DEVELOPING A FRAMEWORK FOR THE ECNOMIC ASSESSMENT OF THE COSTS OF AIRPORT LAND USE INCOMPATIBILITY

This working paper has been prepared as part of the ACRP 03-03 Land Use Compatibility Study. This paper provides guidance on the methodology that would be used to assess the economic costs of airport land use incompatibility. It provides discussion the consequences and costs associated with the development of incompatible land uses and the impacts those uses can have on an airport. Additionally, the paper contains a framework for assessing these costs within an economic setting. The following is an outline of the contents of this document:

Incompatible Land Uses Around Airports: Some Evidence
The encroachment of incompatible land uses around airports is a significant problem in the United States. Incompatible land uses hinder the efficient and safe operation of airports, constrain airport development, and in the extreme case, threaten the very existence of airports. The following land uses are considered incompatible with airport operations:

- *Land uses with high concentration of people* – Land uses with high concentration of people are incompatible with airports because they expose more people not only to aircraft noise but also to risk of property damage and personal injury from aircraft accidents near airports.
- *Noise-sensitive land uses* – Aircraft noise can intrude on a person's quality of life by interrupting sleep, conversation, and other activities. Noise-sensitive land uses – such as residences, schools, hospitals, and churches – are therefore incompatible with airports.
- *Tall structures* – Tall structures, including tall trees, present accident risk to aircraft.
- *Land uses that create visual obstruction* – Land uses that produce dust, glare, light emissions, smoke, steam, and smog can obscure visibility and cause aircraft accidents.
- *Land uses that attract wildlife* – Collisions with wildlife are known to cause aircraft accidents.

A preliminary assessment survey conducted by the Mead & Hunt ACRP 03-03 Team in 2007 (the 2007 survey) looked into the incidence of incompatible land uses around airports, among other related issues. **FIGURE 1** illustrates the responses to the question posed to survey respondents. The 2007 survey obtained responses from 123 airports, consisting of 34 commercial service (CS) airports and 89 general aviation (GA) airports. This section presents a summary of the survey responses. The results have not been weighted to correct for any sample biases since the objective of this section is simply to show empirical evidence of the presence of incompatible land uses around airports and not to draw any statistical inferences regarding the extent of incompatible land use encroachment in all the airports in the United States.

Land Uses with Concentration of People
Nearly 58% of 123 airport respondents reported moderate to extensive presence of land uses with concentration of people around them (**TABLE 1**). Relatively more CS airports (61.8%) reported moderate to extensive presence, compared to GA airports (56.2%).

Residential Land Uses
Over 68% of 123 airport respondents reported moderate to extensive presence of residential developments (**TABLE 2**). Relatively more CS airports (85.3%) reported moderate to extensive presence compared to GA airports (61.8%).

Noise-Sensitive Land Uses Other than Residential
Only 29.3% reported moderate to extensive presence of noise-sensitive, non-residential land uses around them (**TABLE 3**). Relatively more CS airports (38.2%) reported moderate to extensive presence compared to GA airports (25.8%).

1. Do you have land uses off-airport property, which create any of the following compatibility concerns? If so, to what extent? (check all that apply)

	None	Minor	Moderate	Extensive
• *Concentrations of people*	□	□	□	□
• *Residential developments*	□	□	□	□
• *Noise sensitive* land uses other than residential	□	□	□	□
• *Tall structures*	□	□	□	□
• Land uses that create *visual obstructions*	□	□	□	□
• Land uses that attract *wildlife*	□	□	□	□

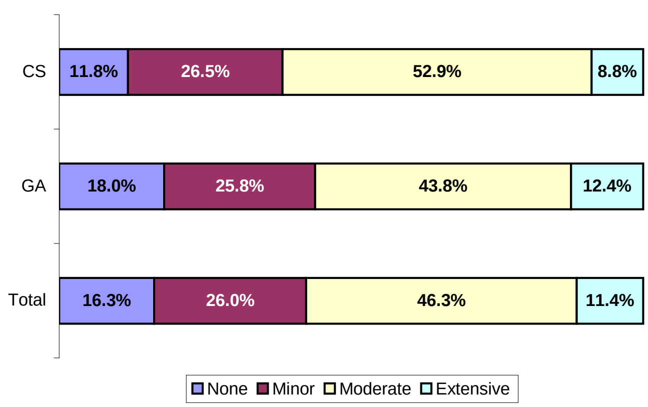
Comments:

FIGURE 1 Survey question about the presence of incompatible land uses.
Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

TABLE 1 Land Uses with Concentration of People

Airport Group	Response				
	None	Minor	Moderate	Extensive	Total
CS	4	9	18	3	**34**
GA	16	23	39	11	**89**
Total	**20**	**32**	**57**	**14**	**123**

CS - Commercial Service; GA - General Aviation

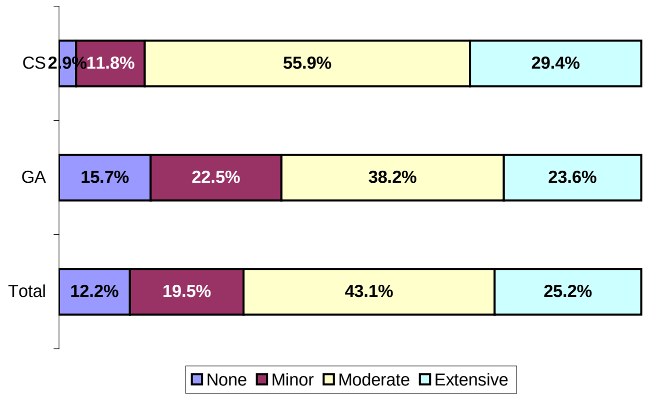


Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

TABLE 2 Residential Developments

Airport Group	Response				
	None	Minor	Moderate	Extensive	Total
CS	1	4	19	10	**34**
GA	14	20	34	21	**89**
Total	**15**	**24**	**53**	**31**	**123**

CS - Commercial Service; GA - General Aviation

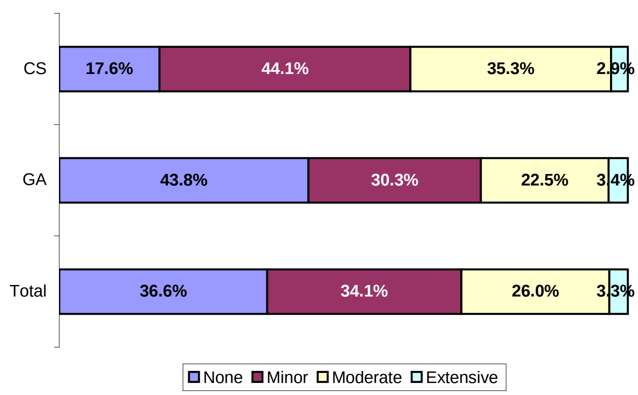


Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

TABLE 3 Noise-Sensitive Land Uses Other Than Residential

Airport Group	Response				
	None	Minor	Moderate	Extensive	Total
CS	6	15	12	1	**34**
GA	39	27	20	3	**89**
Total	**45**	**42**	**32**	**4**	**123**

CS - Commercial Service; GA - General Aviation



Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

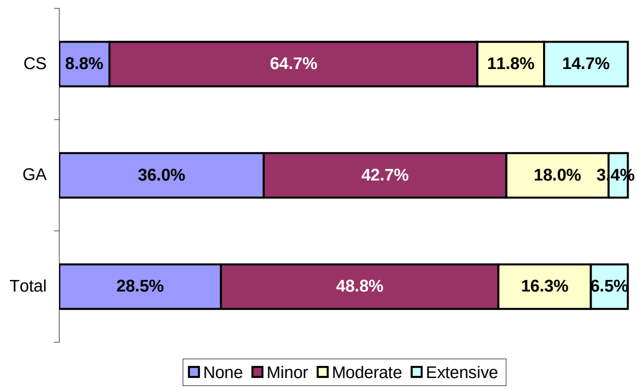
Tall Structures

Only 22.8% reported moderate to extensive presence of tall structures (**TABLE 4**). Relatively more CS airports (26.5%) reported moderate to extensive presence, compared to GA airports (21.3%).

TABLE 4 Tall Structures

Airport Group	Response				
	None	Minor	Moderate	Extensive	Total
CS	3	22	4	5	**34**
GA	32	38	16	3	**89**
Total	**35**	**60**	**20**	**8**	**123**

CS - Commercial Service; GA - General Aviation



Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

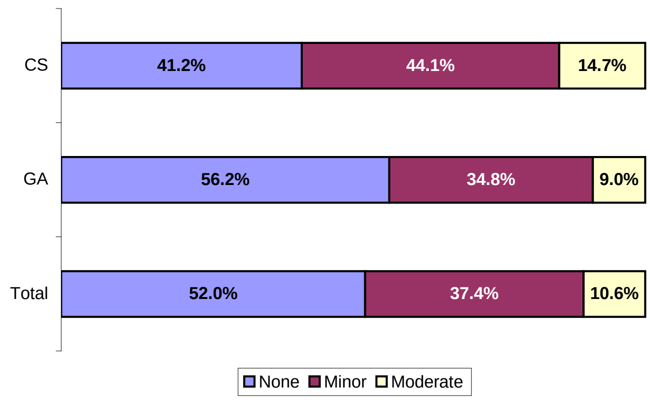
Land Uses That Create Visual Obstructions

Only 10.6% reported moderate presence, and 0% reported extensive presence of land uses that create visual obstructions (**TABLE 5**). Relatively more CS airports (14.7%) reported moderate presence compared to GA airports (9.0%).

TABLE 5 Land Uses That Create Visual Obstructions

Airport Group	Response				
	None	Minor	Moderate	Extensive	Total
CS	14	15	5	0	**34**
GA	50	31	8	0	**89**
Total	**64**	**46**	**13**	**0**	**123**

CS - Commercial Service; GA - General Aviation



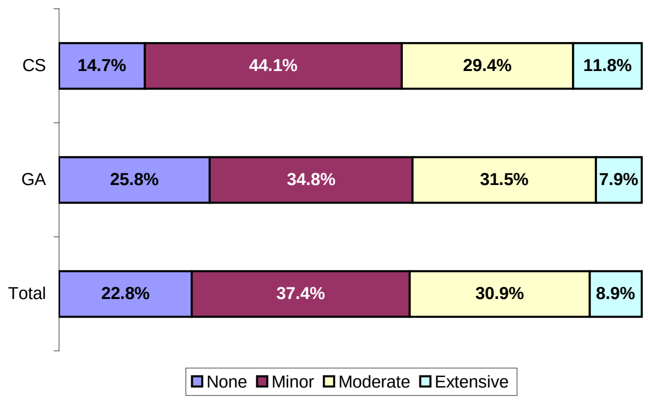
Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

Land Uses That Attract Wildlife
Only 39.8% reported moderate to extensive presence of land uses that attract wildlife (**TABLE 6**). Relatively more CS airports (41.2%) reported moderate to extensive presence compared to GA airports (39.3%).

TABLE 6 Land Uses That Attract Wildlife

Airport Group	Response				
	None	Minor	Moderate	Extensive	Total
CS	5	15	10	4	**34**
GA	23	31	28	7	**89**
Total	**28**	**46**	**38**	**11**	**123**

CS - Commercial Service; GA - General Aviation



Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

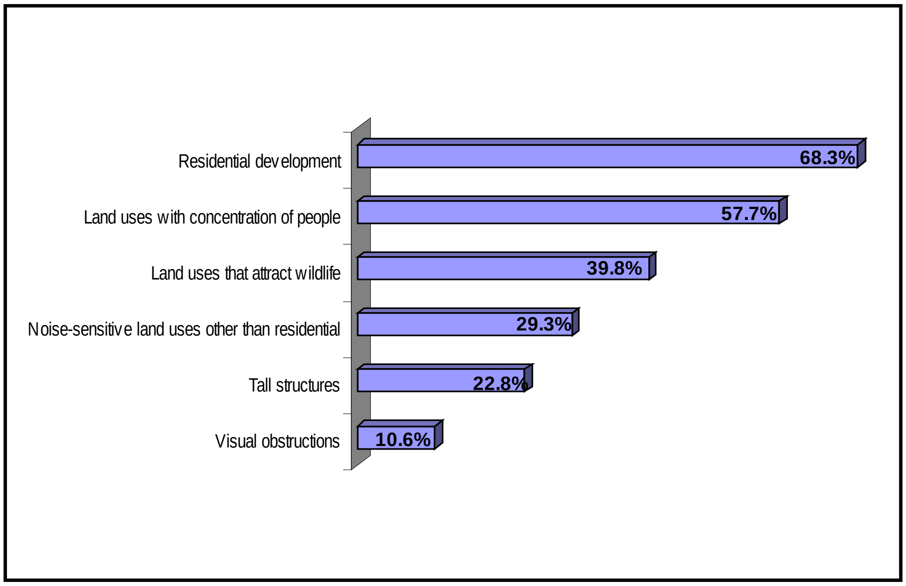


FIGURE 2 Incidence of incompatible land uses around airports.
Percent of airports reporting moderate to extensive presence (Sample=123 airports)
Source: The Mead & Hunt ACRP 03-03 Team, Preliminary Assessment Survey, 2007.

The above results show that the most prevalent incompatible land use is residential development (**FIGURE 2**).

Summary
This section presented some empirical evidence of the presence of incompatible land uses around U.S. airports, based on the results of a preliminary assessment survey conducted by the Mead & Hunt ACRP 03-03 Team. Land uses that are incompatible with airport operations include: (1) land uses with high concentration of people, (2) noise-sensitive land uses, (3) tall structures, (4) land uses that create visual obstruction, and (5) land uses that attract wildlife. Responses from a sample of 123 airports show that the most prevalent incompatible land use is residential development.

Incompatible Land Uses: Consequences and Costs
The presence of incompatible land uses around airports has consequences for different stakeholders. These consequences give rise to costs – monetary and non-monetary – to airport sponsors, airport users, residents in surrounding communities, and concerned local and regional jurisdictions. Concerns about incompatibility arise from a number of reasons:

- Airport operations generate negative externalities. Communities often oppose airport growth because residents in the airport vicinity are exposed to adverse environmental effects, such as noise. Community opposition often leads to restrictions on aircraft operations and constraints on airport capacity expansion.
- Aircraft operations have certain safety requirements. Certain land uses – such as those that pose physical obstructions, create visual distractions and attract wildlife – can threaten the safety of aircraft operations.
- The encroachment of incompatible land uses around airports places physical limits to safe and efficient aircraft operations and airport capacity expansion.

Noise is the greatest environmental concern with aircraft operations, as found in a survey of the United States' 50 busiest airports conducted by the U.S. Government Accountability Office (GAO) in 2000.[1] Exposure to the undesirable environmental effects of aviation gives rise to community opposition. In particular, community opposition to aviation noise is a major obstacle to airport development (GAO 2008a, and Commission on the Future of the U.S. Aerospace Industry 2002).

Community opposition leads to delays in airport development, constraints to capacity expansion, restrictions on airport operations, more stringent environmental standards, more extensive environmental review and mitigation requirements, and more extensive public outreach requirements (GAO 2000, GAO 2008b). In some cases, community opposition also leads to litigation. Ultimately, all these lead to a variety of costs to airport users and sponsors:

- Operating restrictions, development delays, and capacity constraints result in delay costs to airlines, passengers and other airport users.
- Project delays, more stringent standards, more extensive requirements for environmental review and mitigation, and more extensive efforts for public outreach all increase the cost of airport development.
- Litigation involves costs such as attorneys' fees, airport staff time, and in some cases, settlement or judgment costs.
- From a broader perspective, according to the GAO, "constraints on efforts to expand airports or aviation operations could affect the future of aviation because the national airspace system cannot expand as planned without a significant increase in airport capacity." The national aviation system cannot accommodate the projected doubling or tripling of air traffic in the coming decades without additional airports and runways (GAO 2008b).

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[1] Other environmental concerns include the potential harmful effects on water quality of deicing and anti-icing operations, land take, and waste management impacts, but these are generic to most large infrastructure developments and are amenable to mitigation to some extent (POST 2003a, GAO 2000).

Constraints on airport growth also have consequences for concerned local and regional jurisdictions. Airports contribute to the local economy by stimulating economic activity, creating employment and generating income. Constraints on airport growth limit the positive economic impacts that surrounding communities and the larger region can derive from airport operations.

Safety is an equally important consideration. While aviation accidents occur rarely, the costs are great when they do occur. Data show that aircraft accidents in the vicinity of airports tend to occur near runway ends below the approach and departure flight paths, as reported in another ACRP 03-03 white paper on accident data location. Land uses that pose physical obstructions, create visual distractions, and attract wildlife in these areas increase the risk of aviation accidents, and land uses with high concentration of people in these areas increase third-party exposure to aviation accident risk.

TABLE 7 lists the negative consequences and resulting costs to different stakeholders of the presence of incompatible land uses around airports.

TABLE 7 Consequences and Costs of Incompatible Land Uses

Consequences	Costs
To the aviation system and its users: ➢ Delays and constraints to airport development, leading to system delays ➢ Restrictions on aircraft operations, leading to system delays and travel time penalties ➢ Constraints to runway approach protection, leading to runway capacity constraints and safety risks ➢ Litigation and related costs ➢ Increased development costs ➢ Increased risk of aviation accident from the presence of tall structures, visual obstructions and wildlife attractants	**To the aviation system and its users:** ➢ Costs of delays ➢ Litigation and related costs ➢ Increased development costs ➢ Costs of aviation accidents
To people who live near airports: ➢ Exposure to noise ➢ Exposure to aviation accident risk	**To people who live near airports:** ➢ Costs of noise impacts ➢ Costs of exposure to aviation accidents
To surrounding local and regional jurisdictions: ➢ Unrealized economic impacts due to constraints on airport growth	**To surrounding local and regional jurisdictions:** ➢ Unrealized economic impacts

Consequences and Costs to the Aviation System and Its Users
Incompatible land uses give rise to community opposition and physical constraints to airport development. These have various consequences that ultimately lead to increased aircraft delays, increased passenger travel time, increased development costs, and increased accident risk.

Delays and Constraints to Airport Development
Community opposition can cause delays in the implementation of airport development projects. Project implementation delays result in monetary costs arising from the need to update project plans, extend or change contracts, renew project approvals and permits, and so forth. All these potentially increase project planning, management and implementation costs significantly. More significantly, delays in much needed capacity expansion cause aircraft delays to continue and worsen.

Community opposition can limit capacity expansion, leading to a variety of outcomes such as persistence of aircraft delays, diversion of aircraft operations to other airports, or, in the extreme case, the need to build a replacement airport at another site. All these are costly outcomes. Aircraft delays and diversions are costly. Every minute of delay costs aircraft operators in additional aircraft operating and maintenance cost, and passengers in additional travel time. The relocation of an airport is a lengthy and costly process, as has been demonstrated in at least two cases in recent decades: the relocation of Denver International Airport and Wilmar Municipal Airport, Minnesota.

The 2007 survey conducted by Mead & Hunt, Inc. also gathered information on where incompatible land uses have affected airport development in some way. Of 123 airports surveyed, 33 (26.8%) indicated that incompatible land uses delayed or prevented airport development from taking place (**TABLE 8**).

TABLE 8 Airports Where Incompatible Land Uses Delayed or Prevented Airport Development (Sample = 123 airports)

	# of Airports	Runway or taxiway	Terminal	Fixed-Base Operator	Cargo	Hangar	Commercial Park
Total reported cases	33	29	5	1	1	1	1
Commercial Service (CS)	11	11	1	0	1	0	0
General Aviation (GA)	21	17	4	1	0	1	1
Private Use	1	1	0	0	0	0	0

Source: Mead & Hunt, Preliminary Interview Assessment Survey, 2007.

Restrictions on Aircraft Operations

Public opposition can result in political action to impose restrictions on aircraft operations. Responding to the 2007 survey, 53 airports (43.1% of all respondents) reported operational restrictions prompted by land use issues (**TABLE 9**). The most frequently cited restriction, reported by 44 airports, involves modification of flight procedures. Other restrictions include curfew on aircraft operations (including voluntary curfews), restriction of certain aircraft types, limit the number of aircraft operations, voluntary noise abatement procedures, and preferential runway use. Twenty-four airports reported more than one type of restriction in place.

TABLE 9 Airports Where Incompatible Land Uses Led to Restrictions on Aircraft Operations (Sample = 123 Airports)

Airport	# of Airports	Curfew on aircraft operations	Limit on # of aircraft operations	Restriction of certain aircraft	Modification of flight procedure	Other
Total reported cases	53	16	4	14	44	10
Commercial Service (CS)	20	4	2	5	17	4
General Aviation (GA)	32	12	2	9	26	6
Private Use	1	0	0	0	1	0

Source: Mead & Hunt, Preliminary Interview Assessment Survey, 2007.

These restrictions on aircraft operations impose artificial limits on airport capacity that can exacerbate or leave aircraft delays unchecked at congested airports, resulting in increased aircraft operating and maintenance costs and increased passenger travel time. Modified flight procedures also often lead to additional minutes of flight when pilots are required to take a less direct route for takeoff and landing.

Impact on Approach Protection

The presence of incompatible land uses can also compromise runway approach protection, restricting runway use and posing potential hazard to aircraft safety. Seventeen airports, representing 13.8% of the 123 airport survey respondents, reported this problem (**FIGURE 3**).

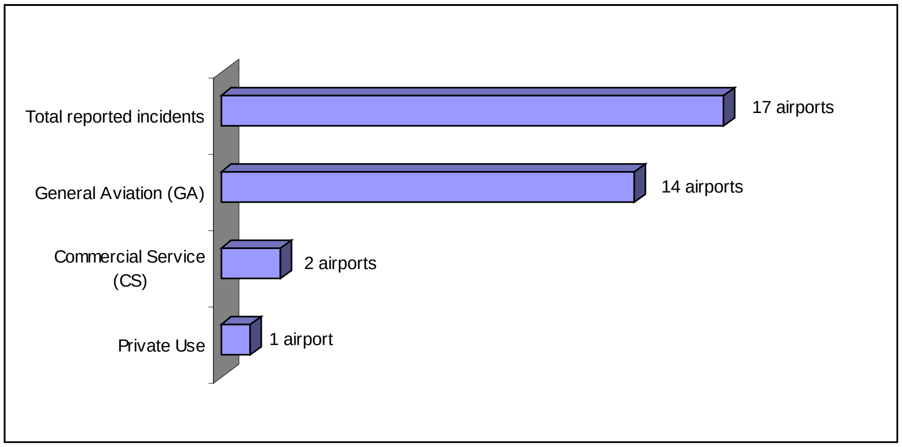

FIGURE 3 ***Airports*** **Where Incompatible Land Uses Impacted Runway Approach Protection.**
(Sample = 123 airports)
Source: Mead & Hunt, Preliminary Interview Assessment Survey, 2007.

Litigation and Related Costs
Community opposition can sometimes lead to litigation. As summarized in **TABLE 10**, 31 airports, representing 25.2% of the 123 airport respondents to the 2007 survey, reported litigation prompted by incompatible land uses. The majority of the reported cases (25 airports) involved noise. The other cases involved land uses with a high concentration of people, tall structures, and land uses that attract wildlife. In one case, litigation involved traffic concerns.

TABLE 10 Airports that Reported Facing Litigation Involving Land Use Issues (Sample = 123 Airports)

Airport	# of Airports	High concentration of people	Noise sensitive	Height/Tall Structures	Visual Obstruction	Wildlife attractant	Other
Total reported incidents	31	9	25	2	0	1	3
Commercial Service (CS)	16	6	14	0	0	0	1
General Aviation (GA)	15	3	11	2	0	1	2

Source: Mead & Hunt, Preliminary Interview Assessment Survey, 2007.

Litigation involves legal fees and other costs. The operators of the 31 airports were asked to complete a follow-on survey (**FIGURE 4**) to get additional information on financial costs associated with litigation.

FIGURE 4 Follow-On Surveys on the Costs of Litigation

Q1. Please provide some additional information about the litigation. In which of the following three forums was the litigation brought– State court, Federal court, administrative agency? When was the litigation first brought, and what was the date of a final judgment, settlement or other resolution?
Q2. What was the amount of your litigation costs in the form of attorney's fees?
Q.3 Please estimate the amount of staff time spent on administrative matters relating to the litigation and separately the amount of staff time spent on public relations matters relating to the litigation. What was the corresponding salary expense? Please describe the basis for your estimates.
Q.4 what was the amount of any settlement or judgment paid by the airport?
Q.5 what was the total amount of any other litigation costs not included in the responses to the previous questions, such as court costs or witness fees? Please list the types of expenses, as well as the total amount of all such expenses.

Source: Unison Consulting, Inc., June-July 2008.

Only 12 airports responded, in whole or in part, and two of them were not at liberty to provide additional information on their litigation. One airport reported that the number and complexity of lawsuits it had faced made it difficult to readily segregate information on land use compatibility litigation. Three airports reported that none of their litigation involved land use compatibility issues. **TABLE 11** summarizes the responses of the remaining six airports – three CS and three GA – to the five questions. The responses are insufficient to serve as basis for any generalized estimate of the costs associated with litigation.

Reported costs show wide variation from airport to airport. Litigation costs include attorneys' fees, staff time, and the amount of settlement, if any. The magnitude of costs depends upon the type of litigation, duration, and outcome. The responses are described below:

- Five of the six reported their litigation occurred in state courts. This result is expected because land use controls are matters of state and local law, rather than federal law. The sixth did not identify the court or the nature of the legal proceeding.
- All six reported the amount of attorneys fees paid, with sums ranging from $2,500 to $4,000,000.
- Two of the six reported additional staff time spent on the litigation, but none were able to provide an estimate of the amount of employee time devoted to the litigation. However, two airports were able to provide estimates of employee salaries devoted to the litigation, with wide variation in the amounts ($2,734 and $500,000).
- One of the five airports prevailed in its litigation. One airport stated that the question on settlement or judgment amount was not applicable. The remaining three airports paid judgments or settlements ranging from $8,500 to $130 million.
- None of the airports reported other litigation costs.

Only two airports provided information on the duration of the litigation. For one airport, the litigation lasted 9 years 7 months. For the other, the litigation lasted 30 months. Digests of recent litigation on airport environmental issues on airport noise were also reviewed (Bell 2008). Four cases, involving medium or large hub airports, were identified as potentially involving airport land use compatibility. All four cases were brought in state court. In two of the cases, the airport prevailed. In one of the other cases (Las Vegas), the court awarded damages in the amount of $6.75 million. In the other (Los Angeles), the airport operator settled the case by committing to spend $326 million on a variety of mitigation measures. Information on attorneys' fees, other litigation costs, and duration of litigation was not available from the digests. **TABLE 12** summarizes available information on these four cases.

TABLE 11 Results of Follow-On Survey on Land Use Incompatibility Litigation

Airport	Type of litigation (Jurisdiction)	Summary of dispute	Litigation costs - Attorneys fees	Litigation and public relations sponsor staff & administrative time spent	Salary expense	Settlement or judgment amount	Other litigation costs	Duration
GA	No response	No response	$10,000	No estimate, part of EA	No estimate	N/A	N/A	No response
GA	State Land Court (settlement) Additional information not provided	No response	$2,500	No public relations time spent	$0	$95,000	0	No response
GA	State court (settlement)	An individual and a group of his neighbors brought a civil action based on damages from noise and vibration of overflights.	$48,144	No response	$2,734	$85,000	No response	9 years 7 months
CS	State court (consent decree)	In 2004 MAC was sued by three cities and a class action suit involving more than 4,400 homeowners was filed against MAC over the airport expansion and an alleged failure by the MAC to provide sufficient mitigation out the 60 DNL noise contour.	$4,000,000	Noise and public relations staff time no estimate of hours	$500,000	$130,000,000	0	30 months
CS	State Court	Inverse condemnation -On airport FBO alleged that Stage 2 aircraft ban was a regulatory taking for which compensation was required.	$282,054	Too difficult to estimate because of other litigation at same time	No response	None, airport prevailed; did not seek to recover its attorney fees	None	No response
CS	State court	No response	$250,000	Unknown	Unknown	$0	Unknown	No response

Source: Unison Consulting, Inc., Follow-on survey, June-July 2008.

TABLE 12 Summary of Land Use Incompatibility Litigation from Digests

Airport	Type of litigation (Jurisdiction)	Summary of dispute	Settlement or judgment amount	Duration
Los Angeles International Airport	State Court, Federal Court	Miscellaneous challenges to new master plan	$326,000,000	12 months
Indianapolis International	State court	Owners' of eight homes within three miles of the airport near airport challenged aircraft overflights, claiming inverse condemnation and nuisance	None, airport prevailed	Not reported
Boston Logan	State court	Town of Hull brought suit, challenging airport, and in particular proposed new runway, as a public nuisance	None, airport prevailed	Not reported
Las Vegas McCarran	State court	Owner of property zoned for casino, hotel or apartment challenged local height restriction (based on airport compatibility) as inverse condemnation	$6,500,000	Not reported

Source: Bell, David Owen, ed., Aviation Environmental Litigation, Great Circle Communications, LLC, 2008.

Increased Development Costs

Actions to lessen environmental effects have increased the costs of development, more so when incompatible land uses are present. Airport sponsors need to conduct more comprehensive environmental assessments, incur higher environmental mitigation costs, and undertake more extensive public outreach efforts (GAO 2000).

The National Environmental Policy Act (NEPA) of 1969 calls for an environmental review of federal actions, including airport expansion projects. In particular, noise-mitigation measures include acquiring noise-sensitive properties, relocating people, modifying structures to reduce noise, encouraging compatible zoning, and assisting in the sale of affected properties. In addition to these efforts, most airports have voluntarily established some type of noise monitoring system, and conduct public outreach and education programs (GAO 2000, GAO 2007).

Since the early 1980s, the federal government has issued grants to mitigate noise around many airports. Since the early 1990s, the FAA has also allowed airports to impose passenger facility charges for that purpose. As shown in **TABLE 13**, the FAA has provided about $5 billion in AIP grants, and airports have used about $2.8 billion in passenger facilities charges (PFC) for Part 150 noise mitigation studies and projects. In total these funding amounts to nearly $8 billion (GAO 2007). In the last 10 years, the FAA has also spent about $42 million on research to characterize noise and improve prediction methods, including developing a capability to determine the trade-offs between noise and emissions and quantifying the costs and benefits of various mitigation strategies (GAO 2007).

Increased Aviation Accident Risk

The safety of aircraft and their occupants, as well as people on the ground, is a very important concern for aviation policy. Aviation accident rates have fallen over the years due to relentless efforts to develop strategies that reduce the occurrence of accidents and to promote technologies, programs, and practices that enhance aviation safety. Air transport has become the safest way to travel with 0.75 accidents per million flights in 2007 (International Air Transport Association (IATA) 2008).

When they do occur, aviation accidents are costly. They can result in substantial loss of lives, injuries, property damage, and substantial monetary costs associated with hospitalization, accident investigation and, in certain cases, litigation. Accident data suggest that aircraft accidents in the vicinity of airports tend to occur near runway ends under the approach and departure flight paths (see the ACRP 03-03 white paper on accident location data analysis). The presence of tall structures, visual obstructions, and land uses that attract wildlife in or near the runway approach and departure areas poses flight safety hazards and increases the risk of aircraft accidents occurring.

TABLE 13 AIP and PFC Investments for Part 150 Noise Mitigation Studies and Projects, 1982-2007
Dollar amounts in millions

Sources and Uses of Funds	Amount
AIP funds, fiscal years 1982-2007	
Mitigation measures for residences	$1,903
Land acquisition	$2,170
Noise monitoring system	$170
Mitigation measures for public buildings	$703
Noise compatibility plan	$87
Total AIP funds	**$5,033**
PFC funds, fiscal years 1992-2007	
Multiphase	$1,283
Land acquisition	$481
Soundproofing	$1,018
Monitoring	$31
Planning	$15
Total PFC funds	**$2,828**
Grand Total AIP and PFC funds	**$7,861**

Source: FAA, as published in GAO 2007.

Consequences and Costs to People Who Live and Work Near the Airport
Community opposition to growth in airport operations and expansion of airport capacity arises because people are exposed to the adverse environmental impacts of aviation. Of these, aircraft noise is the leading cause of community opposition, and local air quality effects are increasingly gaining attention. In addition to being exposed to adverse environmental effects, people who live in certain areas near the airport face greater risk of exposure to aviation accidents than those who live far away from airports.

Exposure to Aircraft Noise
While more stringent noise standards and advances in technology have made aircraft quieter, aviation noise will remain a concern when communities allow incompatible land uses, such as residences, schools, and hospitals, to be built near airports. Incompatible land uses expose people to aircraft noise (GAO 2007). Exposure to aircraft noise is the leading cause of community opposition to airport expansion (GAO 2008b). People find noise annoying, so that, if exposed to noise, people generally prefer to reduce the loudness of noise, avoid it, or leave the noisy area, if they can.[2] Noise can disrupt sleep, conversation, and certain leisure activities. A World Health Organization (WHO) report in 1993, entitled *Community Noise*, found that noise also gives rise to a number of health problems, ranging from insomnia, stress and mental disorders to heart and blood circulation problems. The various ill effects of excessive noise on human health are listed in **TABLE 14**. The more severe of these adverse health effects, however, have not been demonstrated to occur at noise levels typically experienced around airports.

[2] Federal Integrated Committee on Aviation Noise (FICAN) website at http://www.fican.org/pages/noise_annoyance.html.

TABLE 14 Adverse Health Effects of Excessive Noise

- Hearing impairment
- Hearing pain
- Increased sensitivity to noise and annoyance
- Interference with communication and speech perception
- Sleep disturbance
- Psycho-physiological reactions during sleep (including effects on heart rate, finger pulse and respiration)
- Cardiovascular effects (e.g. Ischaemic heart disease)
- Stress
- Dulled startle reflex and orienting response (i.e. the person affected is less likely to respond to noise signals that matter e.g. approaching vehicles and dangerous machinery)
- Other effects on physical and psychological health including: nausea, headaches, irritability, argumentativeness, reduction in sexual drive, anxiety, nervousness, insomnia, abnormal somnolence and loss of appetite
- Mental disorders
- Impaired task performance and productivity
- Deficits in reading acquisition in children
- Damaging effects on positive social behavior (e.g. willingness to help others)

Source: World Health Organization, *Community Noise*, Copenhagen, Denmark, 1993.

Exposure to Aviation Accident Risk
The presence of land uses with a high concentration of people near airports, especially near the runway approach and departure areas, increases third-party exposure to aviation accident risk. The findings in the literature on third-party accident risk are discussed in Chapter 7 of the ACRP 03-03 Report.

Consequences and Costs to Surrounding Local and Regional Jurisdictions
The constraints placed by incompatible land uses on airport growth indirectly result in unrealized economic benefits to surrounding local and regional jurisdictions.

Unrealized Local and Regional Economic Benefits
Airports are local economic engines – they stimulate local economic activity, create employment, and generate income to local residents. To the extent that incompatible land uses around airports constrain airport use and efficient air service, local and regional jurisdictions cannot realize the full potential of airports to generate positive regional economic impacts. The assessment of regional economic impacts is addressed in Section 4.

Why Incompatible Land Uses Continue to Develop Around Airports
Given that the negative consequences of airport land use incompatibility are substantial, why do incompatible uses, particularly housing, continue to develop around airports? There are at least two reasons:

- There are benefits to people from living near airports.
- The costs of imposing land use controls are concentrated in one stakeholder, while the benefits are diffused among many.

Benefits of Proximity to Airports
Proximity to an airport benefits people in some way. People are drawn to live near airports to have easy access to travel and employment opportunities (Nelson 2004, Lipscomb 2003). Residential development, in turn, benefits local jurisdictions by expanding the local tax base.

Why Incompatible Land Uses Continue to Develop Around Airports

- There are benefits to people from living near airports
- The costs of imposing land use controls are concentrated in one stakeholder, while the benefits are diffused among many

Concentrated Costs and Diffused Benefits of Imposing Land Use Controls

The costs of imposing land use controls around airports to prevent incompatible developments are concentrated in one stakeholder – the local government that also has the authority to impose land use controls. In particular, there are costs to affected local jurisdictions in placing restrictions on residential development near airports. These costs fall into three categories: (1) welfare losses, (3) planning and enforcement costs and (3) fiscal losses. Disallowing residential developments near airports results in welfare losses, because it reduces the supply of land available for residential development in the entire city or county, making land scarcer and indirectly limiting choices elsewhere in the city or county (Dings, et al 2003). There are staffing and related costs involved in formulating land use plans and enforcing land use controls. Finally, local governments can suffer from fiscal losses from a reduced property tax base, if alternative land uses do not generate the same amount in net fiscal revenues as residential development. While fiscal losses do not necessarily translate into economic welfare losses to society as a whole, they are probably the more palpable consideration to local government officials and planners.

In contrast, the benefits of preventing incompatible land use development, while far more substantial than the costs, are diffused among many different stakeholders who otherwise suffer the consequences of incompatible land uses: (1) the airport sponsors and users who suffer the consequences of operational restrictions, development constraints, and safety hazards; (2) the people living near airports who are exposed to negative environmental effects; and (3) the local and regional jurisdictions that fail to realize the full economic impact of unconstrained air service.

Summary

This section identified the different types of problems that can arise when there are incompatible land uses near airports and provided a qualitative assessment of the consequences and costs to airports and surrounding communities.

Airport land use incompatibility arises from a number of reasons: (1) Airport operations generate negative externalities, and exposure to these externalities prompts affected communities to oppose airport growth. (2) Aircraft operations have safety requirements, and certain land uses pose hazards to aircraft operations. (3) The encroachment of incompatible land uses around airports hinders safe and efficient aircraft operations, and airport capacity expansion.

The presence of incompatible land uses has negative consequences for different stakeholders, giving rise to monetary and nonmonetary costs:

- Aviation system and its users: costs of delays, litigation and related costs, increased development costs, and costs of aviation accidents
- People who live near airports: costs of noise impacts, and costs of exposure to aviation accidents
- Surrounding local and regional jurisdiction: unrealized economic impacts

Given that the negative consequences and costs are substantial, why do incompatible land uses, particularly residential, continue to develop around airports? There are at least two reasons:

- There are benefits to people from living near airports.
- The costs of imposing land use controls are concentrated in one stakeholder – the local governments who also have the ultimate authority over land use around airports, while the benefits are diffused among many.

Among the different types of costs that have been identified to result from the presence of incompatible land uses, the following can benefit from more systematic survey efforts and case studies:

- Litigation and related costs
- Project delays caused by community opposition and related costs
- Increased development costs such as costs of environmental impact assessment and mitigation
- The extent of third-party exposure to aviation accidents in the United States
- The incidence of aviation accidents near airports caused by the presence of incompatible land uses
- Further research is recommended to better understand the costs to local governments of imposing land use controls.

FRAMEWORK FOR THE ECONOMIC ANALYSIS OF AIRPORT LAND USE INCOMPATIBILITY

The objective of this section is to present a framework for the economic analysis of the consequences and costs of the presence of incompatible land uses near airports. Different analytical tools are available depending upon the context and purpose of the analysis. The main tools for economic analysis are *economic valuation* and *benefit-cost analysis* (BCA).

To assess the economic costs arising from the presence of incompatible land uses around airports, the main tool is economic valuation. By itself, economic valuation is useful for increasing awareness of the costs of incompatible land uses and gaining support for efforts to promote airport-compatible land use planning. It is also useful in setting appropriate values for taxes and fees to charge airport users to compensate for negative externalities. Finally, economic valuation provides useful information in decision making - for example, in weighing the benefits of reducing or avoiding the costs of incompatible land uses against the costs of proposed public investments and regulatory interventions to mitigate aviation's environmental effects, prevent the development of incompatible land uses, and promote compatible land use development around airports. This can be done within the framework of benefit-cost analysis.

Tools for Economic Analysis
Economic valuation
Benefit-cost analysis (BCA)

Economic Valuation

Economic valuation is one of many ways of defining and measuring value, and economic values are useful to consider when making economic choices – choices that involve tradeoffs in allocating resources. In economics, the term *value* has a specific meaning, defined in terms of what people want (preferences) and the choices they make. Something has value only if people value them directly or indirectly, and value is relative to the maximum amount of other things being given up. Money is a convenient measure of economic value because the amount of money that a person is willing to pay for something indicates how much of all other things a person is willing to give up for it. This concept is called *willingness-to-pay* (WTP) (King and Mazzotta 2000, Lipton and Wellman 1995). A concept related to WTP is a person's *willingness-to-accept* (WTA) compensation for suffering a loss or not receiving an improvement in one's wellbeing. There are special circumstances as described in Office of Management and Budget (OMB) (2003) where WTA can also provide a valid measure of opportunity cost and produce a measure comparable to WTP.

Concepts of Economic Value
Willingness-to-pay (WTP)
Willingness-to-accept (WTA)

Uses of Economic Valuation

Economic valuation can be used for the following purposes:

- Contribute to public debate and awareness of a particular problem, for example, airport land use incompatibility and its consequences. People can more readily grasp the extent of the problem when the consequences are expressed in monetary terms (Moons 2003).
- Aid in decision-making by using economic valuation in benefit-cost analysis of policy and investment decisions (for example, benefit-cost analysis of a policy decision to enforce compatible land use zoning). Economists are interested in measuring how much better off people would be if a specific policy or investment were implemented (Moons 2003, Lipton and Wellman 1995, POST 2003b).
- Help set values for economic instruments to deal with environmental externalities (for example, aviation fuel taxes, noise-related landing charges, and tradable permits on emissions) (POST 2003b).

Economic Valuation Methods

Economic Valuation Methods
Revealed preference (RP) - direct use of market data - indirect use of market data
Stated preference (SP)

- contingent valuation
- contingent choice

Benefit transfer (BT)

Economic valuation methods have been developed largely in the field of environmental economics. Detailed descriptions of these methods, illustrations of their applications, specifications of data requirements, and discussions of advantages and disadvantages are provided in Lipton and Wellman (1995), King and Mazzotta (2000), and OMB (2003).

A range of methods can be used to measure economic value. When goods and services are traded in the market, actual data on prices and quantities traded (*revealed preferences*) are used. When valuing something that is not traded in the market – like noise exposure, one can make inferences from observable prices in related markets – for example, home prices. In cases where values cannot be inferred from market transactions, economists have devised measurement techniques based on *stated-preference* surveys − by asking people what they would be willing to pay (WTP) for a particular benefit or how much compensation they would be willing to accept (WTA) to bear a particular cost (Lipton and Wellman, 1995; HM Treasury, 2003).

The presence of incompatible land uses gives rise to certain financial costs, for example: (1) additional aircraft operating and maintenance costs incurred by airlines due to flight delays; (2) increased airport development costs due to the need for more extensive environmental reviews, more expensive environmental mitigation programs, litigation costs, among others; (3) replacement and repair of damaged aircraft in the case of accidents; (4) and accident investigation costs. For these types of costs, economic values can be based on revealed-preference data from actual market transactions.

Airport land use incompatibility also gives rise to certain non-monetary costs, for example: (1) increase in passenger travel time due to flight delays; (2) injuries and fatalities due to aviation accidents; (3) annoyance and adverse health effects from aircraft noise; and (4) adverse health effects and environmental damage from local air pollution. For these types of costs, there are no direct market transactions that can be observed. Economic values can be derived either from revealed preferences in related market transactions − for example, home sales, wages and salaries, job choices, and travel choices – or from stated preference surveys.

A popular revealed preference method used in valuing environmental effects is *hedonic pricing*. The hedonic pricing method is used to estimate economic values for certain attributes of a particular commodity or service that directly affect market prices. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes – for example, exposure to aircraft noise.

Sometimes economic value can be measured by estimating the amount people are willing to pay, or the cost of actions they are willing to take, to avoid the adverse effects that would occur if these services were lost (*damage cost avoided*), replace the lost services (*replacement cost)*, or provide substitute services (*substitute cost*). These cost-based RP methods, however, do not provide good measures of WTP. An application of these measures is in the valuation of noise reduction by measuring the cost of noise abatement and mitigation measures.

SP methods have also been used in deriving an economic value for exposure to aircraft noise. SP methods are used when economic values cannot be measured directly or indirectly from market data. On can conduct a survey to ask people directly what they are willing to pay, presented a hypothetical scenario (*contingent valuation* method). Alternatively, the survey can be designed to ask people to make tradeoffs among different alternatives, and the analyst can then estimate WTP from these tradeoffs (*contingent choice* method). SP surveys, however, are expensive to implement. In addition, because they are based on asking people about their preferences instead of observing actual choices, SP estimates of economic value can be biased.

Ideally, one should conduct an original economic valuation study specific to a particular airport using either RP or SP methods. However, faced with limited time and money, one can also adopt estimates of economic values from completed studies in similar context. This is called the *benefit transfer* method.

Limitations of Economic Valuation

Economic valuation has a number of limitations: (1) Economic valuation requires making numerous assumptions and is therefore subject to a number of uncertainties especially when applied to the environment. (2) Economic analysis is geared toward achieving economic efficiency, and policies maximizing economic efficiency do not necessarily lead to a fair outcome when there are ethical issues to consider. (3) Finally, certain things just cannot be measured by money, and the application of economic valuation in these cases is limited (POST 2003b).

Relevant Economic Values for Evaluating the Costs of Airport Land Use Incompatibility

The FAA publishes a guide titled *Economic Values for FAA Investment and Regulatory Decisions, A Guide*, most recently updated in December 2004 by GRA, Incorporated (GRA 2004). This document recommends standardized methods and economic values to be used in evaluating airport investment and regulatory decisions. This guide presents economic values for many of the costs arising from the presence of incompatible land uses:

- Value of time to be used in estimating the cost to passengers of travel delays resulting from constraints to airport operations and capacity development
- Aircraft operating and ownership cost to be used in valuing the costs to airlines of aircraft delays
- Value of statistical life to be used in estimating the cost of fatalities and personal injuries from aviation accidents, as certain incompatible land uses increase the risk of aviation accidents or expose communities to risk of aviation accidents
- Aircraft replacement and restoration costs to be used in valuing damaged aircraft from aviation accidents
- Aviation accident investigation costs for valuing costs to the federal government and the private sector of the increased risk of aviation accidents

Relevant Economic Values
Travel delay costs
- value of travel time
- aircraft operating costs
Aviation accident costs
- value of statistical life
- other injury costs
- aircraft replacement costs
- aircraft restoration costs
- accident investigation costs
Noise impacts
- noise discount or noise depreciation index (NDI)

GRA (2004) does not present standard economic values for quantifying the costs to people living near the airports of exposure to noise, but the literature provides extensive references on the valuation of noise effects.

Valuation of Travel Delay Costs
Incompatible land uses present both political and physical constraints to efficient airport operation and capacity development, leading to restrictions on airport operations, delays in project implementation, and, in some cases, the inability of the airport sponsor to expand capacity at all. Ultimately, these operating restrictions and development constraints lead to delays in aircraft operations.

As the saying goes "Time is money", and delays are costly. Delays impose costs on passengers in terms of increased travel time and on aircraft operators in terms of increased operating costs. To assess these costs, the following data are needed: (1) a measure of the difference in delay or travel time per aircraft operation with and without the constraint, (2) the number of affected aircraft operations, (3) the number of affected passengers, (4) economic values for travel time, and (5) unit aircraft operating costs.

Measures of changes in delay or travel time per aircraft operation are derived using appropriate analytical or simulation models that vary in technical sophistication and computational requirements. The FAA Airport Benefit-Cost Analysis Guidance, published by the FAA Office of Aviation Policy and Plans in 1999, provides a summary of airfield and capacity simulation models used to estimate aircraft operational delay: (1) the FAA Airport and Airspace Simulation Model (SIMMOD), (2) the Airfield Delay Simulation Model (ADSIM), and (3) the Runway Delay Simulation Model (RDSIM) (FAA 1999).

The economic values needed to assess delay costs – value of passenger travel time and aircraft operating costs – are presented below.

Value of Travel Time
The value of travel time is important in assessing the costs of delays, the reduction of which usually account for a large portion of the benefits of transportation policies and projects (Small and Verhoef, 2007). Passenger travel time has value for two reasons: (1) time spent traveling can otherwise be spent on work or leisure (*opportunity cost)*; and (2) travel is usually associated with unpleasant conditions such as having to walk, wait, and suffer other inconveniences (*disutility cost*) (DOT 1997). While there is no market price for travel time, researchers have used RP and SP economic valuation methods described above to estimate its value, typically expressed as a proportion of the wage rate. Based on a recent summary of the literature, Small and Verhoef (2007) concludes that the value of time for personal travel varies widely by circumstance, usually between 20% and 90% of the gross wage rate, and average around 50%. The value of time is much higher for business travel,

generally taken as 100% of total compensation. Time spent walking and waiting is also valued much higher – 1.6 to 2.0 times that of time spent in-vehicle.

The DOT and the FAA recommend values for aviation passenger travel time, by type of air carrier used and trip purpose, as presented in **TABLE 15** (DOT 2003, GRA 2004). These values were derived from passenger survey data and represent fractions of the average hourly wage. Business travel time is valued at 100% of average hourly income, and personal travel time is valued at 70% of average hourly income. The DOT Office of the Secretary provides periodic updates of the recommended values of travel time. Between updates, analysts should _not_ make interim adjustments based on general price inflation measures.

TABLE 15 Recommended Hourly Values of Travel Time
(In 2000 U.S. Dollars per Person)

Category	Recommended Value	Sensitivity Range	
		Low	High
Air Carrier:			
Personal	$23.30	$20.00	$30.00
Business	$40.10	$32.10	$48.10
All Purposes*	$28.60	$23.80	$35.60
General Aviation:			
Personal	$31.50	NR	NR
Business	$45.00	NR	NR
All Purposes	$37.20	NR	NR

NR - No recommendation.
Sources:
GRA, Incorporated, *Economic Values for FAA Investment and Regulatory* Decisions, *A Guide* , Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
FAA Office of Aviation Policy and Plans, "Treatment of Values of Travel Time in Economic Analysis," *APO Bulletin APO-03-01* , March 2003.
U.S. Department of Transportation, "Revised Departmental Guidance--Valuation of Travel Time in Economic Analysis," *Office of the Secretary of Transportation Memorandum* , February 11, 2003.

Aircraft Operating Costs

Delays are costly not only to passengers, but to airlines as well. Every minute spent in flight, taxiing or idle on the ground costs airlines in fuel and/or ties up aircraft and crew. **TABLE 16** presents the average operating costs for air carrier, general aviation, and military aircraft. For detailed analyses, appropriate unit costs for specific equipment types operating at an airport must be used. The detailed aircraft operating cost tables by equipment type are presented in Appendix A of this paper.

TABLE 16 Aircraft Operating Costs per Block Hour

Air Carrier Category	Crew	Fuel & Oil	Total Maintenance	Subtotal Variable Costs	Rentals	Depreciation	Insurance	Subtotal Fixed Costs	Total Costs
Large (Form 41) Passenger Part 121 Air Carrier	$737	$722	$641	$2,100	$377	$246	$17	$640	$2,741
Large (Form 41) Air Freight Carrier	$1,417	$1,443	$1,479	$4,339	$835	$680	$69	$1,583	$5,922
Regional (Form 41) Passenger Air Carrier	$426	$1,015	$901	$2,342	$876	$1,008	$1,884	$3,218	$4,226
Regional (Form 41) Air Freight Carrier	$514	$1,177	$326	$2,017	$1,219	$702	$1,921	$3,235	$3,938
Alaskan (Form 298) Passenger Air Carrier[1]	$104	$102	$153	$359	-	$76	$32	$108	$467
Non-Alaskan (Form 298) Passenger Air Carrier[1]	$169	$214	$238	$622	-	$225	$31	$256	$878

[1] For these air carrier categories, the figures under depreciation includes rental, and the figures under insurance include other fixed expenses.

Source: BTS Form 41 for year-end 2002. Also Schedule P5.2. Compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.

Valuation of Aviation Accident Costs

Safety is another important motivation for discouraging incompatible land uses around airports. The presence of certain land uses that create physical and visual obstructions increases the risk of aviation accidents. And the presence of land uses with a lot people near runway approaches exposes these people to harm from potential aviation accidents. Aviation accidents are costly to society. They can result in fatalities, injuries, property damage, and significant resources spent on accident investigation. A major responsibility of the FAA and airport sponsors is to reduce the incidence of such outcomes (FAA 1998).

To assess the costs of increased accident risk from the presence of safety hazards, the analyst needs to determine the extent by which the incidence of preventable accidents is increased (or reduced in the case of regulations or investments to promote safety), determine the rate of fatality, injury and property damage per accident, and quantify the associated costs (or benefits) in dollars. To assess the costs of incompatible land uses that expose communities to aviation accidents, the analyst needs to delineate the areas exposed to this risk, determine the extent of risk exposure within these areas, estimate the number of people in these areas, and quantify the costs of third-party fatalities, injuries, and property damage in dollars.

FAA's revised guide to *Economic Analysis of Investment and Regulatory Decisions* (FAA 1998) describes a standard approach for measuring accidents per unit of exposure – for example, accidents per number of aircraft operations – and methodologies for estimating changes to this rate of accident exposure. The alternative methodologies include (1) the construction of models that compute the number of accidents that can be expected to occur per unit of exposure with and without a particular variable (for example, a safety obstruction, or a particular measure to increase safety), and (2) judgmental accident evaluation. There are also ways to estimate accident risks when limited or no historical data are available, – for example, analytical deduction, analogies, and statistical estimation with limited data.

The FAA recommends the use of standard economic values for assessing the costs of fatalities and injuries, aircraft damage, and accident investigation (see GRA 2004).

Value of Statistical Life

Many government regulations, policies, and investments are geared toward enhancing safety and protecting the environment, and the principal benefits of such efforts are avoided fatalities and injuries. The standard economic values prescribed for assessing the costs of fatalities and injuries are based on the *value of statistical life* (VSL) – the monetary value that individuals are willing to accept in exchange for a small change in the probability of a fatality (Ashenfelter 2006). The phrase "value of statistical life" is used to make it clear that

VSL is a technical term and is not intended not to place value on a specific individual's life (DOT 1992, Ashenfelter 2006).

Past estimates of VSL were based on an individual's discounted lifetime earnings, which measure the loss in economic productivity resulting from mortality. This approach has been criticized on a number of grounds, but the most fundamental objection is that a person's willingness to pay to reduce the risks of death is not necessarily related to one's earnings (Kenkel 2003). Recent studies estimate WTP using three principal methods:

- Wage-risk tradeoffs – This is the most common method based on the wage premiums that must be paid to induce workers to accept riskier employment.
- Revealed-preference studies – These use data on consumer decisions observed in real markets, such as willingness to accept cost or inconvenience in exchange for safety improvements from smoke detectors, automobile seat belts, bicycle helmets, and so forth.
- Contingent valuation – This uses SP survey techniques to elicit responses to carefully structured hypothetical questions.

Recent reviews of empirical research have produced the following estimates of VSL, adjusted to 2007 prices: Mrozek and Taylor (2001), $2.6 million; Miller (2000), $5.2 million; Viscusi (2004), $6.1 million; Kochi et al (2003), $6.6 million; and Viscusi and Aldy (2003), $8.5 million. DOT (2008) recommends using the mean of these five values, $5.8 million, for transportation regulatory and investment analysis, and alternative values of $3.2 million and $8.4 million for sensitivity analysis.

The cost of nonfatal injuries, or the value of averted nonfatal injuries, can be assessed as a proportion of VSL – called *relative disutility factors* – depending on the severity and duration of injury, as shown in **TABLE 17**. Injuries are categorized into levels using the Abbreviated Injury Scale (AIS), ranging from AIS 1 (minor) to AIS 5 (critical). The underlying body of research is described in Miller, Luchter, and Brinkman (1989) and Rice, MacKenzie & Associates (1989). The relative disutility factors can be used to establish the value of nonfatal injuries or to convert nonfatal injuries into fatality equivalents.

TABLE 17 Relative Disutility Factors by Injury Severity Level

AIS Level	Injury Severity	Selected Injuries	Fraction of VSL
1	Minor	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs).	0.0020
2	Moderate	Major abrasion or laceration of skin; cerebral concussion (unconscious less than 15 minutes); finger or toe crush/amputation; closed pelvic fracture with or without dislocation.	0.1550
3	Serious	Major nerve laceration; multiple rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush/amputation.	0.0575
4	Severe	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours).	0.1875
5	Critical	Spinal cord injury (with cord transection); extensive second- or third-degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours).	0.7625
6	Fatal	Injuries, which although not fatal within the first 30 days after an accident, ultimately result in death.	1.0000

AIS - Abbreviated Injury Scale
VSL - Value of statistical life
Sources:
U.S. DOT, "Revised Departmental Guidance: Treatment of the Value of Preventing Fatalities and Injuries in Preparing Economic Analyses, February 5, 2008.
GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.

Other Injury Costs
The values recommended by the FAA for other costs (**TABLE 18**), such as the costs of emergency services, medical care, and legal and court services (the cost of carrying out court proceedings, not the cost of settlement). Similar costs apply to fatalities but such costs are very small relative to the VSL – less than $50,000 per fatality according to FAA estimate – that it is not worthwhile to account for them separately (GRA Incorporated 1994).

TABLE 18 Per Victim Medical and Legal Costs Associated with Injuries (2001 dollars)

AIS Code	Description of Maximum Injury	Emergency/ Medical	Legal/Court	Total Direct Costs
AIS 1	Minor	$600	$1,900	$2,500
AIS 2	Moderate	$4,000	$3,100	$7,100
AIS 3	Serious	$16,500	$4,700	$21,200
AIS 4	Severe	$72,500	$39,100	$111,600
AIS 5	Critical	$219,900	$80,100	$300,000
AIS 6	Fatal	$52,600	$80,100	$132,700

Sources: Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs, FAA-APO-89-10, October 1989, Section 3, as adjusted for price level changes. Presented in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.

When available aviation injury data are not detailed enough to be categorized at the AIS level, the FAA recommends values using the International Civil Aviation Organization (ICAO) injury classification into “minor” and “serious”, as shown in **TABLE 19.**

TABLE 19 Average per Victim Injury Values for Serious and Minor Injuries (2001 dollars)

ICAO Code	WTP Values	Emergency/ Medical	Legal/ Court	Total Value
Minor (ICAO 2)	$37,900	$2,300	$2,700	$42,900
Serious (ICAO 3)	$536,000	$31,300	$13,400	$580,700

Source: GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.

Aircraft Replacement and Restoration Costs
Aviation accidents result in damage to aircraft, the cost of which is borne by aircraft operators and ultimately by users and society in the form of higher fares and shipping costs. The FAA recommends values for the replacement cost of destroyed aircraft and the restoration cost of substantially damaged aircraft, by equipment type, as presented in Appendix B. A summary by general category of aircraft is presented in **TABLE 20.**

TABLE 20 Aircraft Replacement and Restoration Values (Amounts in 2003 dollars)

Air Carrier Category	Aircraft in Fleet	Avg. Replacement Value		Avg. Monthly Lease Rate	Restoration Costs as % of Replacement
		Base Value	Market Value		
Air carrier					
Passenger	8,666	$13,481,560	$11,460,743	$140,811	13%
Cargo	1,065	$13,138,732	$10,641,925	$153,671	15%
General aviation					
Pre-1982	160,592		$94,661		26%
1982 and beyond	50,651		$1,817,062		15%
All years	211,244		$361,943		20%
Military	15,974		$24,400,000		3%

Source: Aviation Specialists Group (data includes all U.S. registered aircraft); compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.

The recommended values for aircraft replacement are based on transactions in the market for used aircraft, except for military aircraft. For air carrier aircraft replacement value, there are two alternatives: base and market value. The base value refers to the aircraft value in a market without excess supply or excess demand, which reflects the long-run relationship between current value, age, and original price. When the aircraft market has substantial excess capacity, as was the case in 2004 when the values were last updated, current market values are significantly lower than base values.

Restoration cost values are to be used only for aircraft with substantial damage.[3] The restoration cost of aircraft with minor damage is generally negligible as a proportion of the market value. The restoration cost approach applies to valuing destroyed aircraft.

Aviation Accident Investigation Costs

In addition to fatality, injury, and property damage costs, the National Transportation Safety Board (NTSB), the FAA, and the private sector expend a significant amount of resources in accident investigation – resources that could otherwise be put to other productive uses. **TABLE 21** presents values for accident investigation cost by type of investigation and category of user (air carrier and general aviation). The two types of investigations are major investigations directed by NTSB headquarters and field office investigations conducted by NTSB field offices. Major investigations are conducted for major air carrier accidents involving numerous fatalities and substantial property damage. Field office investigations are classified into regular or limited. Regular investigations are conducted for air carrier accidents involving limited loss of life and for most fatal general aviation accidents. Limited investigations are conducted for other general aviation accidents.

Valuation of Noise Impacts

Land uses with concentrations of people – particularly residences, schools, and hospitals – near airports increase the number of people exposed to aviation noise. Noise is an example of a negative externality – an uncompensated external cost (Nelson 2008). External costs are by-products of economic activities that affect third parties – people not directly involved in the market transactions. Because the costs are generally not borne by those who caused them, they are often not reflected in market prices and hence not taken into account when making decisions on how much to produce or use of a particular good or service.

[3] The National Transportation Safety Board (NTSB) classifies aircraft involved in accidents as “destroyed,” having “substantial damage,” having “minor damage,” or having “no damage”.

TABLE 21 Aviation Accident Investigation Cost (Amounts in 2002 dollars)

Category	Cost per Accident					Number of Accidents 1991-2002
	Federal			Private	Total	
	NTSB	FAA	Subtotal			
By type of investigation:						
Major	$1,931,800	$681,700	$2,613,500	$5,933,400	$8,546,900	59
Field Office:						
Regular	$38,300	$25,700	$64,000	$57,400	$121,400	6,016
Limited	$300	$13,800	$14,100	0	$14,100	18,648
Weighted Average by User Type:						
Air Carrier (including Air Taxi)	$110,300	$57,800	$168,100	$280,900	$449,000	1,551
General Aviation	$7,700	$16,200	$23,900	$11,200	$35,100	23,172

Source: National Transportation Safety Board, Federal Aviation Administration, Aviation Rulemaking Cost Committee, and GRA, Incorporated. See GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.

The costs of noise – and the benefits of reducing the exposure of people to noise – must be addressed in economic analysis. For example, the European Commission's "Green Paper on Future Noise Policy" (EC 1996) and Directive 2002/49/EC on noise assessments (EC 2002) called attention to the need to value noise effects as part of benefit-cost analyses of specific noise mitigation and abatement measures (Nelson, 2008). Economic valuation of noise is also important in determining the full costs of aviation and in designing economic instruments to make aviation users pay for the costs of noise (Nelson 2008). Over the last decade, transportation policy and research in Europe has been geared toward developing economic instruments to promote the internalization of transportation's external costs – making "polluters" pay (Pearce and Pearce 2000; United Kingdom (UK) Department for Transport 2003; Dings, et al 2003; van Essen, et al 2007).

The valuation of noise effects, however, is easier said than done because there are no clearly defined property rights to peace and quiet, and hence no market where people can buy and sell these rights. Deriving empirical estimates is difficult because it requires numerous assumptions and compromises (FAA 1998). Existing FAA guidance addresses the measurement of noise effects, but not monetary valuation. The *BCA On-line Guide* maintained by the California Department of Transportation (Caltrans) also acknowledges the difficulty of assigning dollar value to noise impacts and states that, for a BCA, it is sufficient to estimate how much noise there will be when a transportation project is complete, choose appropriate abatement methods, if necessary, and include the cost of abatement in the cost of the project. For very large projects that drastically increase or reduce noise, Caltrans suggests the use of hedonic pricing and contingent valuation methods – the two most commonly used methods (Lambert, et al 1998).

Hedonic pricing (HP) is a revealed preference (RP) method that derives the value of noise impacts – also called *noise discount* or *noise depreciation index* (NDI) – from differences in housing prices. Assuming two similar properties, the one exposed to higher noise levels will tend to be cheaper. The observed differences in prices paid for homes exposed to different levels of noise, after controlling for differences in other housing characteristics, can be used to calculate a noise discount. This noise discount, usually expressed as percentage reduction in the market value of a residential property per one-decibel (dB) increase in noise exposure, is expected to fall with increasing distance from the airport as exposure to aircraft noise diminishes. Regression analysis of real estate transactions is used to unbundle housing prices and calculate a hedonic price for the avoidance of noise (Nelson 2008).

Contingent valuation (CV) falls under the category of stated preference (SP) methods. People are asked in a survey to state how much they are willing to pay – for example, in terms of additional rent or mortgage, local taxes, or payments to local businesses – to reduce their noise exposure by a given amount (EC 2003), or how much they are willing to accept for increased noise exposure (Dings, et al 2003). The survey must be designed and implemented very carefully to avoid biases in the responses.

While countries in Europe have adopted representative values for use in economic analysis (EC 2003, UK Department for Transport 2003, Dings et al, 2003, van Essen et al 2007), there is yet no standard value recommended in the United States for aircraft noise. Over the past 40 years, however, empirical research has produced a variety of estimates for specific airport environs. Earlier literature reviews reported mean NDI values of 0.50 to 0.70% per dB (Nelson 1980, 2004). Studies, that are more recent, reviewed in Nelson (2008) yield 24 estimates with an unweighted mean value of 0.92%, an interquartile mean value of 0.80% and a median value of 0.74% per dB. Recent estimates are slightly higher than earlier ones, possibly reflecting rising real incomes and differences in econometric techniques. Nelson (2008) concludes that the unit NDI values are reasonably stable over time, a finding that could support their use under the benefit transfer method. **TABLE 22** presents NDI estimates from studies done in the United States.

TABLE 22 Noise Depreciation Index: Estimates from Studies in the United States

Reference Study	Method	Airport &/or Area	Study Period	NDI %
Nicosia (2003)	HP	Addison, TX	2002	0.80 for apartmebts
Cohen & Coughlin (2008)	HP	Atlanta, GA	2000-2002	0.89-1.59 in 65 dB zone; 1.34-2.65 in 75 dB zone
O'Byrne et al (1985)	HP	Atlanta, GA (blocks)	1970	0.64
O'Byrne et al (1985)	HP	Atlanta, GA (houses)	1979-80	0.67
BAH-FAA (1994)	HP	Baltimore, MD	1990	1.07
Price (1974)	HP	Boston, MA (rentals)	1970	0.81
Nelson (1979)	HP	Buffalo, NY	1970	0.52
McMillen (2004a, 2004b)	HP	Chicago O'Hare	1996-2001	0.74 in the 65 dB zone; 0.91 in the 75 dB zone
Nelson (1979, 1980)	HP	Cleveland, OH	1970	0.29
Blaylock (1977)	HP	Dallas, TX	1970	0.99
De Vany (1976); NAS (1977)	HP	Dallas Love Field, TX	1970	0.58-0.8
Feitelson, et al (1996)	CV	Dallas-Fort Worth	1996	1.5 for houses; 0.9 for apartments
BAH-FAA (1994)	HP	John F. Kennedy, New York, NY	1993	1.2
BAH-FAA (1994)	HP	La Guardia, New York, NY	1993	0.67
BAH-FAA (1994)	HP	Los Angeles, CA	1991	1.26
Emerson (1969, 1972)	HP	Minneapolis, MN	1967	0.58
Fromme (1978)	HP	National, Washington, DC	1970	1.49
Nelson (1978)	HP	National, Washington, DC	1970	1.06
Nelson (1979, 1980)	HP	New Orleans, LA	1970	0.4
Pope (2007)	HP	Raleigh-Durham, NC	1992 and 2000	0.19 in the 55-65 dB zone before noise disclosure; 0.25 in the 65-70 dB zone before noise disclosure; 0.39 in the 65-70 dB zone after noise disclosure
Kaufman (1996); Espey & Lopez (2000)	HP	Reno, NV	1991-1995	0.28-0.43
Myles (1997)	HP	Reno, NV	1991	0.37
Maser et al (1977); Quinlan (1970)	HP	Rochester, NY (suburban)	1971	0.55-0.68
Maser et al (1977); Quinlan (1970)	HP	Rochester, NY (urban)	1971	0.82-0.95
Nelson (1979, 1980)	HP	San Diego, CA	1970	0.74
Nelson (1979, 1980)	HP	San Francisco, CA	1970	0.58
Dygert (1973)	HP	San Francisco, San Mateo, CA	1970	0.5
Dygert (1973)	HP	San Jose, CA	1970	0.7
Nelson (1979, 1980, 1981)	HP	Six airports	1970	0.55
Mark (1980)	HP	St. Louis, MO	1969-1970	0.56
Nelson (1979, 1980)	HP	St. Louis. MO	1970	0.51

Sources: Individual studies, and literature reviews in Nelson (2004, 2008), McMillen (2004a); Jacobs Consultancy and Nelson (2008).

Benefit-Cost Analysis (BCA)
An important application of economic valuation is in the benefit-cost analysis of regulatory policies and public investment. In the context of the research on enhancing airport land use compatibility, examples include:

- Noise mitigation and abatement measures including curfews, quieter aircraft, preferential runway use, modification of flight paths, restriction of certain aircraft
- Airport expansion, taking into account the full costs including environmental effects
- Regulations, policies, and measures to promote compatible land use planning, taking into account the full benefits of removing restrictions on aviation system capacity and development, as well as reducing or avoiding the exposure of third parties to adverse environmental effects.

BCA helps decision makers to anticipate and evaluate the likely consequences of rules, policies, and public investment projects. It provides a formal way of organizing the evidence on the key effects – good and bad – of various alternatives. The motivation is to (1) learn if the benefits of an action are likely to justify the costs, or (2) determine which of various possible alternatives would be most cost-effective. To promote efficient policy development and use of resources, the analysis needs to take into account the wider social costs and benefits of proposed measures or investments. To the extent possible, benefits and costs must be quantified and expressed in monetary units. Where this is not possible, the analysis can include an assessment of certain costs and benefits in physical units or in qualitative terms.

Official Guidance
The following laws, regulations, and guidance provide the official guidance on the requirement and recommended methodologies for the benefit-cost analysis of public investment projects and regulatory actions:

- Executive Order (EO) 12866, "Regulatory Planning and Review," September 30, 1993
- Executive Order 12893, "Principles of Federal Infrastructure Investment," January 26, 1994
- Airport Noise and Capacity Act of 1990 (ANCA) [49 U.S.C. App. 2158]
- Office of Management and Budget Circular No. A-4, "Regulatory Analysis," September 17, 2003
- Office of Management and Budget Circular No. A-94 Revised, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 29, 1992
- Economic Analysis of Investment and Regulatory Decisions – Revised Guide, FAA-APO-98-4, January 1998
- 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), December 15, 1999
- FAA Airport Benefit-Cost Analysis Guidance, December 15, 1999

A brief description of each one is provided in Appendix C.

The BCA Process

The BCA process consists of the following steps:

The BCA Process
1. Define objective 2. Specify assumptions 3. Identify base case 4. Identify alternatives 5. Determine evaluation period 6. Estimate benefits and costs 7. Compare benefits and costs 8. Perform sensitivity analysis 9. Make recommendations

1. Define the objective of the proposed investment, policy, or regulation.
2. Specify the assumptions about future airport and local market conditions.
3. Identify the base case. The base case serves as the reference for assessing the incremental benefits and costs of alternatives.
4. Identify reasonable alternatives for meeting the stated objective.
5. Determine the evaluation period. The evaluation period must be long enough (for example, 20 years) to encompass the important benefits and costs of the proposed action.
6. Estimate benefits and costs. For each alternative, identify the associated incremental benefits and costs over the entire evaluation period, measure them in physical units, and, to the extent feasible, express them in monetary terms.
7. Compare benefits and costs. Benefits and costs must be discounted using the appropriate discount rate, and compared using the following criteria: (1) net present value (NPV) and (2) benefit-cost ratio (BCR), which must be at least one. The NPV equals the present value of benefits minus the present value of costs, and must be positive. When comparing two or more alternatives, select the one that yields the highest NPV. To calculate the BCR, the present value of benefits (both positive and negative) is divided by the present value of costs (capital costs and operating and maintenance costs, net of any residual value). The BCR must be at least one.
8. Perform sensitivity analysis. The impact of uncertainties must be evaluated using techniques such as sensitivity analysis, Monte Carlo simulation, and decision analysis.
9. Make recommendations. Recommend (1) whether to pursue the objective, and/or (2) which alternative should be undertaken to meet the objective. The recommendation will depend on the comparison of benefits and costs, sensitivity analysis of results to changes in assumptions, and consideration of *non-monetized* or *hard-to-quantify* benefits and costs.

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*, not to the Federal government, should be the basis for evaluating government programs and policies. 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, because airport investments are funded in whole or in part using AIP funds from the Airport and Airway Trust Fund, which historically has received its revenue from taxes imposed on the aviation system users.

Basic Principles and Other Considerations in a BCA
The following are some basic principles and considerations in a BCA:

- Economic analysis versus financial analysis. Economic analysis is not financial analysis. Economic analysis considers social costs and benefits, while financial analysis considers only the cash benefits and costs accruing to the entity making the investment or implementing a particular measure.
- Willingness to pay. The starting point for measuring costs or benefits is the concept of WTP. WTP measures how much individuals or firms are willing to pay to avoid a particular cost or enjoy a particular benefit.
- Life-cycle costs and benefits. A given project or regulation will generate costs and benefits over a number of years – over its service life-cycle in the case of an infrastructure or equipment. Life-cycle costs and benefits must be considered.
- Treatment of inflation. Inflation occurs when the prices of goods and services in the economy are rising over time. Because inflation is very hard to predict, it is best practice to forecast life-cycle costs and benefits without inflation – that is, expressed in constant base-year dollars.
- Time value of resources. Benefits and costs that occur sooner than later have greater value. The time value of resources 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 a 7% real discount rate for federal investment and regulatory analysis.

BCA Principles

- Economic analysis not financial analysis
- Economic analysis considers social costs and benefits
- The measurement of costs and benefits must be based on WTP
- Costs and benefits must be measured over many years
- Costs and benefits must be measured without inflation
- Future costs and benefits must be discounted
- BCA must exclude transfers
- BCA must exclude regional economic impacts
- Hard-to-quantify benefits must be described
- Distributional impacts must be disclosed

- Difference between real costs (benefits) and transfer payments. Benefit and cost estimates should reflect real resource use, and exclude transfer payments. There are no economic gains (or losses) from a pure transfer payment because the benefits to those who receive it are offset by the costs borne by those who pay it (OMB 1992, 2003). Tolls, other user charges, taxes, subsidies, and insurance payments are examples of transfer payments and should not be included in the BCA of public investment and regulation (DOT Economic Analysis Primer).
- Treatment of regional economic benefits. According to OMB Circular A-94, resources should be treated as if they were likely to be fully employed. Therefore, regional economic benefits should not be included in BCA, because they are either transfers from other location or another representation transportation benefits (Small and Verhoef 2007, Lee 2000, FAA 1999, OMB 1992).
- Treatment of hard-to-quantify benefits and costs. There may be certain intangible benefits and costs that are just too difficult to measure in dollars. They should be identified and expressed in physical units if possible, or described qualitatively.
- 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. BCA should identify the gainers and losers, and significant distributional effects must be disclosed (OMB 1992, FAA 1998).

Summary
This section presented a framework for the economic analysis of the consequences and costs of the presence of incompatible land uses near airports. The main tools for economic analysis are *economic valuation* and *benefit-cost analysis*.

Economic valuation provides a way of defining and measuring value in terms of money, based on individual preferences, choices, and opportunity costs. Economic value is measured based on how much people are willing to pay (WTP) to acquire a certain good, service or benefit. Economic valuation methods fall into three categories:

- Revealed preference (RP) studies, which use market data
- Stated preference (RP) surveys, which ask people what they are willing to pay
- Benefit transfer methods, which use results from other RP and SP studies

This section presented relevant economic values, from the latest FAA guidance titled *Economic Values for FAA Investment and Regulatory Decisions, A Guide* and other published references, for the assessment of the following costs:

- Travel delay costs
  - value of travel time
  - aircraft operating costs
- Aviation accident costs
  - value of statistical life
  - other injury costs
  - aircraft replacement costs
  - aircraft restoration costs
  - accident investigation costs
- Noise impacts
  - noise discount or noise depreciation index

BCA provides a quantitative framework for weighing the benefits of reducing or avoiding the costs of airport land use incompatibility against the costs of proposed public investments and regulations to mitigate aviation's environmental effects, prevent the development of incompatible land uses, and promote compatible land use development around airports. BCA takes into account broader social costs and benefits, measures them in money terms, and compares their present values using the net present value and benefit-cost ratio criteria. The section outlined the steps, principles and other considerations involved in conducting BCA.
The following subjects can benefit from further research:

- Third-party property damage costs in aviation accidents
- Establishing standard economic values for noise discount

FRAMEWORK FOR THE ASSESSMENT OF REGIONAL ECONOMIC AND FISCAL IMPACTS

Regional economic impacts and fiscal impacts are typically not considered in economic analysis because they do not represent net gains or losses in economic welfare. They typically represent transfers of resources from one region to another, from one industry to another, or from one stakeholder group to another. The assessment of regional and fiscal impacts, however, is important especially to local governments in understanding the implications to them of airport land use incompatibility issues. Local and regional jurisdictions may stand to lose from the constraints imposed by incompatible land uses on airport development because airports are important drivers of the local economy and restricting their growth may limit economic development. On the other hand, residential developments near airports contribute to the local tax base, and local governments stand to lose tax revenue from disallowing residential development. The assessment of economic and fiscal impacts can be addressed by economic impact analysis and fiscal impact analysis.

Other Assessment Tools
Economic impact analysis **Fiscal impact analysis**

Economic Impact Analysis

Economic impact analysis should not be confused with BCA. Economic impact analysis is a methodology for determining how a change in regulation, policy, or 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 (Lipton and Wellman 1995). Airport sponsors conduct economic impact studies to educate the public about the significant economic contributions of airport operations. Economic impact studies can be used as public information tools to gain community and local government support for airport development and compatible land use planning.

Economic impact analysis estimates the local economic activity generated by airport operations in terms of employment, earnings, and output. Total economic impact includes direct, indirect, and induced effects from the provision and use of aviation services.

Economic Impact Analysis – Modeling Options

DiPasquale and Polenske (1980), Pleeter (1980), and Richardson (1972) identify three basic categories of models used to derive regional multipliers for estimating total economic impact:

- Economic base models. Economic base models divide local industries between export and service, and consider regional trade as the primary driver of growth.
- Econometric models. 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. Econometric models calibrated for specific counties, or aggregation of counties, are commercially available from Regional Economic Models, Inc. (REMI).
- Input-output models. 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. The FAA guidance on airport economic impact studies (FAA 1992) recommends the use of input-output multipliers from the Regional Input-Output Modeling System (RIMS II) maintained by the U.S. Bureau of Economic Analysis (BEA). Input-output multipliers from MIG, Inc. (IMPLAN) are also widely used.

Components and Sources of Airport Economic Impact

Total economic impact consists of the direct impact of an initial demand spending and the multiplier effects on the local economy (**FIGURE 5**). Multiplier effects arise when businesses buy inputs from each other (indirect impact) and when their workers spend their income on various purchases (induced impact). Airports generate economic impact from the following sources:

- Aviation provision. This refers to the economic activity of business and government entities engaged in providing aviation and aviation-support services at an airport.
- Aviation use. This refers to the economic activity of off-airport businesses that provide goods and services to users of aviation services. Visiting airport passengers spend money on lodging, food, retail purchases, ground transportation, and recreation, supporting various off-airport businesses within the region.

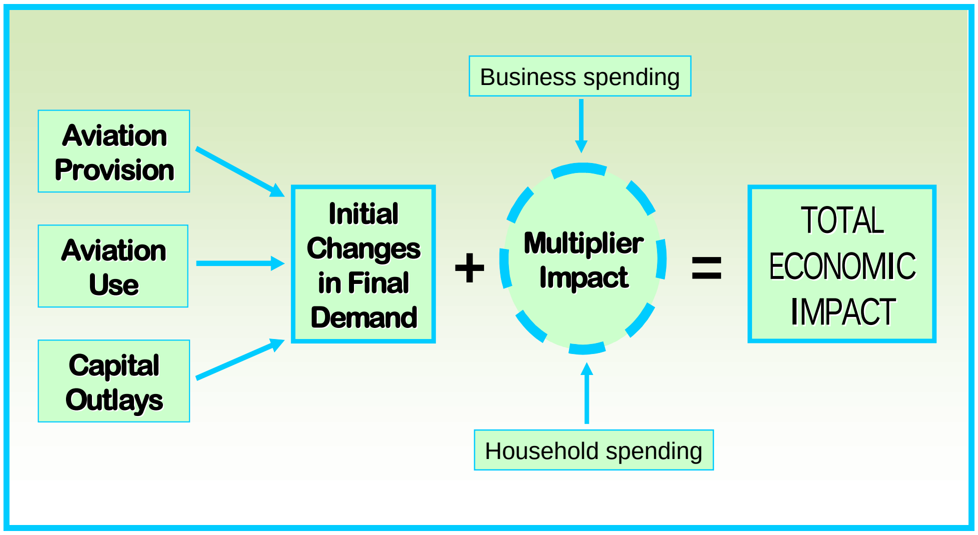

FIGURE 5 Components and Sources of Airport Economic Impact

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 on 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. Airport economic impact studies also often presents an assessment of the state and local tax revenue associated with the economic activity generated by airport operations.

Fiscal Impact Analysis
Local governments are often interested in how a particular development or land use change would affect the local budget. Fiscal impact analysis is a planning tool for estimating the impact of a development or land use change on the costs and revenues of governmental units serving the development. It is particularly relevant in assessing and comparing the net fiscal impact of residential and non-residential development in airport-compatible land use planning. Fiscal impact analysis helps local governments:

- Estimate the difference between the costs of providing services to a particular development and the tax revenues that will be generated by the development.
- Compare the net fiscal impacts of alternative land uses – for example, residential and commercial/industrial developments.

The following discussion is based on the description of fiscal impact analysis in Edwards' Community Guide to Development Impact Analysis (Edwards, 2008).

Approaches to Fiscal Impact Analysis
There are a number of standard approaches to fiscal impact analysis, ranging from a per-capita multiplier method to a case study method, which relies on local interviews. A key consideration in selecting the appropriate method is the approach to assessing the cost of services that development imposes on a local government. There are two cost assessment approaches:

- Average costing is the simpler more common procedure. It attributes costs to new development based on the average cost per unit of service in existing development times the number of units in the new development. It does not take into account excess or deficient capacity to deliver services, and it assumes that the average cost of municipal services will remain stable in the future.

- Marginal costing relies on the analysis of supply and demand for public services. It recognizes excess or deficient capacity existing in communities, and views growth as a cyclical process – as opposed to linear – in terms of the impact on local expenditures.

Fiscal Impact Estimation Process
This section illustrates the fiscal impact estimation process for a mixed-use development using a combination of per-capita and case study approach. In comparing alternative land use developments, the same process can be followed to estimate the fiscal impact of only one type of development – residential development only or non-residential development only. The following data are needed:

- Description of development – for example, number and type of homes in residential development; square footage of non-residential space
- Local revenue and expenditure data
- Local property value data and current mill rate
- Number of workers in the community
- Number of workers anticipated with the new development

The process can be described in nine steps:

1. Determine the number of residents and/or employees associated with the development.
2. Disaggregate local government budgets into categories of service expenditures (for example, general government, police, fire protection, inspection, public works, conservation/development, health/human services, culture/recreation, and debt service).
3. Allocate costs to residential and non-residential land uses.
4. Divide residential costs by total population to estimate service costs per capita. Divide nonresidential costs by total employees to estimate service costs per employee.
5. Calculate the total costs associated with the development under study. Calculate services costs by multiplying per unit costs by the number of people in the case of a residential development, or the number of workers in the case of a nonresidential development. Where applicable, determine the annual debt service payment on the capital costs of required public infrastructure. In many cases, these capital costs are paid by developers or by residents through user fees, and are therefore not explicitly included in traditional fiscal impact analysis.
6. Disaggregate local budgets into categories of revenue (for example, property taxes, other taxes, special assessments, state-shared revenues, other inter-government revenues, licenses and permits, fines and forfeits, public charges, intergovernmental charges and miscellaneous).
7. Allocate revenues to land uses and estimate per capita and per employee revenues.
8. Calculate property taxes, shared revenues, and total revenues associated with the development.
9. Compare estimated costs to estimated revenues to determine the net fiscal impact of the development.

Limitations of Fiscal Impact Analysis
Fiscal impacts are only one type of impact associated with a development, and fiscal impact analysis has a number of limitations:

- Interaction of land uses. Fiscal impact analysis does not capture the interaction among land uses when development occurs. For example, a commercial development may show a net positive fiscal impact but may generate costs outside of the development – for example, traffic congestion leading to higher expenditures for street maintenance and repair. It may also affect property values in adjacent developments, which are not captured in fiscal impact analysis.
- Fiscal impacts on other jurisdictions. While a development could have impacts on jurisdictions other than where it is located, standard approaches to fiscal impact analysis are typically designed to examine the effects of development on a single unit of government.

- Cumulative impacts of development. Standard fiscal impact analysis does not consider cumulative impacts. Whereas a single development may have a slight effect on a community's fiscal balance sheet, a series of development over time may have a significant impact.

Summary
Economic and fiscal impacts are important considerations to local government agencies, but are typically not considered in economic analysis because they represent *transfers*. This section presented two other analytical tools for assessing economic and fiscal impacts: *economic impact analysis* and f*iscal impact analysis*. These methods, however, should not be confused with BCA. They do not provide measures of economic value and do not guide decisions intended to achieve efficient resource allocation or welfare improvement.
Economic impact analysis estimates the local economic activity generated by airport operations in terms of employment, earnings, and output. Airport economic impact studies are useful as a public information tool to educate the public of the significant economic contributions of airports and gain community support for airport development and compatible land use planning.

Fiscal impact analysis is a planning tool for estimating the impact of a development or land use change on the costs and revenues of governmental units serving the development. It is useful in assessing and comparing the net fiscal impact of residential and non-residential development in airport-compatible land use planning.

The following topics are recommended for further research:

- Standardized planning factors for evaluating the local government costs and revenues of residential versus nonresidential land uses
- Review of literature on fiscal impact assessment studies

SELECTED CASE STUDIES
The purpose of this section is to present case studies that (1) illustrate the assessment of the types of costs associated with incompatible land uses described in Section 2, and (2) provide estimates of the magnitude of these costs. All the costs identified in Section 2 represent the costs arising from the presence of incompatible land uses; and reducing or preventing these costs represents the benefits of promoting compatible land use development. The assessment of benefits and costs, however, takes on a different perspective when incompatible land uses such as residential communities are already present. It becomes focused on measures intended to alleviate the consequences of airport land use incompatibility, and it often involves weighing costs and benefits to different stakeholders, usually airport users and residents of surrounding communities. This section also presents case studies that demonstrate the assessment of the benefits and costs of measures to reduce noise impacts on residential communities around airports.

Regional economic impacts are typically not addressed in economic analysis, yet they are important considerations to local governments. Educating the public about the significant economic contributions of airports could be help in gaining support for efforts to remove constraints to aviation system capacity development and promote compatible land use planning around airports. This section presents studies on the economic impacts of U.S. airports and the U.S. civil aviation sector as a whole.

The case studies were selected from published government and industry reports, published research in peer-reviewed professional and academic journals, and completed Part 161 studies. This section provides a summary of the key points in each study and highlights any important contribution to the literature. Readers are encouraged to refer to the actual reports and publications for the details of the analyses and results

Cost of Flight Delays to Passengers, Airlines, and the U.S. Economy
Source: Joint Economic Committee (JEC) Majority Staff, *Your Flight Has Been Delayed Again, Flight Delays Cost Passengers, Airlines, and the U.S. Economy Billions,* May 2008.

This report is presented here to demonstrate the assessment of the economic costs of air traffic delays in general. The presence of incompatible land uses around airport, to the extent that they impose restrictions on capacity and delay or prevent capacity expansion, contributes to these costs. Reducing these costs is one of the ultimate benefits of efforts to promote airport land use compatibility.

The report shows that the number of domestic flights and air flight delays has reached record levels, and increasing flight delays and cancellations are costing passengers and airlines billions of dollars each year. Based on an analysis of DOT data on more than 10 million individual U.S. domestic scheduled flights in 2007 operated by more than 400 different carriers through more than 1,100 airports, JEC (2008) found that:

- The total cost of domestic air traffic delays to the U.S. economy was as much as $41 billion for 2007 alone.
- Air traffic delays raised airlines' operating costs by $19 billion for extra crew, fuel and maintenance costs while planes sat idle at the gate or circled in holding patterns. These include more than $1.6 billion in additional fuel consumption.
- Delays cost passengers in wasted time worth up to $12 billion – time that could have been spent otherwise on productive work or enjoyable leisure activities.
- There are indirect costs to other industries that rely on air travel, adding roughly $10 billion to the total burden, resulting from increased production and distribution costs and decreased revenues.

JEC (2008) attempted to estimate the environmental costs of delay resulting from excess consumption of jet fuel – jet fuel produces pollution when burned. The study estimated that delay-related jet fuel burn emitted at least 7.1 million metric tons of climate-changing carbon dioxide (CO_2). In addition to CO_2, airplanes emit carbon monoxide, unburned hydrocarbons, nitrogen oxides, fine particulate matter, and sulphur oxides that cause local air pollution. JEC (2008) acknowledged that local air pollution effects could contribute to the costs of delays particularly in EPA-designated non-attainment areas. However, the study did not attempt to quantify the local air pollution costs because the process is not as simple as estimating CO_2 emissions as a factor of fuel consumption. Local air pollution effects depend upon weather conditions and the exact type of aircraft engine and body combination.

Time and Cost Impacts of Offshore Routing of Aircraft Departures at Los Angeles International Airport
Source: Hoffman, Jonathan H., Danijela Hajnal, Debra Moch-Mooney and Brian T. Simmons, *Time and Cost Impacts of Offshore Routing of LAX Departures*, MITRE Technical Report, MITRE Center for Advanced Aviation System Development, McLean, Virginia, June 2000.

This report was selected to demonstrate the assessment of the costs to aircraft operators of flight modifications to reduce aircraft noise impact on communities near airports. Aircraft departing Los Angeles International Airport (LAX) for the eastern, southern, and Midwestern United States takeoff west over water, turn south as they climb, and then turn east toward their destinations. This offshore routing of aircraft departures is done to reduce aircraft noise experienced in Los Angeles and surrounding cities. Hoffman, et al (2000) evaluated proposals to modify the turboprop departure routes from LAX to the south and east to reduce aircraft noise impact on the residents of communities on or near the Palos Verdes Peninsula.
The study examined the impact of route modifications on the efficiency of air traffic operations. The new routes require greater spacing of aircraft, which was shown to lead to large ground delays (see **TABLE 23**). These delays, in turn, were estimated to cost aircraft operators tens of millions of dollars per year, depending on the details of the routing chosen (see **TABLE 24**).

TABLE 23 Annualized Ground Movement Penalties at Lax (Minutes)

Departure Routing	Per Flight	Penalty	Per Day	Per Year
Baseline	18.2	-	-	-
1 mile offshore	21.8	3.6	3,717	1,168,100
2 miles offshore	23.0	4.8	4,956	1,557,466
3 miles offshore	24.2	6.0	6,195	1,946,833
5 miles offshore	25.6	7.4	7,641	2,401,094
Hybrid	21.2	3.0	3,098	973,416

Source: Hoffman, et al (2000), page 4-4.

TABLE 24 Annual Costs of Delays to Aircraft Operators (Million $ Per Year, in 1998 $)

Departure Routing	Ground	Airborne	Total
1 mile offshore	$34.8	$1.1	$35.8
2 miles offshore	$46.4	$5.8	$52.2
3 miles offshore	$58.0	$10.6	$68.5
5 miles offshore	$71.5	$14.2	$85.7
Hybrid	$29.0	$8.8	$37.8

Source: Hoffman, et al (2000), page 4-5.

Economic assessment of the 1990 Airport Noise and Capacity Act
Source: Morrison, Steven A., Clifford Winston and Tara Watson, "Fundamental Flaws of Social Regulation: The Case of Airplane Noise," *Journal of Law and Economics*, Vol. XLII, October 1999, pages 723-743.

This article provides an economic assessment of federal regulatory policy toward airplane noise in the 1990 Airport Noise and Capacity Act (ANCA). The ANCA mandated the restriction of certain aircraft – Stage II aircraft such as the Boeing 724 and the DC-9 – from operating at all U.S. airports by the end of 1999 to meet quieter noise requirements. This article quantified and compared the economic benefits and costs of this mandate. The authors found that the present value of benefits, reflected in higher property values for homeowners, fall $5 billion short of the ANCA's costs to airlines, reflected in the reduced economic life of their capital stock.

Noise regulations make the environment in communities surrounding airports quieter, and their benefits are reflected in higher housing values. Morrison, et al (1999) estimated the national benefits of ANCA by first determining the extent to which it has reduced noise and the value that noise reduction adds to affected homes. They then estimated how many U.S. households benefited from higher home values because of the legislation. They estimated the present value of these benefits at $5 billion (in 1995 dollars).

The benefits came at a cost to airlines. Noise regulations can disrupt carriers' replacement cycles and raise their capital costs if they force carriers to replace a portion of their fleet earlier than planned. Morrison, et al (1999) estimated these costs at $10 billion (in 1995 dollars), reflected in the accelerated depreciation of affected aircraft.

Benefit-Cost Analysis of Alternative Operational Restrictions at Naples Municipal Airport
Source: Harris Miller Miller & Hanson, Montgomery Consulting Group and Simat, Helliesen & Eichner, *Part 161 Study for Naples Municipal Airport*, 2001.

Naples Municipal Airport (APF) was the first airport to complete a Part 161 Study. The Part 161 Study for APF presented a BCA of alternative operational restrictions intended to reduce noise impacts on surrounding communities. The base case includes the noise abatement programs in effect at APF as of the time of the study. These noise abatement programs include Stage I restriction, preferential runway use, voluntary night curfew and noise education efforts targeted at the pilot community. Three alternative restrictions were evaluated against the base case: (1) night restriction of Stage 2 operations, (2) 24-hour restriction of Stage 2 operations, and (3) night restriction of all operations. The authors developed forecasts of aircraft operations for the base and alternative scenarios, defined the operational impacts of proposed restrictions based on a survey of airport users, and evaluated the benefits and costs of each alternative restriction relative to the base case.

Based on the survey findings, the authors determined that the costs of the proposed operational restrictions would result from the following:

- Use of another airport – Costs include (1) the additional passenger travel time getting to and from another airport, (2) ground transportation costs to get to and from another airport, and (3) value of pilot overnight stays. The shorter average air trip to the alternative airports serves to offset a small portion of the aforementioned costs.

- Cancellation of trip – Cancelled trips cost local businesses in an amount equivalent to how much passengers and pilots would have spent on food and accommodations in Naples.
- Substitution of a Stage 3 aircraft – Aircraft substitution costs depend on whether (1) the operators would substitute Stage 3 aircraft already in their fleet, (2) they would equip Stage 2 aircraft with hushkits, or (3) they would acquire Stage 3 aircraft to replace Stage 2 aircraft.
- Rescheduling flights – Associated costs include value of displaced passenger or pilot time from rescheduling flights from nighttime to daytime.
- Lost FBO revenues – The City of Naples Airport Authority (NAA) serves as an FBO selling fuel to aircraft using AFP. The operational restrictions will result in lost fuel sales.
- Increased activity at alternate airports – Flight diversions would increase aircraft operations and noise impacts at alternate airports.

The total costs resulting from all of the above responses to the operational restrictions, based on the volume of aircraft operations in 2000, were estimated to be on the order of $4.3 - $4.9 million with a night restriction of Stage 2 aircraft operations, $6.6 - $8.0 million with a 24-hour restriction of Stage 2 aircraft operations, or $11.4 - $18.4 million with a night restriction of all aircraft operations. Based on projected aircraft operations in 2005, total costs were estimated to be on the order of $479,000 - $770,000 with a night restriction of Stage 2 aircraft operations, $0.8 - $1.6 million with a 24-hour restriction of Stage 2 aircraft operations, or $16.6 - $26.7 million with a night restriction of all aircraft operations.

The NAA established the goal of minimizing residential exposure within the 60 dB DNL, and so the benefits of the proposed restrictions were measured in terms of the reduction in residential population within the 60 dB contour. The study did not assess the monetary value of the estimated noise benefits. A 24-hour restriction on Stage 2 aircraft operations was recommended because this was found to provide the greatest reduction in the population within the 60 dB contour, and carry significantly less cost than the next best alternative of a night restriction of all aircraft operations.

The Costs of a Proposed Curfew at Bob Hope Airport
Source: Jacobs Consultancy, "Chapter 4: Benefit-Cost Analysis," *FAR Part 161 Application for a Proposed Curfew, Bob Hope Airport*, Prepared for Burbank-Glendale-Pasadena Airport Authority, March 2008.

The study characterized the costs of a proposed curfew at BUR as follows:

General aviation and air taxi

- Costs of relocation to other airports, including additional commute and travel time costs for employees
- Additional costs to set up satellite operations at another airport
- Costs of picking up and dropping off passengers at other airports, including ground transportation costs for passengers, overnight accommodations for pilots, and the repositioning of flights

All-cargo carriers

- Costs of relocation to other airports, including additional commute and travel time costs for employees
- Lost cargo revenues
- Increased operating costs from flying into LAX and trucking cargo from LAX to the ground sorting facilities

Airline passengers

- Additional expenses on food, accommodation and ground transportation
- Loss of time from cancelled and diverted flights

Passenger airlines

- Lost ticket revenues
- Increased operating costs due to flight diversion and cancellation
- Opportunity costs

The Impact of Aircraft Noise on Residential Property Values in the Bob Hope Airport Environs
Sources:
Jacobs Consultancy, in association with Jon P. Nelson, "Technical Report No. 2: The Impact of Aircraft Noise on Residential Property Values in the Bob Hope Airport Environs," *FAR Part 161 Application for a Proposed Curfew, Bob Hope Airport*, Prepared for Burbank-Glendale-Pasadena Airport Authority, March 2008.
Jacobs Consultancy, "Appendix D: Methodology for Estimating the Effects of Noise on Residential Property Values," *FAR Part 161 Application for a Proposed Curfew, Bob Hope Airport*, Prepared for Burbank-Glendale-Pasadena Airport Authority, March 2008.

The authors developed a hedonic pricing model of the Bob Hope Airport (BUR) area housing market to investigate the impact of aircraft noise on housing prices. The model results showed a distinct relationship between noise levels and housing prices, providing a basis for computing a noise depreciation index (NDI). The results imply that the imposition of a curfew in aircraft operations at BUR would result in an improvement in property values within the Airport's 65 CNEL contour.

In interpreting the meaning of NDI, the study distinguished situations whereby residential development preceded airport development and situations whereby residential development followed airport development. In the former situation, a significant increase in noise levels from a new airport could lower home values relative to pre-airport values, or slow the rate of appreciation relative to similar neighborhoods not affected by airport noise. In this case, it can be claimed that noise caused "depreciation" in property values. In the latter situation where residential communities developed long after an airport started operations, in a well-functioning housing market, any noise impact has already been capitalized into property values. This means that whatever prices residents have paid for their homes already reflected a noise discount, so that homeowners can no longer claim any "depreciation" in property values from airport noise. In the case of BUR, residential communities developed long after the airport had been in operation. Therefore, the NDIs computed in the study, while offering evidence of a difference in property values between high and low-noise areas are not evidence of a loss in property values. A reduction in airport noise over time, however, could result in an increase in property values as predicted by the NDIs.

The NDIs calculated from the hedonic pricing models were used in combination with CNEL values computed using INM grid analysis for all curfew scenarios for each residential building within the 2008 baseline 65 CNEL contour to compute the range of property value increases that could result from the adoption of a curfew.

Airport Expansion and Property Values: the Case of Chicago O'Hare Airport
Sources:
McMillen, Daniel P., "Airport expansions and property values: the case of Chicago O' Hare Airport," *Journal of Urban Economics*, Vol. 55, 2004, pages 627-640.
McMillen, Daniel P., "House prices and the proposed expansion of Chicago O'Hare Airport," *Federal Reserve Bank of Chicago Economic Perspectives*, 3rd Quarter, 2004, pages 28-39.

The expansion program at Chicago O'Hare Airport (ORD) motivated this study. The expansion program will add an additional runway and reconfigure the seven existing runways at ORD to allow the airport to handle a projected 60% increase in flights. ORD is surrounded by a densely populated ring of suburban municipalities whose residents have already been complaining about noise from flights into and out of the airport. In theory, people generally are well informed when they make decisions to buy a new home, so that they will be willing to buy in an area exposed to severe noise only if they receive a discount on the home price. The author used home sales data in a hedonic pricing model to estimate the effect of noise on property values in the area around ORD. The author found that home values are 10% lower in areas that are subject to severe noise (in the 65-db contour band around ORD), explaining some of the community opposition to the expansion. However, the author argues that property values may not necessarily drop after the expansion because changes in fleet to replace older aircraft with new, quieter aircraft would continue to shrink the area exposed to severe noise. The author estimates that noise reductions will cause the average home in an area formerly subject to severe noise to increase in value by as much as $17,000 (in 1997 dollars) between 1997 and the time after the expansion.

Third-Party Risk Near Airports and Public Safety Zone Policy at Five Sample Airports in the United Kingdom

Source: Evans, A.W., P.B. Foot, S.M. Mason, I.G. Parker and K. Slater, *Third Party Risk Near Airports and Public Safety Zone Policy*, R&D Report 9636, Research and Development Directorate, National Air Traffic Services Limited, London, June 1997.

This study was conducted for the UK Department of Transport to support the review of airport Public Safety Zone (PSZ) policy. The study developed an approach to model third-party risk, calculate individual risk for different locations around an airport, and produce individual risk contours for five sample UK airports. The calculation of individual risk contours required the following model inputs: (1) the annual probability of a crash occurring near a given airport (*crash frequency*), (2) the distribution of such crashes with respect to location (*crash location model*), and the size of the crash area and the proportion of people likely to be killed within this area (*crash consequence model*). After calculating individual risk contours, the authors used benefit-cost analysis to set tolerability criteria for airport third-party risk, determine which areas are best candidates for PSZ policy, and make appropriate policy recommendations. The value of statistical life (VSL) concept was use to estimate fatality costs in aviation accidents. Avoiding these costs represented the main benefit weighed against the cost of PSZ policy options. No similar studies on third-party risk modeling and economic valuation have been found for U.S. airports, this is recommended for further research.

Economic Impact of U.S. Airports

Source: Airports Council International, *The Economic Impact of U.S. Airports*, 2002.

Airports are crucial in the everyday operations of the American society. They serve as catalysts of moving passengers and cargo, and play an essential role in facilitating commerce and national defense. As globalization continues, the competitiveness of American industry increasingly relies on airports and the aviation infrastructure. National, regional, and local economic growth depends upon the U.S. airport industry. Airports create $507 billion each year in total economic activity nationwide, 6.7 million jobs, $190 billion in employee earnings, and $33.5 billion in local, state and federal taxes. Over 1.9 million passengers and over 38,000 tons of cargo go through U.S. airports each day. The report presents case studies on the economic impact of the following airports:

- Baltimore/Washington International Airport
- Blue Grass Airport
- Hartsfield Atlanta International Airport
- Kansas City International Airport
- Minneapolis-St. Paul International Airport
- Nashville International Airport
- Oakland International Airport
- Philadelphia International Airport
- Rickenbacker International Airport
- Savanna International Airport
- Seattle-Tacoma International Airport
- Southwest Florida International Airport

Economic Impact of U.S. Commercial Aviation
Source: The Campbell-Hill Aviation Group, Inc., *Commercial Aviation and the American Economy*, March 2006.

Civil aviation is a vital component of the U.S. passenger and cargo transportation sector. The air transportation sector supports travel and tourism industries, and is, in turn, supported by the aircraft-manufacturing sector. In 2004, the contributions of the U.S. civil aviation sector to the U.S. economy were estimated as follows:

- $1,365 billion in economic output
- $418 billion in earnings
- 12.3 million in jobs

Summary
This section presented brief summaries of case studies that illustrate the assessment of some of the costs associated with incompatible land uses and provide estimates of the magnitude of these costs. It also presented studies that demonstrate the assessment of benefits and costs of measures to reduce aircraft noise impacts, as well as studies that provide estimates of the economic impact of U.S. airports and the U.S. commercial aviation. This section did not present individual airport economic impact studies because they are quite numerous. These individual airport economic impact studies are available as reference to those interested in conducting airport-specific studies. Areas that can benefit from further research include the following:

- Assessment of third-party aviation accident risk
- Assessment of local air pollution impacts from airport sources
- Benefit-cost analysis of land use controls in airport environs
- Examples of fiscal impact assessment of alternative land uses in airport environs

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APPENDIX A FAA-RECOMMENDED VALUES FOR AIRCRAFT OPERATING COSTS

TABLE A-1 Large (Form 41) Passenger Part 121 Air Carrier Operating Costs per Block Hour

Economic Values Category	Per Block Hour									
	Crew 1	Fuel & Oil 2	Total Maintenance 3	Total Variable Costs 4	Rentals 5	Depreciation 6	Insurance 7	Total Fixed Costs 8	Total Costs 9	Block Hours 10
Two-Engine Narrow-Body	$674	$616	$589	$1,879	$357	$180	$15	$552	$2,432	11,353,179
Two-Engine Wide-Body	$1,120	$1,225	$941	$3,285	$409	$509	$31	$949	$4,234	1,878,384
Three-Engine Narrow-Body	$1,196	$807	$496	$2,499	$79	$390	$9	$478	$2,976	170,762
Three-Engine Wide-Body	$1,369	$1,753	$1,363	$4,485	$723	$1,259	$46	$2,027	$6,512	255,679
Four-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Four-Engine Wide-Body	$1,941	$2,455	$1,655	$6,051	$1,275	$784	$42	$2,102	$8,153	321,888
Regional Jet under 70 seats	$235	$304	$208	$748	$203	$102	$7	$312	$1,060	933,530
Regional Jet 70 to 100 seats	$353	$443	$343	$1,139	$448	$70	$50	$567	$1,707	102,049
Turboprops under 20 seats (Part 23)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops with 20 or more seats	$266	$147	$562	$975	$330	$56	$7	$393	$1,369	270,929
Piston Engine (Part 23)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Piston Engine (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
All Aircraft	$737	$722	$641	$2,100	$377	$246	$17	$640	$2,741	15,286,400

Source: BTS Form 41 for year-end 2002. Also Schedule P5.2. Compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
NR: None reported
Note: Part 25 aircraft unless otherwise noted.
Col 1: Total flight deck (pilot) costs divided by total block hours.
Col 2: Cost of total fuel and oil consumed divided by total block hours.
Col 3: Airframe and Engine Maintenance, plus overhead (burden).
Col 4: Columns 1+2+3.
Col 5: Total amortization (for capital leases) and rental charges (for operating leases) divided by total block hours.
Col 6: Total depreciation charges divided by block hours.
Col 7: Total insurance costs divided by total block hours.
Col 8: Columns 5+6+7.
Col 9: Columns 4+8.
Col 10: Block hours reported in Form 41.

TABLE A-2 Large (Form 41) Air Freight Carrier Operating Costs per Block Hour

Economic Values Category	Per Block Hour									
	Crew 1	Fuel & Oil 2	Total Maintenance 3	Total Variable Costs 4	Rentals 5	Depreciation 6	Insurance 7	Total Fixed Costs 8	Total Costs 9	Block Hours 10
Two-Engine Narrow-Body	$1,339	$886	$1,068	$3,293	$105	$1,082	$97	$1,284	$4,577	116,769
Two-Engine Wide-Body	$1,366	$1,180	$1,133	$3,679	$1,113	$640	$89	$1,842	$5,521	276,283
Three-Engine Narrow-Body	$1,894	$891	$2,171	$4,956	$311	$646	$42	$998	$5,955	190,932
Three-Engine Wide-Body	$1,353	$1,663	$1,396	$4,412	$1,196	$491	$60	$1,746	$6,158	327,390
Four-Engine Narrow-Body	$1,292	$1,713	$1,904	$4,908	$360	$829	$79	$1,268	$6,177	92,226
Four-Engine Wide-Body	$1,182	$2,909	$1,545	$5,636	$1,226	$862	$48	$2,136	$7,772	105,813
Regional Jet under 70 seats	$267	$480	$573	$1,320	$0	$601	$119	$720	$2,040	8,842
Regional Jet 70 to 100 seats	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 23)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops with 20 or more seats	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Piston Engine (Part 23)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Piston Engine (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
All Aircraft	$1,417	$1,443	$1,479	$4,339	$835	$680	$69	$1,583	$5,922	1,118,255

Source: BTS Form 41 for year-end 2002. Also Schedule P5.2. Compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
NR: None reported
Note: Part 25 aircraft unless otherwise noted.
Col 1: Total flight deck (pilot) costs divided by total block hours.
Col 2: Cost of total fuel and oil consumed divided by total block hours.
Col 3: Airframe and Engine Maintenance, plus overhead (burden).
Col 4: Columns 1+2+3.
Col 5: Total amortization (for capital leases) and rental charges (for operating leases) divided by total block hours.
Col 6: Total depreciation charges divided by block hours.
Col 7: Total insurance costs divided by total block hours.
Col 8: Columns 5+6+7.
Col 9: Columns 4+8.
Col 10: Block hours reported in Form 41.

TABLE A-3 Regional (Form 41) Passenger Air Carrier Operating Costs per Block Hour

Economic Values Category	Crew 1	Fuel & Oil 2	Flight Ops Other (Except Rentals) 3	Total Flight Ops (Except Rentals) 4	Maintenance Flight Equipment 5	Depreciation & Rental Flight Equipment 6	Flight Equipment Expenses 7	Total Flight Operations Plus Maintenance 8	Total Cost 9	Block Hours 10
Two-Engine Narrow-Body	$279	$745	$423	$1,447	$525	$1,087	$1,612	$1,972	$3,059	42,238
Two-Engine Wide-Body	$501	$1,012	$791	$2,305	$857	$1,082	$1,940	$3,162	$4,244	2,129
Three-Engine Narrow-Body	$613	$1,361	$893	$2,867	$749	$708	$1,457	$3,616	$4,324	16,095
Three-Engine Wide-Body	$762	$1,668	$3,198	$5,628	$2,764	$1,161	$3,926	$8,392	$9,553	8,951
Four-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Four-Engine Wide-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Regional Jet under 70 seats	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Regional Jet 70 to 100 seats	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 23)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops with 20 or more seats	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Piston Engine (Part 23)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Piston Engine (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
All Aircraft	**$426**	**$1,015**	**$901**	**$2,342**	**$876**	**$1,008**	**$1,884**	**$3,218**	**$4,226**	**69,413**

Source: BTS Form 41 for year-end 2002. Also Schedule P5.1.Compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
Note: Part 25 aircraft unless otherwise noted.
Col 1: Total flight deck (pilot) costs divided by total block hours.
Col 2: Cost of total fuel and oil consumed divided by total block hours.
Col 3: Total of all other flight operations expenses (except rentals) divided by total block hours.
Col 4: Columns 1+2+3.
Col 5: Total for maintenance of flight equipment divided by total block hours.
Col 6: Total depreciation and flight equipment rental expenses divided by block hours.
Col 7: Columns 5+6.
Col 8: Columns 4+5.
Col 9: Columns 4+7.
Col 10: Block hours reported in Form 41.

TABLE A-4 Regional (Form 41) Air Freight Carrier Operating Costs per Block Hour

Economic Values Category	Crew 1	Fuel & Oil 2	Flight Ops Other (Except Rentals) 3	Total Flight Ops (Except Rentals) 4	Maintenance Flight Equipment 5	Depreciation & Rental Flight Equipment 6	Flight Equipment Expenses 7	Total Flight Operations Plus Maintenance 8	Total Cost 9	Block Hours 10
Two-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Two-Engine Wide-Body	$590	$1,277	$348	$2,215	$1,615	$781	$2,396	$3,830	$4,611	34,622
Three-Engine Narrow-Body	$483	$1,167	$328	$1,978	$962	$556	$1,517	$2,940	$3,496	31,306
Three-Engine Wide-Body	$663	$2,068	$92	$2,823	$763	$1,170	$1,933	$3,585	$4,755	1,414
Four-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Four-Engine Wide-Body	$570	$2,465	$1,047	$4,082	$1,711	$2,034	$3,745	$5,793	$7,828	9,434
Regional Jet under 70 seats	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Regional Jet 70 to 100 seats	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 23)	$80	$77	$58	$214	$44	$138	$182	$259	$397	1,482
Turboprops under 20 seats (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops with 20 or more seats	$933	$920	$161	$2,014	$1,749	$1,054	$2,803	$3,764	$4,818	9,076
Piston Engine (Part 23)	$106	$134	$20	$260	$169	$18	$187	$429	$447	5,375
Piston Engine (Part 25)	$280	$699	$72	$1,051	$733	$18	$751	$1,784	$1,802	14,653
All Aircraft	$514	$1,177	$326	$2,017	$1,219	$702	$1,921	$3,235	$3,938	107,362

Source: BTS Form 41 for year-end 2002. Also Schedule P5.1.Compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
Note: Part 25 aircraft unless otherwise noted.
Col 1: Total flight deck (pilot) costs divided by total block hours.
Col 2: Cost of total fuel and oil consumed divided by total block hours.
Col 3: Total of all other flight operations expenses (except rentals) divided by total block hours.
Col 4: Columns 1+2+3.
Col 5: Total for maintenance of flight equipment divided by total block hours.
Col 6: Total depreciation and flight equipment rental expenses divided by block hours.
Col 7: Columns 5+6.
Col 8: Columns 4+5.
Col 9: Columns 4+7.
Col 10: Block hours reported in Form 41.

TABLE A-5 Alaskan Form 298-C Operating per Block Hour

Economic Values Category	Crew Expense 1	Fuel & Oil 2	Maintenance 3	Total Variable Costs 4	Depreciation Rental 5	Other 6	Total Fixed Costs 7	Total Costs 8	Total Block Hours 9
Two-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Two-Engine Wide-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Three-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Three-Engine Wide-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Four-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Four-Engine Wide-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Regional Jet under 70 seats	$239	$308	$367	$914	$475	$48	$523	$1,437	2,395
Regional Jet 70 to 100 seats	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 23)	$127	$142	$199	$468	$120	$41	$161	$629	106,024
Turboprops under 20 seats (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops with 20 or more seats	$235	$243	$412	$890	$190	$52	$242	$1,132	25,263
Piston Engine (Part 23)	$75	$62	$95	$232	$35	$25	$60	$292	209,742
Piston Engine (Part 25)	$315	$226	$1,247	$1,788	$320	$104	$425	$2,213	238
Alaskan Total	$104	$102	$153	$359	$76	$32	$108	$467	343,662

Source: BTS Form 298 filings for the four quarters ending September 30, 2001. Compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
Note: Part 25 aircraft unless otherwise noted.
Col 1: Total flight deck (pilot) costs divided by total block hours.
Col 2: Cost of total fuel and oil consumed divided by total block hours.
Col 3: Total for maintenance costs divided by total block hours.
Col 4: Columns 1+2+3.
Col 5: Total depreciation and rental expenses divided by block hours.
Col 6: Other expenses divided by block hours.
Col 7: Columns 5+6.
Col 8: Columns 4+7.
Col 9: Block hours reported in Form 41.

TABLE A-6 Non Alaskan Form 298-C Operating Costs per Block Hour

Economic Values Category	Crew Expense 1	Fuel & Oil 2	Maintenance 3	Total Variable Costs 4	Depreciation Rental 5	Other 6	Total Fixed Costs 7	Total Costs 8	Total Block Hours 9
Two-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Two-Engine Wide-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Three-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Three-Engine Wide-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Four-Engine Narrow-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Four-Engine Wide-Body	NR	NR	NR	NR	NR	NR	NR	NR	NR
Regional Jet under 70 seats	$168	$286	$241	$695	$307	$34	$341	$1,036	739,853
Regional Jet 70 to 100 seats	NR	NR	NR	NR	NR	NR	NR	NR	NR
Turboprops under 20 seats (Part 23)	$126	$128	$314	$567	$140	$17	$157	$725	272,093
Turboprops under 20 seats (Part 25)	$194	$288	$227	$710	$297	$21	$318	$1,027	25,545
Turboprops with 20 or more seats	$189	$165	$204	$557	$163	$34	$197	$754	614,451
Piston Engine (Part 23)	$74	$82	$106	$263	$28	$18	$46	$308	5,510
Piston Engine (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR	NR
Non-Alaskan Total	$169	$214	$238	$622	$225	$31	$256	$878	1,657,585

Source: BTS Form 298 filings for the four quarters ending September 30, 2001. Compiled in GRA, Incorporated, *Economic Values for FAA Investment and Regulatory Decisions, A Guide*, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.

Note: "Sum of Unknown Types" and aircraft with 0 airborne hours not included

Note: Part 25 aircraft unless otherwise noted.

Col 1: Total flight deck (pilot) costs divided by total block hours.

Col 2: Cost of total fuel and oil consumed divided by total block hours.

Col 3: Total for maintenance costs divided by total block hours.

Col 4: Columns 1+2+3.

Col 5: Total depreciation and rental expenses divided by block hours.

Col 6: Other expenses divided by block hours.

Col 7: Columns 5+6.

Col 8: Columns 4+7.

Col 9: Block hours reported in Form 41.

APPENDIX B FAA-RECOMMENDED VALUES FOR AIRCRAFT REPLACEMENT AND RESTORATION COSTS

TABLE B-1 Estimated Base Values, Current Market Values, and Monthly Lease Rates of Air Carrier Aircraft (Amounts in 2003 dollars)

Economic Values Category	Air Carrier - Passenger				Air Carrier - Cargo			
	Number of Aircraft in Fleet	Weighted Average Base Value US$ Millions	Weighted Avg Current Market Value US$ Millions	Weighted Avg. Monthly Lease Rate US$ Thousands	Number of Aircraft in Fleet	Weighted Average Base Value US$ Millions	Weighted Avg. Current Market Value US$ Millions	Weighted Avg. Monthly Lease Rate US$ Thousands
	1	2	3	4	1	2	3	4
Two-Engine Narrow-Body	3,913	$16.47	$13.67	$143.29	128	$14.99	$11.23	$208.04
Two-Engine Wide-Body	554	$49.24	$42.26	$417.44	177	$26.35	$23.03	$259.42
Three-Engine Narrow-Body	368	$0.71	$0.71	$17.33	348	$1.08	$1.02	$32.51
Three-Engine Wide-Body	169	$7.77	$6.44	$168.23	163	$20.22	$16.90	$318.67
Four-Engine Narrow-Body	50	$0.32	$0.32	NR	128	$2.92	$2.92	NR
Four-Engine Wide-Body	133	$38.42	$30.02	$395.31	121	$27.79	$19.33	$169.10
Regional Jet Under 70 seats	976	$14.07	$13.23	$126.88	NR	NR	NR	NR
Regional Jet 70 to 100 seats	101	$14.99	$13.40	$129.96	NR	NR	NR	NR
Turboprop Under 20 seats (Part 23)	1,147	$0.48	$0.56	$19.53	NR	NR	NR	NR
Turboprop Under 20 seats (Part 25)	112	$0.10	$0.10	N/A	NR	NR	NR	NR
Turboprops with 20 or more seats	1,143	$1.95	$2.19	$35.09	NR	NR	NR	NR
Piston Engine (Part 23)	NR	NR	NR	NR	NR	NR	NR	NR
Piston Engine (Part 25)	NR	NR	NR	NR	NR	NR	NR	NR
All Aircraft	**8,666**	**$13.48**	**$11.46**	**$140.81**	**1,065**	**$13.14**	**$10.64**	**$153.67**

Source: Aviation Specialists Group (data includes all U.S. registered aircraft); compiled in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
NR = None Reported
Col 1: Aircraft fleet count.
Col 2: Total base value of aircraft fleet, divided by column 1.
Col 3: Total estimated current market value of aircraft fleet, divided by column 1.
Col 4: For jets, projected monthly lease rate (from base value). For turboprops, estimated current market lease rate.

TABLE B-2 Restoration Costs as a Percentage of Aircraft Value for Air Carrier Passenger and All-Cargo Aircraft

Economic Values Category	Passenger	All-Cargo
Two-engine narrow body jet	15%	NR
Two-engine wide body jet	11%	54%
Three-engine narrow body jet	18%	33%
Three-engine wide body jet	11%	8%
Four-engine narrow body jet	33%	22%
Four-engine wide body jet	10%	11%
Regional jet under 70 seats	8%	NR
Regional jet with 70 seats of more	8%	6%
Turboprops under 20 seats Part 23	15%	45%
Turboprops under 20 seats Part 25	NR	NR
Turboprops with 20 seats or more	24%	36%
Piston Engine (Part 23)	NR	NR
Piston Engine (Part 25)	NR	NR
All Aircraft	**13%**	**15%**

Source: GRA analysis of Airclaims data for the period 1990-2003; presented in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
NR = None Reported

TABLE B-3 Estimated Market Values of General Aviation Aircraft (Amounts in 2003 dollars)

	Economic Values Category	Certi-fication	All Years			Pre-1982			1982 and Beyond		
			No. of Aircraft in Fleet 1	Avg. Value Per Aircraft in 2003$ 2	Avg. Aircraft Age in 2003 3	No. of Aircraft in Fleet 1	Avg. Value Per Aircraft in 2003$ 2	Avg. Aircraft Age in 2003 3	No. of Aircraft in Fleet 1	Avg. Value Per Aircraft in 2003$ 2	Avg. Aircraft Age in 2003 3
1	Piston engine airplanes 1 to 3 seats (<200hp)	Part 23	33,050	$24,249	40	31,246	$21,496	42	1,804	$76,108	9
2	Piston engine airplanes 1 to 3 seats (>200hp)	Part 23	6,079	$123,843	33	4,364	$72,982	42	1,714	$256,885	10
3	Piston engine airplanes 4 to 9 seats one-engine (<200hp)	Part 23	54,352	$46,095	33	49,970	$40,991	34	4,382	$108,914	11
4	Piston engine airplanes 4 to 9 seats one-engine (>200hp)	Part 23	49,993	$114,594	30	41,924	$85,927	34	8,069	$264,955	10
5	Piston engine airplanes 4 to 9 seats two-engine	Part 23	16,783	$152,680	30	15,187	$132,754	32	1,596	$360,326	15
6	Piston engine airplanes 10 or more seats	Part 23	801	$137,688	34	783	$130,762	34	18	$290,000	19
7	Turboprop airplanes 1 to 9 seats one-engine	Part 23	1,004	$803,011	8	62	$187,976	24	942	$824,903	8
8	Turboprop airplanes 1 to 9 seats two-engine	Part 23	2,150	$517,788	24	1,546	$383,106	27	603	$918,754	14
9	Turboprop airplanes 10 to 19 seats	Part 23	3,650	$1,222,412	19	1,690	$773,026	25	1,960	$1,628,946	13
10	Turboprop airplanes 20 or more seats	Part 25	219	$2,014,790	22	148	$699,467	27	72	$3,179,785	18
11	Turbojet/Turbofan two-engine airplanes <12,000 lbs.	Part 23	2,029	$2,568,083	14	710	$824,692	29	1,319	$3,187,683	9
12	Turbojet/Turbofan airplanes >12,500 lbs. And <65,000 lbs.	Part 25	4,969	$5,851,422	12	1,524	$1,715,000	25	3,445	$7,170,976	9
13	Turbojet/Turbofan airplanes >65,000 lbs.	Part 25	1,204	$17,549,160	13	473	$3,878,931	29	731	$22,347,618	7
14	Rotorcraft piston <6,000 lbs.	Part 27	2,326	$135,430	16	1,107	$69,630	33	1,219	$166,504	8
15	Rotorcraft turbine <6,000 lbs.	Part 27	3,640	$606,739	18	2,004	$319,045	27	1,636	$856,887	10
16	Rotorcraft piston >6,000 lbs.	Part 29	25	NA	NA	18	NA	NA	6	NA	NA
17	Rotorcraft turbine >6,000 lbs	Part 29	657	$1,888,082	23	333	$1,047,191	32	324	$2,620,187	14
18	Other		28,313	NA	NA	7,504	NA	NA	20,810	NA	NA
All Aircraft			211,244	$361,943	31	160,592	$94,661	35	50,651	$ 1,817,062	10

Source: GA Survey 2002; Aircraft Bluebook Price Digest (Summer, 2003); Aircraft Types and Price Guidelines 2002-2003; and GRA estimates.
The above summary statistics are presented in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
NA=Not Available
Note: "Other" economic values class is included in calculating fleet total for all aircraft but not in calculating estimated market values and age for all aircraft.
Col 1: Total number of aircraft in GA Survey.
Col 2: Average aircraft value weighted by the number of aircraft.
Col 3: Average aircraft age (weighted) for data with known aircraft value and year of manufacture.

TABLE B-4 Restoration Costs as a Percentage of Aircraft Value for General Aviation Aircraft (Amounts in 2003 Dollars)

	Economic Values Category	Certification	Year Manufactured		
			All Years	Pre-1982	1982 and Beyond
1	Piston engine airplanes 1 to 3 seats (<200hp)	Part 23	30%	34%	21%
2	Piston engine airplanes 1 to 3 seats (>200hp)	Part 23	18%	20%	18%
3	Piston engine airplanes 4 to 9 seats one-engine (<200hp)	Part 23	22%	22%	18%
4	Piston engine airplanes 4 to 9 seats one-engine (>200hp)	Part 23	18%	20%	13%
5	Piston engine airplanes 4 to 9 seats two-engine	Part 23	24%	25%	18%
6	Piston engine airplanes 10 or more seats	Part 23	10%	10%	15%
7	Turboprop airplanes 1 to 9 seats one-engine	Part 23	20%	26%	15%
8	Turboprop airplanes 1 to 9 seats two-engine	Part 23	20%	26%	15%
9	Turboprop airplanes 10 to 19 seats	Part 23	1%	1%	15%
10	Turboprop airplanes 20 or more seats	Part 25	20%	26%	15%
11	Turbojet/Turbofan two-engine airplanes <12,000 lbs.	Part 23/25	20%	26%	15%
12	Turbojet/Turbofan airplanes >12,500 lbs. And <65,000 lbs.	Part 25	21%	31%	16%
13	Turbojet/Turbofan airplanes >65,000 lbs.	Part 25	6%	31%	2%
14	Rotorcraft piston <6,000 lbs.	Part 27	20%	26%	15%
15	Rotorcraft turbine <6,000 lbs.	Part 27	20%	26%	15%
16	Rotorcraft piston >6,000 lbs.	Part 29	NR	NR	NR
17	Rotorcraft turbine >6,000 lbs	Part 29	20%	26%	15%
18	Other		24%	33%	23%
All Aircraft			**20%**	**26%**	**15%**

Source: Estimates by GRA, Incorporated based on data from Airclaims and AVEMCO; preseented in GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
NR = Not Reported

TABLE B-5 Summary of Military Aircraft Values and Restoration Costs (FY2003)
(Amounts in 2003 million dollars; Average Weighted by Fleet)

Aircraft Type	Total Fleet 1	Average Replacement Value 2	Average Restoration Value 3	Restoration as a Percentage of Replacement 4
Piston	3	$0.1	NA	N/A
Rotary Wing Aircraft	7,125	$10.9	$0.7	6.1%
Turbojet/fan 3+ Engines	1,167	$74.9	$0.4	0.5%
Turbojet/fan Attack/Fighter	4,051	$34.7	$0.7	1.9%
Turbojet/fan Other	1,587	$12.3	$0.9	7.5%
Turboprop	2,017	$31.9	$1.3	4.0%
Other	22	$23.2	NA	N/A
N/A	2	NA	NA	N/A
Total	**15,974**	**$24.4**	**$0.7**	**3.0%**

Source: Analysis by GRA, Incorporated using data from the following:
For aircraft restoration: Navy and Marine Corps restoration costs.
For aircraft replacement: Army, Army Reserve and National Guard; Air Force, Air Force Reserve and Air National Guard Planning Factors; Navy, Naval Reserve, Marine Corps, and Marine Corps Reserve; Coast Guard.
The above table was obtained from GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report Prepared for FAA Office of Aviation Policy and Plans, December 31, 2004.
Note: Replacement and restoration values were not available for all aircraft types.
Col 1: Total number of aircraft for each aircraft type in military service.
Col 2: Average replacement value for each aircraft type, weighted by fleet.
Col 3: Average restoration value for each aircraft type, weighted by fleet.
Col 4: Column 3 divided by column 2.

APPENDIX C
OFFICIAL GUIDANCE ON ECONOMIC ANALYSIS

The following laws, regulations, and guidance provide the official guidance on the requirement and recommended methodologies for the economic analysis of public investment projects and regulatory actions:

- **Executive Order (EO) 12866, "Regulatory Planning and Review," September 30, 1993.** With this EO, the Federal Government begins a program to reform the regulatory process and make it more efficient. Specifically, Section 6(a)(3)(C) requires that, for significant regulatory actions within the scope of Section 3(f)(1), the following information be 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 Order 12893, "Principles of Federal Infrastructure Investment," January 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. AIP level) and individual project level.

- **Airport Noise and Capacity Act of 1990 (ANCA) [49 U.S.C. App. 2158].** This legislation requires local airports seeking to impose new noise rules to analyze all the benefits, costs, and impacts of these proposed noise rules before they can seek approval from the FAA. Part 161 refers to a section of the FAA's regulations that prescribes the process airports must follow in conducting the study.
- **Office of Management and Budget Circular No. A-4, "Regulatory Analysis," September 17, 2003.** This Circular provides the OMB's guidance to Federal agencies on the development of regulatory analysis as required under Section 6(a)(3c) 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 – using BCA as a primary tool – and standardizing the way benefits and costs of Federal regulatory actions are measured and reported.
- **Office of Management and Budget Circular No. A-94 Revised, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 29, 1992.** 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. It recommends the use of BCA as the technique to use 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. The Circular also provides specific guidance on the discount rates to be used in evaluating Federal programs whose benefits and costs are distributed over time.

- **Economic Analysis of Investment and Regulatory Decisions – Revised Guide, FAA-APO-98-4, January 1998.** This document is intended to provide basic guidance for economic analysis of investments, including certain AIP grants, and regulations subject to FAA decision-making. Like all the other regulations and guidance, it emphasizes the importance of economic analysis in providing a systematic approach in making decisions to make sure that limited resources are used efficiently in pursuing objectives. The document provides guidance on two types of economic analysis: (1) benefit-cost analysis and (2) cost-effectiveness analysis.
- **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), December 15, 1999.** This policy requires all airport sponsors to submit BCAs when requesting AIP grants or LOI to be awarded for capacity projects at the discretion of the Secretary of Transportation. 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. Airport sponsors must show that airport capacity projects meeting a dollar threshold of $5 million or more in AIP discretionary grants over the life of the project and all airport capacity projects requesting LOIs have 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.
- **FAA Airport Benefit-Cost Analysis Guidance, December 15, 1999.** This document is intended to:
    - Provide clear and thorough guidance to airport sponsors on the conduct of project-level benefit-cost analysis (BCA) for capacity-related airport projects
    - Facilitate the production of consistent, thorough, and comparable analyses that can be used by the FAA in considering airport projects for AIP discretionary and LOI funding.