government taxes and fees with the airline fare. Please do not include any baggage fees you may have incurred.

My airfare was: $**Please click and slide the gray box to select your answer.**

$50 or less | $780 | $1520 | $2260 | $3000 or greater

- One-way
- Round trip

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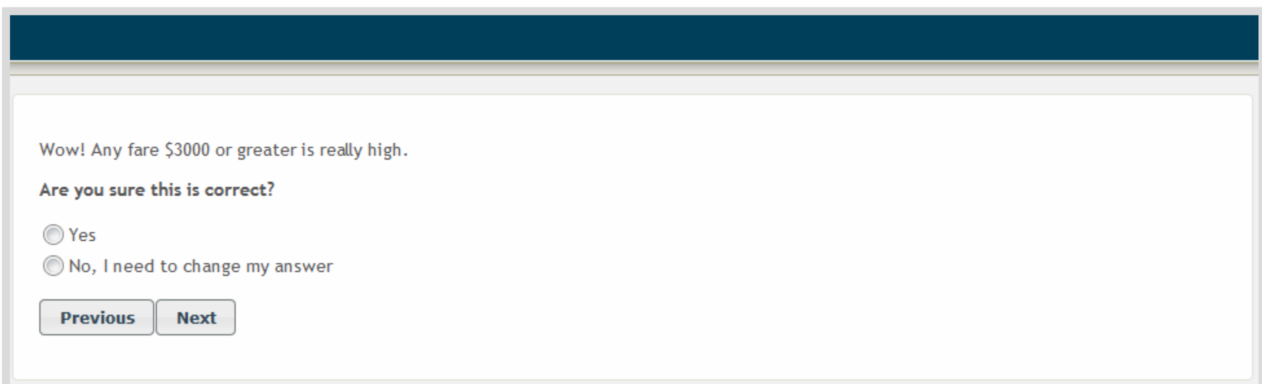
Airfare Warning – if airfare reported was too high


Wow! Any fare $3000 or greater is really high.

Are you sure this is correct?

- Yes
- No, I need to change my answer

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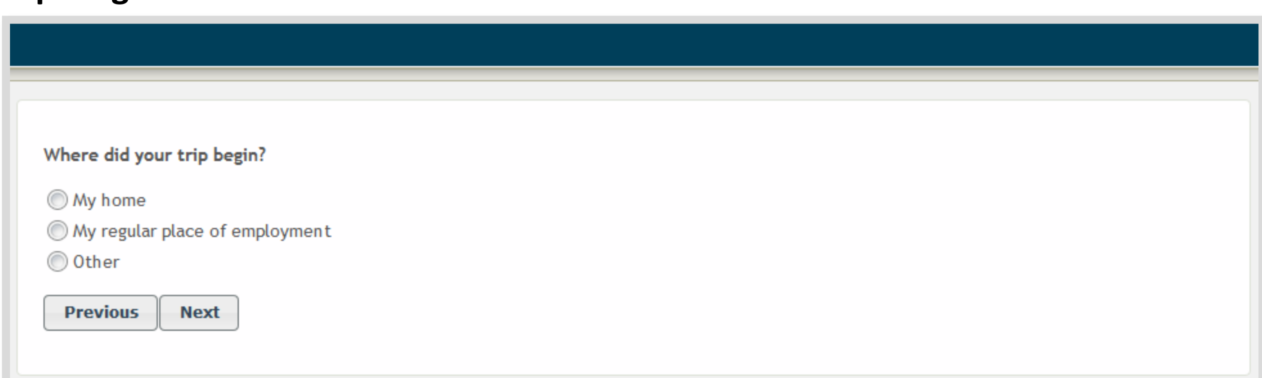
Trip Origin Location


Where did your trip begin?

- My home
- My regular place of employment
- Other

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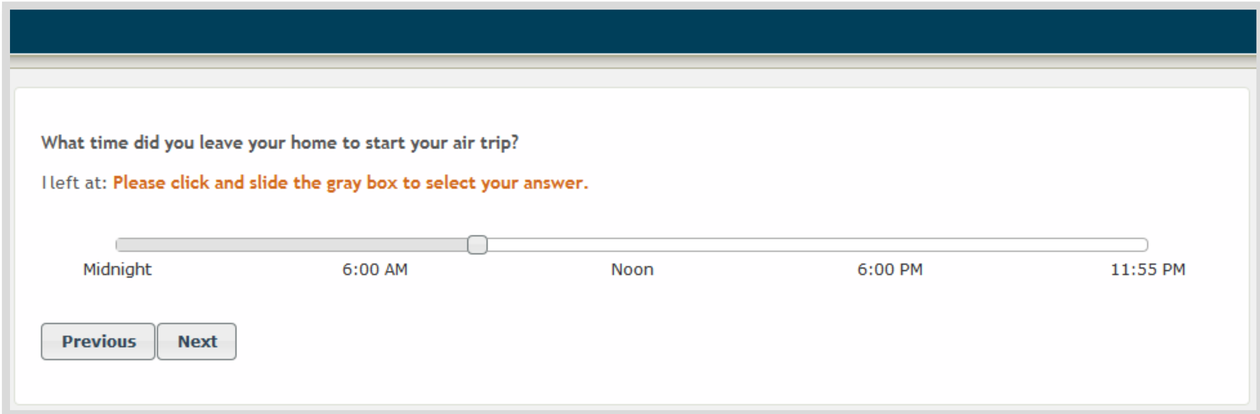
Trip Departure Time


What time did you leave your home to start your air trip?

I left at: Please click and slide the gray box to select your answer.

Midnight 6:00 AM Noon 6:00 PM 11:55 PM

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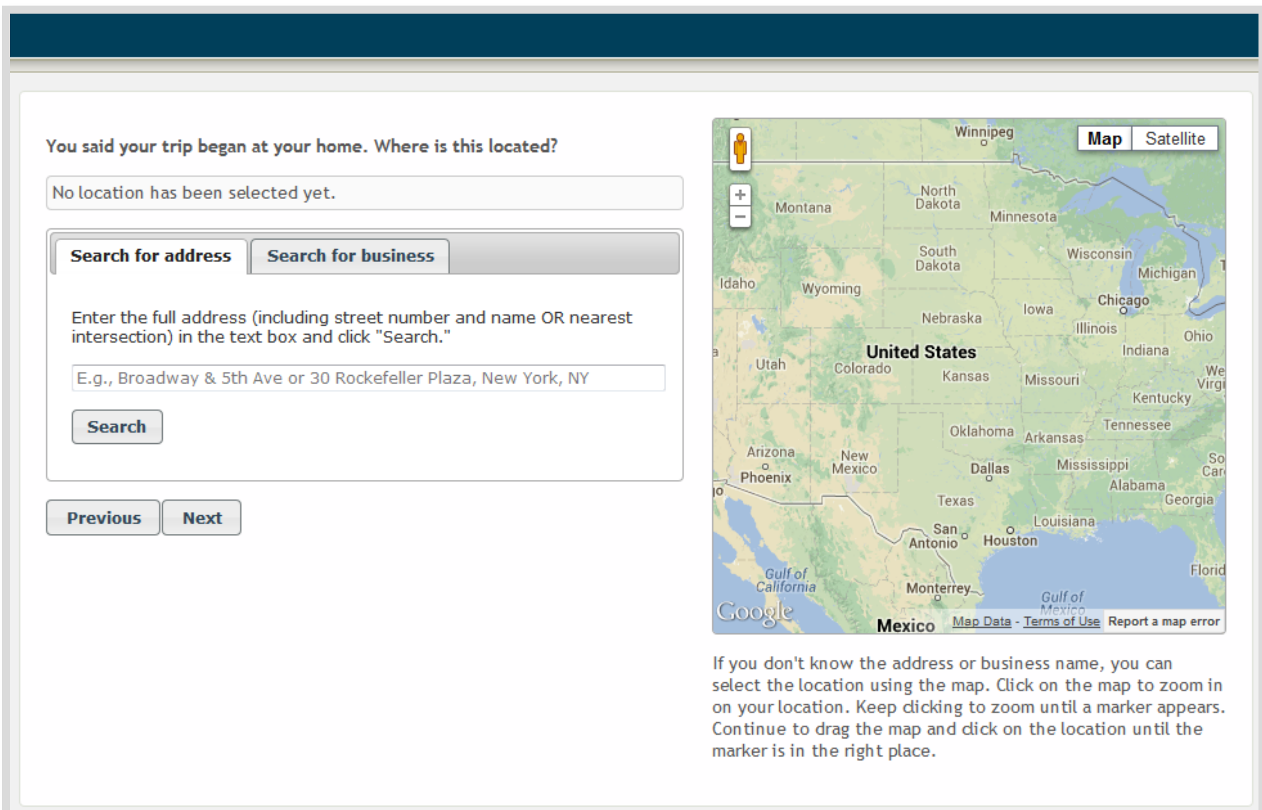
Trip Origin Location Address


You said your trip began at your home. Where is this located?

No location has been selected yet.

Search for address | Search for business

Enter the full address (including street number and name OR nearest intersection) in the text box and click "Search."

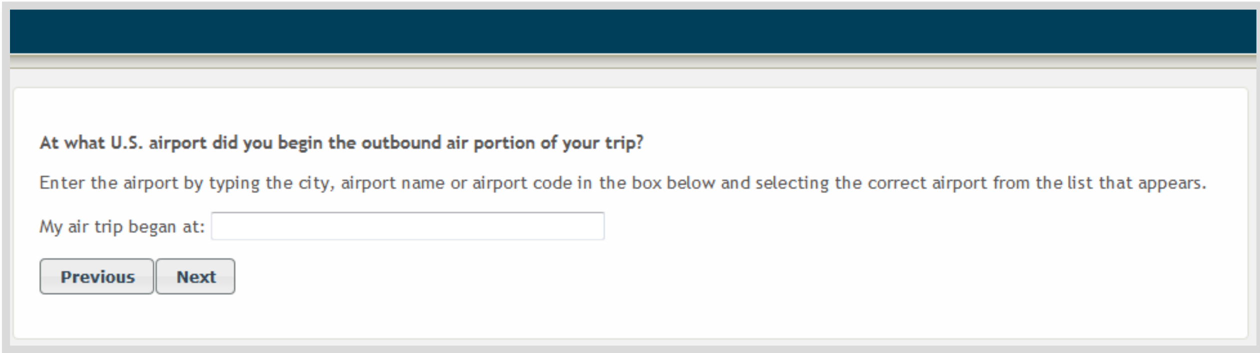
E.g., Broadway & 5th Ave or 30 Rockefeller Plaza, New York, NY

Search

Previous Next

If you don't know the address or business name, you can select the location using the map. Click on the map to zoom in on your location. Keep clicking to zoom until a marker appears. Continue to drag the map and click on the location until the marker is in the right place.

Origin Airport



At what U.S. airport did you begin the outbound air portion of your trip?

Enter the airport by typing the city, airport name or airport code in the box below and selecting the correct airport from the list that appears.

My air trip began at:

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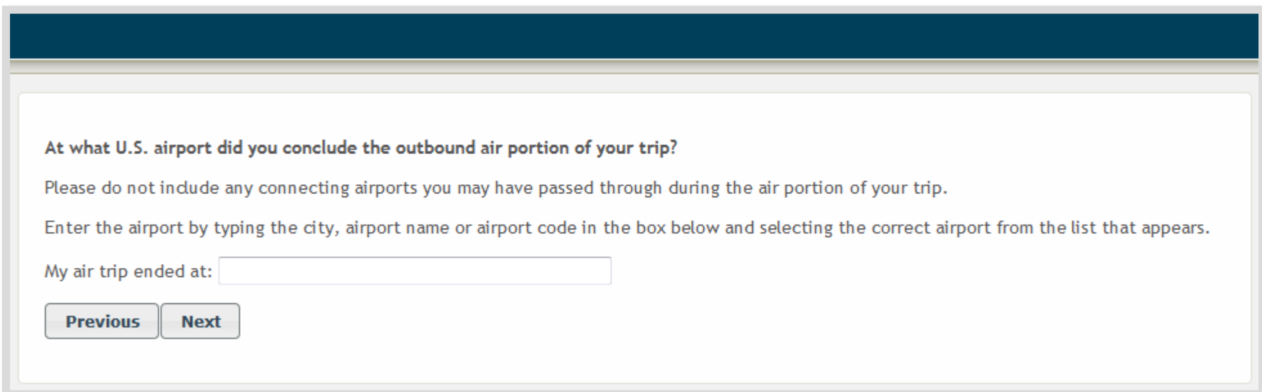
Destination Airport



At what U.S. airport did you conclude the outbound air portion of your trip?

Please do not include any connecting airports you may have passed through during the air portion of your trip.

Enter the airport by typing the city, airport name or airport code in the box below and selecting the correct airport from the list that appears.

My air trip ended at:

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Trip Destination Location Address

Where did your trip end after you left Los Angeles International (LAX)?

No location has been selected yet.

Search for address | Search for business

Enter the full address (including street number and name OR nearest intersection) in the text box and click "Search."

E.g., Broadway & 5th Ave or 30 Rockefeller Plaza, New York, NY

Search

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If you don't know the address or business name, you can select the location using the map. Click on the map to zoom in on your location. Keep clicking to zoom until a marker appears. Continue to drag the map and click on the location until the marker is in the right place.

Trip Purpose

What was the primary reason you flew from Orlando International (MCO) to Los Angeles International (LAX)?

- Business
- Attend conference
- Vacation
- Visit friends or relatives
- Attend school/college
- Other, please specify:

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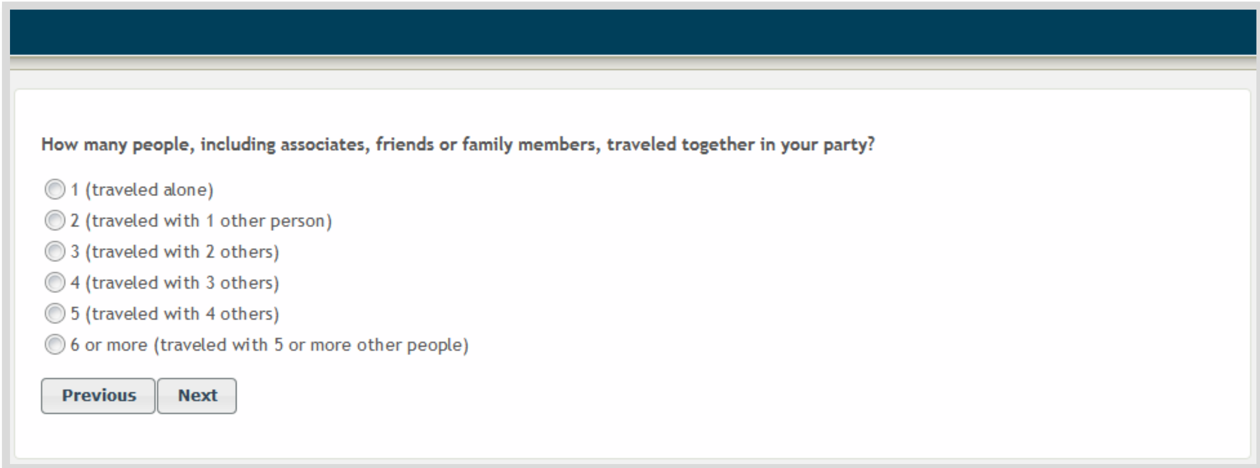
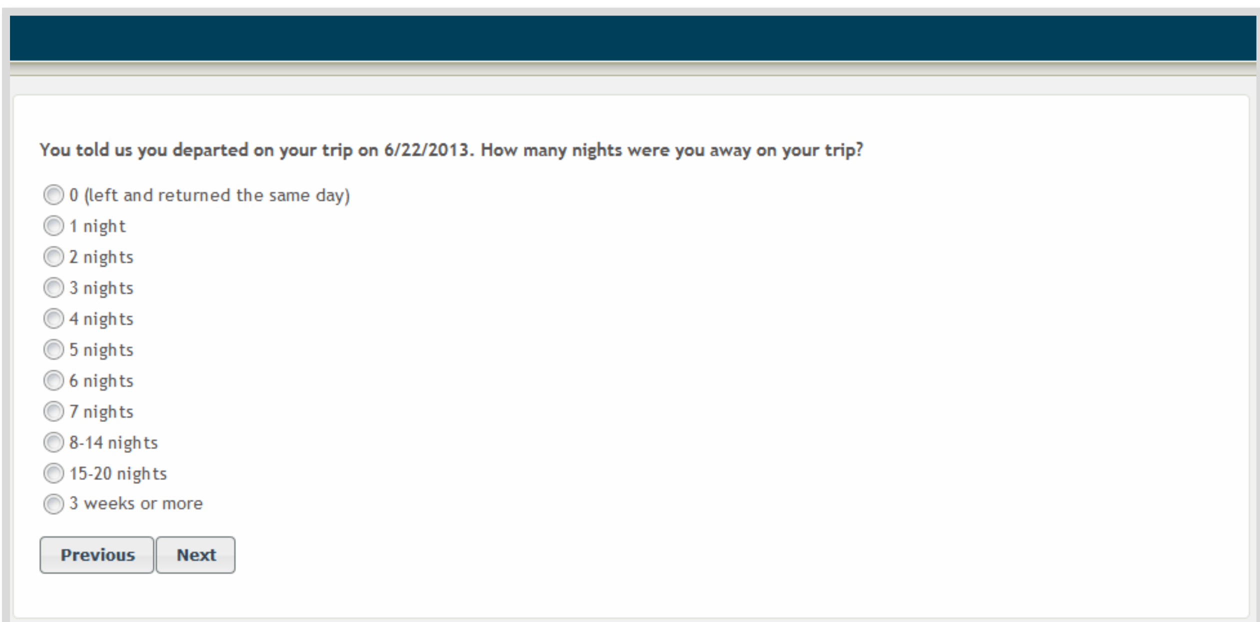
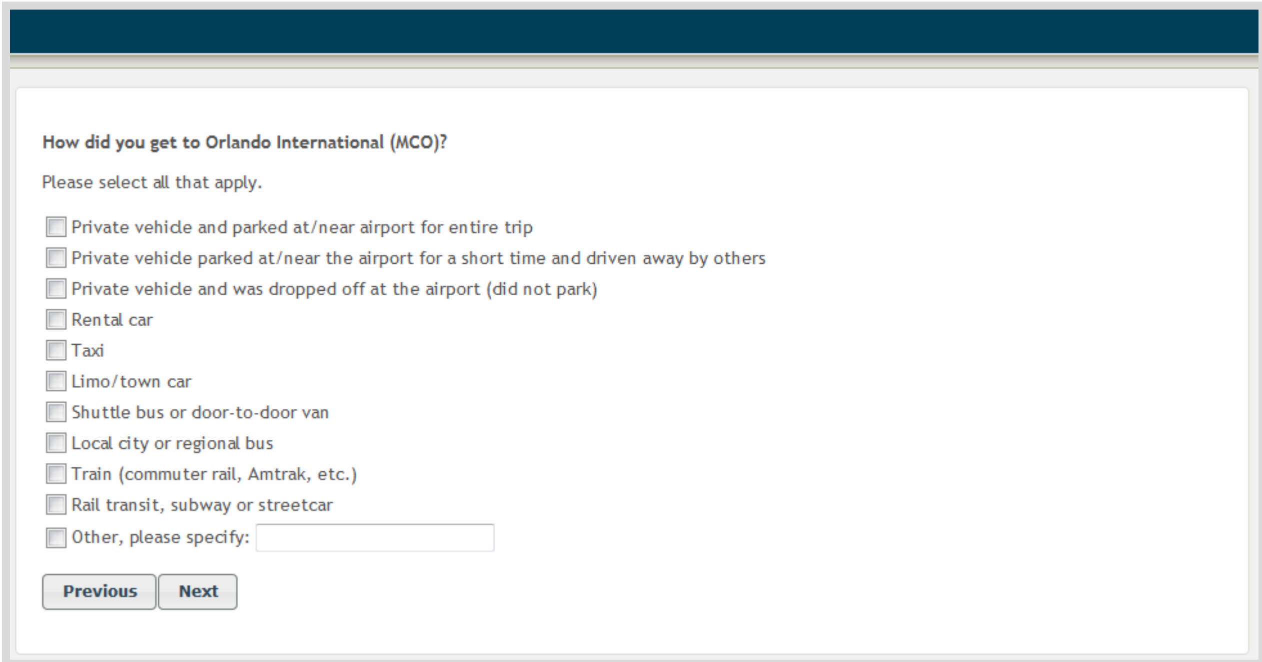
Party Size



Trip Duration



Access Mode to Airport


How did you get to Orlando International (MCO)?

Please select all that apply.

- [ ] Private vehicle and parked at/near airport for entire trip
- [ ] Private vehicle parked at/near the airport for a short time and driven away by others
- [ ] Private vehicle and was dropped off at the airport (did not park)
- [ ] Rental car
- [ ] Taxi
- [ ] Limo/town car
- [ ] Shuttle bus or door-to-door van
- [ ] Local city or regional bus
- [ ] Train (commuter rail, Amtrak, etc.)
- [ ] Rail transit, subway or streetcar
- [ ] Other, please specify:

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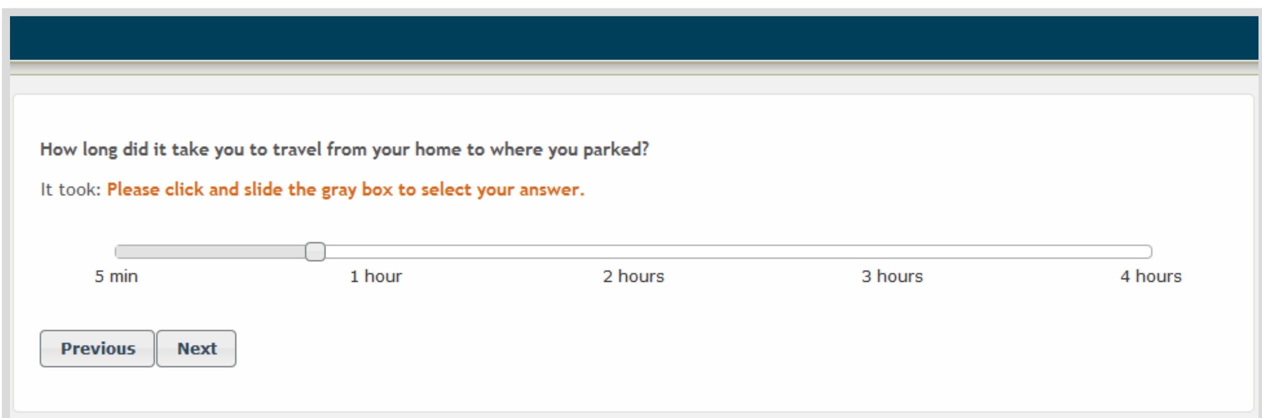
Access Time to Airport


How long did it take you to travel from your home to where you parked?

It took: **Please click and slide the gray box to select your answer.**

5 min | 1 hour | 2 hours | 3 hours | 4 hours

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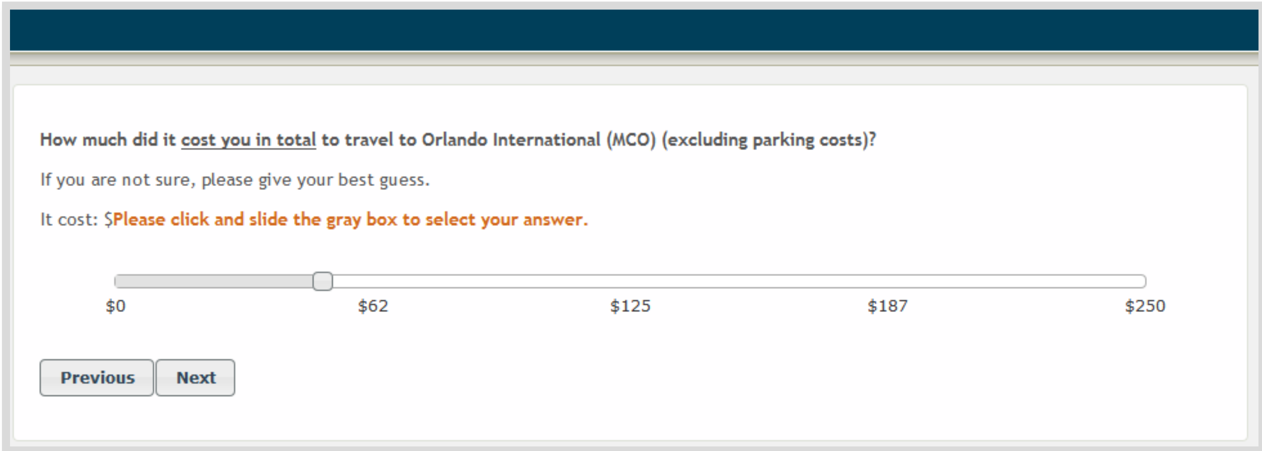
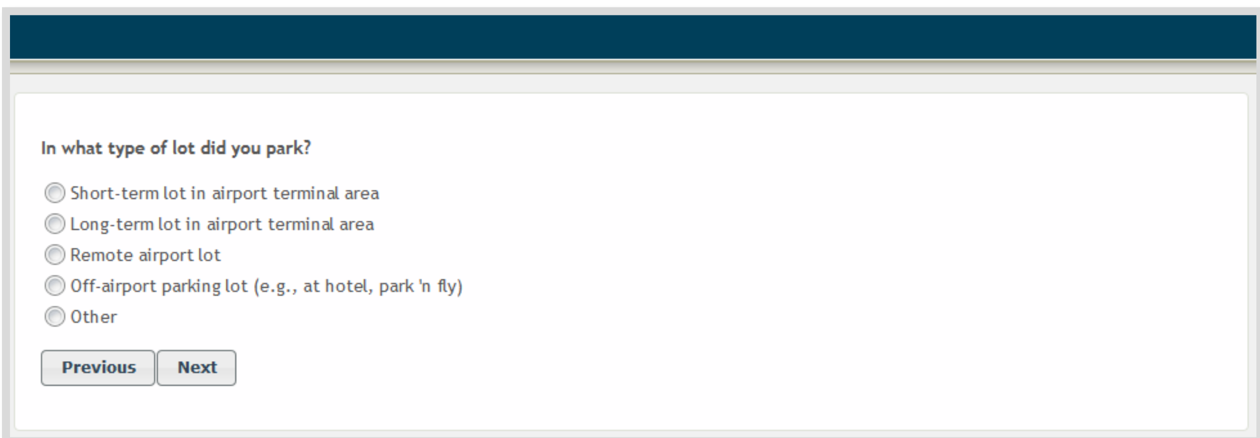
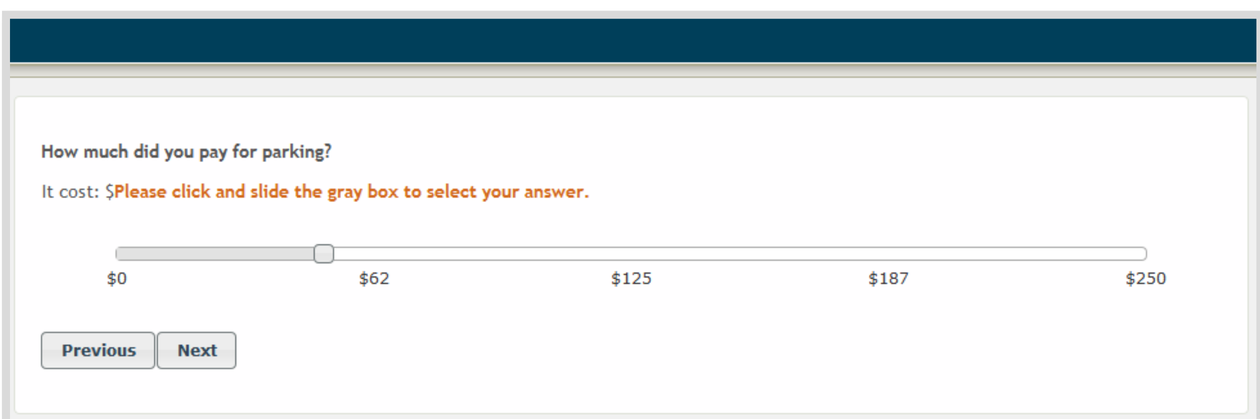
Access Cost – if didn't drive



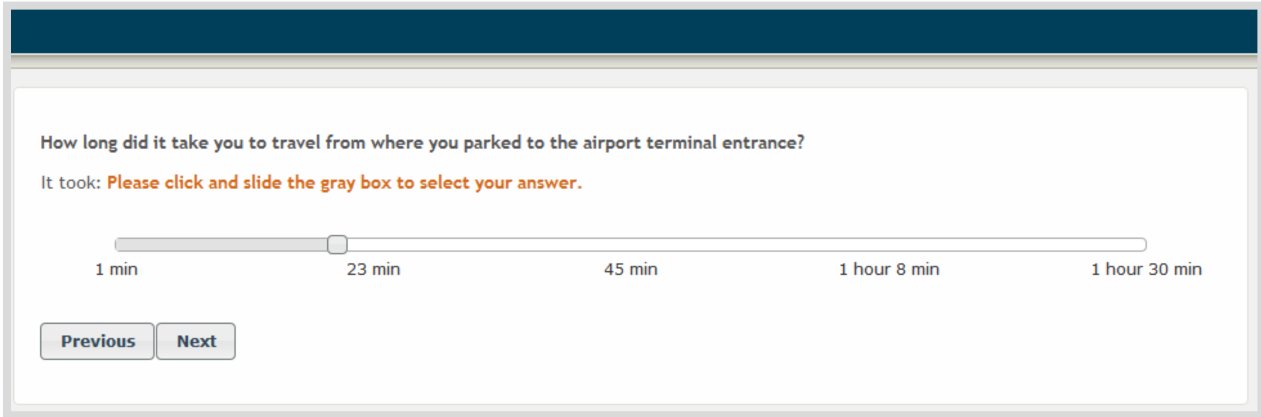
Type of Parking Lot – *if drove and parked*



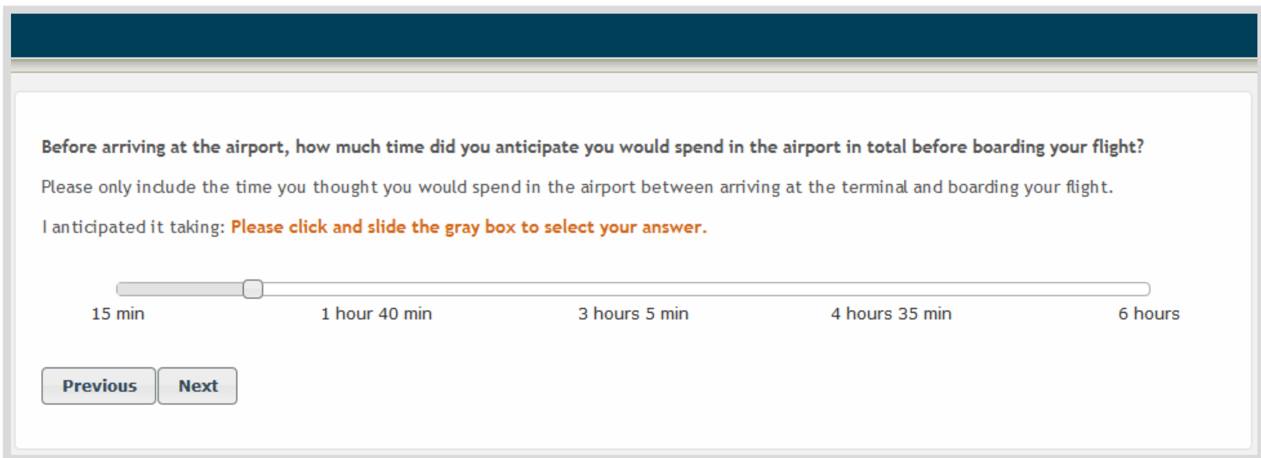
Parking Cost – if drove and parked



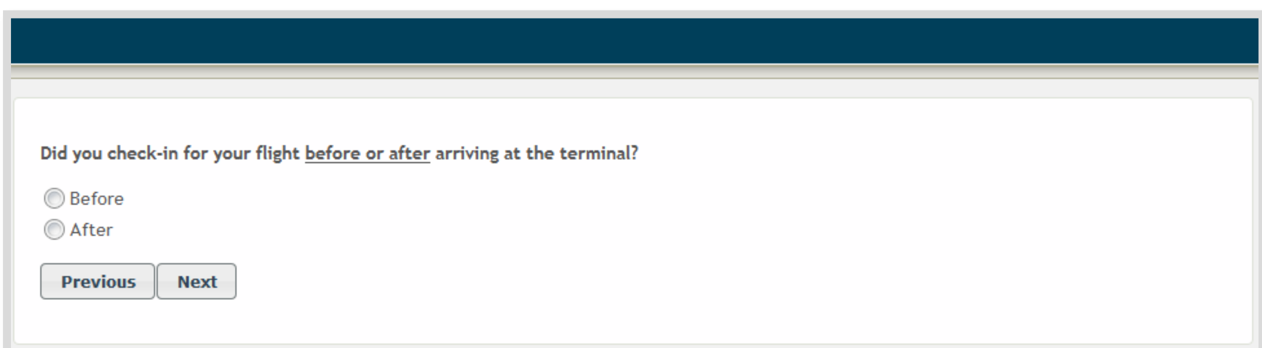
Terminal Access Time



Anticipated Airport Time



Flight Check-in



Checked Baggage

Did you check any bags?

- ○ Yes
- ○ No

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Baggage Fee

How much in extra fees were paid for checked or carry-on baggage?

Please include only the baggage fees paid for your own travel, not for anyone who may have traveled with you.

Baggage fees: $**Please click and slide the gray box to select your answer.**

$0 $62 $125 $187 $250

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Time to Reach Security after Entering the Airport Terminal

Approximately how long after you arrived at the terminal did you reach the security area/line?

It took: **Please click and slide the gray box to select your answer.**

1 min 30 min 1 hour 1 hour 30 min 2 hours

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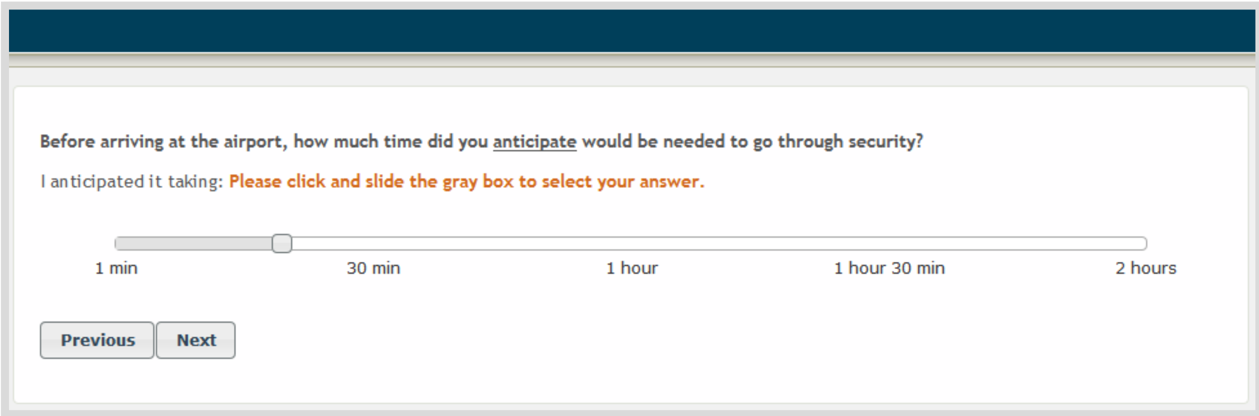
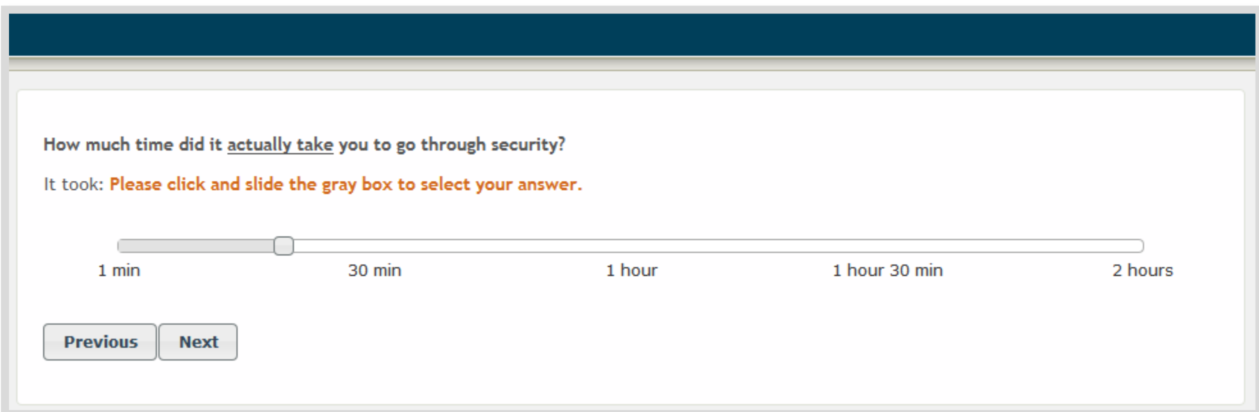
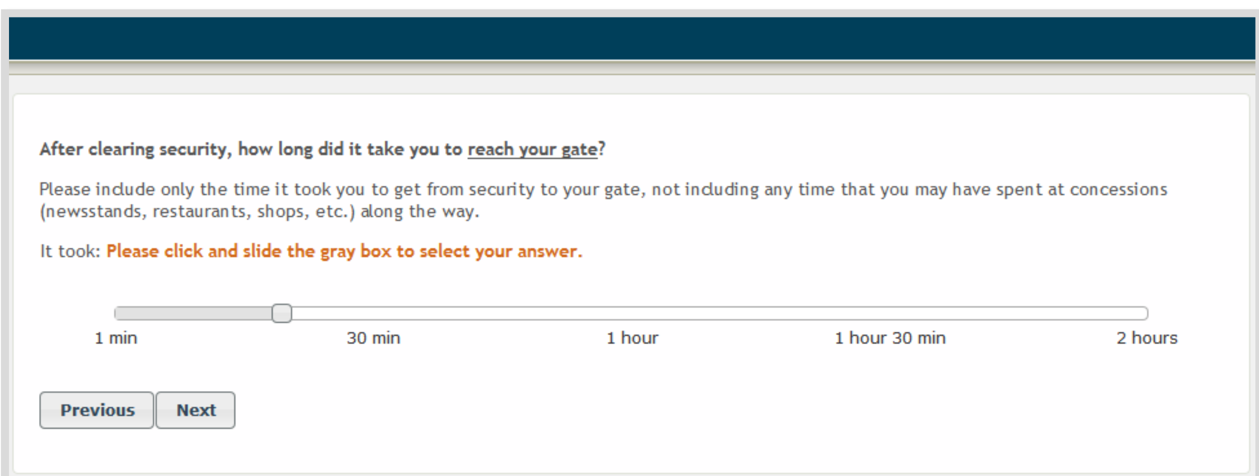
Anticipated Security Time



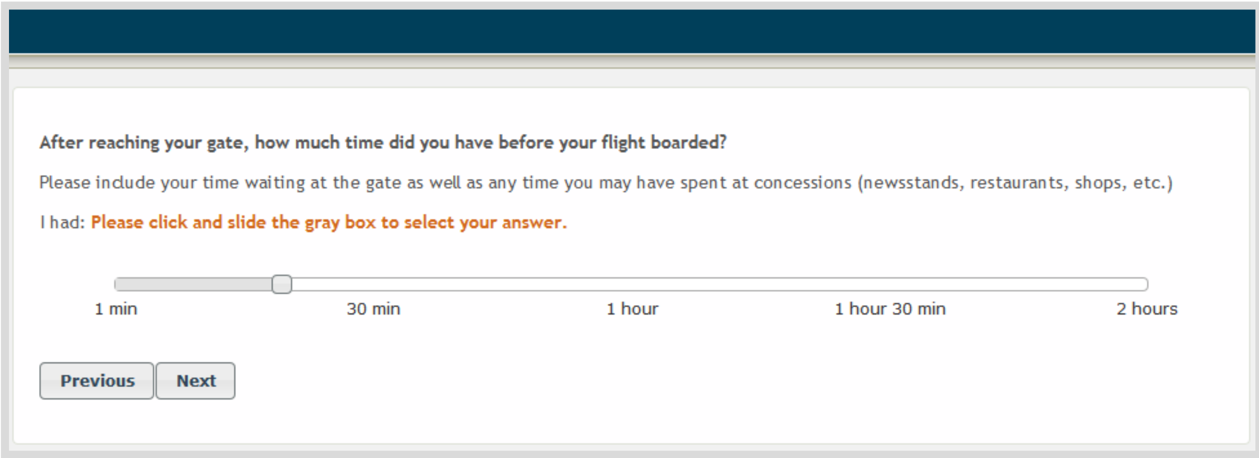
Security Time



Time to Reach Gate Area after Clearing Security



Time after Reaching the Gate until Boarding Commenced



After reaching your gate, how much time did you have before your flight boarded?

Please include your time waiting at the gate as well as any time you may have spent at concessions (newsstands, restaurants, shops, etc.)

I had: **Please click and slide the gray box to select your answer.**

1 min | 30 min | 1 hour | 1 hour 30 min | 2 hours

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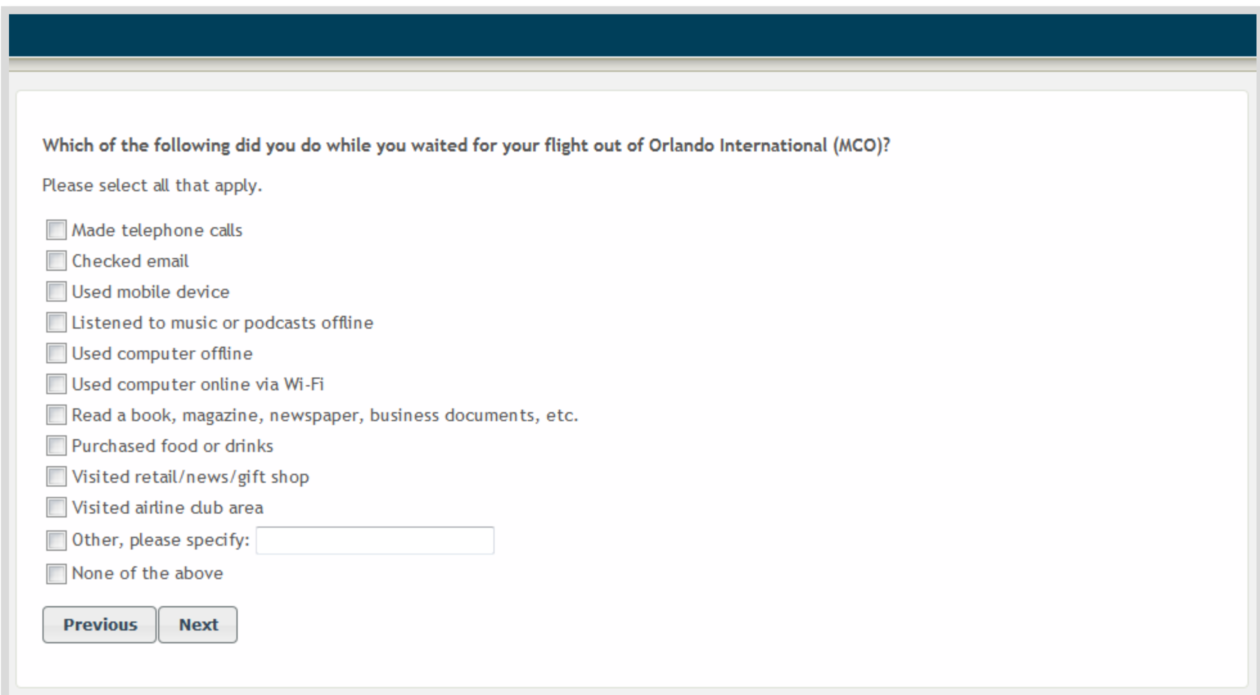
Activities at the Gate



Which of the following did you do while you waited for your flight out of Orlando International (MCO)?

Please select all that apply.

- Made telephone calls
- Checked email
- Used mobile device
- Listened to music or podcasts offline
- Used computer offline
- Used computer online via Wi-Fi
- Read a book, magazine, newspaper, business documents, etc.
- Purchased food or drinks
- Visited retail/news/gift shop
- Visited airline club area
- Other, please specify:
- None of the above

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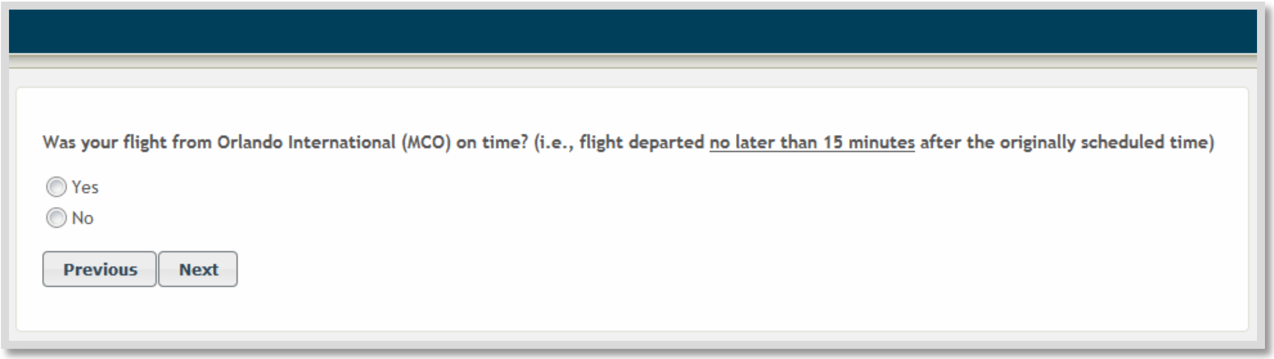
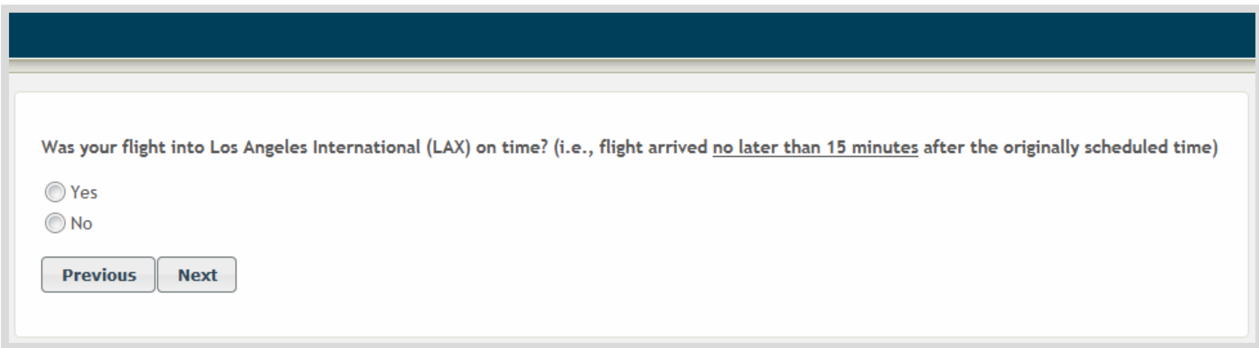
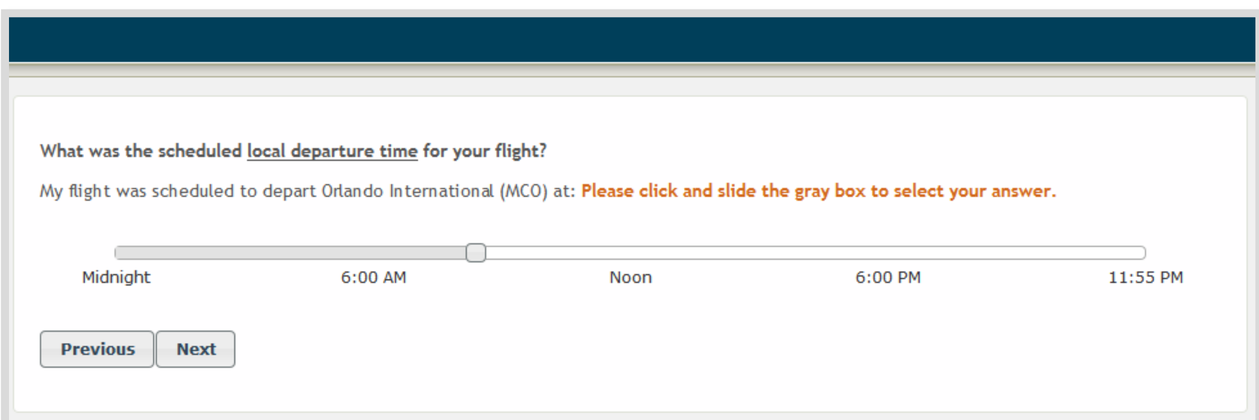
Departing Flight On-time



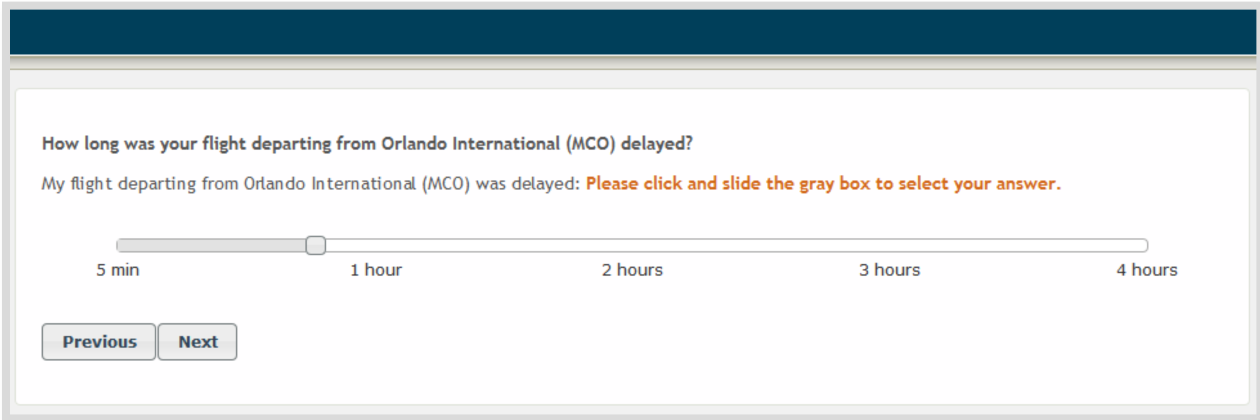
Flight Arrived at Destination Airport On-time



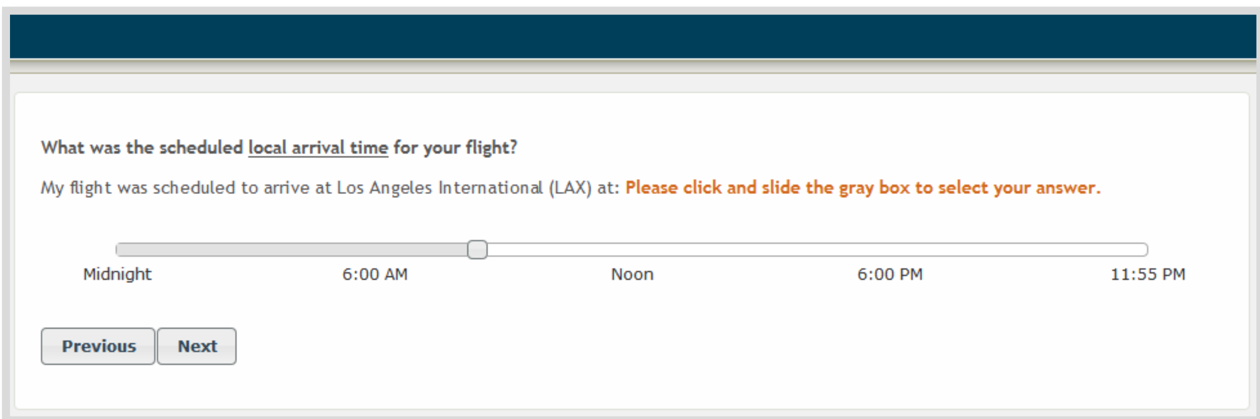
Flight Departure Time



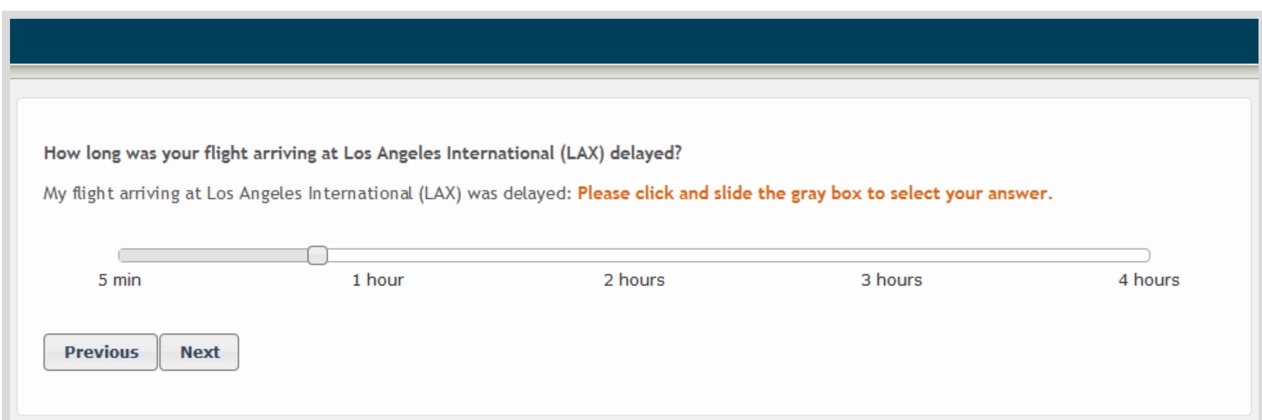
Amount of Delay at the Departing Airport – *if experienced delays*



Scheduled Arrival Time



Amount of Delay at the Destination Airport – *if experienced delays*



Preferred Arrival Time

You said that your scheduled arrival time into Los Angeles International (LAX) was 12:05 PM. At what time would you have most preferred to arrive, taking into account the reason for your trip?

I preferred to arrive at: **Please click and slide the gray box to select your answer.**

Midnight — 6:00 AM — Noon — 6:00 PM — 11:55 PM

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Flight Connections

Did you make any connections where you changed planes during your trip?

- ○ Yes
- ○ No

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Number of Connections – *if had connection(s)*

How many connections did you make on your trip from Orlando International (MCO) to Los Angeles International (LAX)?

- ○ 1 connection
- ○ 2 connections
- ○ 3 connections
- ○ 4 connections
- ○ 5 connections

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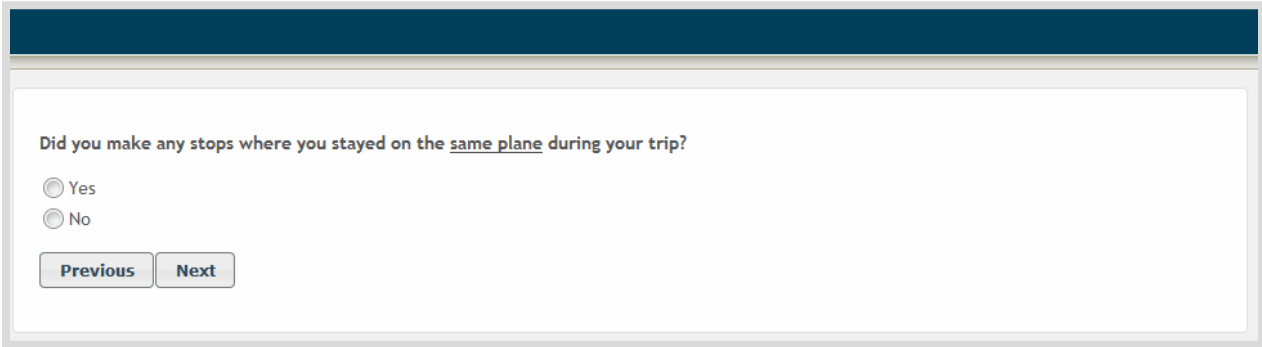
Stops



Did you make any stops where you stayed on the same plane during your trip?

- Yes
- No

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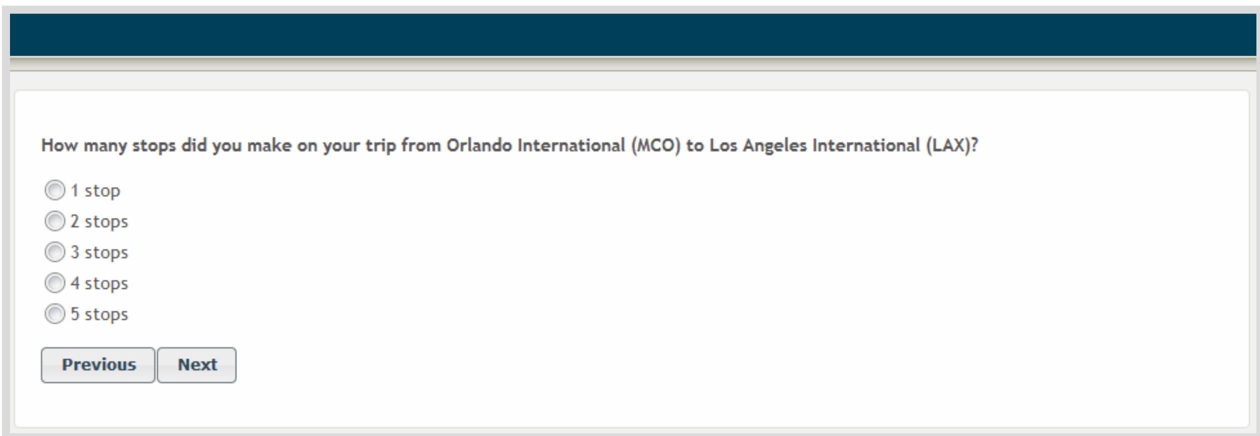
Number of Stops – *if had stop(s)*



How many stops did you make on your trip from Orlando International (MCO) to Los Angeles International (LAX)?

- 1 stop
- 2 stops
- 3 stops
- 4 stops
- 5 stops

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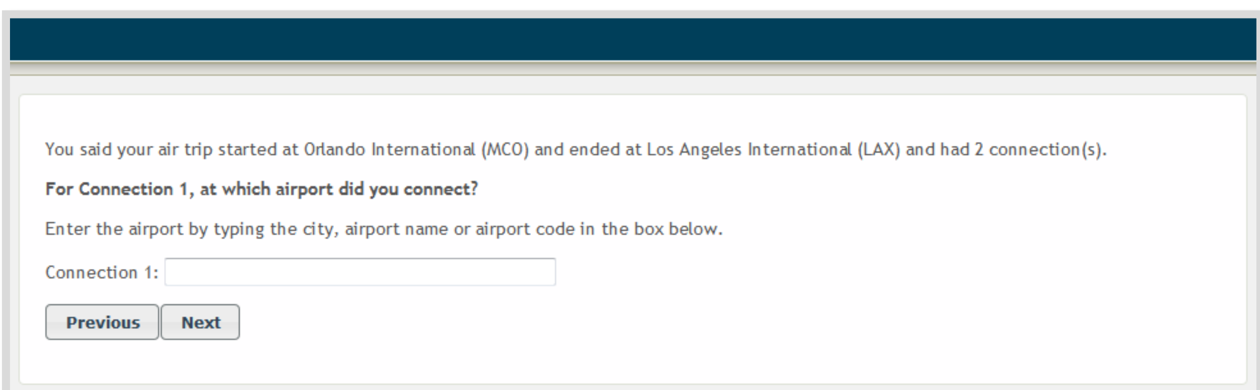
Name of the First Connecting Airport – *if had connection(s)*



You said your air trip started at Orlando International (MCO) and ended at Los Angeles International (LAX) and had 2 connection(s).

For Connection 1, at which airport did you connect?

Enter the airport by typing the city, airport name or airport code in the box below.

Connection 1:

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Connection Time at the First Connecting Airport – *if had connection(s)*

Please indicate your scheduled connection time at Minneapolis-St Paul (MSP).

This is the amount of time between when your inbound flight was scheduled to land and your connecting flight was scheduled to depart.

Scheduled connection time: **Please click and slide the gray box to select your answer.**

20 min | 1 hour 45 min | 3 hours 10 min | 4 hours 35 min | 6 hours

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Name of the Second Connecting Airport – *if had connection(s)*

You said your air trip started at Orlando International (MCO) and ended at Los Angeles International (LAX) and had 2 connection(s).

For Connection 2, at which airport did you connect?

Enter the airport by typing the city, airport name or airport code in the box below.

Connection 2:

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Connection Time at the Second Connecting Airport – *if had connection(s)*

Please indicate your scheduled connection time at Dallas Love Field (DAL).

This is the amount of time between when your inbound flight was scheduled to land and your connecting flight was scheduled to depart.

Scheduled connection time: **Please click and slide the gray box to select your answer.**

20 min | 1 hour 45 min | 3 hours 10 min | 4 hours 35 min | 6 hours

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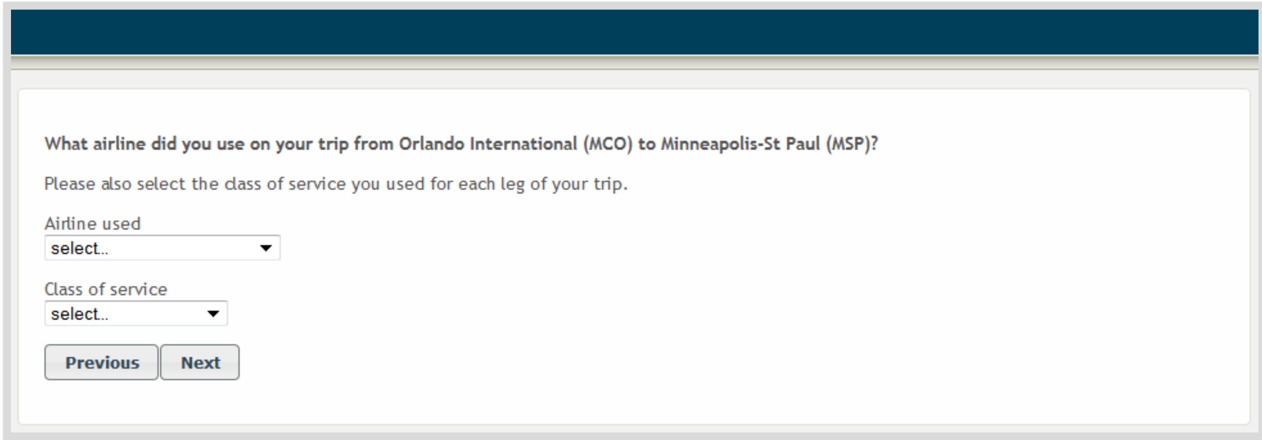
Airline Used from the Origin Airport to the First Connecting Airport


What airline did you use on your trip from Orlando International (MCO) to Minneapolis-St Paul (MSP)?

Please also select the class of service you used for each leg of your trip.

Airline used

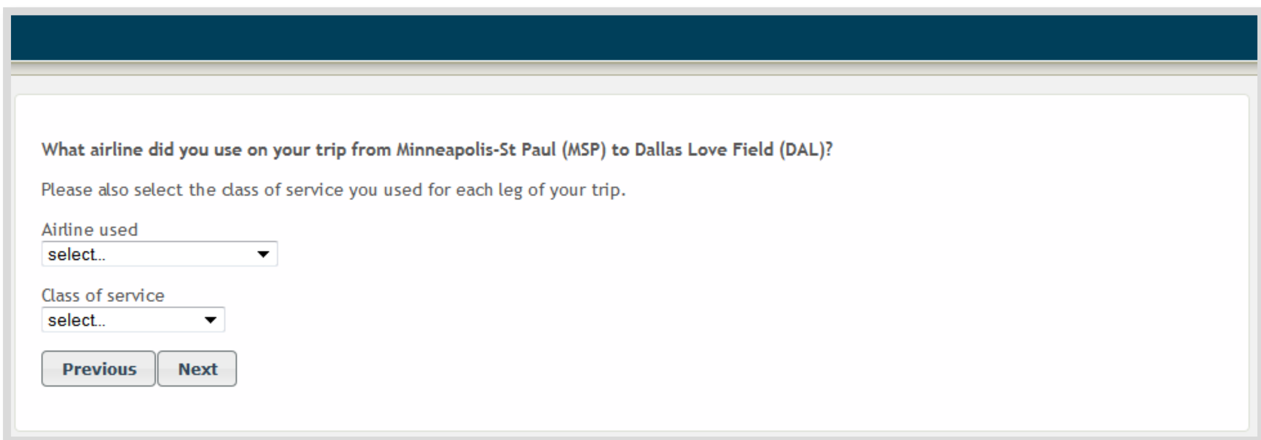
select...

Class of service

select...

Previous Next

Airline Used from the First Connecting Airport to the Second Connecting Airport


What airline did you use on your trip from Minneapolis-St Paul (MSP) to Dallas Love Field (DAL)?

Please also select the class of service you used for each leg of your trip.

Airline used

select...

Class of service

select...

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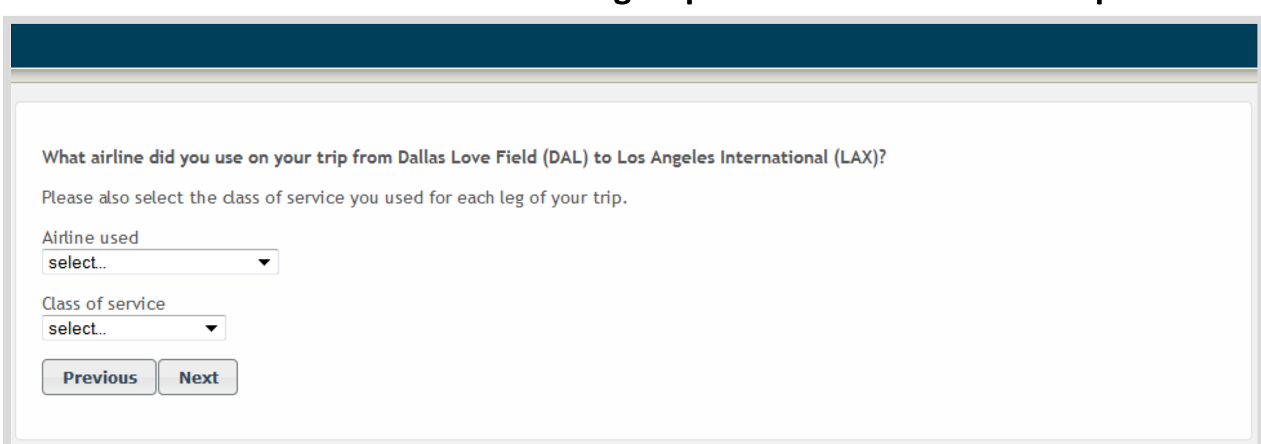
Airline Used from the Second Connecting Airport to the Destination Airport


What airline did you use on your trip from Dallas Love Field (DAL) to Los Angeles International (LAX)?

Please also select the class of service you used for each leg of your trip.

Airline used

select...

Class of service

select...

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Most Preferred Airline

Ignoring price for now, please rank the 3 airlines that you most prefer.

Please select your most preferred airline.

- AirTran Airways
- Air Canada
- Alaska Airlines
- Allegiant Air
- America West Airlines
- American Airlines
- Atlantic Southeast Airlines
- American Eagle
- Cape Air
- Continental Airlines
- Delta Airlines
- Delta Connection
- ExpressJet
- Frontier Airlines
- Hawaiian Airlines
- Horizon Air
- JetBlue Airways
- SkyWest Airlines
- Southwest Airlines
- Spirit Airlines
- Sun Country Airlines
- United Airlines
- United Express
- US Airways
- US Airways Express
- Virgin America
- WestJet

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Second Most Preferred Airline

Please select your second most preferred airline.

Most preferred: AirTran Airways

- Air Canada
- Alaska Airlines
- Allegiant Air
- America West Airlines
- American Airlines
- Atlantic Southeast Airlines
- American Eagle
- Cape Air
- Continental Airlines
- Delta Airlines
- Delta Connection
- ExpressJet
- Frontier Airlines
- Hawaiian Airlines
- Horizon Air
- JetBlue Airways
- SkyWest Airlines
- Southwest Airlines
- Spirit Airlines
- Sun Country Airlines
- United Airlines
- United Express
- US Airways
- US Airways Express
- Virgin America
- WestJet

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Third Most Preferred Airline

Please select your third most preferred airline.

- Air Canada
- Alaska Airlines
- Allegiant Air
- America West Airlines
- American Airlines
- Atlantic Southeast Airlines
- American Eagle
- Cape Air
- Continental Airlines
- Delta Airlines
- Delta Connection
- ExpressJet
- Frontier Airlines
- Hawaiian Airlines
- Horizon Air
- JetBlue Airways
- SkyWest Airlines
- Southwest Airlines
- Spirit Airlines
- Sun Country Airlines
- United Express
- US Airways
- US Airways Express
- Virgin America
- WestJet

Most preferred: AirTran Airways
Second most preferred: United Airlines

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Stated Preference Choice Experiments

Flight Itinerary Choice Experiments

Stated Preference Introduction

For the next 8 questions, we will show you different options for the trip that you described. The characteristics of the trips that are shown will vary. These will reflect different possible future air service conditions that may exist at different times of the day. Please indicate which of the options you would have chosen had these been the only ones available for this trip and assuming that the travel conditions were exactly as shown.

Assume that only these two alternatives were available for your trip and select the one you most prefer. Please keep in mind that:

- The options shown on each screen are hypothetical; they may be different than the options that were available to you when you made this trip.
- The travel times and costs presented are the actual amounts you can expect.
- Assume all else is equal between the options shown.

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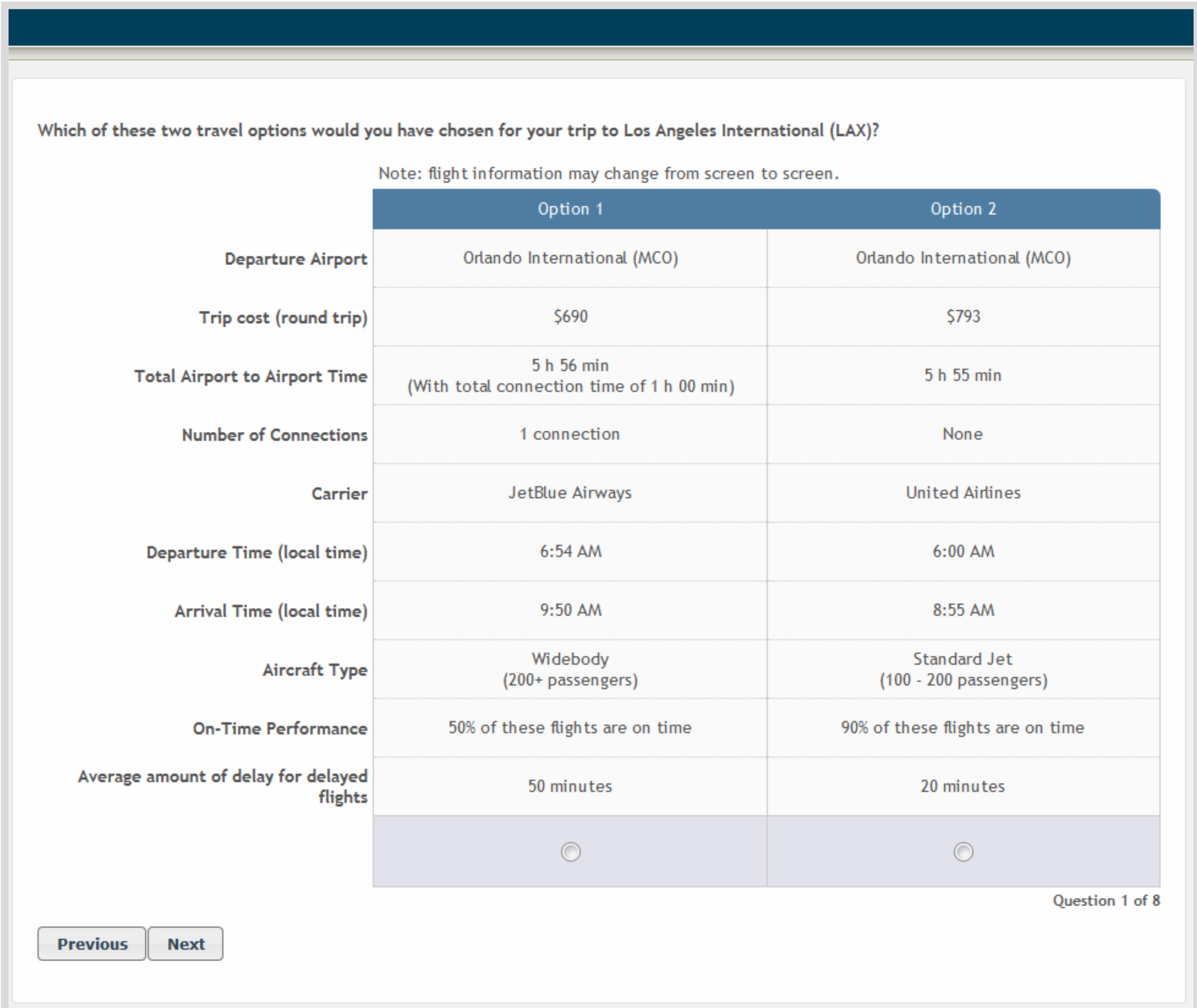
Example Stated Preference Experiment I



Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$690	$793
Total Airport to Airport Time	5 h 56 min (With total connection time of 1 h 00 min)	5 h 55 min
Number of Connections	1 connection	None
Carrier	JetBlue Airways	United Airlines
Departure Time (local time)	6:54 AM	6:00 AM
Arrival Time (local time)	9:50 AM	8:55 AM
Aircraft Type	Widebody (200+ passengers)	Standard Jet (100 - 200 passengers)
On-Time Performance	50% of these flights are on time	90% of these flights are on time
Average amount of delay for delayed flights	50 minutes	20 minutes

Question 1 of 8

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Example Stated Preference Experiment II

Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$897	$483
Total Airport to Airport Time	4 h 56 min	4 h 56 min
Number of Connections	None	None
Carrier	AirTran Airways	AirTran Airways
Departure Time (local time)	6:54 AM	9:54 AM
Arrival Time (local time)	8:50 AM	11:50 AM
Aircraft Type	Standard Jet (100 - 200 passengers)	Widebody (200+ passengers)
On-Time Performance	90% of these flights are on time	60% of these flights are on time
Average amount of delay for delayed flights	40 minutes	30 minutes
	○	○

Question 2 of 8

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Example Stated Preference Experiment III

Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$586	$793
Total Airport to Airport Time	7 h 25 min (With total connection time of 1 h 00 min)	4 h 26 min
Number of Connections	1 connection	None
Carrier	AirTran Airways	AirTran Airways
Departure Time (local time)	6:00 AM	6:24 AM
Arrival Time (local time)	10:25 AM	7:50 AM
Aircraft Type	Standard Jet (100 - 200 passengers)	Widebody (200+ passengers)
On-Time Performance	60% of these flights are on time	80% of these flights are on time
Average amount of delay for delayed flights	20 minutes	50 minutes
	○	○

Question 3 of 8

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Example Stated Preference Experiment IV

Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$483	$897
Total Airport to Airport Time	4 h 56 min	5 h 25 min
Number of Connections	None	None
Carrier	United Airlines	JetBlue Airways
Departure Time (local time)	6:00 AM	9:25 AM
Arrival Time (local time)	7:56 AM	11:50 AM
Aircraft Type	Standard Jet (100 - 200 passengers)	Widebody (200+ passengers)
On-Time Performance	50% of these flights are on time	90% of these flights are on time
Average amount of delay for delayed flights	30 minutes	40 minutes
	○	○

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Example Stated Preference Experiment V

Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$897	$483
Total Airport to Airport Time	5 h 55 min	4 h 56 min
Number of Connections	None	None
Carrier	AirTran Airways	AirTran Airways
Departure Time (local time)	8:55 AM	6:54 AM
Arrival Time (local time)	11:50 AM	8:50 AM
Aircraft Type	Widebody (200+ passengers)	Standard Jet (100 - 200 passengers)
On-Time Performance	80% of these flights are on time	60% of these flights are on time
Average amount of delay for delayed flights	20 minutes	50 minutes
	○	○

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Example Stated Preference Experiment VI

Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$690	$690
Total Airport to Airport Time	5 h 25 min	4 h 56 min
Number of Connections	None	None
Carrier	AirTran Airways	JetBlue Airways
Departure Time (local time)	6:25 AM	8:54 AM
Arrival Time (local time)	8:50 AM	10:50 AM
Aircraft Type	Standard Jet (100 - 200 passengers)	Widebody (200+ passengers)
On-Time Performance	50% of these flights are on time	80% of these flights are on time
Average amount of delay for delayed flights	30 minutes	40 minutes
	○	○

Question 6 of 8

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Example Stated Preference Experiment VII

Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$897	$483
Total Airport to Airport Time	4 h 56 min	9 h 25 min (With total connection time of 3 h 00 min)
Number of Connections	None	2 connections
Carrier	United Airlines	AirTran Airways
Departure Time (local time)	8:54 AM	12:00 AM
Arrival Time (local time)	10:50 AM	6:25 AM
Aircraft Type	Standard Jet (100 - 200 passengers)	Standard Jet (100 - 200 passengers)
On-Time Performance	70% of these flights are on time	60% of these flights are on time
Average amount of delay for delayed flights	40 minutes	30 minutes
	○	○

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Example Stated Preference Experiment VIII

Which of these two travel options would you have chosen for your trip to Los Angeles International (LAX)?

Note: flight information may change from screen to screen.

	Option 1	Option 2
Departure Airport	Orlando International (MCO)	Orlando International (MCO)
Trip cost (round trip)	$793	$586
Total Airport to Airport Time	5 h 56 min (With total connection time of 1 h 00 min)	9 h 55 min (With total connection time of 3 h 00 min)
Number of Connections	1 connection	2 connections
Carrier	AirTran Airways	AirTran Airways
Departure Time (local time)	6:54 AM	6:00 AM
Arrival Time (local time)	9:50 AM	12:55 PM
Aircraft Type	Widebody (200+ passengers)	Standard Jet (100 - 200 passengers)
On-Time Performance	70% of these flights are on time	50% of these flights are on time
Average amount of delay for delayed flights	20 minutes	50 minutes
	○	○

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Airport Time Components Choice Experiments

Stated Preference Introduction

Now we would like you to think about the time you spend getting to your departure airport and the time you spend making your way through your departure airport.

On each screen, you will compare two different options for getting to Orlando International (MCO) and making your way through the airport. Please indicate which of the options you most prefer given the times and costs that are presented to you. Please note that these options are hypothetical and the times and costs will most likely be different than what you currently experience at Orlando International (MCO).

When making your decision, please assume that:

- Travel conditions to the airport may be different than what you currently experience
- The times and costs presented are the actual amounts you experience
- All else is equal between the options shown

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Example Stated Preference Experiment I

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Transit	Transit
Cost to airport (fare, parking, etc.)	$3 (one-way fare per person)	$7 (one-way fare per person)
Travel time to parking/drop-off location	1 h 13 min	1 h 13 min
Time to reach the terminal from parking/dropoff location	29 min	37 min
Time to reach security, wait in line, and pass security	37 min	18 min
Time to reach gate area	02 min	13 min
Time after reaching the gate area until boarding commences	1 h 01 min	1 h 01 min
	◉	○

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Example Stated Preference Experiment II

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Transit	Transit
Cost to airport (fare, parking, etc.)	$9 (one-way fare per person)	$7 (one-way fare per person)
Travel time to parking/drop-off location	1 h 09 min	1 h 22 min
Time to reach the terminal from parking/dropoff location	1 h 01 min	37 min
Time to reach security, wait in line, and pass security	24 min	24 min
Time to reach gate area	02 min	13 min
Time after reaching the gate area until boarding commences	29 min	37 min

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Example Stated Preference Experiment III

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Taxi	Taxi
Cost to airport (fare, parking, etc.)	$41 (one-way taxi fare)	$22 (one-way taxi fare)
Travel time to parking/drop-off location	40 min	49 min
Time to reach the terminal from parking/dropoff location	29 min	37 min
Time to reach security, wait in line, and pass security	37 min	43 min
Time to reach gate area	02 min	09 min
Time after reaching the gate area until boarding commences	37 min	53 min
	○	○

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Example Stated Preference Experiment IV

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Transit	Transit
Cost to airport (fare, parking, etc.)	$5 (one-way fare per person)	$7 (one-way fare per person)
Travel time to parking/drop-off location	1 h 22 min	1 h 18 min
Time to reach the terminal from parking/dropoff location	53 min	1 h 01 min
Time to reach security, wait in line, and pass security	43 min	24 min
Time to reach gate area	09 min	02 min
Time after reaching the gate area until boarding commences	1 h 01 min	29 min
	○	○

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Example Stated Preference Experiment V

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Transit	Transit
Cost to airport (fare, parking, etc.)	$5 (one-way fare per person)	$3 (one-way fare per person)
Travel time to parking/drop-off location	1 h 09 min	1 h 13 min
Time to reach the terminal from parking/dropoff location	29 min	53 min
Time to reach security, wait in line, and pass security	37 min	24 min
Time to reach gate area	09 min	02 min
Time after reaching the gate area until boarding commences	37 min	29 min
	○	○

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Example Stated Preference Experiment VI

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Transit	Transit
Cost to airport (fare, parking, etc.)	$7 (one-way fare per person)	$3 (one-way fare per person)
Travel time to parking/drop-off location	1 h 09 min	1 h 18 min
Time to reach the terminal from parking/dropoff location	1 h 01 min	53 min
Time to reach security, wait in line, and pass security	37 min	43 min
Time to reach gate area	02 min	09 min
Time after reaching the gate area until boarding commences	53 min	53 min
	○	○

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Example Stated Preference Experiment VII

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Transit	Drive and park
Cost to airport (fare, parking, etc.)	$5 (one-way fare per person)	$30 (parking per vehicle for duration of trip)
Travel time to parking/drop-off location	1 h 22 min	54 min
Time to reach the terminal from parking/dropoff location	53 min	29 min
Time to reach security, wait in line, and pass security	18 min	43 min
Time to reach gate area	02 min	13 min
Time after reaching the gate area until boarding commences	53 min	29 min
	○	○

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Example Stated Preference Experiment VIII

Please indicate the option you most prefer for getting to Orlando International (MCO) and making your way through the airport.

	Option 1	Option 2
Get to the airport by	Drive and dropped off	Drive and park
Cost to airport (fare, parking, etc.)	$0	$50 (parking per vehicle for duration of trip)
Travel time to parking/drop-off location	49 min	36 min
Time to reach the terminal from parking/dropoff location	37 min	1 h 01 min
Time to reach security, wait in line, and pass security	18 min	18 min
Time to reach gate area	13 min	02 min
Time after reaching the gate area until boarding commences	1 h 01 min	37 min
	○	○

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Attitude and Air Travel Background Questions

Air Travel Attitudes

To what extent do you agree with the following statements?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Recent changes to airport security have discouraged me from flying					
I am trying to fly less for environmental reasons					
I regularly search websites for cheap flights and sometimes will fly if I see a bargain					
I try to fly without checked baggage whenever possible					
I generally shop for the cheapest flights and do not consider other factors					

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Air Travel Frequency

The last few questions are about you and your household. Your responses are confidential and will only be used to classify your previous answers.

Approximately how many round trips have you made by air within the U.S. in the past year for business or work?

Approximately how many round trips have you made by air within the U.S. in the past year that were not for business or work?

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Membership Status on Preferred Airlines

What is your membership status in each of these frequent flyer programs?

AirTran Airways
select...

United Airlines
select...

JetBlue Airways
select...

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Missed Flight Connection

Have you missed a flight at a connecting airport in the last 2 years?

- Yes
- No

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Demographic Questions

Gender

What is your gender?

- Male
- Female

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Adults in Household

How many adults (18 years or older) are in your household?

- 1 adult (I live alone)
- 2 adults
- 3 adults
- 4 adults
- 5 adults
- 6 or more adults

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Children in Household

How many children (under 18 years) are in your household?

- No children
- 1 child
- 2 children
- 3 children
- 4 children
- 5 children
- 6 or more children

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Individual Income

Which category best represents your individual annual income before taxes last year?

- Under $10,000
- $10,000 - $19,999
- $20,000 - $29,999
- $30,000 - $39,999
- $40,000 - $49,999
- $50,000 - $74,999
- $75,000 - $99,999
- $100,000 - $149,999
- $150,000 - $199,999
- $200,000 - $249,999
- $250,000 or more

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Household Income

Which category best represents your household's annual income before taxes last year?

- Under $10,000
- $10,000 - $19,999
- $20,000 - $29,999
- $30,000 - $39,999
- $40,000 - $49,999
- $50,000 - $74,999
- $75,000 - $99,999
- $100,000 - $149,999
- $150,000 - $199,999
- $200,000 - $249,999
- $250,000 or more

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Employment Status

What is your employment status?

- Employed full-time
- Employed part-time
- Self-employed
- Student
- Retired
- Homemaker
- Not currently employed
- Unable to work due to illness or injury

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Survey Comments

Thank you for participating! You have completed the survey. If you have any additional comments please enter them in the box below and click "Finish". These comments may be edited and included anonymously with the study's findings.

Previous Finish

2 SURVEY TABULATIONS

Trip Characteristics

Recent air trip

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
In the past month	115	38.7%	243	27.8%	**358**	**30.6%**
1-2 months ago	79	26.6%	244	27.9%	**323**	**27.6%**
3-6 months ago	103	34.7%	387	44.3%	**490**	**41.8%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Where purchased or obtained ticket

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Online - using the airline website	147	49.5%	672	76.9%	**819**	**69.9%**
Online - from a site other than the airline	47	15.8%	140	16.0%	**187**	**16.0%**
From a travel agent (in person or by phone)	18	6.1%	30	3.4%	**48**	**4.1%**
By phone - directly from the airline	1	0.3%	13	1.5%	**14**	**1.2%**
Company travel office or similar organization	82	27.6%	10	1.1%	**92**	**7.9%**
Other, please specify:	2	0.7%	9	1.0%	**11**	**0.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Who paid for ticket

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
I paid personally	90	30.3%	806	92.2%	**896**	**76.5%**
My company paid or reimbursed me	199	67.0%	16	1.8%	**215**	**18.4%**
It was free through the airline (either through a frequent flyer program, a voucher or from getting bumped)	0	0.0%	0	0.0%	**0**	**0.0%**
Family or friend	3	1.0%	47	5.4%	**50**	**4.3%**
Other, please specify:	5	1.7%	5	0.6%	**10**	**0.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Company rules when choosing the itinerary for the trip (multiple responses allowed)

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
No, I didn't have to follow rules	106	53.3%	7	43.8%	**113**	**52.6%**
I had to use the company's preferred airline	26	13.1%	3	18.8%	**29**	**13.5%**
I had to choose the lowest price	42	21.1%	5	31.3%	**47**	**21.9%**
I had to follow other company rules	29	14.6%	1	6.3%	**30**	**14.0%**
Total	**199**		**16**		**215**	

One-way/round trip

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
One-way	21	7.1%	85	9.7%	**106**	**9.1%**
Round trip	276	92.9%	789	90.3%	**1065**	**90.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

One-way airfare

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Up to $250	12	57.1%	56	65.9%	**68**	**64.2%**
$250 to $500	8	38.1%	17	20.0%	**25**	**23.6%**
$501 to $750	1	4.8%	7	8.2%	**8**	**7.5%**
$751 to $1,000	0	0.0%	2	2.4%	**2**	**1.9%**
More than $1,000	0	0.0%	3	3.5%	**3**	**2.8%**
Total	**21**	**100.0%**	**85**	**100.0%**	**106**	**100.0%**

Round trip airfare

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Up to $250	29	10.5%	173	21.9%	**202**	**19.0%**
$250 to $500	141	51.1%	424	53.7%	**565**	**53.1%**
$501 to $750	63	22.8%	127	16.1%	**190**	**17.8%**
$751 to $1,000	22	8.0%	40	5.1%	**62**	**5.8%**
More than $1,000	21	7.6%	25	3.2%	**46**	**4.3%**
Total	**276**	**100.0%**	**789**	**100.0%**	**1065**	**100.0%**

Trip origin location

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
My home	259	87.2%	779	89.1%	**1038**	**88.6%**
My regular place of employment	26	8.8%	10	1.1%	**36**	**3.1%**
Other	12	4.0%	85	9.7%	**97**	**8.3%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Departure time from origin location

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
12AM - 12:59AM	0	0.0%	3	0.3%	**3**	**0.3%**
1AM - 1:59AM	0	0.0%	2	0.2%	**2**	**0.2%**
2AM - 2:59AM	0	0.0%	1	0.1%	**1**	**0.1%**
3AM - 3:59AM	3	1.0%	12	1.4%	**15**	**1.3%**
4AM - 4:59AM	18	6.1%	63	7.2%	**81**	**6.9%**
5AM - 5:59AM	32	10.8%	80	9.2%	**112**	**9.6%**
6AM - 6:59AM	43	14.5%	107	12.2%	**150**	**12.8%**
7AM - 7:59AM	33	11.1%	92	10.5%	**125**	**10.7%**
8AM - 8:59AM	23	7.7%	83	9.5%	**106**	**9.1%**
9AM - 9:59AM	30	10.1%	67	7.7%	**97**	**8.3%**
10AM - 10:59AM	20	6.7%	87	10.0%	**107**	**9.1%**
11AM - 11:59AM	19	6.4%	54	6.2%	**73**	**6.2%**
12PM - 12:59PM	15	5.1%	44	5.0%	**59**	**5.0%**
1PM - 1:59PM	15	5.1%	35	4.0%	**50**	**4.3%**
2PM - 2:59PM	10	3.4%	31	3.5%	**41**	**3.5%**
3PM - 3:59PM	13	4.4%	29	3.3%	**42**	**3.6%**
4PM - 4:59PM	5	1.7%	23	2.6%	**28**	**2.4%**
5PM - 5:59PM	10	3.4%	17	1.9%	**27**	**2.3%**
6PM - 6:59PM	5	1.7%	20	2.3%	**25**	**2.1%**
7PM - 7:59PM	3	1.0%	10	1.1%	**13**	**1.1%**
8PM - 8:59PM	0	0.0%	9	1.0%	**9**	**0.8%**
9PM - 9:59PM	0	0.0%	2	0.2%	**2**	**0.2%**
10PM - 10:59PM	0	0.0%	1	0.1%	**1**	**0.1%**
11PM - 11:59PM	0	0.0%	2	0.2%	**2**	**0.2%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Trip purpose

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Business	206	69.4%	0	0.0%	**206**	**17.6%**
Attend conference	91	30.6%	0	0.0%	**91**	**7.8%**
Vacation	0	0.0%	386	44.2%	**386**	**33.0%**
Visit friends or relatives	0	0.0%	391	44.7%	**391**	**33.4%**
Attend school/college	0	0.0%	9	1.0%	**9**	**0.8%**
Other, please specify:	0	0.0%	88	10.1%	**88**	**7.5%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Number of people traveled together

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
1 (traveled alone)	203	68.4%	306	35.0%	**509**	**43.5%**
2 (traveled with 1 other person)	72	24.2%	432	49.4%	**504**	**43.0%**
3 (traveled with 2 others)	10	3.4%	61	7.0%	**71**	**6.1%**
4 (traveled with 3 others)	5	1.7%	50	5.7%	**55**	**4.7%**
5 (traveled with 4 others)	2	0.7%	9	1.0%	**11**	**0.9%**
6 or more (traveled with 5 or more other people)	5	1.7%	16	1.8%	**21**	**1.8%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Number of nights away on the trip

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
0 (left and returned the same day)	5	1.7%	4	0.5%	**9**	**0.8%**
1 night	30	10.1%	11	1.3%	**41**	**3.5%**
2 nights	68	22.9%	58	6.6%	**126**	**10.8%**
3 nights	70	23.6%	100	11.4%	**170**	**14.5%**
4 nights	54	18.2%	109	12.5%	**163**	**13.9%**
5 nights	31	10.4%	80	9.2%	**111**	**9.5%**
6 nights	12	4.0%	90	10.3%	**102**	**8.7%**
7 nights	9	3.0%	126	14.4%	**135**	**11.5%**
8-14 nights	15	5.1%	204	23.3%	**219**	**18.7%**
15-20 nights	0	0.0%	42	4.8%	**42**	**3.6%**
3 weeks or more	3	1.0%	50	5.7%	**53**	**4.5%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Ground access mode (multiple responses allowed)

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Private vehicle and parked at/near airport for entire trip	178	59.9%	358	41.0%	**536**	**45.8%**
Private vehicle and was dropped off at the airport (did not park)	4	1.3%	32	3.7%	**36**	**3.1%**
Taxi	65	21.9%	303	34.7%	**368**	**31.4%**
Shuttle bus or door-to-door van	9	3.0%	18	2.1%	**27**	**2.3%**
Limo/Town car	15	5.1%	40	4.6%	**55**	**4.7%**
Private vehicle parked at/near the airport for a short time and driven away by others	7	2.4%	33	3.8%	**40**	**3.4%**
Rental car	11	3.7%	39	4.5%	**50**	**4.3%**
Local city or regional bus	0	0.0%	11	1.3%	**11**	**0.9%**
Train (commuter rail, Amtrak, etc.)	1	.3%	11	1.3%	**12**	**1.0%**
Rail transit, subway or streetcar	3	1.0%	19	2.2%	**22**	**1.9%**
Other	6	2.0%	18	2.1%	**24**	**2.0%**
Total	**297**		**874**		**1171**	

Reported ground access time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
30 minutes or less	103	34.7%	295	33.8%	**398**	**34.0%**
31 minutes to 60 minutes	125	42.1%	383	43.8%	**508**	**43.4%**
60 minutes to 120 minutes	54	18.2%	155	17.7%	**209**	**17.8%**
More than 120 minutes	15	5.1%	41	4.7%	**56**	**4.8%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Reported ground access cost

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
$10 or less	11	22.0%	52	28.6%	**63**	**27.2%**
$11 to $25	4	8.0%	32	17.6%	**36**	**15.5%**
$26 to $50	16	32.0%	50	27.5%	**66**	**28.4%**
More than $50	19	38.0%	48	26.4%	**67**	**28.9%**
Total	**50**	**100.0%**	**182**	**100.0%**	**232**	**100.0%**

Type of parking

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Short-term lot in airport terminal area	29	15.9%	44	11.3%	**73**	**12.8%**
Long-term lot in airport terminal area	78	42.9%	130	33.3%	**208**	**36.4%**
Remote airport lot	21	11.5%	61	15.6%	**82**	**14.3%**
Off-airport parking lot	51	28.0%	141	36.2%	**192**	**33.6%**
Other	3	1.6%	14	3.6%	**17**	**3.0%**
Total	**182**	**100.0%**	**390**	**100.0%**	**572**	**100.0%**

Reported parking cost

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
$25 or less	47	25.8%	90	23.1%	**137**	**24.0%**
$26 to $50	85	46.7%	146	37.4%	**231**	**40.4%**
$51 to $75	30	16.5%	71	18.2%	**101**	**17.7%**
More than $75	20	11.0%	83	21.3%	**103**	**18.0%**
Total	**182**	**100.0%**	**390**	**100.0%**	**572**	**100.0%**

Reported terminal access time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
5 minutes or less	155	52.2%	498	57.0%	**653**	**55.8%**
6 minutes to 10 minutes	69	23.2%	173	19.8%	**242**	**20.7%**
11 minutes to 15 minutes	47	15.8%	106	12.1%	**153**	**13.1%**
16 minutes to 20 minutes	15	5.1%	46	5.3%	**61**	**5.2%**
More than 20 minutes	11	3.7%	51	5.8%	**62**	**5.3%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Anticipated airport time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
30 minutes or less	10	3.4%	12	1.4%	**22**	**1.9%**
31 minutes to 60 minutes	88	29.6%	179	20.5%	**267**	**22.8%**
61 minutes to 90 minutes	119	40.1%	311	35.6%	**430**	**36.7%**
91 minutes to 120 minutes	64	21.5%	285	32.6%	**349**	**29.8%**
More than 120 minutes	16	5.4%	87	10.0%	**103**	**8.8%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Check-in for your flight before or after arriving at the terminal

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Before	213	71.7%	653	74.7%	**866**	**74.0%**
After	84	28.3%	221	25.3%	**305**	**26.0%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Check bags

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Yes	156	52.5%	591	67.6%	**747**	**63.8%**
No	141	47.5%	283	32.4%	**424**	**36.2%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Baggage fee

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
None	211	71.0%	568	65.0%	**779**	**66.5%**
$25 or less	61	20.5%	219	25.1%	**280**	**23.9%**
$26 to $50	19	6.4%	62	7.1%	**81**	**6.9%**
More than $50	6	2.0%	25	2.9%	**31**	**2.6%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Reported time to reach security after entering the airport terminal

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
5 minutes or less	100	33.7%	200	22.9%	**300**	**25.6%**
6 minutes to 10 minutes	74	24.9%	223	25.5%	**297**	**25.4%**
11 minutes to 15 minutes	48	16.2%	194	22.2%	**242**	**20.7%**
16 minutes to 20 minutes	28	9.4%	121	13.8%	**149**	**12.7%**
21 minutes to 25 minutes	14	4.7%	38	4.3%	**52**	**4.4%**
26 minutes to 30 minutes	18	6.1%	47	5.4%	**65**	**5.6%**
More than 30 minutes	15	5.1%	51	5.8%	**66**	**5.6%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Anticipated security time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
5 minutes or less	21	7.1%	31	3.5%	**52**	**4.4%**
6 minutes to 10 minutes	39	13.1%	125	14.3%	**164**	**14.0%**
11 minutes to 15 minutes	66	22.2%	165	18.9%	**231**	**19.7%**
16 minutes to 20 minutes	49	16.5%	151	17.3%	**200**	**17.1%**
21 minutes to 25 minutes	14	4.7%	59	6.8%	**73**	**6.2%**
26 minutes to 30 minutes	68	22.9%	185	21.2%	**253**	**21.6%**
More than 30 minutes	40	13.5%	158	18.1%	**198**	**16.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Reported security time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
5 minutes or less	46	15.5%	80	9.2%	**126**	**10.8%**
6 minutes to 10 minutes	65	21.9%	208	23.8%	**273**	**23.3%**
11 minutes to 15 minutes	69	23.2%	240	27.5%	**309**	**26.4%**
16 minutes to 20 minutes	48	16.2%	151	17.3%	**199**	**17.0%**
21 minutes to 25 minutes	23	7.7%	59	6.8%	**82**	**7.0%**
26 minutes to 30 minutes	16	5.4%	58	6.6%	**74**	**6.3%**
More than 30 minutes	30	10.1%	78	8.9%	**108**	**9.2%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Reported time to reach gate area after clearing security

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
5 minutes or less	148	49.8%	375	42.9%	**523**	**44.7%**
6 minutes to 10 minutes	92	31.0%	300	34.3%	**392**	**33.5%**
11 minutes to 15 minutes	32	10.8%	128	14.6%	**160**	**13.7%**
16 minutes to 20 minutes	16	5.4%	49	5.6%	**65**	**5.6%**
21 minutes to 25 minutes	6	2.0%	9	1.0%	**15**	**1.3%**
26 minutes to 30 minutes	0	0.0%	10	1.1%	**10**	**0.9%**
More than 30 minutes	3	1.0%	3	0.3%	**6**	**0.5%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Time after reaching the gate until boarding commenced

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
15 minutes or less	30	10.1%	54	6.2%	**84**	**7.2%**
16 minutes to 30 minutes	77	25.9%	183	20.9%	**260**	**22.2%**
31 minutes to 45 minutes	63	21.2%	211	24.1%	**274**	**23.4%**
46 minutes to 60 minutes	73	24.6%	221	25.3%	**294**	**25.1%**
More than 60 minutes	54	18.2%	205	23.5%	**259**	**22.1%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Activities performed at the gate (multiple responses allowed)

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Made telephone calls	104	35.0%	272	31.1%	**376**	**32.1%**
Checked email	173	58.2%	382	43.7%	**555**	**47.4%**
Used mobile device	172	57.9%	418	47.8%	**590**	**50.4%**
Listened to music or podcasts offline	27	9.1%	73	8.4%	**100**	**8.5%**
Used computer offline	15	5.1%	21	2.4%	**36**	**3.1%**
Used computer online via Wi-Fi	48	16.2%	107	12.2%	**155**	**13.2%**
Read a book, magazine, newspaper, business documents, etc.	132	44.4%	487	55.7%	**619**	**52.9%**
Purchased food or drinks	143	48.1%	479	54.8%	**622**	**53.1%**
Visited retail/news/gift shop	52	17.5%	214	24.5%	**266**	**22.7%**
Visited airline club area	21	7.1%	30	3.4%	**51**	**4.4%**
Other	16	5.4%	64	7.3%	**80**	**6.8%**
None of the above	12	4.0%	26	3.0%	**38**	**3.2%**
Total	**297**		**874**		**1171**	

Departing flight on-time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Yes	268	90.2%	791	90.5%	**1059**	**90.4%**
No	29	9.8%	83	9.5%	**112**	**9.6%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Flight arrived at destination airport on-time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Yes	267	89.9%	795	91.0%	**1062**	**90.7%**
No	30	10.1%	79	9.0%	**109**	**9.3%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Departure time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
12AM - 4:59AM	0	0.0%	9	1.0%	**9**	**0.8%**
5AM - 5:59AM	8	2.7%	15	1.7%	**23**	**2.0%**
6AM - 6:59AM	29	9.8%	95	10.9%	**124**	**10.6%**
7AM - 7:59AM	32	10.8%	110	12.6%	**142**	**12.1%**
8AM - 8:59AM	36	12.1%	91	10.4%	**127**	**10.8%**
9AM - 9:59AM	25	8.4%	82	9.4%	**107**	**9.1%**
10AM - 10:59AM	34	11.4%	90	10.3%	**124**	**10.6%**
11AM - 11:59AM	22	7.4%	69	7.9%	**91**	**7.8%**
12PM - 12:59PM	23	7.7%	51	5.8%	**74**	**6.3%**
1PM - 1:59PM	18	6.1%	57	6.5%	**75**	**6.4%**
2PM - 2:59PM	13	4.4%	49	5.6%	**62**	**5.3%**
3PM - 3:59PM	18	6.1%	37	4.2%	**55**	**4.7%**
4PM - 4:59PM	13	4.4%	23	2.6%	**36**	**3.1%**
5PM - 5:59PM	9	3.0%	20	2.3%	**29**	**2.5%**
6PM - 6:59PM	7	2.4%	19	2.2%	**26**	**2.2%**
7PM - 7:59PM	3	1.0%	18	2.1%	**21**	**1.8%**
8PM - 8:59PM	4	1.3%	24	2.7%	**28**	**2.4%**
9PM - 9:59PM	0	0.0%	5	0.6%	**5**	**0.4%**
10PM - 10:59PM	2	0.7%	4	0.5%	**6**	**0.5%**
11PM - 11:59PM	1	0.3%	6	0.7%	**7**	**0.6%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Amount of delay at the departing airport

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
No delay	268	90.2%	791	90.5%	**1059**	**90.4%**
Up to 30 minutes	10	3.4%	28	3.2%	**38**	**3.2%**
More than 30 minutes	19	6.4%	55	6.3%	**74**	**6.3%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Scheduled arrival time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
12AM - 4:59AM	2	0.7%	6	0.7%	**8**	**0.7%**
5AM - 5:59AM	0	0.0%	3	0.3%	**3**	**0.3%**
6AM - 6:59AM	1	0.3%	4	0.5%	**5**	**0.4%**
7AM - 7:59AM	5	1.7%	8	0.9%	**13**	**1.1%**
8AM - 8:59AM	11	3.7%	20	2.3%	**31**	**2.6%**
9AM - 9:59AM	18	6.1%	40	4.6%	**58**	**5.0%**
10AM - 10:59AM	17	5.7%	78	8.9%	**95**	**8.1%**
11AM - 11:59AM	32	10.8%	71	8.1%	**103**	**8.8%**
12PM - 12:59PM	22	7.4%	94	10.8%	**116**	**9.9%**
1PM - 1:59PM	32	10.8%	80	9.2%	**112**	**9.6%**
2PM - 2:59PM	37	12.5%	72	8.2%	**109**	**9.3%**
3PM - 3:59PM	32	10.8%	79	9.0%	**111**	**9.5%**
4PM - 4:59PM	15	5.1%	62	7.1%	**77**	**6.6%**
5PM - 5:59PM	15	5.1%	45	5.1%	**60**	**5.1%**
6PM - 6:59PM	16	5.4%	48	5.5%	**64**	**5.5%**
7PM - 7:59PM	11	3.7%	26	3.0%	**37**	**3.2%**
8PM - 8:59PM	9	3.0%	30	3.4%	**39**	**3.3%**
9PM - 9:59PM	11	3.7%	33	3.8%	**44**	**3.8%**
10PM - 10:59PM	9	3.0%	37	4.2%	**46**	**3.9%**
11PM - 11:59PM	2	0.7%	38	4.3%	**40**	**3.4%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Amount of delay at the destination airport

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
No delay	267	89.9%	795	91.0%	**1062**	**90.7%**
Up to 30 minutes	5	1.7%	23	2.6%	**28**	**2.4%**
More than 30 minutes	25	8.4%	56	6.4%	**81**	**6.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Preferred arrival time

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
12AM - 4:59AM	0	0.0%	1	0.1%	**1**	**0.1%**
5AM - 5:59AM	1	0.3%	0	0.0%	**1**	**0.1%**
6AM - 6:59AM	2	0.7%	5	0.6%	**7**	**0.6%**
7AM - 7:59AM	7	2.4%	2	0.2%	**9**	**0.8%**
8AM - 8:59AM	11	3.7%	26	3.0%	**37**	**3.2%**
9AM - 9:59AM	16	5.4%	56	6.4%	**72**	**6.1%**
10AM - 10:59AM	27	9.1%	77	8.8%	**104**	**8.9%**
11AM - 11:59AM	37	12.5%	108	12.4%	**145**	**12.4%**
12PM - 12:59PM	35	11.8%	131	15.0%	**166**	**14.2%**
1PM - 1:59PM	26	8.8%	77	8.8%	**103**	**8.8%**
2PM - 2:59PM	32	10.8%	78	8.9%	**110**	**9.4%**
3PM - 3:59PM	18	6.1%	82	9.4%	**100**	**8.5%**
4PM - 4:59PM	25	8.4%	37	4.2%	**62**	**5.3%**
5PM - 5:59PM	21	7.1%	57	6.5%	**78**	**6.7%**
6PM - 6:59PM	15	5.1%	36	4.1%	**51**	**4.4%**
7PM - 7:59PM	11	3.7%	24	2.7%	**35**	**3.0%**
8PM - 8:59PM	11	3.7%	33	3.8%	**44**	**3.8%**
9PM - 9:59PM	1	0.3%	25	2.9%	**26**	**2.2%**
10PM - 10:59PM	1	0.3%	10	1.1%	**11**	**0.9%**
11PM - 11:59PM	0	0.0%	9	1.0%	**9**	**0.8%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Flight connections

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Yes	109	36.7%	297	34.0%	**406**	**34.7%**
No	188	63.3%	577	66.0%	**765**	**65.3%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Number of connections

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
1 connection	105	96.3%	281	94.6%	**386**	**95.1%**
2 connections	4	3.7%	16	5.4%	**20**	**4.9%**
Total	**109**	**100.0%**	**297**	**100.0%**	**406**	**100.0%**

Made stops where respondent stayed on the same plane during the trip

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Yes	12	4.0%	39	4.5%	**51**	**4.4%**
No	285	96.0%	835	95.5%	**1120**	**95.6%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Number of stops

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
1 stop	12	100.0%	36	92.3%	**48**	**94.1%**
2 stops	0	0.0%	3	7.7%	**3**	**5.9%**
Total	**12**	**100.0%**	**39**	**100.0%**	**51**	**100.0%**

Attitudes and Air Travel Background

Agreement with: I regularly search websites for cheap flights and sometimes will fly if I see a bargain

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Strongly disagree	51	17.2%	99	11.3%	**150**	**12.8%**
Somewhat disagree	64	21.5%	153	17.5%	**217**	**18.5%**
Neither agree nor disagree	68	22.9%	191	21.9%	**259**	**22.1%**
Somewhat agree	82	27.6%	289	33.1%	**371**	**31.7%**
Strongly agree	32	10.8%	142	16.2%	**174**	**14.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Agreement with: I generally shop for the cheapest flights and do not consider other factors

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Strongly disagree	26	8.8%	65	7.4%	**91**	**7.8%**
Somewhat disagree	90	30.3%	217	24.8%	**307**	**26.2%**
Neither agree nor disagree	73	24.6%	140	16.0%	**213**	**18.2%**
Somewhat agree	94	31.6%	373	42.7%	**467**	**39.9%**
Strongly agree	14	4.7%	79	9.0%	**93**	**7.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Agreement with: I try to fly without checked baggage whenever possible

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Strongly disagree	38	12.8%	104	11.9%	**142**	**12.1%**
Somewhat disagree	37	12.5%	156	17.8%	**193**	**16.5%**
Neither agree nor disagree	32	10.8%	107	12.2%	**139**	**11.9%**
Somewhat agree	89	30.0%	235	26.9%	**324**	**27.7%**
Strongly agree	101	34.0%	272	31.1%	**373**	**31.9%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Agreement with: Recent changes to airport security have discouraged me from flying

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Strongly disagree	86	29.0%	275	31.5%	**361**	**30.8%**
Somewhat disagree	68	22.9%	198	22.7%	**266**	**22.7%**
Neither agree nor disagree	86	29.0%	227	26.0%	**313**	**26.7%**
Somewhat agree	42	14.1%	130	14.9%	**172**	**14.7%**
Strongly agree	15	5.1%	44	5.0%	**59**	**5.0%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Agreement with: I am trying to fly less for environmental reasons

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Strongly disagree	139	46.8%	421	48.2%	**560**	**47.8%**
Somewhat disagree	73	24.6%	199	22.8%	**272**	**23.2%**
Neither agree nor disagree	75	25.3%	215	24.6%	**290**	**24.8%**
Somewhat agree	9	3.0%	28	3.2%	**37**	**3.2%**
Strongly agree	1	.3%	11	1.3%	**12**	**1.0%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Business travel frequency

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Up to 3 trips	118	39.7%	779	89.1%	**897**	**76.6%**
4-7 trips	86	29.0%	66	7.6%	**152**	**13.0%**
8-12 trips	43	14.5%	25	2.9%	**68**	**5.8%**
More than 12 trips	50	16.8%	4	0.5%	**54**	**4.6%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Leisure travel frequency

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Up to 3 trips	238	80.1%	551	63.0%	**789**	**67.4%**
4-7 trips	46	15.5%	274	31.4%	**320**	**27.3%**
8-12 trips	12	4.0%	41	4.7%	**53**	**4.5%**
More than 12 trips	1	0.3%	8	0.9%	**9**	**0.8%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Membership status in frequent flyer programs: most preferred airline

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Not a member	44	14.8%	179	20.5%	**223**	**19.0%**
Standard level	157	52.9%	574	65.7%	**731**	**62.4%**
Elite – 1st (or only) level	96	32.3%	121	13.8%	**217**	**18.5%**
Elite – highest level	0	0.0%	0	0.0%	**0**	**0.0%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Membership status in frequent flyer programs: second most preferred airline

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Not a member	83	27.9%	298	34.1%	**381**	**32.5%**
Standard level	183	61.6%	521	59.6%	**704**	**60.1%**
Elite – 1st (or only) level	31	10.4%	55	6.3%	**86**	**7.3%**
Elite – highest level	0	0.0%	0	0.0%	**0**	**0.0%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Membership status in frequent flyer programs: third most preferred airline

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Not a member	113	38.0%	416	47.6%	**529**	**45.2%**
Standard level	167	56.2%	422	48.3%	**589**	**50.3%**
Elite – 1st (or only) level	17	5.7%	36	4.1%	**53**	**4.5%**
Elite – highest level	0	0.0%	0	0.0%	**0**	**0.0%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Membership status in each of these frequent flyer programs: airline used for recent trip (if not one of the three most preferred)

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Not a member	19	30.2%	76	39.6%	**95**	**37.3%**
Standard level	37	58.7%	107	55.7%	**144**	**56.5%**
Elite – 1st (or only) level	7	11.1%	9	4.7%	**16**	**6.3%**
Elite – highest level	0	0.0%	0	0.0%	**0**	**0.0%**
Total	**63**	**100.0%**	**192**	**100.0%**	**255**	**100.0%**

Missed flight connection in last 2 years

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Yes	65	21.9%	119	13.6%	**184**	**15.7%**
No	232	78.1%	755	86.4%	**987**	**84.3%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Demographics

Gender

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Male	182	61.3%	351	40.2%	**533**	**45.5%**
Female	115	38.7%	523	59.8%	**638**	**54.5%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Age

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Under 18	0	0.0%	0	0.0%	**0**	**0.0%**
18-24	9	3.0%	38	4.3%	**47**	**4.0%**
25-34	26	8.8%	76	8.7%	**102**	**8.7%**
35-44	42	14.1%	81	9.3%	**123**	**10.5%**
45-54	76	25.6%	129	14.8%	**205**	**17.5%**
55-64	75	25.3%	233	26.7%	**308**	**26.3%**
65-74	59	19.9%	283	32.4%	**342**	**29.2%**
75 years or older	10	3.4%	34	3.9%	**44**	**3.8%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Number of adults in household

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
1 adult (I live alone)	52	17.5%	163	18.6%	**215**	**18.4%**
2 adults	199	67.0%	590	67.5%	**789**	**67.4%**
3 adults	29	9.8%	81	9.3%	**110**	**9.4%**
4 adults	15	5.1%	31	3.5%	**46**	**3.9%**
5 adults	2	0.7%	6	0.7%	**8**	**0.7%**
6 or more adults	0	0.0%	3	0.3%	**3**	**0.3%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Number of children in household

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
No children	233	78.5%	777	88.9%	**1010**	**86.3%**
1 child	33	11.1%	49	5.6%	**82**	**7.0%**
2 children	25	8.4%	36	4.1%	**61**	**5.2%**
3 children	6	2.0%	10	1.1%	**16**	**1.4%**
4 children	0	0.0%	2	0.2%	**2**	**0.2%**
5 children	0	0.0%	0	0.0%	**0**	**0.0%**
6 or more children	0	0.0%	0	0.0%	**0**	**0.0%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Individual annual income before taxes

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Under $10,000	4	1.3%	37	4.2%	**41**	**3.5%**
$10,000 - $19,999	4	1.3%	30	3.4%	**34**	**2.9%**
$20,000 - $29,999	7	2.4%	37	4.2%	**44**	**3.8%**
$30,000 - $39,999	10	3.4%	74	8.5%	**84**	**7.2%**
$40,000 - $49,999	23	7.7%	83	9.5%	**106**	**9.1%**
$50,000 - $74,999	66	22.2%	199	22.8%	**265**	**22.6%**
$75,000 - $99,999	58	19.5%	161	18.4%	**219**	**18.7%**
$100,000 - $149,999	70	23.6%	161	18.4%	**231**	**19.7%**
$150,000 - $199,999	30	10.1%	44	5.0%	**74**	**6.3%**
$200,000 - $249,999	10	3.4%	26	3.0%	**36**	**3.1%**
$250,000 or more	15	5.1%	22	2.5%	**37**	**3.2%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Household income (multiple-adult households)

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Under $10,000	2	0.8%	6	0.8%	**8**	**0.8%**
$10,000 - $19,999	2	0.8%	3	0.4%	**5**	**0.5%**
$20,000 - $29,999	0	0.0%	12	1.7%	**12**	**1.3%**
$30,000 - $39,999	8	3.3%	21	3.0%	**29**	**3.0%**
$40,000 - $49,999	6	2.4%	28	3.9%	**34**	**3.6%**
$50,000 - $74,999	37	15.1%	129	18.1%	**166**	**17.4%**
$75,000 - $99,999	45	18.4%	157	22.1%	**202**	**21.1%**
$100,000 - $149,999	64	26.1%	194	27.3%	**258**	**27.0%**
$150,000 - $199,999	44	18.0%	73	10.3%	**117**	**12.2%**
$200,000 - $249,999	25	10.2%	43	6.0%	**68**	**7.1%**
$250,000 or more	12	4.9%	45	6.3%	**57**	**6.0%**
Total	**245**	**100.0%**	**711**	**100.0%**	**956**	**100.0%**

Household income (single-adult households)

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Under $10,000	0	0.0%	6	3.7%	**6**	**2.8%**
$10,000 - $19,999	2	3.8%	9	5.5%	**11**	**5.1%**
$20,000 - $29,999	2	3.8%	6	3.7%	**8**	**3.7%**
$30,000 - $39,999	3	5.8%	20	12.3%	**23**	**10.7%**
$40,000 - $49,999	7	13.5%	22	13.5%	**29**	**13.5%**
$50,000 - $74,999	12	23.1%	40	24.5%	**52**	**24.2%**
$75,000 - $99,999	11	21.2%	37	22.7%	**48**	**22.3%**
$100,000 - $149,999	7	13.5%	17	10.4%	**24**	**11.2%**
$150,000 - $199,999	3	5.8%	2	1.2%	**5**	**2.3%**
$200,000 - $249,999	1	1.9%	2	1.2%	**3**	**1.4%**
$250,000 or more	4	7.7%	2	1.2%	**6**	**2.8%**
Total	**52**	**100.0%**	**163**	**100.0%**	**215**	**100.0%**

Employment status

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Employed full-time	203	68.4%	309	35.4%	**512**	**43.7%**
Employed part-time	23	7.7%	70	8.0%	**93**	**7.9%**
Self-employed	39	13.1%	57	6.5%	**96**	**8.2%**
Student	3	1.0%	27	3.1%	**30**	**2.6%**
Retired	23	7.7%	356	40.7%	**379**	**32.4%**
Homemaker	2	0.7%	30	3.4%	**32**	**2.7%**
Not currently employed	3	1.0%	19	2.2%	**22**	**1.9%**
Unable to work due to illness or injury	1	0.3%	6	0.7%	**7**	**0.6%**
Total	**297**	**100.0%**	**874**	**100.0%**	**1171**	**100.0%**

Industry of employment (if employed)

	Business		Leisure		Total	
	Count	Percent	Count	Percent	Count	Percent
Airline	0	0.0%	0	0.0%	**0**	**0.0%**
Arts	4	1.5%	5	1.1%	**9**	**1.3%**
Communications	8	3.0%	4	0.9%	**12**	**1.7%**
Construction	2	0.8%	5	1.1%	**7**	**1.0%**
Education	38	14.3%	92	21.1%	**130**	**18.5%**
Finance/insurance	15	5.7%	29	6.7%	**44**	**6.3%**
Government	14	5.3%	41	9.4%	**55**	**7.8%**
Health/medical	31	11.7%	80	18.3%	**111**	**15.8%**
Manufacturing	34	12.8%	18	4.1%	**52**	**7.4%**
Marketing/market research	0	0.0%	0	0.0%	**0**	**0.0%**
Professional services	37	14.0%	34	7.8%	**71**	**10.1%**
Retail trade	8	3.0%	26	6.0%	**34**	**4.9%**
Technology	12	4.5%	25	5.7%	**37**	**5.3%**
Transportation	7	2.6%	8	1.8%	**15**	**2.1%**
Wholesale trade	6	2.3%	5	1.1%	**11**	**1.6%**
Other	49	18.5%	64	14.7%	**113**	**16.1%**
Total	**265**	**100.0%**	**436**	**100.0%**	**701**	**100.0%**

3 ADDITIONAL ANALYSIS

Comparison of Reported Flights in Survey to National Data

Chapter 3 documenting the stated preference (SP) survey and results showed the location of the origin and destination airports for the recent trip reported by each survey respondent graphically and compared the percentage of survey reported trips using the top five origin and destination airports in the reported trips with the corresponding distribution of originating passengers at those airports from the U.S. Department of Transportation (DOT) 10% Origin & Destination (O&D) survey data for 2008. The comparison suggested that the SP survey trips were somewhat over-sampled at four out of the five top origin airports in the survey sample and significantly over-sampled in three of the five top destination airports. It was noted that the three over-sampled destination airports were all warm weather destinations (Orlando, Fort Lauderdale, and Phoenix), which could reflect the fact that the survey was performed in the February to April time frame and covered trips taken over the preceding six-month period, when those destinations are likely to be more popular than at other times of the year.

The U.S. DOT 10% O&D Survey (also termed Database 1B, or DB1B, data) is a sample of (nominally) 10% of all air passenger itineraries as shown on the ticket or equivalent record. There is believed to be a small amount of under-reporting for a variety of reasons, so the sample is generally somewhat less than 10%. However, the sample is believed to provide quite accurate data on the distribution of air trips across different U.S. domestic airport-pair markets.

The following analysis considers a broader range of markets and uses the DB1B data for the first quarter of 2013, which corresponds to when the majority of the trips reported in the survey were undertaken. Although the majority of the SP survey responses were obtained during the period April 1-20, 2013 (8% of the responses used in the analysis were collected during the pilot “soft launch” on February 20-22, 2013), the recent air trips that were reported by respondents occurred in the previous six months, with the majority of these taking place during the first quarter of 2013, as shown in Table B-1. In total, some 59% of the reported air trips took place during the first quarter of 2013, with 24% taking place in the fourth quarter of 2012 and 14% taking place in the second quarter of 2013.

Table B-1. Date of Reported Recent Air Trip

Survey Date	February 22-23		April 1-20	
When trip taken	Responses	Percent	Responses	Percent
Third quarter 2012	13	13%	26	2.4%
Fourth quarter 2012	41	42%	238	22.2%
First quarter 2013	44	45%	648	60.4%
Second quarter 2013			161	15.0%
Total	98	100%	1,073	100%
	8.4%		91.6%	

The analysis of the DB1B data was based on the "market" dataset, which reports travel itineraries in directional airport-pair markets, without considering whether a directional trip is non-stop or has any intermediate flight connections. Some adjustments were made to the DB1B data before comparing the distribution of passenger trips to that of the reported trips in the SP survey. The DB1B data was limited to one-way trips and the first leg of round trips. This avoided double-counting the return leg of round trips or downstream legs of more complex, multi-leg itineraries and resulted in the number of outbound trips from a given origin airport. Thus travel between Los Angeles International Airport (LAX) and New York Kennedy International Airport (JFK), say, counts only passengers beginning their trip at LAX, while travel between JFK and LAX counts only passengers beginning their trip at JFK.

Distribution of Trip Origin and Destination Airports

The comparison was made between the number of SP survey responses with a given trip origin or destination airport (i.e. the number of ***air parties***) and the number of ***passengers*** reported in the DB1B data. Although the number of passengers in each air party in the SP data was given in the survey responses, it was felt that the relatively small number of respondents with a given origin or destination airport (and particularly a given airport-pair market) would mean that a small number of larger air parties in SP data for trips using a given airport or market would be likely to distort the distribution. Thus in effect it was assumed that the distribution of air party size was the same in all markets and hence that the distribution of air parties across different markets is the same as the distribution of air passengers.

In comparing the geographic distribution of air trips from the SP survey data with the distribution from the DB1B data, it should be noted that necessarily some airports or markets in the DB1B data would not appear in the SP survey data due to the survey sample size. In comparison to the 1,171 usable responses in the SP survey, there were 443 origin airports and 446 destination airports in the DB1B data. Given that a relatively small number of markets account for a large proportion of all trips, there are thus many itineraries in the DB1B data that could not appear in the SP data. The percentage of SP survey trips with origin and destination airports with varying levels of survey responses for each airport, together with the corresponding percentage of passengers in the DB1B data is shown in Table B-2.

The correspondence of the distribution of trips across airports between the SP survey responses and the DB1B data is fairly close. Origin airports with 10 or more air trips in the SP data accounted for 66% of the reported trips in the survey and 68% of the passengers in the DB1B data, while destinations with 10 or more trips in the SP data accounted for 72% of the reported trips in the survey and 69% of the passengers in the DB1B data. The difference between the SP data and the DB1B data becomes less (much less in the case of origin airports) when considering origin and destination airports with five or more air trips in the SP data.

Table B-2. Percentage of Reported Recent Air Trips in Markets of Different Size

Trip Origin Airport					
Survey Responses per Airport	Airports	Survey Responses	Percent	2013 Q1 O&D Passengers	Percent
10+	40	770	65.8%	4,021,584	67.6%
5-9	34	222	19.0%	1,003,815	16.9%
2-4	47	128	10.9%	511,341	8.6%
1	51	51	4.4%	220,604	3.7%
Total	172	1,171	100%		96.8%
Trip Destination Airport					
Survey Responses per Airport	**Airports**	**Survey Responses**	**Percent**	**2013 Q1 O&D Passengers**	**Percent**
10+	35	839	71.6%	4,099,275	68.9%
5-9	24	159	13.6%	884,533	14.9%
2-4	49	133	11.4%	667,446	11.2%
1	40	40	3.4%	179,956	3.0%
Total	148	1,171	100%		98.1%

As can be seen from the totals in Table B-2, the origin airports in the SP survey trips account for about 97% of all the domestic passenger trips in the DB1B data, while the destination airports in the SP survey trips account for about 98% of all domestic passenger trips in the DB1B data. While the percentage of the SP survey trips at individual airports and the corresponding percentage of passenger trips in the DB1B data naturally vary more widely from airport to airport, the correspondence is still generally reasonable, as shown in Figure B-1 for origin airports and Figure B-2 for destination airports, in each case for airports with more than 5,000 outbound passengers (for origin airports) or inbound passengers (for destination airports) in the DB1B data.

The solid diagonal line in Figure B-1 and Figure B-2 shows the percentage of survey responses in the SP survey that would have occurred at each airport if the survey sample had matched the distribution of passengers in the DB1B data exactly. The two dashed lines in each figure show a range of 5 survey responses (0.43%) above and below this relationship. It can be seen that the majority of airports fall within this range. It can also be seen that more origin airports are under-sampled (and by a larger number of survey responses) than are over-sampled.

Figure B-1. Correspondence between Survey Trips and DB1B Passengers – Origin Airports with more than 5,000 Outbound DB1B Passengers

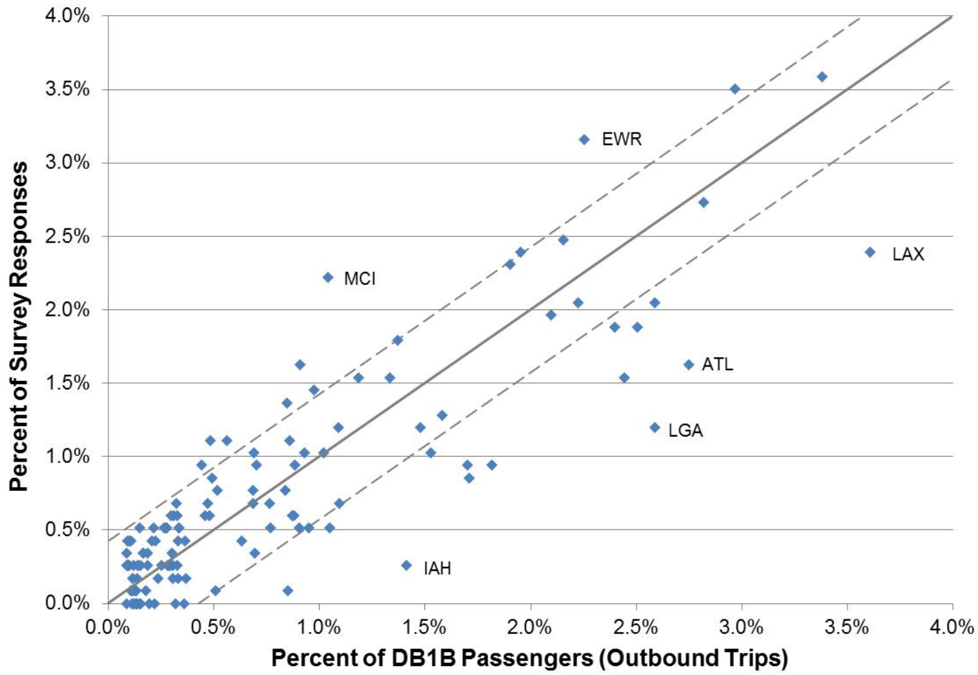
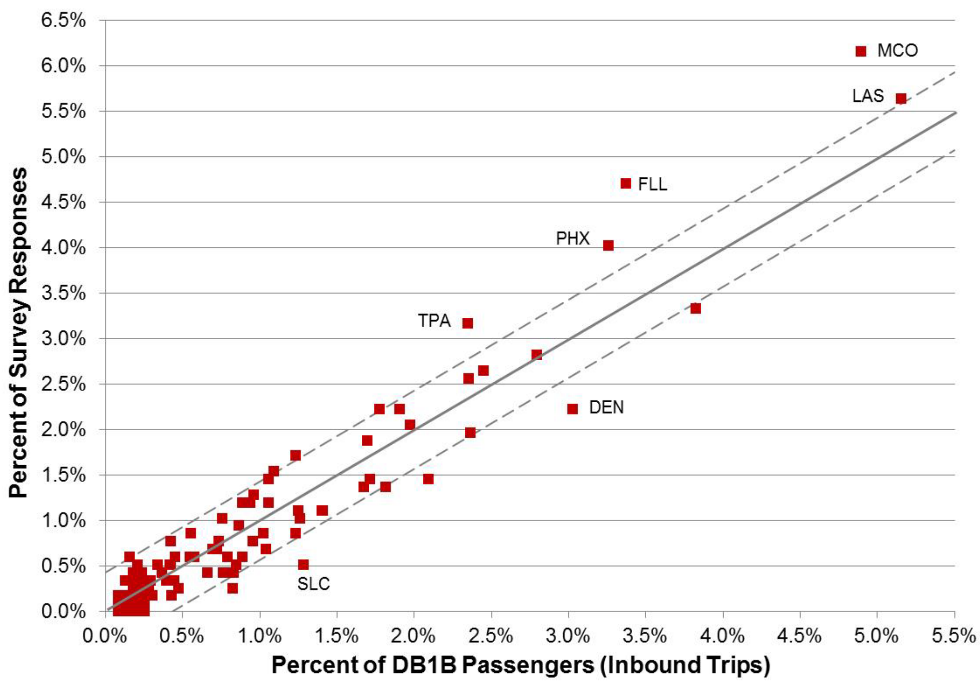


Figure B-2. Correspondence between Survey Trips and DB1B Passengers – Destination Airports with more than 5,000 Inbound DB1B Passengers



Destination airports show a similar number of under-sampled and over-sampled airports, but several over-sampled airports have a greater level of over-sampling than the under-sampled airports. As noted in Chapter 3, these over-sampled airports correspond to major vacation destinations, particularly in winter.

The lower limit of 5,000 passengers for the airports shown in Figure B-1 and Figure B-2 was chosen because this is slightly less than the traffic level (5,184 passengers) that is equivalent to one survey response in the SP survey if the sample had matched the distribution of passengers in the DB1B data exactly. As can be seen from Figure B-1 and Figure B-2, there were only a few airports with traffic levels above 5,000 passengers that had no air party trips in the SP survey (12 origin airports and 15 destination airports), and all had traffic levels that would have resulted in less than five survey responses if the survey sample had matched the distribution of DB1B passengers exactly.

Obviously, a much higher proportion of airports with less than 5,000 passengers in the DB1B data would not appear in the SP survey sample, since they would have had a fraction of a response, had the survey sample matched the distribution of the DB1B passengers. In total, origin airports with less than 5,000 outbound passengers in the DB1B data account for 5.4% of the total DB1B passengers, while the airports in this set that appear in the SP survey data account for 7.0% of the survey trips, although only 19% of the airports in this range appear in the survey data. Thus the SP survey appears to have slightly over-sampled the origin airports with the lowest levels of traffic, notwithstanding the fact that the majority of these airports do not appear in the survey trips. Conversely, destination airports with less than 5,000 inbound passengers in the DB1B data account for 4.5% of total DB1B passengers, while the airports in this set that appear in the SP survey data account for 4.4% of the survey trips. Thus the destination airports with the lowest levels of traffic appear to have been slightly under-sampled, although the difference is equivalent to less than two survey responses.

Distribution of Airport-Pair Markets

In order to compare the distribution of air party trips by airport-pair markets in the SP survey data with the DB1B data for the first quarter of 2013, the directional DB1B markets appearing in the data were divided into four size ranges: those with more than 5,000 reported passengers in the data, those with between 501 and 5,000 passengers, those with 11 to 500 passengers, and those with 10 or less passengers. The lower bound of 5,000 reported passengers in the upper size range was chosen for the reason given above for the analysis of the distribution of SP survey responses by origin and destination airports: directional markets with a little over 5,000 reported passengers (strictly 5,184) would be equivalent to one reported trip in the SP survey data if the distribution of survey responses by market corresponded to that in the DB1B data.

However, given 1,171 SP survey responses, those responses necessarily reflect a small fraction of all the markets in the DB1B data. There were over 57,000 directional markets in the DB1B data, as shown in Table B-3. However, there were only 146 markets with more than 5,000 reported passengers (less than 0.3% of all markets), although these accounted for 18% of all reported passengers. A further 2,277 markets (about 4% of all markets) with 501 to 5,000 reported passengers accounted for 55% of all reported passengers. Thus, the top 4.2% of directional markets reported in the DB1B account for 73% of all passengers.

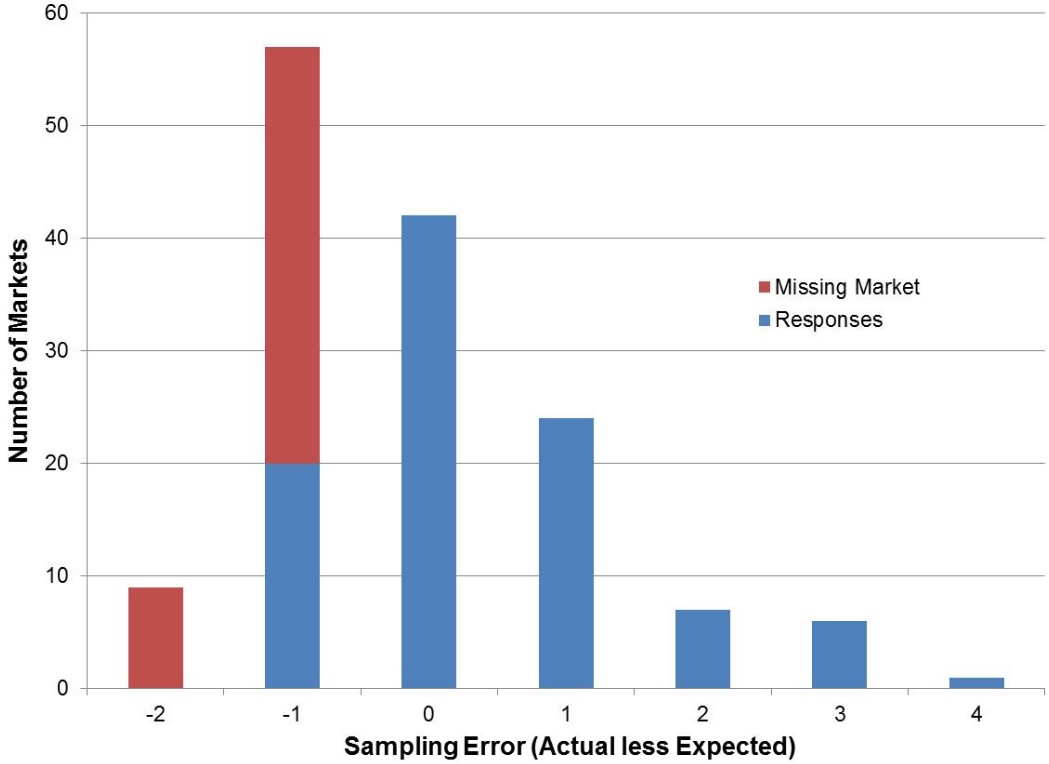
Table B-3. Distribution of Markets by Size – DB1B 2013Q1 Passengers vs. SP Survey

Market Size (DB1B Pax)	Number of Markets	DB1B Passengers	Percent	SP Survey Reported Trips		
				Markets	Responses	Percent
>5,000	146	1,112,444	18.3%	100	192	16.4%
501-5,000	2,277	3,327,614	54.8%	475	572	48.8%
11-500	19,553	1,520,226	25.0%	357	363	31.0%
10 or less	35,159	110,431	1.8%	43	44	3.8%
Total	57,135	6,070,715	100%	975	1,171	100%

The distribution of the recent trips reported by SP survey respondents by market size according to the DB1B data is generally close to the distribution of reported passengers in the DB1B data, with the larger markets (those with more than 500 DB1B reported passengers) somewhat under-represented (about 8% fewer trips than would be expected if the distribution corresponded to the DB1B data) and smaller markets correspondingly over-represented.

For the 146 directional markets with more than 5,000 reported DB1B passengers, the number of SP survey responses that would have been expected if the reported trips in SP survey had reflected the distribution of DB1B passengers was calculated and compared to the actual number of reported trips in each market. Obviously, in general the expected number of trips in a given market is non-integer. The resulting sampling error (the difference between the actual number of reported trips in each market and the expected number) was rounded to an integer and the distribution of these errors is shown in Figure B-3.

Figure B-3. Distribution of Sampling Errors for SP Survey Trips – Markets with Over 5,000 DB1B Passengers



Of the 146 directional markets with more than 5,000 reported DB1B passengers, only 100 had reported trips in the SP survey data, so the survey missed 32% of the markets. However, as can be seen from Figure B-3, the majority of these (80%) would only have been expected to have had one reported trip and the remainder would only have been expected to have had two reported trips. Of the markets for which trips were reported, 42% had the expected number of trips, with 24% having one more reported trip than expected and 20% having one less reported trip than expected. There were no markets with reported trips that were under-sampled by more than one trip. Only 14 markets (10% of all markets) were over-sampled by more than one reported trip. The largest over-sampled market (Newark International to Fort Lauderdale Hollywood International) had four more reported trips than would have been expected from the DB1B data. The six markets with three more reported trips than expected from the DB1B data were:

- Denver International (DEN) to Las Vegas McCarran (LAS)
- Newark International (EWR) to Orlando International (MCO)
- Detroit Metropolitan (DTW) to Fort Lauderdale Hollywood International (FLL)
- Denver International (DEN) to Los Angeles International (LAX)
- Atlanta Hartsfield-Jackson International (ATL) to Orlando International (MCO)
- Hartford Bradley International (BDL) to Orlando International (MCO)

With the exception of DEN to LAX, these are all major vacation destinations, particularly warm-weather destinations. Even Southern California could be considered a vacation destination, and in fact two of the four SP survey respondents reporting a trip in this market were taking a vacation trip.

As discussed in Chapter 3.6 and the following section of this appendix, the profile of the SP survey respondents appears to be skewed toward those who may be more likely to take a vacation trip to a warm weather destination (older, higher income) than air travelers in general, so the over-sampling of these markets is not surprising. Equally, it is not surprising in a survey with a sample size that would result in only one or two expected trips in many markets that a number of such markets would not have any reported trips.

On balance, the distribution of reported trips by market appears to be generally representative of the distribution of air passenger trips across the full range of markets of varying size and geographic location in the U.S.

Comparison of Reported Air Party Characteristics in Survey to Airport Survey Data

In order to assess whether the recent air trips reported by the stated preference (SP) survey respondents are broadly representative of air passengers in general, the reported air party characteristics from the SP survey data were compared to those reported in a survey of departing air passengers performed at Los Angeles International Airport (LAX) in 2011 The LAX survey was chosen for the comparison because it had one of the largest sample sizes of recent air passenger surveys, with some 8,984 respondents making directional domestic trips that began at LAX (*i.e.* excluding passengers making flight connections at LAX). The survey was conducted in two waves in late August (Aug. 22-28) and mid-October (Oct. 17-23) 2011 in order to capture some of the seasonal differences in air party characteristics. However, it should be noted that the LAX survey respondents were traveling at a different time of year from the majority of the reported trips by the SP survey respondents.

The respondents making domestic trips were divided into Southern California residents (those departing on the outbound leg of their trip) and visitors who lived elsewhere in the U.S. (those departing on the return leg of their trip). This gave 4,177 resident responses and 4,060 U.S. visitor responses (131 U.S. resident respondents did not provide enough information on their place of residence to be classified as residents or visitors and 616 respondents were not U.S. residents). This allowed the distinction to be made between survey respondents for whom LAX was their trip origin and those for whom LAX (or Southern California) was their trip destination.

However, in comparing the profiles of respondents to the LAX and SP surveys it should be borne in mind that it is not known how closely air travelers using LAX compare to a national profile of air travelers using the full network of U.S. commercial airports. In particular, the median household income of residents of Southern California is somewhat higher than the median national income. According to the U.S. Census Bureau, the 2012 Los Angeles metropolitan area median household income was $57,745, or about 12.5% higher than the national median household income of $51,324. It should also be borne in mind that the SP survey was a survey of individual ***air travelers***, while the LAX survey (like all intercept surveys) was a survey of ***air trips***. The distribution of respondent characteristics in an intercept survey will reflect a higher presence in the survey sample of travelers who make more frequent air trips, since they have a higher likelihood of being surveyed. This will affect the observed distribution of those characteristics (such as household income) that influence the propensity for air travel (measured by the number of air trips made per year) or differ across travelers making different numbers of air trips per year.

Air Party Size

The distribution of air party size for the SP survey reported trips and the LAX survey is shown in Table B-4.

Table B-4. Distribution of Air Party Size – Reported Trips vs. LAX Survey

				LAX Air Pax Survey	
Air party	Survey Responses	Percent	Survey Passengers	SoCal Residents	Other US Residents
1	509	43.5%	509	65.2%	62.2%
2	504	43.0%	1,008	21.2%	23.7%
3	71	6.1%	213	6.7%	7.1%
4	55	4.7%	220	3.5%	4.1%
5	11	0.9%	55	1.8%	1.3%
6+	21	1.8%	210	1.4%	1.6%
Total	1,171	100%	2,215	100%	100%

The SP survey trips have a much smaller proportion of single-person parties and a correspondingly higher proportion of two-person parties. The proportion of air parties of three or more is approximately the same between the SP survey trips and the LAX survey, although there are minor differences in the proportion of parties of different sizes. The LAX survey also gave a somewhat higher proportion of single-person parties for Southern California (SoCal) residents than other U.S. residents.

Trip Purpose

The distribution of trip purposes for the SP survey trips compared to the LAX survey is shown in Table B-5. The SP survey trips had a much smaller proportion of business trips, although a significantly higher proportion of trips to attend a conference. The proportion of SP survey trips for a vacation was only slightly higher than in the LAX survey, while the proportion of trips to visit friends or relatives was significantly higher. The proportion of SP survey trips to attend school or college was significantly lower than in the LAX survey, although this could be a reflection of the age profile of the SP survey respondents discussed below. It might also be partly influenced by the timing of the two surveys, since the first wave of the LAX survey took place in late August when many students would be returning to school.

Table B-5. Distribution of Trip Purposes – Reported Trips vs. LAX Survey

	SP Survey Responses					LAX Air Pax Survey	
Trip purpose	Survey Responses	Percent	Survey Passengers	Percent	Avg. Party Size	SoCal Residents	Other US Residents
Business	206	17.6%	306	13.8%	1.49	32.9%	37.9%
Attend conference	91	7.8%	151	6.8%	1.66	1.8%	4.4%
Vacation	386	33.0%	914	41.3%	2.37	32.1%	29.1%
Visit friends/relatives	391	33.4%	644	29.1%	1.65	23.0%	19.1%
Attend school/college	9	0.8%	10	0.5%	1.11	5.8%	3.3%
Other	88	7.5%	190	8.6%	2.16	4.3%	6.2%
Total	1,171	100%	2,215	100%		100%	100%
Business	305	26.0%	478	21.6%	1.57	34.7%	42.3%
Personal	866	74.0%	1,737	78.4%	2.01	65.3%	57.7%
Total	1,171	100%	2,215	100%	1.89	100%	100%

The LAX survey responses showed a somewhat different trip purpose profile for SoCal residents than visitors, with a higher proportion of trips for business, to attend a conference or convention, or “other” purposes (which include military travel) by visitors compared to SoCal residents. This is not particularly surprising, since it is likely that Southern California is a stronger attractor of business and convention trips from elsewhere in the U.S. than other areas attract such trips from Southern California.

The SP survey respondents reported making 3,337 air trips in the previous year for business or work and 3,669 air trips for other purposes, implying that on an annual basis some 48% of all air trips made by the survey respondents were for business, compared to only 26% of the most recent reported trips. Compared with the LAX survey results, the proportion of business trips (which would have included attending a conference or convention) was somewhat higher than given by the LAX survey for Southern California visitors and significantly higher than given by the LAX survey for Southern California residents. It follows that the proportion of air trips in the previous year reported by SP survey respondents for non-business purposes was correspondingly lower than the proportion of non-business air trips given by the LAX survey. The SP survey asked respondents for the number of business and non-business trips taken in the previous year without any further breakdown by purpose, so it is unclear how the lower proportion of non-business trips reported by the SP survey respondents relates to the various trip purpose categories in the LAX survey. The lower proportion of business trips in the LAX survey relative to the annual trips by SP survey respondents may also reflect the timing of the LAX survey, with the first wave being conducted in late August, when it could be expected there would be a lower proportion of business trips than at other times of the year, as well as the importance of Southern California as a vacation destination.

In comparing the trip purpose profile from the two surveys, it should be noted that the surveys used slightly different wording and trip purpose categories, so some of the differences may be due to this. The LAX survey included a trip purpose category of "business and pleasure." It was assumed that such trips would have been reported as business trips in the SP survey (which did not have this response category), since generally such trips are primarily for business, with the pleasure aspect secondary to the business purpose. The LAX survey had a trip purpose category of "school related," which is somewhat broader than "attend school or college," although it was assumed that respondents making such trips in the SP survey would most likely have selected the "attend school or college" trip purpose. A few respondents in the SP survey selected the "other" trip purpose and wrote in a description that appeared to be school related (e.g. attending a college sporting event). These responses were recoded to "attend school or college." The use of different survey question response categories in different air passenger surveys is a recurring issue in comparing response data from different surveys.

The detailed trip purposes shown in Table B-5 were grouped into the two broader categories of "Business" and "Personal," where "Business" included attending a conference or convention and eight SP survey responses stating an "other" trip purpose where the trip purpose description suggested a business purpose. In the case of the LAX survey, "Business" included attending a conference or convention and military travel. Table B-5 also shows the number of air passengers in air parties for the SP survey trips and the resulting average air party size for trips of different purposes. Perhaps not unexpectedly, the average air party size for business trips was significantly lower than for vacation trips or trips to visit friends or relatives. Interestingly, the average air party size for trips to attend a conference or convention in the SP survey data was effectively the same as for trips to visit friends or relatives. This could be due to respondents attending a conference or convention traveling with a colleague or being accompanied by a spouse, family member, or friend. The higher average air party size for vacation trips may reflect the presence of children in the travel parties.

The average air party size for each trip purpose in the LAX survey compared to that for the SP survey reported trips is shown in Table B-6.

Table B-6. Average Air party Size – Reported Trips vs. LAX Survey

	SP Survey	LAX Air Pax Survey	
Trip purpose	Recent Trip	SoCal Residents	Other US Residents
Business	1.49	1.38	1.49
Attend conference	1.66	2.09	1.92

Vacation	2.37	2.03	2.03
Visit friends/relatives	1.65	1.45	1.51
Attend school/college	1.11	2.04	1.99
Other	2.16	1.40	1.66
Business	1.57	1.41	1.53
Personal	2.01	1.78	1.82
Total	1.89	1.66	1.70

Overall, the average air party size for visitors to Southern California is slightly higher than for Southern California residents. However, Southern California residents attending a conference or convention have a somewhat higher average air party size than visitors, while the average air party size for those on vacation trips is the same for both residents and visitors.

The average air party size for the reported trips in the SP survey was generally higher than that for LAX survey respondents, with the exception of SP survey respondents attending a conference or convention or making a trip to attend school or college. SP survey respondents making a business trip had the same average air party size as visitors making a business trip to Southern California, but somewhat higher than that for Southern California residents making business trips.

Household Income

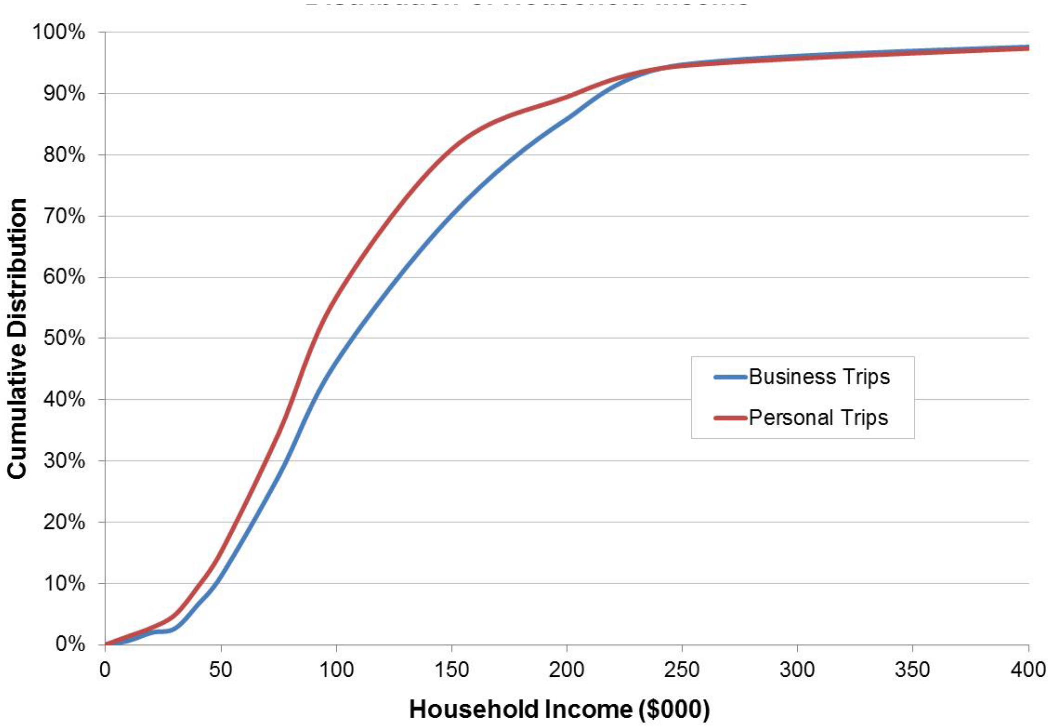
The reported household income of the respondents to the SP survey is shown in Table B-7 for those for whom their recent reported trip was for business (including attending a conference or convention) and those whose recent trip was for personal purposes. It can be seen that a somewhat higher proportion of respondents reporting a recent business trip had household incomes in the range $150,000 to $250,000 than those reporting a recent personal trip, although there was no significant difference for household incomes above $250,000.

Table B-7. Distribution of Household Income – SP Survey Reported Trips

	Business Trips		Personal Trips	
Household Income	Survey Responses	Percent	Survey Responses	Percent
Under $10,000	2	0.7%	12	1.4%
$10,000 - 19,999	4	1.3%	12	1.4%
$20,000 - 29,999	2	0.7%	18	2.1%
$30,000 - 39,999	12	3.9%	40	4.6%
$40,000 - 49,999	14	4.6%	49	5.7%
$50,000 - 74,999	50	16.4%	168	19.4%
$75,000 - 99,999	57	18.7%	193	22.3%
$100,000 - 149,999	73	23.9%	209	24.1%
$150,000 - 199,999	48	15.7%	74	8.5%
$200,000 - 249,999	27	8.9%	44	5.1%
$250,000 or more	16	5.2%	47	5.4%
Total	305	100%	866	100%

The two distributions are shown graphically in Figure B-4. It can be seen from the figure that in order to divide the survey respondents into three groups based on household income, given the income ranges used in the survey, the appropriate ranges would be below $75,000, from $75,000 to $150,000, and $150,000 or more. However, this would over-represent responses in the middle range and significantly under-represent responses in the upper range for personal trips and in the lower range for business trips.

Figure B-4. Distribution of Reported Household Incomes – SP Survey Respondents



The corresponding distributions for LAX survey respondents compared to the SP survey respondents are shown in Table B-8.

Table B-8. Distribution of Household Income – SP Survey Reported Trips vs. LAX Survey

Household Income	SP Survey Responses		LAX 2011 Air Pax Survey			
	Recent Trip		Business Trips		Personal Trips	
	Business Trips	Personal Trips	SoCal Residents	Other US Residents	SoCal Residents	Other US Residents
Under $20,000	2.0%	2.8%	5.0%	3.4%	14.2%	12.2%
$20,000 - 49,999	9.2%	12.4%	14.5%	10.4%	22.8%	20.5%
$50,000 - 99,999	35.1%	41.7%	30.7%	28.1%	28.3%	31.9%
$100,000 - 149,999	23.9%	24.1%	21.9%	26.0%	16.4%	17.3%
$150,000 - 199,999	15.7%	8.5%	12.9%	16.4%	8.8%	8.9%
$200,000 - 249,999	8.9%	5.1%	6.0%	7.1%	4.1%	4.5%
$250,000 or more	5.2%	5.4%	9.0%	8.7%	5.6%	4.7%
Total	100%	100%	100%	100%	100%	100%

The income ranges used in the LAX survey used only three categories for household incomes below $100,000, but used the same ranges as the SP survey for household incomes above $100,000. It should be noted that the LAX survey was performed two years earlier than the SP survey, so the income ranges are not strictly the same in real terms. However, inflation has been relatively low during this two-year period, so the comparison should be fairly close. In any case, errors in reporting household income by survey respondents are likely to be a much more significant issue than changes in income over a two-year period.

It can be seen from Table B-8 that a higher proportion of Southern California residents making business trips had household incomes below $100,000 than visitors, while a higher proportion of Southern California residents making personal trips had household incomes below $50,000 than visitors. On the other hand, a higher proportion of Southern California residents making both business and personal trips than visitors had household incomes of $250,000 or more. However, the household income distributions for each trip purpose for Southern California residents and visitors are broadly consistent.

In contrast to the LAX survey respondents, the household income distributions for SP survey respondents have a much smaller proportion with incomes below $50,000 for both trip purposes and a much higher proportion with incomes between $50,000 and $100,000 (for those whose recent trip was for business purposes) or $150,000 (for those whose recent trip was for personal purposes). Above those income levels, the proportion in each income range was generally fairly close to the corresponding proportions for the LAX survey respondents, except for the proportion of SP survey respondents whose recent trip was for business purposes with a household income of $250,000 or more, which was significantly less than the corresponding proportion of LAX survey respondents.

Thus overall it appears that a higher proportion of the SP survey respondents were reasonably well-off (household incomes between $50,000 and $150,000) compared to the LAX survey respondents, but the SP survey respondents whose recent trip was for business purposes included a smaller proportion of higher-income households ($250,000 or more).

Gender and Age

The gender of the SP survey respondents compared to the LAX survey respondents is shown in Table B-9 by trip purpose.

Table B-9. Gender of Survey Respondents – SP Survey Reported Trips vs. LAX Survey

	SP Survey Responses – Recent Trip				LAX 2011 Air Pax Survey			
	Business Trips		Personal Trips		Business Trips		Personal Trips	
Gender	Survey Resp.	Percent	Survey Resp.	Percent	SoCal Residents	Other US Residents	SoCal Residents	Other US Residents
Male	187	61.3%	346	40.0%	61.8%	62.6%	42.8%	44.3%
Female	118	38.7%	520	60.0%	38.2%	37.4%	57.2%	55.7%
Total	305	100%	866	100%	100%	100%	100%	100%

The SP survey respondents have a slightly higher proportion of female respondents than the LAX survey respondents, although the difference is not significant in the case of those whose recent trip was for business purposes. However, it should be noted that in the case of an intercept survey, such as the LAX air passenger survey, there may be a tendency for a male member of an air party with both genders to respond on behalf of the party, whereas in the SP survey the respondent, male or female, will report the recent trip irrespective of the composition of that air party. Therefore the slightly lower proportion of female respondents in the LAX survey, particularly in the case of trips for personal purposes, is not surprising.

The age distribution of the SP survey respondents compared to the LAX survey respondents is shown in Table B-10 by gender. The LAX survey used the same age ranges as the SP survey with two exceptions. The second oldest age range in the LAX survey was 55 to 65 (rather than 55 to 64 in the SP survey) and the oldest age range was over 65. Thus in comparing the two surveys one could expect a small difference in the proportions in these two age ranges.

Table B-10. Age of Survey Respondents – SP Survey Reported Trips vs. LAX Survey

<table>
<tr><th rowspan="3">Age</th><th colspan="4">SP Survey Responses – Recent Trip</th><th colspan="4">LAX 2011 Air Pax Survey</th></tr>
<tr><th colspan="2">Male Respondents</th><th colspan="2">Female Respond.</th><th colspan="2">Male Respondents</th><th colspan="2">Female Respondents</th></tr>
<tr><th>Survey Resp.</th><th>Percent</th><th>Survey Resp.</th><th>Percent</th><th>SoCal Residents</th><th>Other US Residents</th><th>SoCal Residents</th><th>Other US Residents</th></tr>
<tr><td>18-24</td><td>6</td><td>1.1%</td><td>41</td><td>6.4%</td><td>14.7%</td><td>12.2%</td><td>18.3%</td><td>14.9%</td></tr>
<tr><td>25-34</td><td>17</td><td>3.2%</td><td>85</td><td>13.3%</td><td>29.2%</td><td>22.9%</td><td>27.4%</td><td>23.8%</td></tr>
<tr><td>35-44</td><td>49</td><td>9.2%</td><td>74</td><td>11.6%</td><td>20.4%</td><td>21.3%</td><td>17.7%</td><td>19.1%</td></tr>
<tr><td>45-54</td><td>91</td><td>17.1%</td><td>114</td><td>17.9%</td><td>17.4%</td><td>21.4%</td><td>14.6%</td><td>17.9%</td></tr>
<tr><td>55-64</td><td>138</td><td>25.9%</td><td>170</td><td>26.6%</td><td>12.6%</td><td>15.4%</td><td>13.6%</td><td>16.9%</td></tr>
<tr><td>65-74</td><td>205</td><td>38.5%</td><td>137</td><td>21.5%</td><td rowspan="2">5.7%</td><td rowspan="2">6.7%</td><td rowspan="2">8.4%</td><td rowspan="2">7.3%</td></tr>
<tr><td>75+</td><td>27</td><td>5.1%</td><td>17</td><td>2.7%</td></tr>
<tr><td>Total</td><td>533</td><td>100%</td><td>638</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
<tr><td></td><td colspan="2">45.5%</td><td colspan="2">54.5%</td><td>49.4%</td><td>52.1%</td><td>50.6%</td><td>47.9%</td></tr>
</table>

However, it is clear from Table B-10 that there is a much larger difference between the SP survey respondents and the LAX survey respondents than can be attributed to the definition of the age ranges, with 70% of the male SP survey respondents and 52% of female SP survey respondents age 55 or older, compared to only 22% of male Southern California visitor respondents and 24% of female Southern California visitor respondents. The proportion of Southern California resident respondents age 55 or older is even lower at 18% of male respondents and 22% of female respondents.

Table B-10 shows another aspect of the SP survey respondents: there were more female respondents (about 55% of all respondents) than male. In contrast, only 51% of the Southern California resident respondents to the LAX survey were female, while only 48% of the Southern California visitor respondents were female. However, as noted above, the proportion of female survey respondents may somewhat understate the proportion of female adult air passengers.

Further Analysis of Survey Results and Model Estimation

This section describes further analysis of the survey results and additional model estimation undertaken by the Research Team in order to explore a number of issues that were identified in the course of the model estimation that generated the willingness-to-pay (WTP) values documented in Chapter 3.5. Some of the issues were resolved while others will require further research beyond the current project to fully address.

WTP for Time Savings by Respondent Age

The Research Team specifically looked at the effect of age on passengers' estimated values of willingness-to-pay (WTP) for various time components, given that the sample has a high proportion of respondents in older age groups. Table B-11 and Table B-12 show the WTP values by age for business and leisure travelers, respectively. This analysis would ideally control for income as well as age, since age is correlated with income. However, sample sizes were too small in each trip purpose category to segment them further by both age and income.

Table B-11. WTP Values by Age and Time Components for Business Travelers

Time Components	Respondent Age				
	up to 34	35-44	45-54	55-64	>= 65
Ground access time	$12.88	$21.51	$21.79	$19.57	$18.90
Terminal access time	$21.18	$35.38	$35.84	$32.20	$31.10
Check-in and security time	$23.98	$40.05	$40.58	$36.45	$35.21
Time to reach the gate area	$19.69	$32.88	$33.32	$29.93	$28.90
Gate time	$14.46	$24.16	$24.47	$21.99	$21.23
Flight time	$59.12	$58.17	$59.45	$37.50	$58.48

As can be seen in Table B-11, the WTP values for business travelers for the airport time components increase sharply from the age group of 34 and below to the next age group (35-44), then increase slightly in the next age group (45-54), drop noticeably in the age group 55-64 to below the values for the age group 35-44, then decline somewhat in the age group of 65 and over. These differences could be partly attributed to the higher median income levels of the older age groups. Table B-13 shows the median individual income for all age groups for both business and leisure travelers. However, the WTP values for business travelers for flight time show a very different pattern from those for the airport time components, with similar values for all age groups except those in the age group 55-64, who have a much lower value of time. It is unclear why the relative values for flight time by age group should be so different from those for the airport time components, or why those in the age group 55-64 would have a much lower value of WTP for flight time than the other age groups.

Similar results were obtained for the airport time components for leisure travelers (see Table B-12), although the large increase occurs between the age group 35-44 and the age group 45-54, rather than from the age group of 34 and below to the age group 35-44, and the WTP values increase from the age group 55-64 to the age group of 65 and over. Again, this could be partly attributed to the fact that the median individual income for the three oldest age groups each fell in the $75,000 to $99,999 category (see Table B-13). Surprisingly, the WTP values for the youngest age group for leisure travelers are higher than for business travelers.

Table B-12. WTP Values by Age and Time Components for Leisure Travelers

Time Components	Respondent Age				
	up to 34	35-44	45-54	55-64	>= 65
Ground access time	$15.79	$16.55	$21.27	$19.07	$19.59
Terminal access time	$21.92	$22.97	$29.54	$26.48	$27.19
Check-in and security time	$24.98	$26.18	$33.67	$30.19	$31.00
Time to reach the gate area	$20.08	$21.04	$27.06	$24.26	$24.91
Gate time	$17.47	$18.31	$23.55	$21.11	$21.68
Flight time	$31.65	$34.64	$34.50	$37.66	$34.88

Table B-13. Median Individual Income by Age

Market Segment	Respondent Age				
	up to 34	35-44	45-54	55-64	>= 65
Business	$50,000 - $74,999	$75,000 - $99,999	$100,000 - $149,999	$75,000 - $99,999	$75,000 - $99,999
Leisure	$40,000 - $49,999	$50,000 - $74,999	$75,000 - $99,999	$75,000 - $99,999	$75,000 - $99,999

The values of flight time for leisure travelers are generally more consistent than for business travelers, with the highest value of time occurring in the age group 55-64, rather than this age group having the lowest value of flight time, as found for business travelers.

WTP Values for Multi-person Travel Parties Compared to One-person Parties

Several model specifications were tested in order to identify the effect of party size on passengers' WTP values for various time components. Multi-person travel parties appear to have lower WTP values per person as compared to one-person parties. It was found during the course of this analysis that the drop in per person WTP values follows more or less a linear trend as the party size increases. This indicates that respondents, for the most part, were behaving as a single-person party instead of assuming that the access cost would be divided among the party members. Further research may be needed in order to confirm the effect of party size on travelers' WTP values, possibly by providing more explicit information related to access cost and party size in the choice experiments.

Differences in WTP Values for Different Time Components

The Research Team looked into the WTP values for various time components in more detail but did not reach different conclusions from those values reported previously. While some of these values may be counter-intuitive, (e.g. lower WTP values for access time compared to the WTP values found for savings of time spent in the airport and in-flight), there are a few points to note.

First, the higher WTP values for flight time compared to other time components could, in part, be attributed to the scale differences as a result of the magnitude of times shown in the experiments, and experienced in actual air trips. There are significant differences in reported times for various time components with average reported flight time (including connections) being the highest (as shown in Table B-14). If survey respondents were less sensitive to the relatively smaller differences in ground access times than the typically much greater differences in-flight times, this could have had an impact on the WTP values.

Table B-14. Reported Time Differences for Different Time Components

Time Components	Mean Reported Time (minutes)
Ground access time	50
Terminal access time	5
Time to security screening from entering the terminal	14
Time to clear security	17
Time to reach the gate area	8
Gate time	49
Flight time (including connections)	256

Second, the higher WTP values for the flight time may not be unreasonable. Flight time can be onerous given the fact that travelers are restricted in the activities they can accomplish and time spent in-flight is often uncomfortable. For example, travelers are more constrained in terms of relatively uncomfortable seating in crowded cabins, unavailability of internet and telecommunication services, limited privacy, inability to move for long periods of time, and so on. Additionally, the flight time in the analysis included the time spent making flight connections, which can be stressful in cases where the passenger has to rush between gates or even terminals to catch the connecting flight, or has to choose between the risk of missing a flight connection or incurring a lengthy wait time at the connecting airport. This suggests that future research should attempt to identify separate WTP values for in-flight time and time spent making flight connections at intermediate airports.

A third reason for the relatively low WTP values for access time could have arisen from the way in which the model estimation handled the perceived disutility of different access modes. From the choice data, it appears that the access modes shown in the choice experiments played a very significant role in travelers' decision-making. Table B-15 and Table B-16 show the WTP values for various time components with and without mode constants for business and leisure travelers, respectively. It is clear from the tables that the WTP values for access travel time savings become higher than for all other on-ground time components without mode constants (with one exception where the difference is probably not significant).

Table B-15. WTP Values for Time Components With and Without Mode Constants for Business Travelers

Time Components	Without Mode Constants	With Mode Constants
Ground access time	$39.06	$18.60
Terminal access time	$31.09	$33.85
Check-in and security time	$34.53	$37.19
Time to reach the gate area	$27.03	$32.25
Gate time	$21.56	$20.48

Table B-16. WTP Values for Time Components With and Without Mode Constants for Leisure Travelers

Time Components	Without Mode Constants	With Mode Constants
Ground access time	$25.05	$16.95
Terminal access time	$23.39	$26.01
Check-in and security time	$25.14	$28.45
Time to reach the gate area	$18.13	$22.83
Gate time	$15.59	$17.62

These results suggest that one possible reason for the relatively low estimated WTP values for ground access is because the modal constants have captured too much of the travel time disutility, reducing the estimated value of the ground access travel time coefficient and hence the implied WTP.

The question of whether the modal constants are accounting for some amount of travel time disutility that should really be accounted for by the ground access travel time variable appears to be an issue deserving of further research, since it could impact not only the WTP values for ground access but the design of future stated preference experiments to update and expand the findings of the current project. As a side benefit, it could also lead to better specifications for airport ground access mode choice models.

Finally, because the Research Team is aware of no other studies to estimate WTP values for on-airport time components, it has not been possible to compare the estimated WTP values with other values in the literature. Furthermore, since the additional analysis was unable to come up with a definitive explanation for the differences in estimated WTP values for flight time and airport time components, this suggests the need to carry out additional research either to confirm the results obtained from this study or to clarify those issues that the current study was not able to resolve.

Possible Non-linearity in Traveler Sensitivity to Time Differences

The Research Team tested possible non-linearity in both time and cost attributes. Specifically, log-linear transformations were tried on flight time, access time, airfare, and access cost components. The log-linear transformation essentially tries to capture any non-linear effect of the attribute values by splitting the coefficient into linear and non-linear components. The following form was used to capture the non-linear effects for different time and cost variables:

$$V_i = \cdots + \beta_{Cost} * Cost + \beta_{logCost} * \log Cost + \beta_{Time} * Time + \beta_{logtime} * \log Time$$

However, the Research Team was unable to find any significant and conclusive results from this analysis. For example, in the model with log-linear transformations for flight time and fare for business travelers, the coefficients for the linear and log-linear components of flight time and the linear component of fare came out to be insignificant.

Possible Non-linearity in Traveler Sensitivity to Expected Delay

Two variables were used to capture the effect of flight delay and reliability on travelers' choices—on-time performance (i.e., the probability of experiencing a delay) and the average delay for delayed flights. On-time performance was presented in the choice experiments as the percent of flights that arrive on-time and the delay-related attribute was presented as the average duration of delay for delayed flights. When these two variables were entered separately as categorical variables in the choice models, some of the estimated coefficients were statistically insignificant. The Research Team then calculated the expected value of delay as the product of the percentage of delayed flights from the on-time performance and the average delay of delayed flights and found this variable to be significant in the choice model estimation.

The reported WTP values for expected delay are based on 60 minutes of expected delay. The average WTP value for business travelers was estimated from the model coefficients to be $286/hour (or $286 per 60 minutes of expected delay) and the average WTP value for leisure travelers was estimated from the model coefficients to be $123/hour. It should be noted that 60 minutes of expected delay can result from many possible combinations of probability of delay and the corresponding amount of delay. For example, if the percentage of flights on-time is 50% (i.e., 50% of flights are delayed) and the corresponding delay is 120 minutes, the expected delay is calculated as 0.5 x 120 = 60 minutes. In other words, a business traveler would be willing to pay $286, on average, to avoid experiencing a situation where there is a 50% chance of experiencing a 2-hour delay. In this sense, the WTP values for flight delay should be interpreted as the value per hour of reducing the amount of expected delay rather than simply as the value per hour of any delay actually experienced (the length of which of course the traveler cannot know in advance of taking a flight). This is noted in the Guidebook.

The Research Team tested a power transformation for expected delay. The power utility for expected delay can be written as:

$$V_i = \cdots + \beta_{expecteddelay} * Expected\ Delay^{\lambda}$$

Where λ is estimated from the model and captures the non-linear effects of expected delay attribute. However, the Research Team was unable to find any significant and conclusive results from this analysis. The estimated values of the β and λ coefficients were found to be statistically insignificant.

The Role of Income on WTP from the Stated Preference Choice Experiments

The Research Team explored differences in the effect on WTP of individual income (as reported in Chapter 3), household income, and per-person household income (household income adjusted for household size and composition), as well as the use of continuous variables for income, rather than simply dividing income into three categories.

Several continuous transformations were tested for respondent income in order to capture any systematic relationship between cost sensitivity and income. The Research Team first estimated models with separate cost variables for each income range to identify the type of relationship (if any) between income and cost sensitivity. Both individual and household incomes were initially used for this model estimation. Based on the results of this initial analysis, it was decided to use individual income as opposed to household income for subsequent analysis because of the following reasons:

- Individual income provided a better model fit compared to household income. The likelihood ratio tests and the adjusted rho-squared values for the models with individual income were higher than the models with household income.
- Household income of multi-person households would be inflated by the incomes of other household members although the income on a per-person basis might actually be lower than the respondent's individual income.
- It seems intuitively reasonable that business travelers would base their travel choice decisions on their individual income, which would largely reflect their salary or wage rate, rather than their household income, which would be influenced by the incomes of other household members.

Next, the Research Team tested various income transformations as discussed below:

1. To capture the relationship between cost sensitivity and income, the elasticities of the cost coefficients relative to income were estimated by including the following transformations in the utility equation:

$$V_i = \cdots + \beta_{Cost} * TC_i * \left(\frac{income}{\overline{income}}\right)^{\lambda_{c,inc}}$$

   where

   - TC_i gives the fare (or access cost) of alternative *i*
   - Income gives the income for the current respondent, with $\overline{income}$ giving the median income mid-point

The results using this transformation, however, did not adequately reflect the pattern of WTP values estimated when separate WTP values were calculated for each individual income group.

2. The second transformation tested involved dividing the cost (or fare) coefficient with different log-functions of income. For example, the WTP for flight time can be calculated by dividing the travel time coefficient by the airfare coefficient, after accounting for the log-income transformation that is used in the model specification. The following equation gives an example of such log-transformation.

$$WTP = 60 \times \frac{\beta_{FlightTime}}{\left[\frac{\beta_{Fare}}{LN(income/1000)}\right]}$$

   However, after trying different log-transformations it was found that none of the log-transformations significantly improved model fit or adequately reflected the pattern of WTP values estimated when separate WTP values were calculated for each individual income group.

3. Finally, a multi-step regression based approach was selected in order to come up with a continuous transformation for income. First, models were estimated with separate cost variables for each income category. The resulting cost coefficients were then regressed against individual income levels using a weighted linear regression. The weight for each cost coefficient was based on the inverse of the standard error of the cost coefficient. In other words, variables that were more significant had higher weights as compared to less significant variables. The resulting regression equation was used to calculate new cost coefficients for each income category. Lastly, these new cost coefficients were used to calculate the new WTP values for each income category.

As an example of the multi-step regression approach, Table B-17 shows the cost coefficients from the multinomial logit (MNL) model estimation for each individual income category for flight time by business travelers, together with the standard errors, implied WTP values, and weights used in the regression analysis to develop the continuous relationship between the cost coefficients and individual income. It is clear from the estimated cost coefficients for each income category (and on theoretical grounds, since the cost coefficient should always be negative, even at very high income levels) that the continuous relationship should be monotonic, non-linear and asymptotic to zero as income increases. Two such relationships were estimated using a weighted log-linear regression, an inverse relationship and a negative exponential relationship.

Table B-17. Business Traveler WTP Values for Flight Time based on Separate Regression Results for each Income Category

Individual Income	Cost Coefficient from MNL Model	Robust Standard Error	WTP based on MNL Model	Inverse of Standard Error	Weight

Less than $10,000	-0.00723	0.00151	$45.44		
$10,000-$19,999	-0.01203	0.00231	$27.30	433	0.0761
$20,000-$29,999	-0.01120	0.00640	$29.34	156	0.0275
$30,000-$39,999	-0.01016	0.00266	$32.33	376	0.0661
$40,000-$49,999	-0.01163	0.00255	$28.24	392	0.0690
$50,000-$74,999	-0.00892	0.00141	$36.81	709	0.1247
$75,000-$99,999	-0.00619	0.00148	$53.06	676	0.1188
$100,000-$149,999	-0.00579	0.00070	$56.70	1439	0.2530
$150,000-$199,999	-0.00434	0.00106	$75.73	943	0.1659
$200,000-$249,999	-0.00463	0.00178	$71.03	562	0.0988
$250,000 or more	-0.00250	0.00093	$131.35		

It can be seen from the WTP values in Table B-17 that the estimated cost coefficient for the lowest income category gave a much higher WTP than would be expected from the pattern of WTP values for the other income categories. This coefficient was therefore omitted from the log-linear regression to avoid distorting the resulting function. The log-linear regression used the mid-points of each income range. However, it was unclear what income level should be used for the top income range, since this was open-ended. Therefore this coefficient was also omitted from the regression, giving nine data points.

The resulting model coefficients for the inverse and negative exponential relationships are shown in Table B-18 and Table B-19, with the resulting relationships plotted on Figure B-5 together with the estimated values of the model coefficients shown in Table B-17. It can be seen that the two functional relationships appear to fit the data reasonably well, although they have a significantly different profile at lower income levels. It appears from Figure B-5 that a combined function using the average value of the cost coefficient given by each function would provide a better fit to the data and would provide a compromise between the two functions for lower income levels.

Table B-18. Weighted Log-linear Regression of Business Traveler Cost Coefficients for Flight Time based on Regression Results by Income Category – Inverse Relationship

Parameters	Units	Description	Value	Standard Error	T-statistic
Constant (ln B_0)	-	Constant	-3.03	0.261	-11.6
B_{income}	$000	ln(Individual Income)	-0.442	0.058	-7.6
Fit Statistics					
Number of parameters:	2				
Number of observations:	9				
Rho-square:	0.893				
Adjusted rho-square:	0.878				

Table B-19. Weighted Log-linear Regression of Business Traveler Cost Coefficients for Flight Time based on Regression Results by Income Category – Exponential Relationship

Parameters	Units	Description	Value	Standard Error	T-statistic
Constant (ln B_0)	-	Constant	-4.43	0.0965	-45.9
B_{income}	$000	Individual Income	-0.00529	0.00077	-6.9
Fit Statistics					
Number of parameters:	2				
Number of observations:	9				
Rho-square:	0.871				
Adjusted rho-square:	0.852				

The predicted cost coefficients for each income category using the two separate functions and the combined function, together with the corresponding WTP values for the combined function, calculated at the mid-point of each income category except for the lowest and highest categories, for which representative values were assumed, are shown in Table B-20.

Figure B-5. Variation of Cost Coefficients with Individual Income – Business Traveler Flight Time

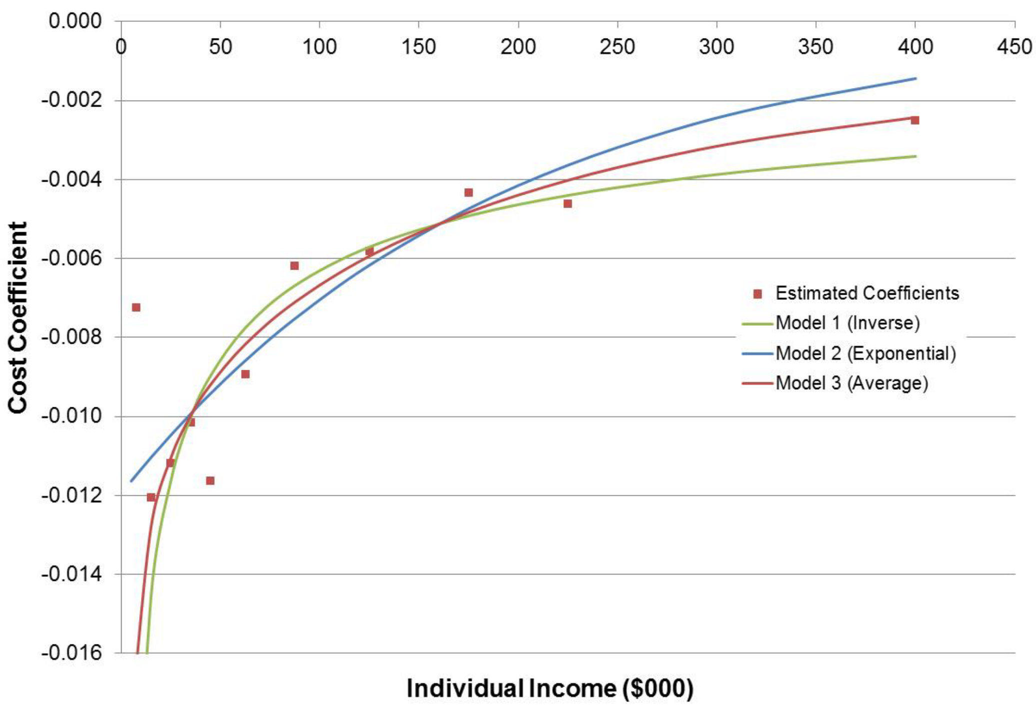


Table B-20. Business Traveler Cost Coefficients and WTP Values for Flight Time based on the Log-linear Regression Relationships by Individual Income

Individual Income	Assumed Income	Estimated Cost Coefficient			Implied WTP ($/hr)	WTP as Percent of Hourly Income
		Inverse Function	Negative Exponential Function	Average		
Less than $10,000	$7,500	-0.01981	-0.01148	-0.01565	$20.82	555%

$10,000-$19,999	$15,000	-0.01458	-0.01104	-0.01281	$25.44	339%
$20,000-$29,999	$25,000	-0.01163	-0.01047	-0.01105	$29.49	236%
$30,000-$39,999	$35,000	-0.01002	-0.00993	-0.00998	$32.66	187%
$40,000-$49,999	$45,000	-0.00897	-0.00942	-0.00919	$35.44	158%
$50,000-$74,999	$62,500	-0.00775	-0.00859	-0.00817	$39.88	128%
$75,000-$99,999	$87,500	-0.00668	-0.00752	-0.00710	$45.88	105%
$100,000-$149,999	$125,000	-0.00571	-0.00617	-0.00594	$54.88	88%
$150,000-$199,999	$175,000	-0.00492	-0.00453	-0.00483	$67.51	77%
$200,000-$249,999	$225,000	-0.00440	-0.00365	-0.00402	$81.11	72%
$250,000 or more	$400,000	-0.00341	-0.00144	-0.00243	$134.33	67%

Note: Estimated flight time coefficient = -0.00543 (time in minutes)

The estimated WTP values for the three broad individual income groups used in the Guidebook correspond reasonably well to the WTP values given by the combined function. The estimated WTP value for the individual income group less than $75,000 ($33.66/hour) corresponds to the WTP value from the continuous income relationship for an individual income of about $38,500, the estimated WTP value for the individual income group from $75,000 to $199,999 ($58.91/hour) corresponds to the WTP value for an individual income of about $141,400, while the estimated WTP value for the individual income group of $200,000 or more ($100.99/hour) corresponds to the WTP value for an individual income of about $292,900.

It should be noted that the WTP values given by the continuous income relationship increase more slowly than the income levels. The final column in Table B-20 expresses the WTP values as a percentage of the hourly individual income, assuming that the respondent worked 2,000 hours per year and all his or her income came from employment. These WTP values declined from over five times the hourly income for an individual annual income of $7,500 to about 67% of the hourly income for an individual annual income of $400,000.

It is unclear why lower income survey respondents appear to value their time at so much greater percentage of their hourly income than higher income respondents, but the evidence of the choice model estimation results is unambiguous. Some decline in the WTP value as a percentage of the hourly income with increasing income could be expected, since higher income individuals pay a higher proportion of their before-tax income in taxes and may gain a higher proportion of their gross income from sources other than employment, so dividing their reported annual income by 2,000 hours may overstate their hourly after-tax earned income by more than for those with lower incomes. Even so, the extent of the decline is surprising, as are the WTP values for lower income respondents who appear to value their time at several times their hourly income.

This suggests the need for future research to explore the relationship between WTP and income in more detail in order to better understand how WTP varies with income and the factors that influence this. Such research could benefit from a larger sample survey that includes questions that obtain more detail on respondent incomes.

Similar analysis to the above was undertaken for flight time savings by respondents who took a leisure trip and for savings of airport ground access time by respondents taking both business and leisure trips. In the interest of space the full details of the model estimation are omitted and the estimated log-linear model coefficients are shown in Table B-21, with the resulting WTP values shown in Table B-22 to Table B-24.

The analysis explored using both individual income and per-person household income, where per-person household income counted each child as equivalent to half an adult, reflecting the fact that children generally impose less cost on a household than adults, although obviously this can vary widely from household to household. The per-person household income was calculated for each respondent assuming that the household income was at the mid-point of the income range reported, except for the lowest and highest income ranges for which representative values were assumed as before. The resulting per-person household incomes were then assigned to the same income ranges that were used for the individual income analysis. However, using per-person household incomes significantly reduced the number of respondents in the three highest categories, which were therefore combined into a single category of $150,000 and above. In estimating and applying the log-linear functional relationships, rather than using the mid-point of each range, the average value of the individual per-person household incomes of respondents in each range was used.

Table B-21. Weighted Log-linear Regression of Cost Coefficients by Income Category for Leisure Traveler Flight Time and Airport Time Components (Business and Leisure)

			Flight Time		Airport Time Components			
			Leisure		Business		Leisure	
Parameters	**Units**	**Description**	**Value**	**T-stat.**	**Value**	**T-stat.**	**Value**	**T-stat.**
Income measure			Per-person h/h		Individual		Per-person h/h	
Inverse Relationship								
Constant (ln B_0)	-	Constant	-2.36	-3.8	-1.38	-3.3	-1.43	-3.3
B_{income}	$000	ln(Income)	-0.567	-3.9	-0.398	-4.5	-0.308	-2.9
Fit Statistics								
Parameters:			2		2		2	
Observations:			8		9		7	
Rho-square:			0.712		0.747		0.621	
Adjusted rho-square:			0.664		0.711		0.546	
Exponential Relationship								
Constant (ln B_0)	-	Constant	-4.08	-34.8	-2.88	-20.5	-2.32	-16.5
B_{income}	$000	Income	-0.00770	-6.8	-0.00256	-3.5	-0.00533	-2.6

Fit Statistics						
Parameters:	2		2		2	
Observations:	8		9		7	
Rho-square:	0.885		0.641		0.569	
Adjusted rho-square:	0.866		0.589		0.483	

It was found that while individual income generally gave a better fit to the choice models for business travelers, per-person household income generally gave a slightly better fit to the choice models for leisure travelers. This is not unreasonable, since business travel generally only involves the individual traveler, not other members of the household, while leisure travel often involves other members of the household, or even the entire household.

Table B-22. Leisure Traveler Cost Coefficients and WTP Values for Flight Time based on the Log-linear Regression Relationships by Per-person Household Income

Income Range	Assumed Income	Estimated Cost Coefficient			Implied WTP ($/hr)	WTP as Percent of Hourly Income
		Inverse Function	Negative Exponential Function	Average		
Less than $10,000	$6,000	-0.03415	-0.01615	-0.02515	$12.71	424%
$10,000-$19,999	$15,000	-0.02031	-0.01507	-0.01769	$18.03	241%
$20,000-$29,999	$25,000	-0.01521	-0.01396	-0.01458	$21.93	175%
$30,000-$39,999	$32,000	-0.01322	-0.01322	-0.01322	$24.19	151%
$40,000-$49,999	$44,000	-0.01104	-0.01206	-0.01104	$27.70	126%
$50,000-$74,999	$62,000	-0.00909	-0.01050	-0.00909	$32.66	105%
$75,000-$99,999	$87,000	-0.00750	-0.00866	-0.00808	$39.58	91%
$100,000-$149,999	$117,000	-0.00634	-0.00687	-0.00661	$48.40	83%
$150,000 or more	$211,000	-0.00455	-0.00336	-0.00396	$80.86	77%

Note: Estimated flight time coefficient = -0.00628 (time in minutes)

Table B-23. Business Traveler Cost Coefficients and WTP Values for Airport Ground Access Time based on the Log-linear Regression Relationships by Individual Income

Income Range	Assumed Income	Estimated Cost Coefficient			Implied WTP ($/hr)	WTP as Percent of Hourly Income
		Inverse Function	Negative Exponential Function	Average		
Less than $10,000	$7,500	-0.1128	-0.0553	-0.0840	$9.67	258%
$10,000-$19,999	$15,000	-0.0856	-0.0542	-0.0699	$11.62	155%
$20,000-$29,999	$25,000	-0.0698	-0.0529	-0.0613	$13.25	106%
$30,000-$39,999	$35,000	-0.0610	-0.0515	-0.0563	$14.43	82%
$40,000-$49,999	$45,000	-0.0552	-0.0502	-0.0527	$15.41	68%
$50,000-$74,999	$62,500	-0.0485	-0.0480	-0.0482	$16.84	54%
$75,000-$99,999	$87,500	-0.0424	-0.0451	-0.0437	$18.59	42%

$100,000-$149,999	$125,000	-0.0368	-0.0409	-0.0388	$20.92	33%
$150,000-$199,999	$175,000	-0.0322	-0.0360	-0.0341	$23.84	27%
$200,000-$249,999	$225,000	-0.0291	-0.0317	-0.0304	$26.74	24%
$250,000 or more	$400,000	-0.0231	-0.0202	-0.0217	$37.47	19%

Note: Estimated airport ground access time coefficient = -0.01354 (time in minutes)

In the case of the log-linear regression models of the business traveler airport time component cost coefficients, it proved necessary to combine the two lowest income ranges and the next two lowest income ranges in order to reduce large swings in the estimated value of the cost coefficients between successive income ranges. Since this reduced the number of data points available for the regressions, the estimated cost coefficient for the highest income range ($250,000 and over) was included in the regressions.

Table B-24. Leisure Traveler Cost Coefficients and WTP Values for Airport Ground Access Time based on the Log-linear Regression Relationships by Per-person Household Income

Income Range	Assumed Income	Estimated Cost Coefficient			Implied WTP ($/hr)	WTP as Percent of Hourly Income
		Inverse Function	Negative Exponential Function	Average		
Less than $10,000	$6,000	-0.1383	-0.0949	-0.1166	$10.99	366%
$10,000-$19,999	$15,000	-0.1042	-0.0905	-0.0974	$13.16	175%
$20,000-$29,999	$24,000	-0.0902	-0.0863	-0.0882	$14.53	121%
$30,000-$39,999	$32,000	-0.0825	-0.0827	-0.0826	$15.52	97%
$40,000-$49,999	$44,000	-0.0748	-0.0776	-0.0762	$16.82	76%
$50,000-$74,999	$62,000	-0.0673	-0.0705	-0.0689	$18.60	60%
$75,000-$99,999	$87,000	-0.0607	-0.0617	-0.0612	$20.95	48%
$100,000-$149,999	$117,000	-0.0554	-0.0526	-0.0540	$23.75	41%
$150,000 or more	$211,000	-0.0462	-0.0319	-0.0390	$32.85	31%

Note: Estimated airport ground access time coefficient = -0.02136 (time in minutes)

The estimated WTP values expressed as a percentage of the hourly income for leisure traveler flight time and business and leisure traveler airport ground access time shown in Table B-22 to Table B-24 exhibit a similar pattern to that of business traveler flight time shown in Table B-20, although of course the values for a given income level are different. It should be noted that the estimated WTP values for business and leisure travelers for either flight time or airport ground access time for a given income level are not directly comparable because the relationships for business travelers are based on individual income while those for leisure travelers are based on per-person household income, which are typically not the same for a given traveler (except in the case of those in one-person households). Overall, per-person household income tends to be lower than individual income, since it accounts for the presence of children in multi-person households.

There are two ways to use the relationships shown in Table B-18, Table B-19 and Table B-21 in order to estimate the corresponding WTP value for any given income. The first is to use the relationships to calculate the estimated value of the cost coefficient and combine this with the estimated value of the flight time or ground access time coefficient to calculate the WTP. The second is to use these relationships to calculate the WTP as a percentage of the hourly income for a range of income values, as has been done in Table B-20 and Table B-22 to Table B-24. These relationships between WTP as a percentage of hourly income and the corresponding income levels could be plotted and the WTP as a percentage of the hourly income for any desired income read from the graph and used to calculate the corresponding WTP value in dollars per hour. Alternatively, a suitable non-linear function could be fitted to the data and this function used to calculate the WTP as a percentage of the hourly income for any desired income and hence the corresponding WTP value in dollars per hour.

Are WTP Values for Travelers Different if They Pay for the Trip Themselves Versus being Reimbursed by Someone Else?

It was found that the WTP values were higher for both business and leisure travelers if their employer or someone else reimbursed them. Table B-25 shows WTP values for flight time and expected delay for both business and leisure travelers after controlling for who paid for the trip. While this finding is not surprising, it only has relevance for benefit-cost analysis if the proportion of travelers paying for their own trip at a given airport differs from the proportion among the SP survey respondents. Determining this will require data on who paid for air traveler trips at each airport in question. Such data can be collected in air passenger surveys that are typically used to collect data on trip purpose, traveler income, and other factors that can influence traveler WTP for time savings, although this has implications for the questions to be asked in such surveys.

The relatively large differences in WTP values between SP survey respondents who paid for their trip themselves and those for whom someone else paid for the trip shown in Table B-25 suggest that a future research would be useful to determine how the proportion of air travelers whose trip is paid for by someone else varies across different airports and different markets.

Table B-25. WTP Values based on Who Paid

Who paid	Business		Leisure	
	Flight Time	Expected Delay	Flight Time	Expected Delay
Traveler	$39.63	$220.97	$34.14	$121.20
Someone else	$57.50	$320.65	$41.23	$146.38

Comparison of Survey Ground Access Coefficients with Prior Airport Ground Access Models

The estimation of choice models that attempted to explain the choices made by the stated preference (SP) survey respondents generated estimated coefficients for airport ground access cost and time (which give the implied willingness to pay for ground access travel time savings) and alternative-specific constants for the four modes included in the stated preference experiments (drop-off by private vehicle, drive and park for the trip duration, taxi, and public transit). The alternative-specific (modal) constant for transit was set to zero, with the other three modal constants measuring the disutility of that mode relative to transit after accounting for the effect of the other variables (travel time and cost) included in the model.

In order to determine how consistent the estimated willingness to pay (WTP) for ground access time savings and the modal constants obtained from the SP survey experiments are with the corresponding values given by airport ground access model choice models developed in prior studies, an analysis was undertaken to compare the values estimated from the SP survey experiments with the corresponding values given by a sample of five prior airport ground access mode choice models. The five prior airport ground access mode choice models are documented in Appendix D of ACRP Synthesis 5 *Airport Ground Access Mode Choice Models* and consist of the following models:

1) The Atlanta Regional Commission Airport Passenger Model, which models air passenger access trips to Hartsfield-Jackson Atlanta International Airport (ATL), and was developed using survey data from 2000.
2) The Boston Logan International Airport (BOS) Model developed by the Boston Central Transportation Planning Staff using survey data from 1993.
3) The Chicago Airport Express Ridership Forecasting Study mode choice model developed by Resource Systems Group, Inc. (RSG) using survey data from 2003. The study estimated separate models for both Chicago O'Hare International Airport (ORD) and Chicago Midway Airport (MDW), although both models used the same variables and structure.
4) The Miami Intermodal Center Travel Demand Forecast Study mode choice model for Miami International Airport (MIA) developed by KPMG Peat Marwick using survey data from 1991.
5) The Portland International Airport (PDX) Alternative Mode Study mode choice model, developed by Cambridge Systematics, Inc. using survey data from 2003 and subsequently updated by modeling staff at Metro, the regional metropolitan planning organization.

The Boston and Chicago models estimated separate cost coefficients (which gave different WTP values) for low-income and high-income survey respondents. In the case of the

Chicago models, low income was defined as a household income less than $100,000 (at the time of the survey). The definition of low income was not clear from the documentation for the Boston model. The Portland model estimated separate cost coefficients for drop-off trips by private vehicle and those using other modes. For those using other modes, the cost coefficient was expressed as a function of the average household income in the zone where the access trip originated, which implied a WTP value that varied with income (although with the average household income in the origin zone, rather than of the survey respondent). However, since the study documentation does not show how the average zonal household income varied across the survey respondents, the WTP value used in the initial comparison with the WTP values estimated from the stated preference data in the current study for all respondent income groups was based on the cost coefficient for drop-off trips.

The ACRP Synthesis study included details of four other mode choice models. However, two of these used model coefficients adopted from a much earlier study that would give very dated estimates of WTP and would most likely have resulted in significantly biased estimates of the mode-specific constants, and the other two were for airports outside the U.S. (Toronto and London, England). Therefore these models were not included in the comparison.

The mode-specific disutility values were expressed in minutes of travel time in order to provide comparative values across models estimated using both survey data and associated travel times and costs assembled at different points in time over a period of more than a decade (from 1991 to 2003) and were adjusted to give the mode-specific disutility relative to drop-off by private vehicle. The implied values of travel time given by the prior studies were adjusted to 2013 dollars using the Consumer Price Index (CPI) for all urban consumers (CPI-U) for the metropolitan area for which the airport ground access model was estimated. This adjustment used the average CPI for the year in which the survey data for the model was assumed to have been collected (in some cases this was not clear from the model documentation) and the average CPI for the first half of 2013, when the stated preference survey was performed. The implied values of time were further adjusted for the change in real average household income in each metropolitan area from the year before each survey was performed to 2012, under the assumptions that air traveler willingness to pay (WTP) for travel time savings varies with their most recent annual household income and increases over time in proportion to household income.

Comparison of Implied Values of Ground Access Travel Time

The comparison between the implied WTP values estimated from the stated preference (SP) data in the current project and the values given by the five prior studies are shown in Table B-26. The table shows the WTP values estimated without considering the respondent income and the average and median values given by the prior studies, as well as the range of values given by those studies. In the case of the Boston and Chicago studies, where different implied WTP values were given for low-income and high-income respondents, the implied WTP values used in the average value were an average of the values for low- and high-income respondents. However, the median value treated the implied values for low- and high-income respondents as separate values.

Table B-26 also compares the implied WTP values that were estimated from the SP survey respondents for three different ranges of individual income with the implied WTP values for low-income and high-income survey respondents in the Boston, Chicago, and Portland studies. However, it should be noted that the income ranges in those prior studies do not correspond to the income ranges used in the model estimation in the current study, which in any case is based on individual income rather than household income, as used in the prior studies.

In interpreting the results shown in Table B-26, it should be noted that the SP model estimation in the current study used the term "leisure" trips for non-business trips, while the prior studies generally used the term "non-business" (which could include trip purposes that survey respondents might not consider "leisure," such as travel to and from college or travel for medical treatment). However, the trip purposes included in "leisure" were broadly consistent with those included in "non-business" by prior studies.

Table B-26. Comparison of Implied Willingness to Pay for Travel Time Savings (2013 $ per hour)

	SP Model	Prior Studies		
		Range	Average	Median
All Business Trips	18.60	19 to 150	83	80
All Leisure Trips	16.95	16 to 150	68	70
Business Trips				
Individual Income				
Less than $100k	13.92			
$100k to 200k	21.31			
$200k and over	38.49			
Household Income				
Low		41 to 80	59	57
High		79 to 117	100	102
Leisure Trips				
Individual Income				
Less than $100k	14.56			
$100k to 200k	16.63			
$200k and over	22.14			
Household Income				
Low		27 to 108	53	38
High		70 to 119	83	72

The range of WTP values implied by the models estimated in five prior studies is very large. The WTP values estimated from the SP data correspond to the lowest values in the range given by prior studies. These lower values correspond to the Atlanta Regional Commission model, which did not estimate coefficients for travel time and cost from the air passenger survey data, but rather adopted values for those coefficients from an urban travel demand model for the region. On the other hand, the WTP values at the upper end of the range given by prior studies correspond to the Miami Intermodal Center model, which also adopted values for travel time and cost coefficients from an earlier airport mode choice model for Newark International Airport, the details for which were somewhat vague in the Miami model documentation. In any case, this was the oldest model in the sample and presumably the Newark model was even older, so the WTP values from the Miami model may well be over-stated.

The WTP values for low- and high-income survey respondents from prior studies span a somewhat narrower range, since they exclude both the Atlanta and Miami models, although this is still quite wide and covers only three studies and mode choice models for four airports, which gives extra weight to the Chicago study. Since the cost coefficient in the Portland model varied with the average household income in each trip origin zone, the WTP values were calculated for average incomes of $50,000 and $150,000 respectively ($67,000 and $200,000 in 2012 dollars). The division between low-income and high-income households in the Chicago study ($100,000) would be a household income of $123,000 in 2012 dollars. However, the income ranges are not directly comparable with those in the SP model, which are based on individual rather than household income. An analysis of the individual and household incomes reported by respondents to the SP survey indicated that respondents with an individual income of $100,000 had an average household income of about $125,000. Thus the definition of low-income households in the prior studies covers the lowest of the three income ranges used in the SP model, while the definition of high-income households in prior studies covers the two higher income ranges in the SP model.

As can be seen from Table B-26, the median WTP values for the low-income households in the prior studies are significantly higher than even the WTP values for the highest income range in the SP model.

Comparison of Ground Access Modal Constants

The alternative-specific constants for each of the ground access modes play a major role in the choice model estimated from the SP data, since the difference between the smallest and largest of these is equivalent to about 100 minutes of travel time in the case of business trips and about 80 minutes of travel time in the case of leisure trips. Thus the mode choice preference could easily dominate differences in travel times in the other time components of the trip from the ground origin to the gate.

Table B-27 compares the value of the modal constants for the model estimated from the SP data with the corresponding constants in the models from prior studies, expressed in minutes of travel time relative to drop-off by private vehicle, where a positive value means the mode provides a greater utility (*i.e.* is more attractive) than drop-off, if all other factors are equivalent, by an amount equal to that many minutes of travel time.

The modal constants shown in Table B-27 for the SP model correspond to the coefficients estimated for all respondents without considering differences in individual income. The modal constants for the SP model estimated for the three different income groups were slightly higher (more positive), although the modal constants and ground access travel time coefficient were the same for each income group (only the cost coefficient varied by income group). These differences varied between about 2 and 5 minutes of travel time.

Table B-27. Comparison of Ground Access Mode-Specific Constants (minutes of travel time)

	SP Model	Prior Studies		
		Average	Median	Range
Business Trips				
Drive and park	10	32	37	-48 to 77
Taxi	-66	13	37	-114 to 118
Transit	-89	-39	-25	-119 to 28
Taxi (incl. BOS)		11	17	
Transit (MNL models)		-57	-57	-104 to -10
Leisure Trips				
Drive and park	5	46	36	-10 to 113
Taxi	-74	16	37	-67 to 66
Transit	-56	-22	-2	-102 to 26
Taxi (incl. BOS)		8	8	
Transit (MNL models)		-24	-24	-52 to 4

In comparing the modal constants from prior studies it should be noted that three of the five studies (covering four airports) used a nested logit (NL) structure, whereas the SP model and the other two prior studies used a multinominal logit (MNL) structure. The interpretation of differences in modal constants in NL models is more complex than for MNL models. While such differences for modes in the same nest have the same interpretation as differences in MNL models, the equivalent minutes of travel time corresponding to differences in modal constants for modes in different nests needs to take account of the probabilities of choosing a mode in each of the nests in addition to the probabilities of choosing a given mode within each nest. This involves the calculation of the so-called logsum values, which depend on the calculated utilities for all the modes within each nest, and which vary for each air party.

For each of the NL models, the transit mode was in a different nest from drop-off by private vehicle. In one of the NL models (the Boston model) taxi was in a different nest from both drop-off and transit. In all the NL models drive and park was in the same nest as drop-off.

Thus differences shown in Table B-27 between the modal constant for transit and those for other modes given by prior studies should be viewed with caution. In any case, the modal constants given by prior studies varied over a very wide range, most likely reflecting in part differences in model structure and the inclusion of other modes in the mode (including different public transport services). The modal constants for taxi from the Boston model were excluded from the average and median values for taxi in the primary comparison shown in Table B-27, although including them reduces both values, as shown in Table B-27, bringing the taxi modal constant closer to drop-off and the median values closer to the average values.

The modal constants for drive and park in the SP model are consistent with the average values from the prior studies in that they indicate that the mode is more attractive than drop-off, after controlling for differences in travel time and cost. This is reasonable, since drive and park avoids the need to have someone take the air party to the airport. However, the relative attractiveness given by the SP model coefficients seem much lower than found in the prior studies, equivalent to 5 to 10 minutes of travel time compared to an average of 32 to 46 minutes given by prior studies. The latter range seems more reasonable, being roughly equivalent to the one-way trip to the airport.

The modal constants for taxi in the SP model are significantly different from the average values from prior studies in that they indicate that the mode is substantially less attractive than drop-off after controlling for differences in cost (travel time is presumably the same), by an amount equivalent to 66 to 74 minutes of travel time, whereas the prior studies suggest that taxi is more attractive than drop-off, by an average amount equivalent to 13 to 16 minutes of travel time (a median amount equivalent to about 37 minutes of travel time). In any case, a disutility of taxi compared to drop-off that is equivalent to over an hour of travel time seems excessive. However, taxi as a mode is more applicable to the major urban areas reflected by the five prior studies than a national profile that includes various urban, suburban and rural areas.

While the comparison of the modal constants for transit between the SP model and the prior studies is subject to the potential bias due to the nested structure of several of the prior models, the values are consistent in that the modal constants for both the SP model and the average values from prior studies indicate that transit is less attractive than drop-off after controlling for differences in travel time and cost. However, the extent of the difference is substantially greater for the SP model compared to the average values from prior studies (as well as the median values, which give a somewhat lower disutility).

Table B-27 also shows the average modal constants for transit given by the two prior studies that used MNL models (the median values are of course the same). These gave average values of about 32 minutes less disutility than the values given by the SP model, although the SP model values lie within the range of the values from the prior studies for business trips (although just outside the range for leisure trips).

On balance, it appears that the modal constants given by the SP model show a greater disutility relative to drop-off trips for all three modes compared to the values found in prior studies, although the difference is much greater for taxi than the other two modes.